2027.M35S2

2027L021G1ES2

Coimisiún na Scrúduithe Stáit
State Examinations Commission

Leaving Certificate Examination
Sample 2

Physics

Ordinary Level

2 hours 30 minutes

300 marks

Examination Number

Date of Birth ☐☐/☐☐/☐☐

For example, 3rd February 2005 is entered as 03 02 05

Centre Stamp

Instructions

There are seven questions on this examination paper. Each question carries 50 marks.

Answer **Question 1** and any **five other** questions.

Write your Examination Number and your Day, Month and Year of Birth in the boxes on the front cover.

Write your answers in blue or black pen. You may use pencil for sketches, graphs and diagrams only.

This examination booklet will be scanned and your work will be presented to an examiner on screen. All of your work should be presented in the answer areas, or on the given graphs, or diagrams. Anything that you write outside of the answer areas may not be seen by the examiner.

You are not required to use all the space provided. There is space for extra work at the back of the booklet. If you need to use it, label any extra work clearly with the question number and part.

The superintendent will give you a copy of the *Formulae and Tables* booklet. You must return it at the end of the examination. You are not allowed to bring your own copy into the examination.

Data from the *Formulae and Tables* booklet, including but not limited to fundamental physical constants, particle physics data and electrical circuit symbols should be used wherever necessary.

You may lose marks if your solutions do not include relevant supporting work.

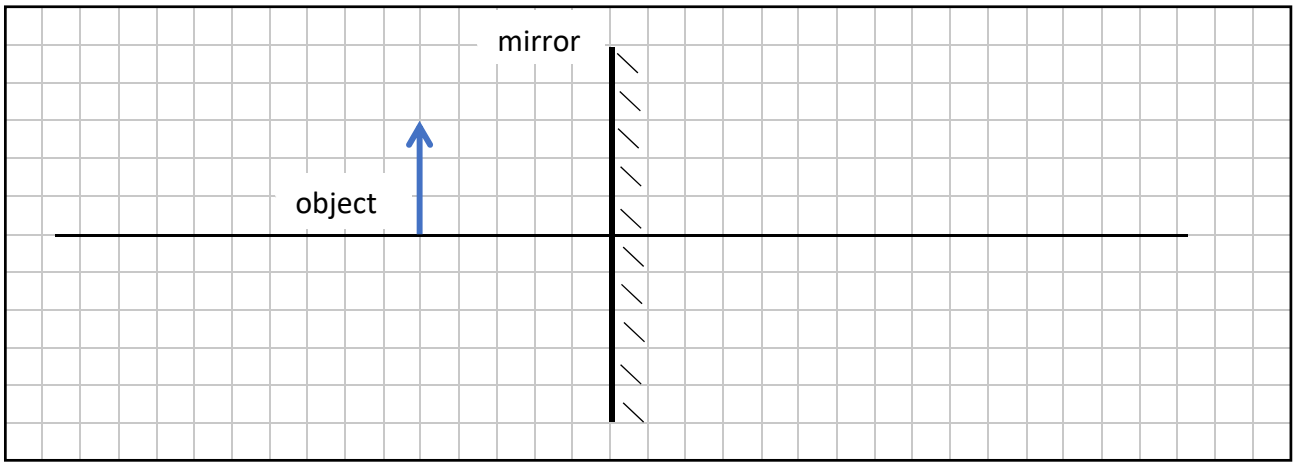
You may lose marks if the appropriate units of measurement are not included, where relevant.

Write the make and model of your calculator(s) here:

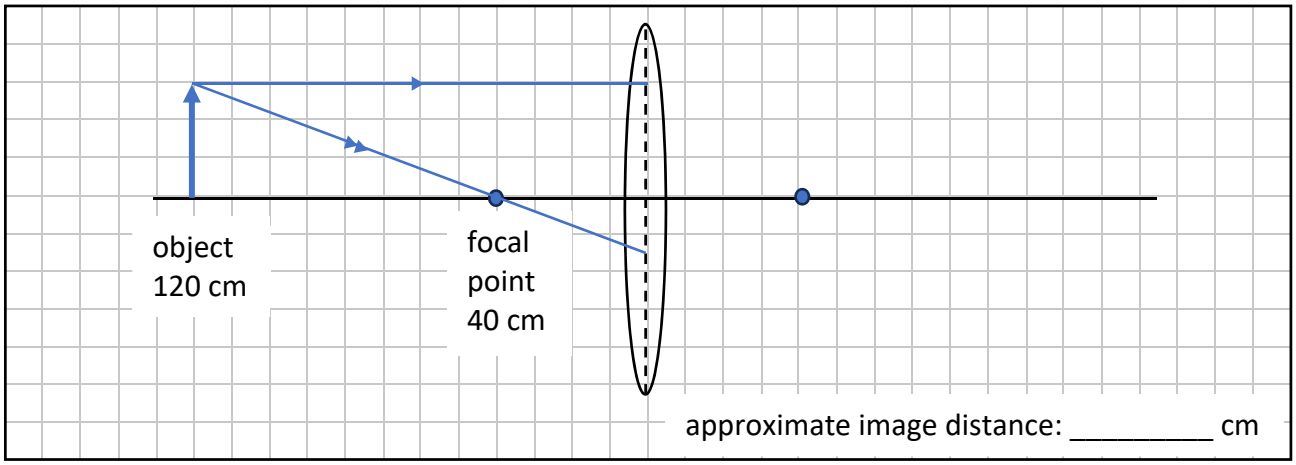
Question 1

(a) Light can be modelled as rays that travel in a straight line. This model of light helps to improve our understanding of mirrors and lenses.

(i) The diagram below shows an object in front of a plane mirror**.**
Draw, on the diagram below, the image of the object produced by the plane mirror.



(ii) Complete the ray diagram for the lens below to determine an approximate image distance.



(iii) Draw a ✓, in one box only, to identify the true statement.

A converging lens can produce an enlarged image. ☐

A diverging lens is thicker in the middle. ☐

A diverging lens always produces a real image. ☐

(b) A crane lifts a weight and uses 5000 joules in 50 seconds.
Estimate the average power of the crane by calculation or otherwise.

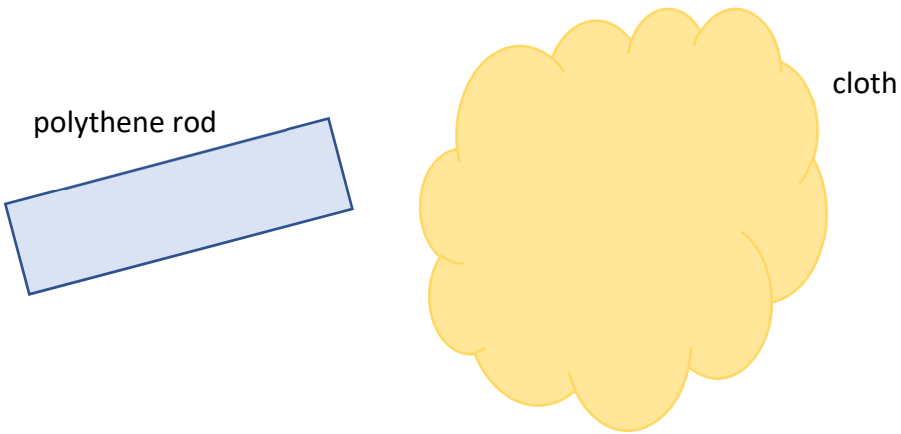
Draw a ✓ in one box only.

100 J	☐
100 W	☐
250 000 J	☐
250 000 W	☐

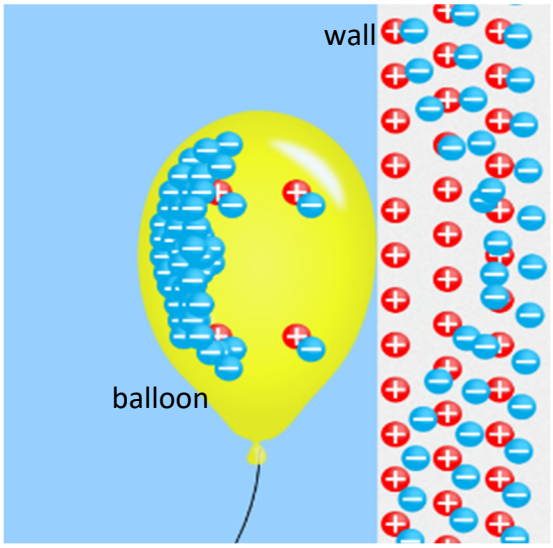
(c) Objects can become electrically charged due to the movement of electrons.

(i) A student rubs a neutral polythene rod with a neutral woollen cloth to charge it by friction.
The polythene rod becomes negatively charged.

Draw the charge on both items.



The image below shows a negatively charged balloon sticking to a neutral wall.



(ii) Explain, with the aid of the image, why the balloon sticks to the wall.

(iii) State a hazard associated with static electricity.

(d) State a useful energy conversion that takes place in a DC motor.

(e) Radioactive emissions can be dangerous to human health.

(i) Complete the paragraph below by adding the terms from the following list.

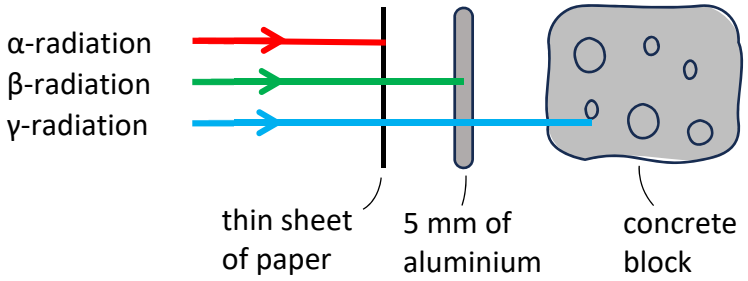
decay **ionising** **radiation**

Radioactive waste can give out three types of _____: alpha, beta and gamma. Human exposure to any of these three types can cause harm due to its _____ ability. Radioactive emissions can cause an environmental hazard for a very long time because some of the radioactive waste takes a very long time to _____.

(ii) Rank, from lowest to highest, the three nuclear emissions in terms of their mass. Write **1**, **2** or **3** in the boxes, where **1** represents the lowest.

alpha ☐ beta ☐ gamma ☐

The following diagram models the penetrating ability of the 3 different types of radioactive emissions.



(iii) Suggest a material that could be used to safely store radioactive samples.

(iv) State one other safety precaution that should be taken when working with radioactive samples.

(f) Draw a ✓, in one box only, to finish the following statement.

Thermionic emission is the

heating effect due to nuclear fission.	☐
heating effect of light.	☐
release of electrons from the surface of a hot metal.	☐
release of gamma radiation.	☐

(g) The paragraph below was adapted from a published online article.

"We show that butterflies and moths accumulate electrostatic charge while in flight. We demonstrate that when within millimetres of a flower, the electrostatic charge of a butterfly or moth generates an electric field in excess of 5000 V m^{-1}, and that an electric field of this magnitude is sufficient for pollen transfer from flowers onto the body of a butterfly or moth."

The following declarations were stated at the end of the article.

- All data are publicly available.
- Both authors agreed to be held accountable for their work.
- Both authors have no competing interests.
- This work was supported by the European Research Council.

Adapted from an article at royalsocietypublishing.org

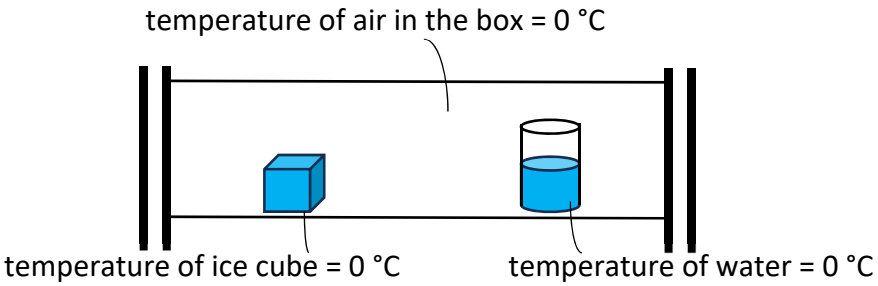
Do you think this article is trustworthy? Justify your answer.

Answer

Justification

Question 2

(a) An ice cube and a container of water are placed in a well-insulated box. The air in the box is at a constant 0 °C. The ice cube and water are also at a temperature of 0 °C.



(i) Predict what will happen to the ice cube and the water in the container as time passes. Draw a ✓, in one box only, to identify the correct statement.

Prediction	✓
The ice cube will remain solid; the water will remain liquid.	
The ice cube will remain solid; the water will freeze.	
The ice cube will melt; the water will remain liquid.	
The ice cube will melt; the water will freeze.	

The ice cube is placed inside a freezer.

(ii) The cube has a side length of 0.045 m. Calculate the volume of the ice cube.

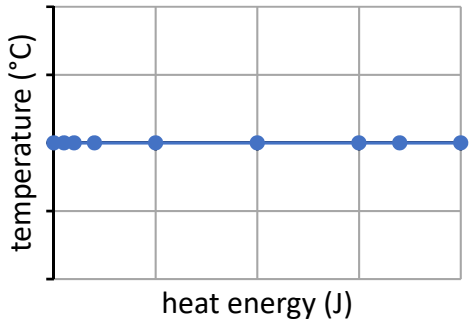
(iii) The density of ice is 917 kg m^{-3}. Calculate the mass m of the ice cube.

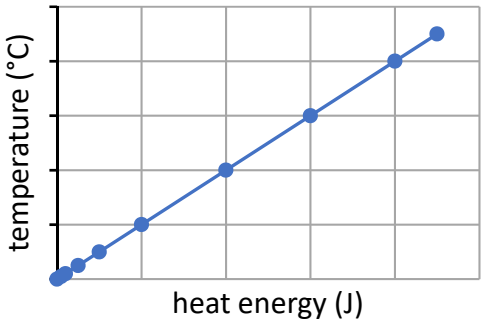
(iv) The ice cube is removed, from the freezer, at a temperature of –20 °C and begins to melt. Calculate the minimum heat energy needed to fully melt the ice cube.

$$\text{Heat energy} = mc\Delta\theta + L$$

specific heat capacity of ice $c = 2093\ \text{J kg}^{-1}\ \text{K}^{-1}$*; latent heat of the ice cube* $L = 27\,826\ \text{J}$

(v) Draw a ✓, in one box only, to identify which of the following graphs, **A** or **B**, best describes latent heat. Justify your answer.





A ☐ **B** ☐

Justification

(vi) An ice cube melts in a drink. The heat energy needed to melt the ice comes from the drink. Draw a ✓, in one box only, to complete the statement below.

The temperature of the drink will be

lower ☐ the same ☐ varying ☐ higher ☐

(vii) Distinguish between heat and temperature.

(viii) Name an instrument that a student could use to measure the temperature of the drink.

instrument name: _____

(b) An experiment is carried out to determine a value for a latent heat of water.

(i) Draw a labelled diagram of apparatus that you used to determine a latent heat value.

As part of the experiment the mass of water is determined.

(ii) Describe how the mass of water could have been determined.

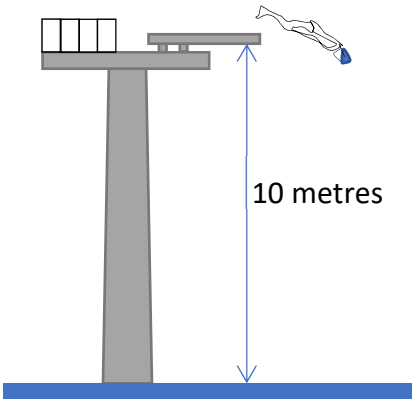
A digital thermometer was used, which gives values to 1 decimal place, as opposed to a glass bulb thermometer, which gives values to the nearest whole degree.

(iii) Does the ability to measure to 1 decimal place instead of the nearest whole degree always increase the accuracy or the precision of the measurement?
Draw a ✓ in one box only.

accuracy ☐ precision ☐

Question 3

(a) The diagram shows a diver diving into the water.



(i) Complete the following statement that summarises the law of conservation of energy.

Energy cannot be _____ or _____

but can be _____ from one form to another.

(ii) The mass of the diver is 60 kg. She is at a height of 10 m. Calculate the energy of the diver due to her height.

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

The diver falls through a height of 10 m. She is then travelling with a velocity, v.

(iii) Fill in the spaces below by naming the main type of energy that the diver has before she falls and the main type of energy that she has after she falls.

energy before due to her height → energy after due to her velocity

_____ → _____

(iv) Use the principle of conservation of energy to determine the energy of the diver due to her velocity.

energy due to velocity after falling 10 m = _____

(v) Calculate the velocity v of the diver after falling a distance of 10 m.

(b) An experiment is carried out to determine g, the acceleration due to gravity.

(i) Draw a labelled diagram of apparatus that could be used to determine g.

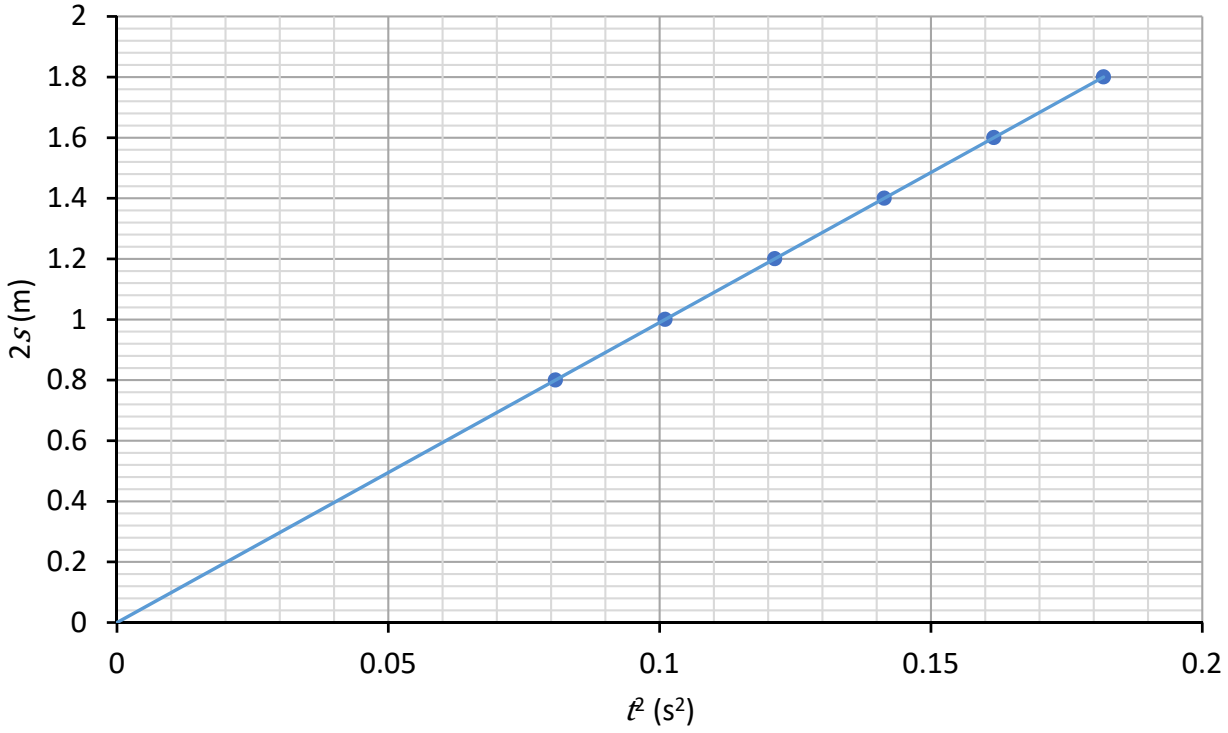
A student decides to verify the mathematical model $g = \frac{2s}{t^2}$.

(ii) Identify the two quantities s and t, in the model, that need to be determined.

quantity 1: _____

quantity 2: _____

The student drew the following graph.



(iii) Calculate the slope of the graph to determine a value for g.

(iv) Given that the value for g is 9.8 m s^{-2}, calculate the % error in the data.

(v) During the experiment the student dropped a dense metal ball and watched it falling through the air. Suggest a reason why the student used a dense metal ball instead of a light plastic cube filled with air.

Question 4

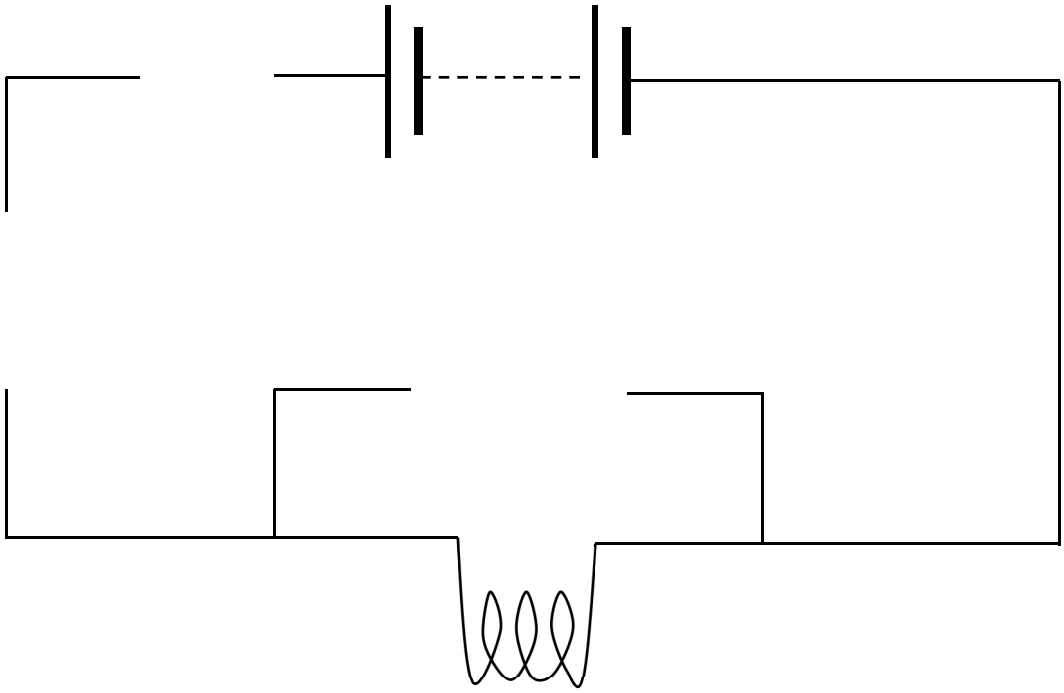
(a) A circuit was used to investigate the relationship between the voltage across and the current flowing through a coil of copper wire.

(i) Using the *Formula and Tables* booklet pages 74 and 75, complete the circuit diagram by drawing in the symbols for the components needed to

(a) measure current,

(b) measure voltage,

(c) change the voltage.



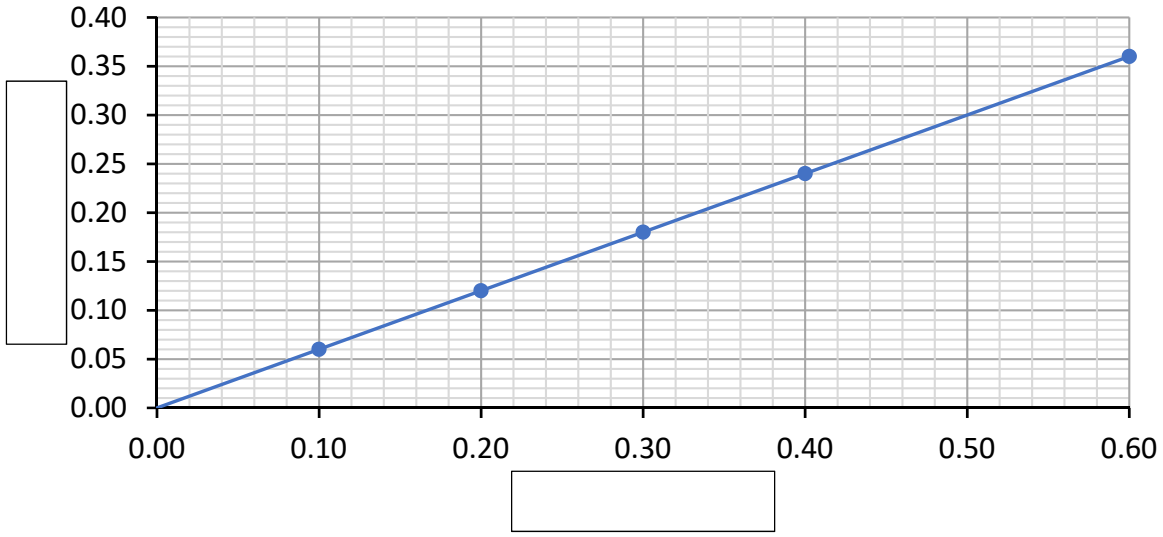
The data below were recorded.

voltage (V)	current (A)
0.10	0.06
0.20	0.12
0.30	0.18
0.40	0.24
0.50	0.30
0.60	0.36

(ii) To complete the graph

(a) write in labels for the two axes by analysing the data points,

(b) plot the data point (0.50, 0.30).



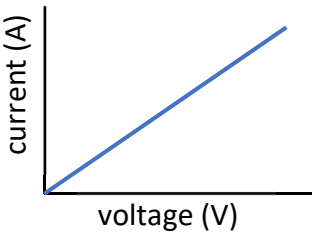
Some substances are said to be ohmic. This means that they obey Ohm's law.

(iii) Complete the following statement of Ohm's law.

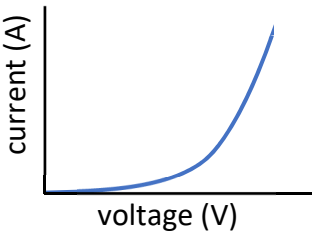
The current through a conductor is _____ to the _____ across the conductor.

Other students carried out similar experiments on objects other than wire.

(iv) Which of the following graphs obey Ohms' law?
Draw a ✓in one box only.

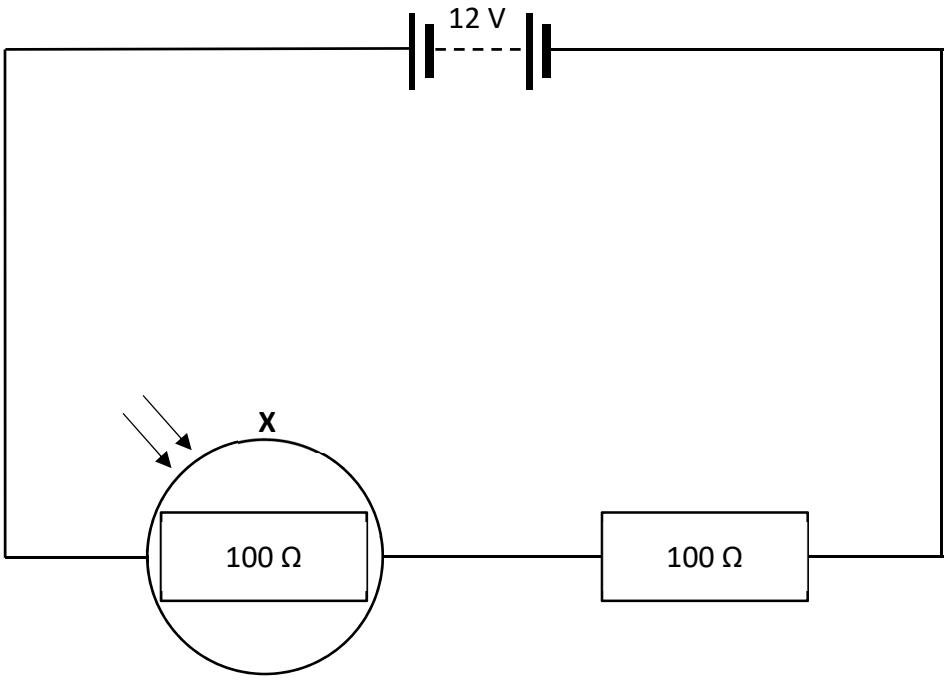


ohmic ☐



ohmic ☐

(b) The circuit below shows two resistors in series. Both resistors have a resistance of 100 Ω.



(i) Identify the type of resistor labelled **X**.

(ii) Calculate the total resistance of the circuit.

(iii) Calculate the current flowing in the circuit.

(iv) Calculate the voltage across resistor **X**.

(v) Describe the effect on the voltage across and the current flowing through the two resistors when light is shone on the resistor labelled **X.**

Draw a ✓ to complete the following statements.

(a) The voltage across the two resistors will be

lower		the same		varying		higher	

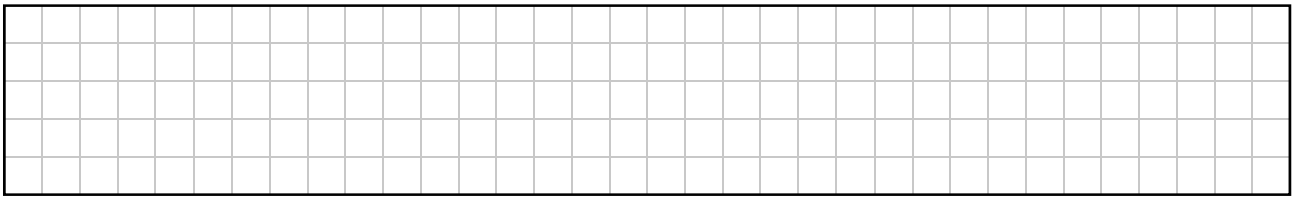
(b) The current flowing in the circuit will be

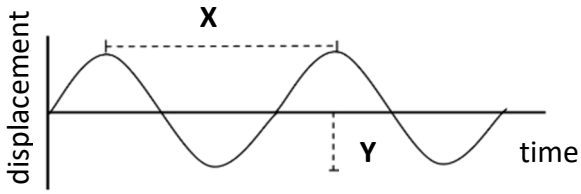
lower		the same		varying		higher	

Question 5

(a) Waves can be classified as mechanical waves, e.g. sound, that need a medium to travel in, or as electromagnetic waves, e.g. light, that do not.

(i) Explain what is meant by the frequency of a wave.





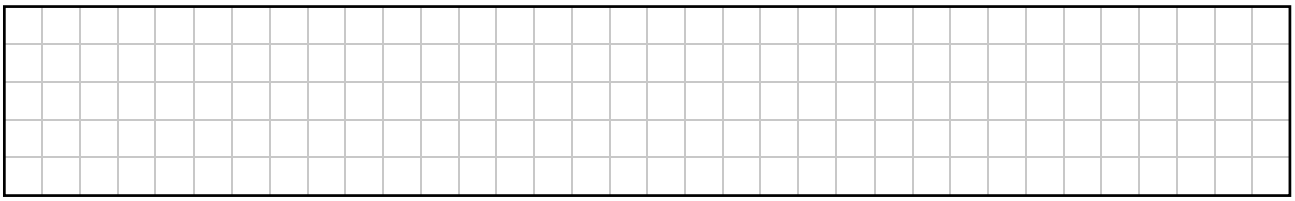
(ii) Identify the wave quantity that is represented by the letter **X**.
Draw a ✓ in one box only.

amplitude	☐	energy	☐	frequency	☐	period	☐	speed	☐	wavelength	☐

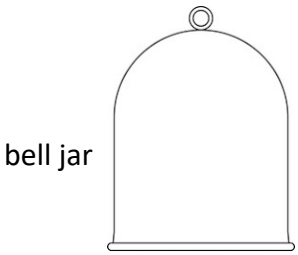
(iii) Identify the wave quantity that is represented by the letter **Y**.
Draw a ✓ in one box only.

amplitude	☐	energy	☐	frequency	☐	period	☐	speed	☐	wavelength	☐

(iv) What change to the sound will be observed if **Y** is increased?



The equipment below is used to demonstrate that sound waves need a medium to travel through.



(v) Suggest one other piece of suitable equipment that you would use to carry out this demonstration.

suitable piece of equipment: _____

(b) Sonar uses reflected sound waves to measure the depth of water under a ship.

A ship emits a sound wave. It takes 0.5 s for the wave to return after leaving the boat.

(i) Calculate the time taken for the sound wave to hit the sea floor.

(ii) Calculate the depth of the water under the ship.
speed of sound in water = 1500 m s^{-1}

(iii) The frequency of the sound is 40 000 Hz. Calculate its wavelength.
speed of sound in water = 1500 m s^{-1}

Ultrasound is used in medicine to create an image of internal body structures.

(c) Suggest an advantage of using ultrasound instead of X-rays.

(d) **(i)** The table shows the electromagnetic spectrum with three parts missing.
Write in the term **X-rays** in the appropriate position in the following table.

radio waves		infrared		UV		gamma rays

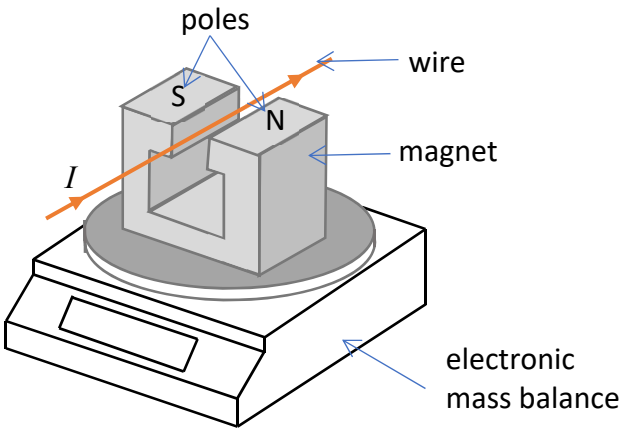
increasing frequency

(ii) Identify one property that is constant for all electromagnetic waves travelling in a vacuum.
Draw a ✓ in one box only.

amplitude ☐ energy ☐ frequency ☐ period ☐ speed ☐ wavelength ☐

Question 6

(a) A student designed an experiment to investigate the relationship between a magnetic field and the electromagnetic force on a current-carrying wire. The diagram shows part of the experimental setup. The wire carries a direct current I.



(i) Use Fleming's left-hand rule, or otherwise, to describe the effect on the balance's reading when the following changes are made.
Draw a ✓ in one box only each time to complete each statement below.

(a) The current I is increased, therefore the balance's reading will be

lower ☐ the same ☐ varying ☐ higher ☐

(b) The current I is reversed, therefore the balance's reading will be

lower ☐ the same ☐ varying ☐ higher ☐

(c) The current I is switched to an alternating current with a low frequency, therefore the balance's reading will be

lower ☐ the same ☐ varying ☐ higher ☐

The force discussed is called a motor effect force and is the principle of operation of a simple DC motor.

(ii) Explain the role of the split ring commutator in a DC motor.

(b) In May 2024, new laws were introduced to make e-scooters legal in Ireland.

E-scooters must
- have a maximum continuous rated output of 400 W,
- have a maximum mass of 25 kg (including batteries),
- have a maximum design speed of 20 km h^{-1} or less,
- be fitted with front and rear lights, reflectors, brakes and a bell.

Adapted from rsa.ie

(i) What is the maximum permitted power of a legal e-scooter in Ireland?

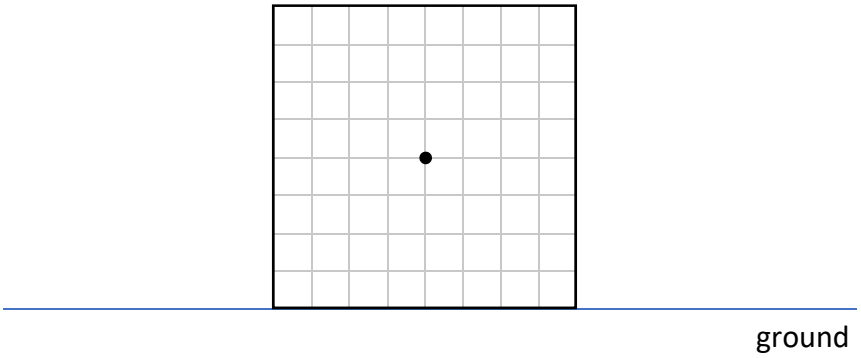
An e-scooter accelerates from rest to 5 m s^{-1} in 10 s.

(ii) Calculate the average acceleration. Include units in your answer.

The scooter continues at an average speed of 5 m s^{-1} for a further 30 s. Finally, the scooter comes to a stop in 3 s.

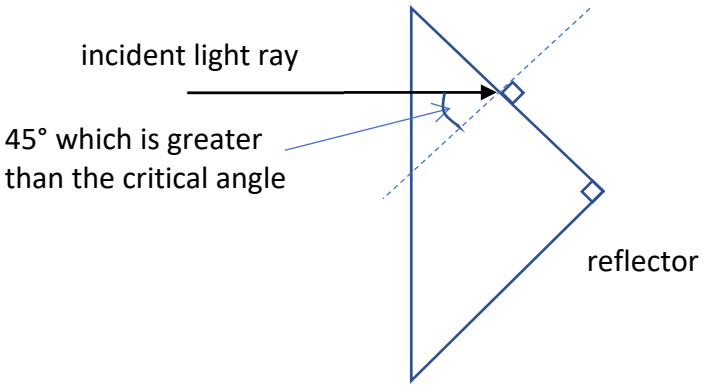
(iii) Sketch a velocity–time graph to show how the velocity changed over the entire journey. Your graph does not have to be to scale.

(iv) The box below is used to model the rider and the scooter as a closed system. The central dot shows the centre of mass.
Draw labelled vector arrows to show three forces experienced by the system when it is accelerating to the right.



(c) A reflector is used as a safety device on e-scooters.

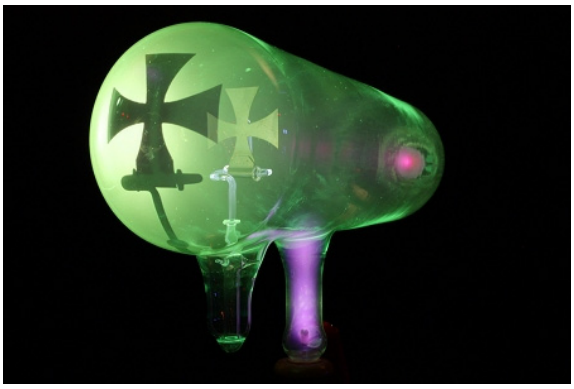
(i) Draw the path of the light ray on the diagram to show how light is reflected from the surfaces of the reflector.



(ii) State the name of the phenomenon that happens when light hits a surface at an angle greater than the critical angle.

Question 7

Below shows a cathode ray tube, firstly, turned off, and then turned on. The cathode ray tube was key to developing our understanding of matter at the turn of the 20th century. It led Thompson to propose the existence of the electron and develop a new model of the atom.



(i) State two properties of cathode rays.

property one: _____

property two: _____

(ii) Match each description below to its particle by writing **X**, **Y** or **Z** in the blank spaces in the table.

X – It is the nucleus of a helium atom.

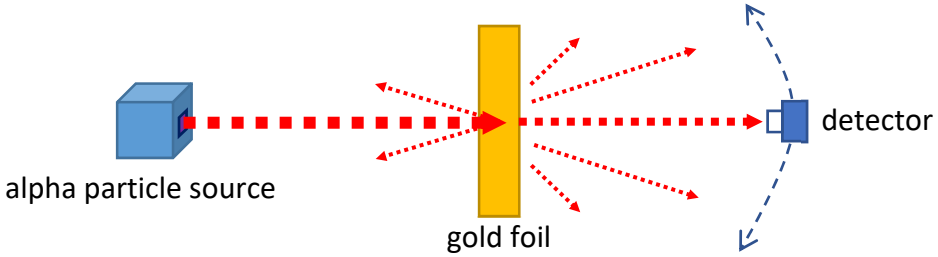
Y – It is a particle found in the nucleus of an atom.

Z – It is a particle found in energy levels outside of the nucleus of an atom.

	electron	**neutron**	**alpha particle**
description			
charge	-1.602×10^{-19} C	0 C	$+3.204 \times 10^{-19}$ C
mass	$+9.109 \times 10^{-31}$ kg	$+1.675 \times 10^{-27}$ kg	$+6.645 \times 10^{-27}$ kg

(iii) By referring to the data in the table, or otherwise, suggest one reason why alpha particles may be the most suitable for use in particle collision experiments.

Alpha particles were used by Rutherford in his famous gold foil experiment, the results of which changed the model of the atom from that proposed by Thompson. The diagram below shows the experimental setup used.



(iv) Use the two observations below to identify the changes that Rutherford made to Thompson's model.
Draw a ✓ in one box only each time.

Observation 1 – Most of the alpha particles went straight through the gold foil.

(a) What change was made to Thompson's model due to **Observation 1**?

Electrons are evenly distributed across a positive sphere.	☐
The atom is mostly empty space.	☐
Positive charge is concentrated in a dense central nucleus.	☐
Electrons are found in fixed energy levels outside a positive nucleus.	☐

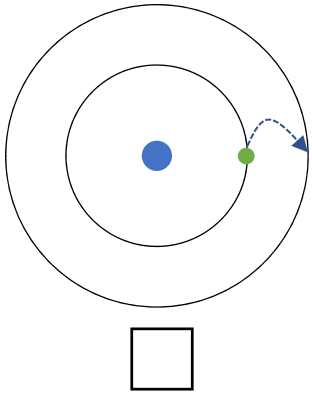
Observation 2 – A very small number of the positive alpha particles were repelled back towards the source.

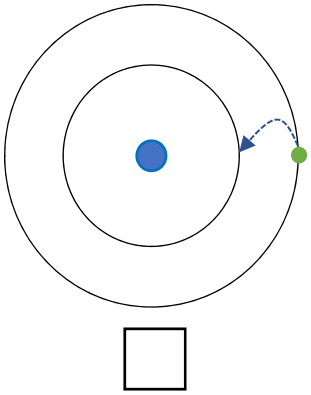
(b) What change was made to Thompson's model due to **Observation 2**?

Electrons are evenly distributed across a positive sphere.	☐
The atom is mostly empty space.	☐
Positive charge is concentrated in a dense central nucleus.	☐
Electrons are found in fixed energy levels outside a positive nucleus.	☐

Bohr further developed the model of the atom. He built on Rutherford's model to explain emission line spectra.

(v) Identify which of the diagrams below represents an electron transition that leads to the emission of a photon of light.
Draw a ✓ in one box only.

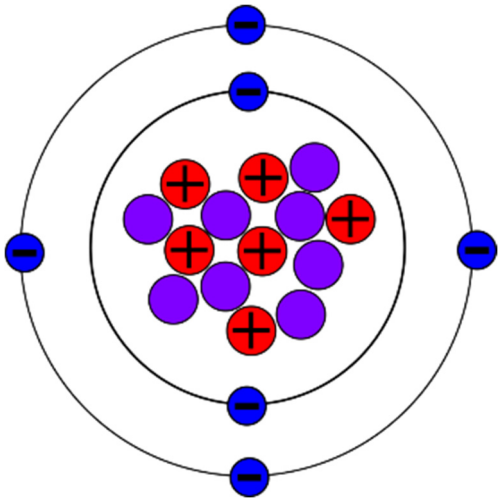




(vi) State one way in which analysis of emission spectra data has contributed to our understanding of the universe.

These models of the atom helped to develop a better understanding of isotopes, for example the carbon–14 isotope shown in the diagram.

(vii) Explain what is meant by isotopes.



(viii) How many protons and neutrons are in a single atom of the carbon–14 isotope $^{14}_{6}C$?

number of protons: _____

number of neutrons: _____

Carbon–14 is a radioactive isotope and it emits beta particles.

(ix) The energy of the emitted beta particle comes from the binding energy of the Carbon–14 nucleus.

(a) Given that the total mass of the number of protons and neutrons in a carbon–14 atom is 2.344×10^{-26} kg and that the observed mass of a carbon–14 nucleus is 2.325×10^{-26} kg, calculate the mass defect m for carbon–14.

(b) Given that the speed of light is $c = 3 \times 10^8$ m s^{-1}, calculate the binding energy E of carbon–14.

(x) Identify the fermion that a beta particle is equivalent to.
Draw a ✓ in one box only.

electron ☐ neutrino ☐ neutron ☐ proton ☐ quark ☐

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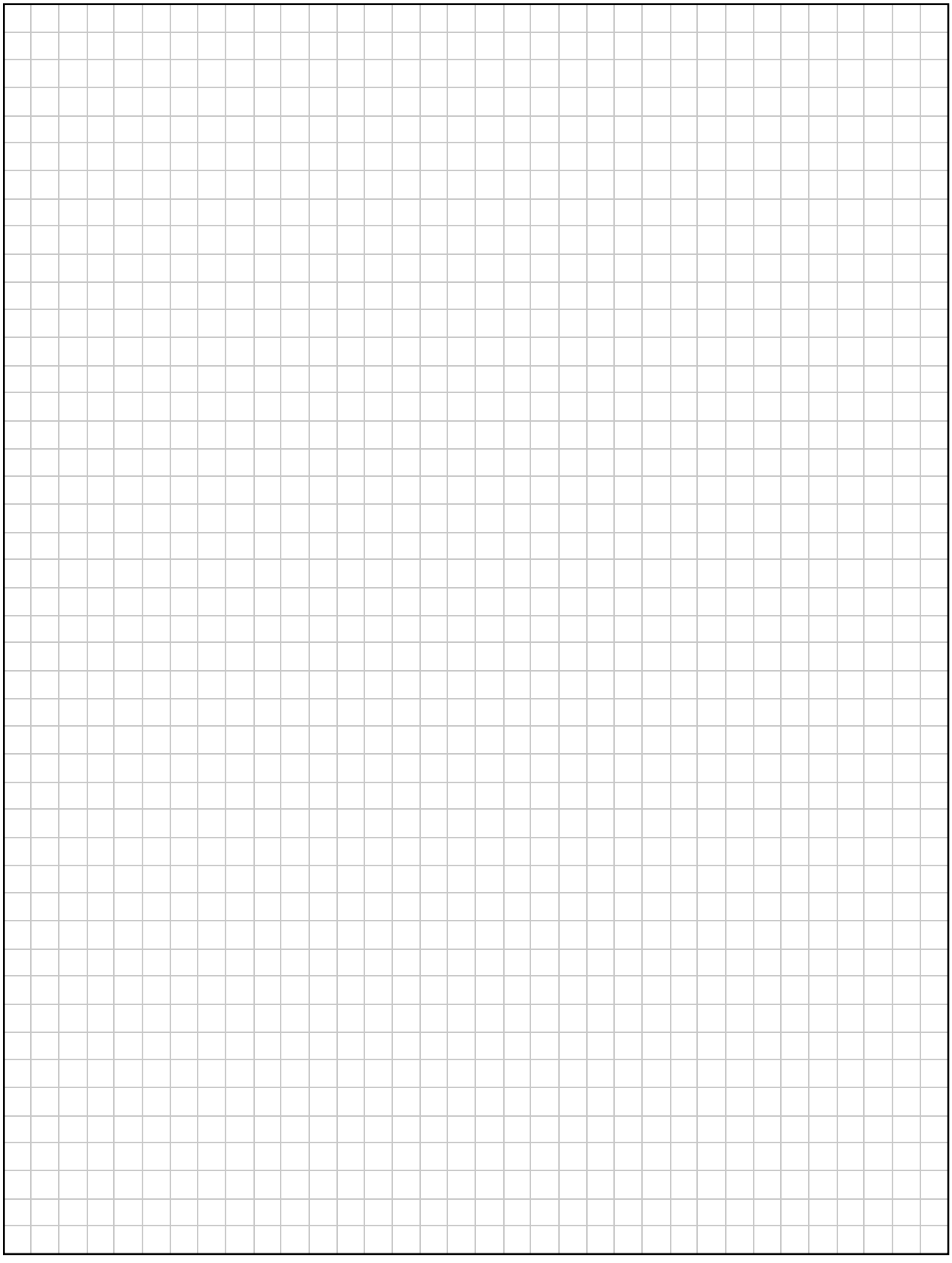
Label any extra work clearly with the question number and part.



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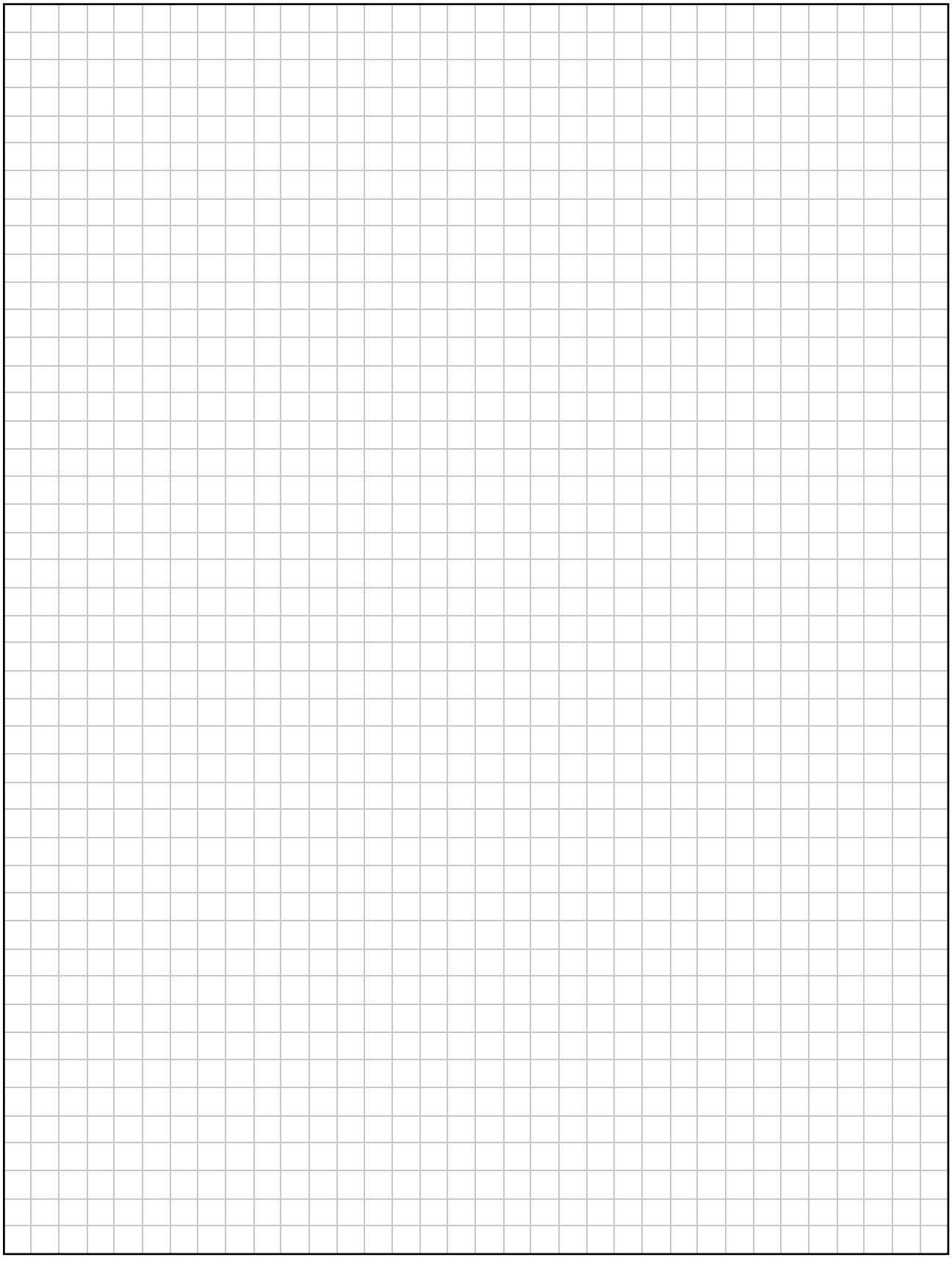

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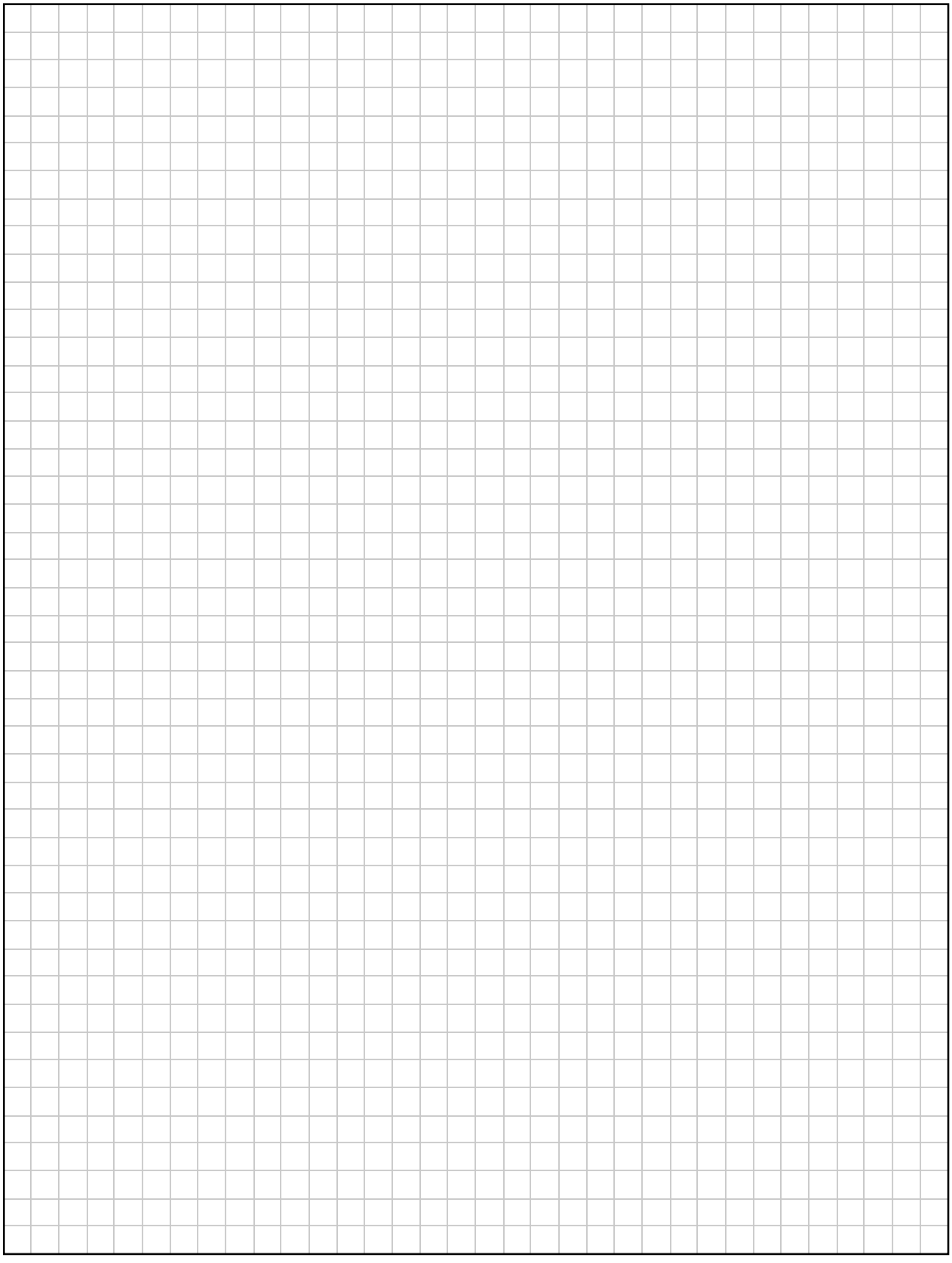

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Leaving Certificate Examination – Ordinary Level

Physics

Sample 2

2 hours 30 minutes