Coimisiún na Scrúduithe Stáit
State Examinations Commission

LEAVING CERTIFICATE EXAMINATION 2009

PHYSICS AND CHEMISTRY – HIGHER LEVEL

MONDAY 15 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 *work.*

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

(*c*) Distinguish between a vector and a scalar.

(*d*) When an object is placed 3 cm in front of a concave mirror, a virtual image is formed 9 cm from the mirror as shown in **Figure 1**. What is the focal length of the mirror?

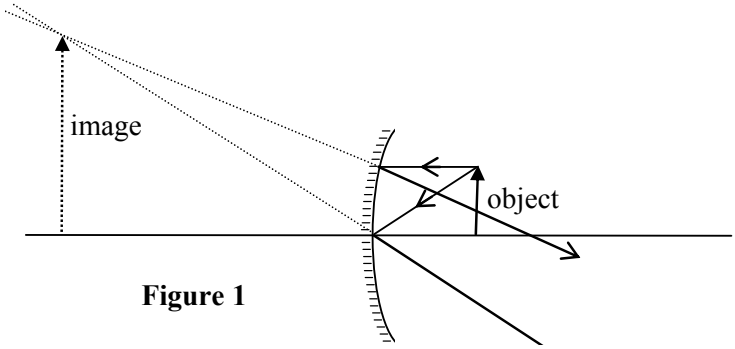

Figure 1

(*e*) Give one difference between a transverse wave and a longitudinal wave.

(*f*) Give two properties of infrared radiation.

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

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

(*i*) What is *Brownian movement*?

(*j*) *F* is the force between the two point charges. What is the force between the charges in terms of *F* when the distance between their centres is halved?

(*k*) State *Ohm's law*.

(*l*) What is *electromagnetic induction*?

(*m*) **Figure 2** shows a transformer that has 5 turns in the secondary coil and 200 turns in the primary coil. Calculate the output voltage when the primary coil is connected to the 230 V mains supply.

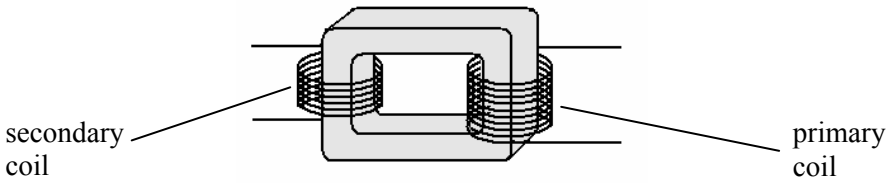

Figure 2

(*n*) Why do alpha particles have a shorter range in air than beta particles?

(*o*) A sample of radioactive iodine–131 had one sixteenth of its original activity after 32 days. What is the half-life of iodine–131?

(11 × 6)

2. Define acceleration. (6)

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

Derive the relationship *force = mass × acceleration* from Newton's second law. (9)

In an experiment to verify Newton's second law, a force F was applied to a trolley that moves over a smooth horizontal surface as shown in **Figure 3**. The acceleration a of the trolley was measured. This procedure was repeated a number of times for different values of the applied force, keeping the mass accelerated constant each time. The values of F and the corresponding vales of a are given in the table.

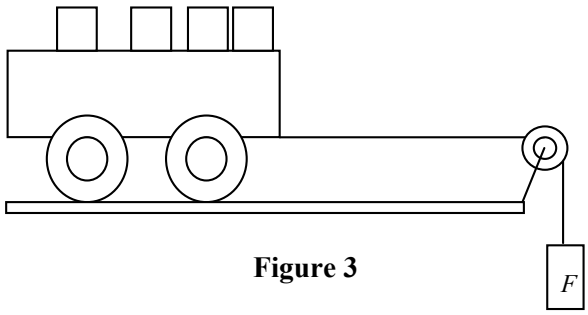

Figure 3

F/N	1.64	3.27	4.90	6.53	8.17	9.80	12.50
a/m s^{-2}	1.1	1.9	3.1	4.1	4.7	6.0	7.4

Describe how the acceleration of the trolley was measured. (9)

Draw a suitable graph on graph paper to show the relationship between the applied force F and the acceleration a. (12)

From your graph, determine the mass accelerated. (9)

Calculate how far the trolley would travel in 0.5 s, starting from rest, if the force applied is 5 N. (9)

The experiment was rearranged, this time applying a constant force to a series of different masses and measuring the corresponding accelerations. What relationship between mass and acceleration was established? (6)

3. What is refraction of light?

When does refraction **not** occur as a ray of light travels from one medium into another?

Define (i) *refractive index*, (ii) *critical angle*. (18)

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

Figure 4 shows a ray travelling from water to air from an underwater light source.

Calculate

(i) the refractive index of water;

(ii) the critical angle of water;

(iii) the speed of light as it travels through water. (18)

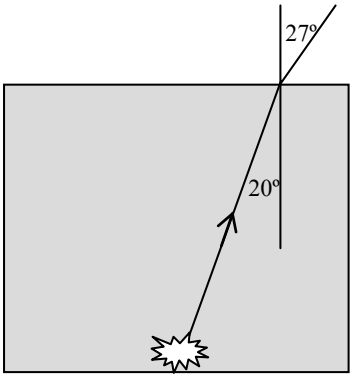

Figure 4

Draw a diagram to show what happens when a ray from the underwater light source strikes the water-air surface at an angle that exceeds the critical angle.

Name this phenomenon and give one application of it. (12)

[speed of light in air, $c = 3.00 \times 10^8$ m s^{-1}]

4. *Boyle's law* describes the relationship between the volume and the pressure of a fixed mass of gas at constant temperature. The *kinetic theory* of gases describes the behaviour of the molecules of an *ideal gas*.

(*a*) Describe, with the aid of a labelled diagram, an experiment to verify Boyle's law. (18)

(*b*) State two assumptions of the kinetic theory of gases.
What is an ideal gas?
How does an increase in temperature affect the behaviour of molecules in an ideal gas? (15)

(*c*) Explain how Boyle's law is consistent with the equation of state of an ideal gas, $PV = nRT$. (6)

(*d*) Each bubble of air released from an aerator placed at the bottom of a lake has a volume 1.2 cm^3 when it reaches the surface where the atmospheric pressure is 1.01×10^5 Pa. The temperature of the lake is 4 ºC throughout.
Calculate
(i) the pressure at the bottom of the lake if the bubbles expand to twice their original size as they rise through the water;
(ii) the number of moles of gas in each bubble of air. (18)

(*e*) Explain the term *thermometric property.*
Name the thermometer that uses the pressure of a fixed mass of gas as its thermometric property. (9)

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

5. Define (i) electric current, (ii) the *ampere*, the SI unit of electric current. (12)

Figure 5 shows a moving coil galvanometer.
Explain how it measures a small electric current. (9)

How is a moving coil galvanometer modified to measure larger currents? (6)

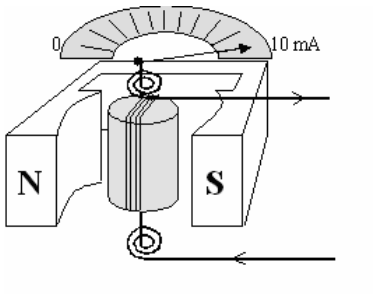

Figure 5

Describe an experiment to demonstrate the heating effect of an electric current. (12)

Why does an electricity supply company
(i) transmit electricity over long distances at high voltage;
(ii) use alternating current instead of direct current? (12)

A power station supplies electrical energy at a voltage of 10 kV and at a rate of 2 MW to a factory. The cables connecting the power station and the factory have a resistance of 9.5 Ω.

Calculate
(i) the current flowing in the cables;
(ii) the power 'lost' in the cables due to heating.

If the supply voltage is maintained at 10 kV, how can power losses in the cables be reduced? (15)

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

(*a*) Define *kinetic energy*. (6)

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

A cannon of mass 1000 kg containing a cannonball of mass 20 kg was at rest on a smooth horizontal surface as shown in **Figure 6**. The cannonball was fired with an initial horizontal velocity of 400 m s^{-1}.

Calculate

(i) the recoil velocity of the cannon;

(ii) the kinetic energy of the cannon as it recoils. (15)

Why does the cannon recoil? (6)

Figure 6

(*b*) Diffraction and interference occur when a narrow beam of monochromatic light passes though a pair of narrow slits, whose separation is 0.5 mm, and then strikes a screen 1.2 m away. A pattern of bright and dark images is formed on the screen as shown in **Figure 7**. The distance from the fifth bright image to the central bright image is 7.1 mm.

Explain the underlined terms. (15)

How does this experiment contribute to our understanding of the nature of light? (6)

Calculate the wavelength of the light. (12)

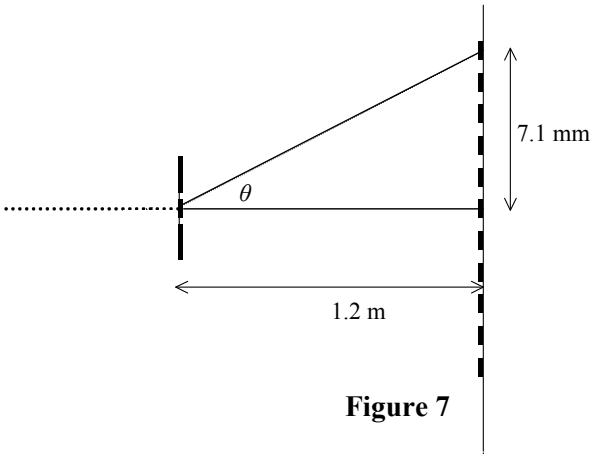

Figure 7

(*c*) Define *capacitance*. (6)

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

Figure 8 shows a 6 V battery connected to an arrangement of capacitors.

Calculate

(i) the effective capacitance of the circuit;

(ii) the charge stored in the circuit when the switch is closed. (12)

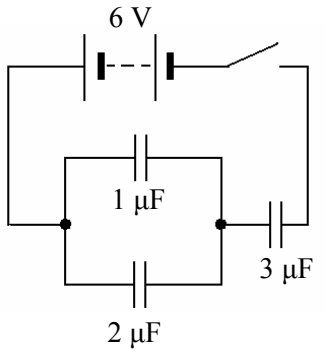

Figure 8

(*d*) Determine the value of *A*, the value of *Z* and the symbol of the element represented by **X** in the following nuclear fission reaction.

$$^{235}_{92}\mathbf{U} + {}^{1}_{0}\mathbf{n} \rightarrow {}^{A}_{Z}\mathbf{X} + {}^{90}_{36}\mathbf{Kr} + 2\,{}^{1}_{0}\mathbf{n} + \text{energy} \quad (9)$$

Explain

(i) why a large quantity of energy is released in this reaction;

(ii) why fission of uranium–235 may result in a chain reaction. (12)

Deuterium ${}^{2}_{1}\mathbf{H}$ is an isotopes of hydrogen. Write a balanced equation for the nuclear fusion reaction when two deuterium nuclei combine to produce a helium nucleus and energy.

Explain why fusion only occurs at extremely high temperatures. (12)

(Refer to Mathematics Tables, p. 44.)

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 isotopes?

(*b*) What do the terms E_2 and f represent in the relationship $E_2 - E_1 = hf$?

(*c*) Define *electronegativity*.

(*d*) What is the maximum number of electrons that can occupy (i) the third shell, (ii) the 3*p* subshell, of an atom?

(*e*) State the number of (i) neutrons, (ii) protons in the $^{27}_{13}Al^{3+}$ ion.

(*f*) What colour change is observed when chlorine gas is bubbled through a solution of sodium iodide as shown in **Figure 9**?

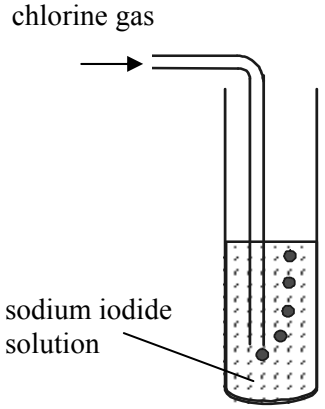

Figure 9

(*g*) Name a metallic element whose salts give a lilac colour to a Bunsen flame.

(*h*) Calculate the pH of a 0.2 M solution of sulfuric acid.

(*i*) Name two oxides that are involved in the formation of *acid rain*.

(*j*) Define the *heat of formation* of a compound.

(*k*) Explain why the molecule $\mathbf{NH_3}$ has a *dipole moment* while $\mathbf{BF_3}$ does not.

(*l*) **Figure 10** shows gigantic gypsum crystals discovered recently in a cave in Mexico. Calculate the percentage by mass of water of crystallisation in gypsum which has the chemical formula $\mathbf{CaSO_4\,2H_2O}$.
[H = 1; O = 16; S = 32; Ca = 40]

Figure 10

(*m*) **Figure 11** shows *Milk of Magnesia* tablets containing the active ingredient $\mathbf{Mg(OH)_2}$ being added to neutralise excess hydrochloric acid in the stomach. Write a balanced equation for this reaction.

(*n*) Name a reagent used to distinguish between an aldehyde and a ketone.

(*o*) Draw the structures of the two compounds that have the molecular formula $\mathbf{C_4H_{10}}$.

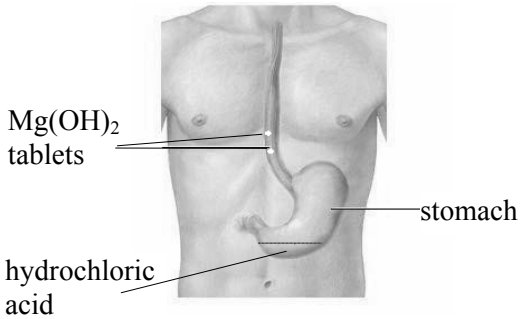

Figure 11

(11 × 6)

8. Explain the term *atomic orbital*. (6)

Write the electron configuration of (i) a carbon atom, (ii) an iron atom. (12)

(*a*) Diamond and graphite are crystalline solids of carbon.
Explain in terms of bonding why diamond and graphite differ
(i) in their hardness, (ii) in their ability to conduct electricity. (12)

(*b*) Iron is a transition metal.

How is a transition element identified from its electron configuration?
State **two** characteristic properties of transition metals. (9)

The metallic crystalline structure of iron is shown in **Figure 12**. Describe the bonding in a metallic crystal. (6)

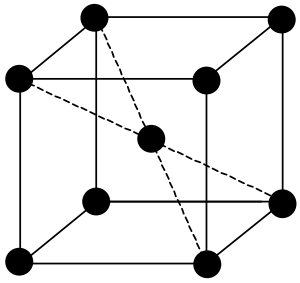

Figure 12

(*c*) What type of bond exists in a water molecule?
State the shape of a water molecule and explain, using the *electron pair repulsion theory*, how this shape arises. (15)

What forces hold the water molecules together in an ice crystal?
What type of crystal lattice is formed in ice? (6)
(Refer to the Mathematics Tables, p. 44, 46.)

9. Define (i) a strong acid, (ii) a conjugate pair, in terms of Brønsted-Lowry theory. (9)

State the conjugate base of the hydrogen sulfate ion $\mathbf{HSO_4^-}$ and the conjugate acid of ammonia $\mathbf{NH_3}$. (6)

Ammonium hydroxide is a solution of ammonia gas in water. To determine the concentration of an ammonium hydroxide solution, it was titrated against a standard solution of sulfuric acid. The balanced equation for the titration reaction is

$$\mathbf{2NH_4OH + H_2SO_4 \rightarrow (NH_4)_2SO_4 + 2H_2O}$$

One rough and two accurate titrations were carried out. On average 18.6 cm^3 of 0.12 M sulfuric acid solution was required to neutralise 20 cm^3 samples of the ammonium hydroxide solution.

(*a*) Describe how a burette was rinsed and then filled with the sulfuric acid solution. (12)

(*b*) Explain why methyl orange is a suitable indicator for this titration. What colour change is observed at the end point in this titration? (9)

(*c*) (i) Why are the sides of the conical flask washed down during a titration?
(ii) Why is deionised water used in washing down the sides of the conical flask?
(iii) Why is the conical flask placed on a white tile during the titration? (12)

(*d*) Calculate:
(i) the molarity of the ammonium hydroxide solution;
(ii) the concentration of the ammonium hydroxide solution in grams per litre (dm^3);
(iii) the mass of ammonia gas dissolved in 500 cm^3 of the solution. (18)

[H = 1; N = 14; O = 16]

10. Define in terms of electron transfer (i) oxidation, (ii) oxidising reagent. (6)

Write a balanced equation for the reaction that occurs between calcium and warm water.
Identify the substance oxidised and the oxidising reagent in this reaction. (12)

Place the following metals in order of **increasing** difficulty of oxidation.

zinc **calcium** **copper** **aluminium**

Which of these metals can be found free in nature?
Why is iron resistant to corrosion when it is galvanised with zinc? (15)

Describe what is observed when

(i) aluminium is placed in copper(II) sulfate solution
(ii) when copper is placed in dilute sulfuric acid. (9)

When 1.27 g of copper is added to excess concentrated sulfuric acid, the copper is oxidised.
The balanced equation for the reaction is:

$$\mathbf{Cu + 2H_2SO_4 \rightarrow CuSO_4 + SO_2 + 2H_2O}$$

Calculate

(i) the number of moles of copper oxidised;
(ii) the mass of copper(II) sulfate produced;
(iii) the volume of sulfur dioxide gas produced at STP;
(iv) the number of molecules of water formed. (24)

[O = 16; S = 32; Cu = 63.5; Avogadro constant = 6.0×10^{23} mol^{-1}; molar volume at STP = 22.4 litres (dm^3)]

11. Define (i) *unsaturated compound*, (ii) *functional group*. (9)

Answer the questions below with reference to compounds **X**, **Y**, **Z** and **W** in the reaction scheme shown in **Figure 13**.

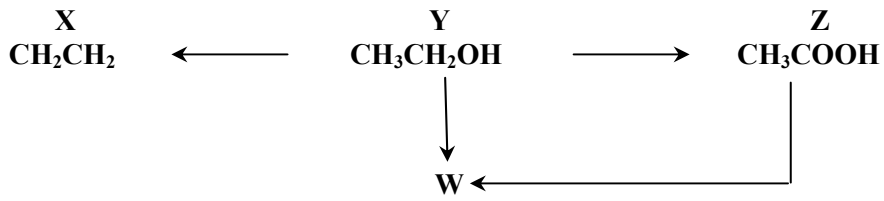

Figure 13

(*a*) Name the compounds **X**, **Y** and **Z**. (9)

(*b*) Name the homologous series to which compound **Z** belongs. (3)

(*c*) Explain why compound **Y** and compound **Z** are soluble in water. (6)

(*d*) Name the inorganic reagent used in the conversion of compound **Y** to compound **X**. (3)

(*e*) What is observed when compound **X** is bubbled through acidified potassium permanganate?
What type of reaction occurs?
Write a balanced equation for the reaction that occurs when bromine is added to **X**. (15)

(*f*) What type of reaction is involved in the conversion of compound **Y** to compound **Z**?
Identify the reagents required for this conversion. (9)

(*g*) Compounds **Y** and **Z** react together in the presence of sulfuric acid to form the ester **W**.
Name the ester **W**.
Draw the structure of the ester functional group. (12)

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

(*a*) **Figure 14** shows molten zinc chloride being electrolysed using inert electrodes.

(i) Name a suitable material for the electrodes.

(ii) Identify electrode **X**.

(iii) Write a balanced equation for the cathode reaction.

(iv) Calculate the mass of zinc deposited when a current of 0.50 A flows for 15 minutes through the molten zinc chloride.
[Zn = 65; 1 faraday = 96 500 C]

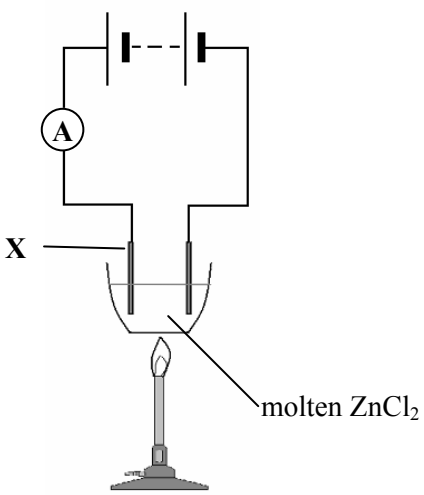

Figure 14

(*b*) Distinguish between an *aliphatic* and an *aromatic* organic compound

Draw the structure of the benzene molecule and describe its bonding.

Name the reagent and the catalyst used in the mono-bromination of benzene.

What type of reaction is the bromination of benzene?

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

What is the general trend in ionisation energy values across the second period of the Periodic Table?

Explain why beryllium has a high first ionisation energy value compared to the other elements in the second period.

Why is the second ionisation energy of an element always greater than the first?

The first, second and third ionisation energy values of beryllium, are 900 kJ mol^{-1}, 1760 kJ $mol^{-1}$and 14,800 kJ mol^{-1} respectively.

Explain the large increase between the second and third ionisation energy values of beryllium.

(Refer to the Mathematics Tables, p. 44, 45.)

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

State *Hess's law.*

At high temperatures, methane is converted to ethyne according to the equation:

$$\mathbf{2CH_{4\,(g)} \rightarrow C_2H_{2\,(g)} + 3H_{2\,(g)}}$$

Calculate the heat change for this reaction using the following heats of combustion:

$$\mathbf{CH_{4\,(g)} + 2O_{2\,(g)} \rightarrow CO_{2\,(g)} + 2H_2O_{(l)} \quad \Delta H = -891\ kJ\ mol^{-1}}$$

$$\mathbf{C_2H_{2\,(g)} + 2½O_{2\,(g)} \rightarrow 2CO_{2\,(g)} + H_2O_{(l)} \quad \Delta H = -1301\ kJ\ mol^{-1}}$$

$$\mathbf{H_{2\,(g)} + ½O_{2\,(g)} \rightarrow H_2O_{(l)} \quad \Delta H = -286\ kJ\ mol^{-1}}$$

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