# Coimisiún na Scrúduithe Stáit
# State Examinations Commission

**LEAVING CERTIFICATE EXAMINATION, 2005**

**PHYSICS AND CHEMISTRY – HIGHER LEVEL**

MONDAY, 20 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*) Define *velocity.*

(*b*) State the *principle of conservation of momentum*.

(*c*) Calculate the potential energy of an object of mass 0.5 kg at a height of 100 m above the surface of the earth. ($g = 9.8\ \text{m s}^{-2}$)

(*d*) Give an example of (i) a transverse wave, (ii) a longitudinal wave.

(*e*) A ray of light enters a 45º right-angled glass prism as shown in **Fig. 1**. Copy the diagram and complete the path of the ray through the prism. (Critical angle for the glass is 42º.)

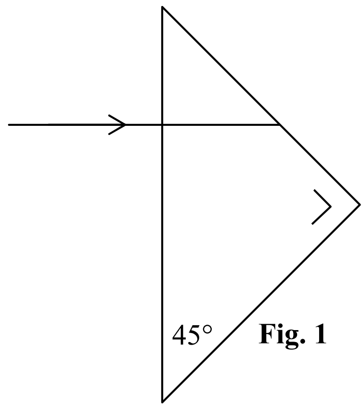



**Fig. 1**

(*f*) When an object is placed 20 cm in front of a concave mirror, a real image is formed 40 cm from the mirror. What is the magnification of the image?

(*g*) What is meant by the *dispersion* of white light?

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

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

(*j*) **Fig. 2** shows a positively charged insulated metal sphere **A** *near* an uncharged insulated metal sphere **B**. Draw a diagram to show the distribution of charge on sphere **B**.

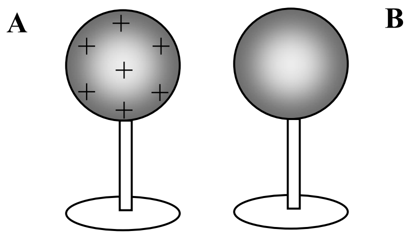



**Fig. 2**

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

(*l*) A current of 6.25 A is drawn by the bulb shown in **Fig. 3** when connected to a 12 V car battery. What is the power rating of the bulb?

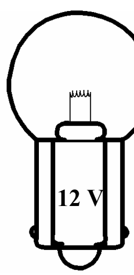



**Fig. 3**

(*m*) Sketch a graph to show the variation of an a.c. voltage with time.

(*n*) List two products of a nuclear fission reaction.

(*o*) What is meant by the *half-life* of a radioactive isotope?

(11 × 6)

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

State *Newton's second law of motion*. (6)

In an experiment to verify Newton's second law of motion, a force $F$ was applied to a body and the acceleration $a$ of the body was measured. This was repeated a number of times for different values of the applied force. The values of $F$ and the corresponding values of $a$ are given in the following table.

| $F$/N | 0.1 | 0.2 | 0.3 | 0.4 | 0.5 | 0.6 | 0.7 | 0.8 |
|---|---|---|---|---|---|---|---|---|
| $a$/m s$^{-2}$ | 0.13 | 0.28 | 0.42 | 0.57 | 0.74 | 0.89 | 0.99 | 1.14 |

Draw a labelled diagram of the apparatus used in this experiment. (9)

Draw a suitable graph on graph paper to show the relationship between the applied force and the acceleration of the body. (15)

From your graph, estimate the acceleration of the body when the applied force was 0.45 N.

If the body was initially at rest, calculate the distance travelled by the body in 2 seconds while the force applied was 0.45 N. (18)

How much work is done by the force of 0.45 N in this time? (6)

**3.** (*a*) Diffraction and interference occur when a narrow beam of monochromatic light passes through a pair of narrow slits, as shown in **Fig. 4**, and then strikes a screen.

Explain the underlined terms. (12)

Describe the pattern observed on the screen. (6)

Explain how this experiment contributes to our understanding of the nature of light. (6)

What measurements must be taken in this experiment in order to determine the wavelength of the light? (9)

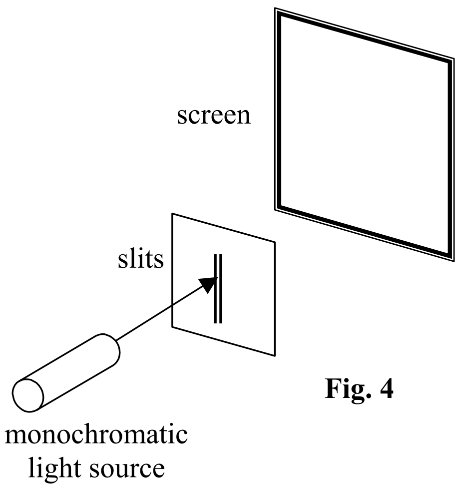



**Fig. 4**

(*b*) What is the photoelectric effect? (9)

Describe an experiment to demonstrate the photoelectric effect. (12)

Monochromatic light of wavelength 450 nm was used to demonstrate the photoelectric effect.

Calculate (i) the frequency, (ii) the energy, of a photon of this light. (12)

**[Speed of light in vacuum, $c = 3.0 \times 10^{8}$ m s$^{-1}$; Planck constant, $h = 6.6 \times 10^{-34}$ J s]**

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

Describe an experiment to verify Boyle's law. (18)

What is meant by an *ideal gas*?

Calculate the volume occupied by 2.5 moles of helium gas at a temperature of 300 K and a pressure of $2 \times 10^5$ Pa. (12)

Calculate the pressure of the helium gas if its temperature is increased to 400 K and the volume of the gas remains constant. (9)

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

A constant volume gas thermometer is shown in **Fig. 5**.

Name the thermometric property on which this thermometer is based.

When the thermometer is in use, the mercury level is adjusted to be at mark **M**. Explain why. (9)

Why is it necessary to have a standard thermometer?

Why is the constant volume gas thermometer used as a standard thermometer? (12)

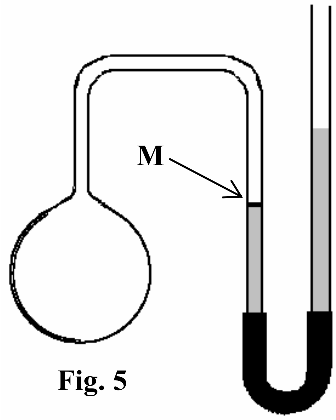



**Fig. 5**

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

Name one factor on which the capacitance of a parallel plate capacitor depends.

Describe an experiment to investigate how the capacitance of a parallel plate capacitor depends on this factor. (15)

(*b*) Define *electric current*. (6)

Describe an experiment to demonstrate that a current carrying conductor in a magnetic field experiences a force.

Name one device based on this principle. (15)

Two 12 Ω resistors and a 6 Ω resistor are connected to a 6 V battery as shown in **Fig. 6**.

Calculate
(i) the total resistance in the circuit;
(ii) the current which flows through the 6 Ω resistor. (15)

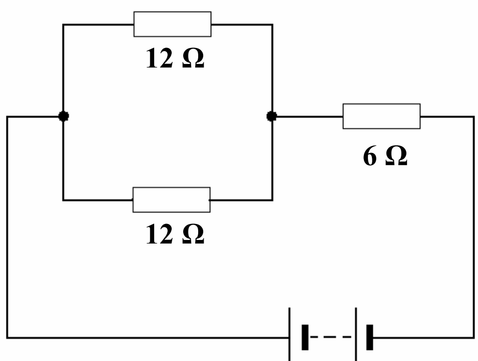



**Fig. 6**

An ammeter of resistance 1 Ω is then connected in series with the 6 Ω resistor in order to measure the current flowing in the circuit.

Calculate the change in the current flowing through the 6 Ω resistor as a result of introducing the ammeter.

What resistance should the ammeter have if it were to have no effect on the size of the current in the circuit? (9)

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

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

What is the relationship between *G*, the gravitational constant, and *g*, the acceleration due to gravity? (6)

Calculate the value of the acceleration due to gravity on the surface of the moon.

What is the weight of a 100 kg astronaut on the surface of the moon? (9)

**[G = $6.67 \times 10^{-11}$ N $m^2kg^{-2}$; mass of moon = $7.35 \times 10^{22}$ kg; radius of moon = $1.74 \times 10^6$ m]**

(*b*) State the laws of refraction of light. (9)

Distinguish between a real image and a virtual image. (6)

Use a ray diagram to show how the final image is formed by an astronomical telescope.

Describe the final image formed. (18)

(*c*) What is *radioactivity*? (6)

Give three properties of beta particles. (9)

Cobalt–60 is radioactive isotope which emits a beta particle. Write an equation for this nuclear reaction.
(Refer to Mathematics Tables, p. 44) (6)

In a nuclear fusion reaction, two protons and two neutrons form an alpha particle, according to the following equation.

$$2\,\text{p} \quad + \quad 2\,\text{n} \quad \rightarrow \quad {}^{4}_{2}\text{He} \quad + \quad \text{energy}$$

Calculate the energy released in this fusion reaction. (12)

**[Speed of light in vacuum, *c* = $2.998 \times 10^8$ m $s^{-1}$; mass of proton = $1.673 \times 10^{-27}$ kg; mass of neutron = $1.675 \times 10^{-27}$ kg; mass of alpha particle = $6.647 \times 10^{-27}$ kg]**

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

Outline how a transformer works. (9)

**Fig. 7** shows a transformer which has 50 turns in the primary coil and 2000 turns in the secondary coil.

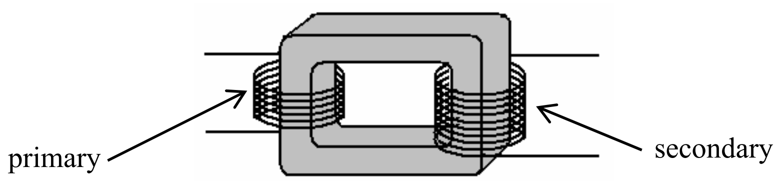



**Fig. 7**

Calculate the output voltage of the transformer when the primary coil is connected to the 230 V mains supply. (6)

Name two devices that use transformers. (6)

Give a reason why a transformer loses energy. (6)

## 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 is an *isotope*?

(*b*) What colour do sodium salts give to a Bunsen burner flame?

(*c*) The covalent crystal structure of diamond is shown in **Fig. 8**.
Why is diamond a poor electrical conductor?

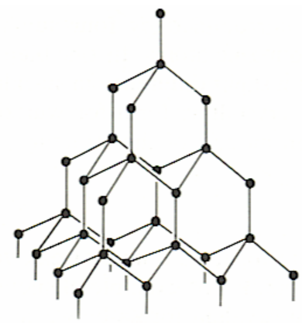


**Fig. 8**

(*d*) What is the maximum number of electrons which can occupy (i) a 2p subshell, (ii) a 2p orbital?

(*e*) State the number of (i) neutrons, (ii) electrons in the $^{33}_{16}\mathbf{S}^{2-}$ ion.

(*f*) Define *electronegativity*.

(*g*) Name the group in the periodic table whose elements are non-metallic and have a valency of one.

(*h*) Define a mole of a substance.

(*i*) Distinguish between a strong acid and a weak acid.

(*j*) Give the two possible shapes of a molecule with the general formula $\mathbf{QH_2}$ where **Q** represents any element.

(*k*) Calculate the percentage by mass of nitrogen in ammonium nitrate ($\mathbf{NH_4NO_3}$).
**[H = 1; N = 14; O = 16.]**

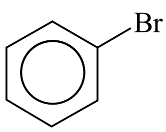
(*l*) Distinguish between an *exothermic* and an *endothermic* reaction.

(*m*) Identify the reagent required and the necessary condition for the following conversion:

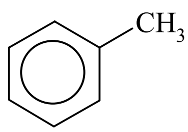
$$\mathbf{CH_4 \quad \rightarrow \quad CH_3Cl}$$

(*n*) Name and draw the structure of the alkene, $\mathbf{C_3H_6}$.

(*o*) Identify the aromatic compounds **A** and **B** that are shown in **Fig. 9**.




**A**




**B**

**Fig. 9**

(11 × 6)

8. (*a*) Write the electronic (s, p) configuration of

(i) the beryllium atom, (ii) the sodium atom and (iii) the sodium ion, $\mathbf{Na^{+}}$.

What is the principal quantum number of the outermost electron in a sodium atom? (12)
(Refer to the Mathematics Tables, p. 44.)

Define *first ionisation energy* of an element. (6)
State and account for the general trend in first ionisation energy values from **Li** to **Ne** on the periodic table.
Explain why the first ionisation energy of beryllium is larger than that of boron. (18)
(Refer to the Mathematics Tables, p. 44, 45.)

(*b*) Define an *ionic bond*. (6)
Use diagrams to show the formation of a bond between a sodium atom and a chlorine atom.
Describe the crystal structure of sodium chloride. (18)
Give two general properties of ionic compounds. (6)

9. The concentration of a potassium hydroxide **(KOH)** solution was determined by titrating it with a standard solution of sulfuric acid ($\mathbf{H_2SO_4}$).

(i) Explain the underlined terms. (9)
(ii) Describe how a pipette is prepared for use in a titration. (6)
(iii) Explain why the sides of a conical flask are washed down during a titration.
Why is deionised water used for this purpose? (12)
(iv) Standing the conical flask on a white tile improves the accuracy of the titration result.
Explain why. (6)
(v) Name a suitable indicator for this titration and state the colour change observed at the end point. (9)
(vi) Write a balanced chemical equation for this titration reaction. (6)
(vii) The table shows the burette readings taken when the 0.05 M sulphuric acid solution is titrated against 25.0 $cm^3$ portions of the potassium hydroxide solution.

| **Titration** | **first** | **second** | **third** |
|---|---|---|---|
| initial reading / $cm^3$ | 0.0 | 24.6 | 0.0 |
| final reading / $cm^3$ | 24.6 | 48.7 | 24.0 |

Use the data in the table to determine the volume of acid required to neutralise 25.0 $cm^3$ of the potassium hydroxide solution.

Calculate the concentration of the potassium hydroxide solution in
(*a*) moles per litre ($dm^3$);
(*b*) grams per litre ($dm^3$). (18)

**[H = 1; O = 16; K = 39]**

**10.** (*a*) Define *oxidation* in terms of electron transfer.

State which substance is oxidised in each of the following reactions:

$$CuO + H \rightarrow Cu + H_2O$$

$$Cl_2 + 2NaBr \rightarrow 2NaCl + Br_2$$ (9)

Place in order of **decreasing ease** of oxidation, according to the electrochemical series, the metals copper, iron, magnesium and zinc. (9)

Which one of these metals may be found free in nature? Justify your answer. (6)

Write a balanced chemical equation for the reaction between magnesium and water. Identify the substance oxidised in this reaction. (12)

(*b*) Define *heat of combustion*. (6)

State *Hess's law*. (6)

When ethanol is burned in a plentiful supply of oxygen the following reaction takes place.

$$C_2H_5OH_{(l)} + 3O_{2\,(g)} \rightarrow 2CO_{2\,(g)} + 3H_2O_{(l)}$$

Use Hess's law to calculate the heat of combustion of ethanol, using the following data:

$$2C_{(s)} + 3H_{2\,(g)} + \tfrac{1}{2}O_{2\,(g)} \rightarrow C_2H_5OH_{(l)} \qquad \Delta H = -278\ \text{kJ}$$

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

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

(18)

**11.** Define (i) *functional group*, (ii) *homologous series.* (12)

Draw the functional group in ethanol and in ethanal. Name the homologous series to which each of these compounds belongs. (12)

The apparatus shown in **Fig. 10** may be used to prepare ethanal from ethanol.

(i) Which nozzle of the condenser, **X** or **Y**, should be attached to the cold water supply?

State the function of the boiling chips.

Why is ethanal collected over ice-water?

Identify a suitable oxidising agent for this reaction. (12)

(ii) Ethanal can be further oxidised to another organic compound**.**

Name and draw the structural formula of this new compound. (9)

(iii) Ethanal can also be prepared using ethyne **($C_2H_2$)** as the starting material.

What are the two reagents and the condition necessary for this conversion? (9)

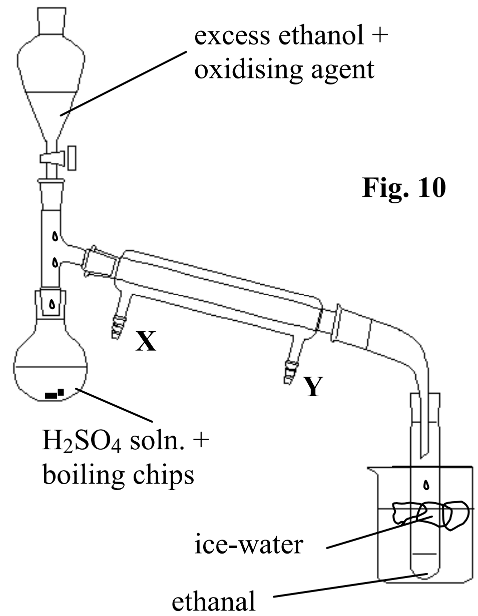



**Fig. 10**

(iv) Write an equation for the reaction between ethanal and phenylhydrazine. (12)

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

(*a*) When limestone (**$CaCO_3$**) is decomposed by roasting, lime (**CaO**) and carbon dioxide (**$CO_2$**) are obtained according to the following balanced equation:

$$\mathbf{CaCO_3 \rightarrow CaO + CO_2}$$

When 250 kg of limestone are completely decomposed, calculate:

(i) the number of moles of limestone used;

(ii) the mass of lime formed;

(iii) the number of molecules of carbon dioxide produced;

(iv) the volume of carbon dioxide produced at STP.

**[C = 12; O = 16; Ca = 40; Avogadro constant = $6.0 \times 10^{23}$ mol$^{-1}$;**
**molar volume at STP = 22.4 litres (dm$^3$)]**

(*b*) Consider the following five oxides:

**$H_2O$ $Al_2O_3$ CO $CO_2$ CuO**

Which one of these oxides is black? Is this oxide acidic, basic or amphoteric?

Which one of these oxides is neutral?

Name the oxides which are solids at room temperature.

Select the acidic oxide from the list and write a balanced chemical equation for its reaction with water.

(*c*) Define (i) an acid, (ii) a conjugate acid-base pair, according to the Brønsted-Lowry theory.

Calculate the pH of 0.05 M sulphuric acid solution.

Identify the two acids in the following equilibrium:

$$\mathbf{HSO_4^- + H_2O \rightleftharpoons SO_4^{2-} + H_3O^+}$$

(*d*) What is *electrolysis*?

**Fig. 11** shows an arrangement to electrolyse a molten sample of sodium chloride using platinum electrodes **A** and **B**.

What substance is produced at electrode **A**?

Write a balanced equation for the reaction which takes place at electrode **B**.

Calculate the mass of sodium formed when a current of 3.86 A flows for 30 minutes.

**[Na = 23; 1 faraday = 96 500 C]**

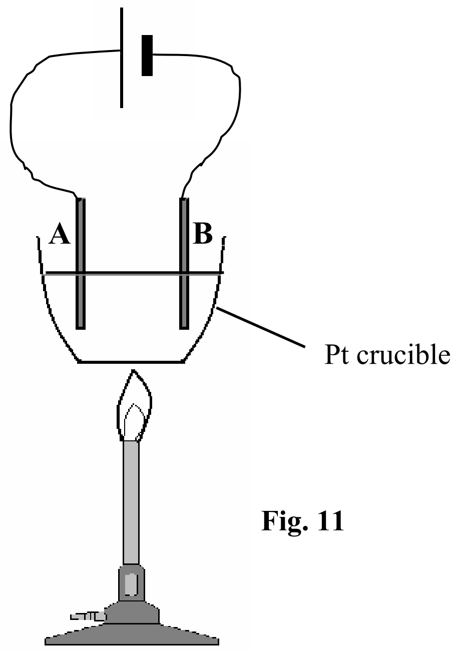



**Fig. 11**

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