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LEAVING CERTIFICATE EXAMINATION, 2002

PHYSICS AND CHEMISTRY - HIGHER LEVEL

MONDAY, 17 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*) State *Newton's first law of motion*.

(*b*) Define the unit of work, i.e., *the joule*.

(*c*) The graph in **Fig. 1** was obtained in an experiment to verify *Charles's law*.

(i) What is the value of the temperature **T**?

(ii) What does the vertical axis, **Y**, represent?

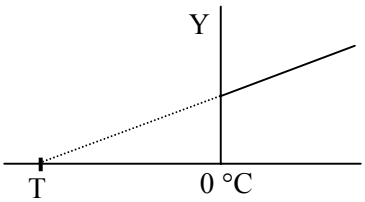

Fig. 1

(*d*) According to the kinetic theory of gases, what determines the temperature of a gas?

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

(*f*) Draw a labelled diagram showing how a spectrum of white light may be obtained using a prism.

(*g*) State *the laws of reflection of light*.

(*h*) An object is placed 4 cm in front of a convex mirror of focal length 12 cm as shown in **Fig. 2**. What is the position of the image?

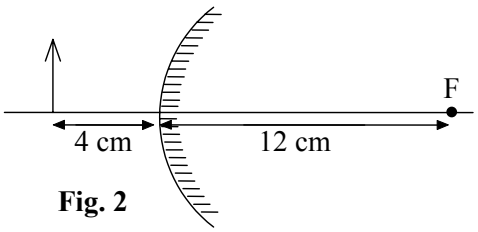

Fig. 2

(*i*) Draw a sketch of the magnetic field around a solenoid, indicating the direction of the current in the solenoid.

(*j*) Give an expression for the capacitance of a parallel plate capacitor.

(*k*) State the principle on which a moving-coil galvanometer is based.

(*l*) Sketch a diagram to show how the magnitude of an a.c. voltage varies with time.

(*m*) What is the current drawn from a 12 V battery by a 75 W car headlamp bulb?

(*n*) Give <u>two</u> uses of radioactive substances.

(*o*) Which type of radiation emitted by a radioactive nucleus (i) causes most ionisation, (ii) has the greatest range in air?

(11 × 6)

2. Define *momentum.* (6)

Describe an experiment to verify Newton's second law of motion. (21)

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

A tennis player drops a tennis ball of mass 0.2 kg from rest at a height of 0.75 m. Calculate the speed of the ball just before it hits the ground (assume that air resistance may be neglected). (9)

After it hits the ground the ball bounces vertically to a height of 0.3 m. Calculate:

(i) the speed of the ball just after it leaves the ground; (6)

(ii) the change in momentum that results from the ball hitting the ground; (9)

(iii) the average force required to produce this change in momentum if the ball is in contact with the ground for 0.15 seconds. (9)

[Acceleration due to gravity, $g = 9.8$ m s^{-2}.]

3. What is meant by (i) *the interference of waves*, (ii) *the photoelectric effect*? (12)

Describe an experiment to measure the wavelength of monochromatic light. (18)

A photon of yellow light has an energy of 3.3×10^{-19} J. Calculate:

(i) the frequency of the photon;

(ii) the wavelength of the yellow light. (18)

State how you would demonstrate the photoelectric effect. (12)

Give <u>two</u> applications of the photoelectric effect. (6)

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

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

In an experiment to verify Boyle's law the volume V of a fixed mass of gas was measured for a series of values of the pressure p at constant temperature. The data obtained are shown in the following table.

p / kPa	120	140	160	180	200	220	240
V / cm^3	25	21	19	17	15	14	12

Plot a suitable graph (on graph paper) to show the relationship between volume and pressure. Explain how this graph verifies Boyle's law. (18)

Give <u>two</u> precautions you would take when carrying out this experiment to ensure a more accurate result. (6)

(*b*) What is meant by *a thermometric property*? (9)

Give a definition of temperature on the Celsius scale. (9)

In a mercury-in-glass thermometer the length of the mercury column is 65 mm at the ice point, 240 mm at the boiling point of water and 178 mm in a liquid of unknown temperature. Calculate the temperature of the liquid in (i) °C, (ii) K. (12)

Name <u>one</u> other type of thermometer and state the thermometric property on which it is based. (6)

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

Describe an experiment to demonstrate an electric field pattern. (12)

Fig. 3 shows two positively charged spheres, with a distance of 10 cm between their centres. The force between the spheres is *F*.

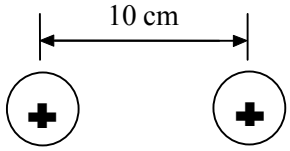

Fig. 3

(i) What would the force be, in terms of *F*, if the distance between the centres of the spheres were decreased to 5 cm?

(ii) How could a similar change in the force between the two spheres be achieved without changing the distance? (15)

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

Fig. 4 shows a number of resistors connected to a 9 V battery. Calculate:

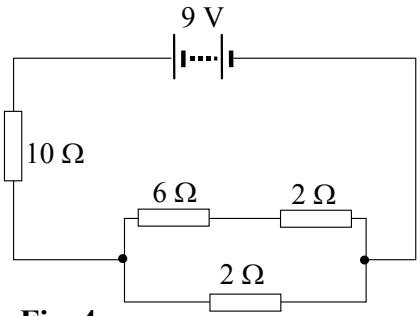

Fig. 4

(i) the total resistance of the circuit; (15)

(ii) the current flowing in the circuit; (6)

(iii) the voltage across the 10 Ω resistor. (6)

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

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

Describe an experiment to determine the value of *g*, the acceleration due to gravity. (18)

Name <u>one</u> factor on which the value of *g* on the earth's surface depends and give the relationship between *g* and this factor. (9)

(*b*) Define *refractive index*. (6)

Fig. 5 shows a ray of light travelling from glass into air.

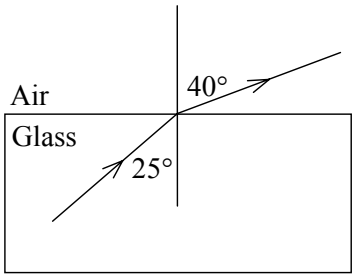

Fig. 5

Using the values shown on the diagram calculate:

(i) the refractive index of the glass; (9)

(ii) the critical angle for the glass. (9)

What is the name given to the phenomenon that occurs if the angle in the glass exceeds the critical angle?

Give <u>one</u> application of this phenomenon. (9)

(*c*) Explain the term *electromagnetic induction*. (6)

Draw a labelled diagram of a transformer and explain how it works. (18)

In a television, transformers are used to increase the voltage and also to reduce the voltage. What is the difference in structure between these two types of transformer? (6)

Give <u>one</u> other application of electromagnetic induction. (3)

(*d*) What is meant by *mass-energy conservation*? (6)

One of the isotopes of hydrogen is deuterium, $^{2}_{1}\mathbf{H}$. In a particular nuclear reaction two deuterium nuclei combine to produce a helium nucleus and energy only. The mass of each deuterium nucleus is 3.34×10^{-27} kg and the mass of the helium nucleus is 6.65×10^{-27} kg.

(i) Write an equation for this nuclear reaction. (9)

(ii) Calculate the energy released in the reaction. (12)

Name the type of nuclear reaction described above and give one place where this type of reaction occurs naturally. (6)

[Speed of light in vacuum, $c = 3.00 \times 10^{8}$ 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 is meant by *the first ionisation energy* of an element?

(*b*) Give <u>two</u> properties of the electron.

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

(*d*) Which one the following acid/base pairs is a conjugate pair?
$\mathbf{OH^- / H_3O^+}$ $\mathbf{H_2SO_4 / HSO_4^-}$ $\mathbf{H_3PO_4 / HPO_4^{2-}}$

(*e*) What is the difference between a *strong acid* and a *weak acid*?

(*f*) The carbon dioxide molecule has a zero dipole moment. What does this indicate about the shape of this molecule?

(*g*) Write the chemical formula for ozone.

(*h*) What is meant by the term *relative atomic mass* of an element.

(*i*) How many atoms are present in 3.4 g of hydrogen sulphide ($\mathbf{H_2S}$) at STP?
[H = 1, S = 32; Avogadro constant = 6×10^{23} mol^{-1}.]

(*j*) Define *heat of solution* of a substance.

(*k*) Methylbenzene (toluene) is an <u>aromatic hydrocarbon</u>. Explain the underlined term.

(*l*) The alkenes form a homologous series. Give the name and molecular formula of the homologue that contains three carbon atoms.

(*m*) In the electrolysis of molten sodium chloride, state the product formed at (i) the anode, (ii) the cathode.

(*n*) What is the systematic name of the organic compound $\mathbf{CH_3CHClCH_3}$?

(*o*) Give <u>two</u> chemical properties of phenol.

(11×6)

8. Define (i) *electronegativity*, (ii) *ionic bond*, (iii) *polar covalent bond*. (18)

Explain why, in the periodic table, there is (a) an increase in electronegativity values across a period, and (b) a decrease in electronegativity values down a group. (12)

Use electronegativity values to predict the type of bonding in (a) phosphine (**PH_3**), (b) potassium chloride (**KCl**). (Refer to Mathematics Tables, p.46.) (6)

The following substances form crystalline solids:

Graphite **Iodine** **Copper** **Potassium chloride**

State the type of crystal present in each solid. (12)

Explain:

(i) why copper conducts electricity and iodine does not conduct electricity;

(ii) why potassium chloride is soluble in water and graphite is insoluble in water;

(iii) why iodine is readily soluble in non-polar solvents. (18)

9. Anhydrous sodium carbonate (**Na_2CO_3**) is used as a primary standard in volumetric analysis.

Explain the underlined term and give two reasons why anhydrous sodium carbonate is suitable for use as a primary standard. (12)

In a titration experiment 22.3 cm^3 of a hydrochloric acid solution were required to neutralise 20 cm^3 of a **0.1 M** sodium carbonate solution.

(i) Name the pieces of apparatus used to measure the volume of (a) the acid, and (b) the base, in this titration. Describe the correct procedure for washing, filling and using each of these pieces of apparatus. (24)

(ii) Name a suitable indicator for this titration, giving its colour change at the end point. (6)

(iii) Write a balanced equation for the reaction involved. (9)

(iv) Calculate the concentration of the hydrochloric acid solution in terms of (a) molarity, (b) grams per litre (dm^3). (15)

[H = 1; Cl = 35.5.]

10. (a) Define (i) *oxidation*, (ii) *reduction*, in terms of electron transfer. (9)

In the following equations identify which species is being oxidised and which is being reduced.

$$2Cu + S \rightarrow Cu_2S$$
$$2KI + Cl_2 \rightarrow 2KCl + I_2$$ (12)

(b) Place the following metals in order of decreasing reactivity according to the electrochemical series.

Ca Fe Zn Cu K Mg (6)

From this list of metals name (i) a metal which occurs free in nature, (ii) the metal which forms the most stable compounds. Give a reason for your answer in (i) or (ii). (9)

Write a balanced equation for the reaction which occurs when zinc is added to a copper sulphate solution. Describe the change which will be observed in the zinc. (12)

(c) Define *electrolysis*. (6)

Fig. 6 shows an arrangement used to plate a nickel coin with silver. Calculate the mass of silver deposited on the coin when a current of 4 A flows for 772 seconds. (12)
[Ag = 108; 1 faraday = 96 500 C.]

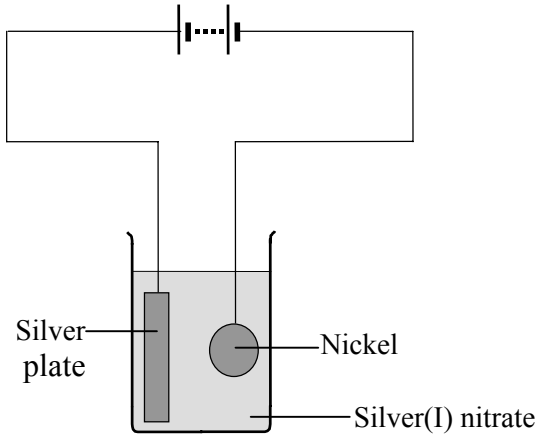

Fig. 6

11. The apparatus in **Fig. 7** may be used in the preparation of ethanal (acetaldehyde) by the oxidation of ethanol.

(i) Name the homologous series to which each of the compounds ethanol and ethanal belongs.
Draw the structural formula of each of these compounds. (18)

(ii) Identify a suitable acid and a suitable oxidising agent for use in this preparation. (6)

(iii) What is observed when a sample of ethanal is reacted with phenylhydrazine?
Write an equation for this reaction. (12)

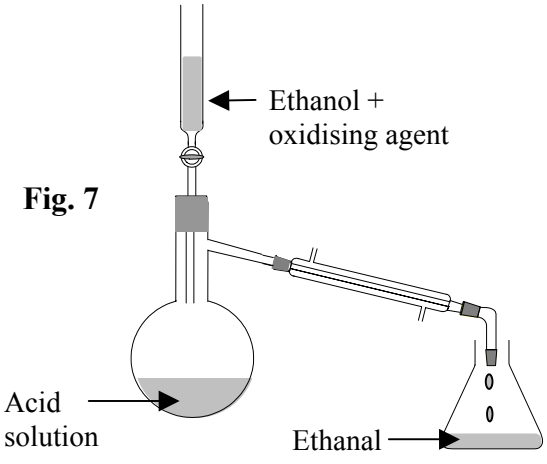

Fig. 7

(iv) Ethanal can be easily oxidised to another organic compound. Give the name and formula of this compound. (12)

(v) Write chemical equations for the reaction of ethanol with (a) concentrated sulphuric acid,
(b) sodium. Name the organic product in each case. (18)

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

(a) With regard to the electronic structure of atoms, state what is meant by (i) *energy levels*, (ii) *sublevels* (s, p, etc.) and (iii) *orbitals*.

Write the electronic configuration (s, p, etc.) of the $\mathbf{Al^{3+}}$ ion. What neutral atom has the same electronic configuration?

(*b*) Give an example of (i) an exothermic reaction, (ii) an endothermic reaction.

Given that the heats of formation of $\mathbf{NO_{(g)}}$ and $\mathbf{NO_{2(g)}}$ are +90 kJ mol^{-1} and +31 kJ mol^{-1} respectively, calculate the heat change for the reaction

$$\mathbf{2NO_{(g)} + O_{2(g)} \rightarrow 2NO_{2(g)}}$$

(*c*) Ammonia gas was prepared in the laboratory using ammonium chloride ($\mathbf{NH_4Cl}$) and calcium hydroxide ($\mathbf{Ca(OH)_2}$).

$$\mathbf{2NH_4Cl + Ca(OH)_2 \rightarrow 2NH_3 + CaCl_2 + 2H_2O}$$

Explain how a dry sample of the ammonia gas was obtained.

If 2.675 g of ammonium chloride were used calculate:

(i) the minimum mass of calcium hydroxide required to ensure that the 2.675 g of ammonium chloride reacted fully;

(ii) how many molecules of water were produced;

(iii) the volume of ammonia collected at STP.

[N = 14; H = 1; Cl = 35.5; Ca = 40; O = 16; molar volume at STP = 22.4 litres (dm^3); Avogadro constant = 6×10^{23} mol^{-1}.]

(*d*) From the following list of oxides identify (i) an acidic oxide, (ii) a basic oxide.

$$\mathbf{SO_3 \quad CO \quad MgO}$$

Write an equation for the reaction of the acidic oxide with water.

Write an equation for the reaction of the basic oxide with hydrochloric acid.