



# Coimisiún na Scrúduithe Stáit State Examinations Commission

LEAVING CERTIFICATE EXAMINATION, 2004

**PHYSICS AND CHEMISTRY - HIGHER LEVEL**

MONDAY, 21 JUNE – MORNING 9.30 TO 12.30

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**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.

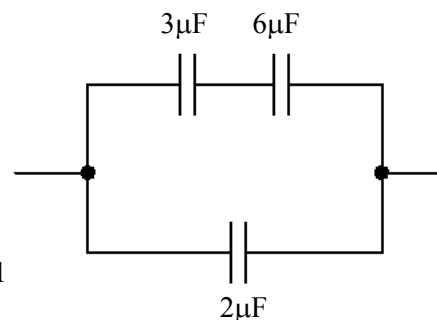
However, in each section, one additional mark will be given to each of the first two questions for which the highest marks are obtained.

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## 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) What is the relationship between  $G$ , the gravitational constant, and  $g$ , the acceleration due to gravity?
- (b) State the *principle of conservation of energy*.
- (c) Define the unit of work, i.e., *the joule*.
- (d) A pin is 30 cm from a concave mirror and a real image is formed 20 cm from the mirror. What is the focal length of the concave mirror?
- (e) Give two properties of the final image formed in a compound microscope.
- (f) Give one difference between transverse waves and longitudinal waves.
- (g) Under what circumstances can light be diffracted?
- (h) State *Boyle's law*.
- (i) A gas occupies  $330 \text{ cm}^3$  at 290 K. If the pressure remains constant, what is the volume of the gas at 350 K?
- (j) Calculate the effective capacitance of the arrangement of capacitors shown in **Fig. 1**.



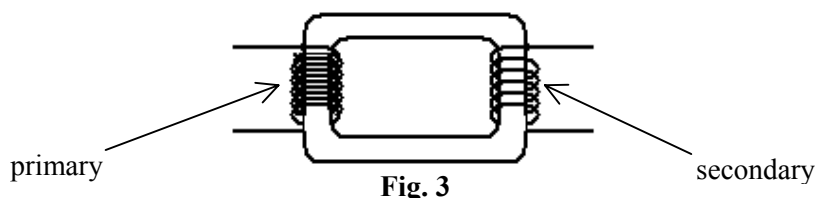
**Fig. 1**

- (k) A pear-shaped conductor is placed on an insulated stand as shown in **Fig. 2**. The conductor is given a positive charge. Copy the diagram and show how the charge is distributed over the conductor.



**Fig. 2**

- (l) What is the principle on which a moving coil galvanometer is based?
- (m) **Fig. 3** shows a transformer with 5000 turns on the primary coil and 250 turns on the secondary. If the primary coil is connected to the 230 V mains supply, calculate the output voltage.



**Fig. 3**

- (n) Give one difference between nuclear fission and nuclear fusion.
  - (o) The energy released in a nuclear reaction is  $1.7 \times 10^{-12} \text{ J}$ . Calculate the loss in mass. [speed of light,  $c = 3 \times 10^8 \text{ m s}^{-1}$ ]
- (11 × 6)

2. Define (i) *momentum*, (ii) *acceleration*. (12)

State *Newton's second law of motion* and use it to derive the expression  $force = mass \times acceleration$ . (15)

Describe an experiment to measure the acceleration of a moving body. (18)

A car travelling at a speed of  $25 \text{ m s}^{-1}$  in a straight line on a level road approaches a speed limit sign. The driver applies the brakes to reduce the speed of the car to  $15 \text{ m s}^{-1}$  over a distance of 100 m. The mass of the car is 750 kg.

Calculate

- (i) the acceleration of the car;
- (ii) the force acting on the car while the brakes are applied;
- (iii) the loss in kinetic energy of the car as a result of slowing down.

What happens to the kinetic energy lost by the car in slowing down? (21)

3. Define the terms (i) *refractive index*, (ii) *critical angle*.

Give the relationship between these two terms. (15)

A rectangular block of glass was used in an experiment to verify Snell's law.

The angle of incidence  $i$  and the angle of refraction  $r$  for a ray of light passing through the glass block were measured.

The following results were obtained:

$i/\text{degrees}$	15	25	35	45	55	65	75
$r/\text{degrees}$	10	16	22	28	33	37	40

Draw a suitable graph on graph paper and explain how your graph verifies Snell's law. (21)

From your graph, find the refractive index of the glass and hence calculate a value for the critical angle of the glass. (18)

A  $45^\circ$  prism is made from the glass block used in the experiment above.

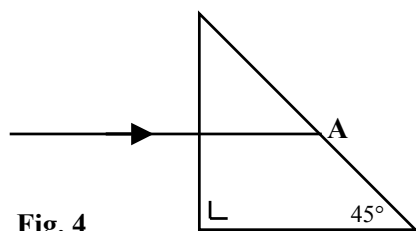


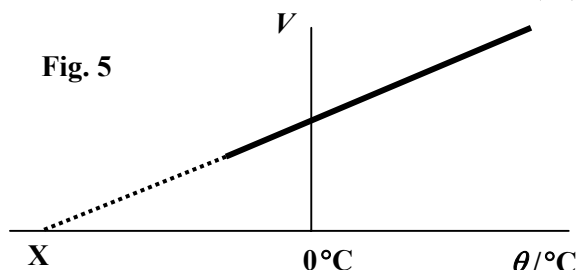
Fig. 4

A ray of light enters this prism from air as shown in Fig. 4.

What happens to the ray of light at A? Explain why. (12)

4. What are the principles involved in establishing a temperature scale? (9)
- Give an expression that defines temperature on the Celsius scale. (9)
- Describe an experiment to calibrate a mercury-in-glass thermometer. (15)
- Name one other type of thermometer and state an advantage it has over the mercury-in-glass thermometer.
- Why is it necessary to have a standard thermometer? (12)

The graph in **Fig. 5** shows the variation of volume  $V$  with temperature  $\theta$  on the Celsius scale for a fixed mass of gas at constant pressure. The solid line represents experimental data and the graph is extended to meet the horizontal axis at **X**.



- What is the temperature on the Celsius scale at **X**? What is the significance of the point marked **X**? (9)
- Give one way in which a real gas differs from an ideal gas. (6)
- How is an increase in the temperature of a gas explained by the kinetic theory? (6)

5. Define the *resistance* of a conductor. (6)

When a current flows through a metallic conductor heat is produced. The heat produced in a given time is proportional to the square of the current. Describe an experiment to verify this relationship. (Assume the resistance of the conductor stays constant.) (18)

Explain why the ESB uses high voltages to transmit electricity over long distances. (9)

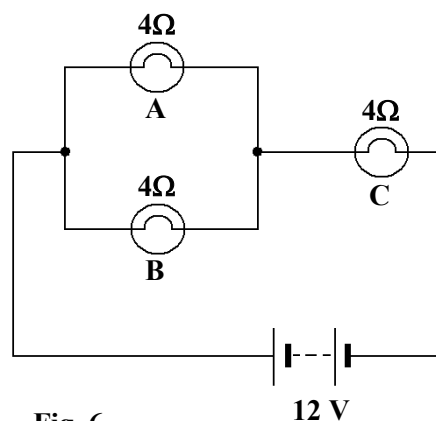
The resistance of a filament light bulb is  $4\ \Omega$ . Three of these bulbs are connected to a  $12\ \text{V}$  power supply as shown in **Fig. 6**.

Calculate

- (i) the total resistance of the circuit; (9)
- (ii) the current flowing in the circuit; (6)
- (iii) the current flowing in each bulb. (12)

Which of the bulbs **A**, **B** or **C** glows the brightest?

Explain your answer. (6)



**Fig. 6**

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

(a) State *Coulomb's law of force* between electric charges. (6)

What is an electric field?

Describe an experiment to demonstrate an electric field pattern. (15)

Two point charges are separated by a distance of 1 cm. The force between the charges is 8 N.

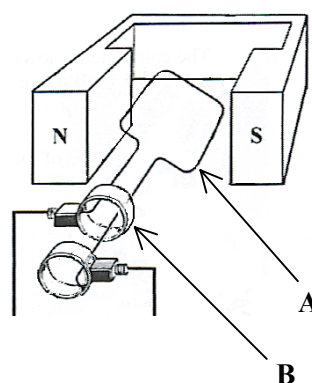
- (i) What is the size of the force between the charges, when each charge is halved?
- (ii) What is the size of the force between the charges, when the separation between the two original charges is increased to 4 cm? (12)

(b) Explain the term *electromagnetic induction*.

Describe an experiment to demonstrate electromagnetic induction. (15)

**Fig. 7** shows an a.c. generator. Name the parts labelled **A** and **B** and state the function of each part. (12)

Give two ways in which the output voltage from an a. c. generator can be increased. (6)



**Fig. 7**

(c) Iodine–131 is a radioactive isotope which emits a beta-particle. Iodine–131 has a half-life of 8 days. Iodine–131 is used in medical investigations. Explain the underlined terms. (15)

Write an equation for the nuclear reaction in which iodine–131 emits a beta particle. (Refer to Mathematics Tables, p. 44.)

Calculate the fraction of a sample of iodine–131 remaining after 32 days. (12)

Carbon–14 is also radioactive. Give a use for carbon–14.

How should radioactive materials be safely stored? (6)

(d) When a freshly cleaned zinc plate is placed on the cap of a negatively charged electroscope and exposed to ultraviolet radiation, the electroscope is observed to lose its charge.

Name this phenomenon.

Give one application of the phenomenon demonstrated in this experiment. (9)

Explain why the negatively charged electroscope loses its charge.

Why is ultraviolet radiation used? (12)

Ultraviolet radiation of wavelength  $3.3 \times 10^{-7}$  m is used in this experiment. Calculate

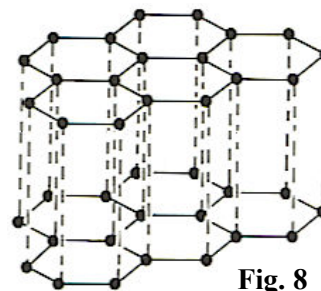
- (i) the frequency of the ultraviolet radiation;
- (ii) the energy of a photon of the ultraviolet radiation. (12)

[speed of light,  $c = 3.0 \times 10^8$  m s<sup>-1</sup>; Planck constant,  $h = 6.6 \times 10^{-34}$  J s]

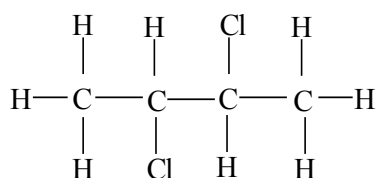
## SECTION II – CHEMISTRY (200 marks)

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

- (a) Define *first ionisation energy*.
- (b) Define *relative atomic mass*.
- (c) Graphite, an allotrope of carbon, is shown in **Fig. 8**. Explain why graphite is an electrical conductor.
- (d) Name the forces which hold a crystal of ice together.
- (e) Name a group in the Periodic Table whose elements are metallic and have a valency of one.
- (f) Give two chemical properties usually associated with transition metals or their compounds.
- (g) Why do electronegativity values decrease down a group in the Periodic Table?
- (h) Define *heat of solution* of a substance.
- (i) Give two properties of an acid-base indicator.
- (j) Write a balanced chemical equation for the reaction of sodium hydride with water.
- (k) Calculate the percentage by mass of oxygen in calcium carbonate ( $\text{CaCO}_3$ ).  
[Ca = 40; O = 16; C = 12]
- (l) Give an example of (i) an acidic oxide, (ii) an amphoteric oxide.
- (m) Give the systematic name for the organic compound shown in **Fig. 9**.

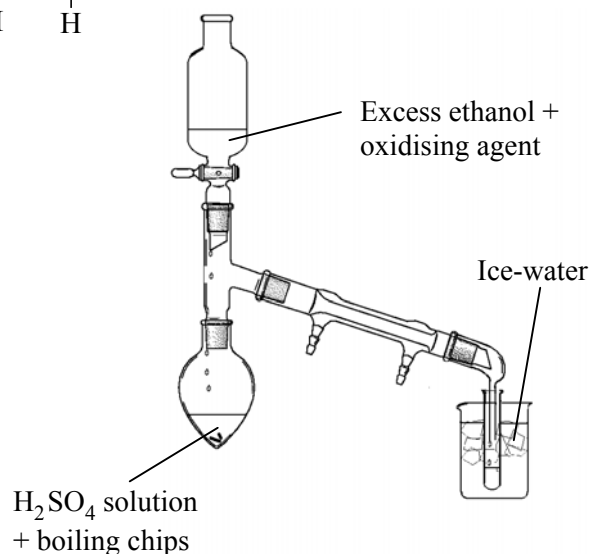


**Fig. 8**



**Fig. 9**

- (n) Draw the structure of the functional group in a carboxylic acid.
- (o) Identify the organic product collected in the test tube in **Fig. 10** when the reagents in the dropping funnel are added to the contents of the reaction flask.



**Fig. 10**

(11 × 6)

8. (a) Explain the terms (i) *energy level*, (ii) *orbital*.  
What information about an electron in an atom is given by the principal (first) quantum number and by the subsidiary (second) quantum number? (18)

In the relationship  $E_2 - E_1 = hf$ , which applies to atomic emission spectra, what do  $E_1$ ,  $E_2$  and  $f$  represent?

Many metallic elements have atomic emission spectra with coloured lines in the visible region of the electromagnetic spectrum. Flame tests use this fact to identify elements. Name one metallic element whose salts give a lilac colour to a Bunsen burner flame. (12)

- (b) Define *electronegativity*.

Use electronegativity values to predict the type of bonding in ammonia.

(Refer to the Mathematics Tables, p. 46.)

Is ammonia soluble in water? Explain your answer in terms of bonding. (15)

Write the electronic (*s*, *p*) configuration of the nitrogen atom.

Draw a diagram to show the valence electrons and the bonding in ammonia ( $\text{NH}_3$ ).

Use electron pair repulsion theory to predict the shape of and the bond angle in the ammonia molecule. (21)

9. Anhydrous sodium carbonate ( $\text{Na}_2\text{CO}_3$ ) is a primary standard. Explain the underlined term. (6)

To prepare 500 cm<sup>3</sup> of 0.05 M solution of sodium carbonate, 2.65 g of anhydrous sodium carbonate was required. Describe how the 500 cm<sup>3</sup> of 0.05 M sodium carbonate solution was accurately made up. (15)

A solution of hydrochloric acid ( $\text{HCl}$ ) was then standardised by titrating it against 25 cm<sup>3</sup> portions of this 0.05 M sodium carbonate solution.

Three titrations were carried out, requiring the following volumes of acid for neutralisation:

22.8 cm<sup>3</sup>

22.5 cm<sup>3</sup>

22.4 cm<sup>3</sup>

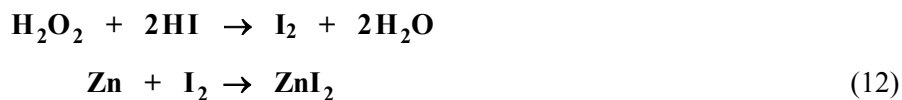
- (i) Having rinsed and filled the pipette correctly, describe how to ensure that exactly 25 cm<sup>3</sup> of sodium carbonate solution was transferred by the pipette into a conical flask. (6)
- (ii) Explain why the accuracy of the titration is improved by using deionised water rather than tap water at all stages of the experiment. (6)
- (iii) Name a suitable indicator for this titration and state the colour change observed at the end point. (9)
- (iv) Write a balanced chemical equation for the titration reaction.

What value should be taken as the final titration figure? Calculate the concentration of the hydrochloric acid in (a) moles per litre (dm<sup>3</sup>) and (b) grams per litre (dm<sup>3</sup>). (24)

[H = 1; Cl = 35.5]

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

Identify the oxidising agent and reducing agent in each of the following reactions:



Why can iron be oxidised by a copper sulfate solution but not by a magnesium sulfate solution?

Can iron be oxidised by an aluminium sulfate solution? Explain your answer.

Name a metal which *cannot* liberate hydrogen from dilute hydrochloric acid. (15)

- (b) State Faraday's first law of electrolysis. (6)

Fig.11 shows an apparatus which may be used in the electrolysis of acidified water using inert electrodes.

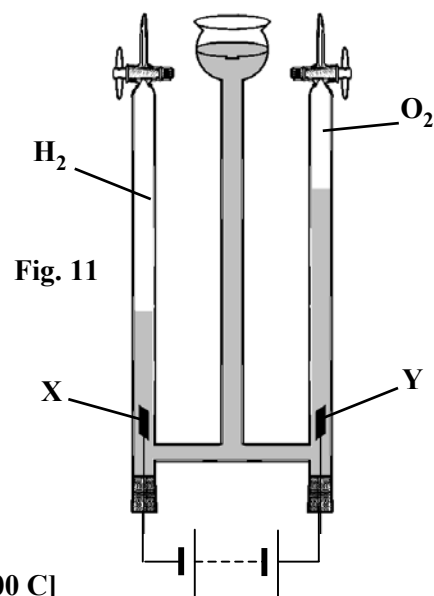
Identify

- a suitable material for the electrodes;
- which electrode is the cathode;
- the electrode where oxidation occurs. (9)

Write a balanced equation for the reaction which takes place at the electrode Y. (6)

Calculate the volume at STP of oxygen gas produced when a current of 0.32 A is passed through the acidified water for 10 minutes. (12)

[Molar volume at STP = 22.4 litres (dm<sup>3</sup>); 1 Faraday = 96 500 C]



11. Study the reaction scheme in Fig. 12 and answer the following parts.

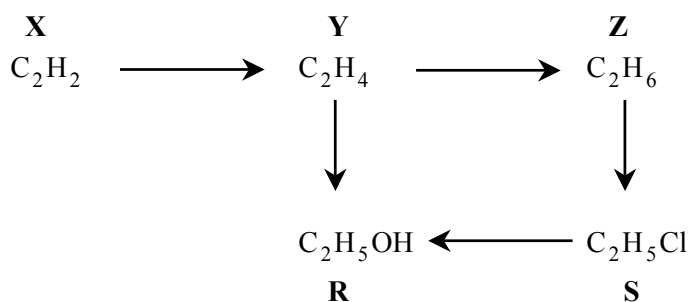


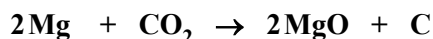
Fig. 12

- Give the name and structural formula for each of the compounds X, Y and Z. (18)
- Name the compounds S and R. Name the type of reaction which converts compound S to compound R. (12)
- State the reagent required and a necessary condition to convert compound Z to compound S. (6)
- What term is used to describe the conversion of compound Y to compound R?  
Write a balanced chemical equation for the reaction of compound R with sodium. (15)
- Describe, with the aid of a labelled diagram, a laboratory experiment to prepare compound X. (15)



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

(a) Magnesium reacts with carbon dioxide according to the following equation:



If 4.8 g of magnesium react completely with carbon dioxide, calculate:

- the number of moles of magnesium used;
- the mass of magnesium oxide formed;
- the number of atoms of carbon produced.

Describe the appearance of both products of this reaction.

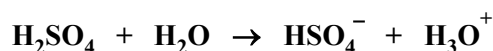
[Mg = 24; C = 12; O = 16; Avogadro constant =  $6.0 \times 10^{23} \text{ mol}^{-1}$ ]

(b) Define the *pH* of a solution.

Name two ways you could measure the pH of an aqueous solution.

Calculate the pH of a 0.02 M solution of  $\text{H}_2\text{SO}_4$ .

Identify (i) the conjugate acid, (ii) the conjugate base in the reaction:

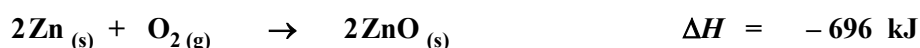


(c) Define *heat of reaction* of a substance.

Zinc carbonate decomposes into zinc oxide and carbon dioxide when heated according to the following equation:



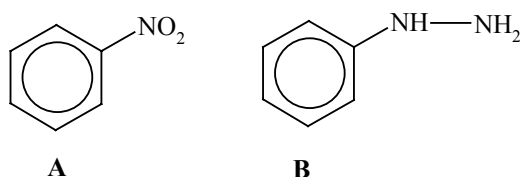
Calculate the heat change for this reaction using the following data:



Is the decomposition of zinc carbonate an exothermic or an endothermic reaction?

(d) Distinguish between *aliphatic* and *aromatic* organic compounds.

Name the compounds **A** and **B** shown in **Fig. 13**.



Name the reagents used to prepare **A** from benzene.

Give a laboratory use for compound **B**.

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