2997

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LEAVING CERTIFICATE EXAMINATION, 1998

PHYSICS AND CHEMISTRY — HIGHER LEVEL

THURSDAY, 18 JUNE — AFTERNOON 2.00 to 5.00

Six questions to be answered. Answer any **three** questions from Section I and any **three** from Section II. All the questions carry equal marks.

SECTION I – PHYSICS (200 marks)

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

(*a*) Define the unit of force, i.e. *the newton.*

(*b*) A force of 20 N acts on a body of mass 3 kg at rest. What is the velocity of the body after 6 seconds?

(*c*) Explain the term *thermometric property.*

(*d*) The volume of a fixed mass of a gas at 273 K is 50 cm^3. If the pressure remains constant, what will be its volume at 364 K?

(*e*) Give an equation which defines temperature on the Celsius scale.

(*f*) What is meant by *an ideal gas*?

(*g*) Which one of the following types of electromagnetic radiation has the *shortest* wavelength:

ultraviolet gamma x-ray?

(*h*) An object is placed 6 cm in front of a concave mirror of focal length 3 cm as shown in **Fig. 1.** What is the position and nature of the image formed?

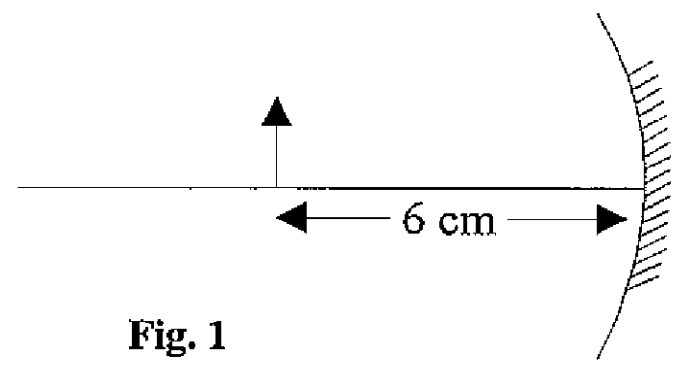


Fig. 1

(*i*) State *one* way in which energy losses may be *reduced* in a transformer.

(*j*) What is the basic principle on which the operation of the moving coil galvanometer depends?

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

(*l*) Calculate the energy dissipated when a current of 2 amperes passes through a 10 ohm resistor for 300 seconds.

(*m*) Calculate the effective capacitance of the arrangement of capacitors shown in **Fig. 2.**

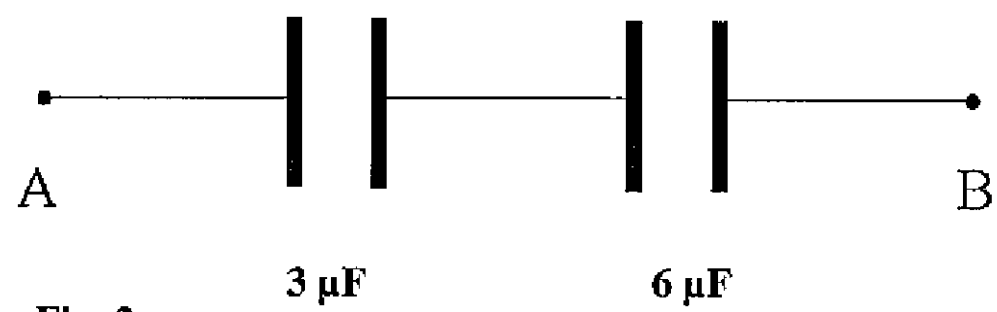


Fig. 2

(*n*) State *two* properties of alpha particles.

(*o*) The half-life of a radioactive isotope is 20 seconds. What fraction of a sample remains undecayed after 120 seconds? (11 x 6)

2. Define *kinetic energy.* (6)

State *the principle of conservation of momentum.* (6)

Describe a laboratory experiment to verify the principle of conservation of momentum. State *two* precautions which should be taken to ensure an accurate result. (24)

Give an everyday example of the principle of conservation of momentum. (6)

Fig. 3 shows two bodies of mass 0.25 kg and 0.2 kg moving towards one another on a linear air track, with velocities 0.6 m s^{-1} and 0.4 m s^{-1} respectively.

The bodies collide and stick together.

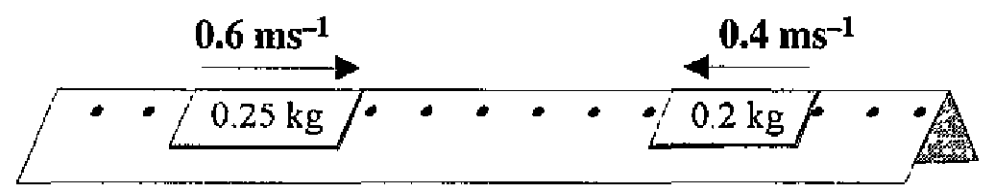


Fig. 3

Calculate: (i) their velocity immediately after collision.

(ii) the loss in kinetic energy of the 0.25 kg body. (24)

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

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

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

Explain how the optical arrangement of the compound microscope differs from that of the astronomical telescope. (6)

A convex (converging) lens has a focal length of 30 cm. Find *two* positions at which an object may be placed so that the image formed may be *three* times the size of the object. (15)

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

In an experiment to verify Ohm's law the circuit shown in **Fig. 4** was used. The experimental results are shown in the table below.

Potential difference across resistor/V	0.5	1.0	1.5	2.0	2.5	3.0	3.5
Current/A	0.10	0.18	0.28	0.38	0.45	0.55	0.64

(i) Draw a suitable graph (on graph paper) and explain how it verifies Ohm's law. (18)

(ii) From the graph determine the resistance of the unknown resistor **R**. (9)

(iii) Explain the function of the rheostat in **Fig. 4**. (6)

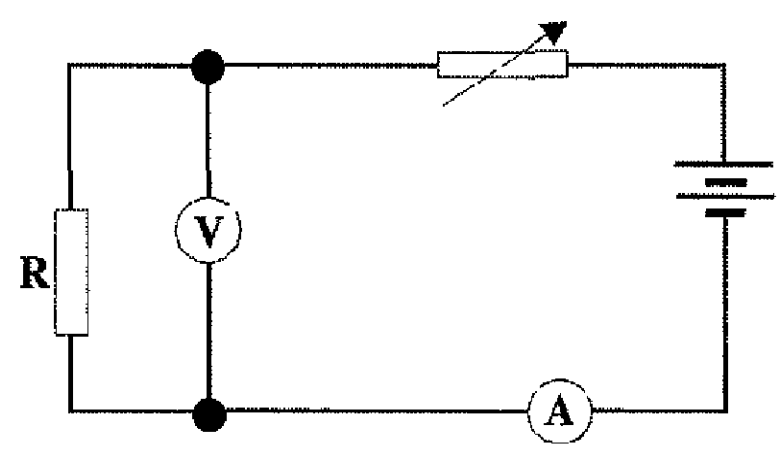


Fig. 4

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

Draw a labelled diagram of an a.c. generator and explain how it works. (21)

5. (*a*) What is meant by *mass-energy conservation* in nuclear reactions? (6)

Radium decays to Radon as shown in the decay scheme

$$^{226}_{88}\text{Ra} \longrightarrow {}^{222}_{86}\text{Rn} + {}^{4}_{2}\text{He} + \gamma$$

The atomic masses are: radium 3.753×10^{-25} kg, radon 3.686×10^{-25} kg and helium 0.066×10^{-25} kg.

Calculate (i) the loss of mass, (ii) the energy released, when an atom of $^{226}_{88}\text{Ra}$ decays. (15)

Distinguish between *nuclear fission* and *nuclear fusion.* (12)

(*b*) What is meant by the *photoelectric effect*? (6)

Outline how the photoelectric effect may be demonstrated in the laboratory. (9)

A sodium lamp emits light of wavelength 593 nm. Calculate (i) the frequency (ii) the photon energy of the light. (12)

Give *two* applications of the photoelectric effect. (6)

[$c = 3.0 \times 10^{8}$ m s^{-1}; $h = 6.6 \times 10^{-34}$ J s.]

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

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

Describe a laboratory experiment to verify Boyle's law. Draw a labelled diagram of the apparatus used. (18)

Give *three* assumptions of the *kinetic theory of gases.* (9)

(*b*) State Newton's *universal law of gravitation.* (6)

Use the *law of gravitation* to establish the relationship between g and G. (12)

If the acceleration due to gravity on the surface of Earth is 9.8 m s^{-2} and the radius of the Earth is 6.4×10^{6} m, calculate the acceleration due to gravity at a height of 6×10^{5} m above the surface of Earth. (15)

[$G = 6.7 \times 10^{-11}$ N m^2 kg^{-2}; mass of Earth = 6×10^{24} kg.]

(*c*) Write down an equation for the electrostatic force between two charges placed a distance apart in a vacuum. (6)

Referring to their structure, distinguish between solid materials that are electrical conductors and those that are insulators. (9)

In a sodium chloride crystal, a sodium ion has a charge of $+1.6 \times 10^{-19}$ C and a chloride ion has a charge of -1.6×10^{-19} C. They are a distance of 0.2 nm apart in a vacuum. What force of attraction exists between them? (12)

Sketch the electric field for a pair of isolated sodium and chloride ions. (6)

[$\varepsilon_0 = 8.9 \times 10^{-12}$ C^2 N^{-1} m^{-2}.]

(*d*) In 1802 Thomas Young designed an experiment which provided a method for measuring the wavelength of light. The experiment also demonstrated both interference and diffraction of light.

(i) Explain the underlined terms. (12)

(ii) What important phenomenon did this experiment demonstrate? (6)

(iii) In a Young's slits experiment, light of wavelength 580 nm falls on a pair of slits which are 1 m from the screen. The distance from the central maximum to the third bright fringe is 5 mm.

Calculate the distance between the slits. (15)

SECTION II – CHEMISTRY (200 marks)

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

(*a*) What is meant by the *relative atomic mass* of an element?

(*b*) Name the types of crystal in which the structural units are (i) neutral atoms, (ii) molecules.

(*c*) Identify the species represented by each of the following electronic structures:
(i) $1s^2 2s^2 2p^6 3s^2 3p^2$, (ii) $[1s^2 2s^2 2p^6]^{2+}$.

(*d*) Define the *first ionisation energy* of an element.

(*e*) Calculate the percentage, by mass, of oxygen in ethanal, CH_3CHO.
[H = 1; C = 12; O = 16.]

(*f*) Define the *heat of combustion* of a substance.

(*g*) Name an oxide which is a major cause of air pollution.

(*h*) Complete and balance the following decomposition in the presence of manganese(IV) oxide:

$$H_2O_2 \longrightarrow \quad +$$

(*i*) Name a chemical test or reagent used to distinguish between an aldehyde and a ketone.

(*j*) Write the structural formula for 1,2-dibromoethane.

(*k*) Name two chemicals which may be used to prepare hydrogen sulphide in the laboratory.

(*l*) Calculate the number of *atoms* in 6 g of water.
[Avogadro constant = 6×10^{23} mol^{-1}; H = 1; O = 16.]

(*m*) Show, in terms of electron transfer, the reaction taking place at the anode when an electric current is passed through molten sodium chloride.

(*n*) Give *two* applications of electrolysis.

(*o*) Explain what is meant by a *standard solution.* (11 x 6)

8. Explain the terms (i) covalent bond, (ii) ionic bond, (iii) electronegativity. (18)

Name and write the formula of the simplest hydride of each of the following elements:

carbon nitrogen sulphur. (9)

For each hydride named:

(i) state the type of bond present.

(ii) sketch the shape of the molecule.

(iii) explain the shape of the molecule using the electron pair repulsion theory. (27)

Explain why nitrogen has a higher electronegativity value than carbon.
Give *two* reasons why the simplest hydride of nitrogen is very soluble in water. (12)

9. (*a*) Define (i) acid, (ii) base, (iii) conjugate pair, in terms of the Bronsted-Lowry Theory. (12)

Identify the conjugate pairs in each of the following:

$$H_2SO_4 + 2HF \rightleftharpoons H_3SO_4^+ + HF_2^-$$

$$S^{2-} + H_3O^+ \rightleftharpoons HS^- + H_2O$$ (12)

Explain why H_2SO_4 is considered to be a strong acid while its conjugate base is a weak base. (12)

(*b*) In a titration, 20 cm^3 of 0.1 M potassium hydroxide were required to neutralise 25 cm^3 of a sulphuric acid solution.

(i) Write a balanced equation for the reaction. (6)

(ii) Calculate the concentration of the sulphuric acid in moles per litre (dm^3). (12)

(iii) Define **pH**, and calculate the **pH** of **0.1 M** potassium hydroxide solution. (12)

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

Calculate the heat of formation of ethanoic acid from the following data:

$$CH_3COOH_{(l)} + 2O_{2(g)} \longrightarrow 2CO_{2(g)} + 2H_2O_{(l)} \qquad \Delta H = -300 \text{ kJ mol}^{-1}$$

$$C_{(s)} + O_{2(g)} \longrightarrow CO_{2(g)} \qquad \Delta H = -393 \text{ kJ mol}^{-1}$$

$$H_{2(g)} + \tfrac{1}{2}O_{2(g)} \longrightarrow H_2O_{(l)} \qquad \Delta H = -286 \text{ kJ mol}^{-1}$$ (18)

(*b*) Place the elements zinc, copper, aluminium and potassium in order of *decreasing* chemical reactivity. (6)

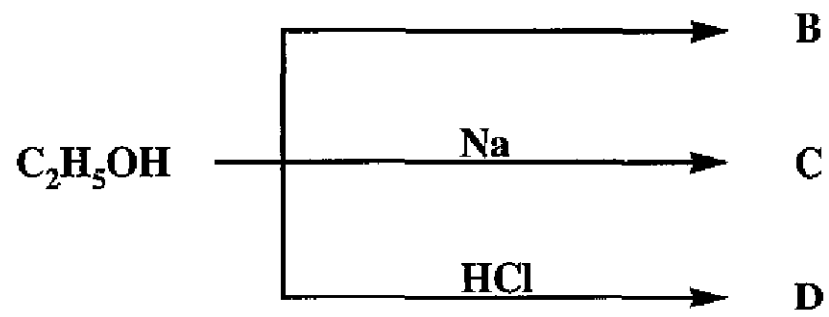
Explain how this order is justified on the basis of the reaction, if any, of the metals (i) with water, (ii) with dilute hydrochloric acid. (18)

Describe what happens when a piece of zinc is placed in a solution of copper(II) sulphate. Write a chemical equation for the reaction. (12)

11. Explain the terms (i) homologous series, (ii) functional group, (iii) primary alcohol. (18)

A compound was found on analysis to contain 37.5% carbon, 12.5% hydrogen and 50% oxygen. The relative molecular mass of the compound is 32. Suggest a name for the compound, give its molecular formula and draw its structural formula. (21)

Study the reaction scheme for ethanol and answer the questions which follow.



(i) Name aldehyde **B** and state the conditions under which it is obtained from ethanol. (9)

(ii) Write a chemical equation for the reaction between ethanol and sodium. Name the compound **C** which is formed. (9)

(iii) Name compound **D** and write down its chemical formula. Name a suitable catalyst used in the formation of **D** using **HCl**. (9)

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

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

Explain how the presence of energy levels in atoms may be used to explain the characteristic emission spectra of elements.

(*b*) The structural formulae of *three* aromatic compounds are shown in **Fig. 5** below.

State how benzene may be converted to each of the named compounds.

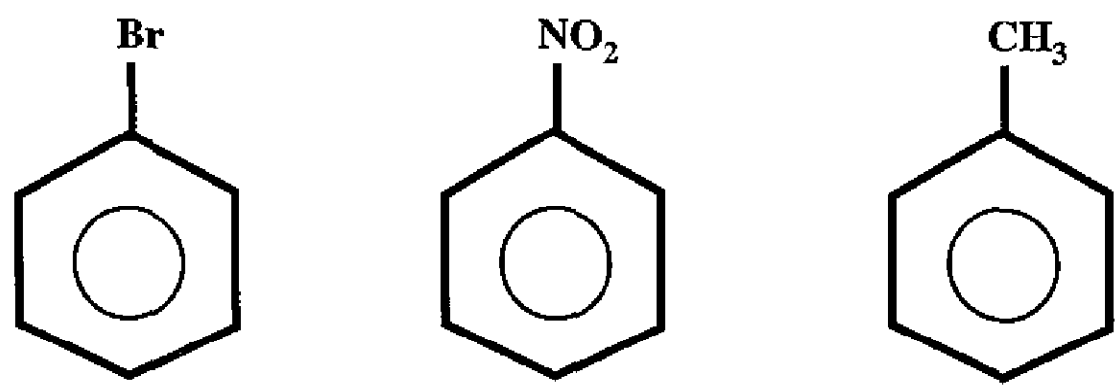


Fig. 5

(*c*) Define (i) oxidation, (ii) oxidising agent, in terms of electron transfer.

Identify the substance oxidised and the oxidising agent in each of the following reactions.

$$MgBr_2 + Cl_2 \longrightarrow MgCl_2 + Br_2$$

$$4Na + O_2 \longrightarrow 2Na_2O$$

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

A sample of ethyne (C_2H_2) was prepared by reacting 0.125 moles of calcium dicarbide with water.

$$CaC_2 + 2H_2O \longrightarrow Ca(OH)_2 + C_2H_2$$

Calculate:

(i) the mass of calcium dicarbide used.

(ii) the number of moles of water required to use up all the calcium dicarbide.

(iii) the volume of ethyne produced.

[Molar volume at STP = 22.4 litres (dm^3); H = 1; C = 12; O = 16; Ca = 40.]