M 38

Coimisiún na Scrúduithe Stáit
State Examinations Commission

LEAVING CERTIFICATE EXAMINATION, 2003

PHYSICS AND CHEMISTRY - HIGHER LEVEL

MONDAY, 16 JUNE – MORNING 9.30 to 12.30

Six questions to be answered.
Answer any **three** questions from **Section I** and any **three** 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*) Calculate the work done when a 100 kg mass is raised through a vertical distance of 15 m. ($g = 9.8$ m s^{-2} .)

(*b*) State *Newton's third law of motion.*

(*c*) What is meant by *dispersion* of light?

(*d*) Calculate the potential difference between two points if the work required to move a charge of 2.5 C from one point to the other is 30 J.

(*e*) **Fig. 1** illustrates a longitudinal wave. What name is given to the parts labelled **A** and **B**?

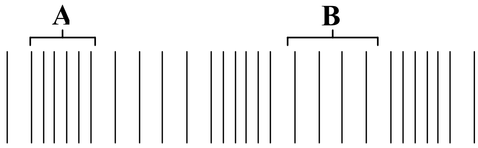


Fig. 1

(*f*) State the basic principle on which the operation of the moving-coil galvanometer depends.

(*g*) Define the *unit of current*, i.e., the ampere.

(*h*) Give an expression to define temperature on the Celsius scale.

(*i*) **Fig. 2** shows a ray of light being reflected by a prism. What is the name given to the phenomenon that occurs at the points marked **X**?

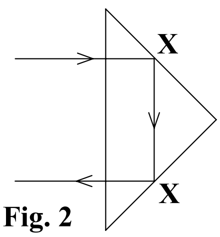


Fig. 2

(*j*) Arrange the following electromagnetic radiations in order of <u>increasing frequency</u>.

gamma **ultraviolet** **X-rays** **infrared**

(*k*) Why is it more economical to use high voltages for the transmission of electrical energy?

(*l*) What is the *photoelectric effect*?

(*m*) A negatively charged rod is brought close to an uncharged insulated metal sphere as shown in **Fig. 3**. Draw a diagram showing the charges induced on the sphere.

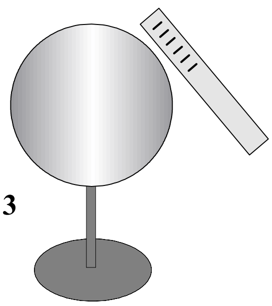


Fig. 3

(*n*) What is meant by *nuclear fusion*?

(*o*) The atom was first 'split' in 1932 by Cockcroft and Walton in the reaction

$$^{7}_{3}\mathbf{Li} + {}^{1}_{1}\mathbf{H} \rightarrow {}^{4}_{2}\mathbf{He} + {}^{4}_{2}\mathbf{He} + \mathbf{energy}$$

Explain why energy is released in this nuclear reaction. (11× 6)

2. Define (i) *momentum*, (ii) *kinetic energy*. (12)

State the principle of conservation of momentum and explain how it is applied in launching a spacecraft. (18)

Describe an experiment to verify the principle of conservation of momentum. (18)

Fig. 4

Fig. 4 shows two billiard balls on a smooth horizontal table. Ball **B** is at rest and ball **A** is moving towards it with a speed of 2.5 m s^{-1}. The mass of each ball is 160 g. After they collide both balls move in the same direction and the speed of ball **B** is 2.4 m s^{-1}. Calculate:

(i) the speed of ball **A** after the collision;
(ii) the kinetic energy lost in the collision. (18)

3. State *the laws of refraction of light*. (12)

Describe an experiment to measure the refractive index of glass. (18)

Draw a ray diagram to show how a converging (convex) lens forms a virtual image. (9)

The focal length of a converging (convex) lens is 12 cm. It forms a virtual image that is three times the size of the object. Find the distance of the object from the lens. (12)

Use a ray diagram to show how the final image is formed in a compound microscope. (15)

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

In a laboratory experiment to verify Ohm's law the current *I* through a metallic conductor was measured for a range of different values of the potential difference *V* applied across it. The values obtained are shown in the following table.

V /V	0.5	1.5	2.5	3.5	4.5	5.5	6.5
I /A	0.03	0.09	0.15	0.21	0.26	0.33	0.38

Draw a circuit diagram of the apparatus used to carry out this experiment and explain how the different values of *I* and *V* were obtained. (15)

Plot a suitable graph (on graph paper) to show the relationship between potential difference and current. (12)

Explain how this graph verifies Ohm's law.
Using the graph, calculate the resistance of the metallic conductor. (21)

An electric current has a heating effect and the resistance of a metallic conductor increases with temperature. If you were carrying out this experiment how would you ensure that the conductor did not become warm?

How would the graph obtained be different if the conductor did become warm?

Give <u>one</u> other precaution you would take when carrying out this experiment to ensure a more accurate result. (12)

5. (*a*) Define *capacitance*. (6)

Give two factors on which the capacitance of a parallel plate capacitor depends.
Describe an experiment to show how the capacitance depends on one of these factors. (18)

Fig. 5 shows a number of capacitors connected to a battery. Calculate:
(i) the total capacitance of the circuit;
(ii) the total charge stored in the capacitors. (12)

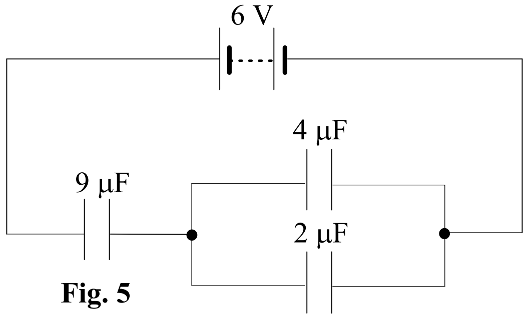


Fig. 5

(*b*) State *Faraday's law of electromagnetic induction* and describe briefly an experiment to verify it. (15)

Fig. 6 shows a transformer with 4000 turns on the primary coil and 200 turns on the secondary. If the primary is connected to the 230 V mains supply what voltage is obtained from the secondary, assuming that no energy is lost in the transformer? (9)

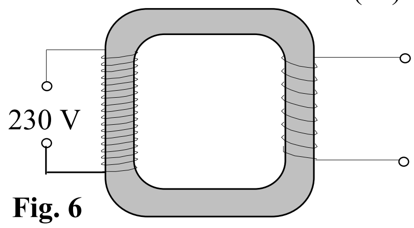


Fig. 6

Give two ways in which the transformer is designed to reduce energy losses. (6)

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

(*a*) Give an expression for *Newton's law of gravitation*. (6)

Use Newton's law of gravitation to show that the acceleration due to gravity on the surface of a planet of mass M and radius r is given by $g = \frac{GM}{r^2}$. (9)

A space shuttle orbits at a height of 5.74×10^5 m above the earth's surface. Calculate:
(i) the acceleration due to gravity at this height;
(ii) the force of gravity on an astronaut whose mass is 80 kg. (18)

[$G = 6.67 \times 10^{-11}$ N m^2 kg^{-2}; mass of earth = 5.98×10^{24} kg; radius of earth = 6.38×10^6 m.]

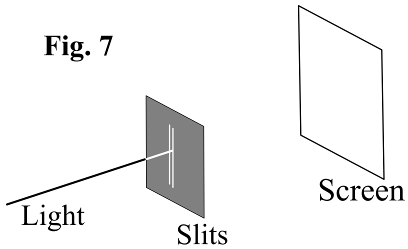
(*b*) Explain what is meant by (i) an ideal gas, (ii) Brownian movement. (12)

Describe briefly an experiment to demonstrate Brownian movement in the laboratory. (9)

A cylinder contains 0.07 moles of carbon dioxide gas at a pressure of 150 kPa. The volume of the cylinder is 1.2×10^{-3} m^3. Calculate the temperature of the gas in degrees Celsius. (12)
[Universal Gas Constant, R = 8.3 J mol^{-1} K^{-1}.]

(*c*) **Fig. 7** shows a narrow beam of monochromatic light striking a pair of narrow parallel slits. After passing through the slits the light strikes the screen.

Fig. 7



(i) Name the two phenomena that occur when the light passes through the slits. What do these phenomena tell us about the nature of light? (12)

(ii) What is seen where the light strikes the screen? Explain, with the aid of a diagram, how this phenomenon occurs. (15)

(iii) Which property of the light can be determined by taking appropriate measurements from the arrangement shown in the diagram? (6)

(*d*) Carbon-14 is a <u>radioactive</u> isotope which emits a <u>beta particle</u>.

Explain the underlined terms. (9)

Describe briefly an experiment to investigate the range of beta particles in air. (12)

Write an equation for the nuclear reaction in which carbon-14 emits a beta particle. (12)

(Refer to Mathematics Tables, p.44.)

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*) How many (i) neutrons, (ii) electrons, are there in the ion $^{37}_{17}\mathbf{Cl}^{-}$?

(*b*) Name a solvent in which iodine crystals are readily soluble.

(*c*) What is meant by the *electronegativity* of an element?

(*d*) In the equation $\boldsymbol{E_2 - E_1 = hf}$, what do $\boldsymbol{h}$ and $\boldsymbol{f}$ stand for?

(*e*) What is meant by *hydrolysis*?

(*f*) Explain the term *principal quantum number*.

(*g*) Give two examples of a covalent crystal.

(*h*) Complete and balance the equation: $\mathbf{Ca + H_2O \rightarrow}$

(*i*) Which two of the following elements would you expect to show variable valency?

Fluorine **Nickel** **Magnesium** **Neon** **Manganese**

(*j*) Calculate the percentage by mass of calcium in calcium carbonate ($\mathbf{CaCO_3}$).

[C = 12; O = 16; Ca = 40.]

(*k*) Define the *heat of reaction* of a substance.

(*l*) Arrange the following elements in order of decreasing reactivity:

Fe **Cu** **Zn** **Mg**

(*m*) Define the term *catalyst*.

(*n*) Give the chemical formula of an ester.

(*o*) Name the compound shown in **Fig. 8**.

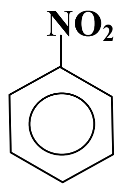


Fig. 8

(11 × 6)

8. (*a*) Define (i) atomic number, (ii) atomic orbital.
Sketch the shape of a p-orbital. (15)

Identify the species represented by each of the following electronic configurations:

$$\mathbf{1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^2} \qquad\qquad \mathbf{[1s^2\ 2s^2\ 2p^6]^+}$$ (6)

(*b*) Explain the terms (i) relative atomic mass, (ii) isotope. (12)

Using a mass spectrometer it was found that a sample of neon contained three isotopes: 80% of $^{20}_{10}\mathbf{Ne}$, 10% of $^{21}_{10}\mathbf{Ne}$ and 10% of $^{22}_{10}\mathbf{Ne}$.
Calculate the relative atomic mass of this sample of neon. (12)

(*c*) What is meant by the *first ionisation energy* of an element? (6)

Give one reason for the decrease in first ionisation energies down a group of the Periodic Table, e.g., **Li** to **K**. (6)

The first and second ionisation energies of potassium and calcium are as shown in the following table.

Ionisation energy /kJ mol^{-1}	**Potassium**	**Calcium**
First	418	590
Second	3052	1145

Explain why potassium has a lower first ionisation energy, but a much higher second ionisation energy, than calcium.
(Refer to Mathematics Tables, p.44.) (9)

9. (*a*) State *Hess's law*.
What is meant by the *heat of combustion* of a compound? (12)

Calculate the heat of combustion of benzene from the following data.

$$\mathbf{C_{(s)} + O_{2(g)} \rightarrow CO_{2\,(g)} \qquad \Delta \mathit{H} = -393\ kJ\ mol^{-1}}$$

$$\mathbf{H_{2(g)} + \frac{1}{2}O_{2(g)} \rightarrow H_2O_{(l)} \qquad \Delta \mathit{H} = -286\ kJ\ mol^{-1}}$$

$$\mathbf{6C_{(s)} + 3H_{2(g)} \rightarrow C_6H_{6(l)} \qquad \Delta \mathit{H} = +49\ kJ\ mol^{-1}}$$

(21)

(*b*) Write down the formula of one oxide formed by each of the following elements:

Na Al Fe (9)

(i) For each of any two of the oxides, state whether it is acidic, basic, neutral or amphoteric and describe its appearance at room temperature.

(ii) Write a balanced equation for the reaction of any one of the oxides with hydrochloric acid. (24)

10. Define (i) base, (ii) conjugate acid-base pair, in terms of the Bronsted-Lowry theory. (9)

Identify two species which may be described as bases in each of the following reactions.

$$NH_3 + H_2O \rightarrow NH_4^+ + OH^-$$

$$C_2H_5COOH + OH^- \rightarrow C_2H_5COO^- + H_2O \quad (12)$$

Write down one conjugate acid-base pair from each of the two reactions. (6)

In carrying out a titration, with an appropriate indicator, 20 cm^3 of a **0.09 M** solution of sodium hydroxide were neutralised by 9.0 cm^3 of a sulphuric acid solution of unknown concentration. The balanced equation for the reaction is

$$H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O$$

(i) Express the concentration of the sodium hydroxide solution in grams per litre (dm^3).

(ii) Calculate the pH of the sodium hydroxide solution.

(iii) Calculate the concentration of the sulphuric acid solution in moles per litre (dm^3). (24)

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

Explain how each of the following precautions improves the accuracy of this titration:

(i) a white tile is placed under the conical flask;

(ii) a rough titration is carried out first;

(iii) the sides of the flask are washed down during the titration. (15)

11. Explain the terms (i) homologous series, (ii) functional group. (12)

The apparatus shown in **Fig. 9** may be used in the preparation of ethene. The flask contains a mixture of an organic compound, **X**, and an inorganic compound, **Y**.

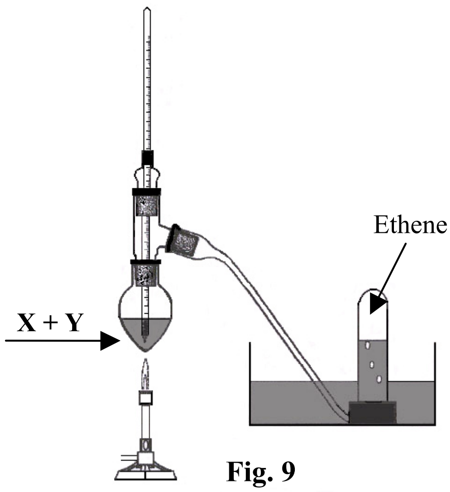


Fig. 9

(i) Identify **X** and **Y** and write a balanced equation for the preparation of ethene. (12)

(ii) Name the homologous series to which the organic compound **X** belongs. Draw the structural formula for **X** and name the functional group of this compound. (15)

(iii) Ethene reacts with bromine. What is the name given to this type of reaction? Give the conditions under which it is carried out. Explain how this reaction may be used as a test to show if a compound such as ethene is unsaturated. (18)

(iv) Name the homologue of ethene that has four carbon atoms and give two of its properties. (9)

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

(*a*) Define (i) oxidising agent, (ii) reducing agent, in terms of electron transfer. Identify the oxidising and reducing agents in each of the following reactions:

$$\mathbf{2Ca + O_2 \rightarrow 2CaO}$$

$$\mathbf{2KBr + Cl_2 \rightarrow 2KCl + Br_2}$$

(*b*) State *Faraday's first law of electrolysis*.

The apparatus shown in **Fig. 10** can be used in the electrolysis of molten calcium chloride.

Write a balanced equation for the reaction occurring at the anode.

A current of 0.25 A was passed through the molten calcium chloride for 12 minutes. Calculate the volume of chlorine released at STP.
[Molar volume at STP = 22.4 litres (dm^3); 1 faraday = 96 500 C.]

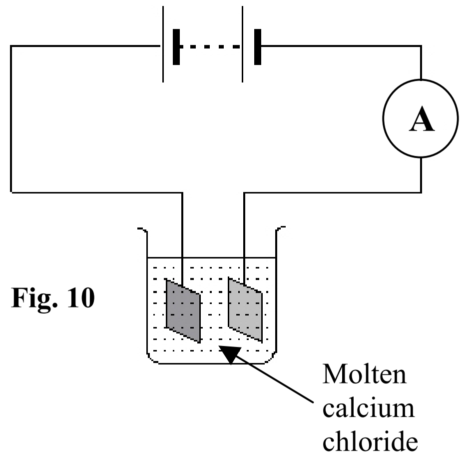


Fig. 10

(*c*) Describe the *electron pair repulsion theory*.

Each of the following compounds has four electron pairs around the central atom:

$\mathbf{H_2O}$ $\mathbf{NH_3}$ $\mathbf{CH_4}$

Sketch the shape of each molecule, showing the position of the atoms.

State the bond angle in the $\mathbf{NH_3}$ molecule and explain why it is greater than the bond angle in the $\mathbf{H_2O}$ molecule.

(*d*) Define the *mole*.

Phosphorus and chlorine react together to form phosphorus(III) chloride according to the following equation:

$$\mathbf{2P + 3Cl_2 \rightarrow 2PCl_3}$$

If 1.65 g of phosphorus were used up in the reaction calculate:

(i) the number of moles of phosphorus used;
(ii) the number of moles of chlorine used;
(iii) the number of <u>molecules</u> of phosphorus(III) chloride produced.

[P = 31; Avogadro constant = 6.0×10^{23} mol^{-1}.]

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