Government of **Western Australia**
School Curriculum and Standards Authority

WACE
Western Australian Certificate of Education

Western Australian Certificate of Education Examination, 2013

Question/Answer Booklet

PHYSICS

Stage 2

Please place your student identification label in this box

Student Number: In figures

In words

Time allowed for this paper

Reading time before commencing work: ten minutes
Working time for paper: three hours

Materials required/recommended for this paper

To be provided by the supervisor
This Question/Answer Booklet
Formulae and Data Booklet

Number of additional answer booklets used (if applicable):

To be provided by the candidate
Standard items: pens (blue/black preferred), pencils (including coloured), sharpener, correction fluid/tape, eraser, ruler, highlighters

Special items: non-programmable calculators approved for use in the WACE examinations, drawing templates, drawing compass and a protractor

Important note to candidates

No other items may be taken into the examination room. It is **your** responsibility to ensure that you do not have any unauthorised notes or other items of a non-personal nature in the examination room. If you have any unauthorised material with you, hand it to the supervisor **before** reading any further.

Ref: 13-123

Structure of this paper

Section	Number of questions available	Number of questions to be answered	Suggested working time (minutes)	Marks available	Percentage of exam
Section One: Short answers	18	18	70	67	40
Section Two: Problem-solving	5	5	90	85	50
Section Three: Comprehension	1	1	20	18	10
				Total	100

Instructions to candidates

1. The rules for the conduct of Western Australian external examinations are detailed in the *Year 12 Information Handbook 2013*. Sitting this examination implies that you agree to abide by these rules.

2. Write your answers in this Question/Answer Booklet.

3. When calculating numerical answers, show your working or reasoning clearly. Give final answers to **three** significant figures and include appropriate units where applicable.

   When estimating numerical answers, show your working or reasoning clearly. Give final answers to a maximum of **two** significant figures and include appropriate units where applicable.

4. You must be careful to confine your responses to the specific questions asked and to follow any instructions that are specific to a particular question.

5. Spare pages are included at the end of this booklet. They can be used for planning your responses and/or as additional space if required to continue an answer.
   - Planning: If you use the spare pages for planning, indicate this clearly at the top of the page.
   - Continuing an answer: If you need to use the space to continue an answer, indicate in the original answer space where the answer is continued, i.e. give the page number. Fill in the number of the question that you are continuing to answer at the top of the page.

6. The Formulae and Data Booklet is **not** handed in with your Question/Answer Booklet.

See next page

Section One: Short answers **40% (67 Marks)**

This section has **18** questions. Answer **all** questions. Write your answers in the spaces provided.

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Suggested working time: 70 minutes.

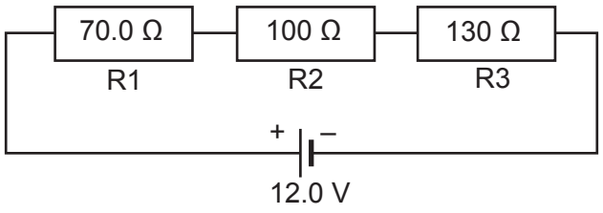
Question 1 **(4 marks)**

A geologist is using a Geiger counter to test some rocks for radioactivity and finds one that gives off radiation. Describe a simple experiment that could be done to determine whether the radiation is alpha, beta or gamma.

See next page

Question 2 **(4 marks)**

Three resistors R1, R2 and R3 are connected in series as shown below.
Calculate the current in amperes through R3.



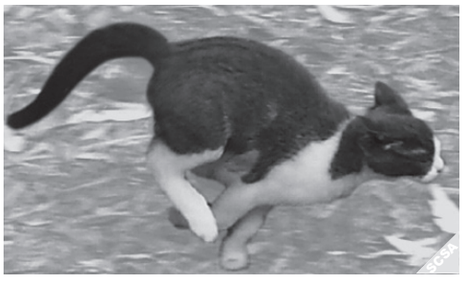
Question 3 **(3 marks)**

Pat has a mass of 62.0 kg. Calculate Pat's weight. Include the correct units in your answer.

See next page

Question 4 **(4 marks)**

The photograph below shows a cat called Hamish accelerating to catch a feather blowing in the wind. At this point, Hamish has one foot in contact with the ground. Draw vector arrows of the appropriate length on the photograph to show clearly the forces acting on Hamish.



Question 5 **(5 marks)**

The heating element of an electric kettle connected to the 240 V mains supply is used to heat 0.500 kg of water from 20.0 °C to the boiling point (100 °C). Knowing that heat energy is equivalent to electrical work, determine the amount of charge that passed through the heating element during this time. Include the correct unit for charge.

See next page

Question 6 **(4 marks)**

The Fukushima nuclear disaster in March 2011 was a result of a combined earthquake and tsunami. Radioactive caesium and iodine were released into the atmosphere and, while most of Japan's population received little additional radiation, workers at the plant itself received, on average, 400 mSv.

Determine the amount of energy in joules that a worker with a mass of 57.0 kg could have received from radiation in the accident if caesium and iodine are both beta and gamma emitters.

Question 7 **(4 marks)**

A calculator uses a 6.00 V battery and is rated at 0.500 W. Calculate the overall resistance of the electric circuit in the calculator. Give the appropriate units with your answer.

See next page

Question 8 **(4 marks)**

Figures 1 and 2 show two types of crash barrier. The barrier in Figure 1 consists of metal posts that support horizontal metal cables. The posts break off easily at the base, and the cables are able to stretch. The barrier in Figure 2 consists of metal posts that support horizontal metal sheets. The posts are fixed strongly in the ground, and the metal sheets resist stretching.

Using your understanding of impulse and Newton's second law of motion, explain why the barrier in Figure 1 is more likely to reduce injury to the occupants of cars that drive off the road.

Figure 1

Figure 2

Question 9 **(4 marks)**

Before the 19th century scientists believed that how hot or cold an object felt was a result of how much 'heat' it contained. This 'heat' was thought to be a result of a weightless liquid called 'caloric' that flowed between objects. Heat and temperature were considered to be the same. Today, scientists have a much deeper understanding of the concepts of heat and temperature.

As a result of your studies of heat and temperature this year, state whether the following statements are True or False.

	Statement	True or False
A	Heat is best described as how hot an object is.	
B	Temperature is a measure of the total kinetic energy that an object contains.	
C	Objects can both gain and lose heat but usually the net heat transfer is from hotter objects to cooler objects.	
D	When a metal cube is heated without melting the kinetic energy of its particles increases.	

Question 10 **(2 marks)**

Many chemical elements that have large numbers of protons and neutrons in their nuclei are unstable. Describe what eventually occurs to an atom that is not stable, compared with one that is stable.

See next page

Question 11 **(4 marks)**

A jeweller is making a gold bar by melting small pieces of pure gold. The gold pieces have a total mass of 4.00×10^{-2} kg and are initially at 20.3 ˚C. The energy required to bring the gold up to its melting point is 5.24×10^{3} J. If the specific heat capacity of gold is 126 J kg^{-1} K^{-1}, determine the melting point of gold.

Question 12 **(3 marks)**

Many devices have fuses installed in their electrical circuits to protect them and their users from excess current.

(a) State a cause of excess current being delivered to a device. (1 mark)

(b) Explain how a fuse works to prevent damage to a device. (2 marks)

See next page

Question 13 **(3 marks)**

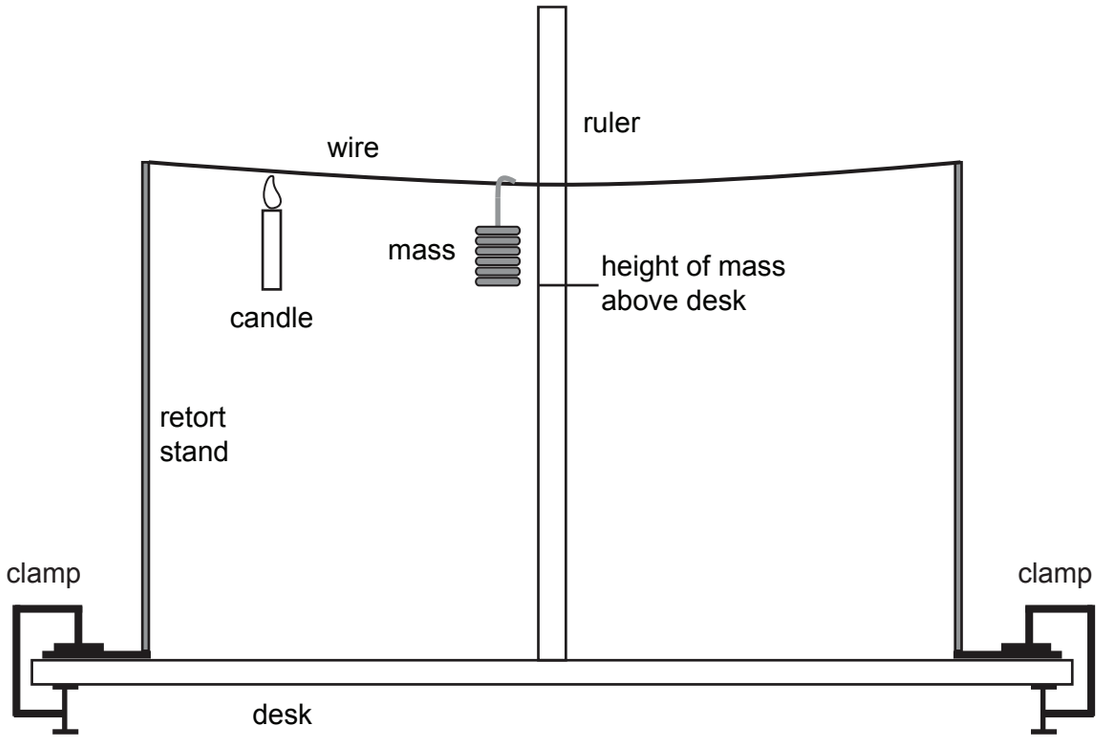
The engine of a toy crane lifts a small block of wood of mass 0.130 kg to a height of 0.700 m at a constant velocity. Calculate the work done in joules to achieve this.

See next page

Question 14 **(4 marks)**

Some students clamped two retort stands onto a desk. They tied a metal wire tightly between the tops of the retort stands and then hung a mass from the wire as shown in the diagram. After they had measured the height of the mass above the desk, they heated the wire evenly with a candle for about three minutes and measured the height of the mass above the desk again. This time, the height was less than it had been before.

Using your understanding of the kinetic theory explain why the mass moved closer to the desk as the wire was heated.



See next page

Question 15 **(4 marks)**

Nuclear fusion within the Sun is the Earth's main source of energy. In the core of the Sun, the temperature is more than 15 million degrees Celsius. The Sun's powerful gravity pulls all of the mass together creating a very high pressure. These two factors combine to force hydrogen atoms to come together in a nuclear fusion reaction. Through several steps, helium-3 nuclei are created. The nuclear equation below shows two of these helium-3 nuclei combining to form helium-4 (an alpha particle) and two protons.

$$ {}^{3}_{2}\mathrm{He} + {}^{3}_{2}\mathrm{He} \rightarrow {}^{4}_{2}\mathrm{He} + 2{}^{1}_{1}\mathrm{H} $$

Using the information below and your Formulae and Data booklet, calculate the energy released in joules during this reaction.

Mass ${}^{3}_{2}\mathrm{He}$ = 5.01×10^{-27} kg

See next page

Question 16 **(4 marks)**

Consider the following nuclear reaction for uranium:

$$^{235}_{92}\mathrm{U} + {}^{1}_{0}\mathrm{n} \rightarrow {}^{143}_{56}\mathrm{Ba} + {}^{91}_{36}\mathrm{Kr} + ?\,{}^{1}_{0}\mathrm{n}$$

(a) Determine the number of neutrons released. (1 mark)

Number of neutrons = _____

(b) Uranium-235 is commonly used to produce a self-sustaining neutron-induced chain reaction. Using U-235 as the example, draw a labelled diagram that illustrates a self-sustaining neutron-induced chain reaction. (3 marks)

Question 17 **(3 marks)**

Each day, when Victoria gets home from work, she climbs the stairs to her second-floor apartment. On some days she walks up the stairs and on other days she runs up them.

Victoria's potential energy, kinetic energy and power output may change as she climbs the stairs. Assuming that Victoria's mass remains constant, and that she is halfway up the stairs:

her potential energy is (circle the correct response)

less for walking than for running	the same for walking and running	greater for walking than running

her kinetic energy is (circle the correct response)

less for walking than for running	the same for walking and running	greater for walking than running

her power output is (circle the correct response)

less for walking than for running	the same for walking and running	greater for walking than running

Question 18 **(4 marks)**

In a stunt at the opening of a football game, a passenger in a helicopter drops a football so that it lands in the centre of the football field. The helicopter is descending toward the ground at a constant velocity of 3.40 m s^{-1} when the football is released. The football takes 6.70 s to reach the ground. Assuming no air resistance, calculate the height in metres of the helicopter at the moment the football was released.

End of Section One

See next page

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See next page

Section Two: Problem Solving **50% (85 Marks)**

This section has **five (5)** questions. Answer **all** questions. Write your answers in the spaces provided.

When calculating numerical answers, show your working or reasoning clearly. Give final answers to **three** significant figures and include appropriate units where applicable.

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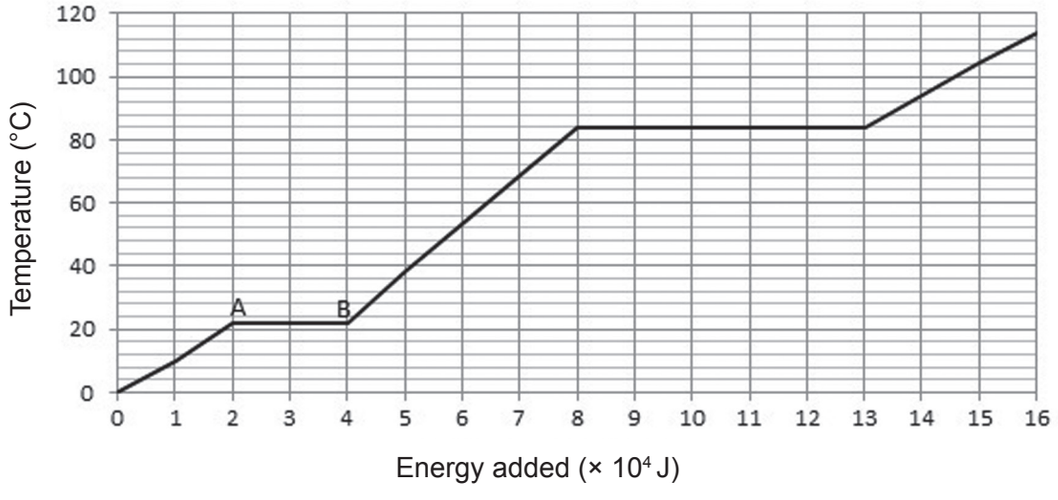
Suggested working time: 90 minutes.

Question 19 **(16 marks)**

A 0.680 kg solid sample of an unknown substance is heated slowly while inside an insulated container. The graph below illustrates the heating curve of this substance.

Heating curve for 0.680 kg of an unknown substance



(a) State the temperature at which

(i) the substance boils. (1 mark)

Answer: _____

(ii) the substance melts. (1 mark)

Answer: _____

See next page

(b) Explain why the temperature remains constant between Points A and B on the graph even though energy has been added. Your answer should demonstrate your understanding of phase change and temperature at a particle level. (6 marks)

(c) Calculate the latent heat of vaporisation of this substance, and give the correct units. (4 marks)

(d) Calculate the specific heat capacity of this substance in the liquid phase. (4 marks)

See next page

Question 20 **(16 marks)**

(a) Polonium-212 is one of the many isotopes of polonium. Explain what is meant by the term ‘isotope’. (2 marks)

(b) Polonium-212 is unstable and can decay to emit alpha radiation from its nucleus. An alpha particle is identical to a helium nucleus. State the atomic number and mass number of an alpha particle. (2 marks)

Atomic number = _____ Mass number = _____

(c) When polonium-212 emits an alpha particle, it also forms a new element, which has been called ‘element X’ in the equation below. Write the nuclide (symbol) for the alpha particle and then name element X. (2 marks)

$$^{212}_{84}\mathrm{Po} \rightarrow {}^{208}_{82}\mathrm{X} + \alpha$$

Nuclide for alpha particle: _____

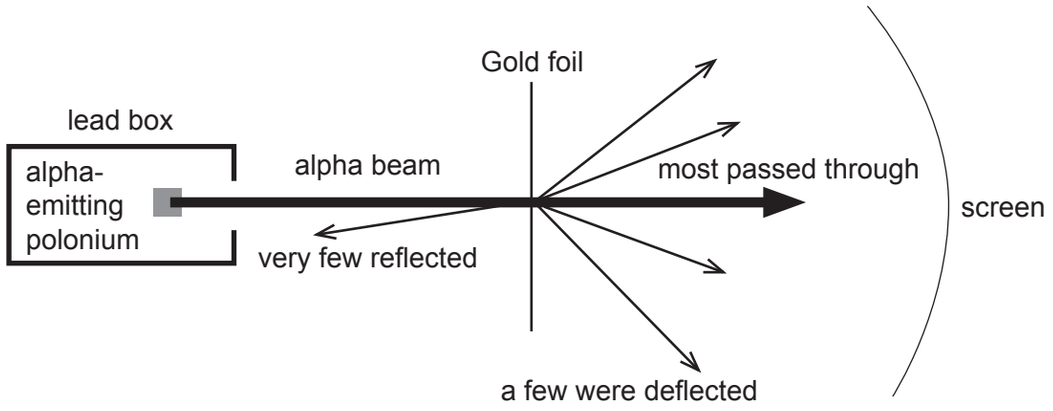
Name of element X: _____

(d) Alpha radiation is dangerous to the human body, as it is an ionising radiation. Explain what is meant by the term ‘ionising radiation’. (2 marks)

(e) Consider polonium-218. This isotope has a half-life of 3.00 minutes. If a sample of polonium-218 has an activity of 21.0 kBq, calculate the activity of the sample 30.0 minutes later. (3 marks)

See next page

Ernest Rutherford (1871–1937) experimented with alpha radiation. He built an alpha probe that consisted of a point source of alpha radiation. This radiation was shot through very thin gold foil to a screen surrounding the equipment. He found that most of the alpha particles passed through the gold foil with little or no change in direction; occasionally a particle was deflected significantly to the side; and, very rarely, a particle was reflected off the foil. The diagram below illustrates Rutherford's experiment.

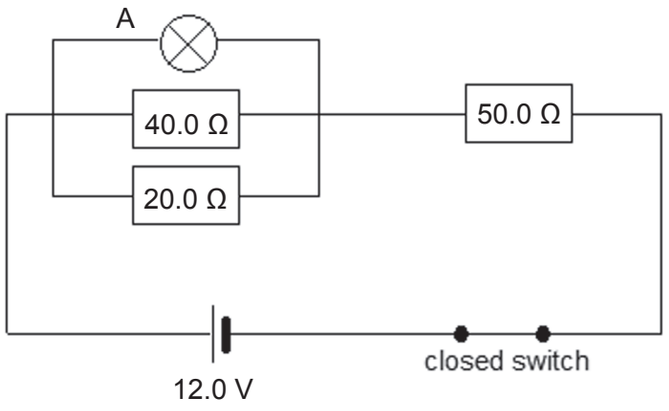


(f) Before Rutherford's experiment, the model of the atom developed by J.J. Thomson was of negatively-charged electrons embedded within a positively-charged gel. This was called the 'plum pudding' model. Rutherford's model of the atom formed the foundation for our current understanding of the atom. Describe Rutherford's model of the atom and explain how the experiment above helped him to develop this model. (5 marks)

See next page

Question 21 **(16 marks)**

During a practical lesson a group of students constructed a circuit that contained a 40.0 Ω resistor, a 20.0 Ω resistor and a lamp ('A'), in parallel with each other. This combination was then placed in series with a 50.0 Ω resistor, as shown below. The lamp had a resistance of 40.0 Ω and the circuit was connected to a power pack set on 12.0 V. For this question, assume that Lamp A was an ohmic resistor.



(a) On the diagram above, use an arrow to indicate the direction of electron current in this circuit. (1 mark)

(b) Calculate the total resistance of the circuit. (4 marks)

See next page

(c) Calculate the total current in the circuit. (2 marks)

(d) The students then used a voltmeter to measure the potential difference across the 50.0 Ω resistor.

(i) On the diagram on page 20, draw how they connected the voltmeter to the circuit. (1 mark)

(ii) Calculate the potential difference across the 50.0 Ω resistor. (2 marks)

(e) Determine the power dispersed in the 50.0 Ω resistor. (2 marks)

(f) The 20.0 Ω resistor was then removed from the circuit and replaced with another ohmic lamp, 'B', with a resistance of 20.0 Ω.

(i) Circle the correct response. Compared with Lamp B, Lamp A is now

brighter the same brightness dimmer (1 mark)

(ii) Explain your answer. (3 marks)

See next page

Question 22 **(18 marks)**

Melissa and Aidan are roller skating at the local park. Aidan, who has a mass of 80.0 kg, is skating at 5.00 m s^{-1} west toward Melissa. Melissa, with a mass of 55.0 kg, is stationary. After Aidan collides with Melissa, she moves away with a velocity of 3.40 m s^{-1} west.

(a) Name one physics quantity that will definitely be conserved in this situation. (1 mark)

(b) Calculate Aidan's momentum before the collision including correct units. (3 marks)

(c) Calculate Aidan's velocity (in metres per second) and direction after the collision. (5 marks)

See next page

(d) Consider the changes in kinetic energy before and after the collision.

(i) Calculate the total kinetic energy in joules before the collision. (3 marks)

(ii) Calculate the total kinetic energy in joules after the collision. (4 marks)

(iii) Considering your answers to (i) and (ii) above, explain how the law of conservation of energy applies to this collision. (2 marks)

See next page

Question 23 **(19 marks)**

Several students were carrying out an investigation to determine the resistance of an unknown device. They set up a suitable circuit and measured the current while changing the potential difference. The table below shows their results.

Potential Difference (V)	Current (A)	Calculated resistance (Ω) to three significant figures
1.00	0.0740	
1.50	0.0940	
2.00	0.136	
2.50	0.165	
3.00	0.198	
3.50	0.230	
	Average resistance	

(a) Complete the table above, calculating each resistance value and the average resistance, to **three** significant figures. (3 marks)

(b) Any investigation has a number of variables that can affect the results. For this investigation, name the independent and dependent variables. (2 marks)

Independent variable: _____

Dependent variable: _____

(c) The accuracy of any measurement is affected by the precision of the instrument used. With the ammeter, the students were able to read the current accurately to three decimal places. Complete the reading below to include the absolute error of this reading. (1 mark)

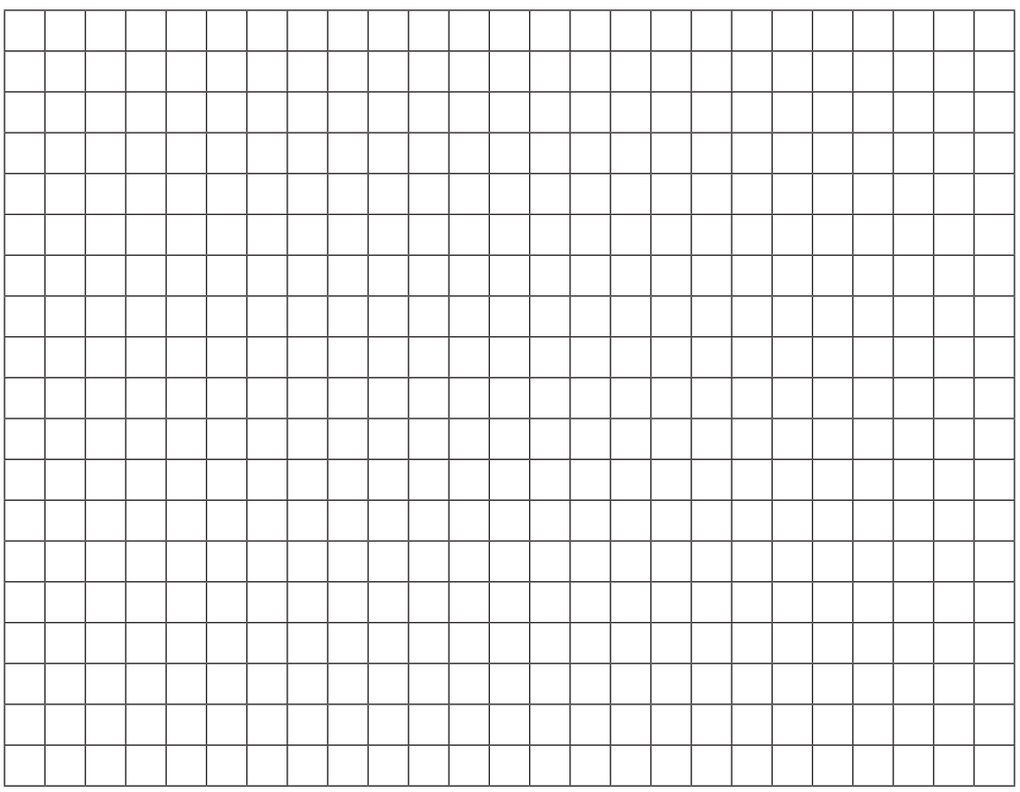
0.250 ± _____ A

(d) Draw a simple circuit that includes the device, power pack, an ammeter and a voltmeter that could be used to conduct this investigation. Label the ammeter ‘A’ and the voltmeter ‘V’. (3 marks)

See next page

(e) Use the grid below to graph the potential difference against the current.

Plot the potential difference on the Y-axis and the current on the X-axis. Rule in a line of best fit. (3 marks)



If you wish to make a second attempt at this item, the grid is repeated at the end of this Question/Answer Booklet. Indicate clearly on this page if you have used the second grid and cancel the working on the grid on this page.

(f) Determine the gradient of the line of best fit and include the correct units in your answer. (3 marks)

See next page

Question 23 (continued)

(g) Resistors can be ohmic or non-ohmic.

(i) Is the unknown device ohmic or non-ohmic? Circle the correct answer. (1 mark)

ohmic non-ohmic

(ii) Justify your choice by explaining the difference between an ohmic and a non-ohmic resistor. (3 marks)

End of Section Two

Section Three: Comprehension **10% (18 Marks)**

This section has **one (1)** question. You must answer this question. Write your answer in the spaces provided.

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Suggested working time: 20 minutes.

Question 24 **(18 marks)**

A forty-three tonne glider

Thunderstorms can produce lightning bolts with an average 1.00×10^9 V carrying a current of 1.00×10^5 A. Most pilots are not seriously concerned about lightning, as the outer skin of most aircraft is made primarily of aluminium. When lightning strikes the skin, charge flows from the contact point to the back of the aircraft, where it is discharged into the air.

In 1988, a new Boeing 737 aircraft with 45 people on board was coming in to land at New Orleans when it passed through a thunderstorm. At an altitude of about 5000 m, the aircraft suddenly lost thrust in both engines and all electrical power. The aircraft was now a 43-tonne glider.

With only three minutes to find a place to land, the pilot had the choice of a crowded freeway or a waterway. New Orleans is surrounded by waterways enclosed in levees (permanent grass-covered banks), which are designed to prevent the water from flooding the city. If he landed the aircraft on the freeway, many more people could die. The pilot then spotted a grass-covered levee to the right of a waterway. While the levee was shorter and narrower than a runway, it was solid, and safer than the water.

Lining up with the levee was difficult, but was successfully achieved. Despite having neither engine thrust nor brakes, a successful landing was made on the levee. The landing was hard and, as one passenger described, their seatbelts prevented them from shooting forward and crashing into the seat in front of them.

Investigators arrived within hours. They decided to replace one engine and the aircraft flew off the levee to New Orleans. The take-off speed for a Boeing 737 is 250 km h^{-1} and this speed was reached in 360 m during the take-off from the levee.

See next page

Question 24 (continued)

(a) Lightning can be five times hotter than the surface of the Sun, but as it strikes an aircraft for only about 4.00×10^{-7} s, this is not usually a problem.

Using the data given in the article, calculate the average energy of one lightning strike on an aircraft. (3 marks)

(b) Calculate the total charge in coulombs involved in one average lightning strike. (2 marks)

See next page

(c) Using the charge on one electron from the Formulae and Data Booklet, calculate the number of electrons that would enter the aircraft during a 4.00×10^{-7} s strike. Assume that all the charge in the lightning strike is carried by electrons. (2 marks)

(d) As well as electricity, heat can be conducted along an aircraft. Explain the process of heat conduction in metals such as aluminium. (3 marks)

See next page

Question 24 (continued)

(e) Part of the air conditioning process in an aircraft involves compressed air being squirted into an expansion chamber, which causes the air to cool rapidly as it expands. Explain why this occurs. (2 marks)

(f) State Newton's first law of motion and then, using your understanding of this law, explain why seatbelts help to prevent injury. (3 marks)

Newton's first law:

Explanation:

See next page

(g) Using the information given in the passage, calculate the acceleration of the aircraft when it took off from the levee. (3 marks)

End of questions

Additional working space

Additional working space

Additional working space

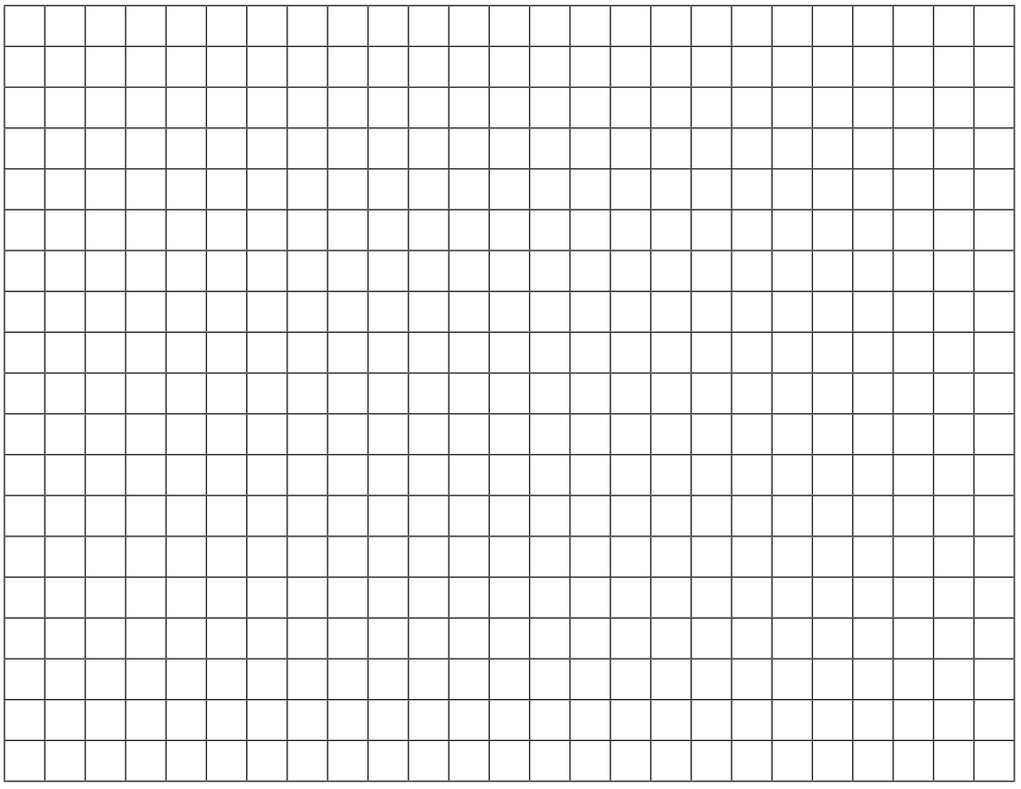
Additional working space

Additional working space

Additional working space

Additional working space

Spare grid



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