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

WACE
Western Australian Certificate of Education

Western Australian Certificate of Education Examination, 2014

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: 14-115

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	66	40
Section Two: Problem-solving	6	6	90	87	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 2014*. 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** to be handed in with your Question/Answer Booklet.

See next page

Section One: Short answers **40% (66 Marks)**

This section has **18** 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.

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.

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Suggested working time: 70 minutes.

Question 1 **(4 marks)**

A farmer walked 745 m west from a gate to repair a fence post. When that job was finished he turned around and walked 984 m east to repair another part of the fence. Draw and label a vector diagram of his total journey then calculate his resultant displacement.

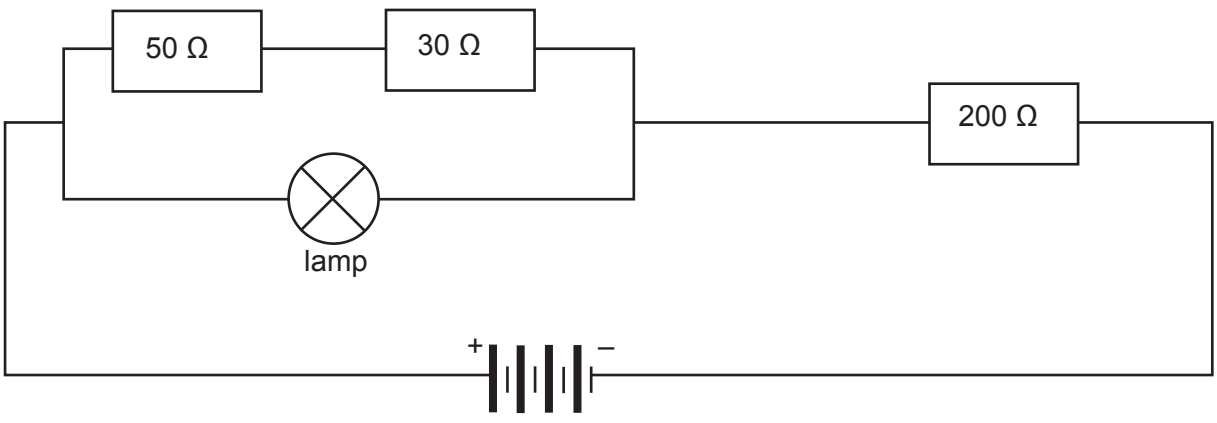
Question 2 **(4 marks)**

Using the lithium-7 atom as the example, draw a labelled diagram to represent the model of the atom.

Question 3 **(5 marks)**

To the circuit diagram below, add:

- an ammeter to measure the current through the 50 Ω resistor, indicating which connection is positive and which is negative
- a voltmeter to measure the potential difference across the 200 Ω resistor, indicating which connection is positive and which is negative
- a switch to allow the lamp to be turned on and off without switching the rest of the circuit on or off.



See next page

Question 4 **(3 marks)**

The fusion of deuterium and tritium to form helium can be represented by the equation:

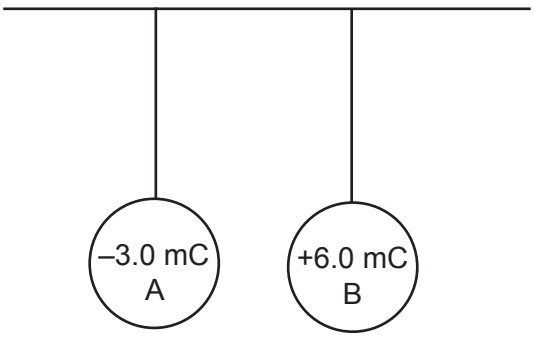
$$^{2}_{1}\mathrm{H} + ^{3}_{1}\mathrm{H} \longrightarrow ^{4}_{2}\mathrm{He} + ^{1}_{0}\mathrm{n}.$$

If the mass defect for this reaction is 0.0189 u, calculate the energy released, in joules, in one such fusion reaction.

See next page

Question 5 **(3 marks)**

A student suspended two identical metallic spheres, ‘A’ and ‘B’, from an insulated wooden rod, and applied a charge to each, as shown below.



(a) Did the spheres attract or repel each other? Circle the correct response: (1 mark)

Attract Repel

(b) (i) The student touched the spheres together, and they then moved apart. Determine the overall charge, in coulombs, on the pair of spheres after they were touched together. (1 mark)

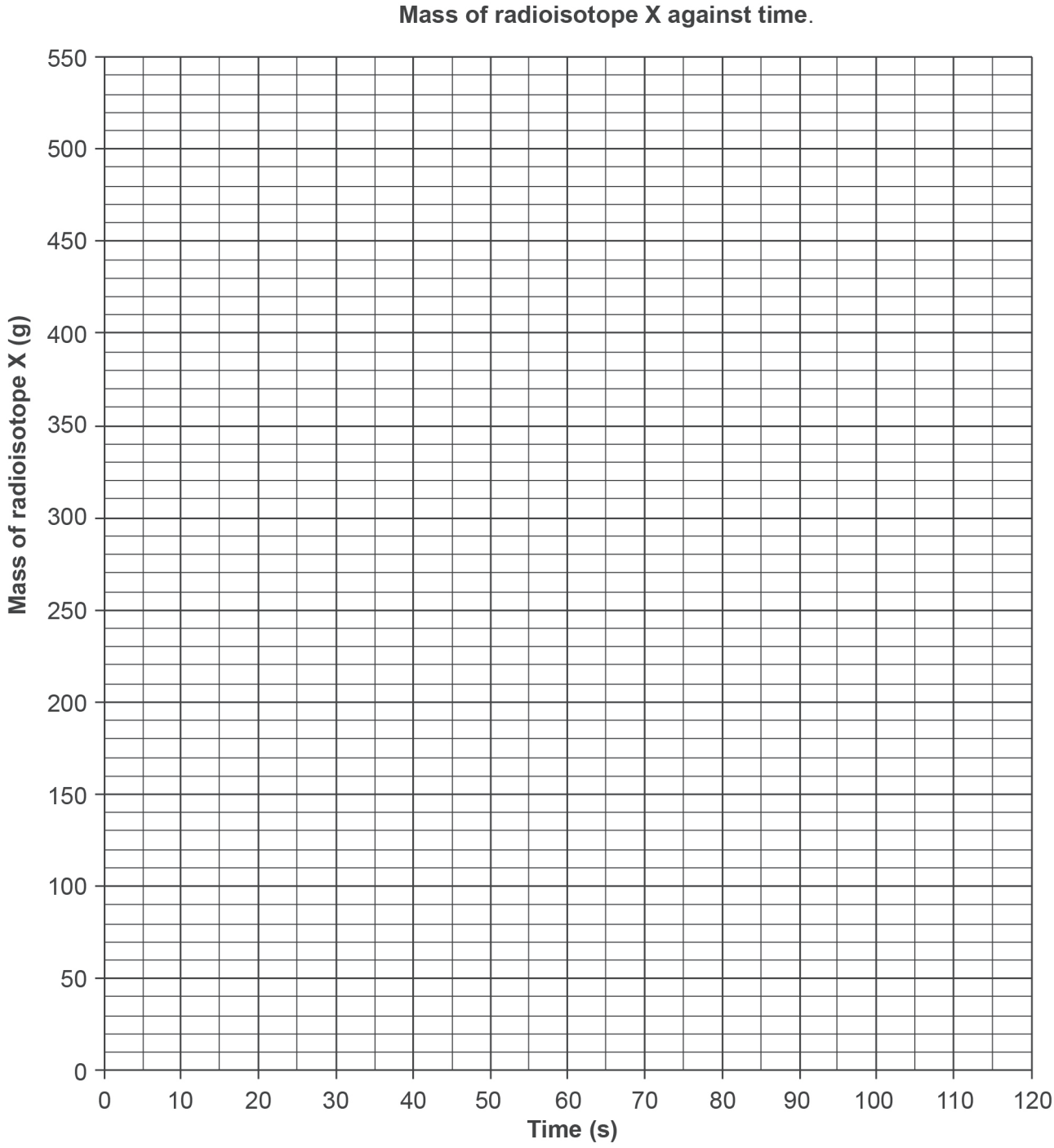
(ii) Determine the charge on each sphere after they had separated. (1 mark)

Charge on A: _____ Charge on B: _____

See next page

Question 6 **(3 marks)**

Radioisotope X has a half-life of 30 s. Given an initial mass of 480 g of pure X, draw a graph of the mass of X present between time = 0 and time = 120 s.



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 this page.

See next page

Question 7 **(4 marks)**

On a stormy night, lightning struck the ground. It took 0.200 s for 1.50×10^{20} electrons to travel from the cloud to the ground.

(a) Calculate the current, in amperes, between the cloud and the ground. (2 marks)

(b) If the potential difference between the storm cloud and the Earth was 7.00×10^{8} V, calculate the energy, in joules, that was released by the lightning during the strike. (2 marks)

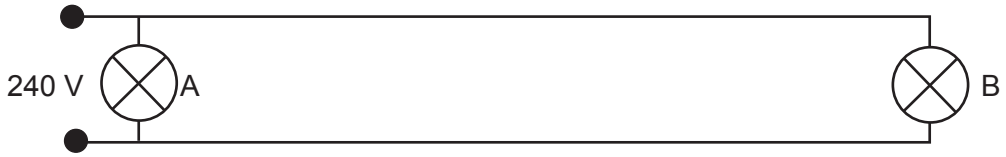
Question 8 **(4 marks)**

A runway at a small airport is 1220 m long. A light aircraft accelerates at 0.785 m s^{-2} along this runway, starting at one end and taking off 200 m before reaching the other end. If the aircraft was initially stationary, calculate its speed when it took off. Show **all** workings, and give the appropriate unit.

See next page

Question 9 **(4 marks)**

An outdoor lighting system uses two identical lamps plugged into the same double power outlet. One lamp is on the end of a 20 m extension cord and the other is plugged directly into the power outlet, as shown below. Assume that the lamps are ohmic and that the wire has a resistance.



(a) Circle the correct response. (1 mark)

When the lamps are turned on,

lamp A is brighter than lamp B.	the lamps are the same brightness.	lamp B is brighter than lamp A.

(b) Explain your answer to Part (a) with reference to Ohm's law. (3 marks)

See next page

Question 10 **(3 marks)**

In a uranium mine the workers are lowered into the mine shaft in an enclosed metal lift. If alpha, beta and gamma radiation are all emitted by the rocks around the lift shaft, state the main radiation type or types the workers are exposed to inside the lift. Justify your answer.

Question 11 **(4 marks)**

State whether each of the following statements is true or false.

	Statement	True or False
A	When a nucleus is unstable, it decays to emit alpha, beta and gamma radiation all at the same time.	
B	Ionising radiation causes an atom to lose a proton and thus become charged.	
C	Solar energy is produced by nuclear fusion reactions.	
D	Binding energy is the energy needed to bind atoms to each other.	

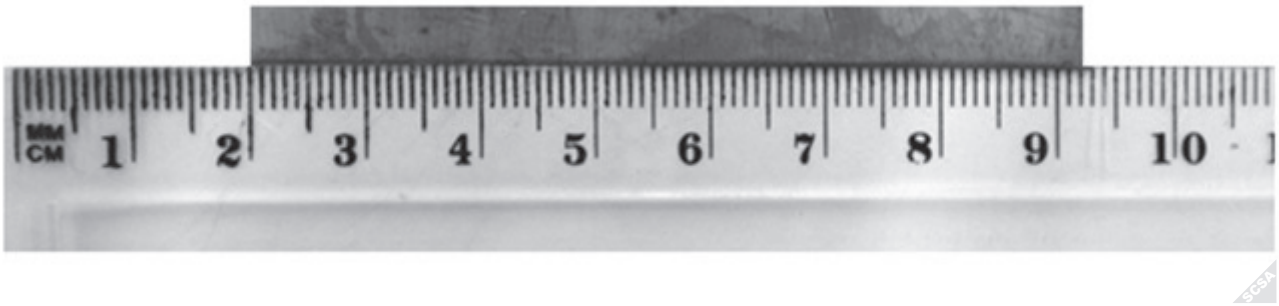
See next page

Question 12 **(4 marks)**

The photographs below show a thermometer used to measure the temperature of a solution, and a ruler measuring the length of a metal strip. For each photograph, record the measurement and state the uncertainty of the measurement.

The temperature measured by the thermometer is _____ ºC.

The uncertainty is _____ºC.



The length of the metal strip measured by the ruler is _____ cm.

The uncertainty is _____ cm.

See next page

Question 13 **(3 marks)**

On a hot day, Sam stepped off a bridge into the water below. Using the idea of conservation of energy, calculate Sam's speed, in metres per second, when he reached the water 3.40 m below. Show **all** workings.

Question 14 **(3 marks)**

When you walk across a bridge you sometimes see expansion joints. These are gaps between the different parts of the bridge. On hot, sunny days these gaps are narrower than on cold winter days. Use your understanding of the kinetic theory to explain why this is so.

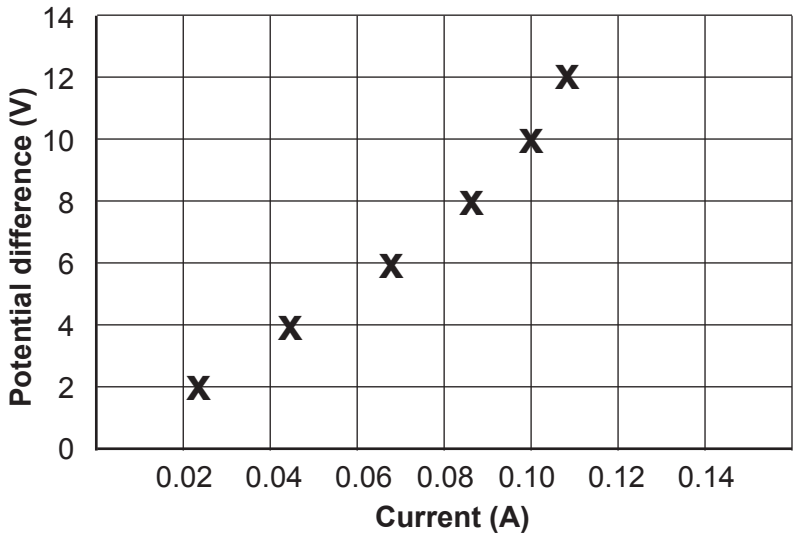
See next page

Question 15 **(3 marks)**

A student was carrying out an experiment on an electrical component by measuring the current and the potential difference. The student graphed the results as shown below.

On the graph, circle the section that shows the component acting as a non-ohmic resistor. Justify your answer.

Potential difference versus current for a component



See next page

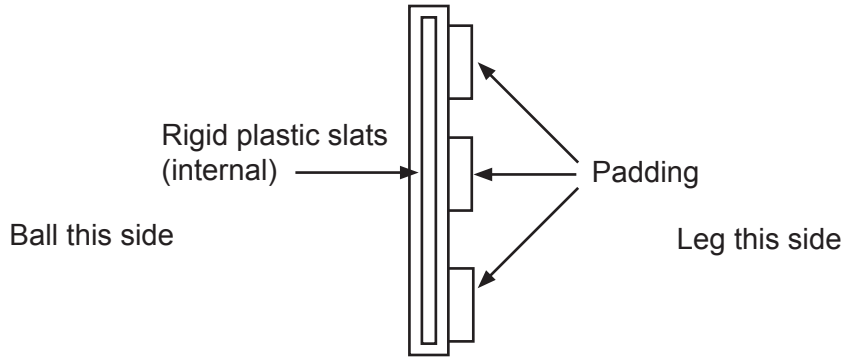
Question 16 **(4 marks)**

A worker with a mass of 85.5 kg was involved in a nuclear accident and received 9.55 J of radioactive energy from an alpha source. Calculate the dose equivalent the worker received. Include the correct unit in your answer. Show **all** workings.

See next page

Question 17 **(3 marks)**

In the game of cricket, a batsman wears pads on his legs to protect them from injury by a fast moving ball. Each pad has 3 cm of padding between it and the batsman's leg and each pad has rigid plastic slats built into it, as shown in the diagram below.



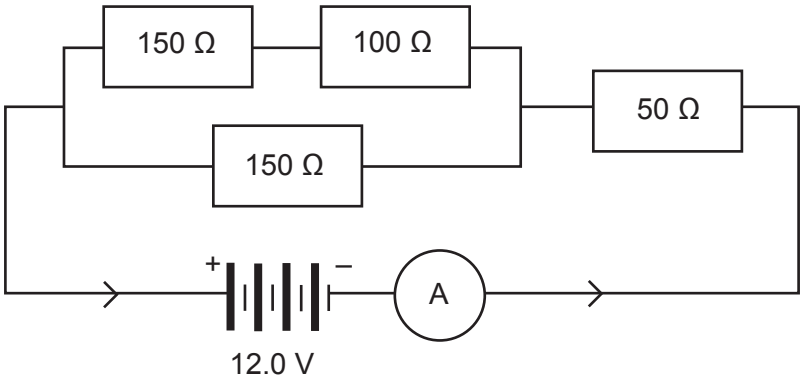
Side view of a cricket pad

Explain, using your understanding of one of Newton's laws, how the padding reduces injury to the batsman's leg if it is hit by a cricket ball.

See next page

Question 18 **(5 marks)**

The diagram below illustrates a simple circuit.



(a) Do the arrows on the diagram indicate conventional current or electron current? Circle the correct response. (1 mark)

Conventional current Electron current

(b) Calculate the current, in amperes, through the ammeter shown in the circuit diagram above. Show **all** workings. (4 marks)

End of Section One

See next page

Section Two: Problem Solving **50% (87 Marks)**

This section has **six (6)** 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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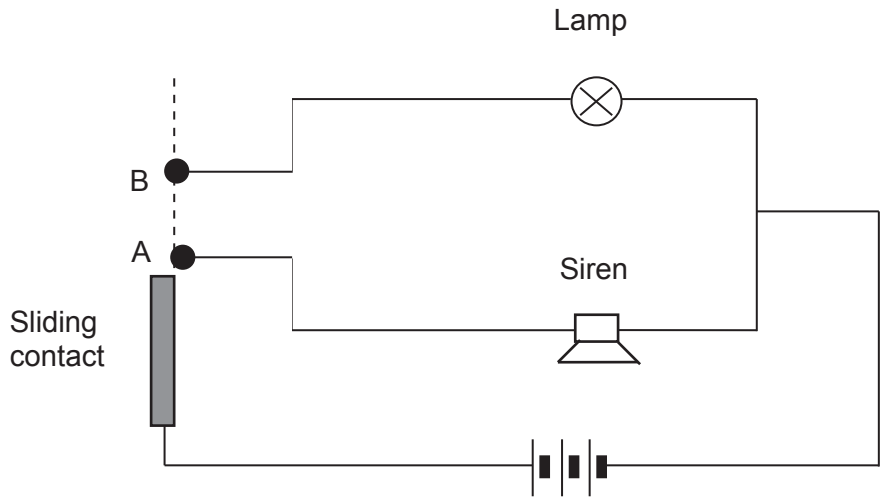
Suggested working time: 90 minutes.

Question 19 **(16 marks)**

A toy police car can have a light on, a siren, on or both light and siren on at the same time. A simplified circuit, showing how a sliding switch achieves these three options, is shown below.



Points ‘A’ and ‘B’ are both contact points. The sliding contact may be moved so that

- only Point A is in contact
- Points A and B are both in contact
- only Point B is in contact.

(a) When the sliding contact is in contact with Point A only, is the circuit a series or parallel circuit? Circle the correct response. (1 mark)

Series Parallel

See next page

Question 19 (continued)

(b) When the sliding contact is in contact with both Points A and B, is the circuit a series or parallel circuit? Circle the correct response. (1 mark)

Series Parallel

(c) The siren has a resistance of 3.00 Ω. If the circuit is powered by a 9.00 V battery, calculate the current in amperes, when only the siren is operating. (2 marks)

(d) When both the lamp and the siren are on, the current supplied by the battery is 1.5 times higher than when the siren is on by itself.

(i) Determine the current, in amperes, in the operating lamp. (3 marks)

(ii) Calculate the resistance, in ohms, of the operating lamp. (2 marks)

(e) The contact is first placed so that only the lamp comes on. The contact is then moved so that only the siren comes on. Which of these two components has the greater power consumption? Explain. (4 marks)

(f) Calculate the total power drawn from the battery when both components are switched on. Include the correct unit in your answer. (3 marks)

Question 20 **(18 marks)**

Pat often makes a hot cup of tea. She brings the water to the boil at 100 ºC and adds it to the tea leaves. As the tea brews for a few minutes, it cools to 90.0 ºC. This is still too hot to drink so Pat pours the tea into a cup and blows on the surface of the tea until it cools to 65.0 ºC.

(a) Define the term 'internal energy'. (2 marks)

(b) Calculate the heat energy lost to the environment as 0.250 kg of tea in the cup cooled down from 90.0 ºC to 65.0 ºC. Assume that the specific heat capacity of tea is the same as that for water. (2 marks)

See next page

Question 20 (continued)

(c) Use the kinetic theory to explain why blowing on the surface of the tea helps the tea to cool down quickly. (5 marks)

On hot days, Pat makes iced tea by adding ice cubes at 0.00 °C to the pot of freshly brewed tea, cooling it from 90.0 ° to 0.00 °C.

(d) If the amount of liquid in the teapot was 0.250 kg, calculate the difference in internal energy between tea at 90.0 °C and iced tea at 0.00 °C. (2 marks)

See next page

(e) Calculate the mass of ice, in kilograms, that has to be added to the tea in the pot in Part (d) to bring the temperature of the liquid down to 0.00 ºC. Assume no loss of heat to the surroundings. Show **all** workings. (4 marks)

(f) In the real world, Pat would not need to add as much ice to the tea as calculated in Part (e) above. Using your understanding of heat transfer, explain why this is so. (3 marks)

See next page

Question 21 **(13 marks)**

Between 1917 and 1926 the U.S. Radium Corporation used radium-228 to produce paint that glowed in the dark. This paint was used by female workers to paint the hands and numbers on clocks and other instruments in aircraft. This enabled military pilots to read these instruments without turning on a light and giving the position of their aircraft away.

(a) An isotope of thorium decays to form radium-228 and an alpha particle.

(i) Write the nuclear equation to represent this decay. (2 marks)

(ii) State the atomic number and mass number of the thorium isotope. (2 marks)

Atomic number: _____

Mass number: _____

(b) Radium-228 is an isotope of radium. Define the term 'isotope'. (2 marks)

(c) The radium-228 paint on a pilot's instruments had an initial activity of 140 kBq. If the half-life of radium-228 is 5.80 years determine the activity in kBq of the radium on the instruments, 52.2 years later. Show **all** workings. (3 marks)

See next page

(d) Alpha particles, ${}^{4}_{2}\alpha$, are often emitted during the decay of radium. An alpha particle is similar in structure to a helium nucleus. Determine the binding energy, in MeV, of a helium nucleus. Use the information in your **Formulae and Data Booklet**, and show **all** workings. (4 marks)

See next page

Question 22 **(12 marks)**

In a dishwasher, the water combines with detergent and then the mixture is heated and sprayed against the dishes to clean them. The dirty water is pumped out and then fresh water, with a rinsing agent, rinses the dishes. Finally, the hot rinse water is pumped out and the hot dishes dry in the machine. The dishwasher in this question is connected to the 240 V electricity supply and draws a total current of 12.0 A.

(a) The heater in the dishwasher draws half the total current to heat the water during the washing cycle. Determine the power rating of the heater, including the correct unit. Show **all** workings. (3 marks)

(b) During the washing cycle, the dishwasher heats 6.50 kg of water from 15.0 ºC to 90.0 ºC. Using your answer from Part (a) above, calculate the time taken to heat the water. If you were unable to calculate a value for the power in Part (a), use a value of 1.50×10^3. Show **all** workings. (4 marks)

See next page

(c) In reality, the time taken to heat the water is longer than the time calculated in Part (b). Suggest **two** reasons why this is so. (2 marks)

One: _____

Two: _____

Another electrical device used in the kitchen is a toaster.

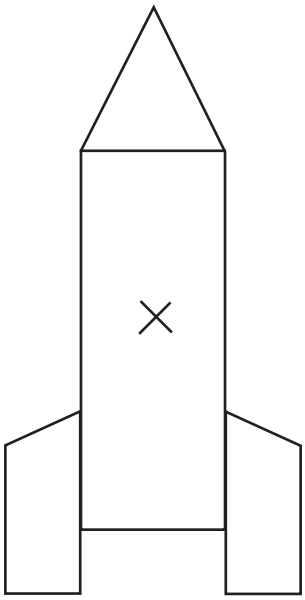
(d) Occasionally a piece of toast will get caught in the toaster. Explain why it is dangerous to use a metal knife to remove this toast without first turning off the toaster. (3 marks)

See next page

Question 23 **(18 marks)**

A toy rocket with a mass of 0.650 kg is fired straight upward. The chemical engine provides 8.50 N of thrust for 1.80 s with negligible loss of mass. The engine works for 1.80 s.

(a) Draw labelled vector arrows from point X on the rocket to show all the forces acting on the rocket in the first 1.80 s of flight. Include any frictional forces. The length of each arrow should represent the approximate magnitude of the force acting. (5 marks)



(b) The net acceleration of the rocket is affected by the thrust of the engine and the force of gravity. Calculate the acceleration of the rocket just before its engine stops working. Ignore any other forces acting on the rocket, and show **all** workings. (4 marks)

See next page

(c) Calculate the height, in metres, reached by the rocket at the moment when the engine stops working. If you were unable to calculate an answer to Part (b), use an acceleration value of 3.00 m s^{-2}.

(2 marks)

(d) Calculate the velocity in metres per second of the rocket, 1.80 s after the engine starts. If you could not calculate an answer to Part (b), use an acceleration of 3.00 m s^{-2} upward. Show **all** workings. (3 marks)

(e) Calculate the maximum height, in metres, reached by the rocket. Show **all** workings.

(4 marks)

(Hint: When calculating the displacement of the rocket after the engine stops working, use the velocity you calculated in Part (d) above as an initial velocity.)

See next page

Question 24 **(10 marks)**

The *Hydroptere*, an experimental hydrofoil super yacht, is one of the fastest yachts to sail the ocean. When it reaches a speed of about 15 knots it starts to rise up out of the water; until at 20 knots only about 2.5 m^2 of the yacht is in contact with the water. From this speed, with the appropriate wind conditions, the *Hydroptere* can accelerate rapidly to about 45 knots, appearing to be almost flying over the water.

(a) Given that 1 knot equals 0.5144 m s^{-1}, complete the third column of the table below to three significant figures. (2 marks)

Time (s)	Speed in knots	Speed in m s^{-1}
0	20.0	10.3
2.00	25.9	13.3
4.00	30.7	
5.00	31.9	
8.00	40.4	20.8
10.0	45.0	23.1

(b) Using the grid on page 29, plot a graph of speed (in m s^{-1}) against time and draw a straight line of best fit. (4 marks)

See next page

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 this page.

(c) Calculate the gradient of the line of best fit, including the correct units. Show **all** workings. (4 marks)

End of Section Two

See next page

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 25 **(18 marks)**

Trains

George Stephenson is considered to be the inventor of the steam locomotive. A locomotive hauling carriages is called a train. Early trains were used for hauling freight. He also built England's first public inter-city railway using steam locomotives in 1830.

Over the next hundred years, steam locomotives were developed and by the early twentieth century trains were travelling at an average speed of 45 km h^{-1} although some could reach a maximum speed of 80 km h^{-1}. A single locomotive, without the carriages, had a mass of about 200 tonnes, while a fully loaded freight train could have a mass of 12 000 tonnes. To keep a fully loaded train moving at an average speed of 45 km h^{-1} required 3000 horsepower (one horsepower equals 746 W).

Coal was usually used to power steam locomotives. A steam locomotive could hold 140 tonnes of coal and could produce enough energy to power a local neighbourhood.

By the 1950s, diesel locomotives were replacing steam locomotives. Diesel trains are now used for moving freight over long distances, but in many cities, such as Perth, electric trains carry passengers over the short distances between railway stations.

Perth's electric trains run on a 25 kV AC supply from overhead lines with the two rails helping to complete the circuit. While a 120 tonne electric train can travel at a speed of 260 km h^{-1}, it usually only reaches a maximum speed of 130 km h^{-1} between railway stations. Electric trains are considered to be safe. However, in 2006, two 120 tonne electric trains collided head-on at their depot. There were no passengers on board and the drivers involved were unhurt but the cost to repair the trains was over a million dollars.

See next page

(a) In steam locomotives, the energy from burning coal heats the water and converts it into steam. Using the kinetic theory of matter, explain the process involved in converting water into steam. (3 marks)

(b) Calculate the horsepower required to keep a train moving at 40 km h^{-1} if the engine provides a driving force of 1.45×10^5 N. Show **all** workings. (4 marks)

See next page

Question 25 (continued)

(c) Calculate the momentum of an electric train travelling at 30.0 m s^{-1} (108 km h^{-1}). Include the correct units in your answer. Show **all** workings. (4 marks)

(d) The energy released when 240.0 kg of coal burns can power one 60 W lamp continuously for one year. Calculate the mass, in tonnes, of coal required to power five hundred (500), 60 W lamps for one year. Show **all** workings. (2 marks)

See next page

(e) When the two 120 tonne electric trains collided at the depot, Train A was travelling at 3.40 m s^{-1} north, while Train B was travelling at 2.20 m s^{-1} south. After the crash, Train B rebounded to be travelling at 3.00 m s^{-1} north. Assuming that momentum was conserved in this collision, calculate the speed, in metres per second, and the direction of Train A after the collision. Show **all** workings. (5 marks)

End of questions

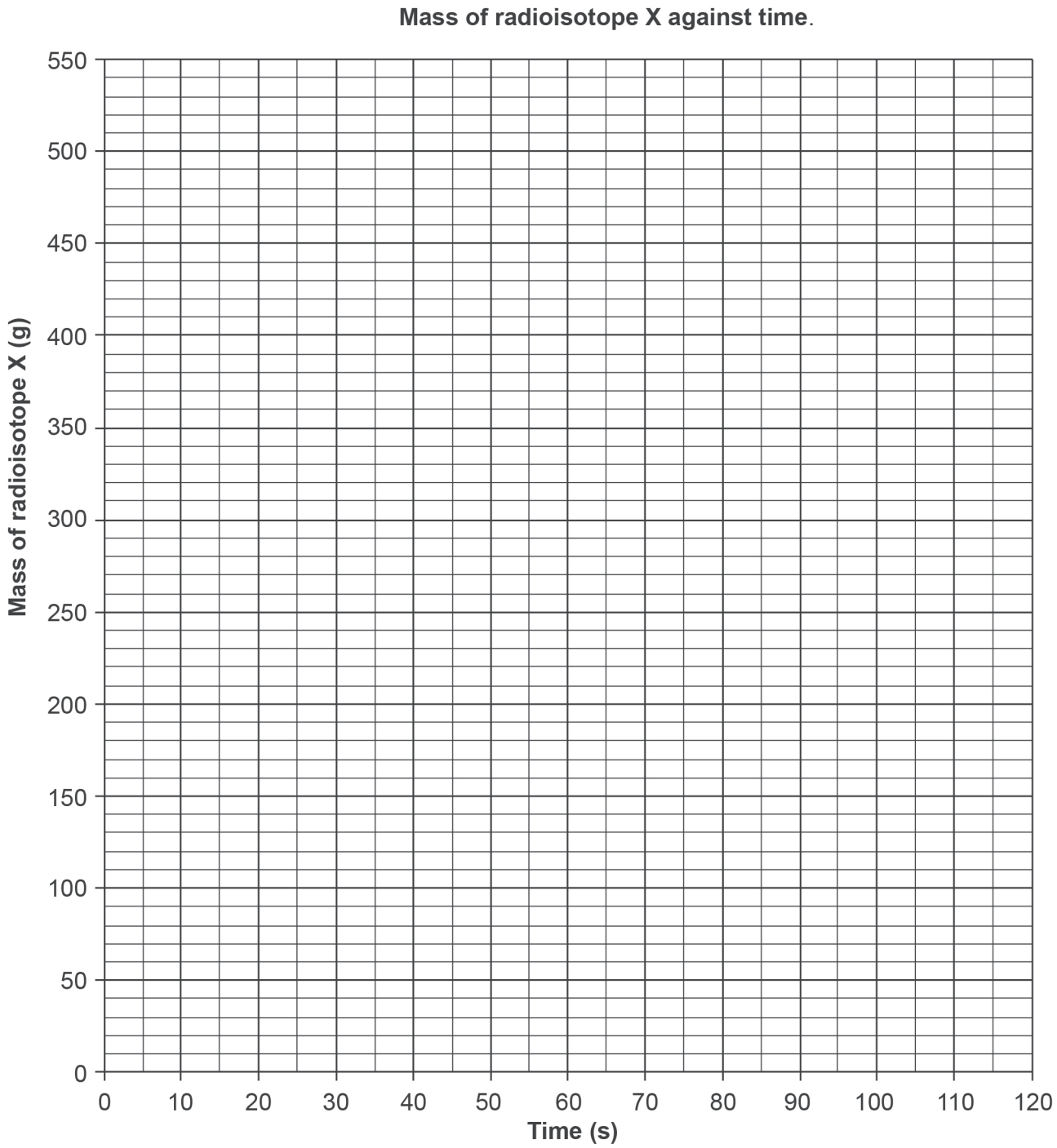
Additional working space

Additional working space

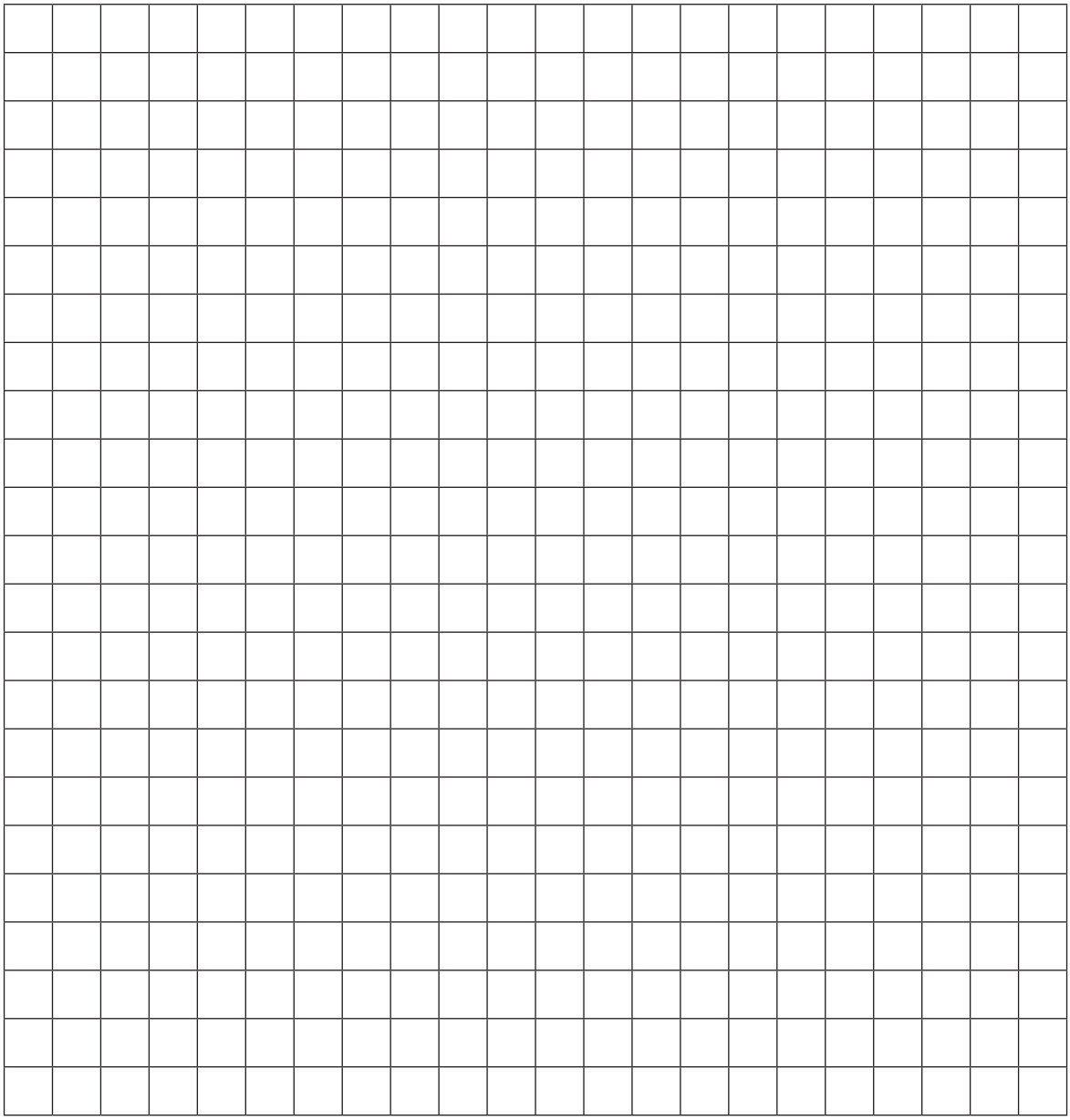
Additional working space

Additional working space

Spare grid for Question 6.



Spare grid for Question 24



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