



Coimisiún na Scrúduithe Stáit State Examinations Commission

LEAVING CERTIFICATE EXAMINATION, 2024

PHYSICS AND CHEMISTRY – ORDINARY LEVEL

WEDNESDAY, 19TH 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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The 2024 examination papers were adjusted to compensate for disruptions to learning due to COVID-19. This examination paper does not necessarily reflect the same structure and format as the examination papers of past or subsequent years.

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) What is the SI unit of energy?
- (b) How long does it take a train, moving at a constant speed of 90 km/h, to travel 40 km?
- (c) State one of Newton's laws of motion.
- (d) A loudspeaker produces sound waves with a frequency of 500 Hz.
How many sound waves pass a point in 3 seconds?
- (e) Pure zinc metal melts at 420 °C. What is this temperature on the absolute Kelvin scale?
- (f) State one assumption of the kinetic theory of gases.
- (g) State Charles' law of gases.
- (h) State one use for a convex mirror.
- (i) What is the focal length of a concave mirror with a radius of curvature of 25 cm?
- (j) State a law of the reflection of light.
- (k) **Figure 1** shows an isolated negatively-charged conductor.
Copy the diagram and sketch the electric field pattern around it.
- (l) What is the effective resistance of *two* 50 Ω resistors connected in series?
- (m) **Figure 2** shows a three-pin plug which contains a removable fuse.
Which effect of an electrical current may require the replacement of the fuse?
- (n) List **two** items needed to make an electromagnet.
- (o) An inductive mat can be used to charge smartphones wirelessly.
State one law of electromagnetic induction.
- (p) Copy the diagram in **Figure 3** and sketch the magnetic field pattern produced by a straight current carrying conductor.
- (q) Identify one method of detecting nuclear radiation.
- (r) Name **two** types of nuclear reaction.



Figure 1

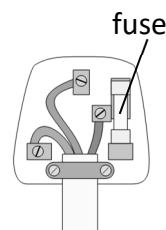


Figure 2

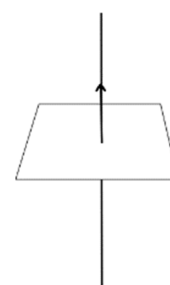


Figure 3

(11 × 6)

2. (a) (i) State the principle of conservation of energy.
Define (ii) work, (iii) potential energy. (18)

- (b) Ten-pin bowling was a competitive event at the Special Olympics held in Berlin during June 2023. **Figure 4** shows a bowling ball used in such events.



Figure 4

- (i) Calculate the weight of a bowling ball of mass 6.1 kg.
(ii) What type of energy has the bowling ball gained when it is lifted from the ground to a height of 85 cm?
(iii) Calculate the work done on the bowling ball when it has been lifted from the ground to a height of 85 cm.
(iv) Sketch a diagram showing the forces acting on the bowling ball when it is held at this height.

The bowling ball is then rolled down the bowling alley.

- (v) State **two** factors which affect the kinetic energy of a moving bowling ball. (27)

[acceleration due to gravity, $g = 9.8 \text{ m s}^{-2}$]

- (c) Copy and complete the statement of *Newton's law of gravitation*:

- (i) "The force of attraction between two bodies is proportional to the of their masses and inversely proportional to the of the between them."

The acceleration due to gravity, g , on the surface of the moon is given by the equation:

$$g = \frac{GM}{r^2}$$

- (ii) What do the symbols G and M stand for?
(iii) Compare the vertical motion due to gravity of a feather and a bowling ball when dropped from the same height above the surface of the moon. (21)

3. (a) **Figure 5** shows a ray of light emerging from a block of glass.

- (i) Copy **Figure 5** and label r , the angle of refraction.
- (ii) State one of the laws of refraction.
- (iii) Describe how to show the path of a light ray through a glass block.
- (iv) What would you use to measure the angle of refraction? (24)

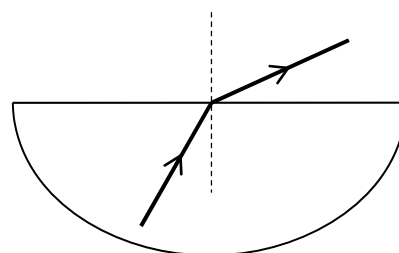


Figure 5

(b) **Figure 6** shows the path of another light ray in the glass block.

- (i) What name is given to the angle labelled **X** in this case?
- (ii) State the value of the angle of refraction in **Figure 6**.
- (iii) Describe, with the aid of a diagram, the path of the light ray when angle **X** is increased. (18)

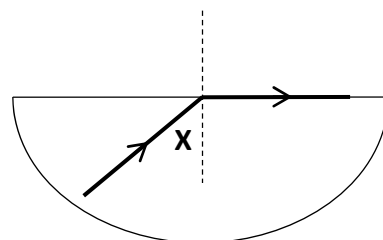


Figure 6

(c) **Figure 7** shows parallel rays of light approaching a glass lens.

- (i) Copy and complete the diagram showing the path of the rays after they pass through the lens.
- (ii) State the name of this type of lens.
- (iii) State **two** uses of lenses.
- (iv) What is the name given to the type of image that can be formed on a screen? (24)

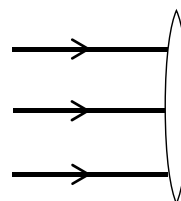


Figure 7

4. (a) **Figure 8** shows a thermistor which uses the thermometric property of electrical resistance.
- Explain the underlined term.
 - State one other example of a thermometric property.
 - Identify the **two** fixed points used to establish the Celsius scale. (18)



Figure 8

- (b) An experiment was carried out to investigate the effect of temperature on the resistance of a thermistor.

The following data were recorded using a digital multimeter.

Temperature (°C)	0	10	20	30	40	50	60
Resistance (kΩ)	100	60	37	24	15	10	7

- Draw a graph on graph paper of resistance (y-axis) against temperature (x-axis).
 - Use your graph to estimate the temperature when the resistance is 50 kΩ. (21)
- (c) The following terms are used in stating Boyle's law of gases:

temperature pressure mass volume inversely

- Copy and complete the following statement of Boyle's law in your answerbook:

"The of a fixed of gas is proportional to the at constant"

Figure 9 shows a sealed syringe containing 20 cm³ of gas.

- Use Boyle's law to predict the volume of the gas, when the pressure applied to the syringe is doubled, if it remains at room temperature.
- What term is given to the gas which obeys the gas laws over all conditions? (27)



Figure 9

5. (a) (i) State Ohm's law.

In a circuit, a voltage was applied across a resistor and the current through it was measured.

The following data were collected:

Voltage (V)	0	2.0	4.0	6.0	8.0	10.0	12.0
Current (A)	0	0.15	0.30	0.45	0.60	0.75	0.90

- (ii) Draw a graph on graph paper of current (y -axis) against voltage (x -axis).
 (iii) How does the graph show that the resistor verified Ohm's law?
 (iv) Use your graph to estimate the voltage across the resistor when the current is 0.55 A. (33)

- (b) (i) Define capacitance.

Figure 10 shows the electric field between the plates of a parallel-plate capacitor when connected to a d.c. power supply unit (PSU).

- (ii) A battery can be used in place of the PSU to give the same result. Explain why.
 (iii) Identify which plate is positively charged.
 (iv) Why is an a.c. power supply necessary to ensure that the lamp remains lit?

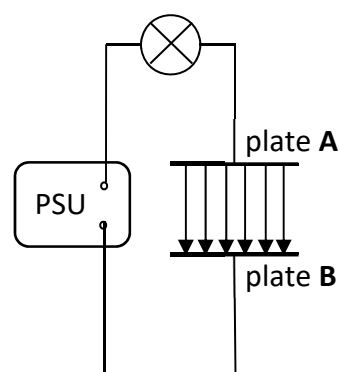


Figure 10

Figure 11 shows two arrangements of capacitors.

- (v) Which arrangement shows the capacitors connected in series?
 (vi) Which arrangement has an effective capacitance of $1\ \mu\text{F}$? (33)

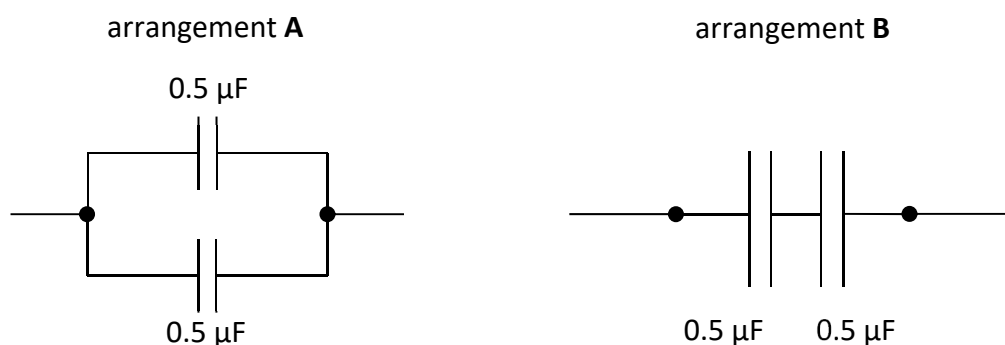


Figure 11

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

(a) **Figure 12** shows two balls each of mass 165 g used in a game of pool.

During a game, ball **A** moving at a velocity of 0.85 m s^{-1} moves toward ball **B** which is at rest. After the collision both balls move in the same direction with ball **A** now moving at 0.56 m s^{-1} .

- (i) State the principle of conservation of momentum.
- (ii) State the SI unit of mass.
- (iii) Calculate

- (a) the momentum of ball **A** *before* the collision,
- (b) the momentum of ball **B** *before* the collision,
- (c) the momentum of ball **A** *after* the collision,
- (d) the velocity of ball **B** *after* the collision.

(33)

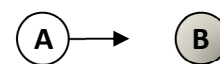


Figure 12

(b) **Figure 13** shows a wavefront of monochromatic light approaching a single narrow slit.

- (i) What is meant by the underlined term?
- (ii) Identify a source of monochromatic light.
- (iii) Copy the diagram and show the path of the wavefront after it passes through the narrow slit.

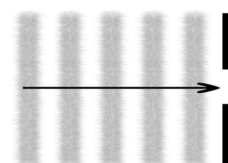


Figure 13

Figure 14 shows the pattern formed if the single slit is replaced by a pair of narrow slits.

- (iv) Which **two** wave phenomena occur in the formation of this pattern?
- (v) What is observed if white light passes through this pair of narrow slits?

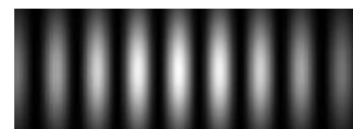


Figure 14

(33)

- (c) **Figure 15** shows a set-up to demonstrate the photoelectric effect.
- (i) Consider the descriptions in the table below about this demonstration.

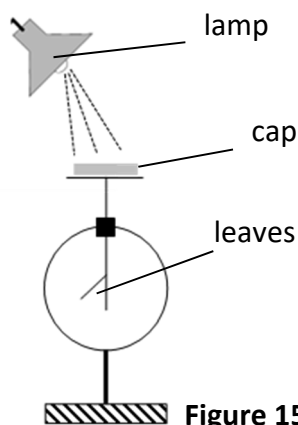


Figure 15

Match the following terms with the appropriate labels in your answerbook.

zinc gold electroscope ultraviolet light electron

A	Electromagnetic radiation with greater energy than visible light
B	A device used to detect the presence of electrical charge
C	A suitable metal used for the leaves
D	A metal which requires preparation and then is placed on the cap
E	The sub-atomic particle emitted

- (ii) How should the metal be prepared before it is placed on the cap?
- (iii) State the overall type of charge that should be present on the leaves before switching on the lamp.
- (iv) What will be observed during a successful demonstration of the photoelectric effect? (33)

- (d) Beta emission occurs during the radioactive decay of tritium. Tritium is a naturally occurring unstable isotope of hydrogen.

- (i) Which sub-atomic particle can be added to an atom to form an isotope?
- (ii) Which sub-atomic particle is emitted in beta emission?

Tritium has a half-life of 12.3 years.

- (iii) What is meant by the underlined term?
- (iv) How many half-lives have passed after 24.6 years?
- (v) What fraction of tritium remains in a given sample after 24.6 years?
- (vi) State one precaution taken when working with radioactive isotopes. (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) Explain what is meant by the atomic number of an atom of an element.
- (b) **Figure 16** represents a *p*-orbital.
What is the maximum number of electrons in a *p*-orbital?
- (c) Select **two** alkali metals from the following list:
potassium magnesium nitrogen lithium argon
- (d) What is the difference between an atom and an ion?
- (e) State one characteristic of metallic bonding.
- (f) Define the *electronegativity* of an atom of an element.
- (g) Name a substance containing *hydrogen bonding*.
- (h) Calculate the percentage by mass of oxygen in beryllium oxide (**BeO**).
[Be = 9, O = 16]
- (i) The modelling balloon shown in **Figure 17** was inflated with 0.033 mol of nitrogen gas.
How many molecules of nitrogen does it contain?
[Avogadro constant = $6 \times 10^{23} \text{ mol}^{-1}$]
- (j) What is the purpose of a catalyst in the decomposition of hydrogen peroxide?
- (k) State Hess's law.
- (l) Copy and complete the following reaction between a metal and an acid:
Zn + H₂SO₄ → _____ + _____
- (m) Calculate the pH of 0.045 M solution of nitric acid (**HNO₃**).
- (n) Name **two** gases formed during the electrolysis of water.
- (o) Name a chemical used to test for unsaturation of a hydrocarbon.
- (p) How many electrons are present in the triple bond between the two carbon atoms in ethyne (**C₂H₂**)?
- (q) State the name of the molecule represented by the structural formula in **Figure 18**.
- (r) State a property of an ester.



Figure 16



Figure 17

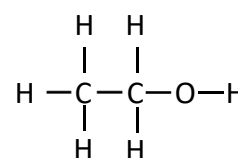


Figure 18

(11 × 6)

8. Refer to page 79 of the *Formulae and Tables* booklet when answering this question.

- (a) Hydrogen and helium have the same period number, but different group numbers on the periodic table of the elements. At room temperature, hydrogen gas exists as molecules and helium gas exists as atoms.

- (i) Define the underlined terms.
(ii) What are the group numbers of hydrogen *and* helium?

Electrons in the lowest energy state of hydrogen and helium occupy the 1s orbital.

- (iii) Sketch an s-orbital.
(iv) State the electron configuration of helium. (36)

- (b) **Figure 19** represents the type of bonding present in a molecule of hydrogen.

- (i) What type of bonding is shown in **Figure 19**?
(ii) State **two** properties of this type of bonding.
(iii) State one use for hydrogen gas.
(iv) Explain why helium does not combine with other atoms.
(v) State one use for helium gas. (30)

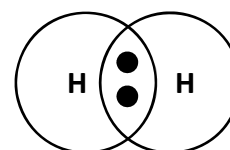


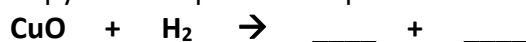
Figure 19

9. (a) Both reduction and oxidation occur during a redox reaction.

- (i) Explain the underlined word in terms of the movement of electrons.
(ii) Which substance is oxidised in the following reaction?



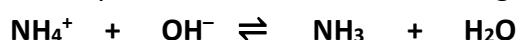
- (iii) Copy and complete the equation for the following redox reaction:



- (iv) Identify the *oxidising agent* in the redox reaction from **part (iii)**. (30)

- (b) (i) What is a *base* according to the Brønsted-Lowry theory?

- (ii) Identify the **two** bases in the following reaction:



- (iii) State one example of an acid-base conjugate pair in this reaction.
(iv) What term is used to describe bases which do *not* fully dissociate?
(v) A base which dissolves in water will form an alkaline solution.
State a typical pH value for such a solution. (36)

10. A titration involves the accurate measurement of the volumes of two solutions. One of these solutions must be previously standardised.
- (i) Explain what is meant by a standardised solution.

In preparation for a titration 20.0 cm³ of a solution of sodium hydroxide (**NaOH**) was accurately measured and transferred into a conical flask.

- (ii) Describe the correct procedure for rinsing, filling and emptying a pipette.
(iii) Explain why a conical flask is used when reacting the solutions.

Before the start of the titration the piece of glassware in **Figure 20** was filled with 0.12 M hydrochloric acid (**HCl**).

- (iv) Name the piece of glassware in **Figure 20**.
(v) State one precaution when preparing the piece of glassware for use in the titration. (33)

The titration was completed when 17.8 cm³ of 0.12 M hydrochloric acid reacted with 20.0 cm³ of the sodium hydroxide solution.

- (vi) What additional substance was needed to show the end point?
(vii) Copy and complete the equation below:
NaOH + HCl → _____ + H₂O
(viii) Calculate the concentration of the sodium hydroxide solution.
(ix) State **two** safety precautions taken when carrying out a titration. (33)



Figure 20

11. (a) **Figure 21** shows an outdoor barbeque grill which uses butane (C_4H_{10}) as a fuel to cook various foods.

Butane is an aliphatic compound.

- (i) Explain the underlined term.
- (ii) Sketch the structural formula of a molecule of butane.
- (iii) State another use of butane gas.
- (iv) In organic chemistry, what is meant by a homologous series?
- (v) State the chemical formula of a compound *before* butane in its homologous series.

(30)



Figure 21

- (b) **Figure 22** is the symbol used to represent a molecule of benzene.

- (i) Why are benzene and butane both classified as hydrocarbons?
- (ii) State one difference between the structure of a molecule of butane and a molecule of benzene.

(12)



Figure 22

- (c) A heat of reaction equation for butane is given as follows:



- (i) What is the significance of the value of the heat of reaction being a *negative* quantity?
- (ii) Calculate the heat of combustion of butane.
- (iii) How many moles of butane would release 28 800 kJ of heat energy?
- (iv) State one condition that could lead to the formation of carbon monoxide (CO) in the above reaction.

(24)

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

- (a) **Figure 23** shows laboratory apparatus used in the preparation of sulphur dioxide (SO_2) gas.

In **stage I**, a dilute form of liquid **B** is used in the preparation of the gas.

- (i) Identify solid **A** used in **stage I**.

In **stage II**, a concentrated form of liquid **B** is used in the separation of a pure sample of the gas.

- (ii) Identify liquid **B**.
 (iii) Which product in the reaction is removed by liquid **B** in **stage II**?

In **stage III**, samples of the gas are collected.

- (iv) What does this method of collection tell you about the density of SO_2 compared to the density of air?
 (v) Describe a chemical test to verify that SO_2 is an acidic gas.
 (vi) Why is this preparation carried out in a fume cupboard?

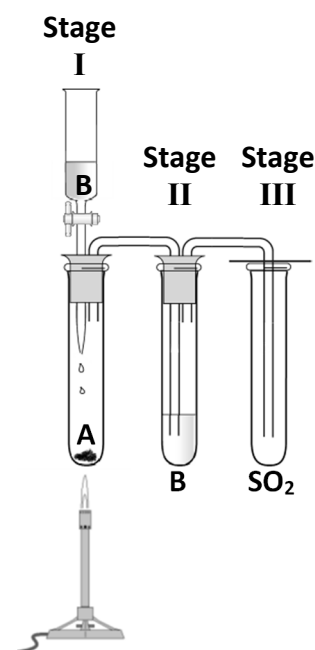


Figure 23

(33)

- (b) Lithium peroxide (Li_2O_2) is a chemical which absorbs carbon dioxide (CO_2) from an enclosed environment according to the equation:



- (i) What is meant by a mole of a substance?
 (ii) Calculate the mass of one mole of Li_2O_2 .
 (iii) When 552 g of Li_2O_2 are completely reacted with CO_2 , calculate
 (a) the number of moles of Li_2O_2 reacted,
 (b) the number of moles of CO_2 absorbed,
 (c) the volume of CO_2 absorbed at STP.
 (iv) Suggest a reason why this type of reaction would be useful in crewed space missions.

[Li = 7, O = 16, molar volume at STP = 22.4 L]

(33)

(c) Some elements react with hydrogen to form hydrides.

(i) Copy and complete the following table showing the hydrides formed:

	Nitrogen	Chlorine	Sulfur
Chemical formula of hydride		HCl	
Chemical name of hydride	Ammonia		
Molecular shape of hydride			v-shaped

(ii) Identify one of the hydrides as acidic.

(iii) Sketch the shape of a molecule of any of the hydrides to show the position of the atoms. (33)

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Acknowledgements

Images

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Leaving Certificate Examination – Ordinary Level

Physics and Chemistry

Wednesday, 19 June

Morning, 9:30 – 12:30