Republic of Lebanon

Ministry of Education and Higher Education

Educational Center for Research and Development (ECRD)

EVALUATION GUIDE

PHYSICS - CHEMISTRY

SAMPLES OF SCHOOL EXAMINATIONS

SAMPLES OF OFFICIAL EXAMINATIONS

SECONDARY CYCLE

October 2000

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الشهادة الثانوية العامة

October 2000

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Preface

The Educational Center for Research and Development is rightfully proud to have scored a significant breakthrough in the field of school work evaluation.

The new curricula, as issued and implemented, had lacked a comprehensive evaluation system in line with the curricular goals, objectives and content. In May 1999, a committee was formed to work out the principles and bases for evaluation as well as prepare lists of competencies to be realized for each subject matter and grade. Teachers were duly trained on the new system during the summer of 1999. As soon as evaluation guidelines for the first two years of each cycle were developed, they were distributed to the schools and teachers. Training sessions continued throughout the school year and summer of 2000. Meanwhile work by the central committee and the various subject–matter teams was kept up to fill out the details for the third year of each cycle, prepare model questions for the official examinations of Grade 9 of Basic Education, and the third year of the secondary cycle, and issue complete evaluation gridlines for each subject from Grade 1 of Basic Education through the end of the secondary cycle. This is definitely a pioneering job in the history of education in Lebanon and indeed in most of the Arab countries.

Scientifically, the value of this achievement lies in the fact that, unlike past efforts, it went beyond mere assessment, which would have marginalized a significant part of the curriculum. It, instead, opted for an integrated evaluation process capable of making a more equitable and accurate judgement of the student's daily work and performance in the official examinations. Here the teacher's attention should be drawn to the difference between assessment and evaluation: the former relies on the mark scored by the student as the sole indicator of his/her results, whereas the latter includes, besides the mark, appreciating how far the student has acquired the competencies and skills envisaged in the discipline as exhibited in class, as well as certain attitudes in various situations.

Therefore, it is of utmost importance to consider education and evaluation as two inseparable complementary entities to the extent that evaluation becomes an essential aspect of the learning/teaching process. It is of course essential that the teacher be fully aware of the required competencies–and inform the student of them–in order to select relevant work techniques for use in the teaching plan.

We can thus say that evaluation is a comprehensive operation, which requires the use of various types of gauging and estimation procedures. This operation is not limited to the mark, but involves numerous activities, which help appraise the student's work. Evaluation does not necessarily depend on pen-and-paper tests, but includes the execution of definite tasks and activities as well as the observation of performance. After collecting information through the evaluation of the student's work, the teacher will make use of it to realize two goals: on the one hand, to reassess continuously the teaching process with a view to improving it; and on the other, to make the student aware of his/her achievements and weaknesses.

Finally, we would like to express our thanks and appreciation to all those who participated in this process from beginning to end. We would also like to emphasize that the Educational Center always welcomes the opinions and comments of all concerned for use in making any necessary modifications to the evaluation system's techniques.

Nemer FRAYHA

2 October 2000 **President**

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Physics

Chemistry

Complementary Explanations for the Physics Evaluation Domains and Competencies

The list of domains and competencies presented throughout this manual are nothing but an evaluation tool. The accompanying explanations are fundamental to ensure proper enactment of the evaluation process we all seek. Explanations relating to a given domain are generally the same for all the disciplines and for all the cycles within the same discipline. These explanations reflect the importance of each domain, and the specific elements we look for during the evaluation of a competency within a given domain. Last but not least, students should be informed of these explanations.

Applying knowledge

"21st century schools are called to operate within a complex social environment; the image of an ideal educational system should change: we must digress from a closed towards an open system, towards a project, the modification of the society" (trans. Gazail et Warnet, 1998).

Generally, the scientific knowledge acquired at the school level has two aims: on one hand, their **investment** into new researches that contribute to scientific progress; and on the other hand, their **reuse** in future everyday life situations. This **transfer of knowledge,** to which we accord a great deal of importance, has to manifest itself within the evaluation process through the interpretation, explanation and analysis of the physical phenomena.

Within this perspective, the "Applying knowledge" domain should not be interpreted as the direct application component of the traditional examinations. For example, applying Coulomb's law to find the magnitude of the interaction between two charged bodies, or simply calculating the voltage across a resistor (knowing its resistance and the intensity of the electrical current that traverses it) are not considered as valid competencies for that first domain.

The competencies of the "Applying knowledge" domain should be evaluated through new complicated situations and/or situations close to those discussed in the classroom. In short, the situation should be presented in a way where different laws might be applicable and it is one of the student's main tasks to select the appropriate law and apply it. The elements that must be exhibited within the competencies of that domain should imply the following:

a- **Select, from factual observation or by reading a scientific document, the relevant information** and physical quantities that are related to a given situation: in electricity and magnetism (intensity, voltage, resistance, amplification…), in waves (frequency, wavelength, celerity…), in optics (position of object and image, focal distance of a lens…), in mechanics (position, speed, acceleration, force, work, energy..), and in nuclear physics (activity, half-life, fission, fusion…)

b- **Data analysis**: that is to sift, based on previous knowledge, the essential and necessary information from those that are merely superfluous. The student should understand that some of the given information is essential to answer one question but may not apply when dealing with other questions of the same problem. For example, the index of refraction in a reflection/ refraction situation is a superfluous given to calculate the angle of reflection but is a relevant one to determine the angle of refraction. Is the student apt enough to identify the physical quantities in a given situation and match them up with his/her previously acquired knowledge?

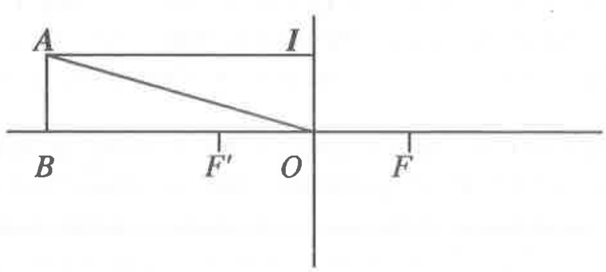
c- **Enact and apply knowledge related to physics**: the questions that automatically arise once the previous hurdle is passed are: will the student be able to select the appropriate knowledge (law, formula, definition, units…)? If the adequate choice has been made, will he/she be able to correctly apply the law? Is he/she able to elaborate an explanatory model or hypothesis? (In fact, this step is relatively difficult and it is simpler and far more practical to ask the students to choose among the given provided models, and have them justify their choice).
This stage is directly linked to the student's autonomy in decision - making. He/she has to decide which knowledge to apply and how to organize its use in order to tackle a given situation.

d- **Enact and apply knowledge related to other disciplines** (calculations, selecting a proper scale, vectors, trigonometric relations…)

e- **Test the validity of the obtained results:** physical sciences deal with situations that are very close to those of the real world. Are the obtained results logical? Will the student accept illogical answers like: negative mass, a speed greater than the absolute speed of light, mass of planet Earth of the order of few grams…? Does he/she respect the order of magnitude of the physical quantities in question?

f- **Project the obtained results to real life situations:** As mentioned at the beginning of this paragraph, this step is the most important step of all.
As an example, consider the situation where the student has to determine the characteristics of the image of a real object through a diverging lens.

The following diagram represents an object AB placed near a lens.



a- Examine the diagram carefully to recognize the nature of the lens. Justify your answer.
b- Draw the path of the emerging rays corresponding to the incident rays AI and AO.
c- Determine the nature of A'B', image of AB through this lens.
d- Can we use this lens to read the percentage in gold of a wedding ring? Justify your answer.

e- The doors of most apartments are equipped with a judas that helps people recognize their guests before opening. Practically, the judas consists of one single lens. Can we say that the judas' lens is of the same nature as the lens described earlier at the beginning of this problem? Justify your answer.

In this problem, questions a), b), and c) focus on drawing information and extract knowledge related to the image given through a diverging lens whereas questions d) and e) tackle the projection of this knowledge to new situations, noticeably real life situations.

It is important here to note that a question that is not related to the initial situation should be avoided, for it is not recommended to add a question to match the grading scheme, for example, with the problem being asked. A question dealing with the vergence of lenses, for example, would be useless in the above situation.

Experimentation

This domain subtends two main titles: enacting an experimental procedure with or without a guiding worksheet as well as resolving problems of experimental nature.
The benefit of this domain resides in the know how to properly use a measuring device in accordance with its specifications. In fact, the competencies of this domain are manifested in real life situations especially as the student grows older and graduates from school. Accordingly, this domain converges with the previous one along that dimension.

In running experimental procedures, the student has to abide mainly by the following steps:

a) Read the procedure before hand.
b) Select and know how to use the necessary apparatus (multimeter, oscilloscope, water tank, mirrors, lenses…)
c) Assemble a given setup given a text or a diagram.
d) Be aware of the safety signals (electrical and other potential hazards)
e) Measure and validate the findings
f) Answer the questions being addressed
g) Develop a report with the necessary annotated diagrams

Items f) and g) could evaluate competencies pertaining to the communication domain. It is not practical to have the students run an experiment without having them develop reports (one of the communication domain competencies). Often, the evaluation of a competency of the experimentation domain correlates with a competency of the communication domain.

In **solving problems of experimental nature**, the student enacts his/her practical knowledge in situations that are kind of theoretical. It is possible to provide him/her the diagram of a setup and even propose relevant changes, in the caliber of the measuring device being used, how it is connected…etc. For example, which knob of an oscilloscope should we turn if we are to obtain to two full cycles on the screen?

What do we look for in a report?

- The objective of the experiment
- The used material
- The physical principle or concept
- The procedure
- The tables and the graphics
- The figures and diagrams
- The relevance of the result
- The conclusion.

Communication

This domain is very important on the practical level. "We are living in a highly interconnected world. To express ones self in a concise way while using different modes of representation is a competency related to the individual's know how skills. The same joke being told by two people might not have the same laughing effect on the same audience. The knowledge components constituting the phenomenon are the same but the whole issue remains on how to integrate and present the final product. This is why we insist that a competency appeal to the know-how-to oriented to develop the autonomy of individuals" (trans. J. M. De Ketele)

To read and interpret a given diagram is a competency included within the communication domain. This competency, common to all other disciplines even if through different contexts, integrates the following basic learning objectives as its basic constituents:

a- Draw a diagram
b- State the physical meaning of the coordinate axes (abscissa and ordinate)
c- Choose an appropriate scale
d- Determine graphically the coordinates of special points (intersection of two curves…)
e- Determine, from a graph, the characteristics of a corresponding device.
Use the available graphical data to calculate other physical quantities.

1st secondary year

Domains and Competencies

<table>
<tr><th>Domains</th><th>Competencies</th></tr>
<tr><td>Applying knowledge</td><td>♦ Apply knowledge specific to:
- Electricity (electrification, Coulomb's law, the laws of voltage and current, the laws of functioning of: resistors, generators, and receivers, Joule's effect).
- Waves (characteristics of waves, reflection, refraction…).
- Optics (plane mirrors, lenses, eye, magnifier…)
- Mechanics (rectilinear motion, Newton's laws…).
♦ Distinguish between closely related physical quantities (e.m.f and b.e.m.f., longitudinal and transverse waves, reflection and refraction, average and instantaneous speeds).
♦ Identify
- An electric device.
- The image given by an optical system.
- A myopic and a presbyopic eye.
♦ Interpret daily life physical phenomena related to: (circuit breakers, short circuit, echo, rainbows, eclipses…)
♦ Explain and abide by the safety measures for humans and appliances against electrical hazards.</td></tr>
<tr><td>Experimentation</td><td>♦ Use measuring devices (multimeter, oscilloscope…)
♦ Assemble simple electric series and parallel circuits.
♦ Verify the laws of reflection and refraction of light.
♦ Follow an experimental conduct in order to plot the I-V characteristic of an electric element.
♦ Determine experimentally the characteristics of the image of a real object through a given optical system.
♦ Verify Newton's laws.
♦ Determine the focal length of a converging lens.</td></tr>
<tr><td>Communication</td><td>♦ Read and interpret a diagram
- I-V characteristic of: resistors, generators, and receivers.
- Oscillograms
- Output of a recording on an air table (using a tracer, a dot marker…)
♦ Use an appropriate scientific vocabulary in accordance with the different representation modes: oral, written, diagrams, tables, graphs…
♦ Look up information from diversified resources.</td></tr>
</table>

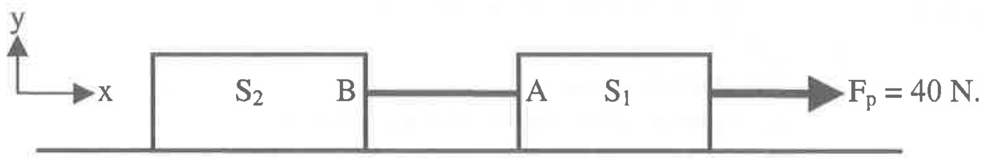
Examples of Competencies Evaluation for the First Secondary Year

1st Domain : Applying Knowledge

Competency: Apply knowledge specific to the principle of inertia.

Exercise 1: ***Equilibrium of a body subjected to many forces***

Two small boxes S_1 and S_2, of respective masses m_1 and m_2, are placed on a horizontal support and interconnected by means of a string AB of negligible mass. A person exerts a horizontal force of magnitude $\mathbf{F_p}$ = 40 N on S_1 such that the system moves at constant speed.



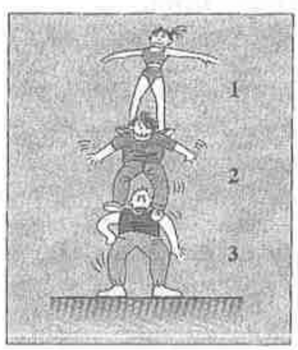
The frictional forces exerted by the table on S_1 have a magnitude of 15 N and a direction opposite to that of $\mathbf{F_p}$. Determine

i- The magnitude of the force exerted by the string on box S_1.
ii- The magnitude of the force exerted by the support on box S_2.

Competency: Determine the external forces acting on a given system.

Exercise 2: ***Analysis of an acrobatic performance.***

During a given circus performance, three acrobats A, B and C, of respective masses m_1 = 60 kg, m_2 = 75 kg and m_3 = 90 kg, are standing on top of each other. Use g = 10 N / kg.



i. Determine the characteristics of the forces acting on each of the three acrobats.
ii. Using the same adequate scale, draw three independent diagrams showing (neatly) the forces acting on each one of the three acrobats.

Competency: Explain the phenomenon of electrification by contact

Exercise 3: ***Charging an electroscope***

The charged end of a glass rod (previously rubbed with a silk cloth) is made to touch the metallic knob of a neutral electroscope. Consequently, the leaves of the electroscope are observed to diverge.

1. Interpret this observation.
2. What would happen if the charged end of the glass rod is moved away from the electroscope? Justify your answer.
3. What is the name of that phenomenon?

Exercise 4: ***Consequences of an electrification process.***

The conducting ball of an electrostatic pendulum is given a negative charge. Afterwards, the pendulum is inserted halfway between two parallel and vertically fixed metallic plates P_1 and P_2. Assume that if for any reason the pendulum deviates, its negatively charged ball gets in touch with either of the two plates. Explain what would happen when P_1 and P_2 are connected across a battery.

Competency: Apply Newton's laws in the case of a body in motion along a straight line.

Exercise 5: ***Motion of a lift's cabin***

Usually, the motion of a lift's cabin comprises three phases:

- The first phase, or the accelerated phase, lasts for a few seconds only;
- The second phase, usually the major phase, as the cabin travels at constant speed during until the desired floor is attained.
- The third phase, or the decelerated phase, as the cabin comes to rest within a few seconds.

In order to get to their apartment located on the fourth floor, Samia and her father, weighing 150 kg in total, get into the lift 's cabin that weighs 350 kg. Use $g = 10\ m.s^{-2}$.
During the first phase of ascension, the lifting cable exerts on the cabin a vertically upward force of 6000 N in magnitude.

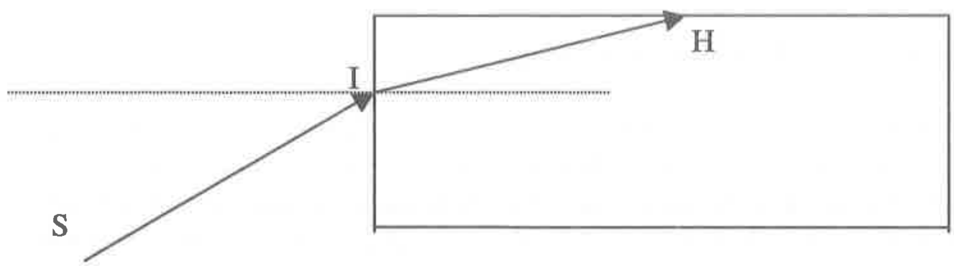
1. Determine the acceleration of the cabin during the first phase.
2. Determine the magnitude of the force exerted by the lifting cable on the cabin during the second phase of motion.

Competency: **Apply knowledge specific to reflection and refraction of light.**

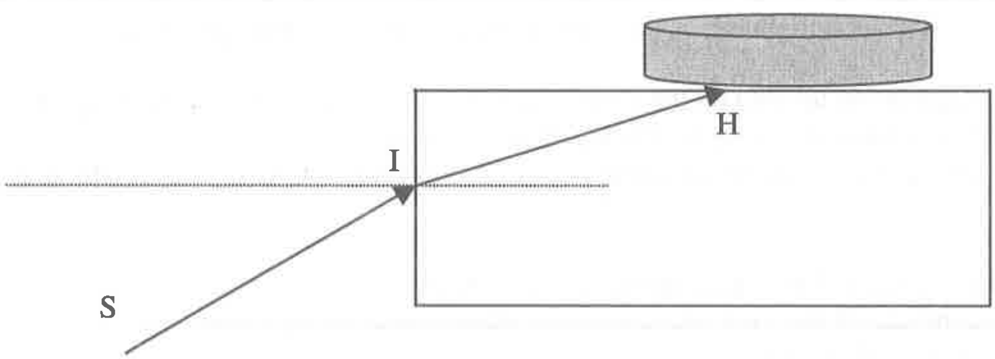
Exercise 6: ***Fiber optics***

In general, an optical fiber is made out of a transparent cylindrical tube coated with a special transparent layer (sheath) that has a lower refractive index than that of the central tube. The system thus formed is then wrapped with an opaque protective layer.

A glass rod of refractive index equal to $\sqrt{2}$ is to be used as an optical fiber. As shown in the following diagram, a light ray SI, making an angle of 45 ° with the normal, falls on one of the tube ends. Use $\sqrt{2}$ = 1,414.



1. Calculate the corresponding angle of refraction.
2. What would happen to the refracted ray IH when it falls on the glass-air interface ? Draw a conclusion about using this tube as an optical fiber.
3. What would happen to the refracted ray IH if an oil drop, of refractive index equals to 1.4, is accidentally placed over the tube? Draw a conclusion about the role of the transparent coating (sheath) of optical fibers.



Competency: Apply knowledge specific to lenses and plane mirrors.

Exercise 7: ***Projection devices.***

A projector is used to display on a big screen or wall situated at a distance D, a magnified image of a slide (transparency, or film) so that the projected image can be shown to a large audience.

The objective of a slide projector could be assimilated as a thin converging lens of focal distance equal to 6.25 cm. A square slide, of side equal to 2.4 cm is to be projected on a screen situated at 3 m from the projector.

1. Determine at what distance from the lens the slide should be placed in order to obtain a well-focused image on the screen.
2. Determine the form and dimensions of the image thus formed.
3. The screen is moved towards the projector by 1 m.
   a. In what direction and by how much should the lens be moved to get a focused image on the screen?
   b. Determine the new dimension of the image.
   c. Would the form of the image change? Justify your answer.

2nd Domain: Experimentation

Competency: Verify experimentally the laws of reflection and refraction of light.

Exercise 1: ***Reflection and refraction of light***

Students' Sheets (to be distributed)

Situation

- In the laboratory.
- Team work.
- Duration: 50 minutes.

Equipment (Per 3 students)

- A narrow light beam source.
- Protractor.
- Rectangular mirror plane that could be fixed vertically.
- Semi-cylindrical glass bloc.

Procedure

- Mount the setup that allows the verification of the laws of reflection.

- Select five different incident angles and measure the corresponding angles of reflection.
- Mount the setup that allows the verification of the law of refraction.
- Starting first with zero, increase the value of the incident angle and measure the corresponding angle of refraction.
- Look for the smallest incidence for which a light ray, incident on the glass-air interface, undergoes total internal reflection.

Questions (Individual work)

1. Compare the angles of incidence to their corresponding angles of reflection. Draw a conclusion.
2. Calculate the index of refraction of glass.
3. On a graph paper, plot the variations of sine i_1 versus sine i_2.

Competency: Verify the laws of reflection and refraction of mechanical waves propagating on water surface (ripple tank).

Exercise 2

Write a report providing all the necessary explanations and diagrams to put into evidence the laws of reflection and refraction of mechanical waves on top of a ripple tank filled with water.

3rd Domain: Communication

Competency: Read and interpret the I-V characteristic of a battery and that of a light bulb.

Exercise 1: ***Optimal conditions of an electric circuit.***

The optimal conditions of a given electric circuit are represented by (U, I) couple; U being the voltage across the generator, and I being the intensity of the current through the generator when the circuit is functioning normally.

In fact, this state is best described as being the point of intersection between the I-U characteristics of the dipoles making up the circuit. To determine the optimal conditions of an electric circuit consisting of a battery and a light bulb, we can proceed as follows:

1. In one experiment, the battery is connected in series with a rheostat and an ammeter while a voltmeter is branched across the terminal of the battery. By gradually changing the position of the rheostat's cursor, the corresponding (I,U) values are tabulated as shown below :

U (V)	*4,25*	*3,85*	*3,45*	*3,00*	*2,60*	*2,05*	*1,30*	*0,35*
I (mA)	*0*	*50*	*100*	*150*	*200*	*250*	*310*	*390*

2. In a second experiment, the bulb is mounted in series with an ammeter, and then across a variable output generator. A voltmeter, branched across the bulb, allows to measure the voltage across the bulb when the generator's voltage is gradually changed. The (I,U) values of the bulb are tabulated as shown below :

U (V)	*0*	*0.20*	*0.76*	*1.70*	*2.60*	*3.75*	*5.20*
I (mA)	*0*	*50*	*100*	*150*	*200*	*250*	*300*

Questions:

a. Plot the I-U characteristic of the battery. Deduce its e.m.f as well as its internal resistance.
b. On the same graph and using the same scale, plot the I-U characteristic of the bulb.
c. Graphically, determine the coordinates of the point of intersection of the two I-U characteristics. Is it possible to algebraically find out the coordinates of that point of intersection? Justify your reasoning.

Competency: Read and interpret the I-V characteristic of a battery and of a resistor.

Exercise 2

The I-V characteristic of a battery is linear. When unloaded, the potential difference across this battery is equal to 22.5 V, and its internal resistance is equal to12 Ω. A 57 Ω resistor is now branched across the battery.

i- Plot, on the same graph, the I-V characteristics of the battery and that of the resistor (I along the abscissa and V along the ordinate).
ii- Determine graphically the coordinates of the point of intersection of the two I-V characteristics.
iii- Determine algebraically the previous results.

Competency: Read and interpret a document dealing with Newton's laws of motion.

Exercise 3: ***Principle of Inertia***

Read the Following paragraph written by Richard Feynman, a famous 20th century physicist.

One day, I was playing with a small cart, a kind of carriage that has a pulling handle. I still remember the strange behavior of a ball placed on that cart when I pulled or pushed the latter. I still remember that happening as if it just happened yesterday, and how I ran to my father for a valid explanation:

"Listen dad, I am a bit dazzled about why the ball rolls backwards when I pull the cart whereas it rolls forward when I stop pulling"

"Son" he replied, "no one really knows why moving things tend to stay in motion whereas things at rest tend to stay at rest...

"If you pay close attention" my father continued, "you will notice that actually the ball is not rolling backwards when you pull the cart: it remained, more or less, in a state of rest. It was the back end of the cart that was moving towards it".

I ran back to my cart pushing and pulling it in all directions while observing the ball; it remained more or less at rest. It moved back with respect to the cart but, with respect to the ground, it was slightly moving forward.

The Pleasure of Finding Things Out, R. P. Feynman
Helix Book / Persus books, 1999

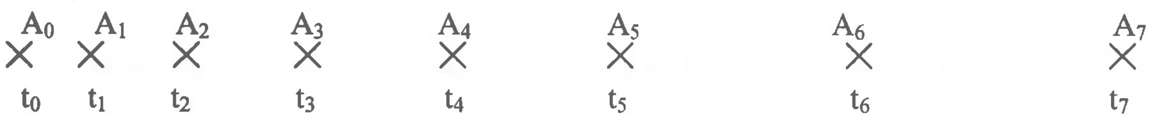
Questions:

a) What is the principle that the text examplifies? In what sentence the principle is best exhibited?
b) Indicate the sentence that explains that motion is relative.
c) In the last paragraph, Richard Feynman talks about the rest state of the ball when he was moving the cart in all directions. Interpret this state of rest, and explain why the ball remains "more or less at rest".

Competency: Read and interpret an air table recording of a rectilinear motion.

Exercise 4: ***Characteristics of a rectilinear motion.***

The following diagram depicts the marks left by a puck, equipped with a dot marker, sliding on an inclined air table without initial velocity ($t_0 = 0$ s; $V_0 = 0$ m/s) . The time interval between two consecutive marks is constant : $\tau = 0.1$ s.

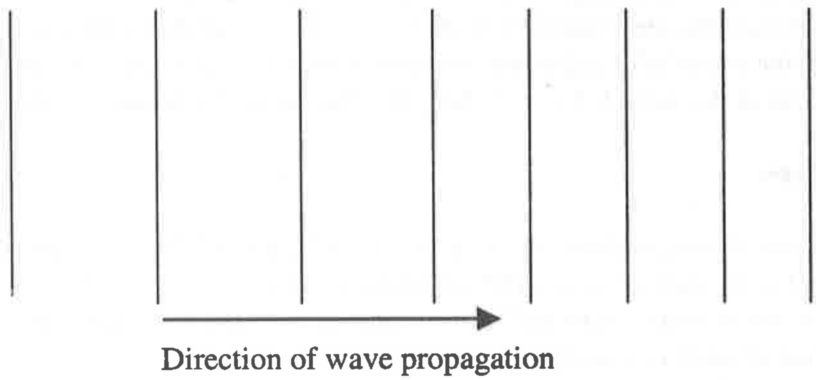


1) Calculate the average speed of the puck between t_2 and t_5 and between t_4 and t_7.
2) Calculate the instantaneous speed of the puck at instants t_1 , t_2 , t_4 , t_5 and t_6.
3) Represent, after choosing an adequate scale, the velocity of the puck at instant t_4.
4) Show that the motion of the puck is rectilinear and accelerated.
5) Write the time equation for this motion. Make sure to indicate your choice of space origin on the diagram.

Competency: Read and interpret a document about waves.

Exercise 5: ***Refraction of waves***

The following diagram represents, to ½ scale, the crests of plane waves in a ripple tank at a given instant in time.



i) This diagram illustrates refraction of waves. Explain why.
ii) Determine, graphically, the wavelengths of an incident wave and that of refracted wave.
iii) The frequency of the source is $f = 10$ Hz. Calculate the speed of propagation of these waves before and after refraction.

Competency: Extract relevant information and appropriate data from a text.

Sun tanning:

Melanoblasts are specific cells embedded within the deep layers of the epidermis. When exposed to ultraviolet radiations, melanoblastes secrete a dark pigment: the melanin. This pigment diffuses throughout the exposed skin giving it a darkish appearance known as sun tan. In fact, melanin plays a role in protecting the skin from the hazards of ultraviolet radiation.

Ultraviolet radiations and sun tanning:

Ultraviolet radiations are classified into three categories:
UVA range (400 nm –320 nm): exposure to radiations pertaining to this category causes sun tanning, but excessive exposure causes premature skin aging processes.
UVB range (320 nm – 280 nm): similarly, exposure to radiations pertaining to this category causes sun tanning but excessive exposure is accompanied by skin redness and burns.
UVC range (less than 280 nm): radiations belonging to this range are usually scattered by the atmosphere before reaching the ground. Yet, some of these rays might reach high mountains and cause severe burns, inflammations, and acute conjunctivitis.

Artificial sun tanning is made available by special mercury vapor bulbs emitting mainly UVA and UVB traces (around 1%).

Sun tanning is beneficial, but should be done gradually and for a limited time only. Excessive sun tanning, whether natural or artificial, causes premature aging of the skin and might trigger skin cancer.

Protection against UV hazards:

Sunglasses and screening lotions absorb and/or reflect parts of the ultraviolet radiations. Sun screening lotions are classified from 1 up to 15 according to their screening effects. Sunglasses prevent the ultraviolet radiations from reaching the eyes. Yet, in case of intense radiation, or radiations of the have UVC wavelengths, like in high mountains, special sunglasses must be used.

Questions

1- Can we have a suntan by sitting next to a fireplace? Justify your answer.
2- What is the role of ultraviolet radiations in the sun tanning process?
3- How are the ultraviolet radiations coming from the sun classified? Indicate the sun tanning effect of each of the three categories.
4- What are the wavelength ranges emitted by a sun tanning lamp?
5- Look for sun screening lotions and study their characteristics.

2nd secondary year – Scientific Series

Domains and Competencies

Domains	Competencies
Applying knowledge	♦ **Apply information specific to** - **Waves** (superposition of waves, sound waves). - **Mechanics** (plane motion, Newton's laws, mechanical energy, rotational dynamics). - **Thermodynamics** (kinetic theory of gases, laws of thermodynamics, calorimetry…) - **Electromagnetism** (electric and magnetic fields, capacitors, electromagnetic force). - **Electronics** (diodes, transistors, operational amplifiers) ♦ **Distinguish** - Charging and discharging of a capacitor. - Sound emitter and receiver. - Microphone and loudspeaker. - Role of transistor and that of operational amplifier. - Interferences and beats. ♦ **Explain** - The phenomenon of standing waves. - The rectification of the alternating current. ♦ **Interpret** - The formation of interference fringes. - Doppler's effect. - The role of a diode. - The deviation of a charged particle in an electric or magnetic field.
Experimentation	♦ **Measure the frequency of a periodic phenomenon by a stroboscope.** ♦ **Visualize on the screen of an oscilloscope the phenomena of beats and of charging and discharging of a capacitor.** ♦ **Set up electric circuits with diodes, transistors and operational amplifier.** ♦ **Verify Newton's laws.** ♦ **Verify the work – energy theorem.**

	♦ **Determine experimentally the characteristics of the electromagnetic force.**
Communication	♦ **Read up:** - Recorded trajectories on an air table. - Tables, graphs or oscillograms specific to diodes, transistors and operational amplifiers. ♦ **Determine graphically the law of functioning of a diode, transistor and operational amplifier.** ♦ **Use an appropriate scientific vocabulary adapted to different modes of representation**: oral, written, diagrams, tables, graphics…

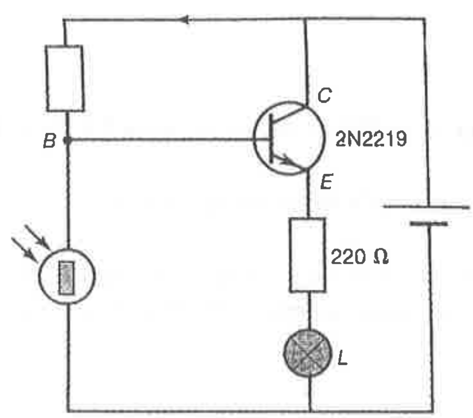
Examples of evaluation of competencies in 2nd year secondary Scientific Series

Domain 1: Applying Knowledge

Competency: Apply knowledge related to electronics

Exercise 1: ***Automated switching of street lamps.***

The following circuit diagram represents the control circuit of automated street lamps. The lamp, denoted by L, is switched off when the photoresistance is illuminated during the day, and viceversa. The photoresistance in question has a resistance of the order of $10^6\ \Omega$ in the dark, and drops down to around $10\ \Omega$ when illuminated.



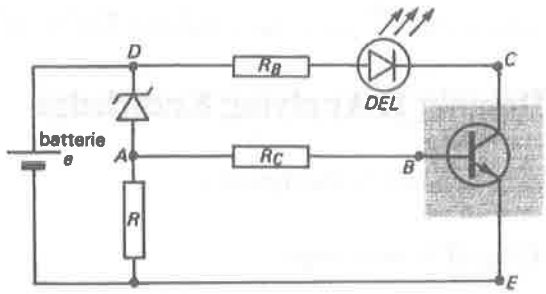
i. Explain why L is switched on during the night.
ii. Explain why L is switched off during the day.

Competency: Apply knowledge related to electronics

Exercise 2:

The circuit represented in the circuit below has a transistor (T) of current gain $\beta = 100$. Accordingly, the threshold voltage of the base-emitter junction is 0.7 V.

The Zener diode, considered as ideal, has a Zener voltage of 10.5 V. The characteristics of the DEL are: $U_{max} = 1.8$ V and $I_{max} = 50$ mA.
A cell of negligible internal resistance and of electromotive force e is connected to the points D and E. Given $R_B = 4\ k\Omega$, $R_C = 250\ \Omega$ and $R = 500\ \Omega$.

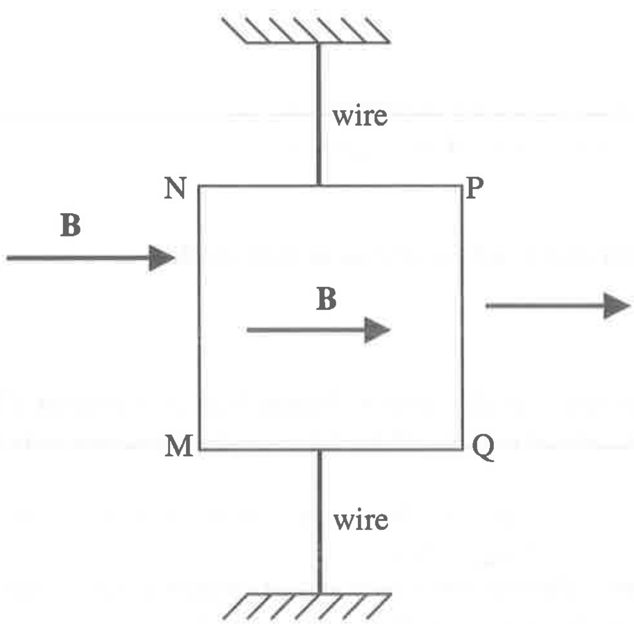


i- Show that if $e < 10.5$ V, the transistor is blocked.
ii- $e > 10.5$ V. Express successively U_{AE}, U_{AB}, I_B and I_C in terms of e.
iii-For what value of e is the transistor passing? For what value of e, does a current of 20 mA traverse the DEL?
iv- Explain qualitatively the role of R_C.

<u>Competency:</u> Apply knowledge specific to electromagnetic forces.

<u>Exercise 3</u>: ***A simplified description of a measuring device.***

A square coil MNPQ, of side a, is free to rotate horizontally around two vertical and insulating wires. The coil is immersed in a uniform magnetic field **B** as shown in the diagram below.



A current I is sent through the coil following the M, N, P, Q (or clockwise) direction. In applying what the following instructions, neglect all the magnetic fields except **B.**

I- The coil being in its initial position:

1. Indicate, on a clear diagram, the direction of the electromagnetic force acting on each side of the coil.
2. Derive, in terms of a, B, and I, the magnitude of each of the above-mentioned forces.
3. Determine, in terms of a, B, and I, the algebraic sum of all the torques acting on the coil with respect to an axis confounded with the vertical supporting wires.
4. Show that the coil tends to rotate in a given direction (to be specified).

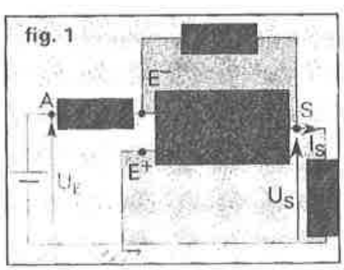
II- As the coil sweeps an angle α, a resistive couple acting on the coil and proportional to α forces the coil to a stop.

1. Assuming that the algebraic sum of the torques calculated in A-3) remains constant, determine I in terms of a, B, and α.
2. Choose a possible name for this setup and indicate the physical quantity that this device could measure.

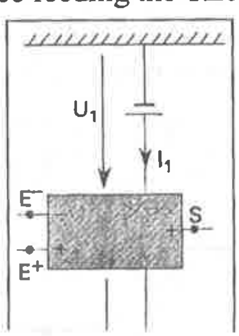
Competency: Apply knowledge specific to electricity.

Exercise 4: ***Efficiency of an electronic circuit having an operational amplifier***

The following circuit diagram (diagram 1) has an operational amplifier (TL081) assumed to be ideal, and three resistors R_1, R_2, and R_3.



(Diagram 2) represents the voltage source feeding the TL081 in the linear range.



Knowing that $U_E = 3.5V$, and that $Rc = 1K\Omega$, the following data were collected:

I_E (mA)	I_1 (mA)	I'_1 (mA)
0.76	1.25	7.5

Us (V)	U_1 (V)	U'_1 (V)
- 7.6	15.2	15.2

1. Compare the input power to that received by Rc. Draw a conclusion.
2. Derive and calculate the total electrical power received by the circuit.
3. Derive and calculate the efficiency of that circuit.
4. Calculate the percent of heat power losses in the circuit.

Competency: Explain the emission of sound by the membrane of a loudspeaker.

Exercise 5

A loudspeaker is connected to the terminals of an L.F.G. delivering a sinusoidal voltage of frequency 100 Hz.
Interpret the sound emitted and determine its frequency.

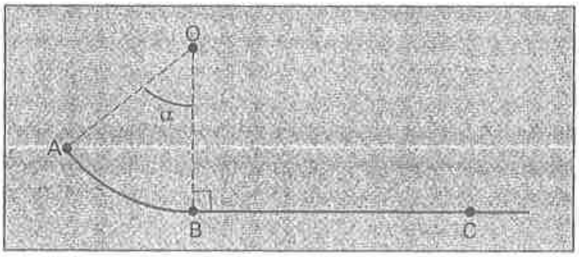
Competency: Explain the emission of sound by the membrane of a loudspeaker.

Exercise 6

An L.F.G. feeds, at the same time, two loudspeakers 80 cm away from each other. Their membranes face each other. The L.F.G. delivers a sinusoidal voltage of frequency 850 Hz.
Explain the physical phenomenon that you detect when you displace, along the line separating the two loudspeakers, one of your ears (the second being closed).

Exercise 7: ***Motion of a skier.***

A skier of mass m slides down a skiing track ABC. AB is assumed to be an arc of center O ($\hat{AOB} = \alpha$) and radius r, whereas BC is horizontal of length L=2.r.
The skier starts at rest, without initial velocity. Assume that frictional forces along AB are negligible whereas those on BC are assumed to be parallel to BC of constant magnitude f.



1. Derive V_B in terms of r, g, and α.
2. The skier stops at C. Derive an equation expressing f in terms of m, g, and α.

2^{nd} Domain: Experimentation

Competency: Measure experimentally the frequency of beats.

Exercise 1

Students' Sheet (to be distributed)

Situation

- In laboratory room
- Team-work
- Duration: 45 minutes

Materials:

- Two L.F.G.
- Oscilloscope.
- 2 Loudspeakers.

Manipulation

- ♦ Assemble the setup represented on the diagram.
- ♦ Adjust the 2 L.F.G. to the same frequency (1000 Hz for example).
- ♦ Change the frequency of one of the two L.F.G. very slowly, while keeping the frequency of the other one fixed., until you obtain the phenomenon of beats.
- ♦ Measure the period of beats.

Questions (Individual work)

i- Knowing the period, determine the frequency of beats.
ii- Compare this value to those indicated by the two L.F.G.
iii- Conclude.
iv- Write a report illustrated with neat and annotated diagrams.

Competency: Realize the superposition of two sinusoidal waves of frequencies f and 2f.

Exercise 2

Students' Sheet (to be distributed)

Situation

- In laboratory room
- Team-work
- Duration: 45 minutes

Materials:

- Two L.F.G.
- Oscilloscope.

Manipulation

- Assemble the setup represented on the diagram.
- Adjust the 2 L.F.G. to the sine mode.
- Select 500 Hz as frequency of the first one and 1000 Hz for the second one.
- Add the two obtained curves visualized on the screen of the oscilloscope.
- Measure the period of resultant signal.

Questions (Individual work)

1. Calculate the frequency of the resultant signal. Conclude.
2. What do both signals represent for the resultant one?
3. What is the difference between a pure sound and a complex sound?
4. Write a report illustrated with neat and annotated diagrams.

3^{rd} Domain: Communication

Competency: Read up a diagram of a plane motion on an air table.

Exercise 1: ***Projectile motion***

The figure below represents the real recording, on an air table, of the positions taken by a projectile at regular intervals of time τ.

i- Represent the velocity vectors of the projectile at instants: 3, 4, 5, 10, 11, 12, 15, 16 and 17.

ii- Represent the components $\mathbf{v_x}$ and $\mathbf{v_y}$ of the velocity vectors $\mathbf{v_4}$, $\mathbf{v_{11}}$ and $\mathbf{v_{16}}$. What can you say about $\mathbf{v_x}$?

iii- Represent the acceleration vectors of the projectile at the instants 4, 11 and 16. Draw a conclusion.

Exercise 2: ***Uniform circular motion***

A puck of 650-g mass is connected to a fixed support O by means of an inextensible massless wire. The recordings of the motion of its center of inertia, on a horizontal air table, each 60 ms are shown on the figure below.

i- Determine the form of the trajectory of the puck.

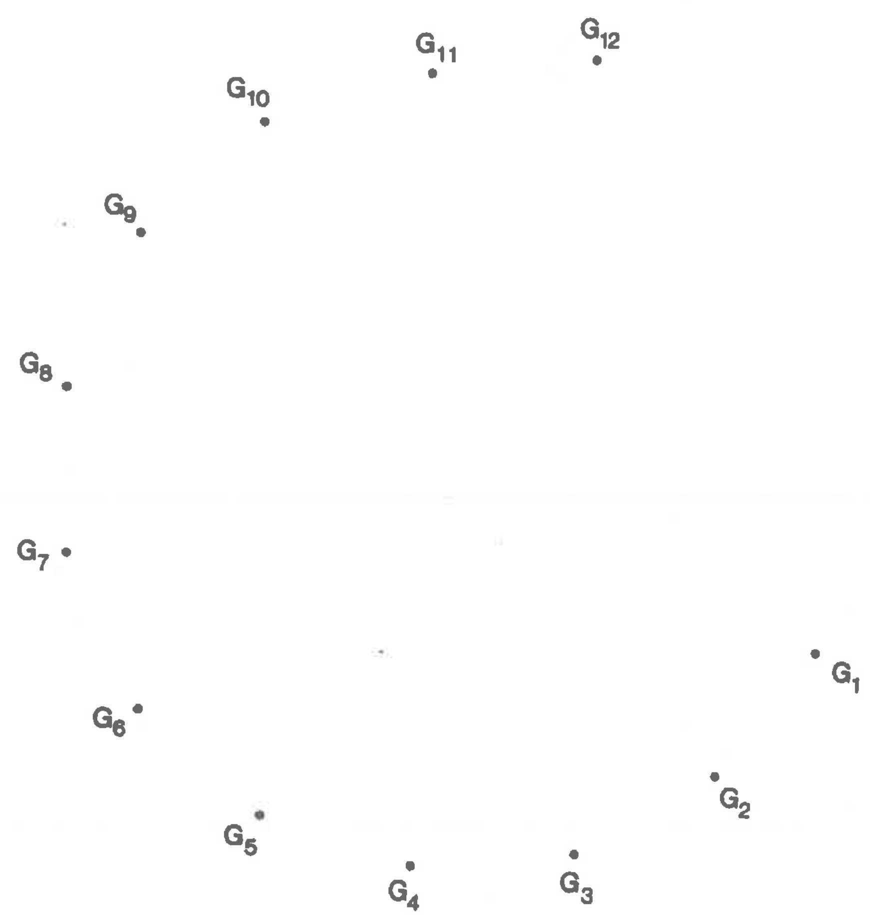
ii- Represent the velocity vectors $\mathbf{v_6}$, $\mathbf{v_7}$, $\mathbf{v_8}$, $\mathbf{v_9}$ and $\mathbf{v_{10}}$.

iii- Deduce the nature of the motion.

iv- Represent, at G_7 and at G_9 respectively, the vectors $\Delta\mathbf{v_7} = \mathbf{v_8} - \mathbf{v_6}$ and $\Delta\mathbf{v_9} = \mathbf{v_{10}} - \mathbf{v_8}$. What do the vectors $\Delta\mathbf{v_7} / 2\tau$ and $\Delta\mathbf{v_9} / 2\tau$?

v- What is the value of the normal acceleration? Justify your answer.

vi- Determine the tension in the wire.



Competency : Extract the necessary information and data from a text

Exercise 3

Galileo, a precursor to Newton

Before Newton's breakthrough, Galileo (1564-1642) had laid the ground for the principle of inertia that Newton published later on.
The following excerpts, taken from Galileo's book, the 'Discourse' that was published in 1638, presents how close Galileo's was to understanding the principle of inertia.
« There is no doubt that the speed level of a moving body is indelible due to the nature of that body and shall remain unchanged as long as external factors that accelerate or impede the body are discarded, something that occurs on horizontal planes only; in fact, a body moving downhill accelerates, and a body moving uphill decelerates; thus the movement of a body on a horizontal surface is eternal »

(Paraphrased from « Galilee-Discours concernant deux sciences nouvelles »
Maurice Clavelin. Edition PUF)

It is interesting in this context to state the principle of inertia as stated by Newton

Laws or Axioms of Motion
First Law

« Every body maintains a state of rest or of uniform rectilinear motion as long as it is not compelled to change either state by an external force acting on it .

Projectiles tend to keep moving, but air resistance and the pull of gravity forces them to fall to the ground.
A spinning top presents symmetry around its axis and has its parts continuously exchanging places. That's why a top would never stops rotating. It is due to air resistance that the top decelerates little by little. Similarly, heavenly bodies like planets and comets have huge masses and while moving throughout a less impeding space, conserve their circular motion for longer periods of time »

(Paraphrased from the « Principia » by Newton, first published in 1686)

Questions:

I- Regarding Galileo's text:

i- What are the 'external factors that accelerate or impede' that Galileo is referring to ?
ii- What is the nature of the motion such that 'that the speed level of a moving body is an intrinsic property of that body and shall remain unchanged'
iii- What are the conditions for a puck to fulfill this statement 'the movement of a body on a horizontal surface is eternal'

II- With respect to Newton's text:

i- Contrarily to Galileo, Newton introduces a specific concept that is widely used in mechanics to account for the motion of bodies. What is that concept?

ii- Write your comments regarding the following statement:
« Projectiles tend to keep moving, but air resistance and the pull of gravity forces them to fall to the ground ».

2nd year secondary – Humanities

Domains and Competencies

Domains	Competencies
Applying knowledge	♦ **Apply knowledge related to** - Electric energy (production, transport, consumption). - Electromagnetic waves. - Sound waves. ♦ **Identify the characteristics of electromagnetic and sound waves.** ♦ **Determine the polluting effects of thermal** (coal and fuel) **and nuclear electric power stations.** ♦ **Explain the safety rules against electrical hazards.** ♦ **Analyze the auditory effects of unhealthy sound.**
Communication	♦ **Read the graphs u (t) and i (t) for DC and AC currents and voltages.** ♦ **Read and interpret diagrams related to electrical energy** (word production of electric energy, standard electric circuit of a house, electricity in the car). ♦ **Determine graphically the physiological qualities of sound** (pitch, loudness, timber). ♦ **Write a report using the appropriate scientific vocabulary adapted to different modes of representation:** oral, writing, figures, tables, …

Examples of competencies evaluation for the 2nd year secondary Humanities Series

Domain 1: Application of Knowledge

Competency: Apply knowledge relative to sound waves.

Exercise 1: ***Characteristics of sound waves***

Two persons pronounce the same vowel (O for example), but one pronounces it much stronger than the other. Among the following physical quantities, in rapport with the two sounds above, which ones are identical and which ones are not:

- i- Speed of propagation
- ii- Frequency
- iii- Wavelength
- iv- Amplitude
- v- Timber.

Justify your answer for each quantity.

Exercise 2: ***Sound level***

Upon explosion, two firecrackers generate an 85 dB sound level. Determine the sound level produced by the explosion of one firecracker? Give the name of the apparatus and how it should be used to verify the result of the previous question.

Competency: Analyze the hazardous effects on the ear.

Exercise 3: ***Sound pollution***

Explain the term «sound pollution ». Name some sound polluting sources.

Exercise 4: ***Sound pollution***

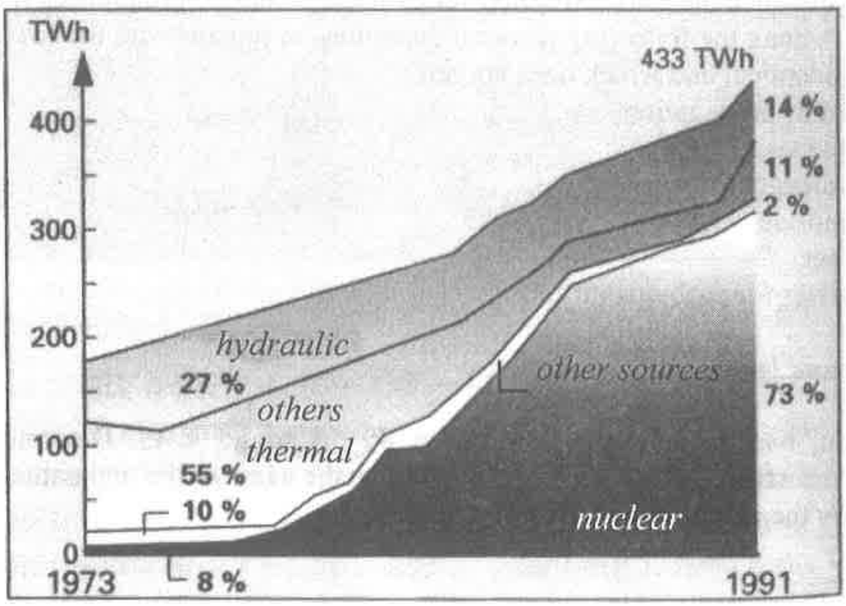
How do you fight sound pollution? Does the Walkman have unhealthy effects? Give the order of magnitude of the maximum sound level allowed in some countries.

Domain 2: Communication

Competency: Exploit a diagram of production of electrical energy.

Exercise 1: ***Production of electric energy in a country***

The following diagram depicts the variation of electrical energy production and its sources for a given country between 1973 and 1991.



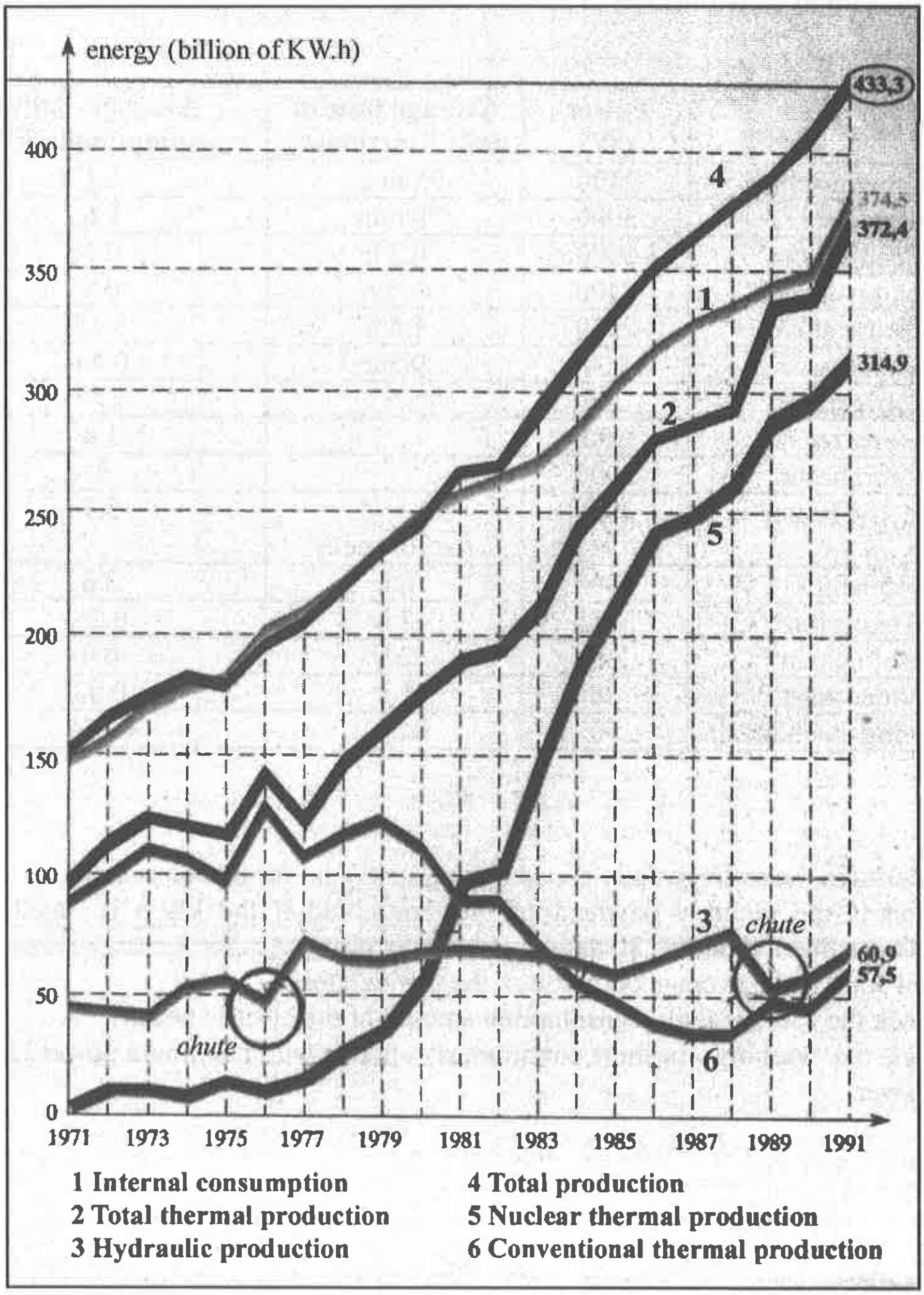
i- Compare the evolution of the electric energy production by nuclear power plants to that produced by thermal power plants.

ii- Explain the consequences of this evolution.

Exercise 2: ***Production and consumption of electric energy***

The following diagram depicts the variation of electrical energy production and consumption for a given country between 1971 and 1991.

1. Which type of electrical energy production increased continuously during that period? Which type of electrical energy production remained more or less the same? Justify your answers.
2. What is the cause behind each of the production decreases?
3. What are the power plants that compensated this decrease?
4. Calculate, in percentage, the increase in electrical energy consumption between
   - i- 1990 – 1991.
   - ii- 1971 and 1991.


energy (billion of KW.h)
400
350
300
250
200
150
100
50
0
1971
1973
1975
1977
1979
1981
1983
1985
1987
1989
1991
433,3
374,5
372,4
314,9
60,9
57,5
4
1
2
5
3
6
chute
chute
1 Internal consumption
2 Total thermal production
3 Hydraulic production
4 Total production
5 Nuclear thermal production
6 Conventional thermal production

Exercise 3: Household consumption of electric energy

Apparatus	Power (W)	Average time of daily functioning	Average daily consumption in kW.h
Washing machine	2400	75 min.	1.1
dishwasher	3000	78 min.	1.6
Electric iron	1000	0.3 h	0.3
Vacuum cleaner	1400	0. 5 h	0.5
Electric stove	2500	1.5 h	3.75
micro-wave	900	0.5 h	0.45
Refrigerator	200		1.45
Freezer	200		1.4
Water-heater	2000		3
Electric heater	2000	5 h / j for 30 weeks	5.7
15 lamps	1200	3 h	3.6
Television	70	3 h	0.21
Hi-Fi chain	200	2 h	0.4
Video-tape	30	1 h	0.03
Sewing machine	70	0,5 h.	0.035

Questions

i- Determine the average daily consumption, in kW.h., for this household.

ii- What is the monthly payment of this household if the kW.h is rated at 80 L.P.? Assume that a month is 30 days.

iii- How long is the average daily use of the refrigerator?

iv- Check the average daily consumption amount of the electric heater.

v- Does the washing machine continuously operate with maximum power? Justify your answer.

Third Secondary Year
General Sciences.

Domains and competencies

Domains	Competencies
Applying Knowledge	▪ **Apply knowledge specific to:** - **Mechanical energy, linear momentum and angular momentum** (whether these quantities are conserved or not). - **Electricity** (Ohm's law, electromagnetic induction). - **The theory of special relativity** (time dilation and length contraction). - **Nuclear reaction** (laws of conservation: of charge, of mass number and of energy; energy librated…) ▪ **Apply the Continuity and Bernoulli's equations on ideal liquids.** ▪ **Relate the emission and absorption spectra to the transition between energy levels.** ▪ **Derive the differential equations related to:** - The current growth and decay in an RL circuit. - The charging and discharging of a capacitor in an RC circuit. ▪ **Identify the type of mechanical and electrical oscillations** (free damped or non-damped, driven, forced, resonance). ▪ **Interpret phenomena related to the two natures of light** (diffraction, interferences, polarization and photoelectric effect). ▪ **Exhibit a well rounded scientific background when discussing:** - The transportation of electrical energy, and the operation of an electrodynamic microphone, etc… - Carbon 12 dating, radiotherapy, nuclear power plants, etc
Experimentation	▪ **Verify experimentally the conservation of Linear Momentum using an air table.** ▪ **Determine experimentally the expression of the period of simple and elastic pendulums.**

	▪ **Display, using an oscilloscope, the voltage and the image of the current in an RL or an RC circuit** (charge and discharge of a capacitor with a square and a sinusoidal signal) **and RLC circuit** (charge and discharge of a capacitor with a square signal; phase difference and resonance with sinusoidal signals). ▪ **Put into evidence some of the optical wave phenomena** (diffraction, interference and polarization). ▪ **Determine experimentally the parameters that affect the induced current and voltage.**
Communication	▪ **Read and interpret:** - The recordings produced by an air-table apparatus. - Oscillograms, graphs and tables specific to RL, RC and RLC electric circuits. - The graph of radioactive decay. - A document dealing with issues about the universe ▪ **Identify an oscillating system using graphs** (the type of oscillation, and its characteristic properties). ▪ **Analyze the processes of energy exchange using a diagram** (in mechanics and electricity). ▪ **Use an appropriate scientific vocabulary adapted to different modes of representation**: orall, written, diagrams, tables, graphics…

Third Secondary Year
Life Sciences.

Domains and competencies

Domains	Competencies
Applying Knowledge	▪ **Apply knowledge specific to:** - **Mechanical energy, linear momentum and angular momentum** (whether these quantities are conserved or not). - **Electricity** (Ohm's law, electromagnetic induction). - **Nuclear reaction** (laws of conservation: of charge, of mass number and of energy; energy librated…) ▪ **Apply the Continuity and Bernoulli's equations on ideal liquids.** ▪ **Relate the emission and absorption spectra to the transition between energy levels.** ▪ **Derive the differential equations of:** - The charging and discharging of a capacitor in an RC circuit. - An RLC circuit fed with a sinusoidal alternating current. ▪ **Identify the type of mechanical oscillations** (free damped or non-damped, driven, forced, resonance). ▪ **Interpret phenomena related to the dual nature of light** (diffraction, interferences, polarization and photoelectric effect). ▪ **Exhibit a well rounded scientific background when discussing:** - The transportation of electrical energy, and the operation of an electrodynamic microphone, etc… - Dating with carbon and radioactive materials, Radiotherapy, nuclear power plants, etc.
Experimentation	▪ **Verify experimentally the conservation of Linear Momentum using an air table.** ▪ **Determine experimentally the expression of the period of simple and elastic pendulums.**

	▪ **Display, using an oscilloscope, the voltage and the image of the current in an RL or an RC circuit** (charge and discharge of a capacitor with a square and a sinusoidal signal) **and RLC circuit** (phase difference and resonance with sinusoidal signal). ▪ **Put into evidence some of optical wave phenomena** (diffraction, interference and polarization). ▪ **Determine experimentally the parameters that affect the induced current and voltage.**
Communication	▪ **Read and interpret:** - Diagrams produced by an air-table apparatus. - Oscillograms, graphs and tables specific to RL, RC and RLC electric circuits. - The graph of radioactive decay. ▪ **Identify an oscillating system using a graph** (characteristics and the mode of oscillations). ▪ **Analyze the processes of energy exchange using a diagram** (in mechanics and electricity). ▪ **Use an appropriate scientific vocabulary adapted to different modes of representation**: orall, written, diagrams, tables, graphics…

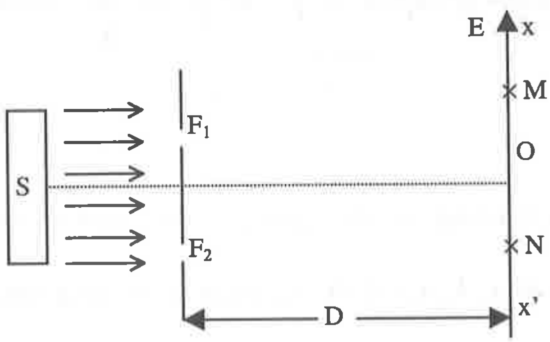
Examples of competencies evaluation for the 3rd secondary year - General and Life Sciences Series

Domain 1: Applying Knowledge

Competency: Interpret the formation of interference fringes.

Exercise 1: ***Interference fringes***

A student is conducting an interference experiment using a He-Ne laser source (S) of wavelength λ = 633 nm. The apparatus consists of an opaque plate bearing two thin and parallel slits F_1, F_2 that are a = 1 mm apart. The obtained interference pattern is observed on a screen (E), parallel to the opaque plane and situated at a distance D = 3 m from it. $F_1$and F_2 are equidistant from the source (S).

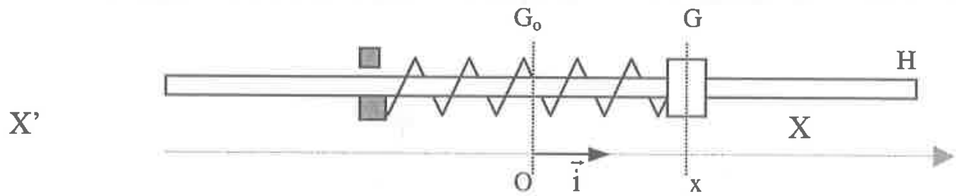


1) Interpret, qualitatively, the phenomenon of interference as observed on the screen (E).
2) Justify the nature of the fringe observed at point O.
3) Derive, in terms of λ, D, a, and k (integer), the x_k abscissa for the set of points of x'Ox for which the light intensity is minimal.
   Deduce the interfringe distance i of the observed pattern.
4) What happens if one of the slits, say F_1, emits a yellow radiation while F_2 emits a blue radiation? Explain.
5) Would the interference pattern persist if an incandescent bulb covered with a red filter replaces the laser source? Justify your reasoning.

Competency: Apply the conservation of mechanical energy in the case of a horizontal elastic pendulum.

Exercise 2: ***Horizontal elastic pendulum***

A solid object of mass $m = 100$ g is made to slide without friction on a horizontal rod (H). The object is hooked to a light elastic spring, of constant $k = 10\ Nm^{-1}$, whose other end is fixed as shown in the diagram below. The position of point G, center of inertia of mass m, is tracked by its abscissa with respect to an oriented axis $(O, \vec{i})$, such that the origin O coincides with the equilibrium position G_o of G.
Being initially at rest, the object is imparted a velocity $\vec{V}_o = V_o\,\vec{i}$ where $V_o = 10\ ms^{-1}$. Consequently, the object oscillates around G_o.



Assuming that the mechanical energy of the (spring - mass) system is conserved:

1. Express, as a function of m, k, x and dx / dt, each of the energies involved in this oscillatory motion.

2.
   i- Show that V_o is the maximum speed point G can have during this motion.
   ii- Determine X_m, the maximum abscissa (amplitude) reached by G.
   iii-Derive the differential equation governing the motion of m.

3. Knowing that the time equation of G is given by $x_{(t)} = X_m \sin(\omega t + \varphi)$. Derive a relation between V_o, X_m and ω.

4. Deduce the expression of ω in terms of k and m, and calculate the period of oscillations of G.

Competency: Apply knowledge related to nuclear reactions.

Exercise 3: ***Emission of alpha particle by uranium*** $^{233}_{92}U$

Uranium $^{233}_{92}U$ is a radioactive isotope that emits α particles.

i) Write the decay equation of $^{233}_{92}U$.

ii) Calculate, in MeV, the total energy liberated upon the decay of one $^{233}_{92}U$ nucleus.

iii) Neglecting the kinetic energies of both, the parent and daughter nuclei, calculate the maximum kinetic energy of the emitted α particle.

iv) Spectral analysis of the radiation emitted during $^{233}_{92}U$ disintegration reveal the existence of γ rays. On the other hand, measurement of the kinetic energy of the emitted α particles can have, besides the maximum value calculated above, the following values

$$E_{k1} = 4.85 \text{ MeV} ; \qquad E_{k2} = 4.89 \text{ MeV}$$

Interpret the origin of the γ radiations. Give the number of the observed lines and their frequencies.

Given: $h = 6.62 \times 10^{-34}$ J.s ; 1 u = 931.5 MeV.

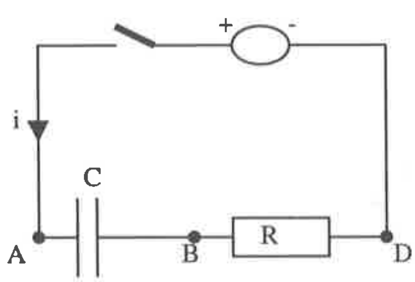
Some elements of the periodic table:

$^{233}_{92}U$	$^{232}_{90}Th$	$^{229}_{90}Th$	$^{4}_{2}He$
233.0395 u	232.0382 u	229.0316u	4.0026u

Competency: Derive the differential equation associated with the charge of a capacitor in an (RC) circuit branched across a regulated DC source.

Exercise 4: Differential equation related to the charge of a capacitor

The circuit diagram shown below is used to study the charging process of a capacitor (C) of capacitance C = 10μF. The resistor R has a resistance R = 1 kΩ, and the regulated



Voltage source maintains a U_{AD}=12 V potential difference across the terminals of the (RC) branch.

Initially (t_o = 0 s), the capacitor is uncharged. Let $q_{A(t)}$ represent the charge accumulated on armature A as the switch is closed.

1. a- Derive i(t) as a function of $\frac{dq_A}{dt}$. The indicated current direction (see diagram) will be adopted as the positive direction.

b- Derive $u_{AB(t)}$ in terms of $q_{A(t)}$ and C.

c- Derive $u_{BD(t)}$ in terms of R and $\frac{dq_A}{dt}$.

2. Derive the differential equation expressing the variations of $q_{A(t)}$ with respect to time.
3. The solution of the differential equation derived in the previous question is:

$q_{A(t)} = K(1 - e^{-\frac{t}{\tau}})$. Derive, in terms C, U_{AD}, and R, the expressions of the constants K and τ. Calculate the numerical value of K and τ.

4. Calculate q_A at $t = \tau$.

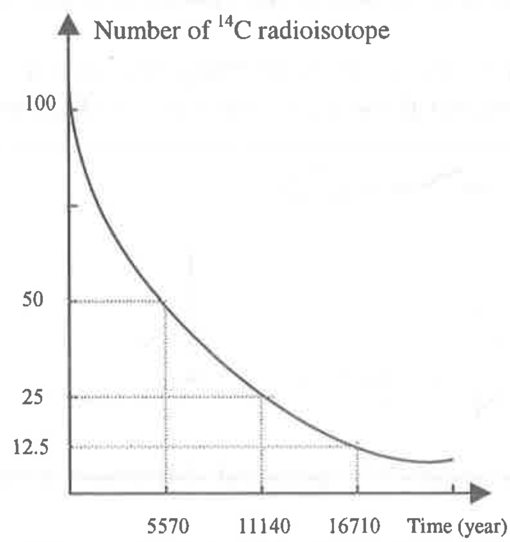
<u>Competency</u>: Integrate scientific knowledge in the analysis of carbon-14 dating technique.

<u>Exercise 5</u>: *Carbon-14 dating technique.*

During photosynthesis, carbon-12 as well as carbon-14 (β^- emitter) are absorbed by plants. Throughout the lifetime of a plant, the proportion of carbon-14 remains constant.

As a plant dies, the proportion of the accumulated carbon-14 starts decreasing. Hence, it is sufficient to measure the proportion of the remaining carbon-14 in a sample to date back when the plant died.

Answer the following questions, referring to the diagram below whenever needed:



1. Why does the amount of carbon-14 decrease in a dead plant?

2. a. Define half-life period of a radioisotope. Determine the half-life period of carbon-14.
   b. Determine the value of the radioactive decay constant of carbon-14?

3. Analysis of a sample taken from a living plant shows that there is one atom of carbon-14 for every 10^{12} atoms of carbon. In contrast, analysis of a given dry piece of wood reveal the existence of one carbon-14 atom for every 8×10^{12} atoms of carbon. What is the age of this given piece of wood?

Competency: Justify the use of transformers in the transport of electrical energy.

Exercise 6: ***Transport of electrical energy***

Electric power is to be transferred to a given town using two cables 100 km long each. The cables have a resistance of 0.15 Ω / Km and a power factor of k = 0.8.
The electric power delivered by the plant, P = 10 MW, is generated at an effective voltage of 6600 volts. This voltage is then increased to U volts using ideal step-up transformers having ten times more turns at their output than their input.

1.
   - i- Calculate the effective voltage U.
   - ii- Determine the effective value I of the current passing through the cables in terms of P, U and k and calculate its value.
   - iii- Determine, in terms of P, U, k and the total resistance R of the cables, the total heat power (p_{loss}) dissipated in the cables during this power transmission. Calculate p_{loss}.
   - iv- Deduce the efficiency of this method of power transmission.

2. Actually, power engineers plan to rise U to 220 000 V. What would become the efficiency in that case? What do you conclude?

3. It is well known that a strong magnetic field is created in the vicinity of the power transmission lines. Besides, research studies have correlated prolonged exposure to strong magnetic fields with serious pathological disorders. Bearing this in mind and considering the findings of question (1d) and (2), account for the use of high voltage in electric power transmission.

Competency: **Interpret daily life phenomena related to angular momentum.**

Exercise 7: ***Angular momentum of a man in rotation***

The spinning stool

A student sits on a pivoted stool while holding a pair of dumbbells (see diagram).

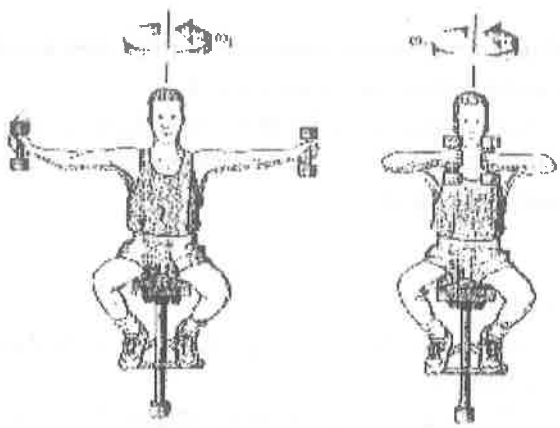


fig. a fig. b

The stool is free to rotate, with negligible friction, about a vertical axis. The moment of inertia of the student, the dumbbells, and the stool is equal to 2.25 kg.m^2. The student is set in rotation with an initial angular speed of 5.00 rad /s, while his hands are outstretched to the maximum as shown in (figure a). As the system rotates, the student pulls the dumbbells as close as possible such that the moment of inertia of the system (student, dumbbells, and stool) becomes 1.80 kg.m^2 (figure b).

1. Explain why the moment of inertia of the system decreases.

2. Describe and interpret the phenomenon that took place and calculate the new value of the angular speed of the system.

3. How does the kinetic energy of the system vary? Justify your answer.

Domain 2: Experimentation

Competency: Verify experimentally the period of an elastic pendulum

Exercise 1

Students' Sheet (to be distributed)

Situation

- Team work
- At the laboratory
- Duration 30 min.

Material

- An elastic spring (R) with spaced turns.
- Vertical support.
- Standard masses (with hooks)
- A ruler
- A chronometer.

Procedure

- Enact the necessary set up to determine k, the spring constant.
- After that, measure the duration of 20 oscillations for different masses.
- Write the obtained values in the following table

m					
t					
T					
T^2					

Questions (individual work)

1. Determine the spring constant k of the spring.
2. Complete the table.
3. Calculate the average value of the period.
4. Draw, on a graph paper, the graph of $T^2 = f(m)$.
5. Deduce graphically the law of variation of the period T with m.
6. Determine the value of k, knowing that $T = 2\pi\sqrt{\frac{m}{k}}$. Compare the obtained value with that found in question (1).
7. Write a report illustrated with neat and labeled diagrams.

(Question 7 evaluates also the competency "Use different modes of representation" within the communication domain).

Competency: **Display the charging and the discharging voltages across a capacitor connected to a square voltage.**

Exercise 2

Students' Sheet (to be distributed)

Situation

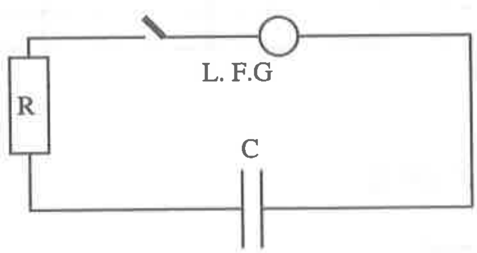
- Team work
- At the laboratory
- Duration: 30 min.

Material

- A low frequency generator. (L.F.G)
- A resistor: R = 500 Ω.
- Two capacitors: $C_1 = 0.22\ \mu F$ and $C_2 = 0.47\ \mu F$
- An oscilloscope
- A switch
- Connecting wires.

Procedure

- Wire up the circuit shown the diagram below using C_1 first.



- Set the L.F.G. to the square signal mode and select a 1000 Hz frequency.
- Using the oscilloscope and after selecting appropriate horizontal and vertical sensitivities, display u_G and u_C, the respective voltages across the L.F.G and C. Duplicate the obtained oscillograms on a graph paper.
- Replace C_1 by C_2. Describe the changes, if any, in the displayed voltages.

Questions (Individual work)

1. Write a report illustrated with neat and labeled diagrams. Show how the oscilloscope was connected.
2. What processes do the different observed modes of u_C represent?
3. Interpret the observed changes in step (4) of the procedure.
4. Determine, using the oscillogram, the time constant of the (R, C_1) circuit.
5. Calculate the theoretical value of this constant and compare it to that determined experimentally.

(Question 1 evaluates the competency "Use the different modes of representation" within the communication domain).

Competency: Display on an oscilloscope the response of a (R, L, C) circuit mounted across a sinusoidal voltage source: phase difference and current at the resonance.

Exercise 3

Students' Sheet (to be distributed)

Situation

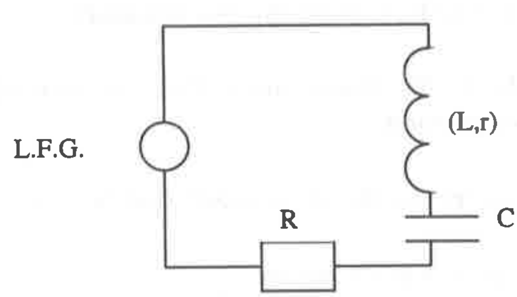
- Team work
- At the laboratory
- Duration: 30 min.

Material

- A low frequency generator (L.F.G)
- A coil of inductance L = 10 mH and of internal resistance r.
- A capacitor: C = 0.22 μF
- A resistor R = 10 Ω.
- An oscilloscope
- Connecting wires.

Procedure

- Mount the setup of the circuit diagram shown below.



- Display on the oscilloscope's screen the voltages: u_1 across the generator and u_2 across R.
- Adjust and maintain u_1 to $U_{1m} = 1$ V throughout the experiment.
- Increase the frequency f of the L.F.G. between 2,000 Hz and 5,000 Hz and write down, for each selected frequency, the corresponding value of the maximum current I.

$$I_m = \frac{U_{2m}}{R}$$

Questions (Individual work)

1. Draw, using a graph paper, the curve representing $I_m = g(f)$.
2. Determine graphically the resonant frequency f_o. Calculate the theoretical value of f_o and compare it to the experimentally determined value.
3. Calculate the resistance r of the coil.
4. Write a report illustrated with neat and labeled diagrams showing all the connections made with the oscilloscope

(Questions 1, 2 and 4 evaluate the competency "Use different modes of representation" within the communication domain).

Domain 3: Communication

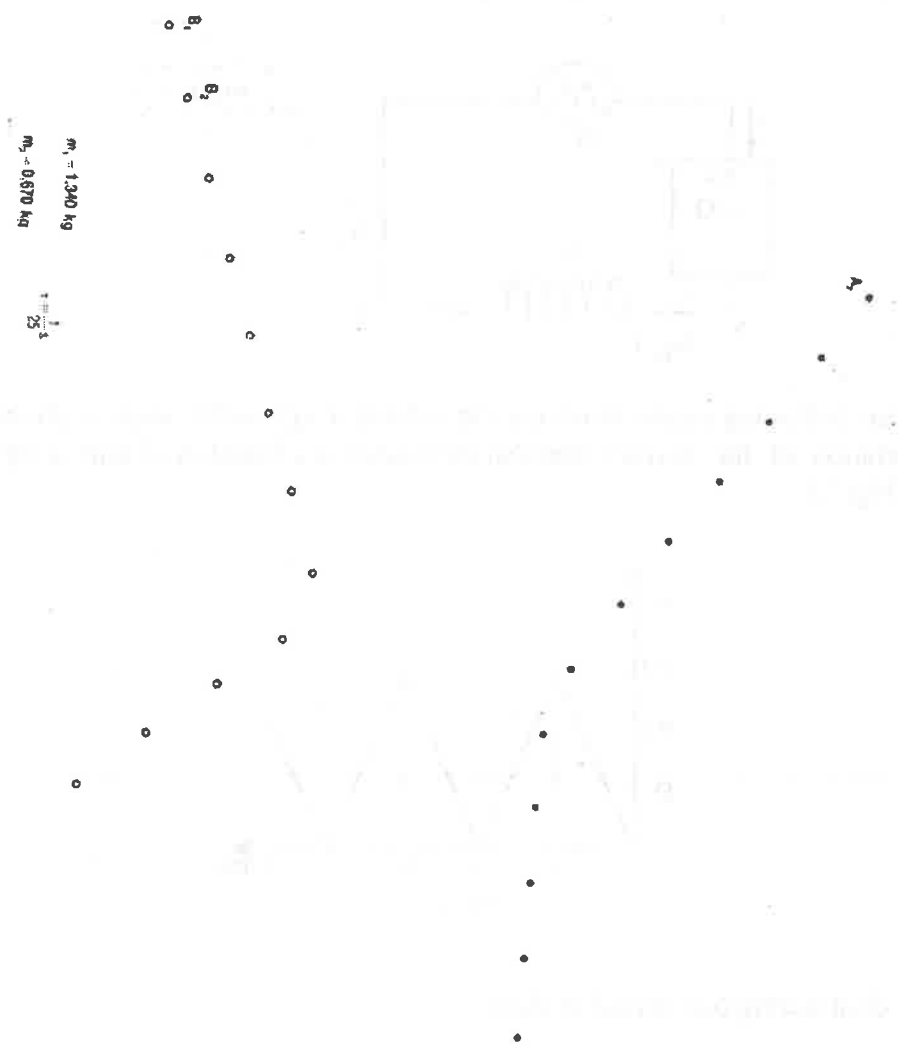
Competency: Use the recordings produced on an air table apparatus.

Exercise 1: ***Collision on an air table***

We have two air-pucks S_1 and S_2 of respective masses $m_1 = 1.34$ kg and $m_2 = 0.670$ kg.
Both air-pucks are launched on a horizontal air table so that they meet and bounce on each other (collision). We obtain the following diagram on which the different positions A_i and B_i, occupied respectively by the centers of inertia of S_1 and S_2, are recorded at the instant t_i. Let G be the center of inertia of the system (S_1, S_2).

1. Let G_i be the position of the center of inertia of the system (S_1, S_2) at the instant t_i. Using the relation $\frac{G_iA_i}{G_iB_i} = \frac{m_2}{m_1}$, construct the trajectory of G.
2. What is the nature of motion of G? Is the system (S_1, S_2) isolated?
3. Using a convenient scale, draw the linear momentum vectors of the system (S_1, S_2) respectively before and after the collision.
4. Is the linear momentum of the system (S_1, S_2) conserved? Justify your answer.
5. Is the kinetic energy conserved? Justify your answer.

6. Represent $\Delta V_B = V_{\text{before collision}} - V_{\text{after the collision}}$. Determine the direction of the action exerted by S_1 on S_2



Competency: Use oscillograms to study RL circuits.

Exercise 2

In the circuit diagram (fig.1), the coil has an inductance L = 100 mH, R is equal to 1 kΩ, and a generator G adjusted to deliver a triangular signal.

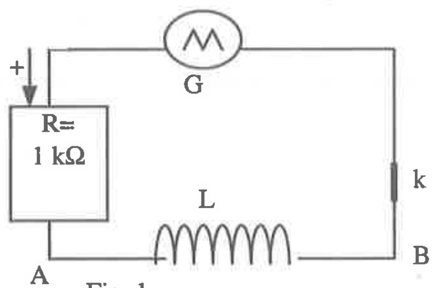


Fig. 1

In applying the following instructions, use the indicated sign as the positive direction around the loop. The variation of the current through the circuit as a function of time is represented in the graph below (Fig. 2).

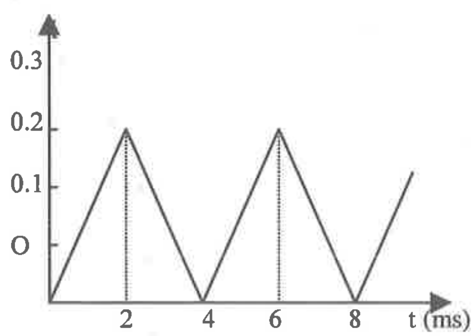


Fig. 2

1. Determine di/dt during one period of time.

2. Derive the voltage u_{AB} across the coil during one period.

3. Draw the graph representing the variation of the voltage u_{AB} versus time

   Scale: 1 cm in abscissa represents 2 ms
   1 cm in ordinate represents 5 V

4. What is the physical phenomenon that accounts for the shape of the u_{AB} versus t graph?

<u>Competency</u>: Read and interpret tables and graphs in the study of RC circuits

<u>Exercise 3</u>: ***Graphical study of the charging of a capacitor***

A capacitor of capacity C, initially discharged, is connected in series with a resistor of resistance R = 104 Ω across a generator delivering a constant voltage $U_o = 6$ V. During the charging of the capacitor, the voltage u_C across it is recorded at 10s intervals as reported in the following table:

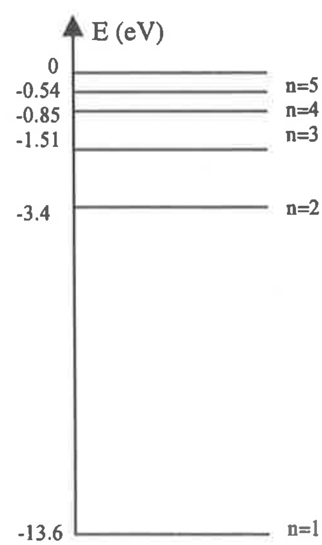
t(s)	0	10	20	30	40	50	60	70	80	90	100
u_C(V)	0	1.60	2.75	3.80	4.20	4.70	5.00	5.30	5.50	5.60	5.75

1. Draw a diagram of the circuit.
2. Derive a mathematical relation between U_0, R, u_C and $\frac{du_C}{dt}$
3. Draw the graph representing $u_C = f(t)$.
   Scale: 1 cm in abscissa corresponds to 10 s.
   1 cm in ordinate corresponds to 0.5 V.
4. What is the ordinate of the horizontal asymptote to the curve $u_C = f(t)$? Interpret this result graphically.
5. Deduce that the tangent to the curve at t = 0 intercepts the horizontal asymptote at an instant $\tau = RC$. Determine the value of τ.
6. Deduce the capacitance of C.

<u>Competency</u>: Read up the energy level diagrams of the hydrogen atom.

<u>Exercise 4</u>: ***Energy levels of the hydrogen atom***

The great nebula of Orion has four very hot stars emitting ultra-violet radiations, of wavelength less than 91.2 nm, within a great "cloud" of interstellar gas mainly constituted of hydrogen.



The diagram above represents some possible energy levels of the hydrogen atom.

Given: Planck's constant $h = 6.62 \times 10^{-34}$ J.s.
Elementary charge $e = 1.6 \times 10^{-19}$ C.
Speed of light $c = 3 \times 10^{8}$ m/s.

1. What does the energy level E = 0 eV corresponds to? Determine the ionization energy of the hydrogen atom.

2. What happens to a ground-state hydrogen atom when it receives a radiation of wavelength λ = 91.2 nm?

3. Would a ground-state hydrogen atom be activated excited when it receives a radiation of 110 nm? Justify your answer.

4. What is the wavelength of the emitted radiation when a hydrogen atom passes from the n =3 activatedstate to the n = 2 activated state? Is the obtained radiation visible?

Third Secondary Year
Humanities and Economics

Domains and competencies

<table>
<tr><th>Domains</th><th>Competencies</th></tr>
<tr><td>Applying Knowledge</td><td>

Apply knowledge specific to energy and its conservation (work, mechanical energy, $E = mc^2$, etc…).
Identify:
- The different forms and sources of energy.
- Nuclear reactions and nuclear radiation.
- The means of transport.
Compare:
- The different cosmological theories (geocentric, heliocentric, and modern cosmology).
- The instruments and the means used in space observation.
Explain physical phenomena related to daily life:
- The biological and environmental effects of fuel combustion or nuclear radiation –Methods of protection.
- Medical usage of nuclear radiation.
Analyze the relationship among energy, economy and pollution.

</td></tr>
<tr><td>Communication</td><td>

Read and interpret diagrams and texts related to: energy, nuclear reactions, the solar system, the universe, petroleum (rate of production, change in prices, reserves, etc…).
Use an appropriate scientific vocabulary adapted to different modes of representation: oral, written, diagrams, tables, graphs…

</td></tr>
</table>

Examples of competencies evaluation for the third year secondary

1^{st} Domain: Apply Knowledge

Competency: Apply knowledge related to mechanical energy.

Exercise 1: *Free falling flower pot*

A flowerpot, of mass $M = 2$ kg, is released, without initial velocity, from a height $h = 20$ m above the ground. The ground level is chosen as the level of zero gravitational potential energy. Use $g = 10$ m/s^2.

1- Calculate, when the pot is at its initial position:
  i- The kinetic energy of the pot.
  ii- The gravitational potential energy of the pot.
  iii- The mechanical energy of the pot.

2- Neglect air resistance in what follows:
  i- What can we say about the mechanical energy of the pot?
  ii- Calculate the kinetic energy of the pot just before touching the ground, and deduce its speed at that moment.

3- In reality, the measured speed of the pot as it touches the ground is 16 m/s. Determine the decrease in mechanical energy. Under which form does this energy appear?

Competency: Apply knowledge related to nuclear energy

Exercise 2: *Nuclear fission*

1. The famous Einstein relation is $E = m \times c^2$. What is the respective meaning of each of the three terms: E, m and c?

2. One of the nuclear fission reactions of the uranium 235 is:

$$^{235}_{92}U + ^{1}_{0}n \rightarrow ^{139}_{53}I + ^{94}_{39}Y + 3^{1}_{0}n$$

   During this reaction the mass diminishes by 3.58×10^{-28} kg. Calculate the energy liberated during the reaction. Given $c = 3 \times 10^8$ m/s.

3. One kilogram of uranium 235 contains 25.6×10^{23} nuclei. Calculate the energy liberated by the fission of one kilogram of uranium 235.

4. Determine the mass of oil corresponding to the production of this energy, knowing that the combustion of one ton of oil liberates 4.2×10^{10} J.

Competency: Identify nuclear reactions.

Exercise 3: ***Disintegration of phosphorus***

The decay of the phosphorus nucleus P is represented by the following equation:

$$^{30}_{15}P \rightarrow ^{A'}_{Z'}X + ^{0}_{1}e$$

i- Justifying your answer, determine the values of A' and Z'.
ii- What is the name of the $^{0}_{1}e$ particle?
iii- What is the name of element X? Justify your answer.

Given:

Element	Aluminum	Silicon	Phosphorus	Sulfur	Chlorine
Atomic number	13	14	15	16	17

iv- Phosphorus P (Z = 15; A = 30) has a half-life period of T = 156 s. A sample contains, at time t, $N = 8.4 \times 10^{15}$ nuclei of this isotope. How much time will it take for the number of remaining nuclei of this isotope to become 2.1×10^{15}?

Competency: Identify different forms of energy.

Exercise 4: ***Energy exchanges***

Consider the following energy chain:

The water retained behind a dam activates an electric generator. The power produced by this generator feeds an electric pump that raises water out of a well.

i- Specify the different forms of energy exchanged throughout this energetic chain.
ii- Specify which element(s) of this chain is a source of energy of solar origin. Justify your answer.
iii- State the principle that could be applied for all types of energy exchanges.
iv- The energy used to pump water from the well is less than the energy produced by the water from the lake. What is the form of the lost energy?

Competency: **Analyze the relationship among energy, economy, and pollution.**

Exercise 5: ***Economizing energy and pollution***

A bottle of propane, a natural gas of formula C_3H_8, contains 13 kg of liquefied gas. The complete combustion of one kilogram of propane liberates an energy of 50 000 kJ (1 kJ = 1 000 J). 4.2 kJ of energy are needed to raise the temperature of one liter of water by 1 °C.

i- Under what form appears the energy liberated by propane combustion?

ii- Calculate the volume of water that can be heated up by 1°C with one bottle of propane.

iii- A bottle of propane is sold at 13 000 L.P. while the average price of one kilowatt-hour (1 kilowatt-hour = 3.6×10^6 J) of electric energy is about 120 L.P. Which one of the two kinds of energy is more economical? Why?

iv- One of the compounds produced by the complete combustion of propane causes an ecological problem called "greenhouse effect". What is this compound? What is the long-term consequence of the greenhouse effect?

Competency: **Analyze the relationship among energy, economy, and pollution.**

Exercise 6

Explain how nuclear energy is simultaneously useful and harmful.

Competency: **Explain the use of nuclear radiation in medicine.**

Exercise 7

If we inject an iodine solution into the circulatory system of a person, the iodine tends to fix on the thyroid gland.

1. The injection of radioactive iodine helps in identifying the possible anomalies in the operation of the thyroid gland. How?

2. Iodine has two radioactive isotopes: ^{131}I and ^{132}I. The radioactive periods are respectively 8 days and 2.3 h. Explain why the use of the ^{131}I isotope is preferred.

Domain 2: Communication

Competency: Analyze a text related to the Universe.

Exercise 1: *The Universe*

« Stars around us are grouped in a galaxy, called Milky Way: our galaxy (…). There are billions of galaxies in the universe similar to our galaxy (…). Thanks to light we can observe the universe. Observations show that all the galaxies move away from each other(…). This expansion has been taking place for fifteen billion years. This expansion started out of an explosion. It is also possible that this expansion continues indefinitely. It is also possible that, after some tens of billions of years, the expansion process would stop and the Universe starts contracting back again (…). The choice between these two possibilities depends on the total quantity of matter in the Universe. Now, we have some clues that lead us to think that -expansion- is most likely to continue (…). an ever expanding Universe does not remain unchanged: matter will slowly disintegrate into light.»

Paraphrased from «Hubert Reeves; Patience dans l'azur»

Questions

1. What is the Milky Way?
2. What is the physical phenomenon that explains this expansion theory of the Universe? Name the scientist who discovered this phenomenon.
3. How do you think the expansion of the Universe started?
4. What is, according to the above document, the age of the Universe?
5. What are the scenarios that the author predicted about the future of the Universe?

Competency: Read and interpret a table related to the solar system.

Example 2: *Solar system*

The following table shows some characteristics of the solar system.

Planet	Average distance to Sun ($\times 10^6$ km)	Orbital speed (km/s)	Duration of one revolution around the Sun (years)	Chemical composition of the atmosphere	Surface temperature (°C)
Mercury	57.6	47.9	0.24	none	-170 to 390
Venus	108.2	35	0.61	CO_2	480
Earth	149.6	29.8	1	N_2, O_2	22
Marsh	227.9	24.1	1.88	CO_2	-23
Jupiter	778.3	13.0	11.86	H_2, He	-150

Planet	Average distance to Sun ($\times 10^6$ km)	Orbital speed (km/s)	Duration of one revolution around the Sun (years)	Chemical composition of the atmosphere	Surface temperature (°C)
Saturn	1429	9.6	29.45	H_2, He	-160
Uranus	2875	6.8	84	H_2, He, CH_4	-180
Neptune	4504	5.4	164	H_2, He, CH_4	-200
Pluto	5916	4.7	247.7	?	-240

i) Why do we need to know the average distance of each planet to the Sun?

ii) Compare the orbital speed of planets to their distances from the Sun.

iii) What is meant by «year» for the duration of one revolution of a given planet around the sun? Compare the duration of one revolution of the planets to their respective distances from the Sun.

iv) Compare the temperature observed on the surface of planets to their distances from the Sun. What is the intriguing data about Venus? Why does this exception occur?

v) In 1987, Voyager 2 passed by Uranus. How much time does it take the information sent by Voyager 2 to reach Earth? The electromagnetic waves propagate at the speed of light (c = 300 000 km/s).

Competency: Read and interpret a text related to radioactivity.

Exercise 3: *The Chernobyl accident*

The following is an excerpt from a report related to the Chernobyl nuclear plant accident.
"For Women to become infertile when exposed to the cesium 137 radiation, the absorbed amount must be large. For 25 years old women, infertility occurs definitely when the ovaries are irradiated by 1200 rems during a very short period of time. But women who have received a dose less than 20 rems for the first year and lesser amounts during later years are safe from infertility due to hazardous radiations."

i) Define the absorbed dose. Specify its unit.
ii) Does the absorbed dose per given mass depend on the duration of exposure to radiation?
iii) When we are near a radioactive source, the absorbed dose diminishes over time. Why?
iv) Name the physical quantity whose unit is the rem.
v) On what factors do the biological effect of a given radiation depend?

OFFICIAL EXAM SAMPLES

General Instructions for official exam in physics

General Sciences and Life Sciences

The physics exam is a means of evaluating the levels of acquired competencies as defined in the list of competencies the evaluation guide.

The exam should be based on the following:

- Strict respect of the spirit of the evaluation policy (guide and samples) and on official No. 21 dated April 30, 1999.
- Pedagogic teaching practices in balancing the three levels of knowledge (acquisition, transfer and production).
- Choice of competencies belonging to all the domains and integrating learning objectives of different topics of the curriculum.
- Good representation of the proposed documents and clear drafting of the subjects. Thus, if we require the justification of a result, a derivation, a comment, a figure, we must ask that clearly in the question. We don't reserve marks for implicit questions.
- A scheme specific to each question to insure a consistency in correcting the copies.
- Allowing the use of scientific non-programmable calculators so that real and practical questions may be asked.

- **Nature of the exam**

The physics exam is made up of four questions. The first three questions, common for Life Sciences and General Sciences, are marked on 20 points. The fourth one, reserved to GS students, is marked on 7.5 points. These questions are independent, and can be solved by the student in any order.

Each of these questions is supposed to evaluate competencies integrated in different domains.

As a rule, each question should represent a real situation. We start by a theoretical or experimental study and end by a practical application of the concept underlying the situation, in daily life.

- **Score weighting**

The score of each of the three questions can vary between 5 and 8 points. To have the score weighted, we multiply the mark (on 20 points for LS, and on 27.5 for GS) by four.

- **Time**

The time of the physics exam is one hour or 60 minutes.

- **What do we look for in the copy of the student?**

In the domain of **applying knowledge**:

- Analysis of the relevant data given.
- Mobilization of knowledge appropriate to physics.:
    - Choice of the concept, principle, model, law, hypothesis…
    - Choice of the formulas
    - Literal expression of the solution
    - Choice of units.
- Mobilization of other knowledge not peculiar to physics (calculation, circular functions, logarithm, vectors…)
- Validity of result.

In the domain of **mastering communication:**

- Passage from one mode of representation to another one.
- Respect of rules of the chosen mode of representation (symbol, equation, scale, writhing of indices…).
- Analysis of important information.
- Mobilization of knowledge peculiar to physics.
- Mobilization of knowledge not peculiar to physics
- Clear redaction.

In the domain of **experimentation:**

- Choice of materials
- Setup
- Respect of safety rules
- Measurement
- Answers to questions
- Validity of result
- Report

This list is not exhaustive.

If the subject of each exercise covers one or more domains, the mark reserved to knowledge appropriate to physics must be greater than that reserved to knowledge non-appropriate to physics.

General Sciences

Physics exam **Session: ....**

Time: 3 hours **Score: 20 points**

This exam is made up of three questions, contains ...... pages numbered from 1 / ... to ... / ...

Answer <u>All</u> Questions

Non- programmable calculators are allowed

First exercise *(… points)*

I.

1.
   a)
   b)

2.
   a)
   b)

Second exercise *(… points)*

II.

1.
   a)
   b)

2.
   a)
   b)

Third exercise *(… points)*

III.

1.
   a)
   b)

2.
   a)

Fourth exercise *(… points)*

IV-

1.
   a)
   b)

2.
   a)
   b)

To students

How to organize your job.

- **By which question do you start?**

By the one you think easiest. Do not hesitate to leave a question if you are blocked (you will go back to it later)

- **How do you start an exercise?**

Read carefully the given data.
Indicate or underline the important terms and words.
Observe carefully any accompanying documents.

- **Presentation of the copy**

No need to copy the given data
Write clearly; if you don't have a good writing, write with detached lettering and acceptable characters.
Use the notation of the given data; do not change it. If you introduce new notations, define them.
Write clearly the number of the question you treat as given.

- **Results and numerical applications**

Start by a literal expression and then pass to the numerical application.
Do not forget the units
Put the final result in a frame.

GENERAL SCIENCES

Physics exam | **Session ...**
Time: 3 hours | **Marks: ... points**

This exam, made up of four questions, contains 4 pages numbered from 1 to 4.

All questions are obligatory

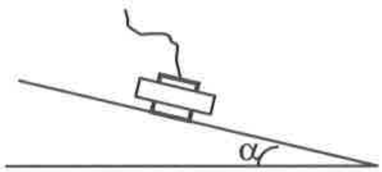
Non-programmable calculators are allowed.

EXAM I

FIRST QUESTION (8 points)

Motion of an object on an inclined plane

To study experimentally the motion of an object on a frictionless inclined plane, we consider an air puck, of mass 0.52 kg, placed on the top of an air table inclined by 14.5° with respect to the horizontal.



The air puck is released without initial velocity at an instant t_0 that can be taken as the origin of times, and the different positions of its center of inertia are registered at equal intervals of time τ.

The diagram below shows some positions of the center of gravity of M the puck for $\tau = 40$ ms. The document is reproduced to the scale ½ .

1. Calculate the speed and the magnitude of linear momentum of the puck at the positions M_2 and M_5, and complete the following table.

M_i	M_o	M_1	M_2	M_3	M_4	M_5	M_6	M_7
Abscissa x (cm)	0	0.5	1.2	2.1	3.2	4.5	6.0	7.7
Speed V (m/s)		0.3		0.5	0.6		0.8	
Linear momentum P (kg.m/s)		0.156		0.26	0.312		0.416	

2. a. Draw the graph representing the linear momentum in terms of t, taking t = 0 s when M is at M_o.
   Scale: 1 cm ⇔ 40 ms and 1 cm ⇔ 0.1 kg m/s.

b. Deduce the magnitude of the net force exerted on the puck.

c. Determine the instant of releasing the puck.

3. The level of M_6 is taken as the zero level of gravitational potential energy. Take $g = 9.8\ m/s^2$.

   i- Calculate the mechanical energy of the system (Earth, air-puck) at the points M_1 and M_6.

   ii- Verify that there is conservation of the mechanical energy of the considered system. To what is the conservation of the mechanical energy due?

SECOND QUESTION **(7 points)**

Phase difference and resonance in RLC circuit

To determine the value of the capacitance of a capacitor, we consider a RLC series circuit fed with a low frequency generator delivering a sinusoidal voltage of frequency f.
The voltage u across the generator and u_R across the resistor R are visualized on the screen of an oscilloscope. Using the vertical sensitivity of 1 V/div for (a), and 5 V / div for (b), the figure 1 shows the obtained oscillograms of these voltages.

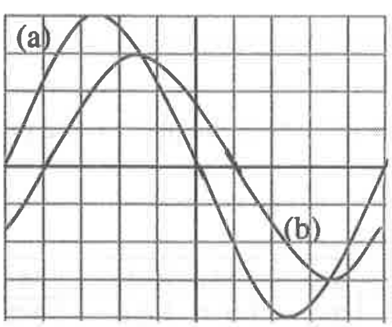


Fig. 1

1. Draw a diagram of the circuit showing the connections to the oscilloscope.

2. Oscillogram (b) corresponds to the voltage u_g. Why?

3. Calculate the effective value I of the current i flowing in the circuit knowing that the resistance $R = 10\ \Omega$.

4. Determine the phase difference φ between the voltage u and the current i flowing in the circuit. Specify which of i or u_g leads the other.

5. The instantaneous current i in the circuit is given by : $i = I_m \cos \omega t$.
   i- Calculate ω.
   ii- Write down the time equation of the instantaneous voltage u_g

6. For a frequency of 1000 Hz the phase difference φ becomes zero.
   i. Determine the mode of oscillation of the circuit and its natural frequency.
   ii. Calculate the capacity C of the capacitor if $L = 0.01$ H.
   iii. What will be the value of the effective value of the current in this case if the coil has a resistance of $20\ \Omega$?

THIRD QUESTION (5 points)

Dating volcanic rocks

To determine the age of some volcanic rocks rich in potassium 40, we use the disintegration of the nuclei of potassium into argon nuclei.
The potassium ${}^{40}_{19}K$, of radioactive period 10^9 years, disintegrates and emits the nucleus argon ${}^{40}_{18}Ar$.

1. a. Write the corresponding equation of the nuclear reaction.
   b. Specify the nature of this decay reaction.

2. The law of radioactive decay of a radio-element gives the evolution of the number n (t) of its nuclei in terms of time. Consider at t = 0, n is equal to n_o.
   i- Give for the potassium 40, the expression of the number n_K in terms of n_o, of the radioactive constant λ and of the time t.
   ii- Deduce the expression of the evolution of the number of argon nucleus n_{Ar} in a specimen having initially only non-nucleic and any argon nucleus.

3. Certain volcanic rocks, as the obsidian, contain potassium. When it is formed, the obsidian rock does not contain argon. A geologist, when analyzing a rock specimen, notices that the number of atoms of argon 40 is half less than that of potassium 40. What is the approximate age of formation of this rock?

FOURTH QUESTION (7.5 points)

Relativity: time dilatation and length contraction

In this question, we have to study the relativistic effects of speeds, which are not negligible with respect to that of light.

On Earth, an astronaut has a heart beat rate of 70 beats / min and his cylindrical space ship has a length of 10 m and a diameter of 2 m. The space ship is traveling away from Earth at the speed of 0.9 c.

1. Determine the heartbeat rate of the astronaut measured by:
   a. an observer on Earth,
   b. an observer also in the ship.

2. Determine the length and the diameter of the ship as they appear for an observer on Earth.

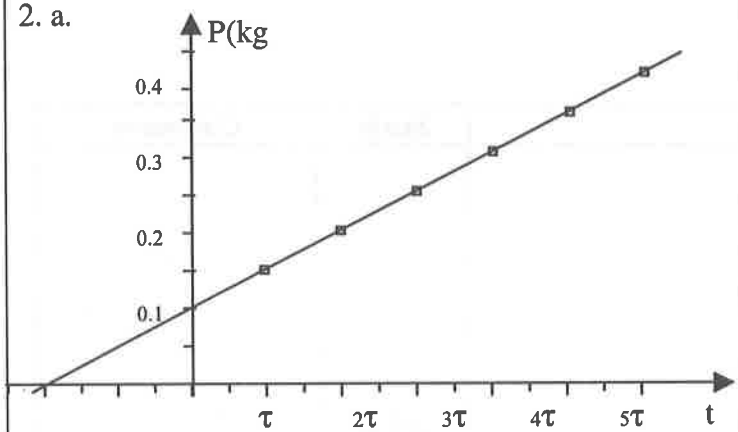
3. Another space ship traveling in the same direction as the first ship appears for an observer on Earth to have the same length as the first. Determine its speed if on Earth one ship has a proper length three times the other.

Solution of the questions of EXAM 1

Question 1 (8 points)

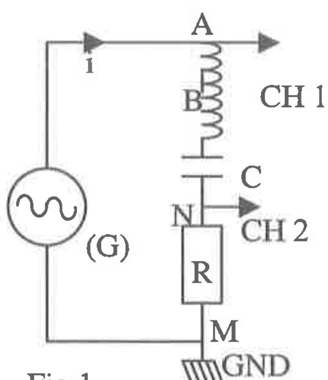
This exercise emphasizes the domain of «communication » but also covers some elements belonging to « applying knowledge ».

Expected answers	Points	Comments
1. $V_2 = \dfrac{M_1M_3}{2\tau} = \dfrac{(x_3 - x_2)\times 2}{2\times 40\times 10^{-3}} = \dfrac{0.016\times 2}{0.08}$ $= 0.4$ m/s $P_2 = mV_2 = 0.208$ kg m/s $V_5 = \dfrac{M_4M_6}{2\tau} = \dfrac{0.028\times 2}{0.08} = 0.7$ m/s	2 pts	

$P_5 = mV_5 = 0.364$ kg m/s 2. a.  b. The magnitude of $\vec{F}$, $F = \frac{\Delta P}{\Delta t}$ $F = \frac{P_6 - P_1}{5\tau} = \frac{0.416 - 0.156}{5 \times 0.04} = 1.3$ N c. The puck is released at the instant corresponding to the intersection of the straight line and the time axis: $t = -2\tau$ $t = -80$ ms $= -0.08$ s	1 pt 1 pt 1 pt	
3. a. <u>At M_6</u>: $KE_6 = ½\, m V_6^2 = ½ \times 0.52 \times 0.8^2 = 0.166$ J. The gravitational potential energy: $GpE_6 = 0$. The mechanical energy is then reduced to the kinetic energy: $ME_6 = 0.166$ J. <u>At M_1</u>: $KE_1 = ½\, m V_1^2 = ½ \times 0.52 \times 0.3^2 = 0.0234$ J. The gravitational potential energy: $GPE_1 = mgh_1 = 0.52 \times 10 \times (x_6 - x_1) \times \sin 14.5 =$ $0.52 \times 9.8 \times (5.5) \times 10^{-2} \times 2 \times 0.25 = 0.140$ J. The mechanical energy: $ME_1 = 0.163$ J b. $ME_1 \approx ME_6$, there is then conservation of the mechanical energy since the air table is considered as frictionless plane.	2 pts 1 pt	

Question 2 (7 points)

This exercise emphasizes the domain of "communication" but includes some competencies of the domain of "applying knowledge".

Expected answers	Scale	Comment
1.  Fig.1	0.5 pt	
2. The maximum voltage is represented by 4 divisions in the graph (a) and by 5 divisions in the graph (b). Then $U_a = 1V / div \times 4\ div = 4\ V$ And $U_b = 5\ V/div \times 3\ div = 15\ V$ Since U (generator) must be greater than U (resistor), $\Rightarrow$ (a) represents the voltage across R and (b) represents the voltage across the generator.	1 pt	
3. $U_R = \frac{U_{Rm}}{\sqrt{2}} = 2.83\ V \Rightarrow I = \frac{U_R}{R} = \frac{2.83}{10} = 0.28\ A$;	1 pt.	
4. The phase difference is given by: $\varphi = 2\pi d / D$ where d is the horizontal distance between the two oscillograms, and D is the horizontal distance covered by a period of any oscillogram. $\varphi = 2\pi \times 1 / 10 = \pi / 5$ rad From the oscillograms we notice that (a) leads (b); then i leads u.	1 pt	

5. a. The period $T = 1$ ms / div $\times$ 10 div = 10 ms $\Rightarrow \omega = 2\pi / T = 200\,\pi$ rad/s b. $u = 15 \cos(200\,\pi t - \pi / 5)$ (u in V; t in s)	1 pt	
6. a. For $\varphi = 0$; the circuit oscillates in resonance then the natural frequency of the circuit is f_o=1000 Hz	1 pt	
b. $LC\omega_o^2 = 1$ with $\omega_o = 2\pi f_0 = 2000\,\pi$ rad/s $\Rightarrow C = 1 / (0.01 \times 2000^2 \times \pi^2) = 2.53 \times 10^{-6}$ F = C = 2.53 μF.	1pt	
c. $U = \frac{U_m}{\sqrt{2}} = \frac{15}{\sqrt{2}} = 10.60$, $I = \frac{U}{R + r} = \frac{10.6}{30} = 0.35$ A.	0.5 pt.	

Question 3 (5 points)

This exercise emphasizes the domain of explanation of physics phenomena related to daily life.

Expected answers	Scale	Comment
1.a. ${}^{40}_{19}K \rightarrow {}^{40}_{18}Ar + {}^{a}_{z}P$ Law of conservation of number of nucleons: $40 = 40 + a \Rightarrow a = 0$. Law of conservation of number of electric charges: $19 = 18 + z \Rightarrow z = 1$. The emitted particle is the positon or positron ${}^{0}_{1}\bar{e}$ and the nuclear reaction is: ${}^{40}_{19}K \rightarrow {}^{40}_{18}Ar + {}^{0}_{+1}e + {}^{0}_{0}\nu$	1.5 pts	
b. The disintegration is a β^+ decay.	0.5 pt	
2. **a.** The law of radioactive decay is given by: $n = n_o e^{-\lambda t}$, with $\lambda = \frac{Ln2}{T} = \frac{0.693}{T}$ For the potassium 40: $n_K = n_{oK} e^{-\lambda t}$.	0.5 pt	
b. From (1.a) we deduce that the decayed nuclei of potassium 40 = to the obtained nuclei of argon 40: Thus: $n_{Ar} = n_{oK} - n_K$ or $n_{Ar} = n_{oK} (1 - e^{-\lambda t})$	1 pt	
3. $n_{Ar} = \frac{n_K}{2} = n_{oK} - n_K$ $\Rightarrow 2/3\ n_K = n_{oK} \Rightarrow n_K = \frac{2n_{oK}}{3}$ $n_{Ar} = \frac{n_{oK}}{3} = n_{oK} (1 - e^{-\lambda t}) \Rightarrow 1/3 = 1 - e^{-\lambda t}$ $e^{-\lambda t} = 2/3 \Rightarrow Ln(2/3) = -\lambda t = -\frac{0.693}{T} t$ $\frac{t}{T} = 0.585$ $t = 0.585 \times 10^9$ years $\Rightarrow t = 585 \times 10^6$ years	1.5 pts	

Question 4 (7.5 points)

This exercise emphasizes the domain of applying knowledge.

<table>
<tr><th>Expected answers</th><th>Scale</th><th>Comment</th></tr>
<tr><td>1.a Suppose that the observer in the space ship uses a clock to measure the time interval $\Delta t' = 1$ minute and that the observer on Earth uses another clock to measure this time interval.
$\Delta t = \dfrac{\Delta t'}{\sqrt{1 - v^2/c^2}}$
$\Rightarrow \Delta t = \dfrac{60}{\sqrt{1 - 0.9^2 c^2/c^2}} = 137.65$ s

Thus the 70 beats are measured with respect to the Earth observer in 137.65 s and the heartbeat rate becomes: $\dfrac{70}{137.65} \times 60 = 30.5$ beats / min.</td><td>2 pts</td><td>If we take:
- $\beta = V/c$ $\beta = 0.9c/c \Rightarrow \beta = 0.9$.
- $\gamma = \dfrac{1}{\sqrt{1-\beta^2}}$
$\gamma = \dfrac{1}{\sqrt{1-0.9^2}}$
$\gamma = 2.29$
$\Delta t = 2.29 \times 60$
$\Delta t = 137.65$ s</td></tr>
<tr><td>b. For the observer in the ship the interval of time (1 minute) remains the same 1minute, thus it measures 70 beats per min.</td><td>1 pt</td><td></td></tr>
<tr><td>2. Since the length L_0 of the ship coincides with the direction Earth-ship, the observer on Earth sees the length of the spaceship to be contracted to a length L such that: $L = L_o\sqrt{1 - v^2/c^2} = 10\ \sqrt{0.19} = 4.36$ m.</td><td>1.5 pts</td><td></td></tr>
<tr><td>Since the diameter is orthogonal to the direction observer space ship, thus the diameter remains the same.</td><td>1 pt</td><td></td></tr>
<tr><td>3. The apparent lengths of the two space ships: $L_2 = L_1 = 4.36$ m
If $L_{o2} = \dfrac{L_{02}}{3} = \dfrac{10}{3} = 3.33$ m $\Rightarrow L_{02} < L_2$ which is in contradiction with the formula of contraction.

If we take the other possibility:
$L_{o2} = 3\ L_{o1} = 30$ m;
$\Rightarrow L_{02} < L_2$; then: $4.36 = 30\ \sqrt{1 - v'^2/c^2}$
$\Rightarrow v' = 0.99$ c.</td><td>2 pts</td><td></td></tr>
</table>

EXAM II

FIRST QUESTION (10 Points)

Energetic study of a simple pendulum

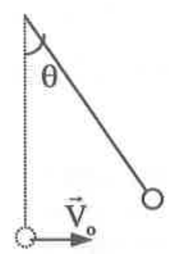
A simple pendulum is composed of a light string of length ℓ and a small metallic sphere of mass m.
To study energetically a simple pendulum, we neglect all frictions and we suppose that satisfied the conditions of non-damped free oscillations exist in the case of small amplitude. In this case, we admit that: $\cos \theta = 1 - \frac{1}{2}\theta^2$.

When the pendulum is in equilibrium, we impart to its sphere a horizontal velocity $\mathbf{V_0}$
The mechanical energy of the system (pendulum, Earth) is conserved.

Let θ be the angular abscissa of the pendulum at time t.

Given:

- $\ell = 0.50$ m
- $m = 50$ g
- $V_0 = 0.40$ m.s^{-1}
- $g = 9.8$ m.s^{-2}



1. Determine, at time t:
   i. The potential energy of the system (S) in terms of : m, g, ℓ, and θ specifying the gravitational potential energy reference level.
   ii. Determine, at time t, the kinetic energy of the sphere in-terms of : m, ℓ, and θ'.

2. Find the relation between ℓ, g , θ and θ''.

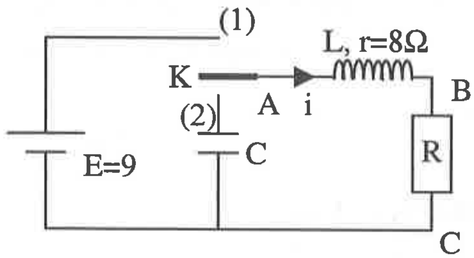
3. Calculate the angular amplitude θ_m of the pendulum. Is the approximation of small angles justified?

4. For what values of θ will the potential energy of the pendulum be equal to its kinetic energy?

SECOND QUESTION (10 Points)

Determination of the inductance of a coil

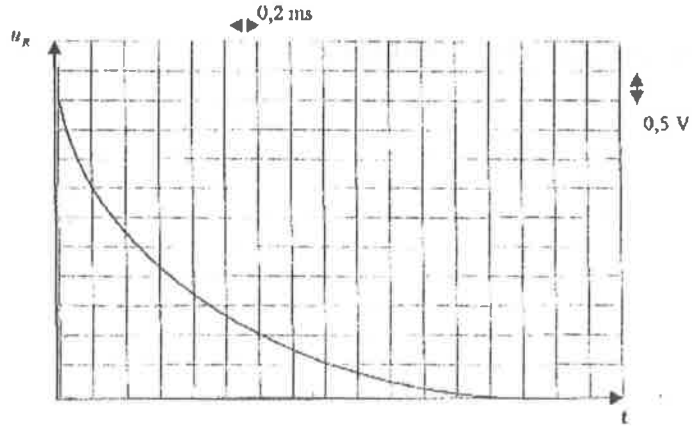
To determine the inductance of a coil, we construct the circuit shown in the figure below. The internal resistance of the generator is neglected.



1. In a first experiment, the switch K is in the position (1). What is, in this case, the value I_0 of the current delivered by the generator?

2. In a second experiment, and at an instant t taken as origin of time, the switch K is abruptly moved from position (1) to position (2). Suppose that there no sparks are produced at the terminals of K. the positive direction of the current i is indicated on the figure.
   i. Express the voltages u_{AB} and u_{BC} in terms of L, R. r, i and di / dt.
   ii. Establish the differential equation which the current in the circuit obeys.
   iii. Verify that the solution of the equation thus formed is: $i(t) = I_0.e^{-t/\tau}$ where $\tau = L / (R+r)$.

3. Let u_R be the voltage across the resistor BC. t_1 and t_2 are respectively the instants for u_R to attain 90 % and 10 % of its maximum value.
   i) Express $t_\alpha = t_1 - t_2$ in terms of τ.
   ii) Using the curve drawn below, determine t_α and deduce the value of τ.
   iii) Calculate the value of the inductance L.



Solution of the exam II

Question 1

This exercise emphasizes the domain of applying knowledge but also covers some competencies belonging to the domain of communication.

Expected answers	Scale	Comments
1.a) Choose the horizontal plane through G_0 (position of the center of inertia of the sphere at equilibrium) as a reference of the gravitational potential energy. Let G be the position of the center of inertia of the sphere at time t. $P.E = m.g.z$ But $z = \ell - \ell \cos\theta \Rightarrow PE = mg\ell(1-\cos\theta)$	1.5 pt	Any other reference of the gravitational potential energy is accepted.
b) $K.E = \frac{1}{2} m.v^2$ $KE = \frac{1}{2} m.\ell^2 \theta'^2$ where $V = \ell\theta'$	1 pt	
2. Mechanical energy $E_m = K.E + P.E$ $\Rightarrow E_m = mg\ell(1-\cos\theta) + \frac{1}{2} m \ell^2 \theta'^2$	0.5 pt	
For small angles of θ the expression of E_m becomes: $E_m = \frac{1}{2} m \ell[g\theta^2 + \ell.\theta'^2]$ $\frac{dE_m}{dt} = 0$ { E_m is conserved} $\Rightarrow m.\ell\theta'[\ell\theta'' + g\theta] = 0$. The pendulum being in motion (i.e $\theta' \neq 0$) $\Rightarrow \ell\theta'' + g\theta = 0$	1 pt	
3. Let G_1 be the position of the center of inertia of the sphere when $\theta = \theta_m$. $E_{m(G0)} = E_{m(G1)}$ {by conservation of E_m } $\Rightarrow \frac{1}{2} m.v_0^2 = mg\ell(1-\cos\theta_m)$	1 pt	
$\Rightarrow \cos\theta_m = 1 - (v_0^2)/(2g.\ell)$ $\cos\theta_m = 1 - \frac{(0.4)^2}{2\times9.8\times0.5} = 0.984 \Rightarrow \theta_m \approx 10°$.	1.5 pt	

The range of oscillations of the pendulum being $\lvert\theta\rvert \le \theta_m = 10°$ The approximation of small angles is justified.	0.5 pt 0.25 pt	
4. E_m is the same during the motion and for any value of t. $\Rightarrow E_m = E_m(G_0) = ½\, m\, v_0^2$ But P.E = K.E $\Rightarrow E_m = 2(P.E) \Rightarrow ½\, m.v_0^2 = 2mg\ell(1 - \cos\theta_□)$, where θ_2 is the value of θ in this case. $\Rightarrow \cos\theta_□ = 1 - (v_0^2)/(4g\,\ell)$ $\cos\theta_□ = 1 - \frac{(0.4)^2}{4\times9.8\times0.5} = 0.992 \Rightarrow \theta_2 \approx 7°$	1 pt 0.75 pt. 0.5 pt	

Question 2

This exercise emphasizes the domain of applying knowledge despite the presence of some constitutive elements of competencies belonging to the domain of communication.

Expected answer	Scale	Comments
1. In steady state, the value i(t) of the electric current attains a constant value I_0.	0.5 pt	
Hence, di / dt = 0 and the coil will be acting as a resistor of r = 8 Ω.	0.5 pt	
$I_0 = E / (R + r) \Rightarrow I_0 = 0.5$ A.	1 pt	
2. a. $u_{AB} = L\, di / dt + r\, i$. (Ohm's law for the coil). $U_R = R.i$.	1 pt	
b. $u_{AB} + u_R = 0 \Rightarrow L\, di / dt + (R + r)i = 0$ (1)	1 pt	
c. $di / dt = - (I_0 / \tau)e^{-t/\tau}$ $\Rightarrow - L(I_0 / \tau)e^{-t/\tau} + (R + r)\, I_0\, e^{-t/\tau}$ $\Rightarrow$ i(t) = $I_0.e^{-t/\tau}$ is a solution of equation (1) when $L = (R + r).\tau$.	2 pts	

3. a) $u_R = R.i. = RI_0.e^{-t/\tau} = U_0.I_0.e^{-t/\tau}$. 90 % $U_0 \Rightarrow t_1 = -\tau.Ln(0.9)$ 10 % $U_0 \Rightarrow t_2 = -\tau.Ln(0.1)$ $\Rightarrow t_\alpha = 2.2\,\tau$. b) Graphically, $t_\alpha = 1.6$ ms $\Rightarrow \tau = 0.72$ ms. c) $u_R / u_{R\,max} = u_R / U_0 = 0.37$ ms. Graphically, $\tau = 0.7$ ms $\Rightarrow L = 12.6$ mH	1.5 pt 1 pt 1.5 pt	

Question 3

This exercise emphasizes the domain of applying knowledge.

Expected answers	Scale	Comments
1.a) The energy level E = 0 eV refers to the ionized hydrogen atom. The electron is no longer bound to (free of) the nucleus to form an atom.	0.5 pt	
b) The energy levels E_n are all negative, signifying that the electron does not have enough energy to escape from the atom. The energy reference (E = 0) being at infinity (the electron is very far from the nucleus), since the ground state has an energy level less than that of the ionization state then the ground state and the other levels (where the electron becomes weakly bounded to the nucleus) thus their energy levels are negative.	0.5 pt	
c) The ionization energy of the hydrogen atom is the energy needed to just extract the electron from its ground state to its ionized state [the e^- has no kinetic energy]. The ionization energy is thus: $E_i = E_{(ionization\ state)} - E_{(ground\ state)} = 0 - (-E_0) = E_0$ Thus the atom in its ground state has less energy than in its ionization state.	1 pt	

2. The energy of the absorbed photon is $E = h\nu = \frac{hc}{\lambda}$ **N.A:** $E = \frac{6.62\times10^{-34}\times3\times10^{8}}{70\times10^{-9}} = 2.84\times10^{-18}$ J In electron-volts: $E = \frac{2.84\times10^{-18}}{1.6\times10^{-19}} = 17.7$ eV. Since $E > E_0$, thus this photon provokes the ionization of the hydrogen atom which needs 13.6 eV and the remaining quantity: 17.7 – 13.6 = 4.1 eV is taken by the electron as a kinetic energy.	0.5 pt 1.5 pt 1.5 pt	
3. A radiation of wavelength λ possesses an amount of energy: $E = h\nu = \frac{hc}{\lambda}$ Since the energy absorbed by the atom corresponds to a certain energy transition, the greatest possible wavelength then corresponds to the smallest possible energy transition. For an atom in its ground state, the smallest electronic transition takes place between the energy levels n = 1 and n = 2. So $E_{min} = E_2 - E_1$ But $E_{min} = \frac{hc}{\lambda_{max}} \Rightarrow \lambda_{max} = \frac{hc}{E_{min}} = \frac{hc}{E_2 - E_1}$ **N.A:** $E_2 = -3.40$ eV and $E_1 = -13.6$ eV $\Rightarrow E_2 - E_1 = 10.2\text{ eV} = 1.6\times10^{-18}$ J $\Rightarrow \lambda_{max} = \frac{6.62\times10^{-34}\times3\times10^{8}}{1.63\times10^{-18}} = 1.22\times10^{-7}$ m $\lambda_{max} \approx 122$ nm. $\lambda_{max} < 400$ nm : the invisible radiation is part of the ultraviolet zone	 2 pts 1 pt 1 pt 0.5 pt	

Question 4

This exercise emphasizes the domain of applying knowledge through an example from daily life, but also some competencies of the domain of communication.

Expected answers	Scale	Comments
1. Let us take the following fission reaction: $^{235}_{92}U + ^{1}_{0}n \rightarrow ^{137}_{55}Cs + ^{97}_{40}Zr + x\,^{1}_{0}n + y\,^{0}_{-1}e$	0.5 pt	
Law of conservation of number of nucleons: $235 + 1 = 137 + 97 + x \Rightarrow x = 2.$	0.5 pt	
Law of conservation of number of electric charges: $92 + 0 = 55 + 40 - y \Rightarrow y = 3.$	0.5 pt	
$\Rightarrow$The fission reaction is then: $^{235}_{92}U + ^{1}_{0}n \rightarrow ^{137}_{55}Cs + ^{97}_{40}Zr + 2\,^{1}_{0}n + 3\,^{0}_{-1}e$		
2. To calculate the energy liberated during this fission reaction, we have to calculate the difference between the binding energies of the reacting nuclei and that of the product nuclei.	0.5 pt	The binding energy of a nucleus can be counted negatively or positively according to the adopted concept. If it is considered as potential energy, it is counted negatively. If it is considered as the energy that should be given to the nucleus to destroy it, it will be counted positively.
The binding energy of a nucleus is given by: $E = A \times E_l$.		
Since neutrons and electrons are not bounded, their binding energy is considered equal to zero. ❑ $E_U = 235 \times 7.62 = 1790.7$ MeV ❑ $E_{Cs} = 137 \times 8.45 = 1157.65$ MeV ❑ $E_{Zr} = 97 \times 8.65 = 839.05$ MeV	1.5 pt	
The energy liberated is $E = [(E_{Cs} + E_{Zr}) - E_U)]$ $= [(1157.65 + 839.05) - 1790.7]$ $= 206$ MeV	0.5 pt	
This liberated energy appears during the fission as kinetic energy taken by the different products of the reaction.	0.5 pt	
3. Let m_l the mass of 1 nucleus of U is: $m_l = 235 \times 1.66 \times 10^{-27}$ kg		

The number n of nucleii in 1 g is then: $n = \frac{m}{m_1}$	0.5 pt	
The enrgy liberated by the combustion of 1 g of U: $E_t = nE = \frac{1\times10^{-3}}{235\times1.66\times10^{-27}\times10^{-25}}\times 206$ $E_t = 5.27\times10^{23}$ MeV	1 pt	
As 1 MeV = 1.6×10^{-13} J $\Rightarrow E_t = 8.43\times10^{10}$ J.	0.5 pt	
4. The electric energy produced in one day: $E_{el} = P\times t = 900\times24\times600 = 7.77\times10^{7}$ MJ $E_{el} = 7.77\times10^{13}$ J	1 pt	
The efficiency r of the nuclear plant is given by: $r = \frac{\text{produced electric energy}}{\text{consimed nuclear energy}} = 0.3$ The consumed nuclear energy in one day: $E_{nu} = E_{el} / 0.3$ $= 7.77\times10^{13} / 0.3 = 2.59\times10^{14}$ J. The mass of uranium used in one day: $M = E_{nu} / E_t$ $= 2.59\times10^{14} / 8.43\times10^{10} = 3072.3$ g $M_U = 3.072$ kg.	1.25 pt	
5. The efficiency r of the thermal plant is given by: $r = \frac{\text{produced electric energy}}{\text{consimed nuclear energy}} = 0.35$ The consumed thermal energy in one day: $E_{thermal} = E_{el} / 0.35$ $= 7.77\times10^{13} / 0.35 = 2.22\times10^{14}$ J. The thermal consumed energy in one day is: $E_{therm} = 2.22\times10^{14}$ J. The mass of consumed fuel oil: $M_F = 2.22\times10^{14} / 4.2\times10^{10} = 5285.7$ tons	1.25 pt	

EXAM III

FIRST QUESTION **(10 points)**

Spectrum emitted by the atom of hydrogen

The quantified energetic levels of the hydrogen atom are given by the following relation:

$$E_n = -\frac{E_o}{n^2} \text{ with } E_o = 13.6 \text{ eV and n an integer number.}$$

Given:

- Planck's constant: $h = 6.62 \times 10^{-34}$ J.s
- Speed of light in vacuum: $c = 3 \times 10^8$ m.s^{-1}
- Elementary charge: $e = 1.6 \times 10^{-19}$ C.
- (Limits of the visible spectrum: 400 nm – 800 nm).

1. Calculate E_o in joules.

2. Calculate, in joules, the numerical values E_1, E_2 and E_3 of the three levels corresponding to $n = 1, 2$ and 3.

3.
   i- Calculate the frequencies ν_{31} and ν_{21} of the photons emitted at the time of the electronic transitions from the level E_3 to the level E_1 and from the level E_2 to the level E_1 respectively.
   ii- Deduce the corresponding wavelengths λ_{31} and λ_{21}.
   iii-To which domain of the electromagnetic spectrum do these photons belong?

4.
   i- Calculate the frequency ν_{32} of the photon emitted at the time of the electronic transition from the level E_3 to the level E_2.
   ii- Give a simple relation between ν_{31},ν_{21} and ν_{32} . Justify your answer. Can we generalize this relation over another three different energy levels? Explain.

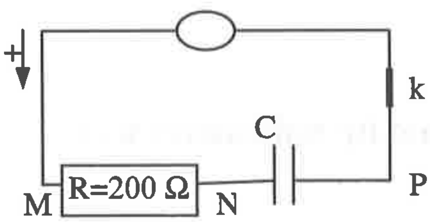
5. Give the shortest wavelength of the radiation that can be found in the hydrogen spectrum.

SECOND QUESTION (10 points)

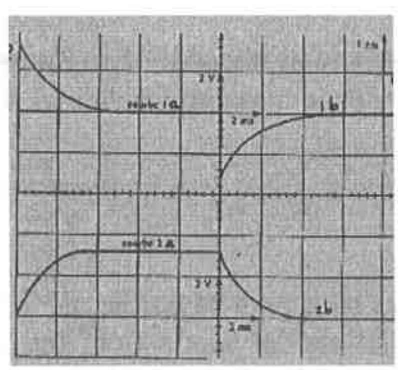
Charging and discharging of a capacitor

To study the charge and the discharge of a capacitor, we realize the circuit having in series:

- A low frequency generator delivering a square voltage signal.
- A resistor of resistance R = 200 Ω
- A capacitor of capacity C.



With a dual trace oscilloscope, we obtain the following oscillograms which they represent the voltages $u_{MN} = u_R$ across R and $u_{NP} = u_C$ across C.



1.a. The curve 1 represents the voltage u_R. Justify this assertion.

b. To what correspond the two parts (a) and (b) of each curve? Justify your answer.

2. Determine, from the two curves, the following quantities:
   - The maximum voltage across the capacitor;
   - The maximum voltage across R;
   - The maximum value of the current of charge.

3.

i- Establish the differential equation which shows the relation between R, C, u_C and $\frac{du_C}{dt}$ in the discharge mode of the capacitor. Verify that $u_C = A\ e^{-\frac{t}{RC}}$ is a solution of the equation and give the numerical value of A.

ii- What is the physical significance of the time constant τ of an RC circuit in the discharge process? Using the oscillogram, calculate τ and deduce the value of the capacity C

THIRD QUESTION (10 points)

Determination of the volume of blood by radioactive way

With the discovery of artificial radioactivity, it is now possible to associate each element with a certain number of radio-isotopes having the same chemical properties as the stable element. Such radio-elements are used in medical analysis.

1. The isotope $^{24}_{11}Na$ is obtained by bombarding the element $^{23}_{11}Na$ with neutrons. Write down the reaction of formation of the sodium $^{24}_{11}Na$.

2. The sodium 24 is a β^- emitter and its period is 15 h. Knowing that the daughter (produced) nucleus is a magnesium one, write the balanced reaction of disintegration of $^{24}_{11}Na$.

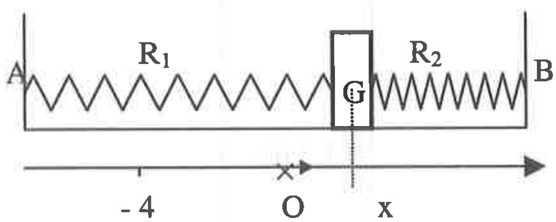
3. A 10 cm^3 of a solution containing $^{24}_{11}Na$ with a concentration 10^{-3} mol / L is injected in the blood of a human body.

   i. Find the number of moles of sodium 24 introduced in the blood.
   ii. After 5 h we take 10 cm^3 of blood from the same person. We find that the concentration of the sodium 24 is then 1.5×10^{-6} mol / L
   - How much moles of sodium 24, will remains after 5 h?
   - Calculate the total volume of the blood.

FOURTH QUESTION (10 points)

Energetic study of a horizontal elastic pendulum

An air-puck, of center of inertia G, of mass 500 g and moving without friction on a horizontal table, is connected to two identical springs R_1 and R_2 of negligible mass, of initial length $\ell_o = 20$ cm and of spring constant $k_1 = k_2 = 10$ N / m. The two springs are stretched between two points A and B and they have at equilibrium the lengths $\ell_1 = \ell_2 = \ell = 25$ cm.



The air-puck G is displaced a distance $x_0 = -4$ cm and then released without initial velocity at an instant considered as origin of time. In the situation described above the mechanical energy of the system (glider, springs R_1 and R_2) is conserved.

1. For a given position x of G at an instant t (OG = x), express the extension of each spring in terms of x, ℓ and ℓ_o.
2. Give in terms of m, k, ℓ, ℓ_o, x and $\frac{dx}{dt}$ the expressions of the energies involved during the motion of the body.
3. Establish, using the conservation of mechanical energy, the differential equation of motion of G.
4. Calculate the natural pulsation ω_o and deduce the period of this motion.
5. Write down the time equation x = x(t) of motion of G.

Solution of the questions of the exam III

Question 1 (10 points)

This exercise emphasizes the domain of applying knowledge.

Expected answers	Scale	Comment
1. $E_o = 13.6 \text{ eV} = 13.6 \times 1.6 \times 10^{-19} = 2.18 \times 0^{-18}$ J	0.5 pt	
2. The (n) energy level, in joules, is given by: $E_n = - (2.18 \times 10^{-18}) / n^2$ For n =1: $E_1 = - 2.18 \times 10^{-18}$ J For n = 2: $E_2 = - \dfrac{2.18\times10^{-18}}{2^2} = 0.54 \times 0^{-18}$ J For n =3: $E_3 = - \dfrac{2.18\times10^{-18}}{3^2} = 0.24 \times 0^{-18}$ J	1.5 pts	
3. a. The photon emitted by the electronic transition from the level m to the level p has an energy: $E_{mp} = h\nu_{mp} = E_m - E_p \Rightarrow \nu_{mp} = \dfrac{E_m - E_p}{h}$ For the transition 3-1: $\nu_{31} = \dfrac{E_3 - E_1}{h}$ $\nu_{31} = -\dfrac{0.24\times10^{-18} - 2.18\times10^{-18}}{6.62\times10^{-34}} = 2.93 \times 10^{15}$ Hz $\nu_{21} = -\dfrac{0.54\times10^{-18} - 2.18\times10^{-18}}{6.62\times10^{-34}} = 2.48 \times 10^{15}$ Hz	2 pts	
b. $\lambda_{31} = \dfrac{c}{\nu_{31}} = \dfrac{3\times10^{8}}{2.93\times10^{15}} = 1.03 \times 10^{-7}$ m $\lambda_{21} = \dfrac{c}{\nu_{21}} = \dfrac{3\times10^{8}}{2.48\times10^{15}} = 1.21 \times 10^{-7}$ m	1 pt	
c. These photons belong to the ultraviolet zone	0.5 pt	

4. a. $\nu_{32} = -\dfrac{0.24\times10^{-18} - 0.54\times10^{-18}}{6.62\times10^{-34}}$ $= 0.45 \times 10^{15}$ Hz	0.5 pt	
b. We can notice that: $\nu_{31} - \nu_{21} = 2.93 \times 10^{15} - 2.48 \times 10^{15}$ $= 0.45 \times 10^{5}$ Hz $\Rightarrow \nu_{31} - \nu_{21} = \nu_{32}$ (law of Ritz). When there is electronic transition between two energy levels: E_P and E_M, the frequency of the emitted photon is so that: $h\,\nu_{PM} = E_P - E_M$. Similarly, between E_Q and E_M, is so that: $h\,\nu_{QM} = E_Q - E_M$. Thus: $h\,\nu_{PM} - h\,\nu_{QM} = E_P - E_M - (E_Q - E_M)$ $\Rightarrow h\,\nu_{PM} - h\,\nu_{QM} = E_P - E_Q = h\nu_{QM}$ $\Rightarrow \nu_{31} - \nu_{21} = \nu_{32}$ (law of Ritz)	2.5 pts	
5. The shortest wavelength of the photon found in the hydrogen spectrum is that emitted between the farthest energy levels, which they are the fundamental and the ionization level. The energy of the emitted photon is $= E_o$. Thus : $E_o = h\nu_{max} = \dfrac{hc}{\lambda_{min}}$ $\Rightarrow \lambda_{min} = \dfrac{hc}{E_o}$ $\lambda_{min} = \dfrac{6.62\times10^{-34} \times 3\times10^{8}}{2.176\times10^{-18}} = 9.13\times10^{-8}$ m $\lambda_{min} = 91.3$ nm.	1.5 pt	

Question 2 (10 points)

This exercise emphasizes the domain of mastering communication but also covers some competencies of the domain of applying knowledge.

Expected answers	Scale	Comments
1. a. u_{MN} is represented by the curve (1) since it presents a discontinuity in its value between the two parts 1a and 1 b. This discontinuity does not occur for the voltage across a capacitor. The observed discontinuity corresponds to the change in the direction of the current i.	1 pt	
b. Since the voltage u_C across C increases, then the parts 1a and 2a correspond to the charging process of the capacitor. While the parts 1b and 2b represents the discharging process of the capacitor, Since the voltage across C decreases.	1 pt	
2. The maximum value of the voltage across C: $U_{c\,max} = 2\ V / div \times 1.6 = 3.2\ V$	0.5 pt	
– The maximum value of the voltage across R: $U_{R\,mzx} = 2V / div \times 1.6 = 3.2\ V$	0.5 pt	
– The maximum value of the current of charge: $I_o = U_{R\,max} / R = 3.2 / 200 = 0.016\ A$	0.5 pt	
3. a. In the discharge mode $u_{MP} = 0$ Thus $u_{MN} + u_{NP} = 0$ $u_{MN} = R\,i$ and $i = \frac{dq}{dt}$ but $q = C\,u_{NP}$ $\Rightarrow i = \frac{Cdu_{NP}}{dt} \Rightarrow u_{MN} = R\cdot\frac{Cdu_{NP}}{dt}$ $\Rightarrow R\frac{Cdu_{NP}}{dt} + u_{NP} = 0 \Rightarrow \frac{du_C}{dt} + \frac{1}{RC}u_{NP} = 0$	2 pts	
$u_C = A\,e^{-\frac{t}{RC}} \Rightarrow \frac{du_C}{dt} = -\frac{1}{RC}A\,e^{-\frac{t}{RC}}$	0.5 pt	
$\Rightarrow -\frac{1}{RC}A\,e^{-\frac{t}{RC}} + \frac{1}{RC}A\,e^{-\frac{t}{RC}} = 0$ For t = 0, $u_C = A = U_{c\,max} = 3.2\ V \Rightarrow A = 3.2\ V$	1 pt	

b. The physical significance of the constant τ in the discharge mode (process) is the time after which $u_c = 0.37$ of the initial value of the voltage across the capacitor. At $t = \tau$, $u_C = 0.37 \times 3.2 = 1.18$ V represented by a number of divisions: $1.152 / 2 = 0.59$ division approximately 0.6 division. From the curve 2b, $\tau = 0.6$ div which is equivalent to $\tau = 0.6 \times 2$ ms/div $= 1.2$ ms $\tau = RC \Rightarrow C = \frac{\tau}{R} = \frac{1.2\times10^{-3}}{200} = 6 \times 10^{-6}$ F $C = 6\ \mu F$.	1 pt 1.5 pts 0.5 pt	

Question 3 (10 points)

This exercise emphasizes the domain of applying knowledge through a physics phenomenon related to daily life.

Expected answers	Scale	Comments
1. ${}_{0}^{1}n+{}_{11}^{23}Na\rightarrow{}_{11}^{24}Na$	1 pt	
2. ${}_{11}^{24}Na\rightarrow{}_{Z}^{A}Y+{}_{-1}^{0}e+{}_{0}^{0}\bar{\nu}$ Using the law of conservation electric charge: $11 = Z + (-1) \Rightarrow Z = 12$ Using the law of conservation nucleons number: $24 = A + 0 \Rightarrow A = 24$ $\Rightarrow {}_{Z}^{A}Y={}_{12}^{24}Mg$. The produced nucleus is the magnesium 24.	2 pts	
3. a- The volume of the injected liquid: $10\ cm^3 = 10^{-2}$ L The number of moles of sodium 24 is: 10^{-3} mol / L $\times 10^{-2}$ L $= 10^{-5}$ mol.	1 pt	
b- Let $n_o = 10^{-5}$ mol the number of moles of sodium 24 at t = 0. At the time t the number n of remaining moles of sodium 24 is given by the decaying formula: $n = n_0e^{-\lambda t}$ with $\lambda = \frac{\ln 2}{T} = \frac{0,693}{15} h^{-1}$	4 pts	

For $t = 5$ h $\Rightarrow n = n_o e^{-0,693 \times 5/15}$ $\Rightarrow n = 10^{-5} e^{-0,693/3} \Rightarrow n = 7{,}94 \times 10^{-6}$ mole Let V the total volume of blood before injection in liters (L). Then the volume of blood becomes after injection V + 0.01 liters The concentration of the sodium after 5 h is then: $\frac{n}{V+0.01} = \frac{7.94\times10^{-6}}{V+0.01} = 1.5 \times 10^{-6}$ mol / L $\Rightarrow V + 0.01 = \frac{7.94\times10^{-6}}{1.5\times10^{-8}} = 5.29$ L $\Rightarrow V = 5.28$ L.	2 pts	

Question 4 (10 points)

This exercise emphasizes the domain of applying knowledge but also covers some competencies belonging to the domain of communication. .

Expected answers	Scale	Comments
1. Let $\Delta\ell_{o1}$ and $\Delta\ell_{o2}$ be the initial lengthening of the two springs, with $\Delta\ell_{o1} = \Delta\ell_{o2} = \ell - \ell_o$ At instant t: $\Delta\ell_1 = \Delta\ell_{o1} + x$ and $\Delta\ell_2 = \Delta\ell_{o2} - x$	2 pts	
2. The elastic potential energy: $EPE = EpE_1 + EPE_2 = \frac{1}{2} k(\Delta\ell_1)^2 + \frac{1}{2} k(\Delta\ell_2)^2$. $EPE = k(\ell-\ell_0)^2 + k x^2$ The kinetic energy: $\frac{1}{2} mV^2 = \frac{1}{2} m(\frac{dx}{dt})^2$. The mechanical energy: $ME = \frac{1}{2}m(\frac{dx}{dt})^2 + k(\ell-\ell_0)^2 + k x^2$.	2 pts	
3. The mechanical energy is conserved $\Rightarrow$ $E_m = \frac{1}{2} m (\frac{dx}{dt})^2 + k (\ell-\ell_0)^2 + k x^2 = \text{constant}$ The derivative of ME with respect to time is equal to zero; thus: $\frac{dE_m}{dt} = m\frac{d^2x}{dt^2}\frac{dx}{dt} + 0 + 2kx\frac{dx}{dt} = 0$ $\Rightarrow$ The differential equation: $\frac{d^2x}{dt^2} + \frac{2k}{m}x = 0$	2 pts	

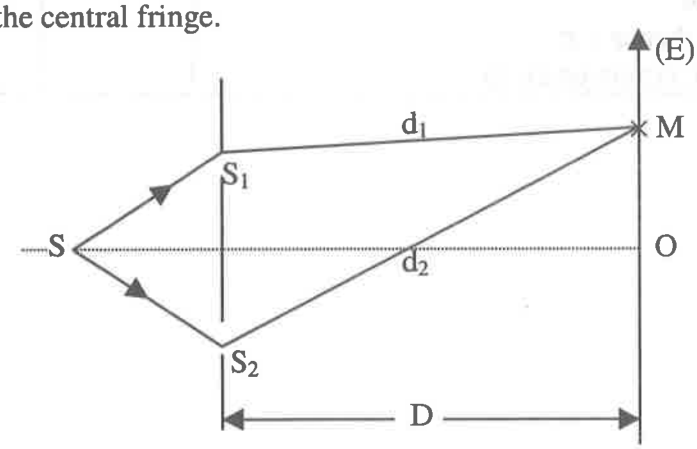
4. The natural pulsation $\omega_o = \sqrt{\frac{2k}{m}}$ $\omega_o = 6.32 rad/s$ The natural period T_o is given by: $T_o = \frac{2\pi}{\omega_o} \Rightarrow T_o = 0.99\ s = 1\ s$	2 pts	
5. The general solution of the differential equation is given by: $x = A\cos(\omega t + \varphi)$ with $A > 0$ The velocity $V = \dot{x} = -\omega A \sin(\omega t + \varphi)$ For $t = 0$: $x = A\cos\varphi = -4$ cm and $V = -\omega A \sin\varphi = 0$ $\Rightarrow \sin\varphi = 0 \Rightarrow \varphi = 0$ or π Since $A > 0 \Rightarrow \cos\varphi < 0$, then $\varphi = \pi$ Thus $x = -4\cos(6.32\ t)$ (x: cm and t: s)	2 pts	

EXAM IV

FIRST QUESTION (10 points)

Interpret the formation of interference fringes

Young's interference system is composed of two slits S_1 and S_2 of separation a = 0.2 mm and illuminated by a luminous source S. At a distance D = 1.5 m from the slits, we place a screen perpendicular to the axis of symmetry of the system. We admit that the path difference $\delta = d_2 - d_1$ of the waves issued from the slits is expressed by $\delta = \frac{ax}{D}$ at a point M of abscissa x relative to the mid-point O of the central fringe.



1) Why is it necessary to use only one very thin luminous source S to obtain an observable system of fringes?

2) What condition is to be verified by δ for a bright fringe to be observed at a point. M on the screen ? Express the abscissa x of M in terms of a, λ, D and an integer k. Deduce the expression of the interfringe.

3) The luminous source emits white light. What do we observe at O. Justify your answer.

4) The source now is a laser emitting radiation of wavelength λ = 543 nm. How many bright fringes are spread over a segment of middle O and of length d = 1.63 cm on the screen.

SECOND QUESTION (10 points)

Identification of the nature of an electric element

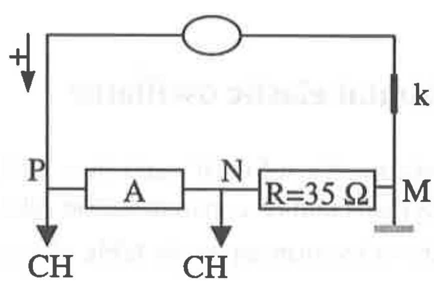
Given two elements:

- A resistor of resistance $R = 35\ \Omega$.
- An unknown element A of characteristic quantity x.

To identify A, we apply across R and A, connected in series, a sinusoidal voltage of time equation:

$$u = u_{PM} = 7.5 \cos 400\pi t. \quad (u \text{ in V and t in s}).$$

A dual trace oscilloscope is connected to the circuit as shown in figure 1.



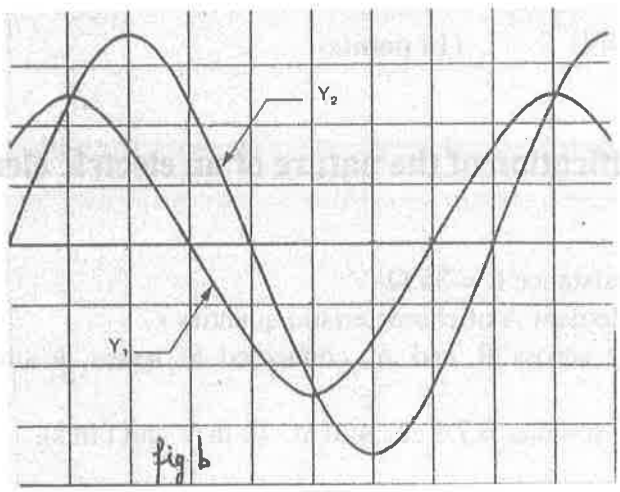
The unknown element A may be:

- A resistor of resistance R';
- A capacitor of capacity C;
- A coil of inductance L and of negligible resistance.

1.a. What voltage is visualized on channel 1 and that on channel 2?
b. Determine from the oscillograms of figure 2 the phase difference between the two quantities.

2. Specify the nature of A? Justify your answer.

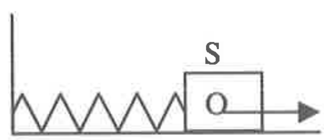
3. The vertical sensitivity of channel 2 is 1 V/ division.
   i) Give the time expression of the current i of the circuit.
   ii) Establish a relation giving u_{PM} in terms of i, $\frac{di}{dt}$, R and x where x being the characteristic quantity of A.
   iii) Deduce the relation between u_{PM}, R, x and t. Knowing that this relation is valid for any time t. Calculate x by choosing a convenient value for t.



THIRD QUESTION **(10 points)**

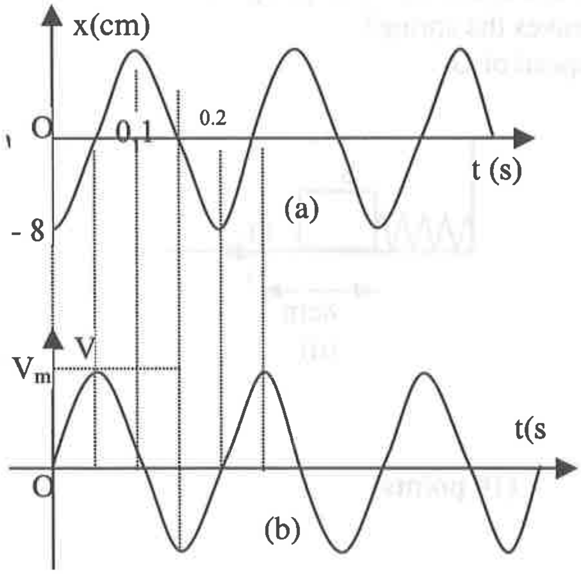
Horizontal elastic oscillator

A horizontal elastic pendulum is made up of a solid, of mass m = 200 g, attached to one end of a horizontal elastic spring of negligible mass and of constant k; the other end of the spring is fixed to a support. The solid S can slide without friction on an air table along a horizontal axis $(O, \vec{i})$.



At rest, the origin O coincides with the center of inertia G of the solid.
In an experiment, the oscillations of the solid are registered. The position and the velocity of its center of inertia G are determined, at an instant t, by the vectors $\overrightarrow{OG} = x\vec{i}$ where $x = A\cos(\omega_0 t + \varphi)$ and $\vec{V} = V\vec{i}$. The force exerted by the spring on S, at the same instant, is given by $\vec{T} = T\,\vec{i}$.

The graphs (a) and (b) represent respectively the variations of x and V in terms of t.

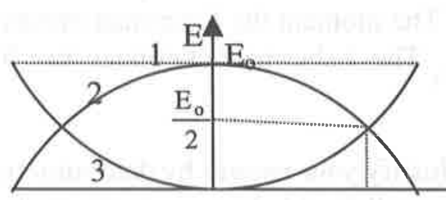


1. Using the graphs (a) and (b):
   i) What is the nature of motion of the solid?
   ii) Determine the natural pulsation ω_o of the oscillator;
   iii) Deduce the constant k of the spring;
   iv) Determine A, φ and V_m.

2. a. Determine at the instant t the expressions of the elastic potential energy (PEP) and of the kinetic energy (KE) of the system (solid, spring)in terms of x, k and A.

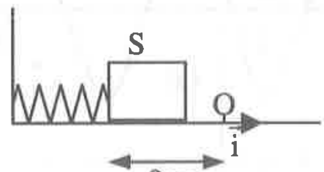
   b. Associate to each number (1, 2 and 3) of the figure (c) the corresponding energy.

   c. Calculate E_o, x_1 and x_2.



(c)

3. The solid is no more attached to the spring. We compress the spring by 8 cm by pressing acting on the solid (figure d). The system (solid, spring) is then released at t = 0.
i) At which instant t_1 the solid leaves the spring?
ii) Determine at this instant the speed of G.



(d)

FOURTH QUESTION (10 points)

Linear momentum

We will study the disembarkation of a fisherman whose mass is $m_1 = 80$ kg and his son, of mass $m_2 = 50$ kg from a boat whose mass is M = 320 kg. We assume that there is no resistance against the motion of the boat on the water.

1. The motionless boat has its prow pointing to the dock. The fisherman is at the stern and his son at the prow. The son jumps onto the dock with a horizontal velocity of $v = 4\ ms^{-1}$.
   a. Justify that the linear momentum of the system (boat + fisherman + son) is conserved.
   b. Determine the velocity of the boat after this jump.

2. The son while on the dock immobilizes the boat whose prow is still pointing to the dock with the fisherman still at the stern. The moment the fisherman moves towards the prow the son, accidentally, lets go of the bark. The fisherman continues his forward movement with a horizontal velocity of $V_1 = 0.3\ ms^{-1}$.

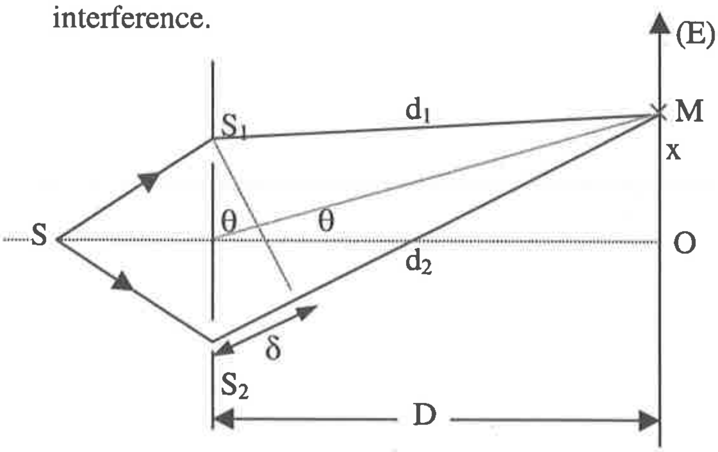
   a. Does the boat stay motionless? Justify your answer by determining the velocity of the boat.
   b. Is it certain that the fisherman will be able to jump to the dock once he reaches the prow? Specify the distance between the prow and the dock knowing that the length of the boat is L=8m.
   c. What advise would you give the fisherman concerning his getting the boat without getting wet?

3. A cylindrical vessel containing a certain quantity of water rests on a cork float at the surface of the water of swimming pool. A hole is produced in the vessel near to its bottom. Apply the results of the preceding questions to explain in details the behavior of the vessel.

Solution of exam IV

Question 1 (10 points)

This exercise emphasizes the domain of communication but also covers some competencies belonging to the domain of applying knowledge.

Expected answers	Scale	Comments
1. A necessary condition to have an observable system of fringes is that the two used sources should be synchronous and coherent. Except laser sources, all other sources are not generally coherent. In these conditions, it is impossible to have, between two independent sources, an observable system of fringes. It must be good to use the images of the same source S.	2.75 pts	
2. A bright fringe is observed on the screen when the interference is constructive, that is to say that luminous waves issued from S_1 and S_2 are in phase $\Rightarrow$ the optic path difference is $\delta = k\lambda$ where k represents the order of interference.	1.5 pt	
		
Sin $\theta = \delta / a$ and $\tan\theta = x / D$; since θ very small $\Rightarrow \sin\theta = \tan\theta \Leftrightarrow \delta / a = x / D$. $\delta = \frac{ax}{D} = k\lambda \Rightarrow x = k\frac{\lambda D}{a}$. The interfringe i is given by: $i = x_{k+1} - x_k = \frac{\lambda D}{a}$.	0.5 pt	
3. Since S_1 and S_2 are coherent and in phase (as $SS_1 = SS_2$) the two luminous vibrations will be in phase at O. O is then a bright fringe for all wavelengths emitted by the source S. This central fringe has the same spectral composition as that of the source. It is white and bright fringe.	2.5 pts	

4. The interfringe distance is given by $i = \frac{\lambda D}{a}$. $i = \frac{543\times10^{-9}\times1.5}{0.2\times10^{-3}} = 4.07 \times 10^{-3}$ m = 4.07 mm The number of interfringes spread on a distance d around the central fringe: $-\frac{d}{2i} \leq n \leq \frac{d}{2i} \Rightarrow -\frac{1.63}{2\times0.407} \leq n \leq \frac{1.63}{2\times0.407}$ $\Rightarrow -2 \leq n \leq 2 \quad \Rightarrow \quad n = 5.$ Thus the number of fringes observed on the screen in the zone of width d is 5 fringes.	2.75 pts	

Question 2

This exercise emphasizes the domain of communication but also covers some competencies belonging to the domain of applying knowledge.

Expected answers	Scale	Comments
1. a. On channel (1), we measure the voltage u_{PM} across the generator. On channel (2) we measure the voltage u_{NM} across the resistor R.	1.5 pt	
b. The difference of phase is given by: $\varphi = 2\pi d / D$ where d is the horizontal distance between the two oscillograms and D is the horizontal distance covered by one complete period. $\varphi = 2\pi \times 1 / 8 = \pi / 4$ rad.	1.5 pt	
2. Since the voltage across R is proportional to i, then the oscillogram (2), which visualizes the variation of i, shows that the current i lags behind u_{PM}, then the unknown element is a coil of inductance L = x.	1.5 pt	
3. a. The maximum voltage of u_{NM} is $U_R = 1$ V / div $\times$ 3.5 div = 3.5 V. The maximum current I = 3.5 / 35 = 0.1 A $i = 0.1 \cos(400\pi t - \pi/4)$ (i in A ; t in s)	1.5 pt	
b. $u_{PM} = u_{PN} + u_{NM} = x\frac{di}{dt} + Ri$	1 pt	
c. $u_{PM} = x[-0.1 \times 400\pi \sin(400\pi t - \pi/4)] + R \times 0.1 \cos(400\pi t - \pi/4)$.	1.5 pt	
At t = 0 $\Rightarrow$ u = 7.5 V $u = -40\pi x \sin(-\pi/4) + 3.5 \cos(\pi/4)$ $7.5 = 88.8\,\pi x + 2.47 \Rightarrow x = 0.057$ H	1.5 pt	

Question 3 (10 points)

This question emphasizes the domain of communication but also covers some competencies belonging to the domain of applying knowledge.

Expected answers	Scale	Comments
1. **a. The motion of the solid is sinusoidal rectilinear, it forms with the spring a non-damped free oscillator.**	0.5 pt	
b. The natural period $T_o = 0.2$ s, the natural pulsation $\omega_o = \frac{2\pi}{T_o} = 31.4$ rad / s.	1 pt	
c. $\omega_o = \sqrt{\frac{k}{m}}$ $\Rightarrow k = m\omega_o^2 = 0.2 \times 31.4^2 = 19.7$ N / m.	0.5 pt	
d. At t = 0, x = - 8 cm and V = 0. $V = x' = -A\omega_o \sin(\omega_o t + \varphi)$ At t = 0 V= 0 $\Rightarrow \sin\varphi = 0$ then $\varphi = 0$ or π And $x = -8 = A\cos\varphi$, since $A > 0 \Rightarrow \cos\varphi < 0$ $\Rightarrow \varphi = \pi$ and A = 8 cm. $V = -A\omega_o \sin(\omega_o t + \pi) = A\omega_o \sin\omega_o t$ $\Rightarrow V_o = A\omega_o = 8 \times 31.4 = 251.2$ cm / s = 2.51 m / s	1.5 pt	The amplitude A is positive. Direct reading of A (from graph) is accepted.
2. a. $PE = ½ kx^2 = ½ \times 19.7 \times 0.08^2 = 6.3 \times 10^{-2}$ J	0.5 pt	The numerical value of PE is not required.
$KE = ½ mV^2$ where $V = -A\omega_o \sin(\omega_o t + \pi)$ $V = -\sqrt{A^2\omega_o^2 - A^2\omega_o^2\cos^2(\omega_o t - \varphi)}$ $KE = ½ m(A^2\omega_o^2 - A^2\omega_o^2 \sin^2(\omega_o t + \pi))$ Since $k = m\omega_o^2 \Rightarrow KE = ½ k(A^2 - x^2)$.	1 pt	
b. Since $ME = PE + KE = ½ kA^2$ = constant; $\Rightarrow E_o = ME$ (1) (horizontal straight line; PE (3) (parabola) and KE (2) = (1) – (3).	1.5 pt	
c. $E_o = ME = ½ kA^2 = ½ \times 19.7 \times 0.08^2 = 6 \times 10^{-2}$ J, x_2: the maximum value of x $\Rightarrow x_2 = A = 8$ cm And for $x = x_1$, then PE = ½ ME $\Leftrightarrow ½ k x_1^2 = ¼ kA^2$ $\Rightarrow x_1 = \frac{A}{\sqrt{2}} = \frac{8}{\sqrt{2}} = 5.65$ cm	1.5 pt	

3. a. The solid leaves the spring when there is no tension exerted by the spring on S; for x = 0 the tension of the spring is zero. The time taken is then equal to ¼ period = T/4 = 0.05 s. b. At this instant V is maximum $V = V_m = 2.51$ m/s.	1 pt 1 pt	

Question 4 (10 points)

This exercise emphasizes the domain of applying knowledge through a phenomenon related to daily life.

Expected answers	Scale	Comments
1. a. The system (boat + fisherman + son) is isolated since the acting forces, weight of the system and reaction of water, are opposite and there is no friction. The linear momentum of the system is thus conserved.	1 pt	
b. Before the son jumps, the system is motionless, its linear momentum $\mathbf{P_1}$ is zero. $\mathbf{P_1 = 0}$	0.5 pt	
After the jump, $\mathbf{P_2} = m_2\,\mathbf{v} + (M + m_1)\,\mathbf{V}$. $\mathbf{V}$ being the velocity of the boat after the jump of the son.	0.5 pt	
The conservation of the linear momentum gives: $m_2\,\mathbf{v} + (M + m_1)\,\mathbf{V} = \mathbf{0}$	0.5 pt	
Or $\mathbf{V} = -\,(m_2 / M + m_1)\,\mathbf{v}$.	0.5 pt	
The velocity of the boat has <u>opposite direction</u> to that of the son. Its magnitude is: $V = (50 / 400) \times 4 = 0{,}5\ \text{m.s}^{-1}$.	0.5 pt	
2. a) Let $\mathbf{V'}$ be the velocity of the boat when the fisherman is moving with the velocity $\mathbf{v_1}$.	1 pt	The determination of the direction and the sense of the velocity by a diagram is accepted.
Before starting to move, the linear momentum of the system is zero.	0.5 pt	
During the motion, the linear momentum of the system is $m_1\mathbf{v_1} + M\mathbf{V'}$ (the son is not now a part of the system since his is on the dock)	0.5 pt	

The system is always isolated; therefore: $m_1 \mathbf{v_1} + M \mathbf{V'} = \mathbf{0}$ $\Rightarrow \mathbf{V'} = -(m_1 / M) \mathbf{v_1}$. The boat moves away from the dock with the speed: $V' = (80 \times 0{,}3) / 320 = 0{,}075$ m.s^{-1}.	0.5 pt 0.5 pt 0.5 pt	
b) Let t be the time taken by the fisherman to move from the stern to the prow: $t = L / v_1$. The distance covered by the boat during this time is: $L' = V' \times t = (m_1 \times v_1 \times t) / M = m_1 L / M$ $\Rightarrow L' = 80 \times 8 / 320 = 2$ m. If he jumps, the fisherman has a very big chance to fall in water.	 0.5 pt	
c) This problem shows that disembarking a boat perpendicularly to the dock represents a serious problem. The boat should be disembarked tangentially to the dock and not parallel to it.	0.5 pt	
3. Before producing the hole in the vessel, the system (vessel + cork float) was at rest; its linear momentum is zero.	0.5 pt	
When the hole is produced, water is ejected out of the vessel in a certain direction AB. To assure the conservation of the linear momentum, the vessel and the cork float will move in the opposite direction.	0.5 pt	
As the water in the vessel diminishes, the speed of the displacement of the system (vessel + float) will also diminish with time.	0.5 pt	
When the vessel becomes completely empty and since the friction is negligible (the surface of water is supposed to be completely polished), the system (vessel + float) will continue its displacement with a uniform rectilinear motion.	0.5 pt.	

General Instructions for official exam in physics
Humanities and Sociology - Economics

The physics exam aims, in general, to appreciate the levels of acquired competencies as defined in the list of competencies of the evaluation guide.

The exam should satisfy some conditions:

- The strict respect of the spirit of the philosophy of the evaluation (guide and annale zero) and the official text.
- The pedagogic practices of the teachers to strike a balance between the three levels of knowledge (acquisition, transfer and production).
- The choice of competencies belonging to all the domains and integrating learning objectives of different topics of the curriculum.
- The good representation of the proposed documents and the clearness of the redaction of the subjects. Thus, if we require the justification of a result, a derivation, a comment, a figure, we must ask that clearly in the question. We don't reserve marks for the implicit questions.
- A scheme specific to each question standardizes the correction of the copies.
- Scientific non-programmable calculators are authorized to ask real and practical questions.

- **Nature of the exam**

  The physics exam is formed of three obligatory questions marked on a total of 20 marks. These exercises are independent, and can be solved by the student in any order.
  Each of these questions is supposed to evaluate integrated competencies taken from different domains.

  As a strategy, each question should represent, as much as possible, a real situation. We start by a theoretical or experimental study to finish by a practical application of the concept, subject of the situation, in daily life.

- **Coefficient**

  The mark attributed to each of the three questions can vary between 6 and 9 points.

- **Duration**

  The time of the physics exam is one hour or 60 minutes.

- **What do we look for in the copy of the student?**

  In the domain of **applying knowledge**:

- Analysis of the relevant data given.
- Mobilization of knowledge appropriate to physics.:
  - Choice of the concept, principle, model, law, hypothesis…
  - Choice of the formulate
  - Literal expression of the solution
  - Choice of units.
- Mobilization of knowledge non-appropriate to physics (calculation, circular functions, logarithm, vectors…)
- Validity of result.

In the domain of **communication:**

- Passage from one mode of representation to another one.
- Respect of rules of the chosen mode of representation (symbol, equation, scale, writhing of indices…).
- Analysis of important informations.
- Mobilization of knowledge appropriate to physics.
- Mobilization of knowledge non-appropriate to physics
- Clear redaction.

In the domain of **experimentation:**

- Choice of materials
- Set up
- Respect of security rules
- Measurement
- Answers to questions
- Validity of result
- Report

This list is not exhaustive.

If the subject of each exercise extends overone or more domains, the mark reserved to knowledge appropriate to physics must be greater than that reserved to knowledge non-appropriate to physics.

Humanities & Sociology - Economics

Physics exam
Time: 1 hour

Session: ....
Marks: 20 points

This exam, is made up of three questions inscribed on...... pages numbered from 1 / ... to ... / ...

All questions are obligatory.

Non- programmable calculators are allowed

First exercise (... points)

I.

1.
   a)
   b)

2.
   a)
   b)

Second exercise (... points)

II.

1.
   a)
   b)

2.
   a)
   b)

Third exercise (... points)

III.

1.
   a)
   b)

2.
   a)
   ii)

To students

How do you organize your job?

- **By which question you start?**

  By the one that appears to be the easiest. Do not hesitate to leave a question if you are blocked (you will go back to it later)

- **How do you start an exercise?**

  Read carefully the given data.
  Indicate or underline the important terms and words.
  Read carefully any accompanying documents.

- **Presentation of the copy**

  Don't copy the given data.
  Write clearly; if you don't have a good writing, write with detatched lettering and acceptable characters.
  Use the notation of the given data, do not change it. If you introduce new notations, define them.
  Write clearly the number of the question you treat as given.

- **Results and numerical applications**

  Start by a literal expression and then pass to the numerical application.
  Do not forget the units
  Put the final result in a frame.

Test 1

FIRST QUESTION **(5.5 points)**

Different forms of energy

We recall the following formulas:

1 W.h = 3600 J
$E = P \times t$ where E is the energy in joules (J), P is the power in watts (W), and t is the time in seconds (s).
$P = U \times I$ where U is the voltage in volts (V) and I is the current in amperes (A).

An electric motor activates a drill. The motor consumes an energy of 1760 W.h and releases 1640 W.h as mechanical energy.

1. What is the form of energy consumed by the motor?

2. The motor, fed with a voltage of 220 V, allows a current of intensity I = 8 A to pass through it. Calculate the time of functioning of the drill.

3. What happens to the energy corresponding to the difference of the two energies 1760 W.h and 1640 W.h? What is the loss of energy due to?

SECOND QUESTION **(5.5 points)**

Dating of rocks

This is an article extracted from a popular scientific periodical about dating of rocks:

"To date a rock, the specialists in earth matters pursue the radioactive isotopes. These are transformed with time by natural radioactivity. As a basic example: uranium 235 (92 protons + 143 neutrons) is changed (by a series of radioactive transformations) to lead 207 (82 protons + 125 neutrons)… It needs exactly 710 million years for half of uranium 235 atoms contained in a rock to change into lead 207; then another 710 million years for a new half to be transformed, and so on untill it disappears totally. tge age if the rick is calculated on the proportion of any of the isotopes in the specimen. Whatever the dose of the radioactive isotopes, the Earth has still some 4.565 billion years.to go."

1. Define the phenomenon of natural radioactivity.

2. What is the atomic number or the charge number Z of uranium 235?

3. What is the mass number A of lead 207?

4. The duration 710 million years represents a characteristic of uranium 235:
   a) Which one?
   b) What is its use in the study of the solar system?

THIRD QUESTION (9 points)

History of Universe

This is an extract of a document concerning the history of astronomy.

"Aristotle thought that the Earth is stationary and that the Sun, the Moon, the planets, and the stars have a circular motion around it. That was so because he estimated that the Earth is the center of the Universe... Developing this idea in the 2nd century A.D, Ptolemy produced a cosmology system. The Earth occupies a central position, encircled with eight spheres carrying respectively the Moon, the Sun, the stars, and the five planets known at that time. The far exterior sphere carried the fixed stars which kept the same position relative to each others but turned as a block... Nicolas Copernicus proposed a simpler system in 1514. According to him, the sun was in a stationary state at the center of the universe and the planets described circular orbits around the sun as the focus...

The fatal shock to the Aristotle/Ptolemy theory emerged unexpectedly in 1609. That year, Galileo started observing the sky at night using a telescope... While observing Jupiter, he discovered that this planet was accompanied by several small satellites (moons) that rotated around it.

During that period, Johannes Kepler modified the Copernicus theory suggesting that the planets are not only describing circles, but ellipses (an ellipse is an elongated circle)...

In 1687 Newton published his book Principia... In his work, Newton proposed the law of universal gravitation... and showed that gravitation was the reason to make the force that made the Moon rotate around the Earth... that the Earth and the planets follow an elliptic trajectory around the sun."

Stephen Hawking
Une brève histoire de temps

1. a) What are the celestial bodies that constitute the Universe according to the Aristotle / Ptolemy theory?
   b) What does the set of these bodies represent to a contemporary astronomer?

2. Compare the Ptolemy system with the Copernicus system?

3. The author mentions the contributions of Galileo and Kepler in the development of Astronomy.
   a) What was Galileo's contribution? Why did it constitute a fatal shock to the Aristotle / Ptolemy theory?
   b) What was Kepler's contribution?

4. a) Which scientist explained the reason of the movement of the planets around the sun?
   b) What was this reason?

Solution of Test 1

First question (5.5 points)

This exercise emphasizes the domain of applying knowledge

Expected answer	Scheme	Comments
1. Electric energy	1 pt.	
2. $P = U \times I = 220 \times 8 = 1760$ W $t = \frac{E}{P} = \frac{1760 \times 3600}{1760} = 3600$ s	1 pt 1.5 pts	
3. Thermal energy.	1 pt.	The answers: heat or heat energy are accepted.
The loss is due to the electric resistance of the motor (Joule's effect).	1 pt.	

Second question (5.5 points)

This exercise emphasizes the domain of communication but also covers the some competencies belonging to the domain of applying knowledge

Expected answer	Scale	Comments
1. It is a spontaneous transformation of an atomic nucleus into another nucleus.	1 pt	Answers as: " it is a reaction or a nuclear phenomenon which are independent of chemical bindings, of temperature ." Are accepted.
2. Z = 92; is the number of protons in the nucleus of uranium 235.	0.5 pt	(value + explanation)
3. A = 207; or A = 82 + 125 = 207; is the number of nucleons (protons & neutrons) of the nucleus of lead 207.	1.5 pts	Explanation (1) + calculation (0.5)
4. a) It is the time for half the amount of uranium nuclide to disintegrate, thus it is the period (half-life) of uranium 235.	1.5 pts	Explanation (1) + nomination (0.5)
b) It permits the determination of the age of the Earth and consequently the age of the solar system	1 pt	

Third question (9 points)

This exercise emphasizes the domain of mastering communication.

Expected answer	Scale	Comments
1. a) According to Aristotle-Ptolemy, the celestial bodies constituting the Universe are: Earth, Moon, Sun, the five known planets during that period and the visible stars.	1 pt	Do not accept the answer: solar system.
b) This represents the Milky Way or the Galaxy.	1 pt	
2. In the two systems - The Universe is made up of the same celestial bodies. - The motion of the planets and of the stars around the center of the Universe is circular. The main difference between the two systems concerns the stationary celestial body and occupyies the center of the Universe: the Earth in Ptolemy's system and the Sun in Copernicus System.	2.5 pts	If another elements are mentioned, they are not marked. We insist on the fact that Earth and Sn are stationary in the considered system. Resemblance (1) Difference (1.5)
3. a) - Galileo developed a method to observe the sky using the telescope which allows us to observe objects and details invisible to the eye such as the satellites of Jupiter. - Discovering the satellites of Jupiter, Galileo demonstrated that the Earth is a planet like the others and has one satellite (the moon). Thus, the Earth cannot make the celestial bodies rotate around it as mentioned in Aristotle-Ptolemy theory.	2 pts 1 pt	Contributions not mentioned in the text are not accepted.
b) Kepler demonstrated that the trajectories of the planets around the Sun are ellipses and not circles as was mentioned by Aristotle-Ptolemy and Copernicus.	0.5 pt	Contribution (1) Fatal shock (1)
4. a) Newton. b) The motion of the planets around the Sun is due to gravity.	1 pt	The force of gravitational attraction is accepted

Test 2

FIRST QUESTION (8 points)

Necessary energy to launch the space telescope Hubble

The space telescope Hubble has a mass $M = 12 \times 10^3$ kg. It rotates at a constant speed $V = 7.5 \times 10^3$ m / s in its circular orbit around the earth at an altitude h = 600 km above its surface. To launch the telescope and put it in motion in its orbit a rocket having an engine run by liquid oxygen and kerosene is used. We suppose that the gravitational field of the Earth, g, has an average value of 8.5 m/s^2 between the levels 0 and 600 km. The Earth surface is considered to be the reference of gravitational potential energy.

1. The telescope is on the Earth's surface at the launching instant; and the speed of taking off of the rocket is supposed to be zero. Calculate:
   i. Its kinetic energy.
   ii. Its gravitational potential energy.
   iii. Its mechanical energy.

2. The telescope is in its orbit. Calculate:
   i) Its kinetic energy.
   ii) Its gravitational potential energy.
   iii) Its mechanical energy.

3.
   i. How much is the variation in the mechanical energy of the telescope for it to be launched and put in motion in its orbit?
   ii. What is this variation due to?
   iii. If 10% of the energy produced by the combustion of kerosene is transferred to the telescope, calculate the amount of kerosene consumed by the rocket to launch the telescope and put it in motion in its orbit. The combustion of one Kg of kerosene releases 4.2×10^7 J of energy.

SECOND QUESTION (6.5 points)

The planets of our solar system

Certain characteristics of the solar system are summarized in the following table:

Planet	Diameter (in km)	Mass (relative to the Earth)	Duration of one revolution around the Sun (d: day; y: year)	Duration of one rotation around itself (h: hour min: minute)	Density (g / cm^3)	Chemical composition of the atmosphere
Mercury	4878	0.055	87.97 d	58.65 d	5.4	none
Venus	12104	0.815	224.7 d	243 d	5.2	CO_2
Earth	12756	1	365.26 d	23 h 56 min	5.5	N_2, O_2
Mars	6794	0.107	687 d	1 d 37 min	3.9	CO_2
Jupiter	142796	318	11.86 y	9 h 55 min	1.3	H_2, He
Saturn	120660	95	29.45 y	10 h 40 min	0.7	H_2, He
Uranus	50800	15	84 y	17 h 14 min	1.3	H_2, He, CH_4
Neptune	48600	17	164.8 y	16 h	1.6	H_2, He, CH_4
Pluton	2300	0.002	247.7 y	6.4 d	2	?

1. The planets: Mercury, Venus and Saturn are called telluric planets because they are composed of the same substances (iron, nickel, silicates…) as those of the Earth.
   Search in the table for a confirmation of this fact.

2. The duration of a day on one of the planets is longer than its year. Which one?

3. One of the planets is considered to be the twin of the Earth.
   a) Which one? Justify your answer.
   b) There is no life on this planet. Why?

4. Which planet has the greatest mass? The other planets do not rotate around it in a regular manner. Why?

THIRD QUESTION (5.5 points)

Identification of nuclear reactions

The induced nuclear reactions are classified in fusion and fission reactions.

1. Are these reactions chemical reactions? Justify your answer.

2. For each of the following reactions, indicate whether it is a fusion or a fission reaction. Justify your answer:

$$^{235}_{92}U + ^{1}_{0}n \rightarrow ^{94}_{38}Sr + ^{140}_{54}Xe + 2^{1}_{0}n$$

$$^{2}_{1}H + ^{2}_{1}H \rightarrow ^{3}_{2}He + ^{1}_{0}n$$

3. Give an example of a natural phenomenon or a technical object where is produced:
   i) fusion
   ii) fission

4. For these reactions, how does the mass of the system vary: Does it increase, decrease or remain the same?

Solution of Test 2

Question 1 (8 points)

This exercise emphasizes the domain of applying knowledge in daily life.

Expected answer	Scale	Comments
1. a) Kinetic energy KE of the satellite is: ½mV^2 = 0 because V = 0. b) The gravitational potential energy of the satellite is: PE = mgh = 0 because h = 0. c) The mechanical energy E_m of the satellite is: ME = KE + PE = 0 + 0 = 0 J.	0.5 pt 0.5 pt 0.5 pt	
2. a. KE = ½ × 12 × 10^3 × (7.5 × 10^3)^2 = 337.5 × 10^9 J. b. PE = 12 × 10^3 × 8.5 × 6 × 10^5 = 612 × 10^8 J. c. ME = 337.5 × 10^9 + 612 × 10^8 = 3987 × 10^8 J.	1 pt 1 pt 0.5 pt	
3. a) The variation in the mechanical energy of the satellite is: 3987 × 10^8 - 0 = 3987 × 10^8 J.	0.5 pt	

b) The mechanical energy of the satellite increases because it has received part of the work furnished by the engine of the rocket. c) The combustion of the kerosene must release a quantity of heat equal to: $\frac{3987\times10^{8}\times100}{10}$ $= 3987\times10^{9}$ J The quantity of kerosene consumed is: $\frac{3987\times10^{9}}{4.2\times10^{7}} = 95\times10^{3}$ kg = 95 tons.	1 pt 2.5 pts (1+1.5)	Answers that tell about the transformation of the chemical energy of kerosene are accepted

Question 2 (6.5 points)

This exercise emphasizes the domain of communication despite the application of some constitutive elements of competencies of the domain of explanation of physics phenomena related to daily life.

Expected answer	Scale	Comments
1. Mercury, Venus and Mars have the same density (≈ 5 g/cm^3) as that of the Earth. Thus, it is normal to admit that they have the same composition as that of the Earth.	1 pt	Nomination (0.5) Explanation (1)
2. The duration of one complete rotation of Venus around itself i.e. the duration of one day on that planet, is 243 earth days. The duration of one rotation of Venus around the Sun is 224.7 earth days. Thus its "day" is longer than its "year".	1.5 pt:	The common characteristics which do not appear in the document are no taken into consideration
3. a) Venus. Its diameter (12104 km) is approximately equal to that of the Earth (12756 km), and of mass equal to 0.815 that of the Earth. b) Its atmosphere does not contain oxygen indispensable for the development of life.	1.5 pt 1 pt	Nomination (0.5) Explanation (1) Reasons which are not deduced from the document are not taken into consideration.
4. Jupiter, of mass 318 times that of the Earth. The other planets do not rotate around it as they are under the influence of the huge force of the gravitational attraction of the Sun.	1.5 pt	Nomination (0.5) Explanation (1)

Question 3 (5.5 points)

This exercise emphasizes the domain of applying knowledge.

Expected answer	Scale	Comments
1. The nuclear reactions are not chemical reactions since they don't deal with electronic cloud but with the nucle of the atoms.	1 pt.	
2. - The first is a fission reaction, because a heavy nucleus is divided under the impact of a neutron.	1 pt.	0.25 pt (nomination) 0.75 pt (explanation)
- The second is a fusion reaction, because two light nuclei unite to form a heavier nucleus.	1 pt.	
3. a) The atomic bomb, nuclear plant…	0.75 pt.	
b) Hydrogen bomb.	0.75 pt.	
4. The mass of the system decreases.	1 pt.	

Test 3

FIRST QUESTION **(6 points)**

Radioactive emission

In this question, we look for comparing the effects of the electromagnetic rays to those of alpha particle.

Polonium $^{21}_{84}Po$ is a radioactive nuclide, which emits by disintegration an α-particle and a lead nuclide Pb according to the following balanced equation:

$$^{21}_{84}Pb \rightarrow ^{4}_{2}He + ^{A}_{z}Pb$$

1. Mentioning the used laws, determine A and Z.

2. The emission of α-particle is, most of the times, accompanied by the emission of an electromagnetic radiation.

i) What is the name of this radiation?
ii) Which is more penetrating, the α-particle or the electromagnetic radiation? How do we protect ourselves?
iii) For the same absorbed dose, which is more harmful, the α-particle or the electromagnetic radiation? Justify your answer.

SECOND QUESTION **(5 points)**

Energy and pollution

This is a document about the electric car:

"... The emission of gas by cars constitutes the principal source of urban pollution. To diminish this pollution we have to develop a car with an electrical engine where a battery of accumulators provides the electric current in the engine. These accumulators have to be recharged from a domestic current source. "The electric car functioning on uranium or on oil" is one of the objections against the use of such a car..."

1. Name two polluting constituents contained in the gas emitted by cars.
2. a) Under which form is the energy stored in the accumulator?
   b) Under which form is this energy supplied to the engine of the electric car?
3. Why are the opponents of using the above described electric car say that it has to function on uranium or oil?
4. Is there an electric car without any polluting emission? Justify your answer.

THIRD QUESTION **(9 points)**

Heater using solar energy

In this exercise, we have to study a heater using solar energy. For this purpose, we consider a thermal solar captor having a transparent plate to trap solar heat energy by greenhouse effect. Water circulates in a blackened metallic tube inserted into the captor, which gets heated by the energy received from the captor.

Given:

- The average sunny interval is 9 hours everyday.
- A solar radiation carries every, second an average energy of 600 J/m^2.
- The surface area of the captor is 1.5 m^2.

1. a) Under which form is the energy stored in the Sun?
   b) Under which form is the energy liberated by the Sun, reaches the Earth?
   c) Under which form is the energy transferred from the captor to the water?

2. Calculate the average solar energy received daily by the captor.

3. Determine the energy supplied to water in one day knowing that 30 % of the energy received by the captor is transferred to the water.

4. A solar captor costs 1.5×10^6 L.L and serves to heat the water for 5 years (1 year = 365 days). The average price of one kilowatt-hour (1 kilowatt-hour = 3.6×10^6 J) of electric energy is 120 L.L.
   Is the solar energy more or less economical than the electrical energy? Why?

5. What is the environmental benefit of the solar energy?

Solution of the test 3

Question 1 (6 points)

This exercise emphasizes the domain of applying knowledge in daily life.

Expected answer	Scale	Comments
1. The total charge of the nucleus or the charge number is conserved, thus: $84 = 2 + Z, \Rightarrow Z = 82.$	1 pt	Explanation (0.5) Calculation (0.5)
The mass number or number of nucleons is conserved, thus: $21 = 4 + A, \Rightarrow A = 17.$	1 pt	
2. a) The γ ray	0.5 pt	
b) The γ ray, because it is more energetic. We protect ourselves by a screen of lead.	2 pts	Protection 1 pt
c) For the same dose absorbed, the α particle is more harmful than γ because its factor of quality (physiological equivalent of the dose) is greater than that of γ.	0.5 pt 1 pt	

Question 2 (5 points)

This exercise emphasizes the domain of applying knowledge in daily life.

Expected answer	Scale	Comments
1. The lead monoxide, oxides of nitrogen and sulfur and lead.	1 pt	Any two polluted constituents are accepted
2. a) The energy stored in the accumulator is a chemical energy.	0.5 pt	
b) It is furnished in the form of electrical energy.	0.5 pt	No accepted inthe form of an electric current
3. The electric energy is used to charge the accumulators. But the electric energy is produced on large scale in power stations, which are mostly operated by uranium (nuclear power station) or by oil (thermal power station). Finally, the electric car functions on uranium or oil; thus we do not diminish the pollution.	2 pts	
4. There are electric cars having accumulators, which convert solar energy into electric energy. The solar energy is due to nuclear reactions on the surface of the Sun.	1 pt	

Question 3 (9 points)

This exercise emphasizes the domain of applying knowledge.

Expected answer	Scale	Comments
1. a) Nuclear energy. b) Radiant or solar energy. c) Calorific energy, thermal energy, or in the form of heat.	1 pt 1 pt 1 pt	
2. The daily average energy received is: $600 \times 1.5 \times 9 \times 3600 = 29.16 \times 0^6$ J	1.5 pt	
3. The energy supplied to water daily is: $29.16 \times 10^6 \times 30\ \% = 87.48 \times 10^5$ J	0.5 pt	
4. The energy used by the heater during 5 days is: $87.48 \times 10^5 \times 365 \times 5 = 15.96 \times 10^9$ J. The cost of the electric energy consumed is: $(15.96 \times 10^9 \div 3.6 \times 10^6) \times 120 = 532 \times 10^3$ L.L This sum is less than the cost of energy produced by the solar captor. Thus, the electric energy is more economical at a price of 120 L.L per kWh.	3 pts	Used energy in 5 years (1 pt) Electric cost (1 pt) Comparison (1 pt)
5. The benefit is that the solar energy does not pollute the environment.	1 pt	

Test 4

FIRST QUESTION (6 points)

Existence of black hole

This is an extract from an article about the black hole:
"The black hole is an offspring of Einstein's theories. It was never observed, but the astrophysicists considered its existence to be practically certain. It is a place … where the gravity is so powerful that nothing, not even light, can escape. This non-returning zone is called the horizon.

How can black holes be located be located? For a start, surely nothing is seen; however seeing nothing is not sufficient to conclude that something exists. Second argument: such phenomenon is related to an extraording gravity that should impose itself on its surroundings, notably by affecting the shape of the light and the movement of the stars. This is how astronomers thought being located that they have a black hole named Cygnus X-1… Last element for locating a black hole: the huge quantity of radiation emitted the instant matter begins to fall in the hole. The gravitational energy generates heat, which is transformed into ultra-energetic rays like X-rays and γ-rays. These rays encircle a black horizon and thus are signs of a black hole."

Science et Vie: les étoiles
No. 37, Juillet 1999.

1. Black hole was never observed. Why?
2. The author mentioned three indicators of the presence of the black hole. What are they?
3. The theories of which scientist contributed to the formulation of the black hole hypothesis?
4. Extract from the text two transformations of energy.

SECOND QUESTION **(8 points)**

Mechanical energy

A car of mass M = 1000 kg has an engine failure on a horizontal road. To start the car, the driver pushes it by applying a constant force of magnitude F = 250 N, in the same direction as the displacement. Forces of friction oppose the displacement of the car. After a displacement of 30 m the car acquired a velocity of 2 m / s. Take $g = 10\ m/s^2$.

1. What is the form of the energy consumed by the driver?

2. Choose the road as a reference of the gravitational potential energy.
   i. Calculate the mechanical energy of the car at rest.
   ii. Calculate the mechanical energy of the car after 30 m of displacement.
   iii. To what reason is the variation of the mechanical energy due? Determine the value Δ(ME) of this variation.

3. Calculate the work W done by the driver.

4. Under which form does the energy difference $W-\Delta E_m$ appear?

THIRD QUESTION (6 points)

Radioactivity of molybdenum

Technetium 99 and molybdenum 99 are two radio-nuclides used in medicine. Technetium Tc 99 is obtained from molybdenum 99 conforming to the following balanced equation:

$$^{99}_{42}\text{Mo} \rightarrow {}^{0}_{-1}\text{e} + {}^{99}_{43}\text{Tc}$$

1. Specify the radioactivity type of molybdenum 99.

2. The disintegration of molybdenum 99 is mostly accompanied by the emission of γ-rays
   i. What is the nature of these γ-rays?
   ii. It is dangerous for living matter. Why?
   iii. What is its benefit in medicine?

3. The period of molybdenum 99 is 2.8 days whereas that of technetium 99 is 6 hours.
   i) What is a period of a radio-nuclide?
   ii) Why should we keep molybdenum 99 on hand (in reserve) in a medical service center using technetium 99?

Solution of Test 4

Question 1 (6 points)

This exercise emphasizes the domain of communication but also covers some competencies belonging to the domain of applying knowledge.

Expected answer	Scale	Comments
1. A black hole was never observed because it is in a region of the Universe where gravity is so intense that it prevents any ray to escape. Thus, it does not emit any ray for it to be observed.	1 pt	
2. The indicators are: - It was never been observed in the appointed region of the space. It is probable that a black hole exists in this region.	0.5 pt	
- Gravity of the black hole is huge. Thus, the presence of black hole can be revealed indirectly by its effect on the path of light rays and the movement of the celestial objects in its surroundings.	1 pt	

- The huge amount of energy emitted in a form like X-rays or γ rays when matter starts to fall in the hole.	1 pt	
3. Einstein.	0.5 pt	
4. The transformation of the gravitational energy (or the energy of mass) into thermal energy (or heat), and the transformation of thermal energy into radiant energy (or luminous)	2 pts (1+1)	Transformations which are not mentioned are not accepted

Question 2 (8 points)

This question emphasizes the domain of applying knowledge but also covers of some competencies belonging to the domain of applying knowledge in daily life.

Expected answer	Scale	Comments
1. Chemical energy	1 pt	
2. a) The kinetic energy K.E. of the car is zero because its velocity is zero. So is its gravitational potential energy P.E because it is at the origin of this energy. Thus, its mechanical energy $E_m = PE + KE =$ zero.	1.5 pt (3×0.5)	
b) After a displacement of 30 m: $KE = \frac{1}{2}mV^2 = \frac{1}{2} \times 100 \times 2^2 = 2 \times 10^3$ J $PE = mgh = 1000 \times 10 \times 0 = 0$ J $ME = 2 \times 10^3 + 0 = 2 \times 10^3$ J	 1 pt 0.5 pt 0.5 pt	
c) The variation of the mechanical energy is due to the frictional force and the pushing force exerted by the driver $\Delta(ME) = 2 \times 10^3 - 0 = 2 \times 10^3$ J	0.5 pt 0.5 pt	
3. $W = F \times D = 250 \times 30 = 7500$ J.	1 pt	
4. The difference: $W - \Delta(ME) = 7500 - 2000 = 5500$ J represents the part of mechanical work done by the driver and which does not appear in the form of mechanical energy transmitted to the car but under the form of heat because of friction opposing the motion of the car.	1.5 pt	

Question 3 **(6 points)**

This exercise emphasizes the domain of applying knowledge.

Expected answer	Scale	Comments
1. The particle emitted during the disintegration of molybdenum 99 is an electron. Thus, radioactivity is of the type β^-.	1 pt	
2. a) It has an electromagnetic nature.	0.5 pt	
b) It is dangerous because it is highly energetic and therefore very penetrating through living material. It destroys the living cells.	1 pt	
c) It is used to destroy cancerous cells.	1 pt	It is sufficient to mention the radioactivity of molybdenum without talking about its activity
3. a) The period of a radio-nuclide is the time at the end of which half of the nuclei of this radio-nuclide are disintegrated.	1 pt	
b) The period of technetium 99 is 6 hours. Thus it disintegrates rapidly; for example half of the initial quantity is left after six hours. For this reason molybdenum 99 has to be kept on hand to compensate for the disintegrated technetium 99 nuclei.	1.5 pt	

Republic of Lebanon
Ministry of Education and Higher Education
Educational Center for Research and Development (ECRD)

EVALUATION GUIDE

CHEMISTRY

SECONDARY CYCLE

SAMPLES OF SCHOOL EXAMINATIONS

SAMPLES OF OFFICIAL EXAMINATIONS

الشهادة الثانوية العامة

October 2000

Explanatory Text for Domains and Competencies in Chemistry

The domains of competencies are almost the same for the different cycles in the same discipline. In chemistry, we have kept for the first, second and third years of the Secondary Level the same domains of competencies listed for secondary cycle.

The Domains of Competencies

The list of competencies and the domains of competencies is a work tool. Complementary explanations are needed to apply them.

In general, the explanations given for a domain are the same, transversally (for different disciplines) and longitudinally (for different cycles of the same discipline). They reveal how tightly each domain is tuned with the elements. which are examined during the evaluation of a competency in each domain. The students should be informed of these explanations.

I- Applying Knowledge

The school in the 21st century is required to function in a complex social environment, and the image of the traditional educative system should change. It should pass from a closed-system towards an open-system, toward a project, the modification of the society (Gazaïel and Warnet, 1998)

The scientific knowledge acquired at school has, in general, double goals: ***investment*** *in new researches to contribute to the scientific progress, and* ***reutilization*** *in new situations related to every day life. This* ***transfer of knowledge****, to which we give very great importance, should be manifested in the process of evaluation through interpretation, explanation, and analysis of chemical phenomenon in the real world*

In the light of the role that the modern school should play, this domain does not imply direct application of knowledge. The competencies of this domain should be evaluated in new complex situations and/or similar situations that have been encountered in the class. The application of a scientific law or many laws in a situation should be very clear.
The student, thus, should choose the proper law as the only convenient knowledge to find out the unknown.
The elements that should appear in the competencies of this domain may be revealed in one or more of the following forms:

a- Draw from observing a fact or reading up a scientific text (document) the pertinent information concerning situations relevant to chemistry.
b- Analyze data, that is to sort, based on the knowledge acquired, the essential information, and add it the information obtained. It should be noted that, in the same situation, information, which is considered to be indispensable to answer a question, might not be necessary to answer another question. Is the student able to identify the data given, with the acquired knowledge, and relate it to the situation?
c- Mobilize and apply appropriate chemical knowledge. Once the preceding relation is achieved, is the student able to choose the relevant knowledge (law, formula, definition, units...)? If he makes the right choices, is he able to apply them? Is he able to elaborate on a

model or a hypothesis? This statement is linked to the autonomy of decision - making. The student has to decide what knowledge he has to mobilize, organize and employ then to answer the question.

d- Mobilize and apply knowledge out-of-chemistry (calculation, scale graph, vectors…)

e- Verify the validity of results: physical sciences describe situations, which are close to everyday life. Are the results obtained, very close? Are the answers logical? Are the dimensions of units and physical quantities properly used?

f- Transfer the results obtained to real situations. This is the most important step.

In this domain, the competencies to be evaluated are also related to the following learning objectives:

- *Sketch a diagram.*
- *Give the physical significance of abscissa and ordinate.*
- *Choose the appropriate scale.*
- *Determine graphically the operating point of a device.*
- *Draw from a graph the characteristics of a device.*
- *Measure the values of some physical quantities in order to calculate the values of other physical quantities.*

II- Designing an Experiment

In this domain, the student should be able to perform an experiment and to resolve problems that have experimental characteristics. The aim is that, before the student leaves school, he should be acquainted with the characteristics of an apparatus and should be able to use the technique sheet that describes how to operate a device properly. The student should be able to follow the steps:

a- Read the procedure of the experiment.
b- Choose and use the materials needed.
c- Assemble apparatus according to schematic drawing for an experiment.
d- Follow safety rules (for persons and installations).
e- Make measurements and verify the validity of results.
f- Answer the questions.
g- Draw conclusions from results, make clear and labeled schematic drawings.

The last two points (f and g) could be also evaluated as competencies that pertain to the domain of communication. It is not reasonable to perform an experiment and record measurements without interpreting the results obtained or without writing a report (competencies that pertain to the domain of communication). The evaluation of a competency in the domain of designing an experiment is correlated, in the majority of cases, to a competency pertaining to the domain of communication.

To resolve a problem having an experimental aspect, the student should mobilize his "manipulative" knowledge rather than his "theoretical" knowledge. It is possible to give the schema of an apparatus or a setup and be asked to suggest changes that should be done to: the schema of the apparatus, the measurement used on the scale of the device, the assembling of the setup.

III. Domain of Mastery-Communicating:

This domain is of great importance on the practical level. We are living in a rapidly changing world where individuals are expected to interact, daily, with others.
To convey ideas on a subject placed in a well-determined context, using different modes of representation, is a competency related to the individual's knowledge.
A joke told by someone may make others laugh; the same joke, when told by someone else, may not produce the same effect.
The knowledge constituting a phenomenon are the same, but how to integrate and how to mobilize these knowledge depends on the capabilities of a person.
For this reason, we summon that competency must appeal knowledge to become directed towards developing the autonomy (J. M. De Kettle).
To make use of a diagram and interpret it is a competency included in this domain. This competency encountered in another context in the different disciplines is the same as the one we see in our magazines and newspapers. It integrates the learning objectives having the following as its constitutive elements:

- *a - Sketch a diagram.*
- *b - Give the physical significance of coordinates (abscissa-ordinate).*
- *c - Choose convenient scales.*
- *d - Determine graphically the functioning point of a device.*
- *e - Conclude from a graph the characteristics of a device.*
- *f - Use the measured values to calculate the values of other physical quantities.*

Evaluation of Competencies

Domain	Competencies
Applying knowledge	• ***Use specific chemistry knowledge:*** ***Atoms:*** *Composition of the atom, atomic symbol, characteristics of the atom and its fundamental particles, notion of isotopes, electron configuration, Lewis electron-dot symbol, principle and importance of the arrangement of the elements in the periodic table, mole of atoms.* ***Molecules:*** *The duet and octet rules, covalent bond (simple, double, and triple), polarity, Lewis dot structure, VSEPR, mole of molecules.* ***Ions:*** *Monoatomic and polyatomic ions, ionic bond, formula unit, mole of ions.* ***Chemical reactions:*** *Evidence for chemical reaction, chemical equation, law of conservation of mass, stoichiometry, characteristics of a chemical reaction, percent yield.* ***Water:*** *Structure, dissolving properties, characteristics of an aqueous solution.* ***Solutions of Acids-bases:*** *Definitions, pH, classification, nomenclature, reactions of acids and bases, definitions of salts, reactions of salts, acid-base titration.* ***Qualitative analysis:*** *Tests to identify some ions.* ***Fertilizers:*** ***Atmospheric pollution:*** *Principal pollutants of air, acid rain, green house effect, the ozone hole, smog, pollution (problems and solutions).* • ***Classify chemical species based on their properties:*** *Fundamental particles of the atom, elements in the periodic table, acids, chemical reactions.*

Domain	Competencies
	• ***Distinguish between:*** *Column (group) / row (period), cation / anion, covalent / ionic compounds, bonding electron pair / lone pair, mole of atoms / molecules / ions, chemical / physical change, solvent / solute, strong / weak electrolyte, acid / base, compatible / incompatible ions, permanent / incidental pollution.* • ***Identify the characteristics of:*** *A nucleus, an atom, an element, cations, anions, a chemical reaction, mechanism of the dissolution of an ionic compound, a gas, sources of pollution.* • ***Relate the parameters and/or the variables:*** *The atom, mole / mass / volume, concentration / mol / volume, acidity-pH, $[H_3O^+]$ and $[HO^-]$* • ***Interpret:*** *Chemical properties of an element, the stability of a molecule, shape of a molecule, polarity of a bond, and a molecule, cohesion of a crystal, chemical reaction.* • ***Explain the consequences of chemistry on health, quality of life and environment:*** *Stalactites and stalagmites, rusting of iron, bleaching agents, anti-tartar agents, nitrogen cycle, greenhouse effect, ozone hole, water pollution, eutrophication.*
Designing an experiment	• ***Perform experimental activities:*** *Evidence for chemical reaction, conservation of mass in a chemical reaction, preparation of solution, acid-base titration, pH measurement, identification of some ions.* • ***Write report of an experiment.*** • ***Build molecular models.*** • ***Devise an experimental procedure.***
Mastery-communicating	• ***Use accurate scientific vocabulary.*** • ***Utilize various methods to present information:*** *Written, schemata, tables, diagrams, graphs …* • ***Read-up a scientific text.*** • ***Make use of a tabulated data:*** *Percent isotopic composition, periodic table, variation of solubility as a function of temperature, composition of dry and clean air.* • ***Interpret a schema and/or a graph:*** *Energy diagram of the atom, isotopic-diagram, molecular model, variation of solubility as a function of temperature, composition of dry and clean air, pH scale.* • ***Conduct documentary research:*** *Using different up-to-date sources of information (library research, CD-ROM, internet sites…).*

Domain: ***Applying knowledge.***
Competency: ***Use specific chemistry knowledge relevant to magnesium atom.***

Exercise 1: ***Magnesium and Chocolate***

Magnesium is a chemical element which is found in many foods.

1- An atom of magnesium is characterized by the numbers Z = 11 and A = 26. Give the symbol of its nucleus.

2- a- Calculate the mass of the magnesium nucleus knowing that the mass of a nucleon is $1.67 x 10^{-27}$ Kg.

b- What is the mass of the magnesium atom? Justify your answer.

3- Write the electronic structure (electron configuration) of the magnesium atom.

4- Consider two other magnesium atoms characterized by the following pair (Z;A): (12;24) and (12;25).

a- What can you say about these two atoms?

b- The charge of a magnesium atom is equal to +2e. Write the symbol of this cation. Give its electronic structure. How many neutrons are there in each of the three magnesium isotopes?

5- The proportions (by atom or ion) of the naturally occurring three isotopes of magnesium are given in the adjacent table.
Assuming that in a chocolate piece there are about 10^{22} Mg^{2+} ions, calculate the number of ions of each isotope, we will consume when we eat the chocolate piece.

Isotope	*% by mole*
^{24}Mg	79
^{25}Mg	10
^{26}Mg	11

Competency: ***Identify the characteristics of an atom.***

Exercise 2: ***Identifying an atom***

An atom X has only one electron on its outer energy level.

1- Assuming that $Z_X \leq 18$, write the possible electron configurations of X.

2- The mass of this atom is $39.1 x 10^{-27}$Kg. Determine the number of nucleons of atom X.

3- Identify this atom, give its name and its symbol.

Given: Mass of a nucleon = $1.7 x 10^{-27}$Kg

Competency: ***Use specific chemistry knowledge relevant to noble gases.***

Exercise 3: ***Xenon lamps***

Some car manufacturers use xenon lamps. The light produced by xenon lamp has characteristic green-blue color. It produces good illumination but it is less bright than iodine lamp. One inconvenience is its price!
Name the family of xenon and that of iodine.

Competency: Use specific chemistry knowledge relevant to conservation of mass.

<u>Exercise 4:</u> Photographic flashbulbs

The first photographic flashbulb used the reaction between magnesium and oxygen gas of air. An intense dazzling white light accompanies this reaction. An ionic compound is formed which consists of magnesium (II) ions and oxide ions.

1- List the chemical elements that are present before the reaction takes place.

2- Indicate, based on the law of conservation of mass, the chemical elements that are present after the reaction has occurred.

3- Give the symbols of the ions formed.

4- Write the formula unit of the compound formed. Give its name.

Competency: Use specific chemistry knowledge relevant to quantity of matter (mole).

<u>Exercise 5:</u> Urea

The molecular formula of urea is CH_4N_2O. It is an organic compound containing nitrogen and found in urine.

1- Calculate the molar mass of urea.

2- Calculate the quantity of matter (moles) and the mass of urea needed to prepare 200 mL solution of concentration 0.5 $mol.L^{-1}$.

Competency: Use specific chemistry knowledge relevant to stoichiometry of chemical reaction.

<u>Exercise 6:</u> Hydrogen chloride and hydrochloric acid

Hydrogen chloride HCl, a very corrosive compound, is a chemical commonly used in chemical industry. In aqueous solution it forms hydrochloric acid which is a strong acid.
Consider the reaction given by the chemical equation:

$$4HCl + O_2 \rightarrow 2H_2O + 2Cl_2$$

A mixture containing 10 mol of oxygen gas and 20 mol of hydrogen chloride is made to react. Determine the composition of the mixture obtained when the reaction is over.

Competency: Use specific chemistry knowledge relevant to shapes of molecules.

<u>Exercise 7:</u> Formic acid

Certain ants defend themselves against predators using methanoic acid, which is commonly called formic acid f formula CH_2O_2. Give the shape of this molecule as predicted by VSEPR model.

Competency: Use specific chemistry knowledge relevant to concentration of solution.

***Exercise 8:* Titration of a mixture of acids**

A solution (S) is obtained by mixing hydrochloric acid and sulfuric acid solutions. 10 mL of (S) is titrated with 40 mL of 0.1 mol.L^{-1} NaOH solution. An excess of $BaCl_2$ solution is added to 20 mL of solution (S). A white precipitate is obtained. The obtained precipitate is washed and dried. It has a mass of 0.233g.

1- Write the ionic equation of the neutralization reaction.

2- Calculate the concentration of H^+ ion present in solution (S).

3- Cite the compatible and incompatible ions in the reaction system after adding barium chloride.

4- Write the net ionic equation of the precipitation reaction.

5- Calculate the molar concentration of each acid solution used to prepare solution (S).

Competency: Explain the consequences of chemistry on health, quality of life and environment.

***Exercise 9:* Freons**

Consider the chemical species made up from C, F, Cl and/or H atoms. All species containing at least one C atom and one F atom are called freons. Freons are used as coolants in refrigerators, and are responsible for the partial destruction of the ozone layer in the stratosphere. For this reason, the production of freons has been banned in some countries.

1- Write the formulas of all freons containing only one C atom.

2- Interpret the formation of the ozone hole.

Domain: Designing an experiment.
Competency: Devise an experimental procedure to prepare a solution.

***Exercise 1:* Preparing a solution**

It is required to prepare 50 mL of hydrochloric acid solution of concentration 0.02 mol.L^{-1} from a 0.1 mol.L^{-1} HCl solution. Describe the steps followed for this preparation.

Materials:

- *Pipets (volumetric): 10 mL, 20 mL and 50 mL*
- *Pipet filler or pipet safety-bulb*
- *Volumetric flask: 50 mL, 100 mL and 250 mL*
- *Beakers: 50 mL, 100 mL and 250 mL*
- *Graduated cylinders: 100 mL and 250 mL*
- *Stoppers assorted sizes*

Competency: ***Devise an experimental procedure to identify carbon dioxide.***

Exercise 2: ***Vitamin C***

When an effervescent tablet of vitamin C is placed in water, carbon dioxide gas is released.
1- Suggest a simple experiment that allows to identify this gas.
2- Sketch a labeled schematic diagram for this experiment.

Materials:

- *Beakers: 50 mL, 100 mL and 250 mL*
- *Erlenmeyer flasks: 50 mL, 100 mL and 250 mL*
- *Graduated cylinders: 50 mL and 100 mL*
- *Test tubes and test tube rack*
- *Glass tubing and rubber tubing*
- *Stoppers assorted sizes*
- *Distilled water (or deionized water)*
- *Saturated and clear lime water*

Competency: ***Devise an experimental procedure to titrate hydrochloric acid solution with sodium hydroxide solution.***

Exercise 3: ***Acid-base titration***

It is required to titrate a volume (V) of sodium hydroxide solution against hydrochloric acid solution. Carry out this titration.

Materials:

- *Pipets (volumetric): 10 mL, 20 mL and 50 mL*
- *Pipet filler or pipet safety-bulb*
- *Buret: 25 mL*
- *Beakers: 50 mL, 100 mL and 250 mL*
- *Graduated cylinders: 100 mL and 250 mL*
- *Magnetic stirrer and magnetic bar*
- *Sodium hydroxide solution (unknown concentration)*
- *Hydrochloric acid solution of concentration 0.05 mol.L^{-1}*
- *Colored indicators*

Competency: ***Devise an experimental procedure to verify some indications of bottled mineral water.***

Exercise 4: ***Mineral water***

The labels of bottles containing mineral water indicate the nature, mass and concentration of the ions present and the pH of water. The label of a bottled mineral water is given in the following table:

Cations	Composition by mass ($mg.L^{-1}$)	Anions	Mass concentration ($mg.L^{-1}$)
Ca^{2+}	467	HCO_3^-	377
Mg^{2+}	84		
Na^+	7	$SO4^{2-}$	1192
K^+	3	Cl^-	7
Dry residue at 180 ^0C: 2032 $mg.L^{-1}$ pH = 7.9			

It is required to verify experimentally:

- *The presence of Calcium ions and Sulfate ions.*
- *The reading of the label concerning the concentration by mass of HCO_3^- ion.*

To verify the above, we titrate the mineral water with hydrochloric acid solution (S) of concentration $C = 0.1\ mol.L^{-1}$.

Materials:

- *Pipets (volumetric): 10 mL, 20 mL and 50 mL*
- *Pipet filler or pipet safety-bulb*
- *Buret, 25 mL*
- *Volumetric flasks: 50 mL, 100 mL and 250 mL*
- *Beakers: 50 mL, 100 mL and 250 mL*
- *Graduated cylinders: 100 mL and 250 mL*
- *Test tubes and test tube rack*
- *Magnetic stirrer and magnetic bar*
- *Stoppers assorted sizes*
- *Mineral water to be analyzed*
- *Hydrochloric acid solution of concentration 0.5 $mol.L^{-1}$*
- *Silver nitrate solution of concentration 0.1 $mol.L^{-1}$*
- *Barium chloride solution of concentration 0.1 $mol.L^{-1}$*
- *Ammonium oxalate solution of concentration 0.1 $mol.L^{-1}$*
- *Copper (II) sulfate solution of concentration 0.1 $mol.L^{-1}$*
- *The following colored indicators:*

Indicator	**Color in acid medium**	**PH range**	**Color in basic medium**
Methyl orange	Red	3.1- 4.4	Yellow
Bromothymol blue	Yellow	6 – 7.6	Blue
Phenophtalein	Colorless	8.2 – 10	Pink

Molar Mass ($g.mol^{-1}$): H = 1 C = 12 O = 16

Questions:

1- *Identification of ions:*

a- *Describe a test to identify the presence of Calcium ions and Sulfate ions in solution.*

b- Write the net ionic equation of the reaction involved in each of these tests.

2- Preparation of hydrochloric acid solution (S). Describe in detail the preparation of 100 mL of solution (S) and indicate the glassware which are used.

3- Determination of the concentration of HCO_3^- ion in the mineral water.

Place a volume V = 100 mL of mineral water in an Erlenmeyer flask. Into this flask, add a few drops of a colored indicator, and, by means of a buret, slowly add the hydrochloric acid solution (S).

The indicator changes color when the volume of the solution (S) added is $V_{eq.} = 6.1$ mL. At this point the resulting solution has a pH = 4.

a- Draw a labeled schematic diagram of the titration.
b- Write the net ionic equation of the reaction taking place during the titration.
c- Determine the concentration of the HCO_3^- ion in the mineral water.
d- Compare the value obtained with the value given on the label.
e- Which indicator is the most indicative for this titration? Justify.

Domain: ***Mastery-communicating.***
Competency: ***Make use of a tabulated data relevant to periodic table.***

Exercise 1: Periodic table

Acetylene is a gas used for welding (oxy-acetylene blow pipe). Its molecular formula is C_2H_2. Use the periodic table to write down the Lewis dot structure of this molecule.

Competency: ***Read-up a scientific text relevant to soil.***

Exercise 2: Soil and pH

The pH of a soil depends on its composition. It varies between 3.5 to 4 in marshy grounds and is about 9 in very calcareous grounds. The pH value has a very important consequence on vegetation.
The heath (moor), rhododendron, develops in acidic soils of pH between 4 and 5. On the other hand, the clematis (vine-like plants that flowers) develops in basic soils of pH between 7.5 and 8. The maximum yield of a plant is not obtained if the pH of the soil does not fall between the two different ranges above.
Practically, it is possible to modify the acidic-basic nature of the soil, by adding moderately lime, marl, or peat. A lime solution makes phenolphthalein pink in color, whereas, a solution of peat makes bromothymol blue yellow in color.
We have a soil of pH = 7.2.
Indicate the means that allow the following plants to grow in this soil:
a- Clematis
b- Heath

Competency: Utilize the bar graph to compare the relative abundance of the isotopes of zinc.

***Exercise 3:* Isotopes of zinc**

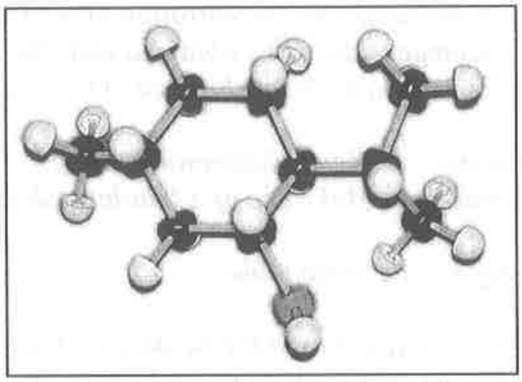
Most chemical elements exist naturally as a mixture of isotopes.
Compare, using a bar graph, the relative abundance of the isotopes of zinc.

Isotope	$^{64}_{30}Zn$	$^{66}_{30}Zn$	$^{67}_{30}Zn$	$^{68}_{30}Zn$	$^{70}_{30}Zn$
% by atoms	*48.89*	*27.81*	*4.11*	*18.57*	*0.62*

Competency: Interpret a schema relevant to the molecular model of menthol.

***Exercise 4:* The green mint**

The odor of green mint is due to the presence of menthol, whose structure is shown by the following molecular model:



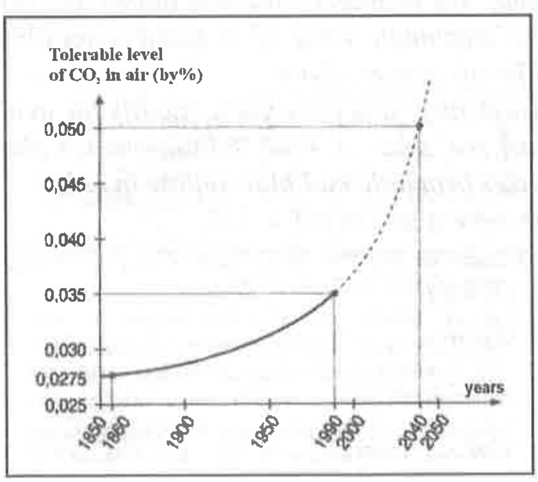
1- *Write the molecular formula of menthol.*
2- *Draw the Lewis dot structure of menthol.*
3- *Is the octet or duet rule satisfied for all the atoms of this molecule?*

Competency: Interpret a graph relevant to carbon dioxide level in air.

***Exercise 5:* Carbon dioxide and greenhouse effect**

Carbon dioxide is one of the constituents of air we breathe. This compound is produced by the natural oxidation of organic substances (respiration by living things).
However, human industrial activity has resulted in raising the carbon dioxide level in air, (especially over the last two centuries). This has led to an enhanced greenhouse effect which, in turn, has led to an increased average global temperature.

1- *Explain the role of carbon dioxide in the increase of the average global temperature.*
2- *Use the graph shown in the adjacent figure to indicate the variation of the carbon dioxide level in air. Is this variation a linear variation? Explain.*
3- *Determine the percentage of the carbon dioxide in the year 2040. Is this a real value? Could it be modified? Explain.*



Competency: Read up a scientific text relevant to the formation of stalactites and stalagmites.

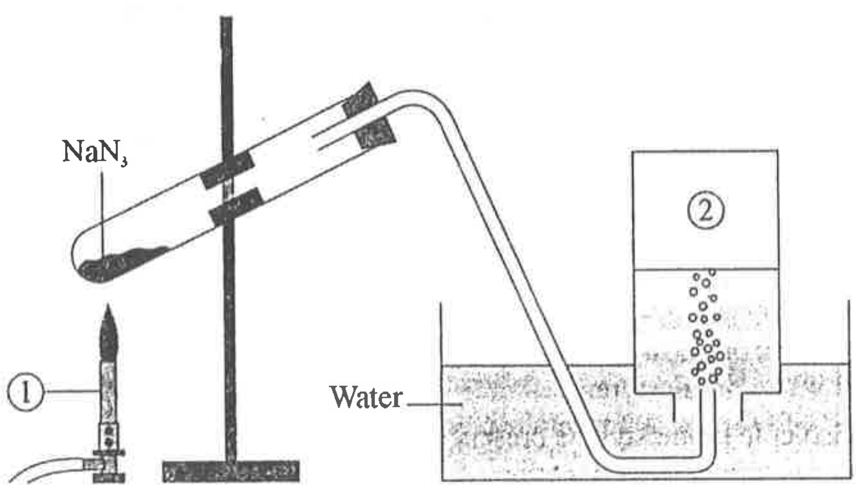
<u>Exercise 6:</u> Jeita cavern

Stalactites are icicles of calcium carbonate suspended from the ceiling in certain caverns, whereas stalagmites from on the ground just below the stalactites.
The formation of stalactites and stalagmites is an extremely slow phenomenon. This formation is due to a series of chemical reactions. Dissolution of calcium carbonate (and other carbonates) by acid rain, which contains carbon dioxide, leads to the formation of soluble calcium hydrogen carbonate. Water containing this latter compound filters in through porous rocks. It reaches into a cavern where it seeps on the walls or slowly drops from the ceiling. The change in the temperature, pressure and the composition of the atmosphere prevailing in the cavern leads to the slow decomposition of the calcium hydrogen carbonate and the formation of insoluble calcium carbonate. This phenomenon allows the formation of suspended stalactites from the ceiling of the cavern in spots where stalagmites are from on the ground just below the stalactites.
Translate using equations, the above-described chemical reactions.

Competency: Read-up a scientific text relevant to airbags.

<u>Exercise 7:</u> The chemistry of airbags

Most experts agree that airbags constitute an important safety device in cars. The airbag hidden in the dashboard deploy and inflate rapidly (in less than 40 milliseconds) in case of head-on-collision and protect the occupant before hitting the dashboard or the instrumental panel.
The airbag is deployed and inflated quickly and prevents occupants from being thrown from their vehicles.
How is the gas generated, which inflates the airbag?
As a consequence of a sudden deceleration (or an impact), a steel spring triggers the electronic lighter of a detonator. This initiates the decomposition of an explosive, sodium azide NaN_3, into sodium Na and nitrogen gas N_2. This system need only a small amount of sodium azide; 100g produces 56L of nitrogen gas. The decomposition of NaN_3 is simulated in the laboratory. The apparatus of the experiment is shown in the following schema:



NaN_3, usually kept in the reservoir of the airbag, is placed in a test tube.
Heating NaN_3 produces a gas, which can be collected in an inverted flask (2) over water.
The airbag is an important application of chemistry, which serves to save the lives of thousands each year.

1- *Find the equivalence of the flame of a Bunsen burner (1) in the airbag.*
2- *Name the gas is formed in the inverted flask. Is it soluble in water?*
3- *Indicate the recipient, which is simulated to an airbag in the apparatus of the experiment.*

Competency: Conduct documentary research relevant to fullerenes.

<u>Exercise 8:</u> Fullerenes

Conduct a research about fullerenes.

Subject: Chemistry

Second Year Secondary
Section: Scientific

Evaluation of Competencies

Domain	***Competencies***
Applying knowledge	• ***Use specific chemistry knowledge:*** ***Thermochemistry:*** *Heat of reaction at constant pressure, heat of formation, Hess's law.* ***Electrochemistry:*** *Oxidation-reduction reactions, electrochemical classification of redox couples, balancing redox reactions, Galvanic cells and storage batteries, electrolysis and redox titrations.* ***Industrial inorganic chemistry:*** *Principles for manufacturing ammonia, sulfuric acid and explosives, types and characteristics of cement and glass.* ***Metallurgy:*** *Extraction of iron, characteristics of alloys, corrosion of metals, protection and recycling of metals.* ***Atomic orbitals:*** *Quantum numbers, electron configuration, atomic and molecular orbitals and hybridization.* ***Organic chemistry*** *Elemental qualitative and quantitative analysis of organic compounds, isomerism, chemical properties of hydrocarbons (alkanes, alkenes and benzene).* ***Petroleum and natural gas:*** *Origin , refining and uses of petroleum, characteristics of natural gas.* ***Pollution:*** *Industrial and household wastes (impact on the environment and treatment).* • ***Classify chemical species based on their properties:*** *Metals, metal ions, redox couples, hydrocarbons, wastes.* • ***Distinguish between:*** *Exothermic / endothermic reaction, oxidant / reductant, oxidation / reduction reaction, Galvanic cell / storage batter, cathode / anode, alkane / alkene / benzene, simple / fractional distillation, cracking / reforming, industrial / household wastes.*

Domain	Competencies
	• **Interpret:** *Electrochemical reactions, equivalence relations in titration, formation of molecular orbital, shape of molecule.* • **Relate properties to uses:** *Of some chemical products and materials.* • **Explain the consequences of chemistry on health, quality of life and environment:** *Galvanic cell, storage battery, electrolysis, energy value of foods, cement, glass, hydrocarbons, pollution.*
Designing an experiment	• **Perform experimental activities:** *Qualitative and quantitative classification of redox couples, simple and fractional distillation, constructing a Galvanic cell, electrolysis, redox titration, identification of an alkene.* • **Write report of an experiment.** • **Build some molecular models.** • **Devise an experimental procedure.**
Mastery-communicating	• **Use accurate scientific vocabulary.** • **Utilize various methods to present information:** *Written, schemata, tables, diagrams, graphs.* • **Make use of tabulated data:** *Label of a food product, table of thermochemical classification,...* • **Interpret a schema and/or a graph:** *Thermochemical diagram, Galvanic cell, electrolytic cell, battery, Haber's process, simple and fractional distillation...* • **Read-up and make use of information from:** *a scientific text, a tabulated data.* • **Conduct documentary research:** *Using different up-to-date sources of information (library research, CD-ROM, internet sites...).*

Domain: ***Applying knowledge.***
Competency: ***Use specific chemistry knowledge relevant to heat of formation.***

<u>Exercise 1:</u> Heat of formation of methanol

During a chemical reaction, an energy exchange takes place between the reaction system and the surroundings. The heat of formation of liquid methanol is the heat of synthesis of one mole of the compound starting from its elements at standard conditions. At 25°C, ΔH_1 is the heat of reaction according to the thermochemical equation:

$$C(s) + 2H_2(g) + \frac{1}{2} O_2(g) \rightarrow CH_3OH(l) \qquad \Delta H_1 = ?$$

Calculate ΔH_1 knowing that:

$\Delta H_{vap}(CH_3OH) = 37.4$ KJ.mol^{-1} and ΔH_2, the heat for the reaction:

$$C(s) + 2H_2(g) + \frac{1}{2} O_2(g) \rightarrow CH_3OH(g) \text{ is equal to } -218 \text{ KJ.mol}^{-1}$$

Competency: ***Use specific chemistry knowledge relevant to electrochemistry.***

<u>Exercise 2:</u> Silver-Nickel Galvanic cell

A Galvanic cell is made at standard state conditions by connecting the redox couples Ag^+/Ag and Ni^{2+}/Ni.

1- *Indicate the polarity of the terminals and calculate the emf of this Galvanic cell.*
2- *Write the overall (cell) reaction.*
3- *What change in mass is produced at the negative terminal of the Galvanic cell, when a current I = 10 mA is passed for 3 hours?*

Given: $E^o(Ag^+/Ag) = 0.80$ V; *$E^o(Ni^{2+}/Ni) = -0.23$ V;* *1F = 96500 coulombs*

Competency: ***Use specific chemistry knowledge relevant to alkenes.***

<u>Exercise 3:</u> Identification of an alkene

The presence of the double bond in an alkene is identified by its reaction with dilute, slightly basic, potassium permanganate solution. It forms a brown precipitate of manganese dioxide. The alkene is changed into alkanediol.

1- *Show that this is an oxidation-reduction reaction.*
2- *Write the half-reaction of the organic compound in basic medium. Is the alkene oxidized or reduced?*

Competency: ***Use specific chemistry knowledge relevant to alkynes and alkenes.***

<u>Exercise 4:</u> Catalytic hydrogenation

The catalytic hydrogenation of 2-butyne, using deactivated palladium, leads mainly to the formation of Z-2-butene and that of 3-hexyne produces only Z-3-hexene.

1- *Write the condensed structural formulas of the alkynes and alkenes mentioned above.*

2- Indicate the important property, catalytic hydrogenation of alkynes, from the above obtained results.
3- The property stated in part (2) is always true.
   a- Give the formula and the name of the alkyne which should be used in order to obtain, by catalytic hydrogen using deactivated palladium, the compound Z-2,5-dimethyl-3-hexene.
   b- Is it possible to obtain E-2-butene through a similar way? Justify.

Competency: Explain the consequences of corrosion on the environment.

Exercise 5: Corrosion of metallic objects

The metallic parts of an abandoned shipwreck are often covered by protecting materials. However, these metallic parts beneath the surface are damaged. How can the degradation of these parts be prevented? Explain.

Competency: Explain the consequences of corrosion on the environment.

Exercise 6: Rusting (corrosion) of iron

Iron slowly is oxidized in humid air forming a porous non-protective layer of rust. For the purpose of rustproofing the two faces of a thin flat sheet of iron having size (20cmx10 cm) and of negligible thickness, we carry out electrolytic nickel plating.

1- What electrochemical reactions will take place at the electrodes?
2- Explain why nickel-plating helos to protect iron from rusting.
3- A constant electric current of intensity 0.5A is passed for one hour. Calculate the mass of nickel deposited and the thickness of the deposited layer knowing that the density of nickel is $8.925x10^{-3}$ $kg.m^{-3}$.

Given: $E^o(Fe^{2+}/Fe) = -0.44$ V; $E^o(Ni^{2+}/Ni) = -0.23$ V; 1F = 96500 coulombs

Competency: Explain the consequences of electrolysis on the quality of life.

Exercise 7: Electrolysis

Some statues are made by electrolytic process.

1- Describe this process.
2- Explain how electrolysis may help to manufacture an object?

Domain: Designing an experiment.
Competency: Devise an experimental procedure relevant to electrochemical classification.

Exercise 1: Classify the couple Pb^{2+}/Pb

Describe clearly, the procedure of an experiment that allows us to verify the placement of the redox couple Pb^{2+}/Pb in the qualitative electrochemical classification.

Materials:

- *Beakers: 50 mL, 100 mL and 250 mL*
- *Graduated cylinders: 50 mL and 100 mL*
- *Hydrochloric acid solution, 0.1 mol.L^{-1}*
- *Silver nitrate solution, 0.1 mol.L^{-1}*
- *Tin (II) chloride solution, 0.1 mol.L^{-1}*
- *Iron (II) chloride solution, 0.1 mol.L^{-1}*
- *Zinc chloride solution, 0.1 mol.L^{-1}*
- *Copper (II) sulfate solution, 0.1 mol.L^{-1}*
- *Lead (II) nitrate solution, 0.1 mol.L^{-1}*
- *Zinc granules*
- *Tin granules*
- *Copper turnings*
- *Iron filings*
- *Lead strip*
- *Silver wire*

Competency: Devise an experimental procedure relevant to identifying an alkene.

Exercise 2: Identifying an alkene

Two unlabeled flasks: one contains a liquid alkane and the other contains a liquid alkene. Describe a simple experiment that allows to identify the content of each flask. Indicate for each case the reagents and the glassware which are used.

Competency: Devise an experimental procedure relevant to protection of a metal.

Exercise 3: Nickel-plating of iron

For the purpose of protecting the two surfaces of a thin iron flat sheet of size (20cmx10cm) and negligible thickness, we carry out electrolytic nickel plating.
1- Suggest a procedure for an experiment that can be used to protect iron.
2- Justify this procedure.
Given: $E^o(Fe^{2+}/Fe) = -0.44$ V; *$E^o(Ni^{2+}/Ni) = -0.23$ V;*

Materials:
- *Electrolytic basin (enough-size)*
- *Nickel electrode*
- *Iron electrode*
- *Direct current power supply*
- *Nickel sulfate solution, (1 mol.L^{-1})*
- *Iron (II) sulfate solution, (1 mol.L^{-1})*

Competency: Devise an experimental procedure relevant to redox titration.

Exercise 4: Titration of sulfur dioxide using permanganate ion

In industrial regions, sulfur dioxide, one of the gases released into air, contributes to the phenomenon of acid rain formation.
It is required to titrate sulfur dioxide gas against potassium permanganate solution of concentration C. The equation of the reaction that takes place during titration is:

$$2MnO_4^-{}_{(aq)} + 5SO_{2(aq)} + 2H_2O_{(l)} \rightarrow 2Mn^{2+}{}_{(aq)} + 5SO_4^{2-}{}_{(aq)} + 4H^+{}_{(aq)}$$

1- Choose from the following list of materials, the glassware to be used to perform the titration.
2- Describe the titration operation.

Materials:

- *Pipets (volumetric): 5mL, 10 mL and 20 mL*
- *Pipet filler or pipet safety-bulb*
- *Buret: 25 mL*
- *Beakers: 50 mL, 100 mL and 250 mL*
- *Graduated cylinders: 100 mL and 250 mL*
- *Magnetic stirrer and magnetic bar*

Domain: ***Mastery-communicating***
Competency: ***Make use of scientific text relevant to explosives.***

Exercise 1: Explosives

Explosives are used extensively by the in the form of bombs, missiles, depth charges and the like. On the other hand, the application of explosives for peaceful purposes are numerous and important. They are used in excavation and in mining.
They have a recognizable role in realizing huge construction projects: dams and tunnels. They also have diverse applications in metallurgy.
1- Mention the most important applications of explosive for peaceful purposes.
2- Are explosives used for the service of humankind?

Competency: ***Use the schematic drawing relevant to electrolysis.***

Exercise 2: Nickel-plating of iron

For the purpose of protecting the two surfaces of a thin iron flat sheet of size (20cmx10cm) and negligible thickness, we carry out electrolytic nickel-plating.
1- Sketch the diagram of the apparatus used for nickel-plating.
2- Indicate the direction of the current flow and the movement of the charge carriers.

Competency: ***Make use of a tabulated data relevant to electrolysis.***

Exercise 3: Electrolysis

During electrolysis, the measured values for the voltage (U) and the intensity (I) are presented in the following table.

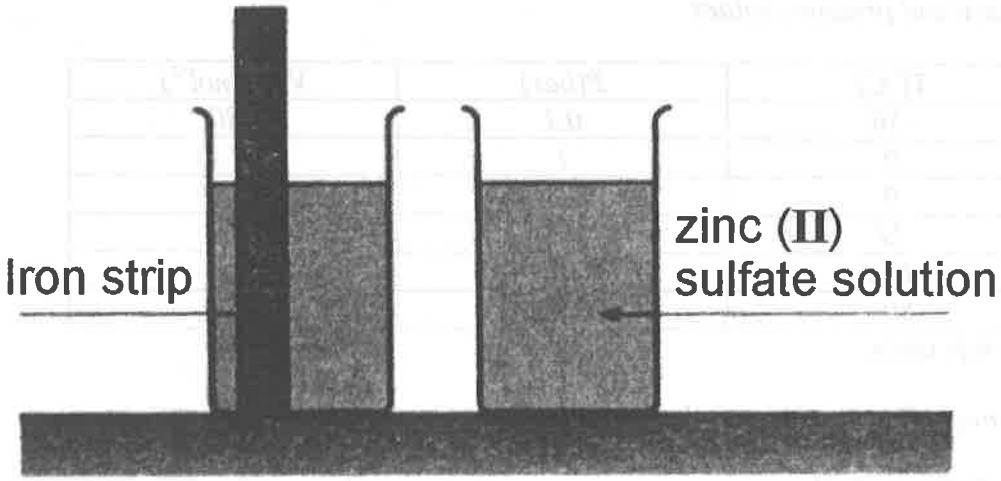
U (V)	0	1	1.5	2	2.2	2.4	2.5	2.6	2.7	2.8
I (mA)	0	0	0	2	5	12	20	30	39	48

1- Plot the graph of the curve U=f(I).
2- Interpret the graph obtained.

Competency: Use the schematic diagram of a Galvanic cell.

<u>Exercise 4:</u> Iron-Zinc Galvanic cell

1- Complete the schematic drawing given below to obtain a standard Galvanic cell.



Given: $E^o(Fe^{2+}/Fe) = -0.44V$ $E^o(Zn^{2+}/Zn) = -0.76V$

2- How does the concentration of Zn^{2+} ions change in the zinc half-cell? Explain.

Competency: Make use of tabulated data relevant to electrochemical classification.

<u>Exercise 5:</u> Electrochemical classification

Using the table for electrochemical classification of redox couples, tell what may happen when:
1- Lead(II) nitrate solution is mixed with copper(II) nitrate solution.
2- A strip of lead is dipped in copper(II) nitrate solution.

Competency: Make use of tabulated data relevant to the change of T, P and V_m.

Exercise 6: Change in T, P and V_m

The following table gives the experimental values of the molar volume of a gas for different temperature and pressure values:

$T(^oC)$	P(bar)	$V_m(L.mol^{-1})$
-56	0.1	180
0	1	22.7
0	1.013	22.4
21	1.013	24.1
100	1	31
800	2	44.6

Interpret this table.

Competency: Read-up a text relevant to biofuels.

Exercise 7: Green fuel

Several months ago, in Rouen (France), vehicles were powered by a biofuel made from the colza oil: the diester. Is this a prelude to generalize the use of biofuels?
Petroleum, fuels are non-renewable, and people have long been looking for alternatives.
Ethanol C_2H_5OH, obtained by the fermentation of sugar, and its derivative, ethyltertbutylether (ETBE) has been tested with success.
The combustion of ethanol releases much less carbon dioxide in the air much less than gasoline, thus, limiting the greenhouse effect and reducing the toxicity of gas emitted from engine exhaust.
The diester, produced from the colza oil, constitutes a renewable source of energy, because it results from the re-absorption of the carbon emitted into the air during its combustion.

1- Explain why the diester and the ethanol are components of biofuels?
2- What is meant by combustible fossils? Give two examples.
3- Give the names and the formulas of two oxides of carbon. Which one is toxic? Which one contributes to the greenhouse effect? What is this effect?
4- Based on the text, explain why the diester is a source of renewable energy.

Competency: Make use of the tabulated data relevant to identify alkenes.

Exercise 8: Density and identification of alkanes

Three bottles numbered 1,2 and 3 are obtained from the stock room of the laboratory: one of them contains hexane, the second contains octane and the third contain decane.
In order to identify the content of each bottle, the density of each of the three liquids is determined using a 50 mL volumetric flask and a precision balance.
Each volumetric flask is weighed when empty, then it is weighed with a liquid filled until the line mark. The results obtained are shown in the table below:

Alkane	*1*	*2*	*3*
Mass of volumetric flask (g), empty	*62.15*	*61.35*	*63.50*
Mass of volumetric flask (g), filled	*98.70*	*94.15*	*98.65*

1- Calculate the mass of the alkane in each of the three volumetric flasks. Deduce the density of each: P_1, P_2 and P_3, then their specific gravity (density relative to water) d_1, d_2, and d_3.
2- Identify the alkanes 1,2 and 3 using the information given in the table and conclude.

Alkane	***Specific gravity***
Pentane	*0.626*
Hexane	*0.665*
Heptane	*0.684*
Octane	*0.703*
Nonane	*0.718*
Decane	*0.730*

Subject: Chemistry

Second Year Secondary
Section: Humanities

Evaluation of Competencies

Domain	Competencies
Applying knowledge	• ***Use specific chemistry knowledge:*** ***Soaps and Detergents:*** *Soap making, composition, cleaning action, impact on the environment and fight against…* ***Synthetic polymers:*** *Properties, classification, synthesis, impact on the environment and fight against…* ***Pesticides:*** *Classification, characteristics, impact on the environment and fight against…* • ***Classify chemical species based on their properties:*** *Detergents, synthetic polymers, pesticides.* • ***Identify:*** *The ingredients of soaps, the active sites of detergents, the raw materials of detergents, biodegradable polymers.* • ***Explain the consequences of chemistry on health, quality of life and environment:*** *Detergents, polymers, pesticides.* • ***Describe some simple experimental activities.***
Mastery-communicating	• ***Use accurate scientific vocabulary*** • ***Utilize various methods to present information:*** *Written, schemata, tables, diagrams, graphs.* • ***Read-up a text, a table or a graph:*** *Soaps and detergents, synthetic polymers, pesticides.* • ***Conduct documentary research:*** *Using different up-to-date sources of information (library research, CD-ROM, internet sites…).*

Domain: ***Applying knowledge.***
Competency: ***Use specific chemistry knowledge relevant to polymers.***

Exercise 1: Plastic bags

On a plastic bag, the following recommendations are written:
This bag is made of P.E., recyclable material. Its destruction by incineration does not release harmful gas or corrosive substances. Protect our environment! Thank you. Do not throw the bag in public places, or in nature.

1- To what category of materials does this plastic bag P.E. belong?
2- What does the term plastic material mean?
3- What does incineration signify?
4- Indicate the products formed during the combustion of this material.
5- Why should not this bag be thrown away in public places or in nature?

Competency: ***Describe some sample experimental activities.***

Exercise 2: Plastic rulers

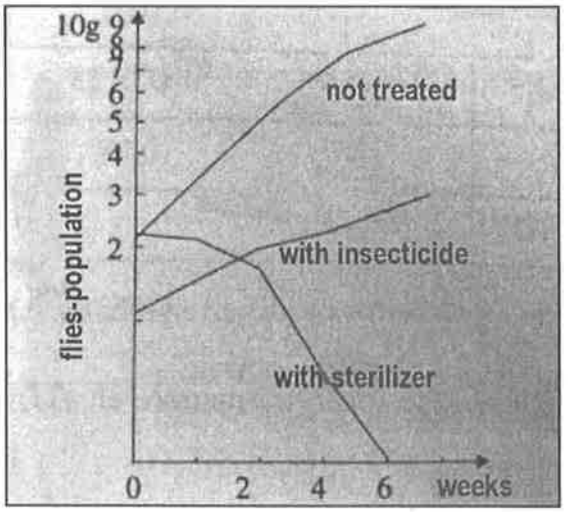
Not all plastic rulers are made up of the same plastic. Some are made of P.V.C. others are made of plexiglass. Describe a chemical test to distinguish one from another?

Materials :
- *Beakers and Erlenmeyer flasks*
- *Test tubes*
- *Bunsen burner*
- *Plastic rulers*

Domain: ***Mastery-communicating.***
Competency: ***Make use of a graph relevant to insects.***

Exercise 1: Insects and insecticides

Some insects intervene in many ecological processes. However, as the population of a certain type increases over a limit the equilibrium of the ecosystem may break down and this may cause, serious damage.
To fight against devastating insects, agriculturists apply various methods: use of insecticides, sterilization,...
Read and interpret the graph shown in the adjacent figure



Competency: Read the text relevant to water pollution.

***Exercise 2:* Detergents and eutrophication**

Lakes and rivers are biologically balanced environments for living things. However, introducing nutrients into the water (mostly phosphorus and nitrogen), causes a change in the aquatic composition of the lake or the river, from oligotrophy (poor in nutrients) into eutrophy (rich in nutrients) and thus produces organic pollution. Excessive nutrients lead to proliferation of algae and their decomposition needs a large consumption of oxygen. This process leads to an anaerobic situation, where hydrogen sulfide is formed, releasing a putrid odor and forming methane, which prevents normal aquatic life. A kilogram of phosphorus allows 114kg of algae to grow. The decomposition of this amount of algae consumes the oxygen dissolved in 14 million liters of water. It is estimated that in European countries 20 to 33% of phosphorus comes from washing powders, in which polyphosphates are added to counteract the effects of calcareous water during washing processes. Moreover, the excessive nutritive mineral wastes (mainly nitrates and phosphates) favor the excessive growth of algae that will bloom and cover the surface of the water. Eutrophication provokes asphyxia and the gradual disappearance of the fauna and flora.

1- Give reasons for the change of an aquatic medium from oligotrophy into eutrophy.
2- What does the following terms mean: eutrophication and proliferation?
3- Indicate the effect of eutrophication on the fauna and flora.

Competency: Conduct documentary research relevant to polymers.

***Exercise 3:* Polymers**

1- Research different types of beverage-making.
2- Compare their advantage and the inconveniences concerning their consumption and the environment.

Subject: Chemistry | *Third Year Secondary*
Section: Life Sciences

Evaluation of Competencies

Domain	Competencies
Applying knowledge	• ***Use specific chemistry knowledge:*** ***Gaseous state:*** *Equation of state of an ideal gas.* ***Chemical kinetics:*** *Rate of reaction, factors influencing reaction rate, auto-catalysis.* ***Chemical equilibrium:*** *Law of mass action, equilibrium constants, displacement of equilibrium.* ***Acid-base reactions in aqueous solutions:*** *pH-metry, acid-base titration, conjugate acid-base pair, ionization constant, buffer solutions.* ***Organic chemistry II:*** *Functional groups, structures, isomerism, physical and chemical properties and preparation of some organic compounds (alcohols, aldehydes, ketones, carboxylic acid and derivatives, amines, and $\alpha-$amino acids).* ***Polymers:*** *Characteristics and uses of natural and synthetic polymers.* ***Soaps and detergents:*** *Preparation and cleaning action, composition and properties of detergents.* ***Medicinal drugs:*** *Formulations, properties, pharmacological effects of some medicinal drugs (analgesics, anesthetics local and general, antacids cationic and anionic, anti-inflammatory, antibiotics, tranquilizers, and antidepressants).* ***New materials:*** *Properties, uses and industry of ceramics and composite materials.* • ***Identify the characteristics of:*** *Reaction of zero, first, and second order, auto-catalysis, chemical equilibrium, acidic and basic medium, quantitative acid-base reaction, some reactions in organic chemistry.*

Domain	Competencies
	• ***Identify the role of:*** *Hydrophilic and hydrophobic groups, surfactants, builders, additives in soaps and detergents, organic functional group of a medicinal drug. (active site).* • ***Classify chemical species based on their properties:*** *Conjugate acid-base pair, organic compounds, polymers, soaps, detergents, medicinal drugs, new materials and their constituents.* • ***Relate the parameters and/or the variables of:*** *Ideal gas, chemical kinetics, chemical equilibrium, acids and bases.* • ***Relate chemical properties to uses:*** *Some chemical products, some materials.* • ***Explain the consequences of chemistry on health, life quality and environment:*** *Catalyzer, physiological role of a chemical product, pH, titration, prolonged use of a medicinal drug, recycling, industry of soaps and detergents, and new materials.*
Designing an experiment	• ***Perform experimental activities:*** *Rate of reaction, factors influencing reaction rate, pH-metry, acid-base titration, identification of organic functional groups (alcohols, aldehydes, ketones), saponification, precipitation of carboxylate ions with metal ions, synthesis of aspirin.* • ***Write report of an experiment.*** • ***Construct molecular models.*** • ***Devise an experimental procedure.***
Mastery-communicating	• ***Use accurate scientific vocabulary.*** • ***Utilize various methods to present information:*** *Written, diagrams, tables, schemes, graphs…* • ***Read-up a scientific text.*** • ***Make use of a tabulated data:*** *Characteristics of ideal gas, parameters of chemical kinetics and chemical equilibrium, classification of conjugate acid-base pair, acid-base titration, physical properties of organic compounds and new materials.* • ***Interpret a scheme and/or a graph:*** *Molecular models, kinetic curves, titration curves.* • ***Conduct documentary research:*** *Using different up-to-date sources of information (library research, periodicals, CD-ROM, internet sites…).*

Subject: Chemistry | | *Third Year Secondary*
Section: General Sciences

Evaluation of Competencies

<table>
<tr><th>Domain</th><th>Competencies</th></tr>
<tr><td>Applying knowledge</td><td>
• Use specific chemistry knowledge:

<u>Gaseous state:</u>
Equation of state of an ideal gas.

<u>Chemical kinetics:</u>
Rate of reaction, factors influencing reaction rate, auto-catalysis.

<u>Chemical equilibrium:</u>
Law of mass action, equilibrium constant, displacement of equilibrium.

<u>Acid-base reactions in aqueous solutions:</u>
pH-metry, acid-base titration, conjugate acid-base pair, ionization constant, buffer solutions.

<u>Organic chemistry II</u>:
Functional groups, structures, isomerism, physical and chemical properties and preparation of some organic compounds (alcohols, aldehydes, ketones, carboxylic acids and their derivatives).

<u>Polymers:</u>
Characteristics and uses of natural and synthetic polymers.

• Identify the characteristics of:
A reaction of zero, first, and second order, auto-catalysis, chemical equilibrium, acidic-basic medium, quantitative acid-base reaction, some reactions in organic chemistry.
• Classify chemical species based on their properties:
Conjugate acid-base pair, organic compounds, polymers.
• Relate the parameters and/or the variables:
Ideal gas, chemical kinetics, chemical equilibrium, acids and bases.
• Relate properties to uses:
Some chemical products, some materials.
• Explain the consequence of chemistry on health, life quality and environment:
Catalyzer, physiological role of a chemical product, pH, titration, recycling.
</td></tr>
</table>

Domain	*Competencies*
Designing an experiment	• ***Perform experimental activities:*** *Rate of reaction, factors influencing reaction rate, pH-metry, acid-base titration, identification of organic functional groups (alcohols, aldehydes, ketones).* • ***Write report of an experiment.*** • ***Construct molecular models.*** • ***Devise an experimental procedure.***
Mastery-communicating	• ***Use accurate scientific vocabulary.*** • ***Utilize various methods to present information:*** *Written, diagrams, tables, schemes, graphs…* • ***Read-up a scientific text.*** • ***Make use of a tabulated data:*** *Characteristics of ideal gas, parameters of chemical kinetics and chemical equilibrium, classification of conjugate acid-base pair, acid-base titration, physical properties of organic compounds.* • ***Interpret a scheme and/or a graph:*** *Molecular models, kinetic curves, titration curves.* • ***Conduct documentary research:*** *Using different up-to-date sources of information (library research, periodicals, CD-ROM, internet sites…).*

Domain: Applying knowledge.
Competency: Identify the characteristics of the oxidation reaction for I^- ion.

Exercise 1: Kinetics for the oxidation of I^- ions.

Study the kinetics of the oxidation reaction for iodide I^- ions by hydrogen peroxide H_2O_2. The equation of the overall reaction is:

$$2I^- + H_2O_2 + 2H^+ \rightarrow 2H_2O + I_2$$

During the progress of this reaction, the temperature and the concentrations of H^+ and I^- ions are kept constant. The table below presents the experimental data for the concentration and the rate of disappearance of H_2O_2 different.

T(s)	0	66	136	210	295	379	469	700	878	1088
$[H_2O_2]$ 10^{-2} mol.L^{-1}	2.55	2.42	2.29	2.16	2.02	1.89	1.76	1.48	1.27	1.08
V 10^{-5}mol.L^{-1}.s^{-1}	1.9	1.9	1.8	1.7	1.6	1.5	1.4	1.16	0.99	0.85

1- *Show that the rate r is proportional to $[H_2O_2]$.*
2- *Verify that the order of the reaction is 1.*

Competency: Identify the characteristics of auto-catalysis.

Exercise 2: Auto-catalysis

The oxidation of oxalic acid $H_2C_2O_4$ by potassium permanganate solution $KMnO_4$ in the presence of sulfuric acid is represented by the equation:

$$2MnO_4^- + 5\ H_2C_2O_4 + 6\ H^+ \rightarrow 2Mn^{2+} + 10CO_2 + 8H_2O$$

We mix 20 mL of $5x10^{-3}$ mol.L^{-1} acidified potassium permanganate solution with 30mL oxalic acid solution of concentration $5x10^{-2}$ mol.L^{-1} .

The progress of the reaction is studied by measuring the amount of the permanganate ions at different times, to determine the rate of disappearance of MnO_4^-. The following results were obtained:

$r_{30(s)}$ = 0.37×10^{-6} mol.s^{-1}
$r_{60(s)}$ = 1.33×10^{-6} mol.s^{-1}
$r_{100(s)}$ = 0.50×10^{-6} mol.s^{-1}

In general the rate of disappearance of a reactant decreases with time as the concentration of this reactant decreases. Is this property verified in the above results? Suggest an interpretation.

Competency: Identify the characteristics of a quantitative acid-base reaction.

Exercise 3: Acidic or basic?

To 1L of potassium cyanide solution (K^+, CN^-) of concentration 4×10^{-2} mol.L^{-1} ($pK_a = 9.4$), we add nitrous acid HNO_2 solution of concentration 8×10^{-2} mol.L^{-1} ($pK_a = 3.4$). Assume the volume of the solution does not change.

1- Calculate the constant K_R of the above reaction. Draw out your conclusion.
2- Determine the pH of the solution obtained. Indicate its nature.

Competency: Identify the characteristics of some reactions in organic chemistry.

Exercise 4: Primary or secondary alcohol?

A molecule of a saturated non-cyclic organic compound A consists of carbon and hydrogen atoms and of only one single oxygen atom. When compound A reacts with sodium metal, hydrogen gas is liberated.

1- Identify the functional group present in compound A. Write the general molecular formula of compound A in terms of n (the number of carbon atoms per molecule).
2- Compound A undergoes mild oxidation to form a compound B which reacts with DNPH and does not reduce Fehling's solution. Give the condensed-structural formula and the name of compound A knowing that its molar mass is 74g mol^{-1}.

Competency: Relate the parameters and/or the variables of chemical kinetics.

Exercise 5: Rate and concentration

In a strong acidic medium, hydrogen peroxide oxidizes bromide Br^- ions to bromine. The equation of the overall reaction is:

$$2Br^- + H_2O_2 + 2H^+ \rightarrow 2H_2O + Br_2$$

The experiment shows that the reaction is first order with respect to each reactant.

1- Under the experimental conditions of the above experiment, the initial rate of consumption of Br^- is $r_0(Br^-) = 10^{-2}$ mol.L^{-1} s^{-1}. Calculate the initial rate of consumption of H_2O_2 and the initial rate of the reaction.
2- At the same previous temperature, the initial concentration of each reactant is halved. Calculate the initial rate of appearance of bromine.

Competency: Relate the parameters and/or the variables of acids and bases.

<u>Exercise 6:</u> Acidic or basic?

One liter of solution (S) is prepared by mixing 500 mL of 1mol. L^{-1} ethanoic acid solution (S_1) with 500 mL of 0.6 mol. L^{-1} ammonia solution (S_2). Calculate the pH of the solution (S).
Given:
$pK_a(CH_3COOH/CH_3COO^-) = 4.8$ *and* $pK_a\ (NH_4^+/NH_3)= 9.2$

Competency: Relate the parameters and/or the variables of chemical equilibrium.

<u>Exercise 7:</u> Displacement of chemical equilibrium

1- Study the effect of: increasing the temperature or decreasing the pressure on the following equilibrium reaction:

$$H_{2(g)} + I_{2(g)} \rightleftarrows 2HI_{(g)} \quad \Delta H= - 10\ kJ.mol^{-1}$$

2- Study the effect of adding carbon (graphite) or adding carbon dioxide on the following equilibrium reaction.

$$C\ (graphite) + CO_{2(g)} \rightleftarrows 2CO_{(g)}$$

Competency: Explain the consequences of acidity on the environment.

<u>Exercise 8:</u> Fish and pH

Fish in fresh water tolerate generally a pH ranging from 6.5 to 7.5. A 500 mL aquarium is filled with rain water whose pH is less than 6.

1- *Interpret the value of pH in rain water? Is this water suitable for fish?*
2- *In an aquarium that initially contains 500L of pure water (pH=7.0), we add mistakenly 25mL of a household compound that contains hydrochloric acid of concentration 2mol L^{-1}.*
3- *Calculate the new pH value and predict the effect of this pollution on fish life.*
4- *Indicate be the effect of a similar error that occurs in an aquarium containing a buffer solution AH/A^-. Draw out your conclusion.*

Given: $[AH] = [A^-]=1.0x10^{-3}$ *mol.* L^{-1} *and* $pK_a(AH/A^-)=6.8$

Competency: Explain the consequences of CO_2 on health.

Exercise 9: ***Blood and pH***

The pH of human blood ranges normally between 7.35 and 7.45; these values are controlled by two acid-base conjugate pairs. CO_2/HCO_3^- ($pK_{a1}=6.1$) and $H_2PO_4^-/HPO_4^{2-}$ ($pK_{a2}=7.2$)

In organisms, methanol CH_3OH is often oxidized in the presence of certain enzymes to methanal HCHO or to methanoic acid HCOOH ($pK_{a3}=3.8$). In the second case, the acid can cause acidosis, which can be fatal when the blood pH becomes less than 6.8,

1- In the acidosis case, calculate the ratios:

$$\frac{[HCO_3^-]}{[CO_2]} \quad ; \quad \frac{[HPO_4^{2-}]}{[H_2PO_4^-]} \quad \text{and} \quad \frac{[HCOO^-]}{[HCOOH]}$$

2- Write the equation of the reaction between HCO_3^- and HCOOH. Calculate the constant K_R.

3- What does the organism do to eliminate the excess carbon dioxide?

Competency: Explain the consequences of the change of lactose in milk.

Exercise 10: ***Degradation of lactose***

Lactose is a milk constituent. Its degradation in the presence of air leads to the formation of lactic acid that is represented by AH of $pK_a=3.8$.
Consequently, the content of lactic acid in milk is considered as a criterion for its freshness and quality.
The average acidity of milk is normally from 1.6to 1.8g L^{-1} of lactic acid that corresponds to a pH from 6.7 to 6.8,
A consumable milk should contain less than 1.8g/L of lactic acid and when the content of the latter exceeds 4 g/L, the milk curdles.

1- Identify the predominant chemical species of the acid-base conjugate pair in a milk of pH =7.

2- It is required to titrate 20mL of a milk with a NaOH solution of concentration 0.1mol L^{-1}. 8.5mL of the basic solution should be added to reach the equivalence point. Is the titrated milk fresh? Justify.

Domain: Designing an experiment.
Competency: Devise an experimental procedure relevant to dilution.

Exercise 1: Dilution

In chemistry, we often prepare diluted aqueous solutions from concentrated or commercial solutions. The label on a bottle containing a hydrochloric acid solution (S_0) of shows the following information:

Density relative to water: d= 1.16
Degree of purity: 37%
Molar mass: $M= 36.5g\ mol^{-1}$

We would like to prepare 1L of hydrochloric acid solution (S) of concentration $C=0.1\ mol^{-1}$ starting from (S_0)

1- *Calculate the volume of the commercial solution (S_0) needed to prepare solution (S).*
2- *List the materials needed to perform this dilution.*
3- *What are the precautions that should be taken into consideration which are recommended on the label of the bottle?*
4- *Describe, in a few lines, the procedure followed to prepare solution (S).*

Competency: Devise an experimental procedure relevant to titration.

Exercise 2: Mineral water

The labels on mineral water bottles indicate the nature of the ions present, their mass concentration and the pH.
We would like to verify experimentally the significance of the label concerning the mass concentration of bicarbonate ion HCO_3^- (bicarbonate ions facilitate digestion).
In order to achieve this, we carry out titration of mineral water with hydrochloric acid solution (S) of concentration $C=0.1\ mol^{-1}$.

Materials:
- *Pipet (volumetric): 5 mL, 10 mL and 20 mL*
- *Pipet filler (Safety bulle)*
- *Washing bottle*
- *Graduated cylinders: 5 ml, 10 mL, 20 mL, 25 mL and 100 mL.*
- *Buret 25 mL*
- *Flasks: 50mL, 100 mL, and 250 mL.*
- *Beakers: 50mL, 100 mL, and 250 mL.*
- *Erlenmyer flasks: 50mL, 100 mL, and 250 mL.*

- *A magnetic stirrer and bar.*
- *Mineral water for analysis*
- *Hydrochloric acid solution of concentration $C=0.5\ mol\ L^{-1}$*
- *Indicator (Bromocresol green, Yellow 3.8 <pH<5.4 blue)*

1- *Describe the steps for preparing 100 mL sample of solution (S) and indicate the glassware used.*
2- *Schematize the glassware used for titration (with legend).*
3- *Describe briefly the procedure followed in titration.*

Competency: Devise an experimental procedure relevant to saponification

Exercise 3: Saponification

Soap is obtained by saponification of fatty substances. This is done by the reaction of sodium hydroxide with a triglyceride.

Materials:
- *Heating mantel*
- *Round bottom flask (250 mL)*
- *Condenser and boiling chips*
- *Graduated cylinder (25mL)*
- *Balance*
- *Washing bottle*
- *Watch glass*
- *Spatula*
- *Gloves and safety goggles*
- *Sodium hydroxide pellets*
- *Olive oil*
- *Ethanol*

I) Using a graduated cylinder introduce, successively, the following into a 250mL round bottom flask:
- *20mL of olive oil*
- *20 mL of ethanol*
- *20 mL of sodium hydroxide of concentration $C=3\ mol.L^{-1}$*

1- *Calculate the mass of solid NaOH that should be weighed to prepare 20mL of sodium hydroxide solution of concentration $C=3\ mol.L^{-1}$ ($M_{NaOH}= 40g\ mol.L^{-1}$)*
2- *Is it necessary to take certain precautions? Why?*

II) Stir the mixture well to homogenize it and subject it to gentle refluxing, for about 30 minutes.
1- *Draw a labeled diagram for the apparatus used.*
2- *Indicate the role of each: heating, reflux condenser and the boiling chips.*
3- *Justify why to use heating mantle instead of a Bunsen burner.*

Domain: Mastery-communicating.

Competence: Utilize the Kinetic curve.

Exercise 1: ***Rate of reaction***

The study of the kinetics for saponification reaction of methyl ethanoate (acetate) gives the following results:

Time (min)	*3*	*5*	*7*	*10*	*15*	*21*	*25*
$[OH^-]$ (10^{-3}mol L^{-1})	*7.4*	*6.3*	*5.5*	*4.6*	*3.6*	*2.8*	*2.5*
$[CH_3COO^-]$ (10^{-3}mol L^{-1})	*2.6*	*3.7*	*4.5*	*5.4*	*6.4*	*7.2*	*7.5*

1- *Write the equation of this saponification reaction.*

2- *Draw on the same graph, the 2 curves representing the concentrations of acetate and OH^- ions versus time. (Take 1 cm for 1 min and 2 cm for 10^3xConcentration)*

3- *Draw the tangents at the 6 and 18 min and determine the gradient (slope) of each tangent.*

Competency: Utilize a schema.

Exercise 2: ***Asymmetric Carbon***

Show using schemes that each of the two compounds: 2-amino propanoic acid and 2-butanol has an asymmetric carbon.

Competency: Use accurate scientific vocabulary.

Exercise 3: ***Catalytic hydrogenation***

In the presence of a catalyst, nickel, the hydrogenation of an aldehyde produces primary alcohol while the hydrogenation of a ketone gives a secondary alcohol.
Write the equations of the two reactions.

Competency: Use accurate scientific vocabulary.

Exercise 4: ***Chemical equations***

Consider the equations of following reactions:

$$CH_3\text{-} CH_2 - CH_2 - CH_2OH + 1/2O_2 \rightarrow CH_3\text{-} CH_2 - CH_2 - CHO + H_2O$$

$$CH_3\text{-} CH_2 - CH_2 - CHO + 2Cu^{2+} + 5\ HO^- \rightarrow CH_3\text{-} CH_2 - CH_2 - COO^- + Cu_2O + 3\ H_2O$$

$$CH_3\text{-} CH_2 - CH_2 - CH_2OH \xrightarrow[(400\ °C)]{Al_2O_3} CH_3\text{-} CH_2 - CH = CH_2 + H_2O$$

$3CH_3- CH_2 - CH_2 - CH_2OH + 2Cr_2O_7^{2-} + 16\ H^+ \rightarrow 3CH_3- CH_2 - CH_2 - COOH + 4Cr^{3+} + 11\ H_2O$

$CH_3- CH_2 - CH_2 - COOH + NH_3 \rightarrow 3CH_3- CH_2 - CH_2 - COONH_4$

1- Name the organic reactants and products involved in the above reactions.
2- Translate these equations into sentences.

Competency: Make use of a tabulated data relevant to chemical equilibrium.

Exercise 5: Chemical equilibrium

The table below shows information about the equilibrium

$$H_{2(g)} + I_{2(g)} \rightleftarrows 2HI_{(g)}\ \Delta H = -10\ kJ.mol^{-1}\ \text{at } 731K$$

Exp.	Initial conc. Mol. L^{-1}			Exp.	Equilibrium conc. mol. L^{-1}		
	$[H_2]$	$[I_2]$	$[HI]$		$[H_2]$	$[I_2]$	$[HI]$
1	2.4×10^{-2}	1.38×10^{-2}	0	1	1.14×10^{-2}	0.12×10^{-2}	2.52×10^{-2}
2	2.44×10^{-2}	1.98×10^{-2}	0	2	0.77×10^{-2}	0.31×10^{-2}	3.34×10^{-2}
3	0	0	3.04×10^{-2}	3	0.345×10^{-2}	0.345×10^{-2}	2.35×10^{-2}
4	0	0	7.58×10^{-2}	4	0.86×10^{-2}	0.86×10^{-2}	5.86×10^{-2}

1- Referring to the data in experiments 1 and 2, show whether
nH_2 reacted $= nI_2$ reacted $= ½n(HI)$ formed.

2- Explain why is $[H_2]_{eq} = [I_2]_{eq}$ in experiments 3 and 4? Is this the same in experiments 1 and 2?

Competency: Make use of a tabulated data relevant to chemical equilibrium.

Exercise 6: Exothermic or endothermic?

Consider the following equilibrium with the tabulated data

$$2SO_{2(g)} + O_{2(g)} \underset{2}{\overset{1}{\rightleftarrows}} 2SO_{3(g)}$$

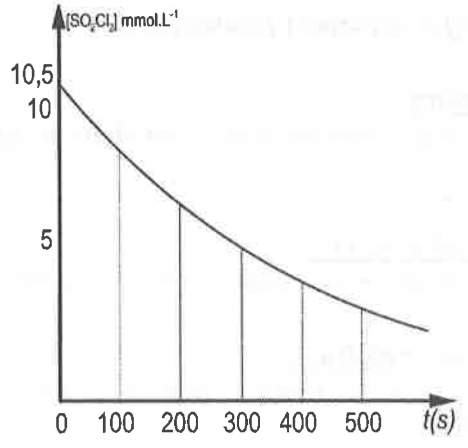
T(°C)	600	700	800	900
K_p	$3.2x10^3$	$2x10^2$	32	6.3

Based on the above given data, deduce whether the forward reaction (direction 1) in the above equilibrium is exothermic or endothermic.

Competency: Interpret a kinetic curve.

***Exercise 7:* Half-life time for a reaction**

Study of the kinetics for the reaction $SO_2Cl_{2(g)} \rightarrow Cl_{2(g)} + SO_{2(g)}$ *allows to plot the graph shown below:*



1- *Determine the half-life time of the above given reaction and show it is constant.*
2- *Indicate the order of this reaction.*

Competency: Read-up a scientific text relevant to new materials.

***Exercise 8:* Composite materials**

Composites can be made by embedding fibers in a plastic base. The fibers may be glass, graphite or nylon. The strength of fibers and the flexibility of plastic produce a material that is strong, light, non-corrosive and ready to absorb vibrations.

1- *Are the materials in a composite chemically combined or retain their own properties?*
2- *List three advantages of using composites instead of metal in car industry.*

Competency: Conduct a research relevant to superconductors

***Exercise 9:* Superconductors**

The "superconductors" are new materials that have great interest in modern industry. Conduct a research in the field of superconductivity relative to: historical overview, principle and fields of application.
Some suggested sources of information are:

1- *Internet: www.yahoo.com (search engine). Visit the following sites:*
http://members.tripod.com/~chabanoiscedric;
http://lema.phys.univ-tours.fr/Matériaux/Supra/IndexS;
2- *Periodicals. CNRS.3 rue Michel-Ange 75794 PARIS CEDEX16-TEL33(0)1 44 96 40-00 FAX33(0) 1 44 96 50 00. JUIN No. ISSN 1162-2024.*

Evaluation of Competencies

Domain	***Competencies***
Applying knowledge	• ***Use specific chemistry knowledge:*** ***Food chemistry:*** *Nature, average composition, contribution of nutrients, catabolism, food diet.* ***Perfumes and cosmetics:*** *Principal formulations, composition, properties.* ***Current medicinal drugs:*** *Brand and generic names, properties and forms of different types of medicinal drugs.* • ***Classify chemical species based on their properties:*** *Carbohydrates, lipids, triglycerides, proteins, minerals, vitamins, additives, cosmetics, raw materials of perfumes, analgesics, anesthetics, pollutants.* • ***Identify:*** *The physical and chemical factors that cause denaturation of proteins;* *The sources, functions, and daily needs for some vitamins;* *The types of proteins in egg;* *The energy requirements of humans;* *The sources of pollution (water, soil);* *The major sources of solid wastes; The considerations for investing in the chemical industry.* • ***Explain the consequences of chemical species on health, quality of life and environment.*** *Food, perfumes and cosmetics, current medicinal drugs, wastes and environment, and chemistry and economy.*
Mastery-communication	• ***Use accurate scientific vocabulary*** • ***Utilize various methods to present information:*** *Written, schemes, tables, diagrams, graphs,…* • ***Read-up a text, make use of a tabulated data or a graph:*** ***Food:*** *nutritional requirements of the body in terms of energy, food supplies, coding system for food additives, composition, food diet.* ***Perfumes and cosmetics:*** *economical aspects, uses, risks, composition, ingredients.*

Domain	*Competencies*
Mastery-communication	***Current medicinal drugs:*** *safety rules, advantages and disadvantages, uses.* ***Wastes and environment:*** *sources, effects, impact and treatment, incineration energy.* ***Chemistry and economy:*** *importance and contribution, social and political effects, production and investment;*
	• ***Conduct documentary research:*** *Using different up-to-date sources of information (library research, periodicals, visits to plants, media, internet,….)*

Subject: Chemistry

Third Year Secondary
Section: Literature and Humanities

Evaluation of Competencies

Domain	***Competencies***
Applying knowledge	• ***Use specific chemistry knowledge:*** ***Food chemistry:*** *Nature, average composition, contribution of nutrients, catabolism, food diet.* ***Perfumes and cosmetics:*** *Principal formulations, composition, properties.* ***Current medicinal drugs:*** *Brand and generic names, properties and forms of different types of medicinal drugs.* • ***Classify chemical species based on their properties:*** *Carbohydrates, lipids, triglycerides, proteins, minerals, vitamins, additives, cosmetics, raw materials of perfumes, analgesics, anesthetics.* • ***Identify:*** *The physical and chemical factors that cause denaturation of proteins;* *The sources, functions, and daily need for some vitamins;* *The types of proteins in eggs;* *The energy requirements of humans.* • ***Explain the consequences of chemistry on health, quality of life and environment.*** *Food, perfumes and cosmetics, current medicinal drugs.*
Mastery-communication	• ***Use accurate scientific vocabulary.*** • ***Utilize various methods to present information:*** *Written, schemes, tables, diagrams, graphs,…* • ***Read-up a text, and make use of a tabulated data or a graph:*** ***Food:*** *nutritional requirements of the body in terms of energy, food supplies, coding system for food additives, composition, food diet.* ***Perfumes and cosmetics:*** *economical aspects, uses, risks* ***Current medical drugs:*** *safety rules, advantages and inconveniences, uses.* • ***Conduct documentary research:*** *Using different up-to-date sources of information (library research, periodicals, visits to plants, media, internet sites…)*

Domain: Applying knowledge.
Competency: Use specific chemistry knowledge relevant to cholesterol.

<u>Exercise 1:</u> Cholesterol

Cholesterol is a compound that is found in our diet and also can be synthesized in the liver.

1- *Is cholesterol a lipid, a protein or a carbohydrate? Justify.*
2- *Is it soluble in water?*
3- *Give two functions of cholesterol in the human body.*

Competency: Use specific chemistry knowledge relevant to milk.

<u>Exercise 2:</u> Milk

Milk is almost a complete food. It is more than a physical-chemical complex structure, because it contains lipids, proteins and carbohydrates.

1- *Identify the principal chemical elements of a protein.*
2- *Name the bond that links protein molecules.*
3- *Cite two functions of proteins in the human body.*

Competency: Identify the sources of pollution relevant to water.

<u>Exercise 3:</u> Water pollution

The analysis of a water sample from a lake shows the presence of ammonium nitrate, bacteria and oil.

1- *Name the possible sources of pollution in the lake.*
2- *Give two water pollutants other than those mentioned above.*

Competency: Use specific chemistry knowledge relevant to cosmetics.

<u>Exercise 4:</u> Baby-cream

Given the composition of a baby-cream:

Ingredients	*Percent mass composition*
Mineral oil	*15*
Softeners	*5*
Emulsifier	*5.5*
Glycerol	*2*
Water	*72.5*
Perfumes, conservatives	*Traces*

1- Indicate the type of emulsion found in this cream.
2- Give the role and the types of the emulsifiers.
3- Indicate the role of glycerol.
4- What does this cream serve for?

Domain: Mastery-communicating.
Competency: Read-up a text relevant to Dutch sauce.

Exercise 1: Dutch sauce

In order to make a Dutch sauce, we beat egg yolk and mix it thoroughly with water, lemon juice and salt. We heat the mixture slowly and add butter gradually while stirring the mixture.
What happens during these successive operations?
At the beginning, we have dispersed the egg yolk molecules so called (surfactants) in the aromatized solution. These molecules, with one of their ends avoiding water, form clusters of structures called micelles; with their hydrophilic ends directed toward the center and their hydrophobic ends directed outward.*
** Surfactant: Molecule or ion, one end being hydrophilic and the other end being hydrophobic.*

While beating, molten butter is gradually introduced into the interior of the micelles. The molten droplets of butter will be covered with surfactant molecules and are dispersed in the aqueous phase. These molecules will be stabilized and give rise for emulsion.

1- What type of mixture is obtained upon mixing directly the different components mentioned in the text?
2- Define the terms: hydrophilic, hydrophobic, and emulsion.
3- Identify the role of a micelle.
4- What does the egg yolk contain?
5- What do we call the phenomena of boiling an egg in water to make it tough?
6- Is the sauce prepared suitable for a person following a low-fat diet? Why?

Competency: Make use of a text relevant to medicinal drug.

Exercise 2: A product not like the others!

In the prescription found in the box of a medicinal drug, we find the following general recommendations:

- *A medicinal drug is a product not like the others.*
- ***It concerns you and your health.***
- ***A medicinal drug is an active product.***
- *Exhaustive research allows us to discover its activity, but its absorption is not always safe.*
- ***Keep out from the reach of the children.***
- *Never abuse medicinal drugs.*
- *Know the medicinal drug you are using*
- ***Use the medicinal drug as prescribed by your physician.***
- *Know what are the medicinal drugs that you need.*

- *Execute the prescriptions exactly as they are required; follow the treatment prescribed.*
- *Do not interrupt, do not take medicinal drugs according to your initiatives.*
- ***Your pharmacist knows the medicinal drug: consult him/her.***
- ***It is not wise to take excessive medicinal drugs.***
- ***It is not wise to take medicinal drugs that you don't need.***

1- A medicinal drug is not a product like the others. Explain.
2- A medicinal drug is prescribed by a physician to a patient. Can it be used by another patient? Why?
3- Whom should you consult to get precise information concerning the diverse effects of a medicinal drug? Why?
4- Indicate to which family do these medicinal drugs belong: Maalox and Panadol?
5- Why should medicinal drugs be kept out of the of children reach of children?

Competency: Read-up a tabulated data relevant to milk.

***Exercise 3:* Composition of milk**

A bottle of powdered milk for children labels the following information:

Average Analysis	*Per 100 g of powder milk*
Energetic value	*2000KJ*
Proteins (caseins, lactoserum)	*16.0 g*
Carbohydrates (lactose, maltose)	*56.4g*
Lipids (lactics, acids vegetal fat, lecithin, lionleic acid)	*21g*
Water	*3.0g*
Mineral salts (Na,K,Ca,Mg,Cl,P)	*3.6g*

1- Define the energetic value of a food.
2- Indicate to which class of oses (saccharides) do maltose and lactose belong.
3- Indicate from which saccharide can we prepare lactose.
4- Write the molecular and linear structural formula of lactose.
5- Linoleic acid in an unsaturated fatty acid. Justify.

Competency: Use accurate scientific vocabulary

***Exercise 4:* Acetyl salicylic acid.**

A drug container is labeled:

Aspirin		
	Acetyl-salicylic acid	*0.5 mg*
	Excipient	*UN tablet*
	Store it in a dry place and at a temperature less than 25 °C	

1- Give the generic name and the brand name of the active constituent.
2- In what formulation is the above analgesic sold?

Competency: Conduct a documentary research relevant to tranquilizers.

***Exercise 5:* Tranquilizers**

1- Conduct a research on the consumption of the two tranquilizers: Valium and Librium in Lebanon.
2- Propose a suitable source to conduct this research and collect information.

Sources of information: physicians, pharmacists, Ministry of Public Health.

Competency: Utilize a table relevant to consumption and wastes.

***Exercise 6:* Consumption and wastes**

A family consumes per day an average of two milk bottles, five boxes of beverages, and 3 bottled water. Allowing for that the masses of the cardboard containing the milk bottles, the aluminium box holding the beverages and the plastic water bottles are respectively: 60, 80 and 50g, give in a table form the mass of the three wastes that are supplied by one family, a dozen of families during one day, one month and one year.

Competency: Make use of text relevant to cosmetics.

***Exercise 7:* The permanent wave: curly hairs**

Hair is mainly composed of a protein, the keratine, formed by the combination of 25 different α-amino acids. It is especially rich (16to 18%) in cystine and possesses a tertiary structure in which there many disulfide S-S linkages (also called disulfide bridge). These disulfide linkages give hair its shape.
A permanent is carried out in two steps.
In the first step, the hair is treated by a reducing agent, ammonium thioglycolate, which causes the breaking of the disulfide linkage and the formation of SH groups.
In the second step, the reduced hair is treated with an oxidizing agent (hydrogen peroxide), which causes the formation of disulfide linkage according to a new location. This linkage gives the keratine a new tertiary structure in the form of curly hair.

1- Define denaturation of a protein.
2- Show that keratine undergoes a denaturation during the treatment described above.
3- What makes the hair curly?

OFFICIAL EXAM. SAMPLES

General Instructions for official exam in chemistry

Third year secondary
Life Sciences and General Sciences Sections

The chemistry exam is a means of evaluating the levels of acquired competencies as defined in the list of competencies in the evaluation guide.

▪ *Nature of the exam*

The chemistry exam is made up of three obligatory questions marked on a total of 20 marks. These questions are independent, and can be solved by the student in any order.
Each of these questions is supposed to evaluate competencies integrated in different domains.

The exam should be based on the following:
- *Strict respect for the spirit of the evaluation policy (guide and samples) and official order. No.21 dated April, 30, 1999*
- *Pedagogic teaching practices balancing the three levels of knowledge (acquisition, transfer and production).*
- *Competencies are chosen from all the domains and designed to integrate the learning objectives of different topics of the curriculum.*
- *Good representation of the proposed documents and a clear drafting of the subjects. Thus, if we require the justification of a result, a derivation, a comment, a figure, we must ask that clearly in the question. We don't reserve marks for implicit questions.*
- *A scheme specific to each question to insure consistency in homogeneous correcting the copies.*
- *Allowing the use of scientific non-programmable calculators so that real and practical questions may be asked*

▪ *Score weighting*

The score of each of the three questions can vary between 6 and 8 points.

▪ *Time*

The time allotted for the chemistry exam is two hours .

Tests should be predesigned and include:
In the domain of ***Applying knowledge****:*

- *Analysis of the relevant data given.*
- *Mobilization of knowledge appropriate to chemistry.:*
  - *Choice of the concept, principle, model, law, hypothesis…*
  - *Choice of the formula*
  - *Literal expression of the solution*
  - *Choice of units.*
- *Mobilization of other knowledge out-of chemistry (calculation, graphs, vectors…)*
- *Validity of result.*

In the domain of ***Designing an experiment:***

- *Choice of materials*
- *Set up*
- *Respect safety rules*
- *Measurement*
- *Answers to questions*
- *Validity of result*
- *Report*

In the domain of ***Mastery - communicating*** *:*

- *Translate one mode of representation to another one.*
- *Respect of rules of the chosen mode of representation (symbol, equation, scale, writing of indices…).*
- *Analysis of important information.*
- *Mobilization of knowledge out-of chemistry.*
- *Mobilization of knowledge relevant to chemistry*
- *Clear redaction.*

This list is not exhaustive.

EXAM SAMPLE – 1

FIRST EXERCISE
(6 points)

MILK

Milk is a complex mixture containing water, sugars, lipids, proteins, mineral salts, vitamins... Fresh milk contains less lactic acid due to the slow degradation of lactose in the presence of bacteria. This is why measuring the acidity of milk gives us an idea about its freshness: increase in milk acidity is due to bad conservation. In what follows, we will suppose that milk acidity is only due to lactic acid.

Given:
Lactic acid $pk_a = 3.9$
Molar mass(M) = $90 g.mol^{-1}$
The concentration of lactic acid in fresh milk should be less than or equal to $1.8 g.L^{-1}$

Materials:
Beakers (100;250 and 500 mL); Erlenmyer flasks (100;250 and 500mL); pipets (graduated) (5;10 and 20mL); pipet fillers; graduated cylinders (10;25 and 50 mL); graduated burets (25 and 50mL) magnetic stirrer; magnetic bar; gloves and goggles for safety.
Indicators and pH range with the corresponding colors.

Methyl orange	*3.1-4.4*	*Red-yellow*
Methyl red	*4.2-6.2*	*Red-yellow*
Phenolphthalein	*8.2-10.0*	*Colorless-pink*

I- Characteristics of lactic acid

1- Degradation of milk is catalyzed by chemical substances. Give the names of the catalysts?
2- Milk is preferably kept in a refrigerator. Indicate the kinetic factor involved in this case to slow down the decomposition of milk.
3- The systematic name of lactic acid is: 2-hydroxypropanoic acid.
  i- Write the condensed structural formula. Circle the functional groups present in this molecule.
  ii- Write the conjugate acid-base pair and identify the predominant species at pH = 6.7: the average value of the pH of fresh milk.

II- Lactic acid titration

1- The acidity of milk is determined by titrating it with sodium hydroxide solution NaOH of concentration 0.05molL^{-1}.

The milk sample is placed in an Erlenmeyer flask. After adding several drops of the indicator, NaOH solution is added progressively while maintaining continuous stirring by a magnetic stirrer.

- *a- Name the glassware that should be used to take a sample of milk (graduated cylinder or pipette)? What glassware is used to add NaOH solution? Draw a labeled schema that shows the titration.*
- *b- Why should we keep on stirring the mixture during the reaction?*
- *c- Discuss the acid-base nature of the solution obtained at the equivalence point.*
- *d- Suggest an indicator for this experiment. How do you detect the equivalence point in this case?*
- *e- Write the balanced equation for the titration reaction.*

2- 20.0mL of milk is titrated with sodium hydroxide solution. The volume of basic solution added to reach equivalence is 9.6mL.

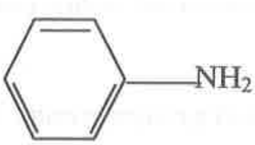
- *a- Calculate the concentration of lactic acid in the milk in both mol.L-1and g.L-1.*
- *b- Is the analyzed milk fresh or not? Justify.*

SECOND EXERCISE
(7.5 points)

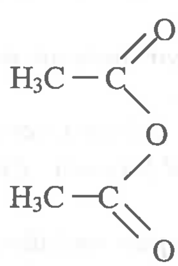
ACETANILIDE

Acetanilide, once was used as an antipyretic under the name of antifebri. In the lab, it can be prepared by the reaction of one mole of aniline (phenylamine or benzamine) of formula $C_6H_5NH_2$ and one mole of ethanoic (acetic) anhydride of formula $(CH_3CO)_2O$.

Given:



Aniline $C_6H_5NH_2$; d= 1.02g/L
Molar mass(M)=93 g.mol^{-1}.



Ethanoic anhydride; d=1.08g/L
Molar mass(M)= 102g.mol^{-1}

Acetanilide: molecular formula C_8H_9NO; molar mass(M)= 135g.mol^{-1}.

pk_a (CH_3COOH/CH_3COO^-) = 4.8; pk_a ($C_6H_5N^+H_3/C_6H_5NH_2$)=4.6

Materials:

Beakers (100, 250, and 500 mL); Erlenmyer flasks (100, 250, and 500 mL), pipets (graduated) (5, 10, and 20 mL); pipet fillers; graduated cylinders (10, 25, and 50 mL) round-bottom flasks (100 and 250 mL), condenser, electric heating mantle; gloves and goggles for safety.

I- Study of the reaction

1- *What is the functional group that characterizes acetanilide? Write the structural formula and give the systematic name of acetanilide.*
2- *Why do we use ethanoic anhydride instead of ethanoic acid to prepare acetanilide?*
3- *Write the equation of the two possible reactions.*
4- *One of the two reactions cannot take place. Which one is that? Justify your result using the two pk_a values that are given.*
5- *What is another derivative of ethanoic acid that can be used to prepare acetanilide? Write its structural formula and give its name.*
6- *Write the balanced equation of the corresponding reaction and indicate its principal characteristics.*

II- Preparation

In a perfectly dry flask, introduce 25mL of acetic (ethanoic) acid as a solvent, 15mL of ethanoic anhydride, 10mL of aniline and some boiling chips.
Reflux the mixture for 15 minutes and then stop heating after refluxing. While the reaction mixture is still hot, add it slowly and carefully into a beaker containing 400mL of distilled water. Acetanilide crystals appear. The mixture is cooled in a cold water bath. The crystals recovered by filtration are recrystallized (to obtain pure acetanilide) filtered again and cleaned with water-ice then dried in an oven. 12.7g of pure product is obtained.

1- *Why should we use a perfectly dry container?*
2- *Indicate the glassware that should be used to measure the different liquids.*
3- *List the precautions to be taken while using ethanoic anhydride.*
4- *Draw a labeled schema for the reflux apparatus.*
5- *Calculate the amount of reactants used. What is the limiting reactant? Calculate the yield of the reaction.*

THIRD EXERCISE
(6.5 points)

DECOMPOSITION OF HYDROGEN PEROXIDE

Hydrogen peroxide decomposes into water and oxygen according to the equation:
$H_2O_{2(l)} \rightarrow H_2O_{(l)} + \frac{1}{2} O_{2(g)}$.
It is suggested to study the kinetics of the decomposition reaction of H_2O_2*. The decomposition reaction of* H_2O_2 *is very slow at* 20^oC*; to make it faster, a suitable catalyst is used.*

Given:

Materials:
Graduated cylinders (10, 25, and 50mL), volumetric flasks (50;100 and 200mL), pipets (graduated) (5;10 and 20mL), pipet fillers, glass tubes, plastic tubing, Erlenmeyer flasks (100;250 and 500mL), beakers (100;250 and 500mL), gloves and goggles for safety.

Experiment I:

During this experiment, the temperature is maintained constant at 20^oC*, the initial concentration of hydrogen peroxide in the solution is* $[H_2O_2]_o = 0.06 mol.L^{-1}$*, the volume of the solution is considered constant during this experiment.*
To determine the concentration of hydrogen peroxide as a function of time, we measure the volume of oxygen formed during the reaction. Results are shown in the table below:

T(min)	0	5	10	15	20	25	30	40	60
$[_1H_2O_2]$ $(\times 10^{-2}) mol.L^{-1}$	6.0	4.7	3.8	3.0	2.4	2.0	1.5	1.0	0.35

1- *Sketch the curve* $[H_2O_2] = f(t)$
Scale x-axis 1cm –5 min.
y-axis 2cm –$0.01 mol.L^{-1}$
2- *Determine graphically the average rate of disappearance of hydrogen peroxide between* $t_1 = 20 min$ *and* $t_2 = 35 min$*.*
3- *Determine graphically the instantaneous rate of disappearance of hydrogen peroxide at* $t=0$ *min and* $t=30$ *min. How does this rate vary? Justify.*
4- *Determine graphically the half-life of the reaction.*
5- *Show that the reaction is of the first order with respect to hydrogen peroxide. Write the rate law of the reaction.*

Experiment II

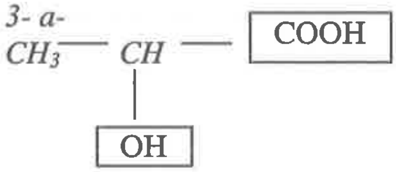
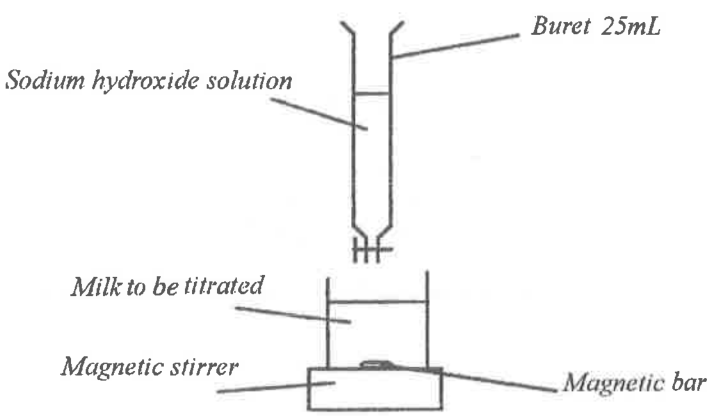
From the initial concentration of $[H_2O_2]_o$=0.06mol.L^{-1} we prepare a solution of concentration of 0.03mol.L without changing the temperature 20^oC.

1- *Describe briefly the experimental procedure that should be followed to prepare 100mL of the diluted solution of hydrogen peroxide. The materials used should be chosen from the above given list.*

2- *Draw, on the same preceding graph, the curve $[H_2O_2]=f(t)$*

3- *Does the variation in the initial concentration of hydrogen peroxide affect the half-life of the reaction? Justify.*

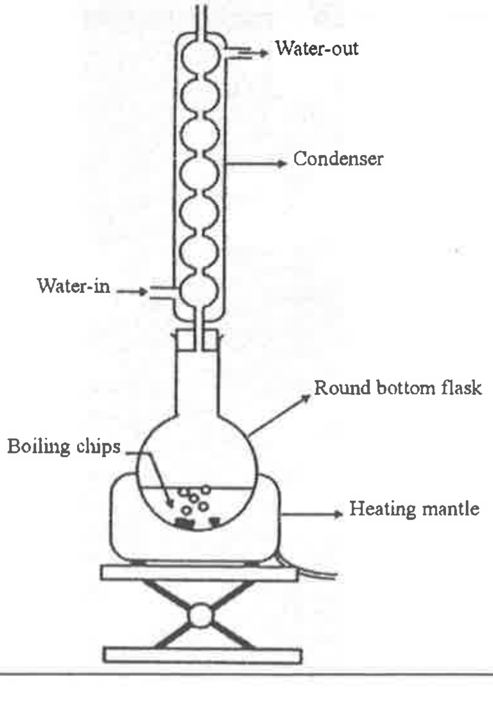
1- MILK (6 points)

Expected solution	***Scale***	***Comments***
I- Characteristics of lactic acid:		
1- Enzymes or biological catalysts	*0.25*	
2- Temperature: the rate of a chemical reaction decreases as the temperature decreases.	*0.25*	
3- a- 	*0.75*	*0.25 for circling the functional groups.*
b- $CH_3CHOHCOOH/CH_3CHOHCOO^-$ (HA/A^-)	*0.25*	
$Ka= \frac{[A^-]\times[H_3O^+]}{[AH]}$ *or* $pH= pKa + log\frac{[A^-]}{[AH]}$	*0.25*	
$= 6.7-3.9 = 2.8;\ \frac{[A^-]}{[AH]}= 631$	*0.25*	
At pH =6.7. it is the anion lactate which predominates.	*0.25*	
II- Lactic acid titration		
To perform titration, you are supposed to use a pipet (graduated) to the milk and buret to add a NaOH solution.	*0.5*	*Any equivalent reasoning is accepted.*
	*0.5*	*0.25 for schema* *0.25 for legend.*

b- *To homogenize the solution.*		*Equivalent reasoning is accepted.*
c- *Lactic acid is a weak acid. At the equivalence point, lactate ion, the conjugate base of lactic acid, dominates. The solution is basic pH>7.*	*0.25*	
d- *The solution being basic at the equivalence point, the indicator should be phenolphthalein. Before equivalence, the color is white (creamy). After equivalence, the color is pink.*	*0.5*	*0.25 for the choice of the indicator.*
e- $CH_3CHOCOOH + OH^- \rightarrow CH_3CHOCOO^- + H_2O$.	*0.5*	
2- a- *At equivalence: na=nb. This is also written as Ca×Va leading to* $Ca=2.4\times10^{-2}$ *mol.*L^{-1} *Mass concentration = Ca×M=2.16g.*L^{-1}.	*0.50* *0.25*	
b- *the mass concentration determined is higher than 1.8g.*L^{-1}*, therefore the milk is not fresh.*	*0.25*	

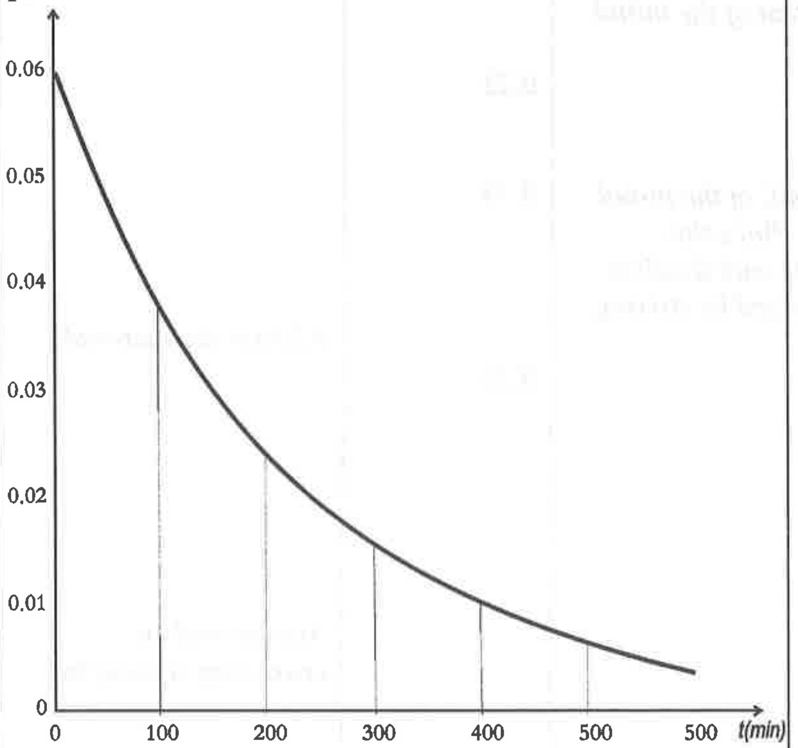
2- ACETANILIDE (7.5 points)

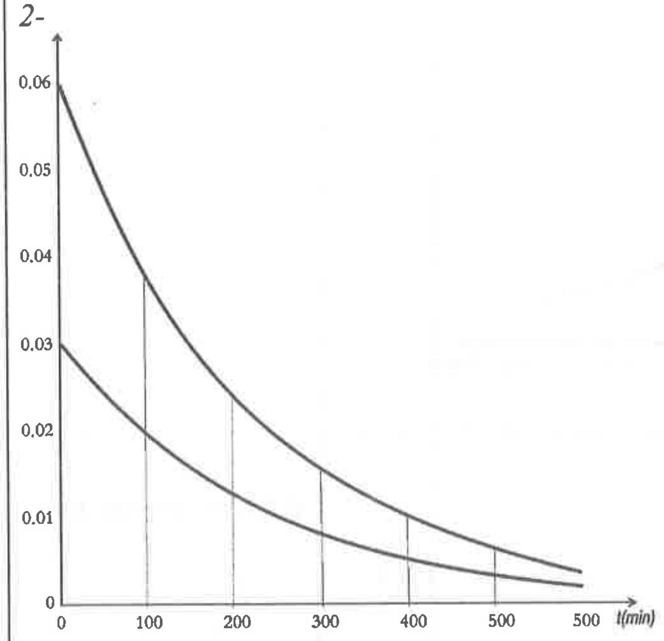
Expected answer	Scale	Comments
I- Study of the Reaction *1- Acetanilide results from the reaction between a primary amine and an acid anhydride; this reaction leads to the formation of an amine and a carboxylic acid. Acetanilide is characterized by the functional group amide:* $-\underset{\underset{O}{\Vert}}{C}-N-$	0.25	*Any equivalent reasoning is accepted.*
Its structural formula is: $CH_3-\underset{\underset{O}{\Vert}}{C}-NH-C_6H_5$	0.25	
It is N-phenylethanamide or N-phenylacetamide.	0.25	
2- The reaction between a carboxylic acid and an amine is an acid-basic reaction leading in general to the formation of an alkylammonium carboxylate. This latter has to be heated at high temperature to form the corresponding amide, while the reaction between acid anhydride and the amine leads directly and rapidly to the formation of the amide.	0.25	*Any equivalent reasoning is accepted.*
3- $(CH_3CO)_2 + C_6H_5NH_2 \rightarrow CH_3CONHC_6H_5 + CH_3COOH$ $CH_3COOH + C_6H_5NH_2 \rightarrow CH_3COO^-, C_6H_5NH_3^+$	0.25 0.25	
4- The second reaction is less favorable. In fact, this reaction is a conjugate acid-base pair reaction having close pka values.	0.25	*Any equivalent reasoning is accepted.*
We have: $K_R = \frac{K_{a1}}{K_{a2}} = \frac{10^{-4.8}}{10^{-4.6}} = 10^{-0.2} = 0.63$	0.25	
The calculated value of K_R *shows that the formation of phenylamonnium ethanoate is not favored.*	0.25	

5- *Ethanoyl chloride (acetylchloride) CH_3COCl can be used to prepare acetanilide.*	*0.5*	*0.25 for the formula*
6- $CH_3COCl + C_6H_5NH_2 \rightarrow CH_3CONHC_6H_5 + HCL$ *N.B:* $HCL + C_6H_5NH_2 \rightarrow C_6H_5NH^+_3, Cl^-$ *This reaction is complete, exothermic, and fast.*	*0.25*	*0 if there is a mistake*
II- Preparation		
1- Ethanoic anyhydride can be easily hydrolyzed. For this reason, you should use dry materials and reactants.	*0.25*	
2- The volume of ethanoic acid is not precise, you can measure it by a 25mL graduated cylinder. Both volumes of aniline and ethanoic anhydride are precise, so you should use a precise instrument for this measurement.	*0.25*	
Use a pipet (volumetric) (20mL) and pipet filler to take 15mL of ethanoic anhydride. Also, use another pipet 10mL with a pipet filler to measure 10mL of aniline.	*0.5*	
3- Ethanioc anhydride being irritating, you should deal with it under a hood and wearing goggles and gloves for safety.	*0.25*	
4- 		*0.5 for the schema.* *0.5 for the legend.*

5- Mass of anhydride: 15 × 14.08 = 16.2g		
Number of moles of anhydride: 16.2/102= 0.16mol.	*0.25*	
Mass of aniline: 10 ×1.02 = 10.2g.		
Number of moles in aniline = 10.2/93 = 0.11mol.	*0.25*	
The stochiometric coefficients of the reaction give us the relation: $\frac{n(anhydride)}{1} = \frac{n(aniline)}{1}$	*0.25*	
or we have: $\frac{n(anhydride)}{1} = 0.16 > \frac{n(aniline)}{1} = 0.11$	*0.25*	
so the limiting reagent is aniline.	*0.25*	
Expected mass of aniline = 0.11 × 135 = 13.5g.	*0.25*	
The yield of the reaction is: $\frac{12.7 \times 100}{13.5} = 94\%$	*0.5*	

3- ***HYDROGEN PEROXIDE DECOMPOSITION*** *(6.5 points)*

Expected Solution	***Scale***	***Comments***
I- Experiment I *1-* 	*1.25*	*-0.25, if each scale is changed.* *0 if the axes are changed.*
2- $r_{average}(20\text{-}35) = \dfrac{-(1.0-3.9)\times10^{-2}}{37.5} = 7.73\times10^{-4}\ mol.L^{-1}.min^{-1}$	*0.75*	*0.25 for the rate unit.*
3- $r_o = \dfrac{-(1.5-6.0)\times10^{-2}}{14} = 3.21\times10^{-3}\ mol.L^{-1}min^{-1}$. $r_{30} = -(1.5-6.0)\times10^{-2} = 6.33\times10^{-4}\ mol.L^{-1}min^{-1}$.	*0.5*	
$r_{30}<r_0$*; the rate of the reaction decreases because the concentration of the reactants decreases with time; the rate of the reaction is directly proportional to the concentration of the reactants.*	*0.5*	*Any equivalent reasoning is accepted*
4- The curve shows that the concentration of hydrogen peroxide becomes equal to half the initial concentration at t=15; so $t_{1/2} = 15$ *min.*	*0.25*	

5- The table and the graph show that the concentration of hydrogen peroxide is always divided by 2 every 15 minutes. This characteristic is specific of the first order reactions where $t_{1/2}$ is independent of the initial concentration of the reaction.	*0.75*	
The rate law of the reaction is: $r = k[H_2O_2]$	*0.25*	
II- Experiment II *1- Using a 50mL pipet, take 50mL of the initial solution of hydrogen peroxide. Place this volume in a 100mL flask. Dilute with distilled water. The solution is homogenized by stirring.*	*0.75*	*0.25 for the material.*
2- 	*0.25*	*Any equivalent reasoning is accepted.*
3- This is a first order reaction. The temperature should remain constant and $t_{1/2}$ is independent of the initial concentration of H_2O_2.	*0.5*	

EXAM SAMPLE-2

FIRST EXERCISE

(7 points)

HOUSEHOLD PRODUCT

On the label of a bottle containing a household product used as drain opener, we read: "19% NaOH max; causes severe burning; dissolves all organic materials; keep out of reach of children; d=1.2kg.L^{-1}.

Given:

Molar mass(M) in g.mol^{-1} M(H) =1; M(O)=16; M(Na)=23.
Pk_a values of conjugate acid-base pair: $H_3O^+/H_2O = 0$; $H_2O/OH = 14$.

Materials:
Beakers (100;200; and 500mL); Erlenmeyer flasks (100; 250 and 500 mL) ; pipets volumetreic (5, 10 and 20mL), pipets (graduated) (5, 10 and 20mL), pipet fillers, graduated cylinders (10, 25, and 50mL), volumetric flasks (100, 250, 500, and 1000mL); burets (25 and 50mL), magnetic stirrer, magnetic bar, pH meter; gloves and goggles for safety.

Indicators and pH range with the corresponding colors:

Methyl orange	*3.1-4.4*	*Red-yellow*
Methyl red	*4.2-6.2*	*Red-yellow*
Bromothymol blue	*6.0-7.6*	*Yellow-blue*
Phenolphthalein	*8.2-10.0*	*Colorless-pink*

Titration is carried out at a temperature of 25°C.

I- Dilution

The concentration of NaOH being very high, we prepare V_1=0.5L of a solution of concentration $C_1=C_0/50$; C_o is the concentration of NaOH in the commercial solution.

1- *Write the equation of ionization of NaOH in water.*
2- *Describe in detail, the procedure followed for preparing the diluted solution NaOH, indicating the precautions that should be taken, the volume of commercial NaOH taken and the glassware used.*

II- Titration

We take V_b=20mL of the diluted solution of concentration C_1 and we place it in a beaker. We add progressively a solution of HCl of concentration C_a=0.1mol.L^{-1}. Using a pH-meter we follow the change of the pH of the mixture in function of V_a; the volume of HCl solution added.

1- *Sketch and label a diagram representing pH-metric titration.*
2- *Indicate the conjugate acid-base pair present? Represent them on a vertical scale of pKa. Circle the species that participate in the acid-base reaction.*
3- *Write the equation of the reaction that takes place.*
4- *Calculate the constant K_R of this reaction and deduce that it can be considered as a complete quantitatively reacted reaction.*

III- Study of Titration

The pH values as a function of the acid volume added V_a are given in the table below

V_a(mL)	0	4	6	10	14	18	20	21	22	23
PH	13.1	12.8	12.7	12.6	12.4	12.2	12.1	11.9	11.6	11.2

V_a(mL)	23.5	24	24.5	25	26	28	30	32	34	36
PH	11.0	7.0	3.4	3.0	2.5	2.0	1.8	1.2	1.1	1.1

1- *Draw the curve pH = f(V_a)*
scale: x-axis 1cm-4mL
y-axis 1cm-2pH units.
2- *Determine the coordinates of the equivalence point and deduce the concentrations of C_0 and C_1.*
3- *Calculate the percentage by mass of NaOH in the household product. Does the result match the indication on the label?*
4- *If the titration were followed by using an indicator, which one of the indicators listed above would be convenient? Justify.*

SECOND EXERCISE
(6 points)

STUDY OF A GASEOUS MIXTURE

Given:

Molar mass(M) g.mol^{-1}: M(C) = 12, M(O) = 16, M(N) = 14.
Universal ideal gas constant: R = 0.085 bar.L.mol^{-1}.K^{-1}

I-*Partial Pressure:*

At 27°C, a non combining gaseous mixture (G) containing, 0.10 mol nitrogen dioxide and 0.03 mol of carbon monoxide is introduced into a closed container of constant volume equal to 10L. Calculate:

1- *The partial pressure of each component of G.*
2- *The molar fraction of each component of G.*
3- *The average molar mass of G. Deduce the density of G relative to N_2.*

II- *Reaction Order:*

At a temperature T=500K, the following reaction takes place:

$NO_2(g) + CO(g) \rightarrow CO_2(g) + NO(g)$

In order to determine the reaction order, we carry out three experiments at a temperature of 500K by introducing successively well determined amounts of carbon monoxide and nitrogen dioxide. We measure in each case the initial rate r_0 of the reaction. The results obtained are shown in the table below:

	Number of moles of NO_2 introduced	*Number of moles of CO introduced.*	*r_0 (mol/L.hr)*
Experiment I	*0.10*	*0.03*	*0.6×10^{-2}*
Experiment 2	*0.01*	*0.06*	*1.20×10^{-2}*
Experiment 3	*0.30*	*0.03*	*1.80×10^{-2}*

1- *Determine the partial orders of the reaction relative to NO_2 and CO and give the rate law.*
2- *Calculate the specific rate constant.*
3- *Determine the initial rate at the same temperature, when we mix 0.02mol of NO_2 and 0.30mol of CO.*

III- Composition of a Mixture at Time t:

We follow the progress of the reaction of mixture G with time, in experiment 1 (0.10 mol of NO_2 and 0.03mol of CO). Let x be the number of moles of CO_2 formed at an instant t:

1- Calculate in terms of x:

a- the partial pressure of each component of the mixture G' obtained at time t.

b- the percentage by mass of each component of G'.

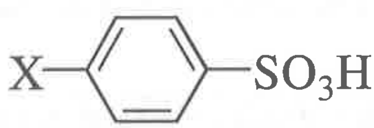
2- Calculate the molar composition of the mixture formed at $t_{1/2}$.

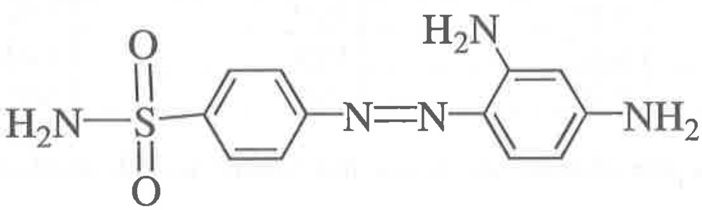
THIRD EXERCISE
(6 points)

SULFANILAMIDE

Aniline, a primary amine, is the simplest aromatic amine where the functional nitrogen atom is directly bonded to the carbon atom of the benzene ring, which contains no functional groups. The substitution reaction of one atom or a group of atoms Y in an aromatic compound C_6H_5-X depends on the nature of X, substitution will occur mainly at the para-position (position-4) relative to X.

During the monosulfonation, Y is the SO_3H group and the reaction in this case leads to a derivative of benzosulfonic acid, where the formula is given below:





Sulfanilamides were developed in 1935 when prontosil (an indicator) was also found. Prontosil possesses antibacterial properties, which are due to a metabolic product in prontosil called sulfanilamide.

Synthesis of sulfanilamide involves N-phenylethanamide, which is obtained during the reaction between aniline and ethanoyl chloride in dry medium.

Given:

Materials:

Beakers (100, 250, and 500 mL); Erlenmeyer flasks (100, 250, and 500mL); pipets (graduated)(5, 10, and 20mL), graduated cylinders (10, 25, and 50mL); pipet fillers, gloves and goggles for safety.

I-*Formula of an organic compound*

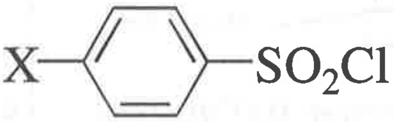
1- Write the structural formula of aniline.
2- Using molecular models kit, refer to:
-Black balls, with 2, 3, or 4 holes representing the carbon atom.
-Blue balls, with 3 or 4 holes representing the nitrogen atoms.
-White balls, with 1 hole representing the hydrogen atoms.
-In addition to plastic rods with different lengths.
a- Choose the corresponding balls to construct ball-and-stick molecular model of aniline.
b- Does the constructed model represent the real and actual structure of aniline? Justify.

II- *Hydrolysis of ethanoyl chloride*

To prepare the compound A, we use ethanoyl chloride instead of ethanioc acid.
1- Describe, with the precautions that should be taken and the materials to be used, an experiment that shows the reactivity of ethanoyl chloride with water.
2- Write the equation of the hydrolysis of ethanoyl chloride.
3- The mixture obtained due to hydrolysis is strongly acidic. Interpret.

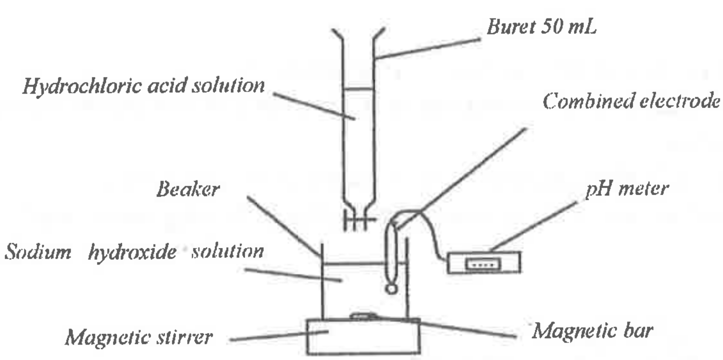
III- *Preparation of sulfanilamide*

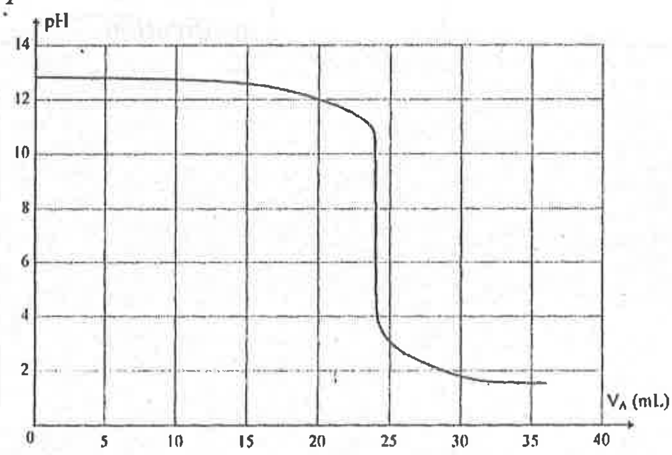
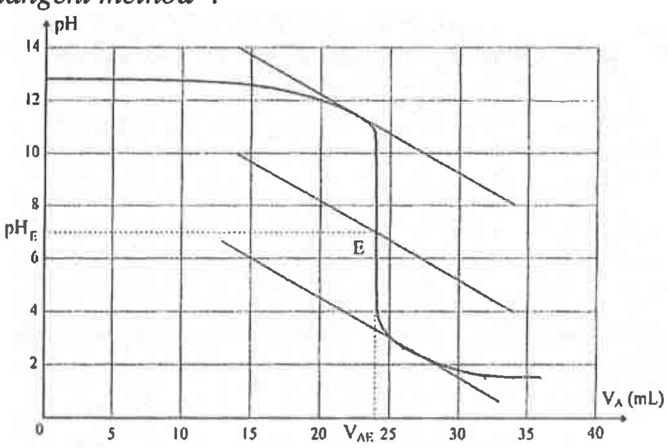
1- Write the balanced equation for the preparation reaction of compound A.
2- We submit compound A to monosulfonation and compound B is obtained. Write the balanced equation of the corresponding reaction.
3- Chlorosulfuric acid Cl-SO_2-OH reacts in the same way at the (para position) with a monosubstituted aromatic compound to give a compound having the following structural formula:



Give the condensed structural formula of the compound C obtained by the action of chlorosulfuric acid and compound A.
4- The group –SO_2Cl, like acylchloride, reacts with NH_3 to form –SO_2NH_2. Write the equation of the reaction of compound C with amonia NH_3 to give compound D.
5- The group CH_3—CO—NH— of compound D is hydrolyzed in an acidic medium to form sulfanilamide. Give the condensed structural formula of this latter.
6- Sulfanilamide is a metabolic product of prontosil.
a- What bond in prontosil is broken to form sulfanilamide?
b- Prontosil and other disubstituted sulfanilamides are administered when a retarded antibacterial effect is desired. Explain what does this signify.

1-HOUSEHOLD PRODUCT (7 points)

Expected solution	*Scale*	*Comments*
I. Dilution *1- $NaOH \rightarrow Na^+ + OH^-$*	*0.25*	
2- $C_1 = Co/50$; $V_1 = 500mL$ *The amount of NaOH in the prepared solution is:* *$n=C_1 \times V_1$.* *This quantity should be taken from the commercial solution.* *So, $n = Co \times Vo$* *Therefore, $C_1 x V_1 = Co x Vo$ and $Vo = V_1/50 = 10mL$.*	*0.50*	
The commercial solution is corrosive. You should wear gloves and goggles for safety.	*0.25*	
We remove using a graduated pipet, 10 mL of the commercial solution and we put them in 500 mL flask. We add distilled water just below the line mark on the volumetric flask then continue adding carefully by a dropper distilled water till the line mark.	*0.5*	
II- Titration *1-*  	*0.75*	*0.5 for labeling the schema.*
2- Conjugate acid-base pairs present: H_3O^+/H_2O and H_2O/HO^-	*0.25* *0.5*	*O is the scale is not oriented.* *0.25 for circling the species.*
3- The reaction takes place between the strongest acid and the strongest base. *Equation of the reaction: $H_3O^+ + HO^- \rightleftarrows 2H_2O$* $\boxed{HO^-}$ — $\boxed{H_2O}$ $\boxed{H_2O}$ — $\boxed{H_3O^+}$	*0.25* *0.25*	*0 if H_2O is not circled.* *0 if one arrow is used without mentioning K_R.*

4- The constant K_R of the reaction is equal to the ratio of Ka constants of the 2 conjugate pairs involved in the reaction. *Pka_1 (H_3O^+/ H_2O) = 0* *Pka_2 (H_2O/HO^-) = 14.* *$K_R = Ka_1/Ka_2 = 10^{(pKa1-pKa2)} = 10^{14}$*	*0.25*	
K_R is higher than 10^{14}, so the reaction between OH^- H_3O^+ is complete i.e. quantitatively are reacted *III- Titration* *1-* 	*0.75*	
2- The equivalence point is determined by "the tangent method". 	*0.5*	*0.25 without drawing the tangent lines.*
Va_E = 24 ml. *PH_E = 7.*	*0.25*	
At the equivalence point: $n(H_3O^+) = n(HO^-)$ *$CaxVaE = C_1xVb$* *Given C_1 = 0.12 mol* *Co = 50 x 0.12 = 6 $mol.L^{-1}$*	*0.5*	

3- The mass concentration of the commercial solutions is: C = CoxM = 6x40 = 240g.L^{-1} *The % by mass of the household product is 240/1200 x100 = 20%. The error is 1%.* *4- You use the bromothymol blue because its pH range is (6.0-7.6) includes the pH of equivalence point.*	*0.25* *0.25* *0.5*	 *Any equivalent reasoning is accepted.* *(Strong acid + strong base; pH = 7)* *0.25 for the justification.*

2- STUDY OF A GASEOUS MIXTURE (7 points)

<table>
<tr><th>Expected solution</th><th>Scale</th><th>Comments</th></tr>
<tr><td>

I- *Partial pressure*

1- We apply the equation of state:
$P \times V = ni \times R \times T$

$P(NO_2) = \frac{0.1 \times 0.085 \times 300}{10} = 2.55 \times 10^{-1}$ bar

$P(CO) = \frac{0.03 \times 0.085 \times 300}{10} = 7.65 \times 10^{-2}$ bar

2- The molar fraction is given by the relation:
$Xi = ni/nt$ with $nt = 0.13$ mol
$X(NO_2) = 0.1/0.13 = 0.77$
$X(CO) = 0.03/0.13 = 0.23$

3- The average molar mass is given by the relation:
$M_G = \sum Xi \times Mi = X_1 \times M_1 + X_2 \times M_2$
$M_G = 0.77 \times 46 + 0.23 \times 28 = 41.85$ g.mol^{-1}

II- *Reaction order:*

1- Calculate the concentrations of NO_2 and CO in each of the 3 experiments. The results are given in the table below:

	$[NO_2]_0$ mol.L^{-1}	$[CO]_0$ mol.L^{-1}	V_0 mol.L^{-1}h^{-1}
Experiment 1	0.01	3×10^{-3}	0.6×10^{-2}
Experiment 2	0.01	6×10^{-3}	1.2×10^{-2}
Experiment 3	0.03	3×10^{-3}	1.8×10^{-3}

</td><td>

0.25

0.25

0.25

0.25
0.25

0.25

0.25

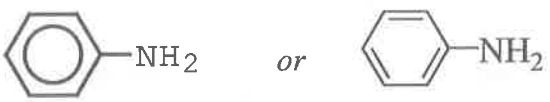
</td><td></td></tr>
</table>

It is obvious: in both experiments 1 and 2, the initial concentration of nitrogen dioxide did not change. *Also, in experiments 1 and 3, the initial concentration of carbon monoxide did not change*		
The rate law of the reaction is: $R = k \times [NO_2]^a \times [CO]^B$	0.25	
From experiments 1 and 2 a=1 *From experiments 1 and 3 B=1.*	0.25	
Therefore, $r = k \times [NO_2]\ [CO]$	0.25	
2- $k = \dfrac{r_0}{[NO_2]\ [CO]_0}$	0.25	
using the results of experiment 1, we obtain: $K = \dfrac{0.006}{0.01 \times 0.003} = 200 mo^{l-1} L.h^{-1}$	0.25	*0 if without unit*
3- $[NO_2]_0 = 2\times10^{-3}\ mol.L^{-1}$; $[CO]_0 = 0.03\ mol.L^{-1}$		*0 if without unit*
$r_0 = k\ [NO_2]_0\ [CO]_0$ $r_0 = 200 \times 0.002 \times 0.03 = 0.012 mol.L^{-1}.h^{-1}$		*0 if without unit*
III- *Composition of the mixture at time t:* *1-* a- $P_i = \dfrac{n_i RT}{V} = 2.55 n_i$ *The results are found in the table below:*	1	

Substance	NO_2	CO	CO_2	NO
n_0 *mol*	0.10	0.03	0	0
n_1*(mol)*	0.10-x	0.03-x	X	X
P_1*(bar)*	$2.55\ (0.10^{-x})$	$2.55(0.03^{-x})$	2.55^x	2.55^x

b- The % by mass of a component is given by: $m_i / m_t \times 100 = \frac{n_i \times M_i}{m_t}$ *with* $m_t = 4.6+0.84=5.44g$	*1*	*0.25 for each value of P.*
$\% \text{ of } NO_2 = \frac{46(0.1-)^{x}\times 100}{5.44} = 845.56(0.1-x)$	*0.25*	
$\% \text{of } CO = \frac{28(0.03^{-x})\times 100}{5.44} = 514.71(0.03-x)$	*0.25*	
$\% \text{ of } NO_2 = \frac{44x\times 100}{5.44} = 808.82x$	*0.25*	
$\% \text{ of } NO_2 = \frac{30x}{5.44} \times 100 = 551.47\,x$	*0.25*	
2- CO is the limiting reactant ; at t ½ $x = 0.015$ *mol* $X_i = n_i/n_t$ *with* $n_t = 0.13$ *mol.*		*0.25 for each value of X.*
$X(NO_2) = \frac{0.1-0.015}{0.13} = 0.65$ $X(CO) = 0.015/0.13 = 0.12 = X(CO_2) = X(NO)$	*1*	

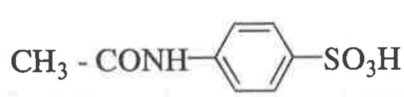
3- SULFANILAMIDE (6 points)

Expected solution	*Scale*	*Comments*
I- Formula of an organic compound *1- Aniline is a primary amine. The general formula is $R—NH_2$ where R is the phenyl group $C_6H_5^-$ in the case of aniline.*		
	*0.5*	*0.25 if written $C_6H_5NH_2$*
2- *a- The hybridization state of the atomic orbitals of carbon atoms in the benzene molecule is sp^2; we choose 6 balls with 3 holes.* *N atom is trivalent, choose a blue ball with 3 holes.* *We also need 7 balls to represent the 7H atoms of the aniline molecule.* *b- No* *A ball-and-stick molecular model represents the bonding axis and the centers of the atoms in a molecule and not the molecule itself.* *In addition, the aromatic ring (phenyl group) of the molecule possesses 3 delocalized bonds while the model represents 3 localized ones.* *II- Hydrolysis of ethanoyl chloride* *1- Carry out the reaction under the hood, while wearing eye goggles and gloves. Add progressively by using a graduated pipette and a pipet filter, about 1mL of ethanoyl chloride into an Erlenmyer flask containing 10mL of distilled water. A sensitive thermometer indicates an elevation of the temperature of the solution. Hydrolysis is an exothermic reaction. The reaction is complete.*	*0.25* *0.25* *0.25* *0.25* *0.25* *0.25* *0.25* *0.5*	*Any equivalent reasoning is accepted.* *Any equivalent reasoning is accepted.*

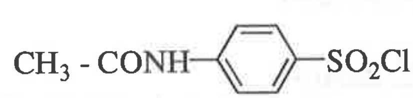
3- Hydrolysis of ethanoyl chloride produces 2 acids, one of which is strong, which is HCl.		
III- Preparation of sulfanilamide		
1- $CH_3-COCl + C_6H_5-NH_2 \rightarrow CH_3-CONH-C_6H_5 + HCl$	*0.5*	
A: N-phenylethanamine	*0.5*	
2- $CH_3-CONH-C_6H_5 + SO_3 \rightarrow CH_3-CONH-C_6H_4-SO_3H$ *B*	*0.25*	
3- *The condensed structural formula of C is:* $CH_3-CONH-C_6H_4-SO_2Cl$		
4- $CH_3-CONH-C_6H_4-SO_2Cl + NH_3 \rightarrow CH_3-CONH-C_6H_4-SO_2NH_2 + HCl$ *D*	*0.5*	
5- $CH_3-CONH-C_6H_4-SO_2NH_2 + H_2O \rightarrow H_2N-C_6H_4-SO_2NH_2 + CO_3COOH$ *Sulfanilamide*	*0.5*	
6- *a- Prontosil molecule is broken at the level of N=N bond.*	*0.25*	*Any equivalent reasoning is accepted.*
b- Retarded antibacterial effect of prontosil or other disubstituted sulfamides is due to the metabolism of the organism leading to formation of monosubstituted sulfamides with antibacterial effect.	*0.25*	

Condensed structural formulas of compounds A, B, C, D, and sulfanilamide

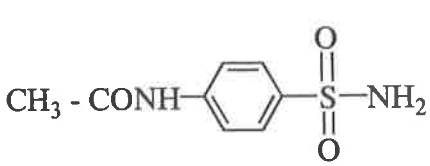
A



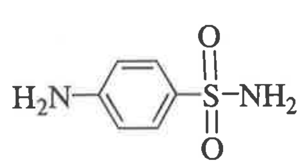
B



C



D



Sulfanilamide

EXAM SAMPLE 3

FIRST EXERCISE
(6 points)

COMMERCIAL HYDROCHLORIC ACID

Hydrochloric acid is used to treat tartar, to clean metals, and renovate stones and marbles; it is sold commercially as a highly concentrated solution.

On the label of a commercial hydrochloric bottle, we read the following:

- *Hydrochloric acid (aqueous solution of hydrogen chloride).*
- *A minimum of 30% hydrogen chloride HCl (percentage by mass)*
- *Density =$1.18 g.cm^{-3}$.*

Given:

Molar mass(M) in $g.mol^{-1}$.
$M(H) = 1$; $M(C) = 12$; $M(O) = 16$; $M(Cl) = 35.5$; $M(Ca) = 40$; $K_w = 10^{-14}$.

I- Dilution:

1- Show that the concentration of the commercial solution of hydrochloric acid is about $10 mol.L^{-1}$
2- We titrate this HCl solution versus a sodium hydroxide solution, which is freshly prepared of concentration $5.0x10^{-2}$ $mol.L^{-1}$.
a- Why should we dilute the hydrochloric acid solution before titrating and measuring?
b- Why do we use a recently prepared sodium hydroxide solution?
3- We want to prepare a hydrochloric solution of concentration close to that of NaOH solution. Using the available materials, describe the experimental procedure to be followed in this preparation.

Materials:
Volumetric flasks (1L, 250mL, 100mL, 50mL); pipets (volumetric): (5mL; 10mL; 20mL;25mL). pipet fillers; distilled water, graduated cylinders: (50mL; 100mL).

II- *Titration*

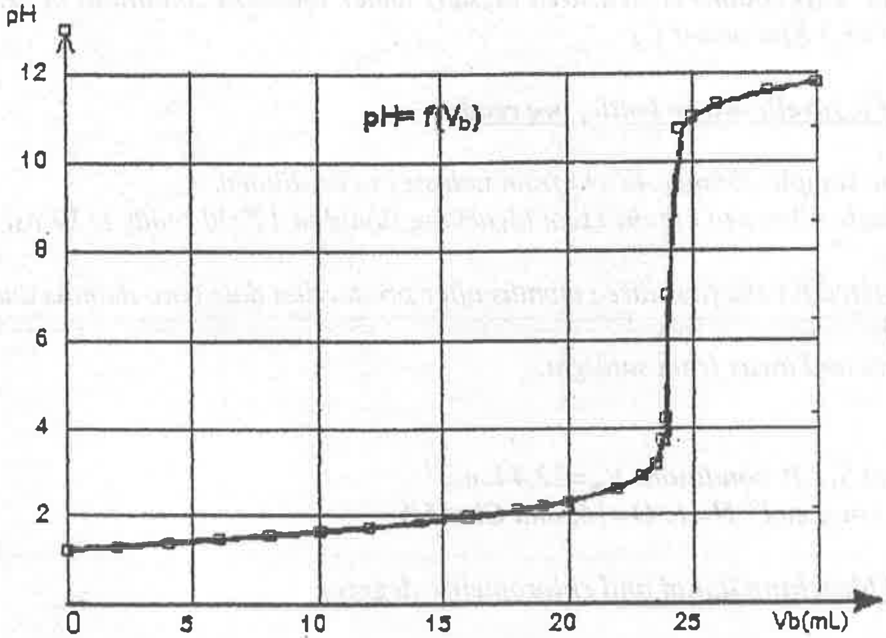
Titration using pH-meter; 20.0mL of the diluted acid solution of concentration C_a versus the NaOH solution of concentration $C_b = 5.0 \times 10^{-2}$ mol.L^{-1}
The curve obtained is represented in figure 1.

1- *Sketch and label the apparatus used in titration.*
2- *Describe briefly the experimental procedure.*
3- *Write down the balanced equation of the reaction. Calculate the equilibrium constant of the reaction. Is this a complete reaction?*
4- *Determine graphically the coordinates of the equivalence point. Determine the concentration of the diluted acid solution. Deduce the concentration of the commercial solution.*
5- *Calculate the real % by mass of HCl dissolved in the commercial solution.*
6- *Hydrochloric acid attacks tartar which is a calcarous white solid which is formed in the sinks of many baths. Tartar is mainly composed of calcium carbonate, $CaCO_3$.*

The reaction between HCl and $CaCO_3$ is:

$$CaCO_3 + 2H_3O^+ \longrightarrow Ca^{2+} + CO_2 + 3H_2O$$

Determine the mass of tartar that can be attacked by 50mL of the commercial acid solution.



SECOND EXERCISE

(8 points)

BLEACHING LIQUID (JAVELLE WATER)

In the industry, bleaching liquid is obtained by dissolving Chlorine gas in an aqueous solution of sodium hydroxide according to the following reaction:

$$Cl_2 + 2OH^- \rightarrow ClO^- + Cl^- + H_2O$$

Javelle water is an aqueous solution containing the ions ClO^-, Na^+ and Cl^- as, well as, excess OH^- ions. The active agent of this bleaching liquid (Javelle-water) is hypochlorite ion which is an oxidant responsible for the disinfecting properties of the liquid.
Javelle-water is decomposed slowly because the ClO^- ions oxidize water. This oxidation reaction is slow and takes a certan time, during which the liquid remains useful until expiry date.
Bleaching liquid is characterized in Francophone countries by its degree or chlorometric titer (°chl).
Degree or chlorometric titer refers to the volume of chlorine necessary to prepare 1L of this bleaching liquid. This volume is measured in liters under standard conditions of pressure and temperature, (101.3 Kpa and 0^oC).

On the label of a Javelle-water bottle, we read:

- *-Recharge sample 250mL, 48^ochl from industry to be diluted.*
- *-This sample allows to obtain 1L of bleaching liquid at 12^ochl ready to be used for 6 months.*
- *-To be diluted for the first three months after production date (two months during the hot season).*
- *-Keep cool and away from sunlight.*

Given:
Molar volume at S.T.P. conditions V_m=22.4 $l.mol^{-1}$
Molar mass(M) in $g.mol^{-1}$ H=1; O=16, and Cl=35.5

I- Titration of bleaching liquid and chlorometric degree:

1- *Determine from the information given the concentration in hypochlorite ions of the bleaching liquid sample of Javelle-water.*
2- *It is suggested to verify the chlorometric degree in bleaching liquid, Javelle-water.*

Step 1:
Into a 250 mL beaker containing 50 mL of acidified water, add 2g of potassium iodide. Add 2mL of diluted Javelle-water prepared according the indications described above.

We observe the formation of Iodine I_2 according to the balanced equation of the following reaction:

$$ClO^{-2} + 2I^- + 2H^+ \rightarrow I_2 + Cl^- + H_2O$$

I^- and H^+ are the reactants in excess.

Step 2:

Titrate the iodine formed with a $(2Na^+ + S_2O_3^{2-})$ solution of sodium thiosulfate of concentration 0.1 molar in the presence of an indicator: Starch or Thiodene. At the equivalence point, the volume of sodium thiosulfate solution added is 20.0 mL the balanced equation of the reaction involved during titration is:

$$I_2 + 2S_2O_3^{2-} \rightarrow 2I^- + S_4O_6^{2-}$$

a- Show that the molar concentration of the hypochlorite ion in the bleaching solution is given by:

$$[ClO^-] = \frac{[S_2O_3^{2-}].v(S_2O_3^{2-})}{2.V(\text{bleaching liquid})}$$

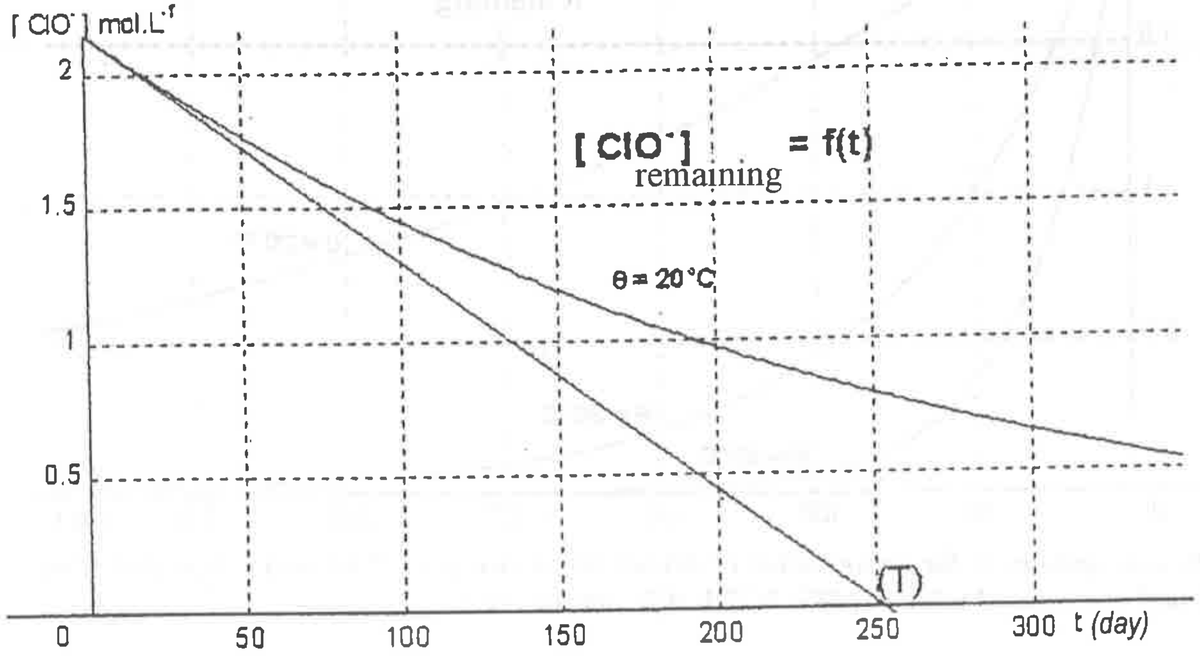
Calculate numerically this concentration.

b- Deduce the concentration of the hypochlorite ion in the recharge sample, as well as its chlorometric degree. Draw out your conclusion.

c- Is it important to introduce excess I^- ions?

II- Study the Kinetics of the Decomposition of the Javelle water

We study the Kinetics of decomposition of the hypochlorite ion in a commercial solution of



The tangent (T) to the curve at t=0 is represented in figure 1.

1- *How much time has elapsed since the sample was taken out from the factory, assuming that the temperature was maintained constant (θ =20 ℃)?*

2- *Define the rate of disappearance of the hypochlorite ion. Calculate the rate at t=0.*

3- *Determine graphically the time corresponding to $t_{1/2}$. Calculate the rate of disappearance of the hypochlorite ion at $t_{1/2}$.*

4- *Compare the rates at t=0 and $t_{1/2}$ and draw out your conclusion.*

5- *Complete the following table by referring to figure 1.*

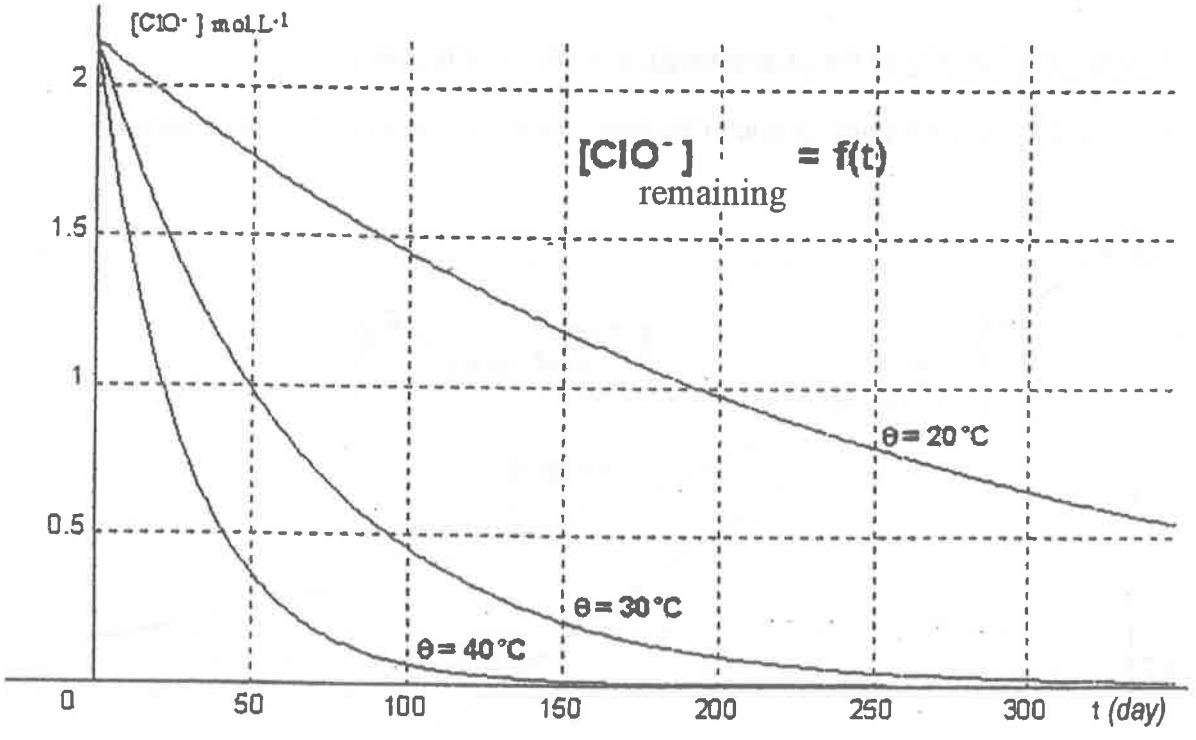
[CLO^-] ($mol.L^{-1}$)	*2*	*1.5*	*1*	*0.75*
T (days)				

a- *What do you conclude?*

b- *Calculate the rate constant K.*

c- *Write the rate law for the reaction.*

6- *Figure 2 shows the curves, of the concentration of the remaining hypochlorite ion as a function of time, at three temperatures 20°C, 30°C and 40°C. Justify, using these curves, the recommendation of the manufacturer to keep the Javelle-water fresh.*



7- In your opinion, is the conservation of diluted Javelle-water (12°chl) better than that of the original commercial solution (48° chl)? Justify your answer.

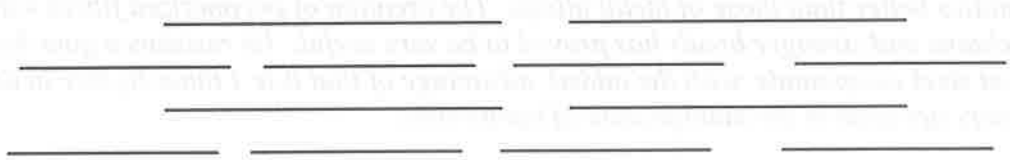
THIRD EXERCISE

(6 points)

FIBERS

I- Polymer Fibers

A polymer fiber is a polymer in which the chains are more or less straight and arranged next to each other on the same axis (as shown in the figure below):

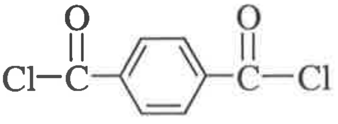


Polymers arranged in fibers in this manner can be used for the manufacture of threads and garments. Polymer fibers are used in making some clothes as well as carpets and ropes. Some polymers that can serve as fibers are: polyethylene, polypropylene, nylon, polyester, kevlar, polyacrylonitrite, cellulose, polyurethanes…
It is very important to note that fibers are made up of crystalline polymers. Chains should be able to arrange in a regular manner in order to be aligned in fibers. Fibers can be considered as a sort of a long crystal.
Now, let us have a closer look at nylon 6,6®

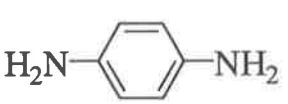
***Given**:*

Molar mass(M) in $g.mol^{-1}$
$M(H) = 1$; $M(C) = 12$.

1- *Explain why it was noted that fibers are always made up of crystalline polymers.*
2- *Write the formula of the repeating unit of polyethylene and the polymerization equation of this polymer.*
3- *A certain fiber is made up of a polymer containing only the elements carbon and hydrogen. Its molar mass is $46.2\ kg.mol^{-1}$ and its average degree of polymerization is 1100. Deduce:*
   a- *The molar mass of the monomer.*
   b- *The structural formula and the name of the monomer, knowing it is an alkene.*
   c- *The repeating unit of the polymer and its name.*
4- *Aramide or Kevlar is polyparaphenylene terphtalamide.*
5- *It is obtained by the action of terephtaloyl chloride of formula.|*



It is obtained by the action of on paraphenylenediamine of formula.



Aramide or kevlar consists of amide groups.

a- *Write the formula of the amide group.*

b- *Properties such as rigidity, longitudinal resistance, thermal and chemical stability of these fibers are due to the presence of hydrogen bonds in their structure. Represent the structure of these aramide fibers indicating the amide group and the hydrogen bond.*

II- *Carbon Fibers*

Carbon has some applications in the formation of fibers. These latter are first slipped in a resin, glass fibers or Kevlar ones, or even amorphous carbon. This is how we can make lighter objects with qualities better than those of metal alloys. The creation of polymerized fibers with long carbon chains and stronger bonds has proved to be very useful. Its resistance goes beyond those of the best steel compounds, with the added advantage of that it is 4 times lighter in density. These fibers are used in the manufacture of composites.

1- *From the test above, list the qualities that justify the use of carbon fibers.*

2- *Some forms of carbon composites are compatible with human tissues. Explain the importance of such a property in the life of human beings.*

1- COMMERCIAL HYDROCHLORIC ACID (6 points)

Expected solution	**Scale**	**Comments**
I- Dilution 1- The mass of commercial hydrochloric acid is $m=1180g$. The mass of hydrogen chloride dissolved in 1L of this solution: $\frac{1180 \times 30}{100} = 345g$ Quantity of hydrogen chloride dissolved in 1L of solution $n = \frac{m}{M}$ M: molar mass of hydrogen chloride $n = \frac{354}{36.5} = 9.7mol$ The concentration of the commercial solution is: $C=9.7mol.L^{-1}$ about $10\ mol.L^{-1}$.	0.25	Any equivalent reasoning is accepted.
2- a- To titrate the commercial solution, we need a basic solution of high concentration.	0.25	
In fact, the commercial hydrochloric acid solution is 200 times more concentrated than the sodium hydroxide solution used ($10/5\times10^{-2}= 200$). So, for titrating 10mL of the commercial solution, we must use $200 \times 10= 2000mL$ =2L of the basic solution.	0.25	
b- The sodium hydroxide solution is mixed with carbon dioxide (originating from the atmosphere) in water, according to the equation: $H_2O + CO_2 + 2(Na^+ + OH^-) \rightarrow 2Na^+ + CO_3^{2-} + 2H_2O$ CO_3^{2-} is the carbonate ion.	0.25	Balanced equation is not necessary.
The concentration of hydroxide OH^- ions decreases with time.	0.25	
3- The concentration of the commercial solution is $10mol.L^{-1}$. To obtain an acidic solution of concentration 5×10^{-2} $mol.L^{-1}$, we must dilute 200 times the commercial solution.	0.25	

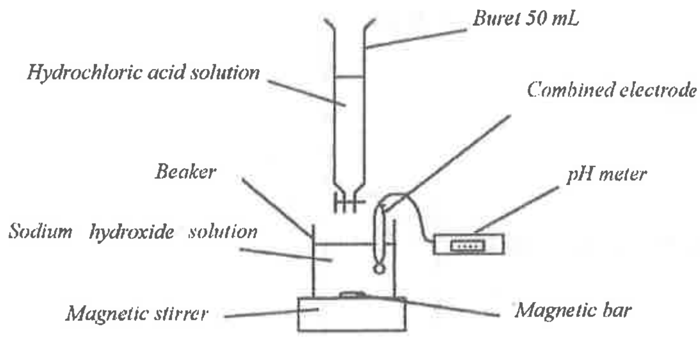
<table>
<tr><td>

Factor of dilution: $\frac{10}{5\times10^{-2}} = 200$

Experimental procedure:
The commercial solution being corrosive and very concentrated, use gloves and eye-goggles for safety.</td><td>0.25</td><td>*0 if it is wrong*</td></tr>
<tr><td>*Take 50 mL of the commercial solution with a pipet and transfer it to a 1L volumetric flask.*</td><td>0.25</td><td>*0 if it is wrong.*</td></tr>
<tr><td>*Add distilled water until the line-mark of the flask.*
Swirl thoroughly to homogenize the mixture.</td><td></td><td>*0 if it is wrong.*</td></tr>
<tr><td>

II- Titration

1-



</td><td>0.5</td><td>*0.25 for the scheme.*
0.25 for the labeling.
0 if there are 2 mistakes.</td></tr>
<tr><td>

2-

- *Fill the buret with sodium hydroxide solution.*
- *Measure 20mL of hydrochloric acid solution using a pipet and transfer it into a beaker.*
- *Caliberate the pH-meter.*
- *Measure the pH of the acid in the beaker.*
- *Add each time 2mL to reach the 'jump' in pH. For every addition, homogenize the solution using a stirrer.*
- *During the significant rise of pH (jump) add gradually 0.5mL, each time, till the end of the jump. Then continue adding 1mL, gradually.*

</td><td>0.5</td><td>*0 if there is an important mistake.*</td></tr>
<tr><td>

3-
The balanced equation of the titration reaction:
$H_3O^+ + OH^- \rightleftarrows 2H_2O$

</td><td></td><td></td></tr>
<tr><td>

Equilibrium constant for the reaction) :
$K_r = \frac{1}{[H_3O^+]\times[OH^-]} = \frac{1}{K_e} = 10^{14}$

</td><td>0.25</td><td></td></tr>
</table>

$K_r > 10^4$: *the reaction is* ***complete (quantitative)***		
4-		
We determine the coordinates of the equivalence point E by the parallel tangent method:		
$E(V_e = 24.5mL;\ pH_e = 7.0)$	0.25	
At the equivalence point, the reactants introduced are in the ratio of their stoichiometric coefficients.	0.25	
$n(H_3O^+)$ *initial* $= n(OH^-)$		
So, $C_a \times V_a = C_b \times V_e$ *where* V_e *is the equivalent volume.*	0.25	
Concentration of the diluted solution :		
$C_a = \frac{C_b V_e}{V_a} = C_a = \frac{5\times 10^{-2} \times 24.3}{20} = 6.1 \times 10^{-2} mol.L^{-1}$.	0.25	
The commercial solution is diluted 200 times, its concentration is:		
$6.1 \times 10^{-2} \times 200 = 12.2\ mol.L^{-1}$	0.25	
5-		
The mass of hydrogen chloride dissolved in 1L of commercial solution is:		
$M = 12.2 \times 36.5 = 445g$	0.25	
Percentage of dissolved hydrogen chloride:		
$\frac{450 \times 100}{1180} = 37.7\%$		
This result is confirmed with the indications on the label; the percentage of hydrogen chloride dissolved is greater than 30%.		
6-		
The quantity of hydronium ions in 50mL of the commercial solution is:		
$n(H_3O^+) = C \times V = 12.2 \times 5 \times 10^{-2} = 0.61mol.$	0.25	
According to the balanced equation of the reaction $n(CaCO_3)$:		
$m = \frac{n(H_3O^+) \times M}{2}$; *(M: molar mass of calcium carbonate)*	0.25	
$m = \frac{12.2 \times 5\times 10^{-2} \times 100}{2} = 30.5g$	0.75	

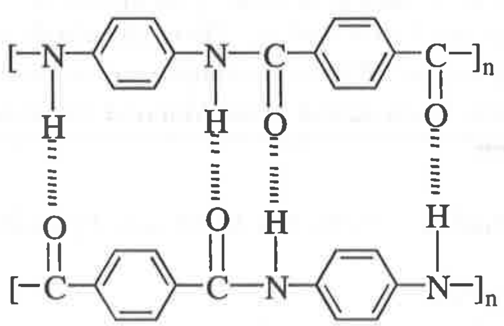
2. <u>JAVELLE WATER</u> *(8 points)*

Expected solution	***Scale***	***Comments***
I- Titraton of Javelle-water. Chlorometric degree		
The chlorometric degree of a Javelle-water is the volume of chlorine necessary for the manufacturing of 1L of this water. So, for manufacturing 1L of Javelle-water at 48°chl, we should have 48L of chlorine as follows: $n\,(Cl_2) = \frac{V_{Cl2}}{V_m} = \frac{48}{22.4} = 2.14 mol.$	*0.25*	
According to the equation of the reaction, $n(Cl_2) = n\,(ClO^-) = 2.14\ mol$	*0.25*	
So, $[ClO^-] = \frac{n(ClO^-)}{V_{Javelle-water}} = 2.14\ mol.L^{-1}$	*0.25*	
a- According to the equation, $n(ClO^-)_{dissolved} = n(I_2)_{formed}$ *The equation of the reaction involved in titration. To reach the equivalence point, the reactants are introduced in the ratio of their stoichiometric coefficients*	*0.25*	
$n(I_2)_{initially\ present} = 1/2n\,(S_2O_3^{2-})_{added.}$	*0.25*	
So, $n(ClO^-) = 1/2n\,(S_2O_3^{2-})_{added}$	*0.25*	
So, $[ClO^-] = \frac{[S_2O_3^{2-}]\,V\,(S_2O_3^{2-})}{2V_{Javelle-water}}$	*0.25*	
$[ClO^-] = \frac{1 \times 10^{-1} \times 20}{2 \times 2} = 5.0 \times 10^{-1}\ mol.L^{-1}$	*0.25*	
b- *Starting with a sample of 250mL of Javelle-water, we prepare 1L of diluted Javelle-water. The dilution factor is 4 times. So, the concentration of hypochlorite ion in the sample is:* $[ClO^-] = 5.0 \times 10^{-1} \times 4\ mol.L^{-1}$	*0.25*	
Chlorometric degree: 2.0 × 22.4 = 45L => 45°chl.	*0.25*	

The chlorometric degree found is less than that indicated by the manufacturer. The Javelle-water is partially decomposed by action of water: *Relative error:* $\frac{48-45}{48} \times 100 = 6\%$ *c-* *To determine the concentration of hypochlorite ion, it must react completely with I_2. For this reason, we use excess iodine.* *II- Kinetics Study of Decomposition of Javelle-water* *1-* *According to the graph of figure 1, the titrated sample in the question 2.b. was manufactured 15 to 20 days before titration.* *2-* *The rate of disappearance of hypochlorite ion at instant t is equal to the negative derivative of the function $[ClO^-]$ as a function of time.* $V= \frac{-d[ClO^-]}{Dt}$ *Graphical determination of this rate at t=0* *The rate of disappearance of hypochlorite ions at instant t=0 is numerically equal to the slope of the tangent at the point of abscissa t=0.* $r_0 \approx \frac{2.15}{250} \approx 8.6 \times 10^{-3}\ mol.L^{-1}.day^{-1}$ *3-* *The half-lifetime is the time needed for half of the quantity of a reactant to disappear.* $t_{1/2}$= *170 to 180 days or* $t_{1/2}$= *6 months.* *The rate of disappearance of* $t_{1/2}$ $r_{1/2} \approx 4.0 \times 10^{-3} mol.L^{-1}.\ day^{-1}$ *4-* *The rate of disappearance of hypochlorite ion diminishes with time because the concentration of the reactants decreases. Therefore, the concentration of reactants is a kinetic factor.*	0.25 0.5 0.25 0.25 0.25 0.25 0.25	*Approximation in calculation is not necessary.* *0 if there are 2 mistakes.* *0.25 if there is 1 mistake.*

<table>
<tr><td>$[ClO^-]$ $(mol.L^{-1})$</td><td>2</td><td>1.5</td><td>1</td><td>0.75</td><td></td><td></td></tr>
<tr><td>t(days)</td><td>17.5</td><td>90</td><td>192.5</td><td>267</td><td>0.5</td><td></td></tr>
<tr><td colspan="5">a-
The half-life time $t_{1/2}$ is constant. This characterizes the first order reaction.</td><td>0.25</td><td></td></tr>
<tr><td colspan="5">b-
The rate constant is:
$K = \frac{0.693}{t_{1/2}} = \frac{0.693}{175} = 4 \times 10^{-3}\ day^{-1}$</td><td>0.25</td><td></td></tr>
<tr><td colspan="5">6-
The disappearance of Javelle-water becomes faster as the temperature increases.</td><td>0.25</td><td></td></tr>
<tr><td colspan="5">The temperature is a kinetics factor. For this reason, Javelle-water should be used fresh.</td><td>0.25</td><td></td></tr>
<tr><td colspan="5">7-
The concentration of the reactant is a kinetic factor. The conservation of Javelle-water (12°chl) is better than the</td><td>0.25</td><td></td></tr>
<tr><td colspan="5">commercial (48°chl). For this reason, the commercial solution can be diluted in three months after manufacture.</td><td>0.25</td><td></td></tr>
</table>

3- ***FIBERS*** *(6 points)*

Expected solution	***Scale***	***Comments***
I- Polymer Fibers		
1- Because the chain of which it consists can be arranged in a regular fiber form.	*0.5*	
2-Repeating unit: $-(-CH_2—CH_2)--$	*0.5*	
Equation:		
$nCH_2 = CH_2 \rightarrow -(-CH_2—CH_2)_n--$	*0.5*	
3-		
a- $M = 46.2\times 10^3/1100 = 42 g.mol^{-1}$	*0.5*	
b- The monomer is an alkene, its formula is given: C_nH_{2n}- $14x = 42 \Rightarrow x=3$. *The formula is:* C_3H_6 *propene.*	*0.5*	
c- Repeating unit: $-(-CH(CH_3)—CH_2)--$		
This is polypropelyne (PP)	*1*	
4-		
a- $-CO—NH--$		
b- 	*1*	
II- Carbon Fibers		
1- The characteristics are: strong bonds, extremely solid, more resistant to vibrations than steel. Non reactive chemically. Low density.	*0.5*	
2-The carbon fibers are compatible with the human tissues, they are the constituents of composites which are manufactured artificially. .	*0.5*	

EXAM SAMPLE 4

FIRST EXERCISE
(6 points)

NYLON

Nylon possesses good mechanical properties. It is used to make and fabricate several objects in several domains (automobiles, bui̇ldings, electricity…) Nylon 6.6 is a polyamide resulting from polymerization reaction between 1,6-hexanedioic acid (adipic acid) and 1,6-diaminohexane.

Given:

$M(H) = 1 g.mol^{-1}$; $M(C) = 12\ g.mol^{-1}$; $M(N)=14\ g.mol^{-1}$; $M(O) = 16\ g.mol^{-1}$ $M(Cl) = 35.5\ g.mol^{1}$

I- *Structure of Nylon 6,6*

1- *Write the condensed structural formula of adipic acid and 1,6-diaminohexane. Circle the functional groups.*
2- *Schematize the condensation reaction between the 2 functional groups (acid-amine)*
3- *Name the functional group –CO—NH—*
4- *Write the condensed structural formula of nylon.*

II- *Nylon making*

To prepare nylon in the lab, prepare a solution (A) containing a mass of acylchloride $ClCO—(CH_2)_x\ COCl$ in carbon tetrachloride and put it in a beaker. Then add slowly an aqueous solution (B) containing a mass m′ of 1,6-diaminohexane. The two solutions are not miscible and the reaction takes place at the phase of separation. Hang up the nylon film and roll it up on a glass rod. A mass m′=11.6g gives 29.05g of nylon.

1- *Which is better to use an acid or the corresponding acylchloride to prepare nylon in the lab? Justify.*
2- *Calculate the mass m, assuming complete reaction.*
3- *Determine x and write the notation following the word nylon of the prepared polymer.*
4- *In some countries, acid pollution in air is due to human activities. The distribution of gases is as follows:*

SO_2: 220 000 tons
Nitrogen oxides: 150 000tons
HCl: 10 000 tons

In a country, 10% of the HCl amount formed during the manufacturing of 318500 tons of nylon indicated in question 2 goes into the atmosphere. What is the percent contribution of the manufactured nylon to the atmospheric acid pollution?.

SECOND EXERCISE
(8 points)

ACETONE

Acetone is a common solvent. Like most of the carbonated compounds, it rarely exists in nature. It is also used in the manufacture of plastic materials. It possesses 3 carbon atoms in its skeletal structure.

Given:

Molar mass(M) in $g.mol^{-1}$
$M(H) = 1$; $M(C) = 12$; $M(O) = 16$,
Ideal gas constant $R = 8.3 J.mol^{-1}.K^{-1}$

I- *Structural formula*

1- *Write the condensed structural formula of acetone. Circle the functional group.*
2- *Give the systematic name of the compound.*
3- *Write the condensed structural formula and give the corresponding name of the isomer of acetone having the same functional group.*

II- *Preparation of Acetone*

In a cylinder with a movable piston, empty from air and containing reduced copper, we heat 3g of 2-propanol. The following equilibrium is established:

Alcohol(g) $\rightleftarrows$ Acetone(g) + Hydrogen (g).

1- *Write down the equation which represents this equilibrium?*
2- *Indicate the role of reduced copper.*
3- *Calculate, in pascal, the pressure of the alcohol vapor at 602.4K, knowing that the volume of the cylinder is $500 cm^3$.*
4- *Calculate, in terms of the degree of conversion of alcohol, the number of moles of the gaseous mixture at equilibrium.*
5- *At equilibrium, the pressure attains a value $6.25 \times 10^5 Pa$. What is the quantity of acetone formed?*

III- *Displacement of the Shifting Equilibrium*

In order to determine the relative density of a gaseous mixture at different volumes, the following results are given:

Volume (cm^3)	*500*	*560*	*600*	*700*
Relative Density	*1.65*	*1.48*	*1.38*	*1.18*

1- Write the expression of the relative density of the gaseous mixture in terms of α.
2- Based on the values given in the above table, explain how we should vary the volume of the cylinder in order to increase the rate of the dehydrogenation of alcohol.
3- What should be the initial volume so that dehydrogenation is complete?

IV- *Acetone in our daily life*

Acetone appears in the urine upon the utilization of fats by the organism. This is established under two conditions:

- *When the person is going on a diet without eating for a long time.*
- *When there is insulin depletion (in the case of diabetes, there is an accumulation of sugar and acetone in the urine).*

1- Explain how a diet can be efficient.
2- What is the significance of the presence of sugar and acetone in the urine?

THIRD EXERCISE
(6 points)

SOAP MANUFACTURING

" The most ancient industrial use of fatty acids is in soap making. Until 1945, this was done in large recipients known as caldrons. But the operations took a long time and were complex and haphazard empirical. They consisted of boiling a mixture of fatty acids with NaOH (to carry out saponification), add salty water to separate the soap from the solution, and then purify the soap flocculating before leaving it to cool in containers. Finally, the soap is molded into different forms and shapes.
"Scientific article extract discussing the industrial use of fatty acids".

I- *Questions relative to the text:*

1- Identify the chemical reaction that refers to the above process.
2- Indicate the importance of flocculating.

II- Molecular Structure

Consider the fatty acid with one triglyceride type, oleine having the following formula:

CH_3-$(CH_2)_7$-$CH=CH(CH_2)_7$-COO-CH_2
|
CH_3-$(CH_2)_7$-$CH=CH(CH_2)_7$-COO-CH
|
CH_3-$(CH_2)_7$-$CH=CH(CH_2)_7$-COO-CH_2

Oleine will be noted as R-COO-CH_2
|
R-COO-CH
|
R-COO-CH_2

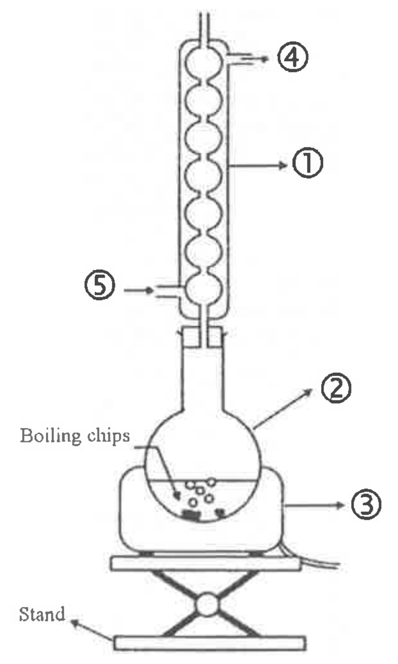
1- *Oleine is a triester of 1,2,3-propanetriol(glycerol) and oleic acid. Write the condensed structural formula of glycerol and oleic acid.*
2- *Circle and name the functional groups.*

Given: *Molar mass(M) in* $g.mol^{-1}$ *Oleine=884*
Soap=304

III- Preparation of soap:

To prepare soap, follow the experimental procedure described in two steps below.

Step 1:
Prepare an alcoholic solution of concentrated NaOH. Add an excess of this solution to 15mL of oil only made up of oleine.
Set up the apparatus shown in the figure:



1- *Give the name and indicate the importance of the apparatus used.*
2- *Name the different numbered parts of the figure.*
3- *Indicate the role of boiling chips.*
4- *Explain the use of circulation of water in the apparatus.*

Step 2: After 30 minutes of reaction, carefully remove the round bottom flask, pour the content over NaCl solution, and keep stirring the floccule.

5- *In the laboratory work, indicate the step that follows step 2 flocculating in order to collect the soap.*

IV- Study of the Reaction

1- Write the equation of the reaction.

2- Among the products, identify the one, which has the properties of detergents?

3- Indicate in this product the hydrophilic and the hydrophobic parts.

4- Calculate the yield of this preparation assume that the mass of the solid product obtained is m=11.8g

1- NYLON (6 points)

Expected solution	***Scale***	***Comments***
I. Structure of Nylon		
1- $\boxed{HOOC}-(CH_2)_4-\boxed{COOH}$	0.5 0.5	*Saturated carbon chains with 6 carbon atoms.*
$\boxed{H_2N}-(CH_2)_6-\boxed{NH_2}$	0.5	*Condensation with elimination of water.*
2- $-HN-\boxed{H + HO}-\overset{\overset{O}{\Vert}}{C}- \rightarrow H_2O + -\overset{\overset{O}{\Vert}}{C}-NH-$		
3- *Amide.*	0.5	
4- $-(-HN-(CH_2)_6-NH-\overset{\overset{O}{\Vert}}{C}-(CH_2)_4-\overset{\overset{O}{\Vert}}{C}-)_n-$	0.5	
II- Nylon Manufacturing		
1-In order to prepare nylon in the laboratory, it is advantageous to use acyl chloride which is a carboxylic acid derivative. This reaction is fast and complete, while, with carboxylic acid, the reaction is slow and requires heating to a very high temperature.	0.5	
2- The stoichiometry of the reaction is given by the following relation: $\frac{n(amine)}{1} = \frac{n(acyl\ chloride)}{1} = \frac{n(nylon)}{1} = \frac{n(HCl)}{1}$	0.5	
Molar mass in $g.mol^{-1}$ $M(amine) = 116$; $M(acyl\ chloride) = 124+14x$ $M(HCl) = 36.5\ g.mol^{-1}$	0.5	
$M(amine) = 11.6/116 = 0.1\ mol \Rightarrow m(HCl) = 36.5g$	0.5	
$\Rightarrow m = m(nylon) + m(HCl) - m' \Rightarrow m = 21.1g.$	0.25	
3- $M(acyl\ chloride) = 21.1/0.1 = 211 g/mol \Rightarrow$	0.25	
$211 = 127 + 14x \Rightarrow x = 6$, *Nylon 6,6®*	0.5	
4- $n_{HCl} = n_{nylon}$ *or* $M(nylon) = 290.5\ g.mol^{-1}$	0.25	
$M(HCl) = \frac{290500 \times 36.5 \times 1}{290.5 \times 100} = 365t$	0.5	
Total mass of pollutants $= 380\ 000t$		
Contribution $= (365 \times 100)/380000 = 0.096\%$	0.25	

2- ACETONE *(8 points)*

Expected solution	Scale	Comments
I- Structural Formula		
1- $CH_3-\overset{\overset{\displaystyle O}{\Vert}}{C}-CH_3$	0.5	Carbonyl group
2- propanone	0.5	
3- CH_3-CH_2-CHO: *propanal*	1	0.5 for the name.
II- Preparation of acetone	0.5	
1- $CH_3-CHOH-CH_3 \rightleftarrows CH_3-CO-CH_3 + H_2$		
2- The reduced copper acts as a catalyst.	0.5	
3- $P = \frac{nRT}{V}$	0.25	-0.25 for each error
N in mole; T in K; R in J/mol.K; V in L and P in Pa		
$M(alcohol) = 60 g/mol \Rightarrow n(alcohol) = 5\times10^{-2}$ mol	0.25	
$V = 500\ cm^3 = 5\times10^{-4} m^3$		
$P = 5.0 \times 10^5 Pa$	0.5	
4- Starting with n moles of alcohol, the composition of the gaseous mixture at equilibrium is: $n(alcohol) = n(1-\alpha)$; $n(acetone) = n(dihydrogen) = n\alpha$	0.5	
Therefore, $n_e = n(1+\alpha)mol. = 5\times10^{-2}(1+\alpha)mol.$ *From the relation of ideal gases, we replace each term with its value:* $6.25 \times 10^5 = \frac{5\times10^{-2}(1+\alpha)\times8.3\times602.4}{5\times10^{-4}}$	0.5	
Thus, $\alpha = 0.25 \Rightarrow n(acetone) = 0.0125$ mol		

III- Displacement of the Equilibrium		
1- Molar mass of the mixture is: $M = \frac{nM(alcohol)}{Ne} = \frac{nM(alcohol)}{n(1+\alpha)} = \frac{60}{(1+\alpha)}$	0.5	
$\Rightarrow d = \frac{60}{29(1+\alpha)}$	0.25	
2- According to the values given in the table, you can see that when V increases, d decreases. This decrease in d is due to the increase in α. *You can conclude that to favor dehydrogenation of the alcohol, you should increase V.*	0.75	
3- Dehydrogenation is practically total when α *tends toward 1. for* $\alpha=1$, $n_t = 5\times10^{-2}(1+1)$, $n_t = 0.1mol$	0.25	
Replace n, R, T, and P by their values: $V = \frac{0.1\times 8.3\times 602.4}{6.25\times10^5} = 0.8m^3$	0.25	
IV- Acetone in our daily life		
1- We can perform the test of acetone in urine, if it is positive, you can conclude that the diet is effective.	0.5	
2- The presence of sugar and of acetone in the urine indicates the absence of insulin.	0.5	

3- SOAP MANUFACTURING (6 points)

Expected solution	***Scale***	***Comments***
I- Questions related to the text		
1- Saponification	*0.25*	*Justification of using sodium chloride is important.*
2- To separate soap from the solution, (to precipitate soap which is very slightly soluble in salty water).	*0.25*	
II- Molecular structure		
Glycerol CH_2OH $CHOH$ CH_2OH	*0.25*	
Oleic acid $CH_3—(CH_2)_7—CH{=}CH{-}{-}(CH_2)_7—COOH$	*0.25*	
2. $CH_2\boxed{OH}$ *Hydroxyl group*	*0.25*	
	0.25 *0.25*	
$CH_3-(CH_2)_7-CH=CH-(CH_2)_7-\boxed{COOH}$ *Carboxyl group*	*0.25*	
$\boxed{CH_2-OH}$ *Primary alcohol* $\boxed{CH-OH}$ *Secondary alcohol* $\boxed{CH_2-OH}$ *Primary alcohol*		
$CH_3-(C\,H_2)_7-CH=CH-(CH_2)_7-\boxed{COOH}$ *Carboxyl group*		
III- Preparation of Soap *1- The name of the apparatus is reflux.*	*0.25*	
The purpose of the apparatus is to increase the rate of the reaction and to eliminate the solvent, leaving the reactants and the products.	*0.25*	
2- *1- condenser. 2- round bottom flask. 3- heating mantle. 4- water-exit. 5- water-in.*	*1.25*	*0.25 for each name.*

3- *The boiling chips are used to prevent bumping.*	0.25	
4- *Water circulation causes continuous of water provides the condensation of vapor.*	0.25	
5- *After flocculating, the soap is filtered and separated by using a Buchner funnel from which the soap is removed and molded.*	0.75	
IV. Study of the Reaction		
1- $R\text{—}COO\text{—}CH_2$ $\qquad\qquad\;\vert$ $R\text{—}COO\text{—}CH + 3\,(Na^+ + HO^-) \rightarrow$ $\qquad\qquad\;\vert$ $R\text{—}COO\text{—}CH_2$ $3(R\text{—}COO^-, Na^+) + CH_2OH - CHOH\text{—}CH_2OH$	0.5	
2- $(R\text{—}COO^-; Na^+)$= *soap.*	0.25	
3- *R: represents the hydrophobic group.* COO^-*: represents the hydrophilic group.*	0.25	
4- $\frac{n(soap)}{3} = n(oil)$ $\frac{m(soap)}{M(soap)} = \frac{3\times m(oil)}{M(oil)}$ $M(soap) = \frac{3\times 10 \times 304}{884} = 10.32g$ *percent yield* $= \frac{103.2}{11.8} \times 100 = 87.5\%$	0.25 0.25	

EXAM SAMPLE – 1

FIRST EXERCISE
(6 points)

MILK

Milk is a complex mixture containing water, sugars, lipids, proteins, mineral salts, vitamins… Fresh milk contains less lactic acid due to the slow degradation of lactose in the presence of bacteria. This is why measuring the acidity of milk gives us an idea about its freshness: increase in milk acidity is due to bad conservation. In what follows, we will suppose that milk acidity is only due to lactic acid.

Given:
Lactic acid $pk_a = 3.9$
Molar mass(M) $= 90 g.mol^{-1}$
The concentration of lactic acid in fresh milk should be less than or equal to $1.8 g.L^{-1}$

Materials:
Beakers (100;250 and 500 mL); Erlenmyer flasks (100;250 and 500mL); pipets (graduated) (5;10 and 20mL); pipet fillers; graduated cylinders (10;25 and 50 mL); graduated burets (25 and 50mL) magnetic stirrer; magnetic bar; gloves and goggles for safety.
Indicators and pH range with the corresponding colors.

Methyl orange	*3.1-4.4*	*Red-yellow*
Methyl red	*4.2-6.2*	*Red-yellow*
Phenolphthalein	*8.2-10.0*	*Colorless-pink*

I- Characteristics of lactic acid

1- *Degradation of milk is catalyzed by chemical substances. Give the names of the catalysts?*
2- *Milk is preferably kept in a refrigerator. Indicate the kinetic factor involved in this case to slow down the decomposition of milk.*
3- *The systematic name of lactic acid is: 2-hydroxypropanoic acid.*
   a- *Write the condensed structural formula. Circle the functional groups present in this molecule.*
   b- *Write the conjugate acid-base pair and identify the predominant species at pH = 6.7: the average value of the pH of fresh milk.*

II- Lactic acid titration

1- The acidity of milk is determined by titrating it with sodium hydroxide solution NaOH of concentration $0.05 molL^{-1}$.

The milk sample is placed in an Erlenmeyer flask. After adding several drops of the indicator, NaOH solution is added progressively while maintaining continuous stirring by a magnetic stirrer.

- *a- Name the glassware that should be used to take a sample of milk (graduated cylinder or pipette)? What glassware is used to add NaOH solution? Draw a labeled schema that shows the titration.*
- *b- Why should we keep on stirring the mixture during the reaction?*
- *c- Discuss the acid-base nature of the solution obtained at the equivalence point.*
- *d- Suggest an indicator for this experiment. How do you detect the equivalence point in this case?*
- *e- Write the balanced equation for the titration reaction.*

2- 20.0mL of milk is titrated with sodium hydroxide solution. The volume of basic solution added to reach equivalence is 9.6mL.

- *i- Calculate the concentration of lactic acid in the milk in both $mol.L^{-1}$ and $g.L^{-1}$.*
- *ii- Is the analyzed milk fresh or not? Justify.*

SECOND EXERCISE
(7.5 points)

CLASSIFICATION OF ALCOHOLS

In a chemistry lab, a student finds 2 identical bottles containing colorless liquids labeled as: alcohol C_3H_8O. The student labels the first bottle A_1 and the second A_2. To identify the content of each bottle the student performs a series of experiments.

Given:

Molar mass of $C_3H_8O = 60 g.L^{-1}$

Density of alcohol $C_3H_8O = 0.80\ g.mL^{-1}$

Compound	*A_1 and A_2 (C_3H_8O)*	*B_1 and B_2 (C_3H_6O)*	*H_2O*	*C ($C_3H_6O_2$)*
Boiling point(^oC)	*97 and 82.5*	*49and 56*	*100*	*141*

List of laboratory materials: Test tubes, droppers, beakers (100, 250 and 500 mL), Erlenmeyer flasks(100, 250 and 500 mL), volumetric pipets (5, 10 and 20 mL), graduated cylinders (10, 25 and 50 mL), pipet fillers, heating mantle, fractionating column, condenser, thermometer, stoppers assorted sizes, boiling chips, gloves and goggles for safety.

The half-reactions involved in the redox reactions in this exercise are:

$$Cr_2O_7^{2-} + 14H^+ + 6e^- \rightleftarrows 2\,Cr^{3+} + 7H_2O$$

$$RCHO + 2H^+ + 2e^- \rightleftarrows RCH_2OH$$

$$RCOR' + 2H^+ + 2e^- \rightleftarrows RCHOHR'$$

I- Mild oxidation and structure

1- *Write the condensed structural formula and give the name and class of each isomer of the alcohol of molecular formula C_3H_8O.*

2- *Name the products obtained by the mild oxidation of these alcohols. Write their condensed structural formulas and give their systematic names.*

3- *Can we use the mild oxidation of alcohols to identify and classify alcohols A_1 and A_2? Explain.*

4- *The student assembles the apparatus of the experiment, as shown in the figure below. He places in B about 10 mL of the liquid A_1 with a few boiling chips, then adds about 100 mL of an acidified potassium dichromate solution of concentration 0.2 $mol.L^{-1}$ .The mixture is then heated in the device A. Vapors are released in C and then condensed in E. The condensed liquid (is colorless), denoted as B_1, is collected in F.*
The volume of the liquid, collected at the end of the reaction (the solution changes from orange to green) is about 4 mL. During the distillation of liquid B_1, the thermometer indicates a temperature close to 55^0C.
The student repeats the same procedure with A_2. During distillation of product B_2, the thermometer indicates a temperature of 50^0C. The volume of the liquid collected at the end of the reaction is about 4 mL.

   a- *Name the materials used in the above-schematized apparatus.*

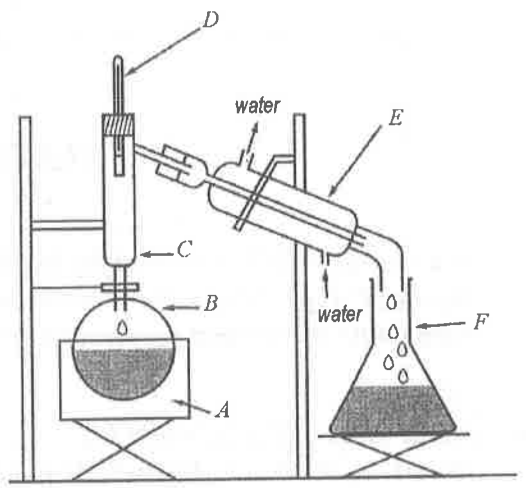
   b- *Calculate the number of moles of alcohols A_1 and A_2, as well as that of dichromate in $Cr_2O_7^{2-}$ ion in 100 mL of the oxidizing solution.*

   c- *In both experiments described above, is it necessary to use specific graduated glassware? Justify.*

   d- *How is the end of the reaction detected?*

   e- *Write down the oxidation reactions of the alcohols A_1 and A_2.*

   f- *Show that in both experiments the oxidant is not in excess. Why?*



II- Identification

1- *The student took 2 test tubes. He placed in each about 1 mL of the yellow-orange solution of 2,4-dinitrophenylhydrazine (DNPH). Using a dropper he added to the first tube 2 drops of B_1, and to the second tube 2 drops of B_2. In both tubes he observed the formation of a yellow-orange precipitate.*

   a- *What is the functional group identified?*

   b- *What are the functional classes of B_1 and B_2?*

2- *Noticing that the tests performed using DNPH is not sufficient, the student performed further identification tests.*

a- In the following list of reactants, mention one reactant that would clearly identify the compounds B_1 and B_2: bromothymol blue(BTB), litmus paper, Fehling's solution, sulfuric acid solution, ammonium chloride solution, NaOH solution, copper(II) sulfate solution. Justify your choice.

b- Describe the procedures that should be followed to perform the identification tests.The necessary materials should be chosen from the list above. What type of change is observed during the tests?

c- Knowing that only compund B_2 reacts with the chosen reactant, attribute the condensed structural formula to each of alcohol A_1 and A_2, as well as to the products of their mild oxidation.

d- Glucose is a sugar, found in many fruits. Its formula contains the aldehyde functional group. Can we use the test proposed in part (a) to identify the glucose? Give a brief explanation.

THIRD EXERCISE
(6.5 points)

DECOMPOSITION OF HYDROGEN PEROXIDE

Hydrogen peroxide decomposes into water and oxygen according to the equation:

$H_2O_{2(l)} \square\ H_2O_{(l)} + ½\, O_{2(g)}$.

It is suggested to study the kinetics of the decomposition reaction of H_2O_2. The decomposition reaction of H_2O_2 is very slow at 20°C; to make it faster, a suitable catalyst is used.

Given:

Materials:

Graduated cylinders (10, 25, and 50mL), volumetric flasks (50;100 and 200mL), pipets (graduated) (5;10 and 20mL), pipets, volumetric (10, 20 and 50mL) pipet fillers, glass tubes, plastic tubing, Erlenmeyer flasks (100;250 and 500mL), beakers (100;250 and 500mL), gloves and goggles for safety.

Experiment I:

During this experiment, the temperature is maintained constant at 20°C, the initial concentration of hydrogen peroxide in the solution is $[H_2O_2]_o = 0.06 mol.L^{-1}$, the volume of the solution is considered constant during this experiment.

To determine the concentration of hydrogen peroxide as a function of time, we measure the volume of oxygen formed during the reaction. Results are shown in the table below:

T(min)	0	5	10	15	20	25	30	40	60
$[_1H_2O_2]$ $(\times 10^{-2}) mol.L^{-1}$	6.0	4.7	3.8	3.0	2.4	2.0	1.5	1.0	0.35

1- Sketch the curve $[H_2O_2] = f(t)$
Scale x-axis 1cm –5 min.
y-axis 2cm –0.01mol.L^{-1}

2- Determine graphically the average rate of disappearance of hydrogen peroxide between t_1 = 20min and t_2=35min.

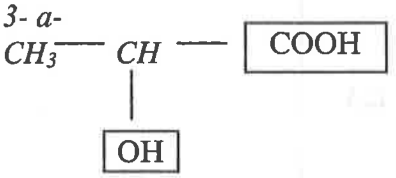
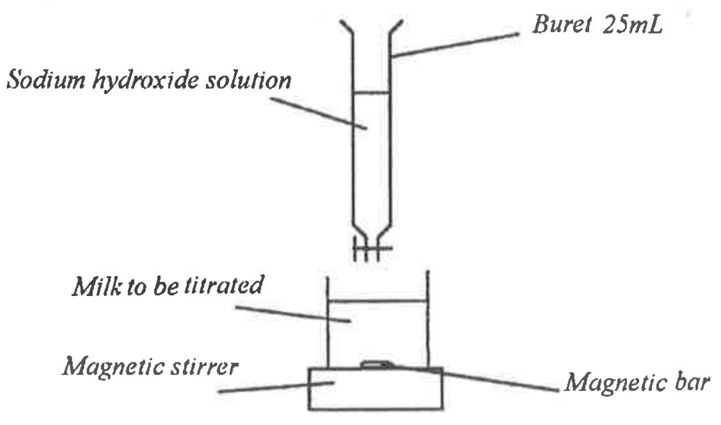
3- Determine graphically the instantaneous rate of disappearance of hydrogen peroxide at t=0 min and t=30 min. How does this rate vary? Justify.

4- Determine graphically the half-life of the reaction.
5- Show that the reaction is of the first order with respect to hydrogen peroxide. Write the rate law of the reaction.

Experiment II

From the initial concentration of $[H_2O_2]_o=0.06 mol.L^{-1}$ we prepare a solution of concentration of 0.03mol.L without changing the temperature 20^oC.
1- Describe briefly the experimental procedure that should be followed to prepare 100mL of the diluted solution of hydrogen peroxide. The materials used should be chosen from the above given list.
2- Draw, on the same preceding graph, the curve $[H_2O_2]=f(t)$
3- Does the variation in the initial concentration of hydrogen peroxide affect the half-life of the reaction? Justify.

1- MILK (6 points)

Expected solution	***Scale***	***Comments***
I- Characteristics of lactic acid:		
1- Enzymes or biological catalysts	*0.25*	
2- Temperature: the rate of a chemical reaction decreases as the temperature decreases.	*0.25*	
3- a- 	*0.75*	*0.25 for circling the functional groups.*
b- $CH_3CHOHCOOH/CH_3CHOHCOO^-$ (HA/A^-)	*0.25*	
$Ka = \frac{[A^-]\times[H_3O^+]}{[AH]}$ *or* $pH = pKa + \log\frac{[A^-]}{[AH]}$	*0.25*	
$= 6.7 - 3.9 = 2.8$; $\frac{[A^-]}{[AH]} = 631$	*0.25*	
At pH =6.7. it is the anion lactate which predominates.	*0.25*	
II- Lactic acid titration		
To perform titration, you are supposed to use a pipet (volumetric) to take the milk and a buret to add NaOH solution.	*0.5*	*Any equivalent reasoning is accepted.*
	*0.5*	*0.25 for schema* *0.25 for legend.*

b- To homogenize the solution.		*Equivalent reasoning is accepted.*
c- Lactic acid is a weak acid. At the equivalence point, lactate ion, the conjugate base of lactic acid dominates. The solution is basic pH>7.	*0.25*	
d- The solution being basic at the equivalence point, the indicator should be phenolphthalein. Before equivalence, the color is white (creamy). After equivalence, the color is pink.	*0.5*	*0.25 for the choice of the indicator.*
e- $CH_3CHOCOOH + OH^- \rightarrow CH_3CHOCOO^- + H_2O$.	*0.5*	
2- *a- At equivalence: na=nb. This is also written as* $Ca \times Va$ *leading to* $Ca=2.4\times10^{-2}$ *mol.L*$^{-1}$ *Mass concentration =* $Ca\times M=2.16g.L^{-1}$.	*0.50* *0.25*	
b- the mass concentration determined is higher than 1.8g.L^{-1}*, therefore the milk is not fresh.*	*0.25*	

2- CLASSIFICATION OF ALCOHOLS (7.5 points)

Expected solution	*Scale*	*Comments*
I- Oxidation and structure:		
1- CH_3—CH_2—CH_2OH: 1-propanol; primary alcohol.	*0.25*	*0.25 for the formula*
CH_3—CHOH—CH_3: 2-propanol; secondary alcohol.	*0.25*	*0.25 for the formula*
2- Oxidation of a primary alcohol leads to an aldehyde or a carboxylic acid.		
CH_3—CH_2—CHO propanal	*0.25*	
CH_3—CH_2—COOH propanoic acid	*0.25*	
Mild oxidation of a secondary alcohol produces ketone.		
CH_3—CO—CH_3 propanone acid	*0.25*	
3- Products of mild oxidation depend on the class of the alcohol. Specifically such a mild oxidation can be used to identify and classify alcohols A_1 and A_2.	*0.25*	*Any equivalent reasoning is accepted*
4-		
*a-**A**:heating mantle; **B**:round bottom flask;**C**:simple distillation column; **D**:thermometer; **E**: condenser; **F**:Erlenmeyer flask.*	*0.25*	
b-m(A1)= m(A2)= 10x0.8=8g	*0.25*	
n(A1)= n(A2)= 8/60= 0.13 mol.	*0.25*	
N($Cr_2O_7^{2-}$)= 0.2x0.1=0.02 mol.	*0.25*	
c- No, because the purpose of the experiment is identify and not to perform titration nor quantitative analysis.	*0.25*	
d- Change of the color of the solution Because $Cr_2O_7^{2-}$ removes the orange color Solution becomes green due to the presence of Cr^{3+} ions in solution.	*0.25*	
e- Mild oxidation of a primary alcohol leads to an aldehyde according to the equation: $Cr_2O_7^{2-} + 3RCH_2OH + 8H^+ \rightarrow 2Cr^{3+} + 3RCHO + 7H_2O$	*0.25*	*0, if any error*

Extensive mild oxidation of a primary alcohol leads to a crboxylic acid according to the equation: $2Cr_2O_7^{2-} + 3RCH_2OH + 16H^+ \rightarrow 4Cr^{3+} + 3RCOOH + 11H_2O$	0.25	*0, if any error*
Mild oxidation of a secondary alcohol leads to a ketone according to the equation: $Cr_2O_7^{2-} + 3RCHOHR' + 8H^+ \rightarrow 2Cr^{3+} + 3RCOR' + 7H_2O$ *The reaction stops at this level.*	0.25	*Any equivalent reasoning is accepted.*
f- Stoichiometry of the (limited) oxidation of an alcohol(primary or secondary) is given by the relation: $\frac{n(A1)}{3} = \frac{n(A2)}{3} = \frac{n(Cr_2O_7^{2-})}{1}$ *or* *in both experiments:* $\frac{n(A1)}{3} = \frac{n(A2)}{3} = 0.044 > n(Cr_2O_7^{2-}) = 0.02$	0.25	
The dichromate ion is the limiting reactant. This allows controlling the oxidation of a primary alcohol to the first step and will not lead to the formation of the carboxylic acid step.	0.25	
II- Identification *1-* *a- DNPH identifies the carbonyl group.*	0.25	
b- B_1 is an aldehyde or ketone. *B_2 is an aldehyde or ketone.*	0.25	
2- *a- Fehling's solution (blue color) distinguishes between B_1 and B_2 because only an aldehyde would react with it.*	0.25	*Any equivalent reasoning is accepted.*
b- In a test tube, place 1 mL of B_1 or B_2 with 2 mL of Fehling's solution. Heat the mixture with gentle boiling.	0.25	
Changes produced in the reaction system indicate whether the compound is an aldehyde or a ketone. *An aldehyde leads to the formation of a red precipitate of Cu(I) oxide Cu_2O , while a ketone does not lead to any change in the blue color of the solution.*	0.5	*Any equivalent reasoning is accepted.*

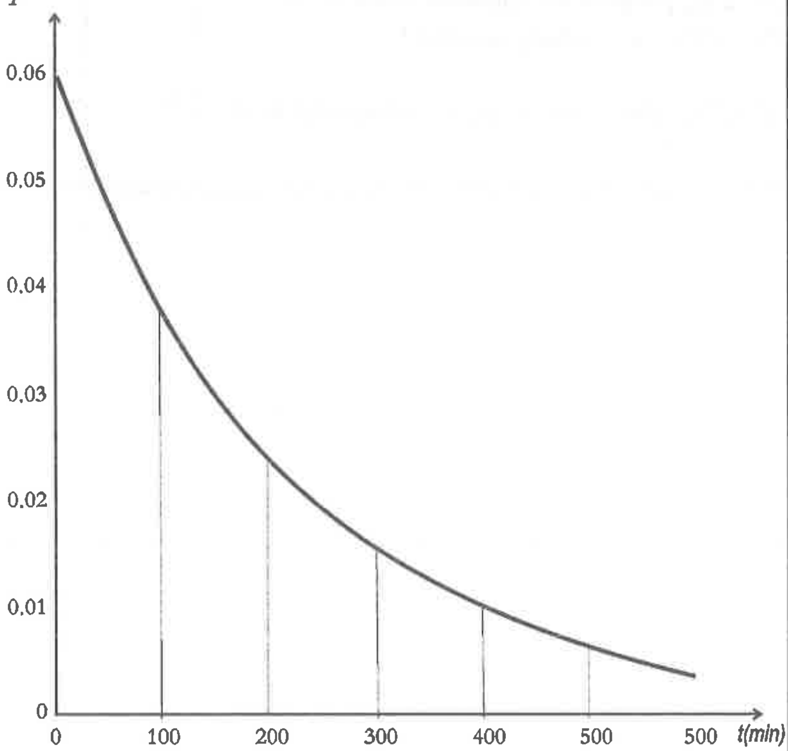
c- B_2 gives a positive test with Fehling, so it should be an aldehyde. *CH_3—CH_2—CHO propanal* *And A_2 is 1-propanol* *CH_3—CH_2—CH_2OH (primary alcohol)*	*0.25*
B_1 is a ketone: CH_3—CO—CH_3 propanone (acetone) and A_1 is *2-propanal: CH_3—$CHOH$—CH_3 (secondary alcohol).*	*0.25*
d- Glucose is identified by Fehling due to the presence of an aldehyde function.	*0.25*

3- <u>HYDROGEN PEROXIDE DECOMPOSITION</u> (6.5 points)

<table>
<tr><th>Expected Solution</th><th>Scale</th><th>Comments</th></tr>
<tr><td>

I- Experiment I

1-



</td><td>1.25</td><td>

-0.25, if each scale is changed.
0 if the axes are changed.

</td></tr>
<tr><td>

2- $r_{average}(20\text{-}35) = \dfrac{-(1.0-3.9)\times10^{-2}}{37.5} = 7.73\times10^{-4}\ mol.L^{-1}.min^{-1}$

</td><td>0.75</td><td>

0.25 for the rate unit.

</td></tr>
<tr><td>

3-

$r_o = -\dfrac{(1.5-6.0)\times10^{-2}}{14} = 3.21\times10^{-3}\ mol.L^{-1}min^{-1}$.

$r_{30} = -(1.5-6.0)\times10^{-2} = 6.33\times10^{-4}\ mol.L^{-1}min^{-1}$.

</td><td>0.5</td><td></td></tr>
<tr><td>

$r_{30} < r_0$; *the rate of the reaction decreases because the concentration of the reactants decreases with time; the rate of the reaction is directly proportional to the concentration of the reactants.*

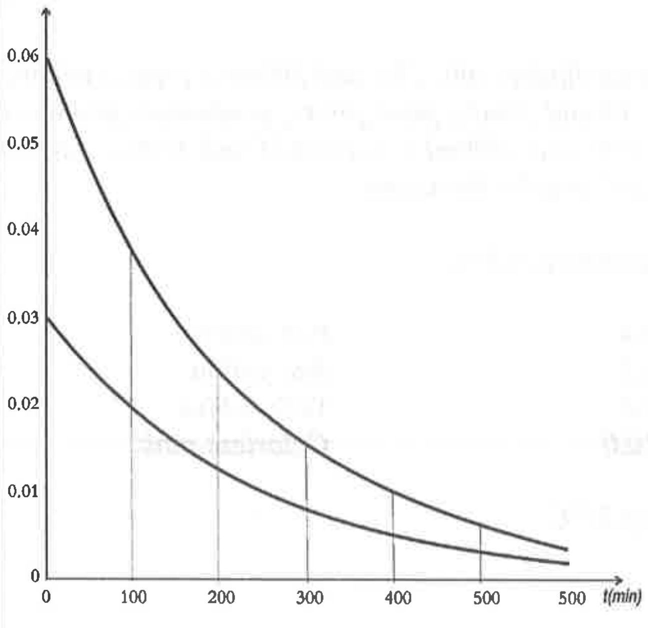
</td><td>0.5</td><td>

Any equivalent reasoning is accepted

</td></tr>
<tr><td>

4- The curve shows that the concentration of hydrogen peroxide becomes equal to half the initial concentration at t=15; so $t_{1/2} = 15$ *min.*

</td><td>0.25</td><td></td></tr>
</table>

5- The table and the graph show that the concentration of hydrogen peroxide is always divided by 2 every 15 minutes. This characteristic is specific of the first order reactions where $t_{1/2}$ is independent of the initial concentration of the reaction.	*0.75*	
The rate law of the reaction is: $r = k[H_2O_2]$	*0.25*	
II- Experiment II *1- Using a 50mL pipet, take 50mL of the initial solution of hydrogen peroxide. Place this volume in a 100mL flask. Dilute with distilled water. The solution is homogenized by stirring.*	*0.75*	*0.25 for the material.*
2- 	*0.25*	*Any equivalent reasoning is accepted.*
3- This is a first order reaction. The temperature should remain constant and $t_{1/2}$ is independent of the initial concentration of H_2O_2.	*0.5*	

EXAM SAMPLE-2

FIRST EXERCISE
(7 points)

HOUSEHOLD PRODUCT

On the label of a bottle containing a household product used as drain opener, we read: "19% NaOH max; causes severe burning; dissolves all organic materials; keep out of reach of children; $d=1.2kg.L^{-1}$."

Given:

Molar mass(M) in $g.mol^{-1}$ M(H) =1; M(O)=16; M(Na)=23.
Pk_a values of conjugate acid-base pair: $H_3O^+/H_2O = 0$; $H_2O/OH = 14$.

Materials:
Beakers (100;200; and 500mL); Erlenmeyer flasks (100, 250, and 500mL); pipets (volumetric (5, 10 and 20mL); pipets (graduated) (5, 10 and 20mL), pipet fillers, graduated cylinders (10, 25, and 50mL), volumetric flasks (100, 250, 500, and 1000mL); burets (25 and 50mL), magnetic stirrer, magnetic bar, pH meter; gloves and goggles for safety.

Indicators and pH range with the corresponding colors:

Methyl orange	*3.1-4.4*	*Red-yellow*
Methyl red	*4.2-6.2*	*Red-yellow*
Bromothymol blue	*6.0-7.6*	*Yellow-blue*
Phenolphthalein	*8.2-10.0*	*Colorless-pink*

Titration is performed at a temperature of 25°C.

I- Dilution

The concentration of NaOH being very high, we prepare $V_1=0.5L$ of a solution of concentration $C_1=C_0/50$; C_o is the concentration of NaOH in the commercial solution.

1- *Write the equation of ionization of NaOH in water.*
2- *Describe in detail, the procedure followed for preparing the diluted solution NaOH, indicating the precautions that should be taken, the volume of commercial NaOH taken and the glassware used.*

II- Titration

We take V_b=20mL of the diluted solution of concentration C_1 and we place it in a beaker. We add progressively a solution of HCl of concentration C_a=0.1mol.L^{-1}. Using a pH-meter we follow the change of the pH of the mixture in function of V_a; the volume of HCl solution added.

1- *Sketch and label a diagram representing pH-metric titration.*
2- *Indicate the conjugate acid-base pair present? Represent them on a vertical scale of pKa. Circle the species that participate in the acid-base reaction.*
3- *Write the equation of the reaction that takes place.*
4- *Calculate the constant K_R of this reaction and deduce that it can be considered as a complete quantitatively reacted reaction.*

III- Study of Titration

The pH values as a function of the acid volume added V_a are given in the table below

V_a(mL)	0	4	6	10	14	18	20	21	22	23
PH	13.1	12.8	12.7	12.6	12.4	12.2	12.1	11.9	11.6	11.2

V_a(mL)	23.5	24	24.5	25	26	28	30	32	34	36
PH	11.0	7.0	3.4	3.0	2.5	2.0	1.8	1.2	1.1	1.1

1- *Draw the curve pH = f(V_a)*
scale: x-axis 1cm-4mL
y-axis 1cm-2pH units.
2- *Determine the coordinates of the equivalence point and deduce the concentrations of C_0 and C_1.*
3- *Calculate the percentage by mass of NaOH in the household product. Does the result match the indication on the label?*
4- *If the titration were followed by using an indicator, which one of the indicators listed above would be convenient? Justify.*

SECOND EXERCISE
(6 points)

STUDY OF A GASEOUS MIXTURE

Given:

Molar mass(M) $g.mol^{-1}$: M(C) = 12, M(O) = 16, M(N) = 14.
Universal ideal gas constant: R = 0.085 $bar.L.mol^{-1}.K^{-1}$

I-Partial Pressure:

At 27^oC, a non combining gaseous mixture (G) containing, 0.10 mol nitrogen dioxide and 0.03 mol of carbon monoxide is introduced into a closed container of constant volume equal to 10L. Calculate:

1- *The partial pressure of each component of G.*
2- *The molar fraction of each component of G.*
3- *The average molar mass of G. Deduce the density of G relative to N_2.*

II- Reaction Order:

At a temperature T=500K, the following reaction takes place:

$NO_2(g) + CO(g) \longrightarrow CO_2(g) + NO(g)$

In order to determine the reaction order, we carry out three experiments at a temperature of 500K by introducing successively well determined amounts of carbon monoxide and nitrogen dioxide. We measure in each case the initial rate r_0 of the reaction. The results obtained are shown in the table below:

	Number of moles of NO_2 introduced	Number of moles of CO introduced.	r_0 (mol/L.hr)
Experiment I	0.10	0.03	0.6×10^{-2}
Experiment 2	0.01	0.06	1.20×10^{-2}
Experiment 3	0.30	0.03	1.80×10^{-2}

1- *Determine the partial orders of the reaction relative to NO_2 and CO and give the expression of the rate law.*
2- *Calculate the specific rate constant.*
3- *Determine the initial rate at the same temperature, when we mix 0.02mol of NO_2 and 0.30mol of CO.*

III- Composition of a Mixture at Time t:

We follow the progress of the reaction of mixture G with time, in experiment 1 (0.10 mol of NO_2 and 0.03mol of CO). Let x be the number of moles of CO_2 formed at an instant t:

1- Calculate in terms of x:

a- the partial pressure of each component of the mixture G' obtained at time t.

b- the percentage by mass of each component of G'.

2- Calculate the molar composition of the mixture formed at $t_{1/2}$.

THIRD EXERCISE

(6 points)

ESTER WITH PINEAPPLE ODOR

Some esters possess odors of fruits and pleasant smells. They are used as food additives in the confection industry.

Given: Molar mass(M) in g/mol: M(C)=12; M(O)=16; M(H)=1

List of Lab Materials:

- *-Graduated cylinders (10. 25 and 50mL)*
- *-Heating mantle*
- *-Distillation column (distillation head)*
- *-Condenser*
- *-Round bottom flask*
- *-Boiling chips*
- *-Pipet filler (safety bulb)*
- *-Gloves and goggles for safety*

A- *Structure of an Organic Compound:*

Quantitative analysis of an organic compound A gives the following percentage by mass:

C: 54.6%　　H: 9.1%　　O: 36.4%

Molar mass(M) of A is $88 g.mol^{-1}$.

1- Verify that the molecular formula of A is $C_4H_8O_2$.

2- Write the condensed structural developed formulas of the isomers corresponding to this molecular formula and containing the group $-\underset{\underset{O}{||}}{C}-O-$

3- A is soluble in water. A solution of A turns the green color of Bromothymol blue to yellow. A admits straight-chain of carbon atoms. Write the structural formula of A and give its systematic name.

B- Esterification:

1- We want to prepare a compound having an artificial aroma with pineapple odor. To obtain this compound, introduce into a flask 1mol of ethanol, 1mol of A and few drops of concentrated sulfuric acid. The mixture is heated while refluxing for one hour and then it is cooled.

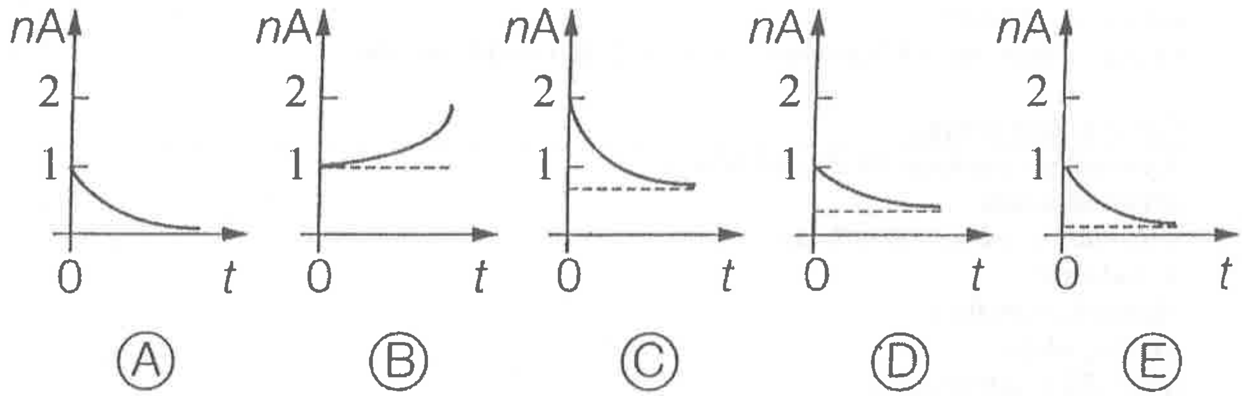
a- Sketch and label the apparatus used.

b- Why is the reaction system heated to reflux?

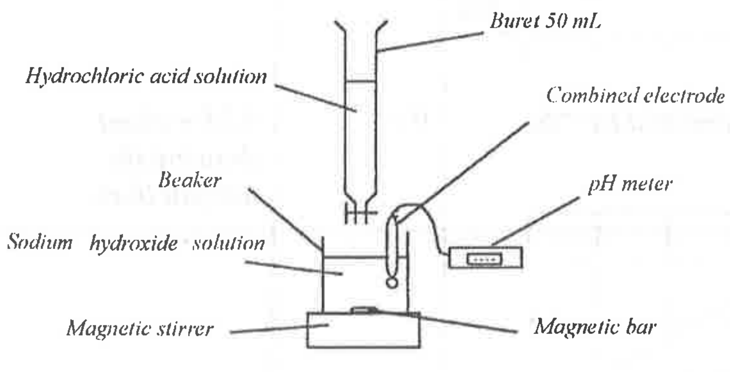
c- What type of reaction takes place in the flask? What is the role of sulfuric acid?

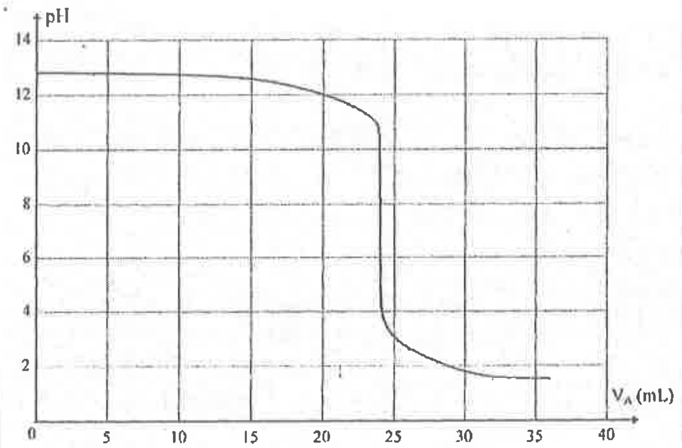
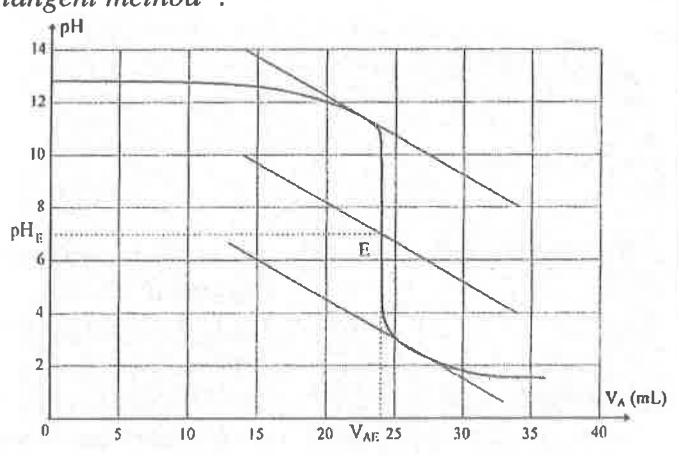
d- Write the equation and give the systematic name of the compound with pineapple odor.

2- We follow the change in the number of moles of compound A, in the reaction mixture as a function of time. We obtain a curve $n_A=f(t)$. Indicate which of the following curves corresponds to the performed experiment. Justify your choice.



1-**HOUSEHOLD PRODUCT** *(7 points)*

Expected solution	***Scale***	***Comments***
I. Dilution		
1- NaOH $\rightarrow$ $Na^+ + OH^-$	*0.25*	
2- $C_1 = Co/50$; $V_1 = 500mL$ *The amount of NaOH in the prepared solution is:* $n = C_1 \times V_1$. *This quantity should be taken from the commercial solution.* *So,* $n = Co x Vo$ *Therefore,* $C_1 x V_1 = Co x Vo$ *and* $Vo = V_1/50 = 10mL$.	*0.50*	
The commercial solution is corrosive. You should wear gloves and goggles for safety.	*0.25*	
We remove using a graduated pipet 10 mL of the commercial solution and we put them in 500 mL flask. Then, add distilled water just below the line mark on the volumetric flask then continue adding carefully by a dropper distilled water till the line mark.	*0.5*	
II- Titration		
1-  	*0.75*	*0.5 for labeling the schema.*
2- Conjugate acid-base pairs present: H_3O^+/H_2O *and* H_2O/HO^-	*0.25*	*O is the scale is not oriented.*
	0.5	*0.25 for circling the species.*
3- The reaction takes place between the strongest acid and the strongest base.	*0.25*	*0 if* H_2O *is not circled.*
Equation of the reaction: $H_3O^+ + HO^- \rightleftarrows 2H_2O$ $\boxed{HO^-}$ — $\boxed{H_2O}$ $\boxed{H_2O}$ — $\boxed{H_3O^+}$	*0.25*	*0 if one arrow is used without mentioning* K_R.

4- The constant K_R of the reaction is equal to the ratio of Ka constants of the 2 conjugate pairs involved in the reaction. *Pka_1 (H_3O^+/ H_2O) = 0* *Pka_2 (H_2O/HO^-) = 14.* $K_R = Ka_1/Ka_2 = 10^{(pKa1-pKa2)} = 10^{14}$ *K_R is higher than 10^{14}, so the reaction between OH^- H_3O^+ is complete i.e. quantitatively are reacted* *III- Titration* *1-* 	*0.25* *0.75*	
2- The equivalence point is determined by "the tangent method". 	*0.5*	*0.25 without drawing the tangent lines.*
Va_E = 24 ml. *PH_E = 7.* *At the equivalence point: $n(H_3O^+) = n(HO^-)$* *CaxVaE = C_1xVb* *Given C_1 = 0.12 mol* *Co = 50 x 0.12 = 6 mol.L^{-1}*	*0.25* *0.5*	

3- The mass concentration of the commercial solutions is: $C = C_0 x M = 6x40 = 240 g.L^{-1}$ *The % by mass of the household product is 240/1200 x100 = 20%. The error is 1%.*	*0.25* *0.25*	
4- You use the bromothymol blue because its pH range is (6.0-7.6) includes the pH of equivalence point.	*0.5*	*Any equivalent reasoning is accepted.* *(Strong acid + strong base; pH = 7)* *0.25 for the justification.*

2- STUDY OF A GASEOUS MIXTURE *(7 points)*

Expected solution	***Scale***	***Comments***
A- Partial pressure	0.25	
1- We apply the equation of state: $P\times V = ni \times R \times T$		
$P(NO_2) = \frac{0.1\times 0.085\times 300}{10} = 2.55\times 10^{-1}$ bar	0.25	
$P(CO) = \frac{0.03\times 0.085\times 300}{10} = 7.65\times 10^{-2}$ bar	0.25	
2- The molar fraction is given by the relation: $Xi = ni/nt$ with $nt = 0.13$ mol		
$X(NO_2) = 0.1/0.13 = 0.77$	0.25	
$X(CO) = 0.03/0.13 = 0.23$	0.25	
3- The average molar mass is given by the relation: $M_G = \sum Xi\times Mi = X_1\times M_1 + X_2\times M_2$ $M_G = 0.77\times 46 + 0.23\times 28 = 41.85\ g.mol^{-1}$	0.25	
B- Reaction order:		
1- Calculate the concentrations of NO_2 and CO in each of the 3 experiments. The results are given in the table below:	0.25	

	$[NO_2]_0$ mol.L^{-1}	$[CO]_0$ mol.L^{-1}	V_0 mol.$L^{-1}h^{-1}$
Experiment 1	0.01	3×10^{-3}	0.6×10^{-2}
Experiment 2	0.01	6×10^{-3}	1.2×10^{-2}
Experiment 3	0.03	3×10^{-3}	1.8×10^{-3}

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It is obvious: in both experiments 1 and 2, the initial concentration of nitrogen dioxide did not change.

Also, in both experiments 1 and 3, the initial concentration of carbon monoxide did not change

The rate law of the reaction is:
$R = k \times [NO_2]^a \times [CO]^B$

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From experiments 1 and 2 $a=1$
From experiments 1 and 3 $B=1$.

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Therefore, $r = k \times [NO_2]\,[CO]$

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2- $k = \dfrac{r_0}{[NO_2]\,[CO]_0}$

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using the results of experiment 1, we obtain:
$K = \dfrac{0.006}{0.01 \times 0.003} = 200 mol^{-1} L.h^{-1}$

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3- $[NO_2]_0 = 2\times10^{-3}$ mol.L^{-1}; $[CO]_0 = 0.03$ mol.L^{-1}
$r_0 = k\,[NO_2]_0\,[CO]_0$
$r_0 = 200 \times 0.002 \times 0.03 = 0.012 mol.L^{-1}.h^{-1}$

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C- *Composition of the mixture at time t:*

1-
a- $P_i = \dfrac{n_iRT}{V} = 2.55 n_i$

The results are found in the table below:

Substance	NO_2	CO	CO_2	NO
n_0 mol	0.10	0.03	0	0
n_1(mol)	0.10-x	0.03-x	X	X
P_1(bar)	$2.55\,(0.10^{-x})$	$2.55(0.03^{-x})$	2.55^{x}	2.55^{x}

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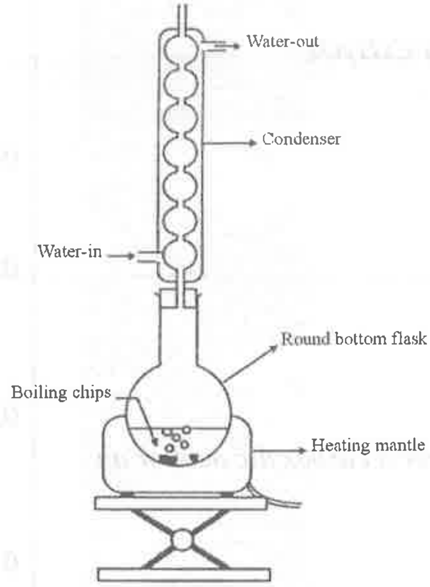
b- The % by mass of a component is given by: $m_i / m_t \times 100 = \frac{n_i \times M_i}{m_t}$ *with* $m_t = 4.6+0.84=5.44g$	1	*0.25 for each value of P.*
% of $NO_2 = \frac{46(0.1-x)}{5.44}\times 100 = 845.56(0.1-x)$	0.25	
%of $CO = \frac{28(0.03-x)}{5.44}\times 100 = 514.71(0.03-x)$	0.25	
% of $NO_2 = \frac{44x\times 100}{5.44} = 808.82x$	0.25	
% of $NO_2 = \frac{30x}{5.44}\times 100 = 551.47\,x$	0.25	
2-CO is the limiting reactant ; at t ½ x= 0.015 mol $X_i = n_i/n_t$ *with* $n_t = 0.13$ *mol.* $X(NO_2) = \frac{0.1-0.015}{0.13} = 0.65$ $X(CO) = 0.015/0.13 = 0.12 = X(CO_2) = X(NO)$	1	*0.25 for each value of X.*

<u>3-ESTER WITH PINEAPPLE ODOR</u> (6 points)

Expected solution	*Scale*	*Comments*
I- Structure of an organic compound *1- The general formula of compound A is CxHyOz* *Applying the relation:*		
$\frac{12x}{\%C} \approx \frac{y}{\%H} \approx \frac{16z}{\%O} \approx \frac{M}{100}$	*0.5*	*0.5 to verify the formula or determine x,y and z*
we get x=4; y=8 and z=2	*0.5*	
2- The group $-\overset{\overset{O}{\|}}{C}-O-$ *corresponds to either a carboxylic acid or an ester.*	*0.25*	
Carboxylic acids $CH_3-CH_2-CH_2-COOH$ $CH_3-\underset{\underset{CH_3}{\vert}}{CH}-COOH$	*0.5*	
Esters: $H-COO-CH_2-CH_2-CH_3$ $H-COO-\underset{\underset{CH_3}{\vert}}{CH}-CH_3$	*0.5*	
$CH_3-COO-CH_2-CH_3$	*0.25*	
$CH_3-CH_2-COO-CH_3$	*0.25*	
3- *A is an acid because it turns BTB to yellow.* *A is butanoic acid because it has a straight-chain carbon atoms.*	*0.25*	
$CH_3-CH_2-CH_2-COOH$	*0.25*	

II- Esterification *1-* *a-*  	*0.25*	*0.25 for the drawing*
b- Heating while refluxing is important because: - *The mixture is heated at a constant temperature; a temperature close to the boiling point of the more volatile liquid.*	*0.25*	
- *The components of the reaction system are conserved, the substance is heated in the solvent for a long period without boiling away the solvent. The vapors produced will condensate in the condenser and fall back into the flask.*	*0.25*	
c- This is an esterification reaction.	*0.25*	
-Sulfuric acid is a catalyst.	*0.25*	
d- $CH_3\text{-}CH_2\text{-}CH_2\text{-}COOH + CH_3\text{-}CH_2\text{-}OH \rightleftarrows CH_3\text{-}CH_2\text{-}CH_2\text{-}COO\text{-}CH_2\text{-}CH_3 + H_2O$	*0.5*	*0.25 if the double arrow is not indicated*
The ester formed has a pineapple odor. It is ethyl butanoate.	*0.25*	
2- Acid A is a reactant and its number of moles n(A) decreases with time. The curve is therefore decreasing.	*0.25*	
Esterification is a limited reaction; the number of moles of the acid attains a minimal limited value. Therefore, the curve possesses a horizontal asymptot.	*0.25*	*Proceed by elimination to choose the kinetic curve.*
The initial mixture being equimolar. The initial number of moles of A is 1 mole and the alcohol used being primary. Therefore, the number of moles of the acid at equilibrium tends to 1/3 mole.	*0.25*	
From all what preceded, we concluded that curve D corresponds to the experiment.	*0.25*	

EXAM SAMPLE 3

FIRST EXERCISE

(6 points)

ANTACID

"Milk of Magnesia" is used to cure acid indigestion in the stomach. A bottle of milk of magnesia is contains to be saturated magnesium hydroxide solution, $Mg(OH)_2$.

Given:

The analysis carried out at 25 °C Ksp of $Mg(HO)_2 = 1.2x10^{-11}$ and $Kw= 10^{-14}$

1. *Determine the molar concentration of each Mg^{2+} and OH^- ions present in the above milk of magnesia.*
2. *Calculate the pH of the milk of magnesia.*
3. *5mL of the milk of magnesia are mixed with 20mL of distilled water. Calculate the pH of the obtained solution.*
4. *Add a few drops of hard water rich in Mg^{2+} ions to a sample of the above milk of magnesia. What happens? How is the pH affected? Justify.*
5. *Upon warming the above milk of magnesia, a precipitate is formed. Deduce whether the dissolution of $Mg(OH)^2$ is endothermic or exothermic.*
6. *Explain how milk of magnesia cures acid indigestion in the stomach.*

SECOND EXERCISE

(8 points)

BLEACHING LIQUID (JAVELLE WATER)

In the industry, bleaching liquid is obtained by dissolving Chlorine gas in an aqueous solution of sodium hydroxide according to the following reaction:

$$Cl_2 + 2OH^- \rightarrow ClO^- + Cl^- + H_2O$$

Javelle water is an aqueous solution containing the ions ClO^-, Na^+ and Cl^- as well as excess OH^- ions. The active agent of this bleaching liquid (Javelle-water) is the hypochlorite ion which is an oxidant responsible for the disinfecting properties of the liquid.

Javelle-water is decomposed slowly because the ClO^- ions oxidize water. This oxidation reaction is slow and takes a certan time, during which the liquid remains useful until expiry date.

Bleaching liquid is characterized in Francophone countries by its degree or chlorometric titer (°chl).

Degree or chlorometric titer refers to the volume of chlorine necessary to prepare 1L of this bleaching liquid. This volume is measured in liters under standard conditions of pressure and temperature, (101.3 Kpa and 0°C).

On the label of a Javelle-water bottle, we read:

-Recharge sample 250mL, 48°chl from industry to be diluted.

-This sample allows to obtain 1L of bleaching liquid at 12°chl ready to be used for 6 months.

-To be diluted for the first three months after production date (two months during the hot season).
-Keep cool and away from sunlight.

Given:
Molar volume at S.T.P. conditions (V_m)=22.4 $l.mol^{-1}$
Molar mass(M) $g.mol^{-1}$ H=1; O=16, and Cl=35.5

I- Titration of bleaching liquid and chlorometric degree:

1- Determine from the information given the concentration in hypochlorite ions of the bleaching liquid sample of Javelle-water.
2- It is suggested to verify the chlorometric degree in bleaching liquid, Javelle-water.

Step 1:
Into a 250 mL beaker containing 50 mL of acidified water, add 2g of potassium iodide. Add 2mL of diluted Javelle-water prepared according the indications described above.

We observe the formation of Iodine I_2 according to the balanced equation of the following reaction:

$$ClO^- + 2I^- + 2H^+ \rightarrow I_2 + Cl^- + H_2O$$

I^- and H^+ are the reactants in excess.

Step 2:
Titrate the iodine formed with a $(2Na+ + S_2O_3^{2-})$ solution of sodium thiosulfate of concentration 0.1 molar in the presence of an indicator: Starch or Thiodene. At the equivalence point, the volume of sodium thiosulfate solution added is 20.0 mL the balanced equation of the reaction involved during titration is:

$$I_2 + 2S_2O_3^{2-} \rightarrow 2I^- + S_4O_6^{2-}$$

a- Show that the molar concentration of the hypoclorite ion in the bleaching solution is given by:

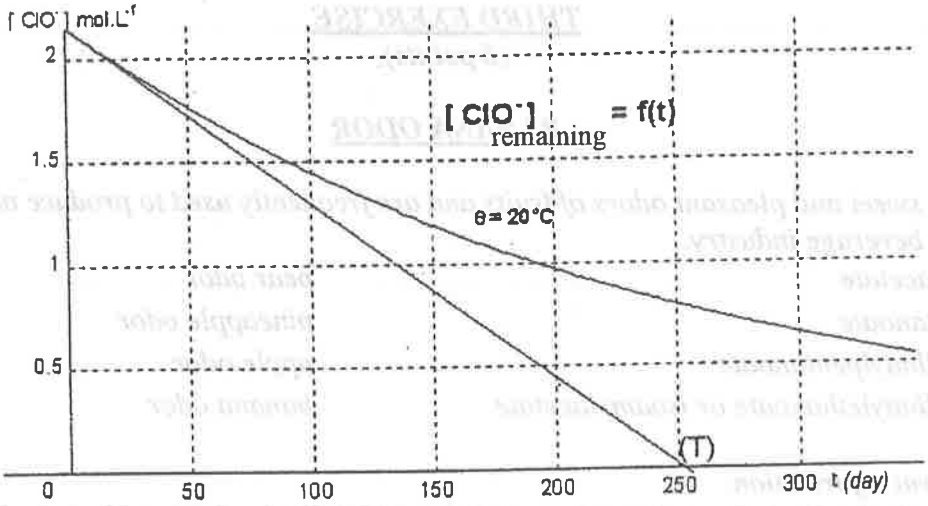
$$[ClO^-] = \frac{[S_2O_3^{2-}].v(S_2O_3^{2-})}{2.V(bleaching\ liquid)}$$

Calculate numerically this concentration.

b- Deduce the concentration of the hypochlorite ion in the recharge sample, as well as its chlorometric degree. Draw out your conclusion.
c- Is it important to introduce excess I^- ions?

II- Study the Kinetics of the Decomposition of the Javelle water

We study the Kinetics of decomposition of the hypochlorite ion in a commercial solution of Javelle-water 48 °chl, kept at 20 °C temperature. The titration of the remaining hypochlorite ion in the commercial solution at different intervals, allows us to draw the curve which gives the concentration of the remaining ClO^- ions as a function of time. Figure 1



The tangent (T) to the curve at t=0 is represented in figure 1.

1- *How much time has elapsed since the sample was taken out from the factory, assuming that the temperature was maintained constant ($\theta = 20\ °C$)?*

2- *Define the rate of disappearance of the hypochlorite ion. Calculate the rate at t=0.*

3- *Determine graphically the time corresponding to $t_{1/2}$. Calculate the rate of disappearance of the hypochlorite ion at $t_{1/2}$.*

4- *Compare the rates at t=0 and $t_{1/2}$ and draw out your conclusion.*

5- *Complete the following table by referring to figure 1.*

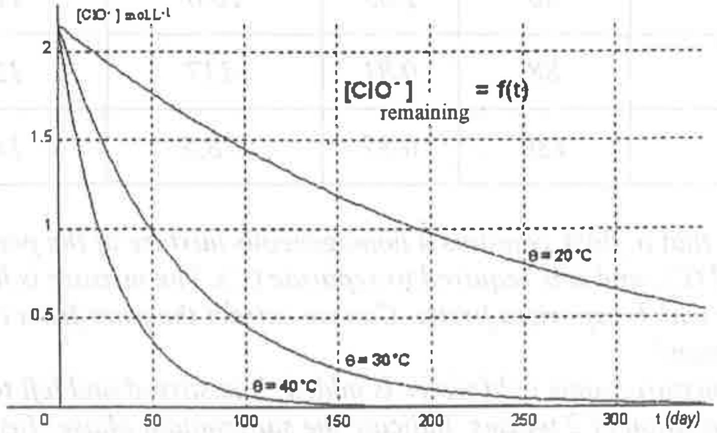
$[ClO^-]$ ($mol.L^{-1}$)	2	1.5	1	0.75
T (days)				

a- *What do you conclude?*

b- *Calculate the rate constant K.*

c- *Write the rate law for the reaction.*

6- *Figure 2 shows the curves, of the concentration of the remaining hypochlorite ion as a function of time, at three temperatures 20°C, 30°C and 40°C. Justify, using these curves, the recommendation of the manufacturer to keep the Javelle-water fresh.*



7- *In your opinion, is the conservation of diluted Javelle-water (12°chl) better than that of the original commercial solution (48° chl)? Justify your answer.*

THIRD EXERCISE
(6 points)

BANANA ODOR

Esters have sweet and pleasant odors of fruits and are frequently used to produce natural flavors in food and beverage industry.

- *n-pentylacetate* — *pear odor*
- *ethyl butanoate* — *pineapple odor*
- *3-metyhlbutylpentanoate* — *apple odor*
- *3-methylbutylethanoate or isoamylacetate* — *banana odor*

A- General information:

3-methylbutylethanoate is used to produce artificially the flavor of banana in some mineral water and some syrups. It is required to prepare this ester by the action of 3-metyhl-1-butanol (isoamylalcohol) with pure acetic acid.

1- Recall the condensed structural formulas of the above-mentioned acid and the alcohol.

2- Write the equation of the esterification reaction and the structural formula of the ester. Name the reverse reaction.

3- Recall the general characteristics of the esterification reacions.

4- Does the use of a catalyst permit to increase the yield of ester formation? Same question for increasing the temperature.

5- Indicate the methods used to obtain maximum possible yield of the ester.

B- Experimental data:

The table given below shows some of the physical characteristics of the reactants and the products obtained in the studied reaction.

	M $g.mol^{-1}$	**Density** $g.cm^{-3}$	**Melting point** ^oC	**Boiling point** ^oC	**Solubility in water**
Acetic acid (A)	*60*	*1.05*	*16.6*	*118*	*Very soluble*
3-methyl-butanal (B)	*88*	*0.81*	*-117*	*129*	*Weak*
3-methyl-acetate (C)	*130*	*0.87*	*-78.5*	*142*	*Weak*

1- Assume that a flask contains a homogeneous mixture of the preceding 3 species (A), (B) and (C), and it is required to separate (C). The mixture is heated. Identify the species which vaporizes firstly. Can we extract the ester from the mixture by distillation?

2- To the mixture, some cold water is added; it is stirred and left to stand. We observe the separation of 2 phases. Indicate the supernatant phase. Justify.

3- Using the information given in the table, calculate the mass and the quantity of matter (number of moles) of each reactant assuming that 25 mL of (B) and 35 mL of (A) are mixed together. Which of the reactants is in ecxess?

4- Calculate the yield assuming that the mass of ester obtained is 15g.

5- Suggest possible reactants that can be used to replace acetic acid in preparing the ester. What is the aim of replacing acetic acid?

1- ANTACID (6 points)

Expected solution	*Scale*	*Comments*
1- The dissolution-precipitation equilibrium of magnesium hydroxide is given by the equation: $Mg(OH)_2 \rightleftarrows Mg^{2+} + 2HO^-$ $\qquad\qquad\quad s \qquad\;\; 2s$	0.5	*0 if there is any mistake*
s being the solubility of $Mg(OH)_2$ $K_{sp} = I.P = [Mg^{2+}][HO^-]^2 = 4s^3$ *I.P is the ion-product of magnesium hydroxide.*	0.5	
$s = 1.44\times10^{-4}\ mol.L^{-1}$, $[Mg^{2+}] = s = 1.44\times10^{-4}\ mol.L^{-1}$ $[HO^-] = 2s = 2.88\times10^{-4}\ mol.L^{-1}$	0.75	*0.25 for each concentration*
2- $pH = -\log[H^+] = -\log\dfrac{Kw}{[HO^-]} = -\log\dfrac{Kw}{2s}$	0.5	
$pH = -\log\dfrac{10^{-14}}{2.88\times10^{-4}} = 10.46$	0.25	
3- The solution being diluted 5 folds. C = s, the initial concentration of HO^- *ion in solution is, C' the concentration after dilution.* $C\times V = C'\times V' \Rightarrow C' = 2.88\times10^{-4}/5 = 5.76\times10^{-5}$	0.5	
$pH = -\log\dfrac{Kw}{C'} = -\log\dfrac{10^{-14}}{5.76\times10^{-5}} = 9.76$	0.25	
4- This is the case of a common ion, magnesium hydroxide, in precipitated in the medium.	0.25	*Any equivalent reasoning is accepted.*
In fact, the concentration of Mg^{2+} *ions increases, causing the equilibrium to be displaced in the opposite direction. (direction 2).*	0.5	
The precipitation of $Mg(OH)_2$ *leads to a decrease in the concentration of* HO^- *ions in solution, thus the concentration of* H^+ *ions increases and the pH of the medium decreases.*	0.5	
5- Heating the milk of magnesia leads to the precipitation of $Mg(OH)_2$*. The equilibrium is displaced in direction2. The reaction in this direction is endothermic, therefore the dissolution (direction 1) is exothermic.*	0.75	*Any equivalent reasoning is accepted.*
6- The pH of the stomach is acidic (1 to 2). *Milk of magnesia is basic, the acidity of the stomach is decreased by the acid-base reaction between* H^+ *ions and* HO^- *ions coming from the magnesium hydroxide.*	0.75	

2- BLEACHING LIQUID (JAVELLE WATER) (8 points)

Expected solution	Scale	Comments
I- Titration of Javelle-water. Chlorometric degree		
The chlorometric degree of a javelle-water is the volume of chlorine necessary for the manufacturing of 1L of this water. So, for manufacturing 1L of javelle-water at 48°chl, we should have 48L of chlorine as follows: $n(Cl_2) = \frac{V_{Cl2}}{V_m} = \frac{48}{22.4} = 2.14 mol.$	0.25	
According to the equation of the reaction, $n(Cl_2) = n(ClO^-) = 2.14\ mol$	0.25	
So, $[ClO^-] = \frac{n(ClO^-)}{V_{javelle\text{-}water}} = 2.14\ mol.L^{-1}$	0.25	
a- According to the equation, $n(ClO^-)_{dissolved} = n(I_2)_{formed}$ *The equation of the reaction involved in titration. To reach the equivalence point, the reactants are introduced in the ratio of their stoichiometric coefficients*	0.25	
$n(I_2)_{initially\ present} = 1/2n\,(S_2O_3^{2-})_{added.}$	0.25	
So, $n(ClO^-) = 1/2n\,(S_2O_3^{2-})_{added}$	0.25	
So, $[ClO^-] = \frac{[S_2O_3^{2-}]\,V(S_2O_3^{2-})}{2V_{javelle\text{-}water}}$	0.25	
$[ClO^-] = \frac{1 \times 10^{-1} \times 20}{2\times2} = 5.0 \times 10^{-1}\ mol.L^{-1}$	0.25	
b- *Starting with a sample of 250mL of Javelle-water, we prepare 1L of diluted Javelle-water. The dilution factor is 4 times. So, the concentration of hypochlorite ion in the sample is:* $[ClO^-] = 5.0 \times 10^{-1} \times 4\ mol.L^{-1}$	0.25	
Chlorometric degree: 2.0 × 22.4 = 45L => 45°chl.	0.25	

The chlorometric degree found is less than that indicated by the manufacturer. The Javelle-water is partially decomposed by action of water: Relative error: $\frac{48-45}{48} \times 100 = 6\%$ c- To determine the concentration of hypochlorite ion, it must react completely with I_2. For this reason, we use excess iodine. II- Kinetics Study for Decomposition of Javelle-Water 1- According to the graph of figure 1, the titrated sample in the question 2.b. was manufactured 15 to 20 days before titration. 2- The rate of disappearance of hypochlorite ion at instant t is equal to the negative derivative of the function $[ClO^-]$ as a function of time. $V = \frac{-d[ClO^-]}{Dt}$ Graphical determination of this rate at t=0 The rate of disappearance of hypochlorite ions at instant t=0 is numerically equal to the slope of the tangent at the point of abscissa t=0. $r_0 \approx \frac{2.15}{250} \approx 8.6 \times 10^{-3}$ mol.L^{-1}.day^{-1} 3- The half-life time is the time needed for half of the quantity of a reactant to disappear. $t_{1/2}$= 170 to 180 days or $t_{1/2}$= 6 months. The rate of disappearance of $t_{1/2}$ $r_{1/2} \approx 4.0 \times 10^{-3}$mol.L^{-1}. day^{-1} 4- The rate of disappearance of hypochlorite ion diminishes with time because the concentration of the reactants decreases. Therefore, the concentration of reactants is a kinetics factor.	 0.25 0.5 0.25 0.25 0.25 0.25 0.25	Approximation in calculation is not necessary. 0 if there are 2 mistakes. 0.25 if there is 1 mistake.

$[ClO^-]$ $(mol.L^{-1})$ t(days)	2 17.5	1.5 90	1 192.5	0.75 267	0.5	

a- *The half-life time $t_{1/2}$ is constant. This characterizes the first order reaction.*	0.25	
b- *The rate constant is:* $K = \frac{0.693}{t_{1/2}} = \frac{0.693}{175} = 4 \times 10^{-3}\ day^{-1}$	0.25	
6- *The disappearance of Javelle-water becomes faster as the temperature increases.* *The temperature is a kinetics factor. For this reason, Javelle-water should be used fresh.*	0.25 0.25	
7- *The concentration of the reactants is a kinetics factor.* *The conservation of Javelle-water (12°chl) is better than the commercial (48°chl). For this reason, the commercial solution can be diluted in three months after manufacture.*	0.25 0.25	

3- BANANA ODOR (6 points)

Expected solution	Scale	Comments
I- General information *1- Condensed structural formula*		
Acetic acid: CH_3COOH	0.25	
3-methyl-butanol $CH_3-\underset{\underset{CH_3}{\vert}}{CH}CH_2OH$	0.25	
2- The equation of esterification is: $CH_3-COOH + CH_3-CH(CH_3)-CH_2-CH_2OH \rightleftarrows$ $CH_3-COO-(CH_2)_2-CH(CH_3)-CH_3 + H_2O$	0.5	0.25 if one error. 0 if two errors.
The condensed structural formula of the ester is: $CH_3-\underset{\underset{O}{\Vert}}{C}-O-(CH_2)-(CH_2)-\underset{\underset{CH_3}{\vert}}{CH}-CH_3$	0.25	
The opposite reaction is hydrolysis.	0.25	
3- The characteristics of the reaction are: *Slow, reversible, limited and catalyzed* H_3O^+ *ion.*	0.5	
4- No; these factors increase the rate of reaction, but not the yield.	0.5	
5- To have a better yield of the ester we should: - *Use an excess of the reactant having low price.* - *Remove the ester formed.*	0.5	
II- Experimental data		
1- Acetic acid is the more volatile reactant, we cannot extract the ester from the mixture by distillation.	0.25	0.25 if no justification.
2- Acetic acid dissolves in water and it renders the ester-alcohol mixture, less dense, thus forming an organic phase on top of the aqueous phase.	0.25	

3- The mass of ester obtained is: m = 15g *Determine the quantity of matter (moles) of reactants used:* $n_{o(acid)} = \frac{V_{o(acid)} \times P_{(acid)}}{M_{(acid)}} = \frac{35 \times 1.05}{60} = 0.61$ *mol*	0.25	*Any equivalent reasoning is accepted.*
$n_{o(alcohol)} = \frac{V_{o(alcohol)} \times P_{(alcohol)}}{M_{(alcohol)}} = \frac{25 \times 0.81}{88} = 0.23$ *mol*	0.25	
The limiting reactant is alcohol.	0.25	
4- The limiting reactant being the alcohol, thus it determines the yield of the ester synthesized.	0.25	
Number of moles of ester formed: $n_{(ester)} = \frac{m_{(ester)}}{M_{(ester)}} = \frac{15}{130} = 0.12$ *mol*	0.25	
Percent yield $= \frac{n_{(ester)}}{n_{o(alcohol)}} \times 100 = \frac{0.12}{130} \times 100 = 52\%$	0.25	
5- The possible reactants to replace acetic acid are: *Acetyl chloride or acetic anhydride.*	0.5	
The aim of replacing acetic acid is to have a better yield.	0.25	

EXAM SAMPLE 4

FIRST EXERCISE
(6 points)

COMMERCIAL HYDROCHLORIC ACID

Hydrochloric acid is used to treat tartar, to clean metals, and renovate stones and marbles; it is sold commercially as a highly concentrated solution.

On the label of a commercial hydrochloric bottle, we read the following:

- *Hydrochloric acid (aqueous solution of hydrogen chloride).*
- *A minimum of 30% hydrogen chloride HCl (percentage by mass)*
- *Density =$1.18 g.cm^{-3}$.*

Given:

Molar mass(M) in $g.mol^{-1}$.
$M(H) = 1$; $M(C) = 12$; $M(O) = 16$; $M(Cl) = 35.5$; $M(Ca) = 40$; $K_w = 10^{-14}$.

I- *Dilution:*

1- Show that the concentration of the commercial solution of hydrochloric acid is about $10 mol.L^{-1}$

2- We titrate this HCl solution versus a sodium hydroxide solution, which is freshly prepared of concentration 5.0×10^{-2} $mol.L^{-1}$.

i- Why should we dilute the hydrochloric acid solution before titrating and measuring?

ii- Why do we use a recently prepared sodium hydroxide solution?

3- We want to prepare a hydrochloric solution of concentration close to that of NaOH solution. Using the available materials, describe the experimental procedure to be followed in this preparation.

Materials:
Volumetric flasks (1L, 250mL, 100mL, 50mL); pipets (volumetric): (5mL; 10mL; 20mL; 25mL). pipet fillers; distilled water, graduated cylinders: (50mL; 100mL).

II- *Titration*

Titration using pH-meter; 20.0mL of the diluted acid solution of concentration C_a versus the NaOH solution of concentration $C_b = 5.0 \times 10^{-2}$ $mol.L^{-1}$
The curve obtained is represented in figure 1.

1. *Sketch and label the apparatus used in titration.*
2. *Describe briefly the experimental procedure.*
3. *Write down the balanced equation of the reaction. Calculate the equilibrium constant of the reaction. Is this a complete reaction?*
4. *Determine graphically the coordinates of the equivalence point. Determine the concentration of the diluted acid solution. Deduce the concentration of the commercial solution.*

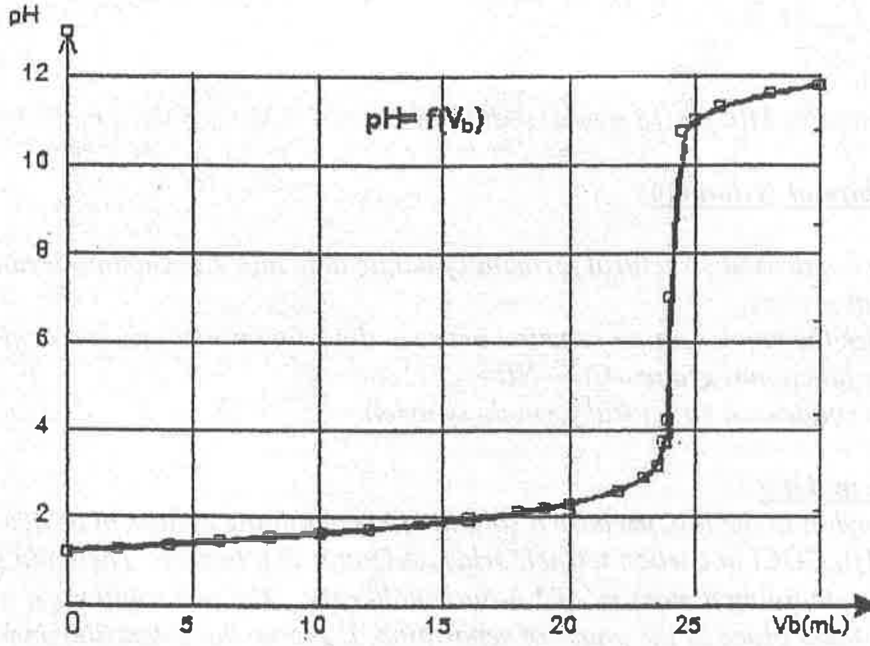
5- Calculate the real % by mass of HCl dissolved in the commercial solution.

6- Hydrochloric acid attacks tartar which is a calcarous white solid which is formed in the sinks of many baths. Tartar is mainly composed of calcium carbonate, $CaCO_3$.

The reaction between HCl and $CaCO_3$ is:

$$CaCO_3 + 2H_3O^+ \longrightarrow Ca^{2+} + CO_2 + 3H_2O$$

Determine the mass of tartar that can be attacked by 50mL of the commercial acid solution.



SECOND EXERCISE
(6 points)
NYLON

Nylon possesses good mechanical properties. It is used to make and fabricate several objects in several domains (automobiles, buildings, electricity...) Nylon 6,6 is a polyamide resulting from polymerization reaction between 1,6-hexanedioic acid (adipic acid) and 1,6-diaminohexane.

***Given**:*

$M(H) = 1 g.mol^{-1}$; $M(C) = 12\ g.mol^{-1}$; $M(N)=14\ g.mol^{-1}$; $M(O) = 16\ g.mol^{-1}$ $M(Cl) =35.5\ g.mol^{-1}$

I- *Structure of Nylon 6,6*

1- Write the condensed structural formula of adipic acid and 1,6-diaminohexane. Circle the functional groups.
2- Schematize the condensation reaction between the 2 functional groups (acid-amine)
3- Name the functional group –CO—NH—
4- Write the condensed structural formula of nylon.

II- *Nylon making*

To prepare nylon in the lab, prepare a solution (A) containing a mass of acylchloride $ClCO—(CH_2)_x\ COCl$ in carbon tetrachloride and put it in a beaker. Then add slowly an aqueous solution (B) containing a mass m′ of 1,6-diaminohexane. The two solutions are not miscible and the reaction takes place at the phase of separation. Hang up the nylon film and roll it up on a glass rod. A mass m′=11.6g gives 29.05g of nylon.

1- Which is better to use an acid or the corresponding acylchloride to prepare nylon in the lab? Justify.
2- Calculate the mass m, assuming complete reaction.
3- Determine x and write the notation following the word nylon of the prepared polymer.
4- In some countries, acid pollution in air is due to human activities. The distribution of gases is as follows:

SO_2: 220 000 tons
Nitrogen oxides: 150 000tons
HCl: 10 000 tons

In a country, 10% of the HCl amount formed during the manufacturing of 318500 tons of nylon indicated in question 2 goes into the atmosphere. What is the percent contribution of the manufactured nylon to the atmospheric acid pollution.

THIRD EXERCISE

(8 points)

ACETONE

Acetone is a common current solvent. Like most of the carbonated compounds, it rarely exists in nature. It is also used in the manufacture of plastic materials. It possesses 3 carbon atoms in its skeletal structure.

Given:

Molar mass(M) in g.mol^{-1}
$M(H) = 1$; $M(C) = 12$; $M(O) = 16$,
Ideal gas constant $R = 8.3 J.mol^{-1}.K^{-1}$

I- *Structural formula*

1- Write the condensed structural formula of acetone. Circle the functional group.
2- Give the systematic name of the compound.
3- Write the condensed structural formula and give the corresponding name of the isomer of acetone having the same functional group.

II- *Preparation of Acetone*

In a cylinder with a movable piston, empty from air and containing reduced copper, we heat 3g of 2-propanol. The following equilibrium is established:

Alcohol(g) $\rightleftarrows$ Acetone(g) + Hydrogen (g).

1- Write down the equation which represents this equilibrium?
2- Indicate the role of reduced copper.
3- Calculate, in pascal, the pressure of the alcohol vapor at 602.4K, knowing that the volume of the cylinder is $500 cm^3$.
4- Calculate, in terms of the degree of conversion of alcohol, the number of moles of the gaseous mixture at equilibrium.
5- At equilibrium, the pressure attains a value $6.25 \times 10^5 Pa$. What is the quantity of acetone formed?

III- *Displacement of the Shifting Equilibrium*

In order to determine the relative density of a gaseous mixture at different volumes, the following results are given:

Volume (cm^3)	*500*	*560*	*600*	*700*
Relative Density	*1.65*	*1.48*	*1.38*	*1.18*

1- Write the expression of the relative density of the gaseous mixture in terms of α

2- Based on the values given in the above table, explain how we should vary the volume of the cylinder in order to increase the rate of the dehydrogenation of alcohol.

3- What should be the initial volume so that dehydrogenation is complete?

IV- *Acetone in our daily life*

Acetone appears in the urine upon the utilization of fats by the organism. This is established under two conditions:

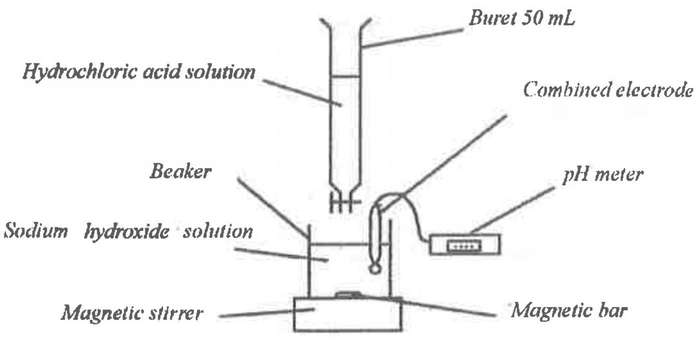
- *When the person is going on a diet without eating for a long time.*
- *When there is insulin depletion (in the case of diabetes, there is an accumulation of sugar and acetone in the urine).*

1- Explain how a diet can be efficient.

2- What is the significance of the presence of sugar and acetone in the urine?

1- COMMERCIAL HYDROCHLORIC ACID (6 points)

Expected solution	*Scale*	*Comments*
I- Dilution *1- The mass of commercial hydrochloric acid is m=1180g.* *The mass of hydrogen chloride dissolved in 1L of this solution:* $\frac{1180 \times 30}{100} = 345g$ *Quantity of hydrogen chloride dissolved in 1L of solution* $n = \frac{m}{M}$ *M: molar mass of hydrogen chloride* $n = \frac{354}{36.5} = 9.7mol$ *The concentration of the commercial solution is:* $C=9.7mol.L^{-1}$ *about* $10\ mol.L^{-1}$.	0.25	*Any equivalent reasoning is accepted.*
2- *a- To titrate the commercial solution, we need a basic solution of high concentration.*	0.25	
In fact, the commercial hydrochloric acid solution is 200 times more concentrated than the sodium hydroxide solution used ($10/5\times10^{-2}= 200$)*. So, for titrating 10mL of the commercial solution, we must use* $200 \times 10= 2000mL$ *=2L of the basic solution.*	0.25	
b- The sodium hydroxide solution is mixed with carbon dioxide (originating from the atmosphere) in water, according to the equation: $H_2O + CO_2 + 2(Na^+ + OH^-) \rightarrow 2Na^+ + CO_3^{2-} + 2H_2O$ CO_3^{2-} *is the carbonate ion.*	0.25	*Balanced equation is not necessary.*
The concentration of hydroxide OH^- *ions decreases with time.*	0.25	
3- *The concentration of the commercial solution is* $10mol.L^{-1}$*.* *To obtain an acidic solution of concentration* 5×10^{-2} $mol.L^{-1}$*, we must dilute 200 times the commercial solution.*	0.25	

Factor of dilution: $\frac{10}{5\times10^{-2}} = 200$		
Experimental procedure: *The commercial solution being corrosive and very concentrated, use gloves and eye-goggles for safety.*	0.25	*0 if it is wrong*
Take 50 mL of the commercial solution with a pipet and transfer it to a 1L volumetric flask.	0.25	*0 if it is wrong.*
Add distilled water until the line-mark of the flask. *Swirl thoroughly to homogenize the mixture.*		*0 if it is wrong.*
II- Titration *1-*  	0.5	*0.25 for the scheme.* *0.25 for the labeling.* *0 if there are 2 mistakes.*
2- • *Fill the buret with sodium hydroxide solution.* • *Measure 20mL of hydrochloric acid solution using a pipet and transfer it into a beaker.* • *Caliberate the pH-meter.* • *Measure the pH of the acid in the beaker.* • *Add each time 2mL to reach the 'jump' in pH. For every addition, homogenize the solution using a stirrer.*		
• *During the significant rise of pH (jump) add gradually 0.5mL, each time, till the end of the jump. Then continue adding 1mL, gradually.*	0.5	*0 if there is an important mistake.*
3- *The balanced equation of the titration reaction:* $H_3O^+ + OH^- \rightleftarrows 2H_2O$		
Equilibrium constant for the reaction) : $K_r = \frac{1}{[H_3O^+]\times[OH^-]} = \frac{1}{K_e} = 10^{14}$	0.25	

$K_r > 10^4$: the reaction is **complete (quantitative)**		
4- We determine the coordinates of the equivalence point E by the parallel tangent method: $E(V_e = 24.5mL; pH_e= 7.0)$	0.25	
At the equivalence point, the reactants introduced are in the ratio of their stochiometric coefficients. $n(H_3O^+)$ initial $=n(OH^-)$	0.25	
So, $C_a \times V_a = C_b \times V_e$ where V_e is the equivalent volume.	0.25	
Concentration of the diluted solution : $C_a = \frac{C_b V_e}{V_a} = C_a = \frac{5\times 10^{-2} \times 24.3}{20} = 6.1 \times 10^{-2} mol.L^{-1}$.	0.25	
The commercial solution is diluted 200 times, its concentration is: $6.1 \times 10^{-2} \times 200 = 12.2\ mol.L^{-1}$	0.25	
5- The mass of hydrogen chloride dissolved in 1L of commercial solution is: $M = 12.2 \times 36.5 = 445g$	0.25	
Percentage of dissolved hydrogen chloride: $\frac{450 \times 100}{1180} = 37.7\%$ This result is confirmed with the indications on the label; the percentage of hydrogen chloride dissolved is greater than 30%.		
6- The quantity of hydronium ions in 50mL of the commercial solution is: $n(H_3O^+) = C \times V = 12.2 \times 5 \times 10^{-2}= 0.61mol$.	0.25	
According to the balanced equation of the reaction $n(CaCO_3)$: $m= \frac{n(H_3O^+) \times M}{2}$; (M: molar mass of calcium carbonate)	0.25	
$m = \frac{12.2 \times 5\times 10^{-2} \times 100}{2} = 30.5g$	0.75	

2- <u>NYLON</u> (6 points)

Expected solution	***Scale***	***Comments***
I. Structure of Nylon		
1- $\boxed{HOOC}-(CH_2)_4-\boxed{COOH}$	*0.5*	*Saturated carbon chains with 6 carbon atoms.*
$\boxed{H_2N}-(CH_2)_6-\boxed{NH_2}$	*0.5*	
2- $-HN-\boxed{H + HO}-\overset{\overset{O}{\Vert}}{C}- \rightarrow H_2O + -\overset{\overset{O}{\Vert}}{C}-NH-$	*0.5*	*Condensation with elimination of water.*
3- Amide	*0.5*	
4- $-(-HN-(CH_2)_6-NH-\overset{\overset{O}{\Vert}}{C}-(CH_2)_4-\overset{\overset{O}{\Vert}}{C}-)_n-$	*0.5*	
II- Nylon Manufacturing		
1-In order to prepare nylon in the laboratory, it is advantageous to use acyl chloride which is a carboxylic acid derivative. The reaction is fast and complete while, with carboxylic acid, the reaction is slow and requires heating to a very high temperature.	*0.5*	
2- The stoichiometry of the reaction is given by the following relation: $\frac{n(amine)}{1} = \frac{n(acyl\ chloride)}{1} = \frac{n(nylon)}{1} = \frac{n(HCl)}{1}$	*0.5*	
Molar mass(M) in g.mol^{-1} *M(amine) =116; M(acyl chloride) =124+14x M(HCl) = 36.5 g/mol*	*0.5*	
N(amine) = 11.6/116 = 0.1 mol => m(HCl) = 36.5g	*0.5*	
=> m= m(nylon) + m(HCl) – m' => m = 21.1g.	*0.25*	
3- M(acyl chloride) = 21.1/0.1 = 211g/mol =>	*0.25*	
211 = 127 + 14x => x = 6, Nylon 6,6 ®	*0.5*	
4- $n_{HCl} = n_{nylon}$ *or M(nylon)= 290.5 g.mol*$^{-1}$	*0.25*	
$M(HCl) = \frac{290500 \times 36.5 \times 1}{290.5 \times 100} = 365t$ *Total mass of pollutants = 380 000t*	*0.5*	
Contribution = (365 × 100)/380000 = 0.096%	*0.25*	

3- ACETONE (8 points)

Expected solution	Scale	Comments
I- Structural Formula		
1- $CH_3-\overset{\overset{\displaystyle O}{\|}}{C}-CH_3$	0.5	*Carbonyl group*
2- propanone	0.5	
3- CH_3-CH_2-CHO*: propanal*	1	*0.5 for the name.*
II- Preparation of acetone *1-* $CH_3-CHOH-CH_3 \rightleftarrows CH_3-CO-CH_3 + H_2$	0.5	
2- The reduced copper acts as a catalyst.	0.5	
3- $P = \frac{nRT}{V}$ *N in mole; T in K; R in J/mol.K; V in L and P in Pa*	0.25	*-0.25 for each error*
M(alcohol)= 60g/mol => n(alcohol) = 5×10^{-2} *mol* $V = 500\ cm^3 = 5\times10^{-4} m^3$	0.25	
$P = 5.0 \times 10^5 Pa$	0.5	
4- Starting with n moles of alcohol, the composition of the gaseous mixture at equilibrium is: *n(alcohol) = n(1-*α*); n(acetone) = n(dihydrogen) =n*α	0.5	
Therefore, $n_e = n(1+\alpha)mol. = 5\times10^{-2}(1+\alpha)mol.$ *From the relation of ideal gases, we replace each term with its value:* $6.25 \times 10^5 = \frac{5\times10^{-2}(1+\alpha)\times8.3\times602.4}{5\times10^{-4}}$ *Thus,* α *=0.25 => n(acetone) = 0.0125 mol*	0.5	

III- Displacement of the Equilibrium		
1- Molar mass of the mixture is: $M = \frac{nM(alcohol)}{Ne} = \frac{nM(alcohol)}{n(1+\alpha)} = \frac{60}{(1+\alpha)}$	0.5	
$\Rightarrow d = \frac{60}{29(1+\alpha)}$	0.25	
2- According to the values given in the table, you can see that when V increases, d decreases. This decrease in d is due to the increase in α. You can conclude that to favor dehydrogenation of the alcohol, you should increase V.	0.75	
3- Dehydrogenation is practically total when α tends toward 1. for $\alpha=1$, $n_t = 5\times10^{-2}(1+1)$, $n_t = 0.1mol$	0.25	
Replace n, R, T, and P by their values: $V = \frac{0.1\times 8.3 \times 602.4}{6.25\times10^5} = 0.8m^3$	0.25	
IV- Acetone in our daily life		
1- We can perform the test of acetone in urine, if it is positive, you can conclude that the diet is effective.	0.5	
2- The presence of sugar and of acetone in the urine indicates the absence of insulin.	0.5	

General Instructions for official exam in chemistry

Third year secondary
Sociology - Economics and Literature – Humanities Sections

The chemistry exam is a means for evaluating the levels of acquired competencies as defined in the list of competencies in the evaluation guide.

- ***Nature of the exam***

The chemistry exam is made up of three obligatory questions marked on a total of 20 marks. These questions are independent, and can be solved by the student in any order.
Each of these questions is supposed to evaluate competencies integrated in different domains.

The exam should be based on the following:
- *Strict respect for the spirit of the evaluation policy (guide and samples) and the official order. No.21 dated April, 30, 1999*
- *Pedagogic teaching practices balancing the three levels of knowledge (acquisition, transfer and production).*
- *Competencies belong are chosen from the domains and designed to integrate the learning objectives of different topics of the curriculum.*
- *Good representation of the proposed documents and the clear drafting of the subjects. Thus, if we require the justification of a result, a derivation, a comment, a figure, we must ask that clearly in the question. We don't reserve marks for implicit questions.*
- *A scheme specific to each question to insure consistency in homogeneous correcting the copies.*
- *Allowing the use of scientific non-programmable calculators so that real and practical questions may be asked*

- ***Score weighting***

The score of each of the two questions is 10 points.

- ***Time***

The time allotted for the chemistry exam is one hour.

Tests should be predesigned and include:
*In the domain of **Applying knowledge**:*

- *Analysis of the relevant data given.*
- *Mobilization of knowledge appropriate to chemistry.:*
  - *Choice of the concept, principle, model, law, hypothesis...*
  - *Choice of the formula*
  - *Literal expression of the solution*
  - *Choice of units.*
- *Mobilization of other knowledge out-of chemistry (calculation, graphs, vectors...)*
- *Validity of result.*

*In the domain of **Mastery - communicating** :*

- *Translate one mode of representation to another one.*
- *Respect of rules of the chosen mode of representation (symbol, equation, scale, writing of indices...).*
- *Analysis of important information.*
- *Mobilization of knowledge out-of chemistry.*
- *Mobilization of knowledge relevant to chemistry*
- *Clear redaction.*

This list is not exhaustive.

EXAM SAMPLE –1

FIRST EXERCISE
(10 points)

MILK

Milk, a drink and food at the same time, is a nutrient rich in calcium. It is a symbol of strength and health. Maternal milk constitutes an essential initial fuel for the newborn. It gives them antibodies to protect them from infections and the necessary nutrients for their growth.

However, milk spoils very quickly, because it is very rich in acidifying germs. So when it is not refrigerated or boiled, it will transform into either:

- *curds resulting from the coagulation of casein (milk protein)*
- *a transparent liquid: lactoserum*

Conserving milk, and the production of the dairy products are of significant economical importance; many industries depend on this natural product. Since the 19th century two important processes to conserve milk have been developed: Pasteurization (elaborated by Louis Pasteur) and Sterilization.

(SCIENCE et VIE)

1- *Indicating the constituents of the milk, justify why it is considered an essential fuel for the newborn .*
2- *"Milk is a vital product". Explain.*
3- *Why does the milk undergo certain transformations? What it is transformed to? What do we call the phenomenon related to coagulation of casein?*
4- *Certain enzymes (proteins) are active during the transformation of milk. What is the role of the enzymes?*
5- *The production, conservation and transformation of milk have an important role in the economy of a country. Explain.*
6- *Name some dairy products.*
7- *Name the two major processes used to conserve milk.*

SECOND EXERCISE
(10 points)

PERFUMES AND COSMETICS

I- *On the shelf of a supermarket, an employee places in a random way the following commercial products: soaps, deodorants, shampoo, sun protection products, toothpaste, cosmetic colors, hair conditioner, bath products, baby care products, dental care products, perfume, hair gel.*

Classify these products into: hygiene products, care products and well being products.

II- *On a deodorant bottle, you read the following indications:*

- *This deodorant provides a sensation of freshness*
- *This freshness will last all day.*

Usage precautions: Content under pressure. Protect from sun rays. Do not expose to temperature higher than 30^0C. Do not vaporize near a flame…
Ingredients: Alcohol, butane, propane, perfume.

1- *To what is the freshness sensation due to?*
2- *Why does the deodorant last all day?*
3- *Identify the role of the alcohol.*
4- *Identify the role of butane and that of propane.*
5- *Explain, why you shouldn't use vaporize it near a flame?*

1- MILK(10 points)

Expected solution	*Scale*	*Comments*
1- Milk contains: carbohydrates, lipids, proteins, minerals, vitamins…All these constituents are necessary to ensure life and normal development for the newborn. Maternal milk contains also antibodies which protect the baby from bacterial and microbial infections.	*2*	*Any equivalent reasoning is accepted*
2- Milk contains several types of microorganisms and bacteria (germs) that can multiply under normal conditions.	*1*	
3- At room temperature, acidifying germs can lead to acidification of milk; the pH of the medium decreases. This causes the milk, to turn into: curds and lactoserum. Caseins are proteins that coagulate in acidic medium: this is protein denaturation.	*1* *1*	*Any equivalent reasoning is accepted*
4- Enzymes are biological catalysts.	*1*	
5- In many countries, several processes and techniques are used to conserve and transform milk in order to develop other industrial and economic sectors which are directly or indirectly related to the-manufacturing of dairy products. The dairy industry is imprtant for the development of the economy of these countries.	*2*	*Any equivalent reasoning is accepted*
6- Butter, yogurt, cheese…	*1*	
7- Pasteurization and sterilization.	*1*	

*2- **PERFUMES AND COSMETICS** (10 points)*

Expected solution	*Scale*	*Comments*
I- Hygiene products: soap, deodorant, shampoo, bath products.	*1*	
Care products: sun protection products, hair conditionner, dental care products, baby care products, toothpaste.	*1*	
Well-being products: cosmetic colors, perfumes, hair gel.	*1*	
II- *1- Due to the presenceof alcohol which evaporates in contact with the skin and the presence of perfume.*	*2*	
2- Because the perfume evaporate slowly.	*1*	
3- The alcohol is a solvent that gives us a homogeneous solution.	*1*	
4-Butane and propane are gases that allow the propulsion of the solution present inside the aerosol bottle.	*2*	
5- Due to the presence of flammable substances: alcohol, butane and propane.	*1*	

EXAM SAMPLE-2

FIRST EXERCISE
(10 points)

PHOSPHOROUS

The element phosphorous is known to be important for the memory. It is found in a great number of foods. It is part of the bone structure and plays the role of a plastic element. It is also important in the transfer of energy, muscle contraction and nervous transmission.

Given: The contribution in mg of the element phosphorous in some foods

Food(mass = 100 g)	*Phosphorous(mass in mg)*
Soya	*580*
Chocolate	*400*
Fish	*200*

An adult needs 1400 mg of phosphorous per day.
The price of 100 g of chocolate bar is 2000 LP.
The price of 1 kg of fish is 14000 LP.

1- *Explain the meaning of the expression "plastic element".*
2- *Give the significance of the term macro-element. Show whether phosphorous is a macro-element or not.*
3- *Determine the mass of soya, chocolate or fish that an adult should consume per day, in order to satisfy his needs if he is eating each food seperately.*
4- *Plot the results using a bar graph.*
5- *Evaluate the mass of proteins taken up by the adult if he/she covers his/her needs of phosphorous by eating only fish; the average percentage by weight of proteins in fish is 24 %.*
6- *Proteins are polymers of α-amino acids. Write the general formula of an α-amino acid and circle the two functional groups that characterize these amino acids. Name two chemical elements, other than carbon and hydrogen that are present in proteins.*

SECOND EXERCISE
(10 points)

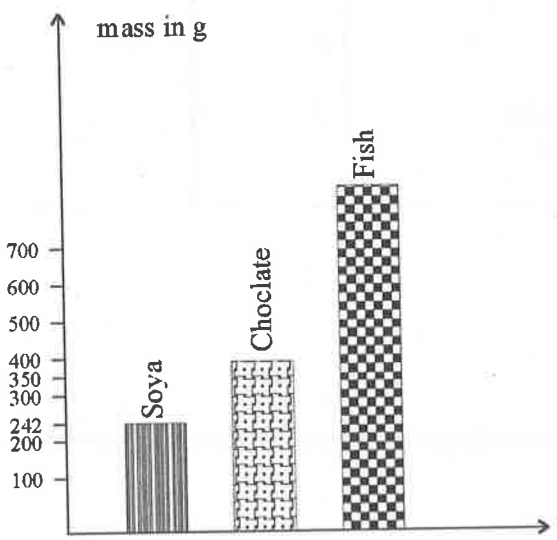
WASTEWATER TREATMENT

Wastewater treatment requires a series of operations.
To treat materials in suspension, screening or decantation is required. Screening, using grate or sieve, will allow us to remove voluminous compounds whose sizes vary from few millimeters to few centimeters. For sizes varying from 2 micrometers to 2 or 3 mm, a sieve is used. Decantation separates, by sedimentation or floating, solid and liquid phases. Its efficiency depends on the size of solid particles and the specific weights of liquid and solid particles, respectively.

- *Treatment of colloids: The possibilities of decantation of particles with sizes varying from 10^{-8} to 10^{-2} mm are considerably limited. Treatment by physical ways may lead to modification of the colloid's structure by neutralization of their electric charge, this is coagulation; flocculation is bridging between coagulated colloids.*
- *Treatment of carbonated organic pollution is usually performed by aerobic biological systems.*
- *Treatment of nitrogenous compounds pollution is controlled by chemical procedures: alkalinization followed by the elimination of the ammonia released or fixation of NH_4^+ on resin. Denitrification is a biological anaerobic process which allows us to reduce nitrates by 80%.*
- *Treatment of phosphorous pollution is based on chemical precipitation.*
- *Treatment of micropollutants is based on: filtration with sand to eliminate particular residual pollution; biological filtration by the dissolution of oxygen in order to eliminate any dissolved biodegradable organic pollutants; filtration with active carbon to eliminate more difficult biodgradable compounds.*
- *Treatment of microorganisms requires harsh techniques of chemical disinfection with halogens.*

1- List the operations for wastewater treatment.
2- Indicate the operations that require chemical treatment. Name the chemical compounds used in these operations.
3- Explain the terms: biodegradable and anaerobic.
4- Name the property taken into consideration during decantation or flocculation.
5- Name the pollutants that require biological treatment.

1- **PHOSPHOROUS** (10 points)

Expected solution	***Scale***	***Comments***
1- An element is said to be a plastic element when it is essential for the formation and maintenance of bones and teeth.	*1*	*Plastic food of plants contains the following elemenst:N,H,P,S…*
2- A macroelement is an element that we need in an amount that goes beyond 100 mg per day.	*1*	
Phosphorous is a macroelement, because our daily need of it is 1400 mg.	*1*	
3- m(soya)= (1400 x 100)/580 = 242 g. *m(chocolat)= (1400 x 100)/400= 350 g.* *m(fish)= (1400 x 100)/200 = 700 g.*	*1.5*	
4- 	*2.5*	
5- m(protein)=700 x 24/100 = 168 g.	*1*	
6- $R\text{-}\underset{\underset{\boxed{NH_2}}{\vert}}{CH}\text{-}\boxed{COOH}$	*1*	
Proteins contain mainly 4 principal elements: carbon C, hydrogen H, oxygen O and nitrogen N.	*1*	

2- <u>WASTEWATER TREATMENT</u> (10 points)

Expected solution	*Scale*	*Comments*
1- Wastewater treatment involves operations for treating the following: substances in suspension, colloids, carbonated organic pollutants, nitrogenous pollutants, micropollutants and micoorganisms.	*2*	*Remove 0.25 for each missing operation*
2- Treatment of nitrogenous pollution is by alkalinization i.e. use of an alkali metal: sodium. Chemical disinfection by halogens like chlorine.	*3*	
3-An organic substance degraded by a biological factor is called biodegradable. When the transformation takes place away from the air, it is called anaerobic.	*2*	
4- The specific mass	*1*	
5- Pollutants: nitrogenous compounds, organic carbonated compounds, micropollutants and microorganisms.	*2*	

EXAM SAMPLE –1

FIRST EXERCISE
(10 points)

ANTIBIOTICS AND RESISTANCE TO MICROBES

There is always a fight between bacteria and antibiotics. The first, ingeniously tries to find out ways to resist the effects of the latter. How do bacteria manage to resist that well?
Bacteria are able to become resistant easily. It seems that when they acquire the resistance against a certain compound, they become resistant to many others i.e. multi -resistant.
You can see that antibiotics are usually prescribed in small doses and for a long time; these can create the best conditions for building the emergence of resistance in germs. Also the misuse of antibiotics can benefit the germs.

Several resistance strategies can be adopted by the bacteria in order to weaken the effect of the antibiotic:
- *Generating pumping system that extracts the antibiotic from the bacteria.*
- *Synthesis of an enzyme (protein) to degrade the antibiotic.*
- *Synthesis of an enzyme that can transform and inactivate the antibiotic molecule…*

(SCIENCE ET VIE)

1- Define an antibiotic.
2- Compare between broad and narrow spectrum of an antibiotic.
3- Describe the resistance of bacteria to antibiotics.
4- Distinguish between the trade name and the generic name of an antibiotic.
5- Indicate the favorable conditions for the development of a resistance in the bacteria.
6- It is known that host cells are the best places where bacteria can develop resistance to antibiotics. Justify this statement based on the above text.

SECOND EXERCISE
(10 points)

VITAMINS A AND C

Vitamins are natural chemical species that are indispensable for life. They are taken from the food of organisms because they cannot be synthesized by the organisms.. Although the amount needed is very small (in the diet), deficiency in vitamins causes major problems.

A project financed by the European Union succeeded in producing rice enriched with β-carotene, a natural precursor of vitamin A. This scientific break through eliminate serious deficiencies in vitamin A for populations where rice is an essential food (more than 2 billion people).
This deficiency constitutes a health problem in more than 118 countries: it constitutes the main cause of infant blindness in under developed countries; it also limits resistance to diseases such as pulmonary infections, diarrhea or measles. According to World Health Organization (WHO), 250 million children actually suffer from vitamin A deficiency. Providing more of this vitamin can decrease the percentage of deaths resulting from the above disease by 33 or even by 50 % .

Vitamin C figures in several cell activities. This substance, unlike vitamin A, is water-soluble (hydro-soluble) and lipo-soluble. You can find it in all cells in increasing amounts as the activity of the cells increases. This is, for example, an essential factor for the production and balance of the bone tissue and resistance to microbial infections.
Daily needed amounts of vitamin C are 75 mg for adults and 35 mg for young children. It may reach 100 mg during growth period. Deficiency in vitamin C leads to certain diseases: scurvy (body fatigue with major troubles leading to death), and painful swollen joints...

(SCIENCE ET VIE)

1- *Define vitamins.*
2- *Classify vitamins A and C into either hydro-soluble or lipo-soluble vitamins.*
3- *What does a deficiency in vitamin A lead to?*
4- *Why is β-carotene enriched rice considered as a scientific breakthrough for under - developed countries?*
5- *Indicate a food diet which can provide the daily need of vitamin C?*
6- *During growth periods, the amount of vitamin C needed is about 100 mg in young children. Justify the increase in the daily need of vitamin C.*
7- *Patients with scurvy have fragile bones. Explain.*

1- ANTIBIOTICS AND RESISTANCE TO MICROBES (10 points)

Expected solution	Scale	Comments
1- An antibiotic is a natural substance but it can also be obtained by chemical synthesis. It is intended to kill or inhibit the growth of pathogenie microorganisms (microbes causing infections)	2	*Any equivalent definition is accepted.*
2- Broad spectrum antibiotics are efficient against a great variety of microorganisms (microbes and bacteria).Antibiotics with narrow-spectrum are efficient only against specific microorganisms.	1 1	
3- A bacterium that cannot any more be eradicated by the antibiotic, is called "resistant". Bacteria resistance to antibiotics can either be natural or acquired. *Different strategies are adopted by bacteria in order to weaken the antibiotic action:* *- Forming a pump to take out the antibiotic from the bacteria.* *- Synthesis of an enzyme(protein) to degrade the antibiotic.* *- Synthesis of an enzyme which can transform or inactivate the antibiotic molecule.*	1 2	*Any equivalent definition is accepted.*
4- Generic name: it is the chemical name of the active substance which forms the medicine. *Trade name: it is the name given by a certain chemical Industry in order to commercialize the medicine.*	1	*Any equivalent definition is accepted.*
5-Prolonged use and in small amounts of the antibiotic.	1	
6-In host cells, germs are many and in continuous contact with all sorts of drugs, mainly antibiotics. *In addition to this, prolonged use and in small doses and sometimes the misuse of antibiotics can allow bacteria to develop resistance to antibiotics.*	1	

2- *VITAMIN A AND C* (10 points)

Expected solution	*Scale*	*Comments*
1- They are chemical substances, natural or synthesized, essential for the proper functioning and balance of the human body.	*2*	*Any equivalent definition is accepted.*
2-Vitamin A is soluble in organic compounds i.e. it is liposoluble. *Vitamin C is soluble in water i.e. it is water-soluble (hydro-soluble).*	*1*	
3- It constitutes the main cause of infant blindness in under-developed countries. It also limits resistance to certain dangerous diseases such as pulmonary infections, diarrhea and measles.	*2*	
4- Because providing this vitamin would decrease death by 33 to 50 % resulting from the diseases mentioned above.	*1*	
5- Daily uptake of food should include vitamin C rich compounds: green vegetables, fruits, milk...	*1*	
6- Vitamin C is an essential factor to the production and balance of bone tissue which develops during growth period.	*2*	
7- Deficiency of vitamin C causes scurvy, weakness of bone tissue where the bone becomes fragile.	*1*	*Any equivalent definition is accepted.*

EXAM SAMPLE-2

FIRST EXERCISE
(10 points)

MEDICINAL DRUG

You read the following on the label of a medicinal-drug box:

Composition	
Acetylsalicylic acid	*0.40 g*
Ascorbic acid	*0.020 g*
Monophosphothiamine cholride(vitamin B_1)	*0.00214 g*
1 tablet (additive)	
Effervescent	

1. *Identify this medicinal-drug.*
2. *What is the active ingredient in this medicinal drug?*
3. *Give two characteristics of this medicinal drug.*
4. *Define these characteristics.*
5. *Indicate the secondary effects of this medicinal drug.*
6. *What is a medicinal drug additive?*
7. *We can also read on the label:*
   [Keep out of humidity and at temperature below 25°C]
   Justify the importance of this recommendation.

SECOND EXERCISE
(10 points)

PERFUMES

Perfume history is very old. In Assyria, Egypt, India, the use of perfume was essentially religious. Later, in Greece and Rome, perfumes were used in cosmetics and in rich homes.
Initially limited to resins, spices, vegetable oils and certain animal secretions, perfumes were further enriched with perfumed oils obtained by the maceration of flowers.
Arabs made the first processed perfumes by the alambic and distillation process. Alcohol (ethanol), resulting from the distillation of fermented sugar juices, and essential oils, obtained by decoction of aromatic plants, became the principal constituents of perfumes.
The second revolution took place in the XIXth century with the chemical development of modern chemistry. The analysis of the constituents of the mixtures of natural origin identified certain perfumes, and gave rise to synthesis of more expensive ones: hence the, perfume chemistry was born.
Nowadays, the perfume industry is based on hundreds of natural essential oils and other thousands of synthesized compounds. The perfume art is based on the discovery of new mixtures of smells capable of seducing the consumer.

1. *Identify raw materials of the perfume.*
2. *How do we obtain the principal constituents of the perfume?*
3. *Is perfume a pure compound? Justify.*
4. *State two physical properties characteristics of the perfume.*
5. *Indicate the difference between a natural and a synthetic essential oil.*
6. *Explain why does industry orient itself towards forming new synthetic products.*

1- <u>MEDICINAL DRUGS</u> (10 points)

Expected solution	*Scale*	*Comments*
1- The drug mentioned is aspirin.	1.5	
2- The active ingredient is acetylsalicylic acid.	1.5	
3- It is an analgesic and anti-inflammatory.	1.5	
4-Analgesic is against pain *Anti-inflammatory is against inflammation.*	1.5	
5- Secondary effects: *Hurting the stomach (Hemorragia)* *Nausea causing.*	1.5	
6- An additive is a substance added to a drug which contributes to the volume, form and taste of the drug.	1.5	
7- To stop the degradation of the drug.	1	

2- <u>PERFUMES</u> (10 points)

Expected solution	***Scale***	***Comments***
1- The raw materials of perfumes are: alcohol and essential oils.	*1*	
2- Alcohol is obtained by distillation of sugar fermented juices. Essential oils are obtained from aromtic plants , by hydro-distillation (distillation with water vapor) or by extraction using a solvent.	*2*	
3- Perfume is not a pure compound; it is a mixture of alcohol and essential oils.	*2*	
4- Natural essential oils are extracted from either plant or animal origin.	*1*	
Synthetic essential oils are synthesized chemically.	*1*	
5- Being volatile.	*1*	
6- Due to quantitative reasons; extraction of essential oils do not usually provide the necessary amounts due to economical reasons.	*2*	

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