Coimisiún na Scrúduithe Stáit
State Examinations Commission

LEAVING CERTIFICATE EXAMINATION, 2015

PHYSICS AND CHEMISTRY – ORDINARY 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.

N.B. Relevant data are listed in the *Formulae and Tables* booklet, which is available from the superintendent.

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*) **Figure 1** shows the greater roadrunner bird which can run at a speed of 8 m s^{-1}.
How far could it travel in 9 seconds at this speed?

Figure 1

(*b*) In the equation $g = \frac{GM}{d^2}$ what does *G* represent?

(*c*) Calculate the work done when a person of mass 70 kg climbs 3 m vertically up a rope ladder.
[acceleration due to gravity, g = 9.8 m s^{-2}]

(*d*) **Figure 2** shows a ray of light passing through a glass block.
Name the phenomenon occurring at **X**.

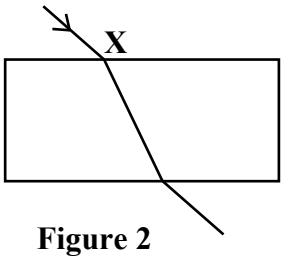

Figure 2

(*e*) What term is used to describe what happens when white light is split into its component colours?

(*f*) What type of lens is used in a magnifying glass as shown in **Figure 3**?

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

(*h*) Ice melts at 0 ºC. What is this temperature on the Kelvin scale?

Figure 3

(*i*) Sketch the magnetic field lines around a bar magnet.

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

(*k*) An energy efficient lamp with a rating of 11.5 W is connected to a 230 V supply.
Calculate the current drawn by the lamp**.**

(*l*) What is the purpose of an electrical transformer?

(*m*) A computer monitor rated at 25 W is used for eight hours per day.
Calculate the number of units (kW h) it uses daily.

(*n*) Why is the element lead (**Pb**) used when dealing with radioactive substances?

(*o*) What happens to a nucleus of an atom during nuclear fission?

(11 × 6)

2. Define (*i*) *mass*, (*ii*) *acceleration*.
Give the SI unit of force. (15)

Copy and complete the following statement of Newton's first law of motion:

"An object remains at . . . . . or at a . . . . . velocity unless there is a resultant . . . . . acting on it." (9)

What is meant by the *kinetic energy* of an object?
List the **two** quantities that determine the kinetic energy of an object. (12)

Figure 4 shows a remote-controlled toy car and an electric car. The mass of the toy car is 650 g and the mass of the electric car is 1500 kg.

Figure 4

Convert the mass of the toy car to kilograms (kg). (6)

The toy car starts from rest and takes 12 s to reach its top speed of 0.75 m s^{-1}.

Calculate

(*iii*) the acceleration of the toy car

(*iv*) the net force produced by the toy car during the acceleration

(*v*) the kinetic energy of the toy car at its top speed.

Why would a greater force be needed to change the speed of the other car by the same amount in the same time? (24)

3. When light strikes a shiny surface it reflects.
State the *laws of reflection of light*. (12)

A shoe shop uses plane mirrors to allow customers to look at shoes while trying them on.
Copy and complete **Figure 5** to show how an image of object **O** is formed by a plane mirror. (12)

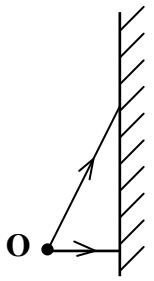

Figure 5

Curved mirrors are also used in shops.
Give **one** use for a curved mirror in a shop and explain why it is used instead of a plane mirror. (12)

Figure 6 shows a pin placed 6 cm in front of a concave mirror of focal length 3 cm.
Copy and complete the diagram to show the formation of the image of the pin.

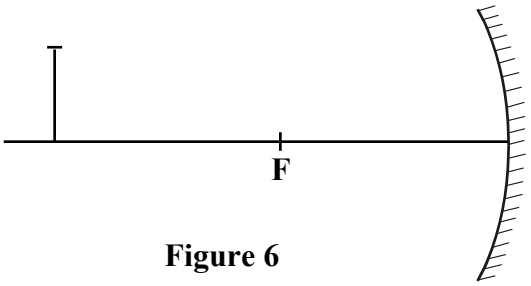

Figure 6

How far from the concave mirror is the image of the pin located? (18)

A concave mirror can form *real* and *virtual* images.
What is meant by a virtual image?
Where must an object be placed in front of a concave mirror to form a virtual image? (12)

4. (*a*) The *kinetic theory* can be used to describe the motion of molecules in a gas.
Give **two** assumptions of the kinetic theory of gases. (9)
Brownian motion provides evidence for the kinetic theory of gases.
What is Brownian motion?
How can Brownian motion be demonstrated? (18)

(*b*) A thermometer is based on a thermometric property.
Explain the underlined term.

Figure 7

Name a liquid used in thermometers. (12)

A student calibrated the unmarked thermometer shown in **Figure 7** by recording the length of the liquid inside the thermometer (*i*) in melting ice, (*ii*) in steam.

length of liquid in melting ice = 4.2 cm
length of liquid in steam = 26.7 cm

State the temperature difference (in ºC) between melting ice and steam.
Find the change in liquid levels corresponding to this temperature difference. (12)
Calculate the change in length of the liquid for every 1 ºC change in temperature.
Calculate the change in length of the liquid for a change in temperature of 18 ºC.
What would the *actual* length of the liquid be when the temperature is 18 ºC? (15)

5. (*a*) The following terms are used in stating *Coulomb's law*.

inversely	**two**	**product**	**square**	**directly**

Copy and complete the statement of Coulomb's law inserting the above terms.

"The force between . . . . . charged particles is . . . . . proportional to the . . . . . of the charges and is . . . . . proportional to the . . . . . of the distance between the charges." (15)

The force between charged particles can be attractive or repulsive.
State the necessary condition for the force to be attractive. (6)

Figure 8 shows a positively-charged electroscope.
What happens to the leaf when a positively-charged rod is brought near to its cap?
Explain how to discharge an electroscope. (12)

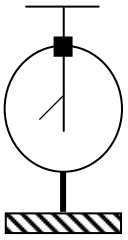

Figure 8

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

Figure 9 shows a parallel-plate capacitor, **C**, connected to a battery.

Copy the diagram to show the charges on the plates of the capacitor.

Sketch a diagram to show how two capacitors can be connected in parallel to a battery. (15)

Calculate the effective capacitance of two 5 μF capacitors connected (*i*) in series and (*ii*) in parallel. (12)

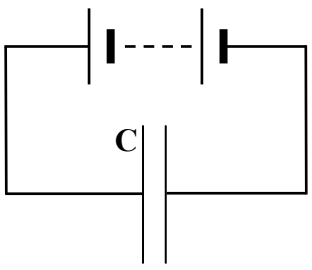

Figure 9

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

(*a*) Define *momentum*. (6)

Figure 10 shows two cans of mass 0.5 kg sliding in the same direction along a smooth worktop. Can **A** is moving at 0.6 m s^{-1} and can **B** at 0.4 m s^{-1} before they collide. After the collision can **A** continues to move in the same direction at 0.3 m s^{-1}.

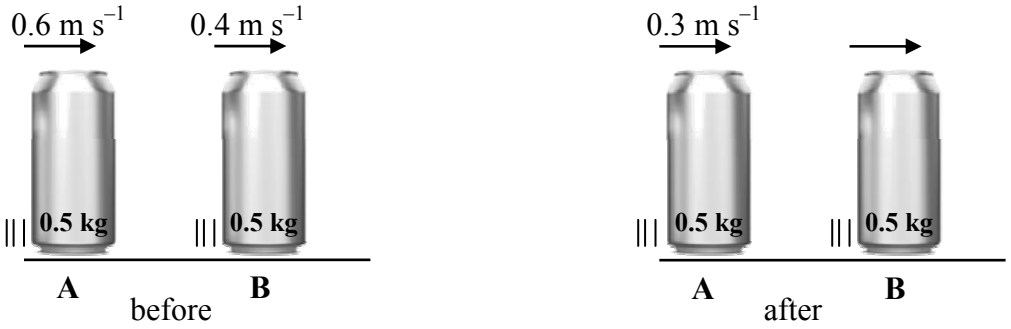

Figure 10

Calculate

(*i*) the initial momentum of can **A**

(*ii*) the initial momentum of can **B**

(*iii*) the total initial momentum

(*iv*) the final momentum of can **B**

(*v*) the final velocity of can **B**. (27)

(*b*) **Figure 11** shows a wavefront of monochromatic light approaching a single narrow slit.

Explain the underlined term.
Identify **one** source of monochromatic light. (12)

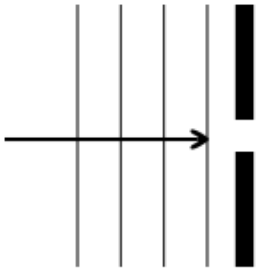

Figure 11

Copy the diagram and show the path of the wavefront after passing through the slit. (9)

Figure 12 shows the light pattern which forms on a screen if the single slit is replaced by a pair of narrow slits.

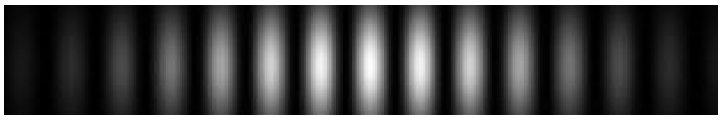

Figure 12

Give the names of the **two** phenomena which lead to the formation of this pattern. (12)

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

Figure 13 shows a circuit with two lamps in series with a battery.

Lamp **A** has a resistance of 3 Ω and lamp **B** has a resistance of 6 Ω.

The current in the circuit is 0.4 A.

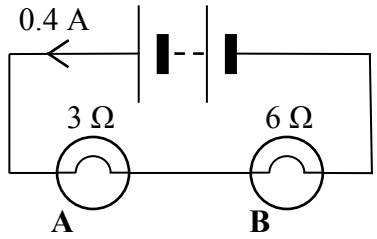

Figure 13

Calculate

(*i*) the effective resistance of the two resistors

(*ii*) the voltage (potential difference) across the battery. (15)

Which lamp will glow brighter? Give a reason for your answer. (12)

(*d*) Radon–222 is a radioactive isotope. It has a half–life of 4 days and it emits alpha–particles.
Explain the underlined terms. (12)

What property of an alpha–particle causes it to be deflected when it enters a magnetic field?
What fraction of a given sample of radon–222 remains after 8 days? (12)

Alpha–particles are one type of nuclear radiation.
List **two** other types of nuclear radiation. (9)

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*) **Figure 14** shows objects made of two different forms of the element carbon (**C**). What term is used to describe different physical forms of the same element?

Figure 14

(*b*) Sketch an *s* orbital.

(*c*) Why is the element helium (**He**) very unreactive?

(*d*) Why is a catalyst sometimes used in chemical reactions?

(*e*) Define *electronegativity*.

(*f*) Copy and complete the following statement about Bohr's atomic theory.
'When an electron in an excited state in an atom falls to a lower energy level it emits . . . . . .'

(*g*) Name the gas detected if it causes a chemical reaction with limewater as shown in **Figure 15**.

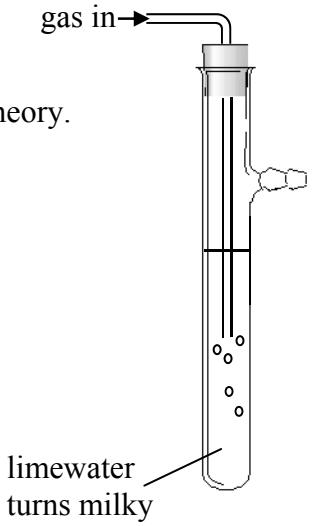

Figure 15

(*h*) Which one of the following oxides is amphoteric?

Na_2O **CO_2** **Al_2O_3**

(*i*) Copy, complete and balance the following equation.

____ + **H_2O** → **NaOH** + ____

(*j*) Calculate the **pH** of a **0.04 M** solution of nitric acid (**HNO_3**).

(*k*) Name the process used to decompose liquids using an electric current.

(*l*) A silica gel (**SiO_2**) sachet, as shown in **Figure 16**, is used to absorb moisture.
Calculate the percentage by mass of silicon in **SiO_2**.
[O = 16; Si = 28]

Figure 16

(*m*) Name the carboxylic acid found in vinegar.

(*n*) Sketch the structural formula of ethanol (**C_2H_5OH**).

(*o*) The relative molecular mass of ethyne is 26.
Calculate the number of molecules in 13 g of ethyne.
[Avogadro constant = 6.0×10^{23} mol^{-1}]

(11×6)

8. In the periodic table the elements are arranged in order of increasing atomic number. Lithium is the first metallic element and its ions are used in batteries to power mobile electronic devices.

Define the underlined terms. (18)

A sample of lithium consists of a mixture of two isotopes, $^{6}_{3}$**Li** and $^{7}_{3}$**Li**.

Copy and complete the table below, filling in the missing numbers. (18)

isotope	atomic number	number of neutrons	mass number
$^{6}_{3}$**Li**			
$^{7}_{3}$**Li**			

The relative atomic mass of lithium is 6.941.
Which of its two isotopes, $^{6}_{3}$**Li** or $^{7}_{3}$**Li**, exists in greater abundance?
Give a reason for your answer. (6)

What is the electron configuration of a lithium atom?
Why do $^{6}_{3}$**Li** and $^{7}_{3}$**Li** have the same electron configuration? (12)

Lithium forms an ionic bond with chlorine.
In the compound lithium chloride (**LiCl**), state the charge on

(*i*) each lithium ion

(*ii*) each chloride ion.

Give **one** property common to ionic compounds. (12)

9. (*a*) In terms of electrons, explain why oxidation and reduction always occur together. (12)

Figure 17 shows a strip of magnesium ribbon placed in a solution of copper ions.

Figure 17

The following reaction occurs:

$$\mathbf{Mg + Cu^{2+} \rightarrow Mg^{2+} + Cu}$$

State which species is (*i*) oxidised, (*ii*) reduced. (9)

Would copper metal react if placed in a solution of magnesium ions ($\mathbf{Mg^{2+}}$)? (6)

Which metal, magnesium or copper, is more easily oxidised? (6)

(*b*) Define an acid in terms of the Brønsted-Lowry theory. (6)

Identify **two** acids in the following reaction.

$$\mathbf{HCl + H_2O \rightleftharpoons H_3O^{+} + Cl^{-}}$$ (12)

On the label of a bottle of Irish mineral water is stated 'pH = 7.2 at source'.
Is this water source *acidic* or *basic*? Give a reason for your answer. (6)

'Sparkling water' is manufactured by adding carbon dioxide gas under high pressure to 'still water'.

Will the addition of carbon dioxide gas *increase* or *decrease* the pH of the water?
Give a reason for your answer. (9)

10. Titrations are often used in chemistry to find the concentrations of solutions.
An acid-base titration was carried out to find the concentration of a solution of potassium hydroxide (**KOH**) by neutralising it with a standard solution of hydrochloric acid (**HCl**). It was found that on average 18.6 cm^3 of a 0.15 M solution of hydrochloric acid was required to neutralise 20.0 cm^3 of the potassium hydroxide solution.

(*a*) Name and draw a diagram of the piece of apparatus used in the titration to measure
(*i*) the volume of the potassium hydroxide solution
(*ii*) the volume of the hydrochloric acid solution. (12)

(*b*) What is the correct procedure for rinsing a conical flask before use in a titration? (6)

(*c*) Describe how the volume of hydrochloric acid required for neutralisation was found.
State **two** precautions that should be taken to ensure an accurate result. (24)

(*d*) Copy and complete the following equation for the titration reaction.

$$\mathbf{HCl + KOH \rightarrow \_\_\_\_ + \_\_\_\_} \quad (9)$$

(*e*) Calculate the concentration of the potassium hydroxide solution. (9)

(*f*) What safety equipment is worn while carrying out a titration? (6)

11. Biogas digesters that use bacteria to break down organic wastes from animal slurry are shown in the background in **Figure 18**. Biogas digesters produce the hydrocarbon gas methane ($\mathbf{CH_4}$) which is then used as a fuel.

Figure 18

Why is methane classified as a hydrocarbon?
Give **one** other major source of methane gas. (12)

Methane is the first member of the homologous series of alkanes.
Explain the underlined term. (6)
Give the names of **two** other members of the alkane homologous series. (12)
What is the structural difference between the members of the *alkane* homologous series and the members of the *alkene* homologous series? (6)

Benzene ($\mathbf{C_6H_6}$) is another hydrocarbon.
Why is benzene **not** classified as an alkane nor an alkene? (6)

Methane burns in oxygen according to the following equation.

$$\mathbf{CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O} \qquad \Delta H = \mathbf{-890\ kJ\ mol^{-1}}$$

How does the information given above indicate that burning methane *releases* heat energy?
What term is used to describe reactions that release heat energy? (12)
Calculate
(*i*) the quantity of heat energy released when 6 moles of methane are burned
(*ii*) the number of moles of methane needed to produce 13,350 kJ of heat energy. (12)

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

(*a*) **Figure 19** shows the International Space Station (ISS).
The ISS uses lithium hydroxide (**LiOH**) to absorb the carbon dioxide breathed out by those on board.
The equation for the reaction is as follows.

Figure 19

$$2LiOH + CO_2 \rightarrow Li_2CO_3 + H_2O$$

Give **two** physical properties of carbon dioxide gas.
Why must carbon dioxide gas be removed from the atmosphere inside the ISS? (18)

When 96 g of lithium hydroxide react completely with carbon dioxide, calculate
(*i*) the number of moles of lithium hydroxide used
(*ii*) the mass of lithium carbonate produced. (15)
[H = 1; Li = 7; C = 12; O = 16]

(*b*) **Figure 20** shows an arrangement that was set up in a fume cupboard to prepare, collect and test a small sample of dry sulfur dioxide (SO_2) gas.

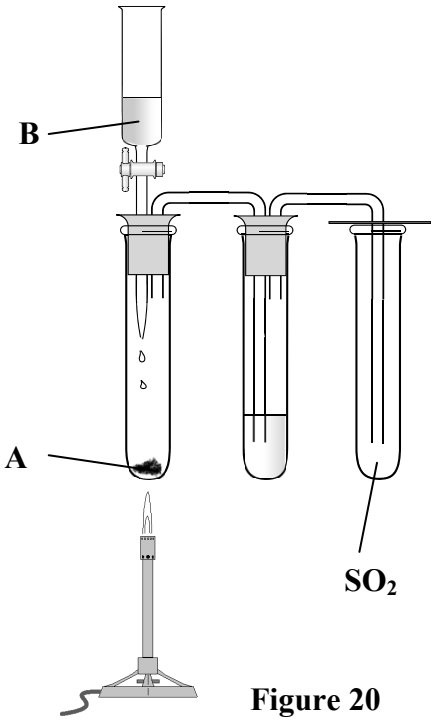

Figure 20

Name the (*i*) solid **A**, (*ii*) liquid **B**. (12)
Why is the gas collected by the upward displacement of air?
What would happen to moist blue litmus paper in the presence of sulfur dioxide gas? (12)
Give **one** industrial use for sulfur dioxide gas.
Why should this preparation *only* be carried out in a fume cupboard? (9)

(*c*) Consider the descriptions in the table below.

A	group of atoms chemically combined together
B	the type of bond where electrons are shared between atoms
C	the subatomic particle with a negative charge
D	the type of attraction *between* water molecules
E	located in the nucleus of an atom
F	a group of electrons not involved in bonding
G	the shape of the methane (CH_4) molecule

In your answerbook match each term below with its corresponding description (**A** to **G**).

proton	**tetrahedral**	**lone pair**
covalent	**molecule**	**electron**
hydrogen bonding		(24)

Sketch a diagram to show the arrangement of atoms in a molecule of methane (CH_4). (9)

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