



Coimisiún na Scrúduithe Stáit State Examinations Commission

LEAVING CERTIFICATE EXAMINATION, 2023

PHYSICS AND CHEMISTRY – ORDINARY LEVEL

WEDNESDAY, 21 JUNE – MORNING, 9:30 to 12:30

Six questions to be answered.

Answer at least **two** questions from Section I, at least **two** questions from Section II and **any two other** questions.

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.

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SECTION I – PHYSICS

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 a tennis ball. During a game a tennis ball was served by a player at 140 km per hour. What was the speed of the ball in m s^{-1} ?
- (b) A table is pushed 2.5 m along a floor by a force of 20 newtons. Calculate the work done.
- (c) In **Figure 2**, what is the displacement of point A from point B?
- (d) State Newton's third law of motion.
- (e) What is the thermometric property associated with a liquid-in-glass thermometer?
- (f) A room thermostat is set at 19°C . What is this temperature on the Kelvin scale?
- (g) How could you demonstrate dispersion of white light?
- (h) What term describes what happens when two waves with the same wavelength meet?
- (i) **Figure 3** shows light passing through a glass lens. What type of lens is shown?
- (j) Light from a laser is described as monochromatic. Explain the underlined term.
- (k) Give an example of a longitudinal wave.
- (l) Define capacitance.
- (m) Sketch a diagram to show two capacitors connected in parallel.
- (n) **Figure 4** shows a 150 kW electric vehicle high power charge point. How long will it take this charger to deliver 75 kilowatt hours of energy?
- (o) What is the purpose of a fuse in a three-pin plug?
- (p) Copy and complete the following statement:
"A wire carrying a in a magnetic field experiences a"
- (q) Taking the charge of an electron as -1 , what is the charge of an alpha particle?
- (r) What type of nuclear reaction produces heat energy in the core of the sun?



Figure 1

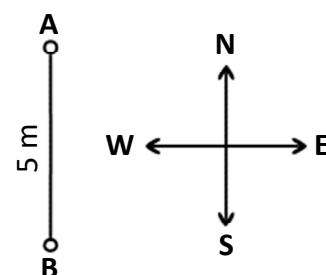


Figure 2

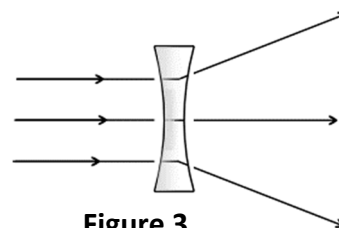


Figure 3



Figure 4

(11 × 6)

2. (a) Define (i) mass, (ii) force.
 (iii) State the S.I. unit of mass. (18)
- (b) **Figure 5** shows a tractor ploughing in a field. The velocity of the tractor increased steadily from zero to 6 m s^{-1} in 8 s. Calculate
- the acceleration of the tractor
 - the distance travelled by the tractor in the 8 seconds.



Figure 5

A force of 5,025 N applied by the tractor engine caused this acceleration. Calculate

- the mass of the tractor
 - the kinetic energy of the tractor when its speed was 6 m s^{-1} . (27)
- (c) (i) Draw a diagram of an arrangement of apparatus, e.g. pendulum, free-fall method, etc, you could use in an experiment to measure the acceleration due to gravity, g .
 (ii) What two measurements are taken in the experiment?
 (iii) How is a value for g obtained from these measurements?
 (iv) Give one precaution to ensure an accurate result. (21)

3. (a) **Figure 6** shows a mirror ball made of small plane mirrors attached to a spherical structure which rotates while illuminated with a beam of light.



Figure 6

- Explain the underlined term.
 Light is reflected by the mirror ball.
- State the laws of reflection of light.
- Draw a labelled diagram of one of the small plane mirrors from the mirror ball showing a ray of light striking it at an angle of incidence i and being reflected.
- State the value of the angle of reflection when a ray strikes a plane mirror at an angle of incidence of 65° . (30)

- (b) A concave mirror is one type of curved mirror.

- (i) Name another type of curved mirror.

Figure 7 shows a pin at a distance of 12 cm from a concave mirror of focal length 6 cm.

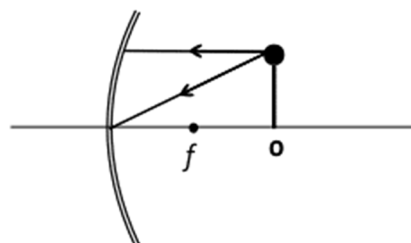


Figure 7

- Copy and complete the diagram to show how the two rays are reflected by the mirror and form an image of the head of the pin.
- Explain the term *real image*.

Consider the images of two identical pins, one placed 12 cm in front of a plane mirror, and the other placed 12 cm in front of a concave mirror of focal length 6 cm. State

- one similarity
- one difference, between the two images. (36)

4. (a) The kinetic theory of gases makes a number of assumptions about the behaviour of the particles of a gas.
- State **two** of these assumptions.
 - Name the scientist who first described molecular agitation based on his observation of the behaviour of pollen grains in water.
 - Which property of a gas, temperature or pressure or volume, is determined by the average kinetic energy of the particles?
 - The following words are used in the statement of Charles' law of gases:
proportional volume temperature pressure
 Using these words, copy and complete Charles' law:
 "The of a fixed mass of gas is to the absolute at constant" .

(36)

- (b) The data in the table below were recorded in an experiment to investigate Charles' law for a fixed mass of a gas.

Volume (cm ³)	75	150	225	300	375	450
Temperature (K)	50	100	150	200	250	300

- Draw a graph on graph paper of volume (y-axis) *versus* temperature (x-axis).
- Does your graph verify Charles' law? Justify your answer.
- Use your graph to estimate the volume of the gas sample at 80 K.
- No experimental data could be obtained for the gas at a temperature of 0 K. Suggest a reason for this.

(30)

5. (a) Heating is one effect of an electrical current in a circuit.
Figure 8 shows a problem caused by excessive heating in an electrical circuit.



Figure 8

- State **two** other effects of a current in a circuit.
- Distinguish between *direct* and *alternating* current.
 Identify the type of current, direct or alternating, supplied
 (iii) by a battery, (iv) by a mains electricity socket.

(30)

- (b) (i) What term describes the arrangement of the two resistors in the circuit shown in **Figure 9**?

Calculate

- the effective resistance of this combination of resistors
- the current in the circuit
- the voltage (potential difference) across the 100 Ω resistor.

(24)

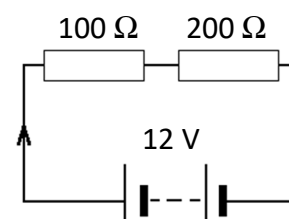


Figure 9

- (c) The car headlamp bulb shown in **Figure 10** has a power rating of 55 W.

- What is the current when the bulb is connected to a 12 V supply?
- What could happen if the current in the filament of the bulb were to exceed this value?

(12)



Figure 10

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

- (a) (i) What is meant by the *momentum* of an object?
(ii) Give the S.I. unit for momentum.

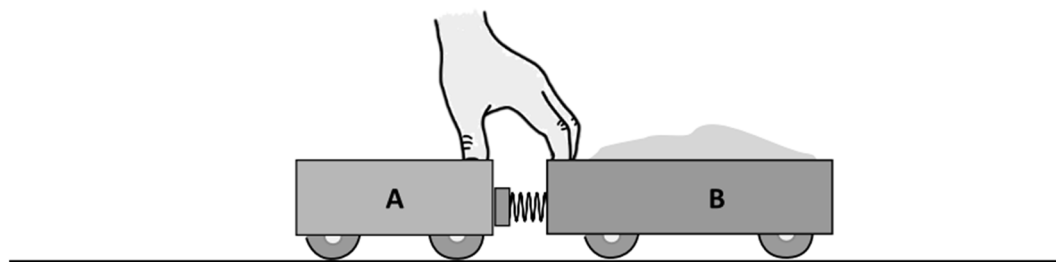


Figure 11a

Figure 11a above shows a trolley **A** held against spring-loaded trolley **B** on a smooth level bench. Both trolleys were initially at rest. Trolley **A** had a mass of 1.5 kg and spring-loaded trolley **B** had a mass of 3.0 kg.

When the spring was released, trolley **A** moved to the left at a speed of 2.8 m s^{-1} while trolley **B** and its spring moved to the right at a speed of 1.4 m s^{-1} , as shown in **Figure 11b** below.



Figure 11b

- (iii) What was the total momentum of the trolleys before the spring was released?
(iv) Calculate the momentum of trolley **A** *after* the spring was released.
(v) Use the figures given above to determine whether the principle of conservation of momentum applied. (33)

(b) **Figure 12** shows the main parts of a transformer.

- (i) What is the purpose of a transformer?
(ii) Give an example of a device in the home which uses a transformer.
(iii) Identify the parts labelled **A**, **B** and **C**.

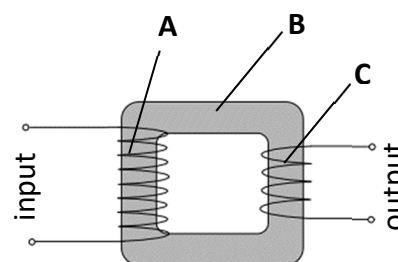


Figure 12

A has 9,800 turns and is connected to a 1,000 V supply.

- (iv) How many turns has **C** when the output voltage is 230 V?

Transformers are used in the supply of electrical power from a generating station to individual households and businesses in a distant town.

- (v) Why are high voltages used to transmit electrical power over long distances? (33)

- (c) During the radioactive decay of a sodium-24 nucleus one beta particle and two gamma rays are emitted.
- Define radioactivity.
- Which type of radiation from the decay of sodium-24
- is blocked by 5 mm of aluminium,
 - is unaffected by a magnetic field?
- The half-life of sodium-24 is 15 hours.
- Explain the underlined term.
 - What fraction of a given sample of sodium-24 remains after 45 hours? (33)

- (d) Five radiations that are part of the electromagnetic spectrum are listed in order of increasing wavelength as follows:

x-rays radiation A visible light radiation B microwaves

- Draw a diagram to explain the term *wavelength*.
- Give one property common to all radiations of the electromagnetic spectrum.

The photoelectric effect was demonstrated using the arrangement shown in **Figure 13**.

The results of the demonstration are given in the table below:

Electromagnetic radiation	Photoelectric effect
x-rays	occurs
radiation A	occurs
visible light	does not occur
radiation B	does not occur
microwaves	does not occur

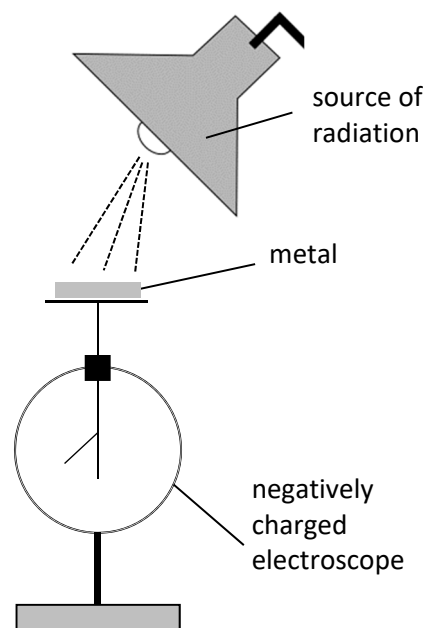


Figure 13

- Which subatomic particle is emitted during the photoelectric effect?
- What is observed in this demonstration when the photoelectric effect occurs?
- Identify radiation A and radiation B. (33)

SECTION II – CHEMISTRY

7. Answer **eleven** of the following items (a), (b), (c), etc. All the items carry equal marks.
Keep your answers short.

- (a) Identify **two** other elements from the same group in the periodic table as argon (**Ar**).
- (b) Define electronegativity.
- (c) **Figure 14** represents an *s*-orbital.
What is the maximum number of electrons in an *s*-orbital?
- (d) What type of bonding is present in the crystalline lattice structure of sodium chloride (**NaCl**)?
- (e) What type of bond exists *between* the molecules in water?
- (f) What property of a molecule does the *electron pair repulsion theory* predict?
- (g) Identify **two** transition metals in the following list:
magnesium manganese neon nickel nitrogen
- (h) Calculate the percentage by mass of oxygen in titanium dioxide (**TiO₂**).
[O = 16; Ti = 48]
- (i) **Figure 15** shows graphite sticks used by artists.
Graphite is an allotrope of the element carbon.
Name another allotrope of carbon.
- (j) Define the heat of combustion of hydrogen.
- (k) Which gas is produced in the greater volume during the electrolysis of acidified water?
- (l) Copy, complete and balance the following equation for the complete combustion of ethyne in oxygen:
$$\text{C}_2\text{H}_2 + \text{O}_2 \rightarrow \text{---} + \text{---}$$
- (m) Starting with the most active, list the following elements in order of *decreasing* chemical activity:
copper calcium potassium iron
- (n) What is the product when sulfur reacts with hydrogen gas?
- (o) Identify the alcohol oxidised to give ethanal.
- (p) Identify the aromatic molecule represented in **Figure 16**.
- (q) Select **two** compounds which contain the hydroxyl group from the following list:
butane ethanol ethene methane phenol
- (r) Give an example of a chemical classified as a ketone.

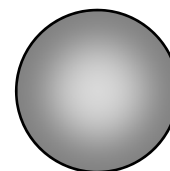


Figure 14



Figure 15

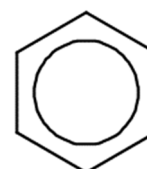


Figure 16

(11 × 6)

8. (a) The table below refers to the two naturally occurring isotopes of the element boron (**B**).

Element	Atomic number	Mass number	Isotope Abundance (%)
B	5	10	20
B	5	11	80

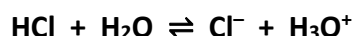
- What is meant by the atomic number of an atom of an element?
- What **two** types of subatomic particle determine the mass number of a boron atom?
- Use the information in the table above to calculate the relative atomic mass of boron.
- Write the electron configuration (*s, p*) for an atom of boron. (33)

- (b) Boron reacts with fluorine to form the compound boron trifluoride (**BF₃**). The boiling points of boron trifluoride and water are given in the table:

Compound	Boiling point (°C)	Overall dipole moment
BF₃	–100	no
H₂O	100	yes

- Sketch a diagram to show the arrangement of atoms in a **BF₃** molecule. State (ii) the shape, (iii) the bond angle, in a **BF₃** molecule.
- What change of state occurs at the boiling point of a substance?
- State the temperature difference between the two boiling points in the table.
- Explain why water has the higher boiling point. (33)

9. (a) (i) Use the Brønsted-Lowry theory to distinguish between an acid and a base.
(ii) Identify two acids in the following equation:



- What is meant by an acid-base conjugate pair?
- Give one example of an acid-base conjugate pair in the equation above.
- Acids dissociate in water. What term describes an acid that is **not** fully dissociated in water? (36)

- (b) (i) Define the pH of a solution.
(ii) Calculate the pH of a 0.014 M nitric acid (**HNO₃**) solution.
(iii) What is the pH value of a neutral solution?

Adding carbon dioxide gas to mineral water changes it from still to sparkling water. See **Figure 17**.

- Is carbon dioxide an acidic, a basic or a neutral oxide?
- Does the addition of carbon dioxide to a water supply increase or decrease its pH?

Give a reason for your answer. (30)



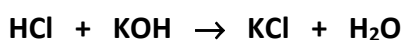
Figure 17

10. A titration was carried out to find the concentration of a solution of potassium hydroxide (KOH). Some pieces of apparatus required to carry out the titration are shown in **Figure 18**. **A** was filled with a standard solution of hydrochloric acid (HCl). The HCl was added to 25.0 cm³ portions of the KOH in a conical flask. The KOH was measured out using **B**.

- (a) (i) Define the underlined term above.
 (ii) Identify pieces of apparatus **A**, **B** and **C**.
 (iii) Give **two** uses of **C** during the experiment.
 (iv) How was **A** rinsed before filling it with the HCl? (36)
- (b) (i) Why was an indicator added to the KOH solution in the conical flask before adding the HCl?

It was found that 13.4 cm³ of a 0.12 M solution of HCl neutralised 25.0 cm³ of the KOH solution.

The balanced equation for the titration reaction is:



- (ii) Calculate the concentration of the KOH solution.
 (iii) How could the accuracy of this titration experiment be improved?
 (iv) Why should eye protection be worn throughout this experiment? (30)

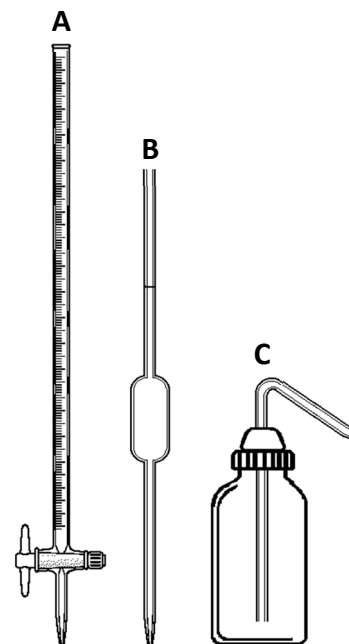


Figure 18

11. **Figure 19** shows a tanker used to transport liquefied natural gas (LNG). Natural gas is mostly methane along with small quantities of ethane, propane and butane. These substances are all hydrocarbons.

- (a) (i) State one use for methane.
 (ii) Suggest an advantage of transporting or storing natural gas in its liquid state.
 (iii) What are hydrocarbons?
 (iv) Name the homologous series which includes methane, ethane, propane and butane.



Figure 19

- (v) Draw the structure of an ethane molecule showing all of its atoms and all of its bonds.
 (vi) Explain why ethane is described as a *saturated* hydrocarbon.
 (vii) Name an unsaturated hydrocarbon with two carbon atoms. (39)

- (b) Methane gas can be converted to hydrogen according to the following balanced equation:



- (i) Is this an exothermic or an endothermic reaction? Give a reason for your answer.
 When 15 moles of methane react completely according to the equation above, calculate
 (ii) the heat change involved
 (iii) the number of moles of hydrogen gas produced.
 (iv) How many moles of methane react when the heat change is 4,120 kJ? (27)

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

- (a) Hydrogen peroxide (H_2O_2) solutions decompose in the presence of an MnO_2 catalyst into water and oxygen gas. **Figure 20** shows a set up to prepare oxygen gas using this reaction and to collect samples of the gas formed in test-tubes.

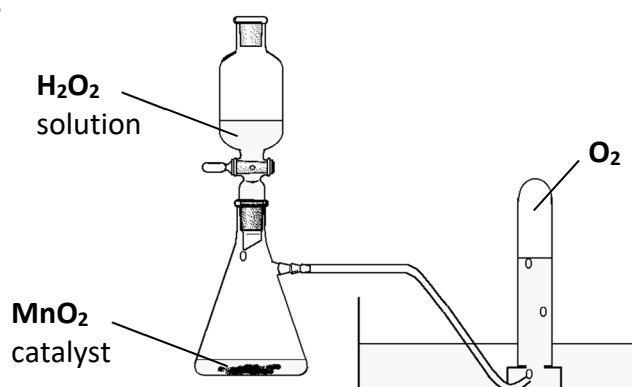


Figure 20

- The MnO_2 catalyst is a black solid.
Describe the appearance of hydrogen peroxide (H_2O_2) solutions.
- Write a balanced equation for the decomposition of H_2O_2 as described above.
- What is the purpose of a catalyst in a chemical reaction?
Oxygen is a colourless, odourless gas.
- Describe a test to confirm that the gas produced is oxygen.
- When collecting the oxygen, how could you tell when a test-tube was full of gas?
- Give one commercial use of O_2 gas.

(33)

- (b) Consider the descriptions in the table relating to the electrolysis of molten sodium chloride (NaCl) using inert electrodes.

A	Loss of electrons during a reaction
B	Negative electrode
C	Electrode where oxidation occurs
D	Species oxidised during the electrolysis
E	Particles that conduct electricity through the molten electrolyte
F	Gain of electrons during a reaction
G	Species reduced during the electrolysis

In your answerbook match each term below with its description (**A, B, C, D, E, F** or **G**) in the table.

cathode **anode** **Na^+** **ions**
oxidation **reduction** **Cl^-**

What are the **two** products of the electrolysis of molten sodium chloride?

Suggest a suitable material for use as the inert electrodes.

(33)

- (c) **Figure 21** shows limescale (mostly CaCO_3) on the surface of a chromium-plated tap.



Figure 21

Limescale is formed when calcium hydrogencarbonate dissolved in water decomposes according to the following balanced equation:



- (i) What is meant by a mole of a substance?
- (ii) How many different elements are in the compound calcium hydrogencarbonate?
- (iii) What is the mass of a mole of $\text{Ca}(\text{HCO}_3)_2$?

When 8.1 g of $\text{Ca}(\text{HCO}_3)_2$ decompose completely, calculate

- (iv) the number of moles of $\text{Ca}(\text{HCO}_3)_2$ which react
- (v) the mass of CaCO_3 formed
- (vi) the volume of the carbon dioxide formed, measured at s.t.p. (33)

[H = 1; C = 12; O = 16; Ca = 40; molar volume at s.t.p. = 22.4 litres]

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Image Q5(a) on page 4: at www.durhampattesting.co.uk

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Image Q5(c) on page 4: at www.winparts.net

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Image Q7(i) on page 7: www.kohinoorusa.com

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Image Q11 on page 9: from www.reuters.com

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Leaving Certificate – Ordinary Level

Physics and Chemistry

Wednesday, 21 June

Morning, 9:30 – 12:30