Coimisiún na Scrúduithe Stáit
State Examinations Commission

LEAVING CERTIFICATE EXAMINATION 2008

PHYSICS AND CHEMISTRY - HIGHER LEVEL

MONDAY 16 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*) Define the unit of work, i.e. *the joule*.

(*b*) What force is required to bring a car of mass 650 kg travelling at 20 m s^{-1} to rest in 5 seconds?

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

(*d*) Why does a dentist use a concave mirror rather than a plane mirror when examining teeth?

(*e*) Name the phenomenon shown in **Figure 1** and name the colour which appears at **X**.

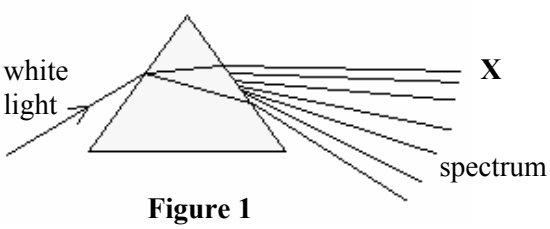

Figure 1

(*f*) Define *critical angle*.

(*g*) Explain the term *diffraction*.

(*h*) What is emitted in the photoelectric effect?

(*i*) State *Boyle's law*.

(*j*) Why is it necessary to have a standard thermometer?

(*k*) A positively charged rod is brought near to an uncharged, insulated metal sphere as shown in **Figure 2**. Draw a diagram showing the charges induced on the sphere.

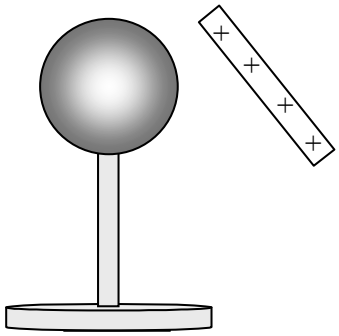

Figure 2

(*l*) Give one use of a capacitor.

(*m*) Explain what happens to the strip of aluminium foil lying between the poles of a horseshoe magnet, as shown in **Figure 3**, when the switch is closed.

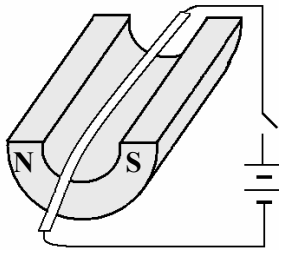

Figure 3

(*n*) How much energy is released when a sample of uranium undergoes a mass loss of 0.002 kg in a nuclear fission reactor?
[speed of light, $c = 2.998 \times 10^8$ m s^{-1}]

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

(11 × 6)

2. Define (i) *acceleration,* (ii) *potential energy*. (12)

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

Discuss the energy conversions that take place as an object falls from a height and strikes the ground. (6)

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

A basketball of mass 0.60 kg which was resting on a hoop falls to the ground 3.05 m below, as shown in **Figure 4**.
What is the maximum potential energy of the basketball? (9)

What is the maximum speed of the ball as it falls? (9)

The ball loses 6.15 joules of energy when it bounces off the ground for the first time.
Calculate the height of the first bounce. (6)
[acceleration due to gravity, g = 9.81 m s^{-2}]

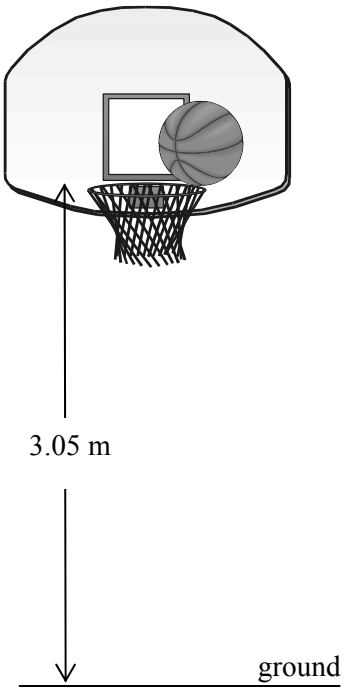

Figure 4

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

Give one difference between a real image and a virtual image. (6)

Draw ray diagrams to show the formation of (i) a real image, (ii) a virtual image, by a converging lens. (9)

In an experiment to measure the focal length of a converging lens a student first obtained an approximate value for the focal length. Then for a range of object distances u the corresponding real image distances v were measured.

The following data were recorded.

u/cm	15.0	25.0	35.5
v/cm	60.5	23.0	18.0

How did the student find an approximate value for the focal length of the lens?

Describe, with the aid of a labelled diagram, how the student found the position of an image. (15)

Using all the data, calculate the average value for the focal length of the lens. (15)

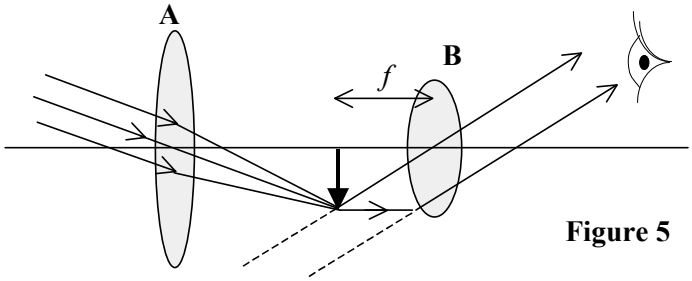

Figure 5

An astronomical telescope has two converging lenses **A** and **B** of focal lengths 120 and 10 cm, respectively, arranged as shown in **Figure 5**.

Name lens **B**.

How far from lens **A** is the first image of a distant object formed?

What is the location of the final image? (9)

4. (*a*) A thermometric property, two reference points and a scale are required to measure temperature. The reference points for the Celsius scale are the temperature of melting ice and the temperature of steam above boiling water. The lower reference point of the Kelvin temperature scale is absolute zero.

Explain the three underlined terms.

What is the upper reference point on the Kelvin scale? (21)

The mercury in a thermometer has a length of 60 mm in melting ice, 280 mm in steam above boiling water and 165 mm in the air of a sauna.

Calculate the sauna temperature in (i) degrees Celsius, (ii) kelvin. (12)

(*b*) Give two assumptions of the kinetic theory of gases. (6)

Outline an experiment in support of the kinetic theory. (9)

State one way in which a real gas differs from an ideal gas. (3)

A fixed mass of gas was sealed into a container as shown in **Figure 6**.
Use the kinetic theory of gases to explain why the pressure reading drops when the container is cooled. (6)

Describe the motion of the molecules of the gas as its temperature approaches absolute zero. (3)

Calculate the temperature of one mole of a gas when it occupies a volume of 2.24×10^{-3} m^3 at a pressure of 1.01×10^5 N m^{-2}. (6)
[Universal gas constant, R = 8.31 J K^{-1} mol^{-1}]

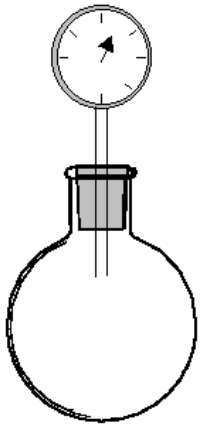

Figure 6

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

State *Ohm's law*. (6)

In an experiment to verify Ohm's law for a metallic conductor, a student measured the current I through the conductor for different values of the potential difference V across it. The temperature of the conductor was kept constant.

The following data were recorded.

V/V	1.00	2.00	3.00	4.00	5.00	6.00	7.00
I/A	0.10	0.19	0.28	0.39	0.46	0.55	0.66

Draw a diagram of a circuit used in this experiment. (9)

How was the circuit adjusted to supply different values of potential difference? (3)

Using the data, draw a suitable graph on graph paper to show the relationship between the potential difference and the current through the conductor.
Explain how your graph verifies Ohm's law for this conductor. (18)

Use your graph to calculate the resistance of the conductor. (9)

The conductor was used as the heating element for a fish tank. Calculate the heat produced when a current of 0.60 A flows for 30 minutes. Assume its resistance stays constant. (9)

What is the relationship between the rise in temperature of the water in the tank in a given period of time and the current flowing through the heating element? (6)

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

(*a*) State *the principle of conservation of momentum*. (9)

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

A child of mass 30 kg skating in a straight line on smooth horizontal ice collides with an adult of mass 60 kg skating in the opposite direction at 1.5 m s^{-1}. After the collision they both slide together at 0.5 m s^{-1} in the direction the child had been skating.

Calculate the speed of the child before the collision. (9)

(*b*) Explain the terms (i) *frequency*, (ii) *photon*. (12)

Give two properties of infrared radiation. (6)

How do the energies of an infrared photon and an ultraviolet photon differ? (3)

A remote control for a television transmits infrared radiation of frequency 1.5×10^{12} Hz.

Calculate

(i) the wavelength of the infrared radiation,

(ii) the energy of a photon of the infrared radiation. (12)

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

(*c*) State the *laws of electromagnetic induction*. (12)

Name a device based on electromagnetic induction. (3)

When a magnet is moved into a coil connected to a galvanometer **G**, as shown in **Figure 7**, the needle of the galvanometer deflects.

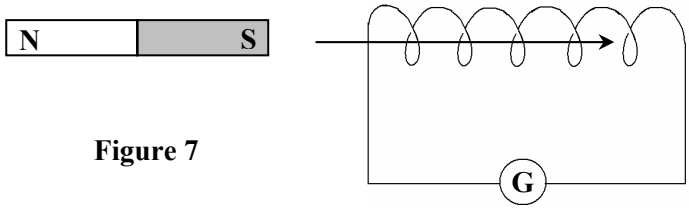

Figure 7

Give two ways of increasing the size of the deflection. (6)

What is observed when the magnet is moved out of the coil? (6)

What is observed when the magnet is stationary? Justify your answer. (6)

(*d*) Define *radioactivity*. (6)

What is meant by the *half-life* of a radioactive isotope? (6)

Radioisotopes are used in medicine.

Iodine–123 emits gamma radiation and is used in cancer treatment.
Give two properties of gamma radiation. (6)

Sodium–24 emits beta particles and is used as a tracer in medical tests.

Write a nuclear equation to represent the decay of a sodium–24 nucleus when it emits a beta particle.
(Refer to Mathematics Tables, p.44.) (6)

Sodium–24 has a half-life of 15 hours.
An injection of sodium–24 is prepared 45 hours before being used.
What fraction of the sodium–24 remains at the time of the injection? (6)

State one precaution medical personnel should take when using radioisotopes. (3)

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 colour do sodium salts give to a Bunsen burner flame?

(*b*) Explain the term *principal quantum number*.

(*c*) How many (i) electrons, (ii) neutrons, are there in $^{9}_{4}\mathbf{Be}$?

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

(*e*) What is a mole of a substance?

(*f*) What is the shape of (i) the $\mathbf{H_2O}$ molecule, (ii) the $\mathbf{CH_4}$ molecule?

(*g*) State two characteristic properties of transition metals.

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

(*i*) Define *heat of combustion*.

(j) Identify (i) the conjugate acid of $\mathbf{HSO_4}$ (ii) the conjugate base of **HF**.

(*k*) Calculate the pH of a 0.05 M solution of nitric acid.

(l) Name the piece of apparatus shown in **Figure 8**.

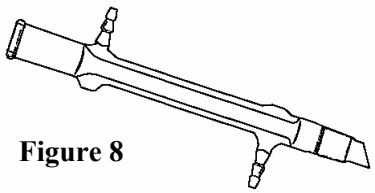

Figure 8

(*m*) Draw the structure of the functional group in an ester.

(*n*) Identify the compound formed when phenylhydrazine reacts with propanone (acetone).

(*o*) Name the aromatic compounds shown in **Figure 9**.

Figure 9

(11 × 6)

8. (*a*) What is an atomic orbital? (6)

Sketch the shape of (i) the *s* atomic orbital, (ii) the *p* atomic orbital.

Identify the species represented by each of the following electron configurations:

(i) $\mathbf{1}s^2\,\mathbf{2}s^2\,\mathbf{2}p^6\,\mathbf{3}s^2\,\mathbf{3}p^3$ (ii) $[\mathbf{1}s^2\ \mathbf{2}s^2\ \mathbf{2}p^6]^{2+}$ (12)

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

(*b*) Define *electronegativity*.

Give one reason for the general increase in electronegativity values from **Na** to **Cl** across the periodic table. (9)

Distinguish between ionic and covalent bonding.

What is meant by a polar covalent bond? (12)

Explain how electronegativity values are used to predict the type of bond in the compound formed between

(i) magnesium and chlorine;

(ii) hydrogen and phosphorus;

(iii) hydrogen and chlorine. (18)

Which one of these compounds would you expect to exist as a solid with a high melting point?

Which one of these compounds would you expect to be insoluble in water? Justify your answer. (9)

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

9. In a titration a student used a standard solution of sodium carbonate to determine the concentration of a solution of hydrochloric acid which is a strong acid.

(*a*) Explain the underlined terms. (12)

(*b*) The student was given exactly 2.65 g of anhydrous sodium carbonate on a clock glass. Describe the correct procedures for dissolving this solid and for making the solution up to exactly 500 cm^3 in a volumetric flask.

Calculate the molarity of this solution. (18)

(*c*) Name a suitable indicator for the titration. Justify your answer. (9)

(*d*) During the titration why did the student

(i) swirl the conical flask;

(ii) use deionised water to wash down the sides of the conical flask;

(iii) stand the conical flask on a white tile? (9)

(*e*) Write a balanced equation for the titration reaction. (6)

(*f*) An average of 22.3 cm^3 of the hydrochloric acid solution was required to neutralise 25.0 cm^3 portions of the sodium carbonate solution.

Calculate the concentration of the hydrochloric acid solution in

(i) moles per litre (dm^3), (ii) grams per litre (dm^3). (12)

[H = 1; C = 12; O = 16; Na = 23; Cl = 35.5]

10. (*a*) Define (i) oxidation, (ii) reduction, in terms of electron transfer.
Identify the substance oxidised in the following reaction:

$$\mathbf{Zn + CuSO_4 \rightarrow ZnSO_4 + Cu}$$

Explain why zinc is placed above copper in the electrochemical series. (15)

A zinc rod and a copper rod are placed in a solution of dilute sulfuric acid as shown in **Figure 10**. What happens when the rods are joined by a conducting wire? (6)

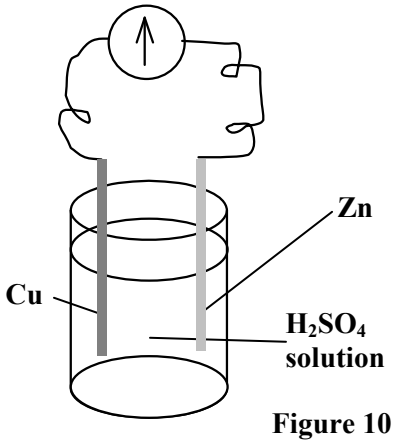

Figure 10

(*b*) State *Faraday's first law of electrolysis*. (6)
Give one application of electrolysis. (3)

Figure 11 shows an apparatus used in the electrolysis of acidified water using inert electrodes. Identify:
(i) a suitable material for the inert electrodes;
(ii) which electrode is the cathode;
(iii) the electrode at which reduction takes place;
(iv) the gas collected at **A**;
(v) the gas collected at **B**. (15)

Write a balanced equation for the reaction at the cathode. (6)

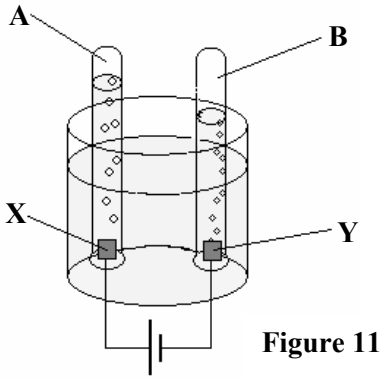

Figure 11

A current of 1.61 A was passed through acidified water for 12 minutes.
Calculate (i) the charge which flowed, (ii) the mass of gas released at **B**.
What volume would this mass of gas occupy at STP?
What volume of gas would be collected at **A** under the same conditions? (15)
[H = 1; O = 16; molar volume at STP = 22.4 litres (dm^3); 1 faraday = 96 500 C]

11. Define (i) *unsaturated compound*, (ii) *homologous series*. (12)
Study the reaction scheme in **Figure 12** and answer the following parts.

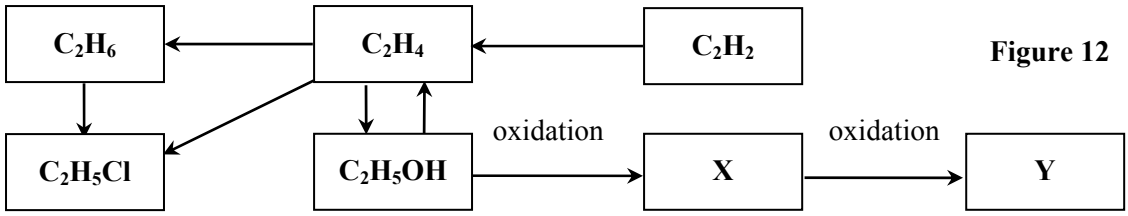

Figure 12

(*a*) Name and draw the structural formula of an unsaturated molecule in this scheme.
Which homologous series does this compound belong? (9)

(*b*) What type of reaction is $\mathbf{C_2H_6 \rightarrow C_2H_5Cl}$? What reagent is required for this conversion? (6)

(*c*) Calculate the percentage by mass of hydrogen in $\mathbf{C_2H_6}$.
$\mathbf{C_2H_6}$ is a good fuel.
Write a balanced equation for the combustion of $\mathbf{C_2H_6}$ in excess oxygen. (12)

(*d*) Describe, with the aid of a labelled diagram, how you would carry out the conversion:

$$\mathbf{C_2H_5OH \rightarrow C_2H_4}$$ (15)

(*e*) $\mathbf{C_2H_5OH}$ can be oxidised first to **X** and then to **Y** using the same two reagents in each conversion. **Y** is a carboxylic acid. Identify **X** and **Y** and the two reagents required. (12)
[H = 1; C = 12]

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

(*a*) Define (i) atomic number, (ii) mass number, (iii) relative atomic mass.

Naturally occurring chlorine consists of two isotopes: 75.50% $^{35}_{17}\mathbf{Cl}$ and 24.50% $^{37}_{17}\mathbf{Cl}$.

Calculate the relative atomic mass of chlorine correct to two decimal places.

(*b*) Define (i) base, (ii) conjugate acid-base pair, according to Brønsted-Lowry theory.

Identify the two bases in the following equilibrium reaction:

$$\mathbf{NH_3 + H_2O \rightleftharpoons NH_4^+ + OH^-}$$

Give one chemical property of a base.

(*c*) Magnesium burns in air with an intensely bright white flame according to the following equation:

$$\mathbf{2Mg + O_2 \rightarrow 2MgO}$$

Calculate

(i) the number of moles in 3.0 g of magnesium;

(ii) the mass of magnesium oxide formed when 3.0 g of magnesium is burned;

(iii) the number of molecules of oxygen required.

The magnesium oxide formed is dissolved in water. Is the solution acidic, basic or neutral?

[Mg = 24; O = 16; Avogadro constant = 6.0×10^{23} mol^{-1}]

(*d*) Define *heat of formation.*

Calculate the heat change for the addition reaction:

$$\mathbf{C_2H_{4\,(g)} + HBr_{(g)} \rightarrow C_2H_5Br_{(l)}}$$

using the following heats of formation.

$$\mathbf{2C_{(s)} + 2H_{2\,(g)} \rightarrow C_2H_{4\,(g)} \qquad \Delta H = 52.3\ kJ\ mol^{-1}}$$

$$\mathbf{\tfrac{1}{2}H_{2\,(g)} + \tfrac{1}{2}Br_{2\,(l)} \rightarrow HBr_{(g)} \qquad \Delta H = -36.3\ kJ\ mol^{-1}}$$

$$\mathbf{2C_{(s)} + 2\tfrac{1}{2}H_{2\,(g)} + \tfrac{1}{2}Br_{2\,(l)} \rightarrow C_2H_5Br_{(l)} \qquad \Delta H = -90.5\ kJ\ mol^{-1}}$$

Is this addition reaction exothermic or endothermic? Justify your answer.

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