Coimisiún na Scrúduithe Stáit
State Examinations Commission

LEAVING CERTIFICATE EXAMINATION 2007

PHYSICS AND CHEMISTRY – HIGHER LEVEL

MONDAY 18 JUNE – MORNING 9:30 to 12:30

Six questions to be answered.
Answer any **three** questions from **Section I** and any **three** questions from **Section II**.
All the questions carry equal marks.
However, in each section, one additional mark will be given to
each of the first two questions for which the highest marks are obtained.

SECTION I – PHYSICS (200 marks)

1. Answer **eleven** of the following items, (*a*), (*b*), (*c*), etc. All the items carry equal marks.
    Keep your answers short.

    (*a*) Define *displacement.*

    (*b*) A car moving with a velocity of 20 m s^{-1} stops in a distance of 50 m. Calculate the acceleration of the car.

    (*c*) What is *potential energy*?

    (*d*) An object is placed inside the focus of a concave mirror. Describe the image formed by the mirror.

    (*e*) **Figure 1** shows a waveform. Name the quantities marked **A** and **B**.
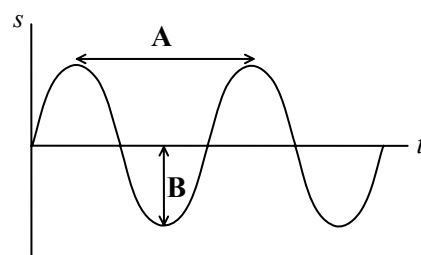
    (*f*) Under what circumstances does *constructive interference* of waves occur?

    (*g*) The temperature inside a freezer is −15 ºC. What is the absolute temperature inside the freezer?

    (*h*) What is the thermometric property of a constant volume gas thermometer?

    (*i*) State *Boyle's law*.

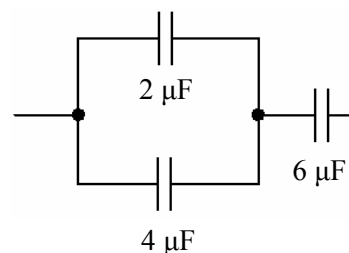   (*j*) Calculate the effective capacitance of the arrangement shown in **Figure 2**.

    (*k*) A pear-shaped conductor is placed on an insulated stand as shown in **Figure 3**. Copy the diagram and show how the charge is distributed over the conductor when it is positively charged.
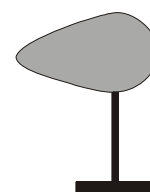
    (*l*) **Figure 4** shows current flowing through a solenoid. Copy the diagram and draw the magnetic field pattern around the solenoid.
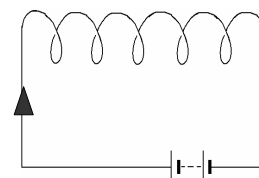
    (*m*) Name one way to reduce energy loss in a transformer.

    (*n*) Give two properties of gamma radiation.

    (*o*) The half-life of polonium-210 is 138 days. When will the activity of a sample of polonium-210 reduce to 25% of its original value?

Figure 1

Figure 2

Figure 3

Figure 4

(11 × 6)

2. Define the term *force*. (6)

State *Newton's law of gravitation*. (9)

Derive the relationship between G, the gravitational constant and g, the acceleration due to gravity.

Why does the value of g vary at different locations on the earth? (15)

Describe an experiment to measure the acceleration due to gravity, g. (18)

(i) Using the relationship between g and G, calculate the mass of the earth.
(ii) Calculate the volume of the earth, assuming it is a sphere.
(iii) Hence calculate the average density of the earth. (18)

$[G = 6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}; \text{ radius of earth} = 6.38 \times 10^6 \text{ m}; \ g = 9.81 \text{ m s}^{-2}]$

3. State *Snell's law of refraction*.

Describe an experiment to verify Snell's law using a glass block.
How is the refractive index of the glass obtained from the experiment? (27)

Explain (i) *critical angle*, (ii) *total internal reflection*. (12)

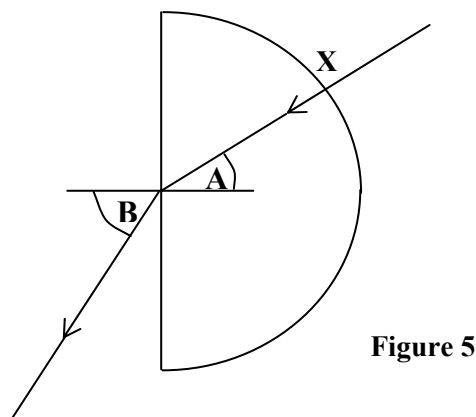A ray of light travels through a semicircular glass block, as shown in **Figure 5**.

Figure 5

(iii) Describe what happens to the ray of light when it enters the glass block at **X**.

(iv) If the refractive index of the glass is 1.48, calculate the value of the angle **B** when angle **A** is 35º.

(v) Describe what is observed as the angle **A** is gradually increased.

(vi) Calculate the critical angle of the glass.

(vii) Give **two** applications of total internal reflection. (27)

4. State *Coulomb's law of force* between electric charges.

What is an electric field?

Figure 6 shows two equal positive charges. Copy the diagram
and draw the electrical field pattern around the charges. (18)

Figure 6

The electrostatic force between two identical charges is 0.16 N.
What is the size of the force between the charges when
(i)   each charge is doubled?
(ii)   the distance between the original charges is doubled? (12)

Describe how an electroscope is charged negatively. (6)

A freshly cleaned piece of zinc metal is placed on the cap of a
negatively charged electroscope. When the zinc is illuminated
with ultraviolet radiation, as shown in **Figure 7**, the leaves of the
electroscope collapse.
Name this phenomenon.
Why do the leaves of the electroscope collapse?

Why do the leaves **not** collapse when the electroscope is positively
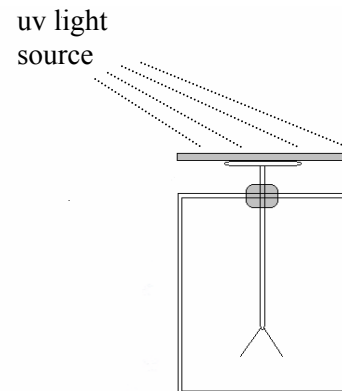charged and the zinc is illuminated with ultraviolet light? (15)

Ultraviolet light of wavelength 254 nm is used in this experiment.
Calculate:
(i)   the frequency of the ultraviolet radiation;
(ii)   the energy of a photon of the ultraviolet radiation. (15)

Figure 7

[speed of light, $c = 3.00 \times 10^{8}$ m s^{-1}; Planck constant, $h = 6.67 \times 10^{-34}$ J s]

5. State *Ohm's law*. (6)

Define the ampere, the unit of electric current. (9)

How would you show that a current-carrying conductor in a magnetic field experiences a force? (12)

In an experiment to investigate the heating effect of an electric current, a student passed a current I
through a heating coil immersed in a fixed mass of water for a certain time. The rise in temperature of
the water $\Delta\theta$ was measured. This was repeated a number of times for different values of the current I.
The following data was recorded.

$I/$A	0.4	0.5	0.6	0.7	0.8	0.9	1.0
$\Delta\theta/$°C	1.2	1.9	2.6	3.6	4.5	5.7	7.0

Draw a labelled diagram of the apparatus used in the experiment.
How was the current changed during the experiment? (12)

Using this data, draw a suitable graph on graph paper to show that the rise in temperature is
proportional to the current squared. (15)

A kettle attached to a 230 V supply has a power rating of 2.5 kW.
Calculate (i) the current flowing, (ii) the resistance of the heating coil in the kettle. (12)

6. Answer any **two** of the following parts (*a*), (*b*), (*c*), (*d*). Each part carries 33 marks.

(*a*)   Define *momentum*.   (6)

State the principle of conservation of momentum.   (6)

Trolley **A** (mass 0.50 kg) moving with constant velocity travels 15.2 cm every 0.2 s and collides with another trolley **B** (mass 0.45 kg) which is at rest. After the collision the two trolleys move together at constant velocity travelling 8.0 cm every 0.2 s.

Calculate
(i)   the initial velocity of trolley **A**;
(ii)   the combined velocity of trolleys **A** and **B** after the collision.   (9)

Show how these values verify the principle of conservation of momentum.   (6)

In the collision kinetic energy is lost. What happens to the lost kinetic energy?   (6)

(*b*)   State two assumptions of the kinetic theory of gases.   (6)

Describe how Brownian movement can be demonstrated.   (9)

What is an ideal gas? What happens to the molecules of a gas as its temperature increases?   (9)

A sample of helium gas contains 0.2 moles and has a volume of 2.5 litres at a pressure of 2.0×10^5 N m^{-2}. What is the temperature of the helium gas?   (9)

[Universal gas constant, $R = 8.3$ J K^{-1} mol^{-1}]

(*c*)   State *Faraday's law of electromagnetic induction*.   (6)

Figure 8 shows an a.c. generator.
Name the parts labelled **A** and **B**.   (6)
Draw a graph to show the variation of the output voltage from the generator with time.   (9)

State how the output voltage from the generator changes:
(i)   as the coil is turned more slowly;
(ii)   if a stronger magnet is used;
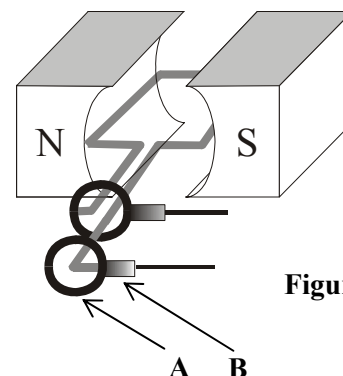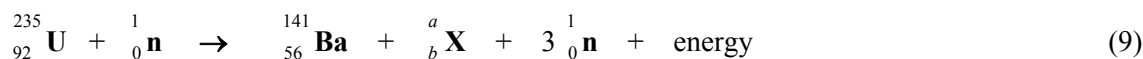(iii)   if more turns of wire are used in the coil.   (12)

Figure 8

(*d*)   Distinguish between nuclear fission and nuclear fusion.

Identify the isotope **X** in the following nuclear equation.

$$^{235}_{92}\text{U} + ^{1}_{0}\text{n} \rightarrow ^{141}_{56}\text{Ba} + ^{a}_{b}\text{X} + 3\,^{1}_{0}\text{n} + \text{energy}$$ (9)

(Refer to Mathematics Tables, p. 44.)

The following nuclear reaction occurs in the sun.

$$^{2}_{1}\text{H} + ^{1}_{1}\text{H} \rightarrow ^{3}_{2}\text{He} + \text{energy}$$

Show that there is a loss of mass in this nuclear reaction and hence calculate the energy released when one He-3 nucleus is formed.   (12)

[mass of H-1 = 1.673×10^{-27} kg; mass of H-2 = 3.345×10^{-27} kg;
mass of He-3 = 5.010×10^{-27} kg; speed of light, $c = 2.998 \times 10^8$ m s^{-1}]

SECTION II – CHEMISTRY (200 marks)

7. Answer **eleven** of the following items, (*a*), (*b*), (*c*), etc. All the items carry equal marks.
Keep your answers short.

(*a*) What are isotopes?

(*b*) Identify the ion that has 23 electrons and 26 protons.

(*c*) Define *relative atomic mass*.

(*d*) Explain in terms of bonding why metals are good conductors of electricity.

(*e*) Select the molecule which has a dipole moment from the following:

BF_3 CO_2 NH_3 CH_4

(*f*) Calculate the percentage by mass of oxygen in ethanoic acid (CH_3COOH).
[**H = 1; C = 12; O = 16**]

(*g*) Define *electronegativity*.

(*h*) Identify two conjugate acid-base pairs in the following reaction:

H_2SO_4 + HF $\rightleftharpoons$ HSO_4^- + H_2F^+
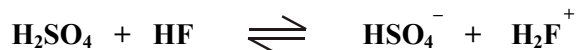
(*i*) According to the Brønsted-Lowry theory, what is a weak acid?

(*j*) What is meant by an amphoteric oxide? Give an example.

(*k*) QCl_3 represents the formula of a covalent chloride where **Q** represents an element from the third period of the periodic table. Identify **Q**. (Refer to Mathematics Tables, p. 44.)

(*l*) When 5 g of sodium hydroxide dissolves in a large quantity of water, 5338 J of energy are released. Calculate the heat of solution of sodium hydroxide.
[**H = 1; O = 16; Na = 23**]

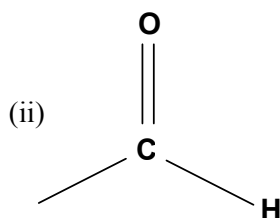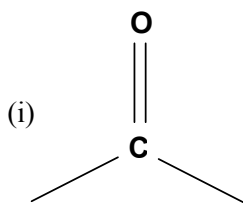(*m*) Identify each of the functional groups in **Figure 9**:

Figure 9

(*n*) Name the ester formed from methanol and ethanoic acid.

(*o*) Draw the structure of the nitrobenzene molecule.

(11 × 6)

8. (*a*) Explain the terms (i) *energy level*, (ii) *atomic orbital*. (12)

When an electron in an atom moves from an excited energy level to a lower energy level, electromagnetic radiation is emitted. **Figure 10** shows an electron falling from the third to the first energy level in a hydrogen atom.
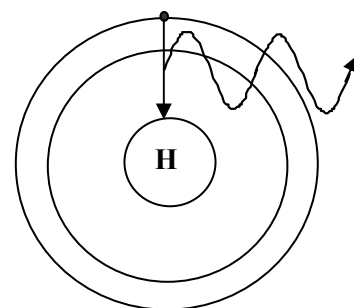

Figure 10

(i) How does an electron in an atom become excited? (3)

(ii) Why does the electron **not** remain in the excited state? (3)

(iii) What is the relationship between the energy of the excited energy level, the lower energy level and the frequency of the electromagnetic radiation emitted? (9)

(iv) Flame tests on metal salts are based on electron transitions within atoms. What colour do potassium salts give to a Bunsen flame? (3)

(v) Write the electronic (s, p) configuration of the potassium ion, K^+. (9)

(vi) State the number of energy levels and the number of orbitals occupied by the electrons in the potassium ion, K^+. (Refer to the Mathematics Tables, p. 44.) (6)

(*b*) Define *first ionisation energy* of an element. (6)

State and explain the general trend in first ionisation energy values **down** any group in the periodic table. (Refer to the Mathematics Tables, p. 45.) (9)

Explain why the second ionisation energy of potassium (3070 kJ mol^{-1}) is significantly greater than its first ionisation energy value (418 kJ mol^{-1}). (6)

9. A <u>standard solution</u> of sulfuric acid was titrated against 25 cm^3 portions of an unknown sodium hydroxide solution.

(*a*) Explain the underlined term in the above statement. (6)

(*b*) Describe how to prepare and fill the pipette to the mark with sodium hydroxide solution. State a precaution to ensure that exactly 25 cm^3 of solution is delivered when the pipette is emptied into the conical flask. (12)

(*c*) Why is the titration reaction carried out in a conical flask rather than in a beaker? How is the conical flask prepared for use? (6)

(*d*) Name an indicator suitable for this titration. Justify your choice of indicator and state the colour change expected in the conical flask at the end point. (15)

(*e*) Write a balanced equation for the titration reaction between sulfuric acid and sodium hydroxide. (6)

(*f*) One rough and two accurate titrations were carried out. The following volumes of 0.12 M sulfuric acid were recorded:

21.5 cm^3   **21.2 cm^3**   **21.1 cm^3**

What is the average volume of the sulfuric acid required to neutralise 25 cm^3 portions of sodium hydroxide solution?

(*g*) Calculate:

(i) the molarity of the sodium hydroxide solution;

(ii) the concentration of the sodium hydroxide solution in grams per litre (dm^3);

(iii) the pH of the sodium hydroxide solution. (21)

[H = 1; O = 16; Na = 23]

10. (*a*) Define in terms of electron transfer (i) oxidation, (ii) reduction. (6)

Place the following metals in order of increasing difficulty of oxidation.

    iron   **magnesium**   **copper**   **zinc** (6)

Write a balanced equation for the reaction which occurs when magnesium is placed in dilute hydrochloric acid. Which element is oxidised in this reaction?

Why is there no reaction observed when copper is placed in dilute hydrochloric acid? (15)

Explain how iron is protected from corrosion by coating it with zinc. (6)

Name the two transition metals in the list above.
State two characteristic properties of transition metals. (12)

(*b*) **Figure 11** shows an arrangement used to purify copper by electrolysis.

How is electricity conducted through the copper(II) sulfate solution? (3)

Write a balanced equation for the reaction that takes place at the cathode. (6)

Calculate the increase in mass of the pure copper electrode when a current of 8.0 A flows for 30 minutes. (12)
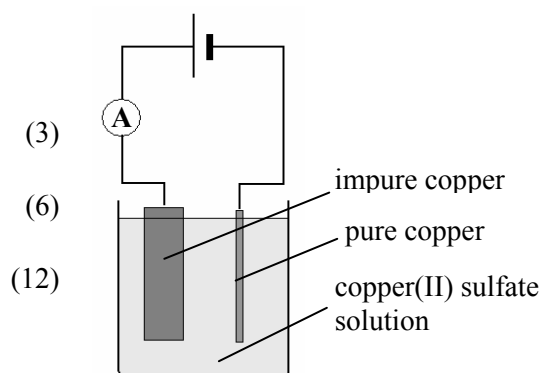**[Cu = 63.5; 1 faraday = 96 500 C]**

impure copper

pure copper

copper(II) sulfate solution

Figure 11

11. Ethane, ethene and ethyne are <u>hydrocarbons</u> which belong to different <u>homologous series</u>. Ethene and ethyne are <u>unsaturated</u>.

(*a*) Define the underlined terms in the statement above. (18)

(*b*) Draw the structural formula for each of the three hydrocarbons: ethane, ethene and ethyne. (9)

(*c*) A sample of ethyne gas was prepared using the apparatus shown in **Figure 12** by dropping liquid **A** on to solid **B**.

Identify the substances **A** and **B**.

Write a balanced equation for the reaction between **A** and **B**.

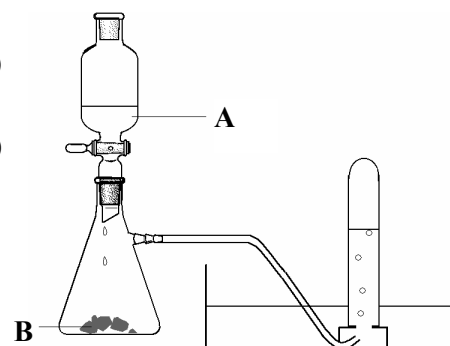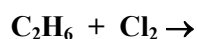Describe a test to verify that ethyne is unsaturated. (21)

A

B

Figure 12

(*d*) Identify two products of the following substitution reaction between one mole of ethane and one mole of chlorine:

$$C_2H_6 + Cl_2 \rightarrow$$

What is the essential condition required for this reaction? (9)

(*e*) Give the name and structural formula for the addition product of bromine and ethane in the following reaction:

$$C_2H_4 + Br_2 \rightarrow$$

(6)

(*f*) Name the product of the hydration of ethyne at 60 ºC in the presence of sulfuric acid and mercury(II) sulfate in the following reaction:

$$C_2H_2 + H_2O \rightarrow$$

(3)

12. Answer any **three** of the following parts (*a*), (*b*), (*c*), (*d*). Each part carries 22 marks.

(*a*)   When 0.23 g of sodium is dropped into water the following vigorous reaction takes place:

$$Na \ + \ H_2O \ \rightarrow \ NaOH \ + \ \tfrac{1}{2}H_2$$

(i)   How many moles of sodium are used? How many atoms are in this mass of sodium?

(ii)   What mass of sodium hydroxide is produced in the reaction?

(iii)   Calculate the volume of hydrogen gas produced in this reaction at STP.

(iv)   Why is sodium metal stored under oil?

[$H = 1$; $O = 16$; $Na = 23$; **Avogadro constant** $= 6.0 \times 10^{23}$ mol^{-1};
 molar volume at STP $= 22.4$ litres (dm^3)]

(*b*)   Methane, ammonia and water are the simplest hydrides of the elements carbon, nitrogen and oxygen, respectively.

Which of these hydrides would you expect to have the highest boiling point? Justify your answer.
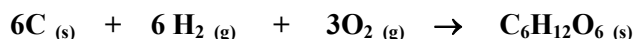
Explain in terms of bonding why methane is insoluble in water while ammonia is very soluble in water.

What is the shape of the methane molecule? State the bond angle in the methane molecule.
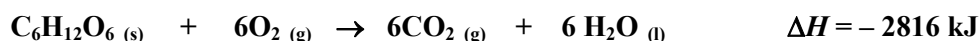
(*c*)   Define *heat of formation*.

State *Hess's law*.

Glucose is formed from its elements in their standard states according to the equation:

$$6C_{(s)} \ + \ 6 H_{2\ (g)} \ + \ 3O_{2\ (g)} \ \rightarrow \ C_6H_{12}O_{6\ (s)}$$

Use Hess's law to calculate the heat of formation of glucose using the following data:

$$C_6H_{12}O_{6\ (s)} \ + \ 6O_{2\ (g)} \ \rightarrow \ 6CO_{2\ (g)} \ + \ 6 H_2O_{\ (l)} \qquad \Delta H = - 2816 \text{ kJ}$$

$$C_{(s)} \ + \ O_{2\ (g)} \ \rightarrow \ CO_{2\ (g)} \qquad \Delta H = - 393 \text{ kJ}$$

$$H_{2\ (g)} \ + \ \tfrac{1}{2}O_{2\ (g)} \ \rightarrow \ H_2O_{\ (l)} \qquad \Delta H = - 286 \text{ kJ}$$

(*d*)   **Figure 13** shows the sodium chloride crystal lattice.

Name:
(i)   the particles which occupy the lattice points of the crystal;
(ii)   the type of bonds holding the crystal together.

Give two properties of compounds with this type of crystal structure.

Diamond and graphite are allotropes of carbon.

Explain the difference in the hardness of diamond and graphite in terms of the bonding in their crystal structures.
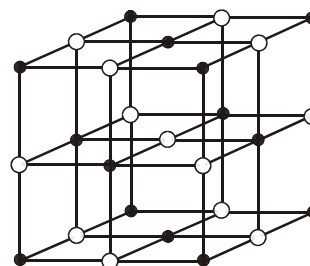

Figure 13

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