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

WACE
Western Australian Certificate of Education

PHYSICS

Stage 2

WACE Examination 2013

Marking Key

Marking keys are an explicit statement about what the examiner expects of candidates when they respond to a question. They are essential to fair assessment because their proper construction underpins reliability and validity.

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

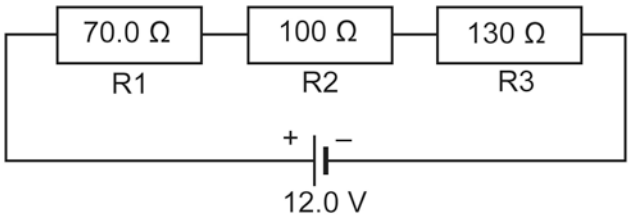
Question 1 **(4 marks)**

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.

Description	Marks
Using a Geiger counter measure the counts per minute a short measured distance from the sample. Place a sheet of paper between the source and Geiger counter and measure counts per minutes, repeat using a sheet of aluminium foil	1–2
If the sheet of paper results in a large drop in the count, the sample is alpha, if the aluminium causes a large drop in count then it is beta, otherwise it is emitting gamma radiation	1–2
Total	**4**

Question 2 **(4 marks)**

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



Description	Marks
Total resistance = 70 + 100 + 130 = 300 Ω	1
I_{total} = V/R	1
I_{total} = 12/300	1
I_{total} = 0.0400	1
Total	**4**

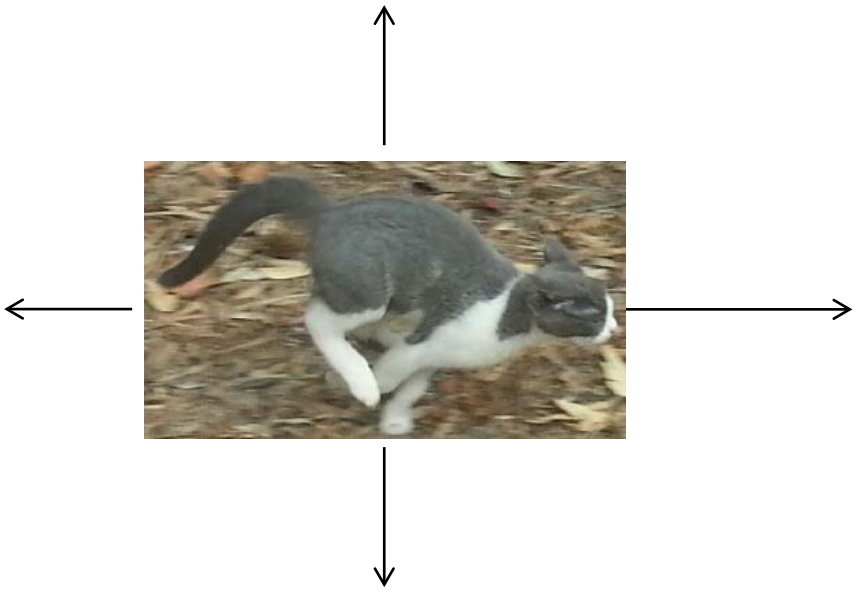
Question 3 **(3 marks)**

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

Description	Marks
F = mg = 62 × 9.8	1
608	1
N	1
Total	**3**

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.



description	Marks
Two vertical forces shown (normal and weight)	1
Two horizontal forces shown (air resistance and accelerating force)	1
Vertical forces same length	1
Accelerating force longer than retarding force	1
Total	**4**

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.

Description	Marks
Heat energy = electrical work (stated in questions) $mc\Delta T = qV$	1
$0.500 \times 4180 \times (100 - 20) = q \times 240$ $167\ 200 = 240 \times q$	1–2
697	1
C	1
Total	**5**

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 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.

Description	Marks
Students must show understanding that mSv is dose equivalent and include appropriate calculations for explanation Absorbed dose = dose equivalent / QF = 0.400 / 1 = 0.400 Gy	1–2
Energy = absorbed dose × mass = 0.400 × 57.0 = 22.8 J	1–2
Total	**4**

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.

Description	Marks
$P = V^2/R$ therefore $R = V^2/P$	1
$= 6^2 / 0.5$	1
72.0	1
Ω	1
Total	**4**

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.

Description	Marks
Ft = mv – mu OR Force × time = change in momentum	1
Value for change in momentum constant	1
If time of crash greater, force on passengers less	1–2
Total	**4**

Question 9 **(4 marks)**

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 the net heat transfer is from hotter objects to cooler objects.	
D	When a metal cube is heated without melting the kinetic energy of the particles increases.	

	Description	Marks
A	F	1
B	F	1
C	T	1
D	T	1
	Total	**4**

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 which is not stable, compared with one that is stable.

Description	Marks
An unstable element undergoes decay giving off radiation	1
A stable element does not decay	1
Total	**2**

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.

Description	Marks
$Q = mc\Delta T$ $5.24 \times 10^{3} = 0.0400 \times 126 \times (T - 20.3)$	1
$5.24 \times 10^{3} / 5.04 = T - 20.3$ $T = 1039.7 + 20.3$	1–2
$= 1.06 \times 10^{3}$ °C	1
Total	**4**

Question 12 **(3 marks)**

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

Description	Marks
Short circuit or other suitable answer	1
Total	**1**

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

Description	Marks
The fuse wire melts if the current is above a certain value	1
Melting wire causes the circuit in the device to be disconnected protecting the device and user from excess current	1
Total	**2**

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.

Description	Marks
Work = mgh	1
Work = 0.130 × 9.8 × 0.700	1
Work = 0.892 J	1
Total	**3**

Question 14 **(4 marks**

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

Description	Marks
Kinetic theory states that particles in fixed positions and vibrate	1
Heat from candle caused particles to increase in vibration	1
Increased in vibration means they move further apart so wire expands	1
Wire expands and gets longer so mass closer to ground.	1
Total	**4**

Question 15 **(4 marks)**

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

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

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

Description	Marks
$(5.01 \times 10^{-27} \times 2) - (6.64 \times 10^{-27} + [2 \times 1.67 \times 10^{-27}])$ $1.002 \times 10^{-26} - 9.98 \times 10^{-27}$ Mass defect = 4×10^{-29} kg	1–2
$E = mc^2$ $= 4.00 \times 10^{-29} \times (3 \times 10^{8})^2$	1
$E = 3.60 \times 10^{-12}$ J	1
Total	**4**

Question 16 **(4 marks)**

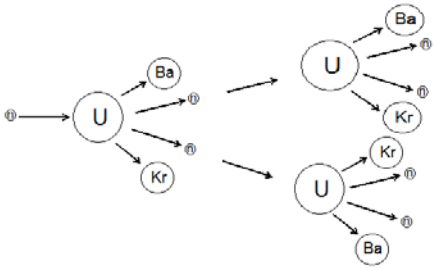
Consider the following nuclear reaction for uranium:

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

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

Description	Marks
2	1
Total	**1**

(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)

Description	Marks
Diagram should contain the following: • A neutron hitting a U-235 atom which splits into daughter products releasing at least 2 neutrons • These two neutrons hit other U-235 atoms releasing daughter products and neutrons • Some appropriate labels  	1–3
Total	**3**

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

Description	Marks
Potential energy – same	1
Kinetic energy – less	1
Power output – less	1
Total	**3**

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.

Description	Marks
$s = ut + ½ gt^2$	1
$s = (3.40 \times 6.7) + (½ \times 9.8 \times 6.7^2)$ $s = 22.78 + 219.961$	1–2
$s = 243$ m	1
Note: If have u = 0 then s = 220 m maximum 3 marks	
Total	**4**

End of Section One

Section Two: Problem-solving **50% (85 Marks)**

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.

(a) State the temperature at which

(i) the substance boils. (1 mark)

Description	Marks
84 °C	1
Total	**1**

(ii) the substance melts. (1 mark)

Description	Marks
22 °C (accept from 21°C to 23 °C)	1
Total	**1**

(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)

Description	Marks
Between these points the substance is melting	1
The energy added is used move particles further apart	1
This is an increase in potential energy	1
Temperature is a measure of the average kinetic energy	1
As there is no change in kinetic energy	1
There is no change in temperature.	1
Total	**6**

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

Description	Marks
$Q = 13 \times 10^4 - 8 \times 10^4 = 5 \times 10^4$ J	1
$L_v = Q/m = 5 \times 10^4 / 0.680$	1
$L_v = 7.35 \times 10^4$	1
J kg^{-1}	1
Total	**4**

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

Description	Marks
$\Delta T = 84 - 22 = 62$ °C	1
$Q = (8 - 4) \times 10^4 = 4 \times 10^4$ J	1
$c = Q / (m \times \Delta T) = 4 \times 10^4 / (0.68 \times 62)$	1
$c = 949$ J kg^{-1} K^{-1}	1
No penalty for using incorrect temperature values from (a) or incorrect or missing units	
Total	**4**

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)

Description	Marks
Two samples that have the same number of protons (same atomic number)	1
But have different numbers of neutrons (different mass number)	1
Total	**2**

(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)

Description	Marks
Atomic number = 2	1
Mass number = 4	1
Total	**2**

(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)

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

Description	Marks
$^4_2He \quad or \quad ^4_2\alpha$	1
Lead	1
Total	**2**

(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)

Description	Marks
Radiation that causes atoms to lose an electron	1
And become an ion	1
Total	**2**

(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)

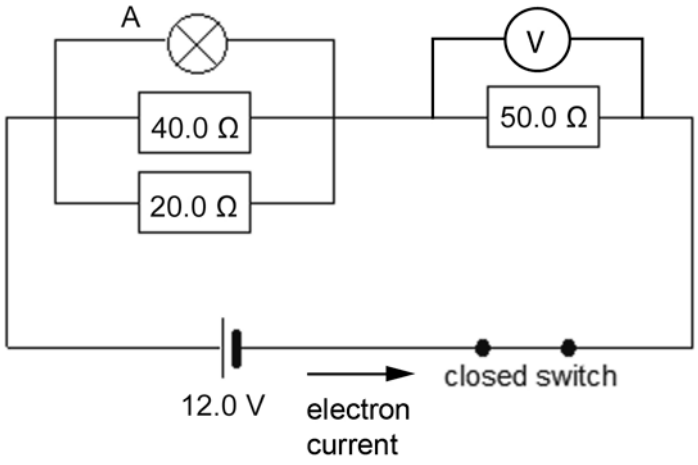
Description	Marks
Number of half-lives = 30/3 = 10	1
$A = A_0 \times (0.5)^n = 21 \times (0.5)^{10}$	1
$A = 21 \times 9.766 \times 10^{-4}$ $= 0.0205$ kBq	1
Student could divide activity by 2 ten times to get answer but must show working for full marks	
Total	**3**

(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 described helped him to develop this model. (5 marks)

Description	Marks
Mainly space with small positively centrally charged nucleus and electrons outside nucleus OR labelled diagram	1–2
Most of the alpha particles went straight through so mainly space	1
Positively charged centre due to a few positively charged alpha particles being repelled (like charges repel)	1
Small, dense centre as occasional alpha particle rebounds	1
Total	**5**

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)

Description	Marks
anticlockwise	1
Total	**1**

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

Description	Marks
$\frac{1}{R_{parallel}} = \frac{1}{20} + \frac{1}{40} + \frac{1}{40}$	1
$R_{parallel}$ = 10 Ω	1
R_{total} = 10 + 50	1
= 60.0 Ω	1
Total	**4**

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

Description	Marks
I = V/R = 12/60	1
I = 0.200 A	1
Total	**2**

(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)

Description	Marks
Shown on diagram, parallel to 50.0 Ω resistor	1
Total	**1**

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

Description	Marks
$V_{50} = I_{total} \times R_{50} = 0.20 \times 50$	1
V_{50} = 10.0 V	1
Total	**2**

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

Description	Marks
P = VI = 10 × 0.20	1
P = 2.00 W	1
Total	**2**

(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)

Description	Marks
Lamp A is the same brightness as Lamp B	1
Total	**1**

(ii) Explain your answer. (3 marks)

Description	Marks
In parallel so same potential difference	1
Same resistance (Lamp A) will have same current I = V/R	1
Brightness of lamp proportional to amount of current so same current in A results in same brightness	1
Total	**3**

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)

Description	Marks
Momentum (or mass)	1
Total	**1**

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

Description	Marks
$p = mv = 80 \times 5.0$	1
$p = 400$	1
kg m s^{-1}	1
Total	**3**

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

Description	Marks
$p_i = p_f$	1
$400 + 0 = (55 \times 3.4) + (80 \times v)$ $400 = 187 + 80v$	1–2
$v = 2.66$ m s^{-1}	1
west	1
Total	**5**

(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)

Description	Marks
Melissa stationary so no kinetic energy	1
Aidan - $E_k = ½ mv^2 = 0.5 \times 80 \times 5^2$	1
$E_k = 1.00 \times 10^3$ J	1
Total	**3**

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

Description	Marks
Melissa: $E_k = 0.5 \times 55 \times 3.40^2 = 318$ J	1
Aidan: $E_k = 0.5 \times 80 \times 2.66^2 = 283$ J	1
$E_k = 318 + 283 = 601$ J	1
$E_k = 601$ J	1
Total	**4**

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

Description	Marks
The change in kinetic energy is due to the initial kinetic energy being transformed into other forms of energy	1
Any numerical reference to the change in kinetic energy. For example, 399 J	1
Total	**2**

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	13.5
1.50	0.0940	16.0
2.00	0.136	14.7
2.50	0.165	15.2
3.00	0.198	15.2
3.50	0.230	15.2
	Average resistance	15.0

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

Description	Marks
Calculated values correct	1
Average is 15.0	1
Three significant figures shown on all values	1
Total	**3**

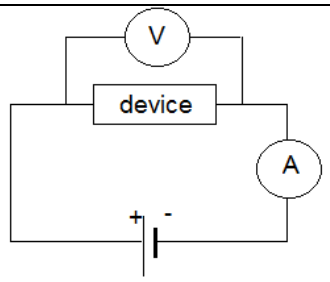
(b) Any investigation has a number of variables that can affect the results. For this investigation, name the independent and dependent variables. (2 marks)

Description	Marks
Independent variable – potential difference	1
Dependent variable - current	1
Total	**2**

(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)

Description	Marks
0.250 ± 0.0005 A	1
Total	**1**

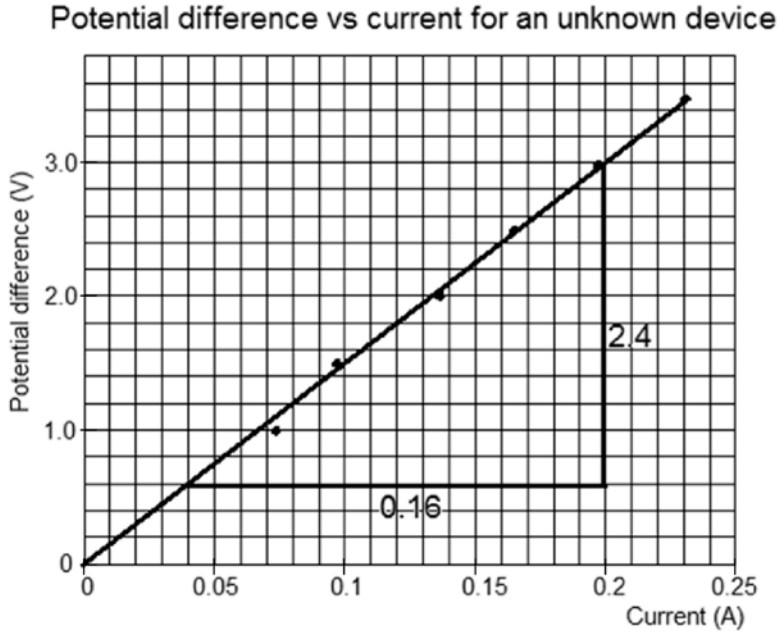
(d) Draw a simple circuit that includes the device, power pack, an ammeter and a voltmeter that could be used to conduct this investigation. Label the ammeter ‘A’ and the voltmeter ‘V’. (3 marks)

Description	Marks
	1–2
Labels for voltmeter and ammeter	1
Total	**3**

(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)

Description	Marks
Axis have correct labels	1
Points clearly shown and correctly plotted	1
Accurate ruled line of best fit	1
Total	**3**



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

Description	Marks
Gradient = rise/run = 2.4 / 0.16 = 15 Ω (range between 14 and 16 Ω)	1
Values are not data points in the table	1
Units = Ω or V A^{-1}	1
Total	**3**

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

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

Description	Marks
Ohmic	1
Total	**1**

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

Description	Marks
Ohmic resistors obey Ohm's Law, V = IR	1
current is proportional to the potential difference producing a straight line graph	1
Non-ohmic resistors do not obey Ohm's Law. Current is not proportional to potential difference	1
Total	**3**

End of Section Two

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

Question 24 **(18 marks)**

(a) Lightning can be five times hotter than the surface of the Sun, but as it strikes an aircraft for only about 4.0×10^{-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)

Description	Marks
Energy = W = VIt = $1 \times 10^{9} \times 1 \times 10^{5} \times 4.0 \times 10^{-7}$	1–2
Energy = 4.00×10^{7} J	1
Total	**3**

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

Description	Marks
Total charge is q = It = $1 \times 10^{5} \times 4.0 \times 10^{-7}$	1
Total q = 0.0400 C	1
Total	**2**

(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)

Description	Marks
Number of electrons = total charge / charge on an electron $= 0.04 / 1.6 \times 10^{-19}$	1
Number of electrons = 2.50×10^{17} electrons	1
Total	**2**

(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)

Description	Marks
Heat energy causes the kinetic energy of the particles to increase	1
Increase in kinetic energy results in an increase in vibrations	1
Vibrations passed along from atom to atom increasing average kinetic energy (and temperature) along the metal or reference to mobile electrons.	1
Total	**3**

(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)

Description	Marks
When particles move apart they gain potential energy	1
This energy is taken from the surroundings thus cooling them	1
Total	**2**

(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)

Description	Marks
Objects remain in their state of motion unless acted on by a net external force	1
As the aircraft comes into land the people are moving at the same speed as the aircraft	1
The seatbelts hold the people against their seats as the aircraft stops quickly and prevents them from continuing forward	1
Total	**3**

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

Description	Marks
$v = 250 \text{ km h}^{-1} = 69.4 \text{ m s}^{-1}$	1
$v^2 = u^2 + 2as$ $69.4^2 = 2 \times a \times 360$ $4823 = 720a$	1
$a = 6.70 \text{ m s}^{-2}$	1
Total	**3**

End of questions

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