Coimisiún na Scrúduithe Stáit
State Examinations Commission

LEAVING CERTIFICATE EXAMINATION, 2006

PHYSICS AND CHEMISTRY - HIGHER LEVEL

MONDAY, 19 JUNE – MORNING 9:30 to 12:30

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.

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*) Distinguish between a vector and a scalar.

(*b*) Define the unit of force, the newton.

(*c*) Write an expression for the gravitational force between two objects each of mass *m* whose centres are separated by a distance *d*, as shown in **Fig. 1**.

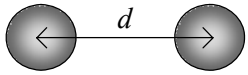

Fig. 1

(*d*) Give two properties of an image formed by a convex mirror.

(*e*) The path of a light ray as it travels through a semicircular block of glass of refractive index 1.4 is shown in **Fig. 2**. What is the size of the angle marked **A**?

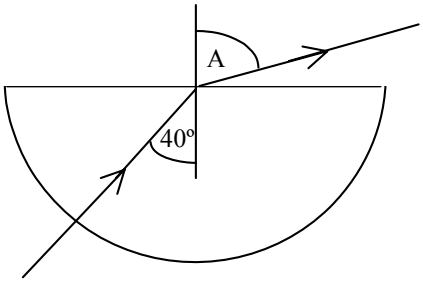

Fig. 2

(*f*) Explain the term *total internal reflection*.

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

(*h*) Give an expression that defines temperature on the Celsius scale.

(*i*) What is Brownian movement?

(*j*) Name two effects of an electrical current as it passes through a conductor.

(*k*) **Fig. 3** shows two equal positive charges. Copy the diagram and sketch the electric field around the charges.

Fig. 3

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

(*m*) Why does the ESB use high voltage to transmit electric current over long distances?

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

(*o*) What is *nuclear fusion*?

(11 × 6)

2. Define *momentum*. (6)

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

State the principle of conservation of momentum and use it to explain how a rocket can change its velocity. (12)

Describe an experiment to verify the principle of conservation of momentum. (15)

A boat of mass 500 kg is propelled through water at a constant velocity, while its propeller pushes 100 kg of water a distance 7.5 m every second in the opposite direction, as shown in **Fig. 4**.

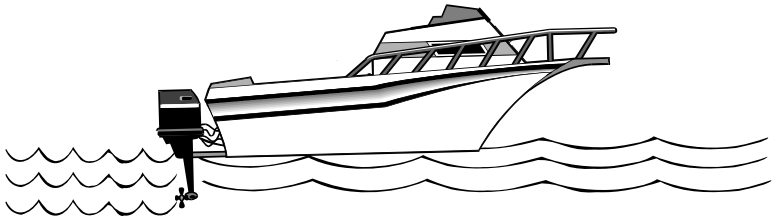

Fig. 4

What is the velocity of the displaced water?

By applying the principle of conservation of momentum calculate the velocity of the boat. (12)

The propeller stops and the boat continues to travel for a further 10 m.
Find, as the boat comes to rest,

(i) the average acceleration of the boat;

(ii) the force exerted by the water on the boat. (15)

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

Describe, with the aid of a labelled diagram, an experiment to measure the focal length of a converging (convex) lens. (18)

Fig. 5 shows a converging lens of focal length 10 cm being used as a simple microscope (magnifying glass) to examine an insect of length 4 mm which is 5 cm from the lens.

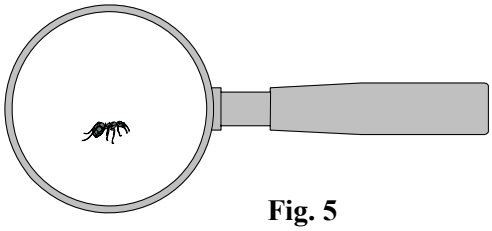

Fig. 5

Find

(i) the position of the insect's image;

(ii) the magnification of the image;

(iii) the length of the image. (15)

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

Greater magnification can be achieved using a compound microscope instead of a simple microscope. Explain why. (6)

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

In an experiment to verify Boyle's law, a student measured the volume V of oxygen gas in a syringe at different values of pressure p. The mass of the gas was not allowed to change and its temperature was kept constant. See **Fig. 6**.

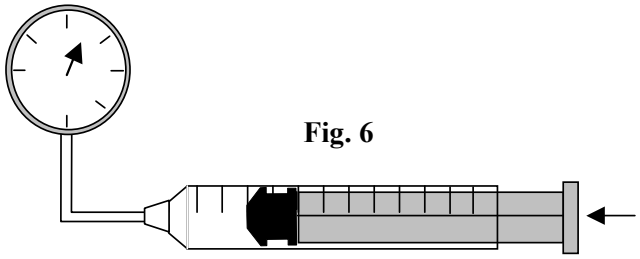

Fig. 6

The following data were recorded.

p/kPa	103	121	133	150	202	243	298
V/cm^3	120	100	90	80	60	50	40

Draw a suitable graph on graph paper to show the relationship between the pressure of the gas and its volume. Explain how your graph verifies Boyle's law. (21)

There are 5.2×10^{-3} moles of oxygen gas in the syringe. Use the slope of your graph to calculate the temperature of the oxygen on (i) the absolute (Kelvin) scale, (ii) the Celsius scale. (18)

What is an *ideal gas*?
Under what conditions do real gases like oxygen behave like an ideal gas? (12)

Define a *thermometric property*.
Name the thermometric property on which the constant volume gas thermometer is based. (9)

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

5. Define the unit of current, the ampere. (9)

Describe an experiment to demonstrate the principle on which a moving-coil galvanometer is based. (12)

Fig. 7 shows a moving-coil galvanometer.
Name the parts labelled **A**, **B** and **C** and give the function of any two of them. (15)

When the galvanometer is connected to a 550 Ω resistor and a 6 V battery as shown in **Fig. 7** it gives a full-scale deflection of 10 mA.

Calculate
(i) the total resistance in the circuit;
(ii) the internal resistance of the galvanometer. (12)

How would you convert this galvanometer to an ammeter capable of reading larger currents? (6)

Calculate the size of the resistor required to enable the galvanometer measure currents up to 10 A. (12)

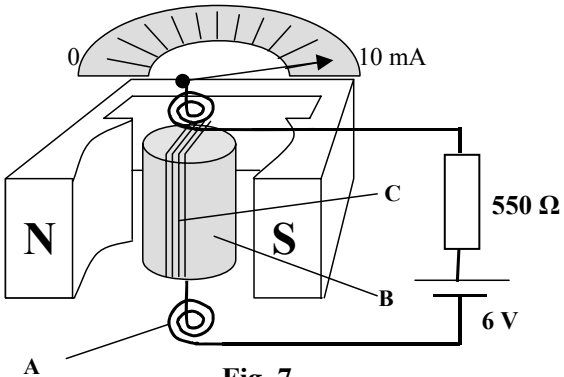

Fig. 7

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

(*a*) Define (i) *potential energy,* (ii) *kinetic energy*. (9)

What is the relationship between the potential energy and the kinetic energy of an object which is falling freely? (6)

A stone of mass 2.5 kg is dropped from a stationary hot air balloon 170 m above the surface of a lake. The occupants of the balloon hear the splash 0.5 s after seeing the stone strike the water.

Calculate

(i) the potential energy of the stone as it is released;

(ii) the kinetic energy of the stone as it strikes the water;

(iii) the speed with which the stone strikes the water;

(iv) a value for the speed of sound in air. (18)

[g = 9.8 m s^{-2}]

(*b*) Define *capacitance*. (6)

Describe an experiment to show how the capacitance of a parallel plate capacitor depends on the common area between the plates. (15)

Name two other factors which affect the capacitance of a parallel plate capacitor. (6)

Give one use for a capacitor. (6)

(*c*) Define *radioactivity*. (6)

Describe the nature of alpha particles.

Name a material which can be used to stop alpha particles. (9)

Radon is a naturally occurring radioactive gas which diffuses out of the ground and can accumulate in houses. The radon-222 isotope decays by emitting an alpha particle and has a half-life of 3.8 days.

Why is the build-up of radon-222 a hazard?

Complete the following nuclear reaction for the decay of radon-222:

$$^{222}_{86}\text{Rn} \rightarrow$$

(Refer to Mathematics Tables, p. 44.) (12)

How long does it take a sample of radon-222 to decay to one-sixteenth of its original mass? (6)

(*d*) Why are light waves and ripples in water classified as transverse waves? (6)

Water waves in a ripple tank approach two small gaps in a barrier placed in their path as shown in **Fig. 8**.
Name the phenomenon which occurs as the water waves pass through the gaps.
How can this effect be made more pronounced?

Another wave phenomenon is observed where the waves overlap. Name this phenomenon. (12)

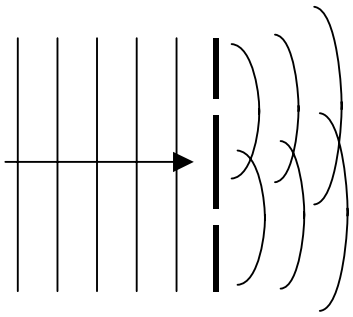

Fig. 8

Describe how you could demonstrate the phenomena shown in **Fig. 8** using a monochromatic light source.
What measurements should you take to calculate the wavelength of the light source? (15)

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 are *allotropes*?

(*b*) Naturally occurring chlorine consists of two isotopes: 75.5% $^{35}_{17}$**Cl** and 24.5% $^{37}_{17}$**Cl**.
Calculate the relative atomic mass of chlorine.

(*c*) How many (i) neutrons, (ii) electrons are there in $^{23}_{11}\mathbf{Na}^{+}$?

(*d*) What colour do lithium salts give to a Bunsen burner flame?

(*e*) **Fig. 9** shows a 2p orbital. State (i) the principal (first) quantum number, (ii) the subsidiary (second) quantum number of an electron in this orbital.

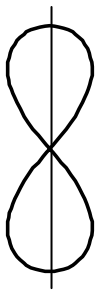

Fig. 9

(*f*) Calculate the molecular formula of the alkane which is composed of 75% carbon and 25% hydrogen by mass.
[H = 1; C = 12]

(*g*) What is the shape of (i) the $\mathbf{BF_3}$ molecule, (ii) the $\mathbf{CO_2}$ molecule?

(*h*) What is the role of a catalyst in a chemical reaction?

(*i*) Write a balanced equation for the reaction which takes place when chlorine gas is bubbled through a solution of sodium bromide.

(*j*) How many molecules are there in 560 cm^3 of carbon dioxide gas at STP?
[molar volume at STP = 22 400 cm^3; Avogadro constant = 6.0×10^{23} mol^{-1}]

(*k*) What is the molarity of the solution when 10.6 g of sodium carbonate ($\mathbf{Na_2CO_3}$) is dissolved in one litre of aqueous solution?
[C = 12; O = 16; Na = 23]

(*l*) Calculate the pH of a 0.2 M solution of **KOH**.

(*m*) In **Fig. 10** a sample of ethyne is bubbled through a solution of two reagents at 60 ºC and is converted to ethanal.
Name the two reagents required for this conversion.

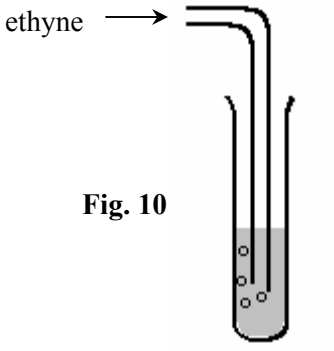

Fig. 10

(*n*) Name and give the structural formula of an aromatic compound whose molecular formula is $\mathbf{C_7H_8}$.

(*o*) Identify the two acidic organic compounds in the following list:

$\mathbf{C_6H_5COOH}$ $\mathbf{CH_3CHO}$ $\mathbf{C_2H_5OH}$ $\mathbf{CH_3COOC_2H_5}$ $\mathbf{CH_3COCH_3}$

(11×6)

8. (*a*) Write the electron configuration of (i) the carbon atom, (ii) the aluminium ion, $\mathbf{Al^{3+}}$. (9)

(*b*) Define (i) a *covalent bond*, (ii) a *polar covalent bond*, (iii) *electronegativity*. (18)

Use electronegativity values to predict the type of bonding in potassium bromide.
(Refer to the Mathematics Tables, p. 46.)
What are the general properties of compounds with this type of bonding? (12)

(*c*) Iodine, aluminium and diamond are all crystalline solids.

What type of crystal exists in each of these substances? (9)

Explain, in terms of bonding, why

(i) iodine is insoluble in water;

(ii) aluminium is a good conductor of electricity;

(iii) diamond is difficult to cut. (18)

9. (*a*) Distinguish between a *strong* acid and a *weak* acid. (9)

What is a conjugate acid-base pair in terms of the Brønsted-Lowry theory? (6)

Ethanoic acid is a weak acid which dissociates in water as follows:

$$\mathbf{CH_3COOH + H_2O \rightleftharpoons CH_3COO^- + H_3O^+}$$

Identify two conjugate acid-base pairs in this reaction.
This equilibrium lies on the left. Explain why. (12)

(*b*) A dilute aqueous solution of ethanoic acid was titrated against a standard solution of sodium hydroxide to determine the concentration of the ethanoic acid.

The balanced equation for the titration reaction is:

$$\mathbf{CH_3COOH + NaOH \rightarrow CH_3COONa + H_2O}$$

One rough and two accurate titrations were carried out. It required, on average, 19.6 cm^3 of the ethanoic acid solution to neutralise 25 cm^3 portions of 0.10 M **NaOH**.

(i) Describe how a burette was rinsed and then filled with the ethanoic acid solution. (15)

(ii) While adding the ethanoic acid solution to the sodium hydroxide solution what two operations should be carried out at the same time to ensure an accurate result? (6)

(iii) Name a suitable indicator for this titration and state the colour change observed at the end point. (6)

(iv) Calculate the concentration of the ethanoic acid in (*a*) moles per litre (dm^3), (*b*) grams per litre (dm^3). (12)

[H = 1; C = 12; O = 16]

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

Identify the reducing agent in each of the following reactions:

$2Fe_2O_3 + 3C \rightarrow 4Fe + 3CO_2$

$Fe_2O_3 + 2Al \rightarrow 2Fe + Al_2O_3$ (6)

(*b*) State *Faraday's second law of electrolysis*. (6)

Fig. 11 shows an apparatus used to electrolyse molten lead(II) bromide ($PbBr_2$) using inert electrodes.

Name a suitable material for the inert electrodes.

Write a balanced equation for the cathode reaction.

Name the electrode where reduction takes place. (12)

A current of 2 A was passed through the lead(II) bromide.

What mass of lead is produced in 10 minutes? (12)

[Pb = 207; 1 faraday = 96 500 C]

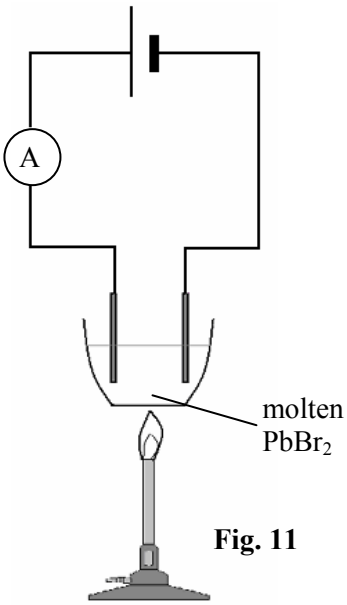

Fig. 11

(*c*) Arrange the following metals in order of **decreasing** ease of oxidation according to the electrochemical series:

Al **Fe** **Cu** **Zn** **Pb**

Which of these elements occurs free in nature?

Write a balanced equation for the reaction between zinc and sulfuric acid. (15)

What is observed when

(i) zinc metal is added to a copper(II) sulfate solution;

(ii) copper metal is added to a zinc sulfate solution? (9)

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

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

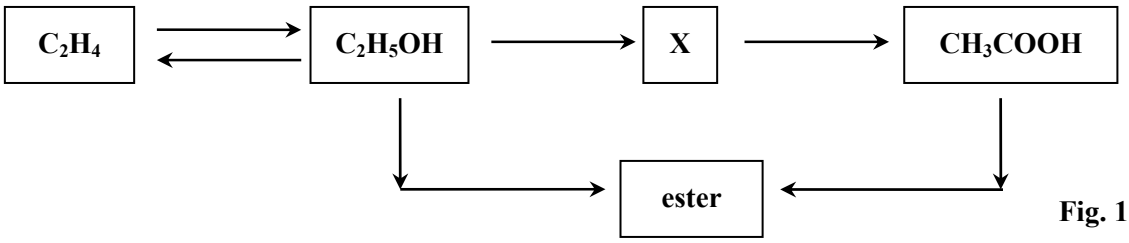

Fig. 12

(i) To what homologous series does C_2H_4 belong? Name and give the structural formula of the next member of this series. (9)

(ii) Name the compound **X** and draw the structure of its functional group. (6)

(iii) What type of reaction is $C_2H_5OH \rightarrow X$? What are the reagents required for this conversion? (9)

(iv) Name the ester formed when ethanol reacts with ethanoic acid. Write a balanced chemical equation for this reaction. Give one use for this ester. (15)

(v) Describe with the aid of a labelled diagram how ethanol is converted to ethene. (15)

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

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

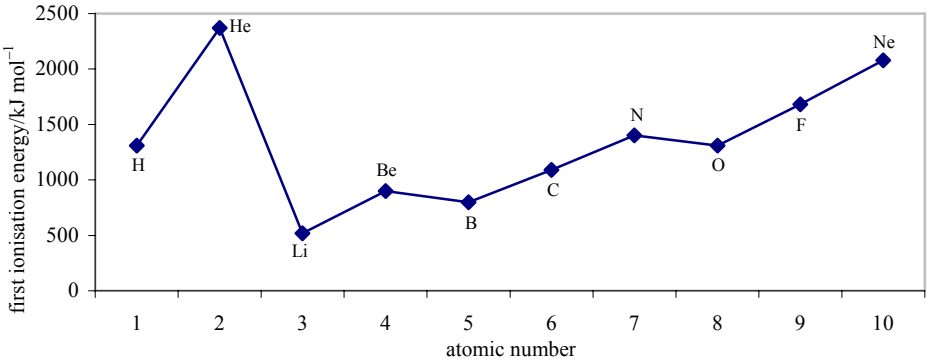

Fig. 13

Explain why first ionisation energies generally increase across a period of the Periodic Table. Explain why beryllium, despite this general increase, has a higher first ionisation energy than boron, and nitrogen has a higher first ionisation energy than oxygen, as shown in **Fig. 13**.

(*b*) Describe what is observed when ethene reacts with a solution of bromine.

What does this reaction tell you about the bonding in ethene?

Name (i) the reagent, (ii) the catalyst used in the mono-bromination of benzene as shown in **Fig. 14**.

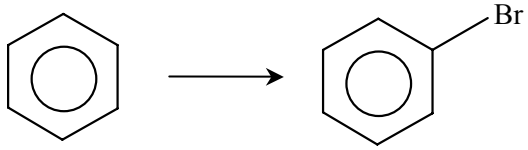

Fig. 14

The mono-bromination of benzene is a substitution reaction rather than an addition reaction.

What does this tell you about the bonding in benzene?

(*c*) Give the formula of an alkali metal hydride and write a balanced chemical equation for its reaction with water.

Which of the following chlorides is a coloured compound? Justify your choice.

$AlCl_3$ **$CaCl_2$** **$FeCl_3$** **PCl_3**

Give the formula for (i) an acidic covalent oxide, (ii) a basic ionic oxide, (iii) a neutral oxide.

(*d*) State *Hess's law*.

The following reaction between powdered iron(III) oxide and powdered aluminium is very exothermic.

$Fe_2O_{3\,(s)} + 2Al_{(s)} \rightarrow 2Fe_{(s)} + Al_2O_{3\,(s)}$

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

$4Al_{(s)} + 3O_{2\,(g)} \rightarrow 2Al_2O_{3\,(s)}$ $\Delta H = -3338$ kJ

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

$2Fe_2O_{3\,(s)} + 3C_{(s)} \rightarrow 4Fe_{(s)} + 3CO_{2\,(g)}$ $\Delta H = 465$ kJ

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