



Methodist Ladies College
Semester Two Examination 2015
Question/Answer Booklet

ATAR Physics Year 11

Student Name: _____

Time allowed for this paper

Reading time before commencing work: 10 minutes

Working time for paper: 3 hours

Materials required/recommended for this paper

To be provided by the supervisor

This Question/Answer Booklet and the Formulae and Constants Sheet

To be provided by the candidate

Standard items: pens (blue/black preferred), pencils (including coloured), sharpener, correction tape/fluid, 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.

Structure of this paper

Section	Number of questions available	Number of questions to be answered	Suggested working time (minutes)	Marks available	Marks Attained
Section One: Short answers	13	13	54	54 (30%)	/54
Section Two: Problem-solving	7	7	90	90 (50%)	/90
Section Three: Comprehension	2	2	36	36 (20%)	/36
				180 (100%)	/180

Instructions to candidates

Write your answers in the spaces provided beneath each question. The value of each question (out of 150) is shown following each question.

The enclosed Physics: Formulae and Constants Sheet may be removed from the booklet and used as required.

Calculators satisfying conditions set by the Curriculum Council may be used to evaluate numerical answers.

Answers to questions involving calculations should be evaluated and given in decimal form. Give final answers to three significant figures and include appropriate units where applicable.

When calculating numerical answers, show your working or reasoning clearly. Despite an incorrect final answer, credit may be obtained for method and working, providing this is clearly and legibly set out.

Questions containing specific instructions to **show working** should be answered with a complete, logical, clear sequence of reasoning showing how the final answer was arrived at; correct answers which do not show working will not be awarded full marks.

Questions containing the instruction **estimate** may give insufficient numerical data for their solution. Students should provide appropriate figures to enable an approximate solution to be obtained. 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.

Section One: Short answers

(54 Marks)

This section has **thirteen (13)** questions. Answer **all** questions. Write your answers in the spaces provided.

Suggested working time: 54 minutes.

Question 1

Suppose you have just finished baking a cake and you open the oven door to remove the cake. You can put your hand safely in the oven for a few seconds but you would be badly burnt if you held the cake tin for this same amount of time.

- (a) Explain why this would happen, even though the air inside the oven and the cake tin are at the same temperature. (2 marks)



(5 marks)

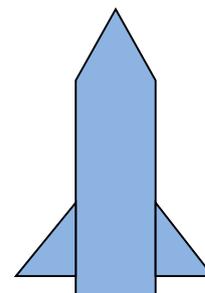
- (b) The cake you have finished baking is removed from the oven and placed on a nearby benchtop to cool down before icing. With reference to the three methods of heat transfer, briefly describe how the cake loses heat energy during this cooling process. (3 marks)



Question 2**(5 marks)**

A model rocket has a mass at launch of 1.5 kg (of which 60% is fuel).

- (a) On the diagram at right, sketch and label the two forces acting on the rocket as it lifts off at launch. (1 mark)
- (b) If the initial acceleration of the rocket is 15 m/s^2 , calculate the thrust force of its engine at launch. (2 marks)



- (c) The acceleration of the rocket increases as it flies higher and higher. Suggest why this would happen. (2 marks)

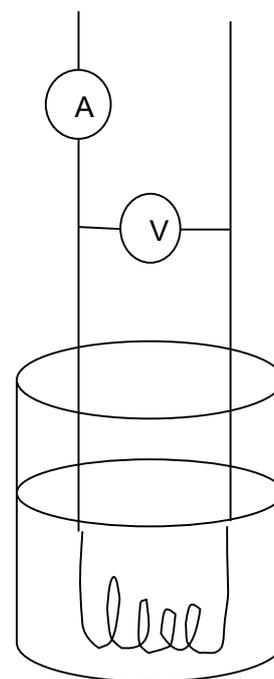
Question 3**(4 marks)**

A sound technician stands 15.0 m from a loudspeaker and measures the intensity of the sound to be $5.6 \times 10^{-3} \text{ W/m}^2$. Assume the sound waves spread out in a spherical pattern from the loudspeaker.

- (a) What is the intensity of the sound at a distance of 60.0 m? (2 marks)
- (b) Calculate the power of the loudspeaker. (2 marks)

Question 4

The apparatus shown at right is used to investigate the specific heat capacity of canola oil. The beaker contains 275 grams of canola oil and an electric current is passed through the heating element in the beaker for a period of 10.0 minutes. During this time the voltmeter shows a steady reading of 6.25 V and the ammeter of 2.20 A. A thermometer placed in the beaker shows that the temperature of the oil increases from 19.0°C to 32.5°C during this time. Find the specific heat capacity of the canola oil, assuming no heat losses to the surroundings.

(3 marks)**Question 5**

A Transperth train leaves Mandurah train station and accelerates steadily up to its cruising speed of 120 km/hr within a distance of 750 m from the station platform. Calculate

(4 marks)

(a) the acceleration of the train.

(2 marks)

(b) the time it takes to accelerate up to its cruising speed.

(2 marks)

Question 6

(4 marks)

The heating elements in a toaster are designed to get red hot in order to toast bread placed in the toaster. A typical toaster draws a current of 7.5 A when operating on household voltage (240 V).



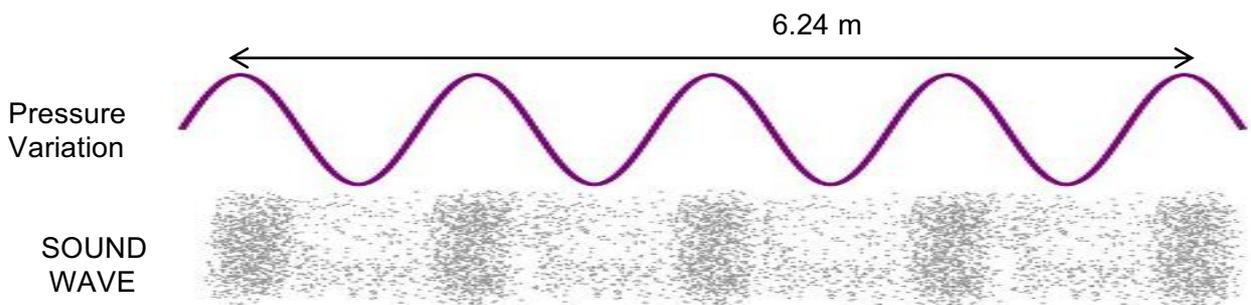
- (a) Calculate the resistance of the heating elements and the power produced by the toaster when in normal operation. (2 marks)

- (b) Describe how and explain why the current through the heating element changes from when the toaster is first switched on until it reaches normal operating conditions. (2 marks)

Question 7

(4 marks)

The diagram below shows a sound wave moving through air at 25°C. The sinusoidal graph above the sound wave indicates the variation in air pressure as the wave travels.

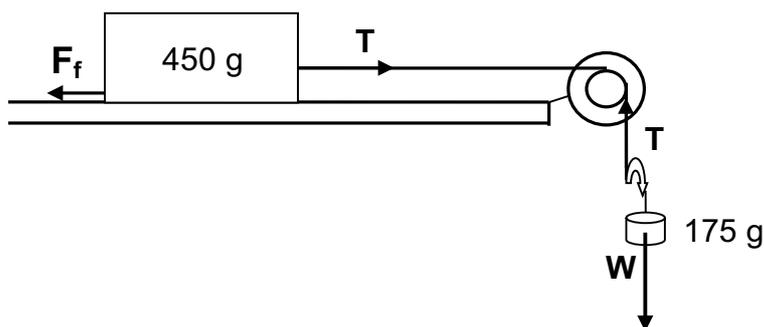


- (a) Calculate the value of each of the following quantities for this sound wave.
 - Wavelength: _____ (1 mark)
 - Frequency: _____ (1 mark)
 - Period: _____ (1 mark)

- (b) On the pressure variation graph above, superimpose a sinusoidal graph to show the variation in particle displacement as the wave travels through the air. (1 mark)

Question 8**(5 marks)**

A hanging mass of 175 g is connected to a 450 g block sitting on a table via a string and pulley as shown in the diagram at right. The two masses accelerate under the influence of gravity. The force of friction, F_f , acting on the block is 0.85 N.



(a) Calculate the acceleration of the 450 g block. (3 marks)

(b) Calculate the tension T in the string.

(2 marks)**Question 9****(4 marks)**

Jimi is practicing guitar in his room with the door open, as shown in the diagram at right. With reference to relevant physics principles, explain why Joni, in the hallway outside his room, can hear the sound of the guitar but not see Jimi.



Question 10

(4 marks)

- (a) Small nuclei, such as the carbon-12 nucleus, are quite stable despite the fact that the six protons in the nucleus repel each other strongly. Why is this? (2 marks)



- (b) Why are large nuclei, such as those of radium or plutonium, less stable and therefore prone to radioactive decay? (2 marks)

Question 11

(4 marks)

A hair dryer is plugged into a domestic power point. Explain each of the following features.

- (a) The switch on the power point is located on the active wire. (2 marks)
- (b) The hairdryer does not need an earth wire. (2 marks)

Question 12

(4 marks)

State which of the three types of nuclear radiation (α , β , γ), that results from natural radioactive decay, best matches each of the following properties.

the radiation that is most ionising _____

the radiation consisting of **particles** of least mass _____

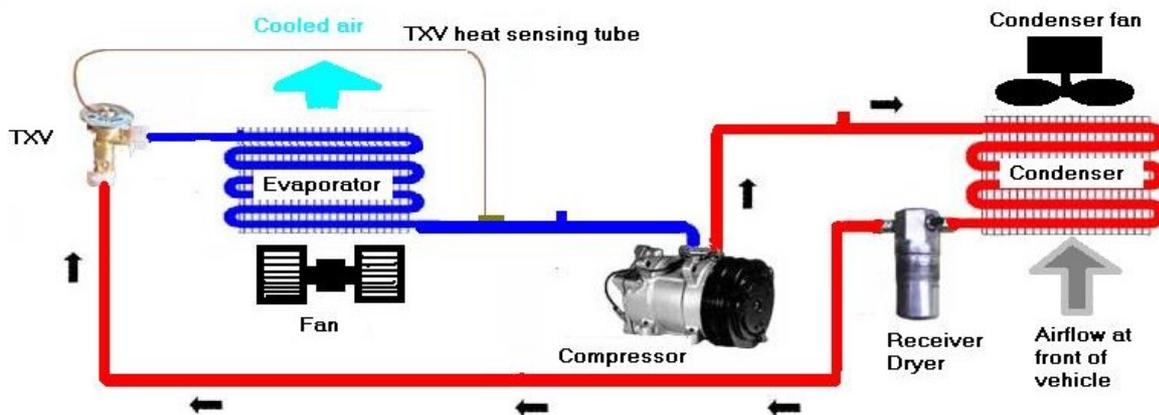
the radiation that is emitted at the lowest speed _____

the radiation that is not deflected by an electric field _____

Question 13

(4 marks)

The diagram below shows how refrigerant fluid is cycled around a typical car air-conditioning system.



- (a) State the change in phase and in temperature of the refrigerant fluid after passing through
- (i) the compressor (1 mark)
 - (ii) the TXV (expansion valve) (1 mark)
- (b) Explain the following features of the evaporator and condenser coils, as shown above
- (i) each coil is contained within a metal grid (1 mark)
 - (ii) each coil has a fan helping move air over the coil (1 mark)

END OF SECTION ONE

Section Two: Problem Solving

(90 Marks)

This section has **seven (7)** questions. Answer **all** questions. Write your answers in the spaces provided.

Suggested working time: 90 minutes.

Question 14

(13 marks)

Consider the dishwasher shown at right. Dishwashers work by heating a mixture of water and detergent, and spraying it against the dishes. The dishes are then rinsed with clean hot water and the hot dishes left to air dry. This particular model of dishwasher draws a current of 6.2 A from the normal household power supply and takes one hour to complete a wash.

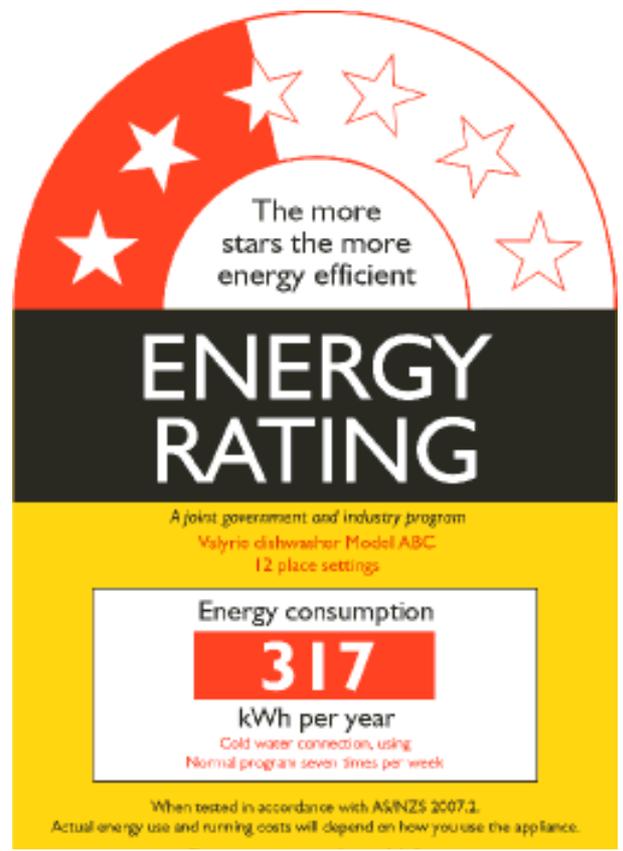


- (a) For the initial wash 5.3 litres of water at a temperature of 18.0°C is drawn into the machine. How much heat energy is needed to heat this water to the washing temperature of 70.0°C ? (2 marks)
- (b) Find the power of the water heater given it draws a current of 3.6 A. (2 marks)
- (c) Determine the time taken for the water heater to heat up the water from 18.0°C to the washing temperature of 70.0°C . Give your answer to the nearest minute. (2 marks)

(d) Do you think that the actual time taken is more or less than the time you calculated above in part (c)? Briefly justify your answer. (2 marks)

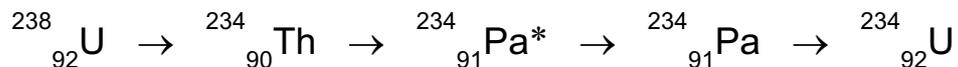
(e) Why do you think that dishwashers have a large quantity of fiberglass foam between the case and the inside? (2 marks)

(f) Could the energy efficiency label shown at right have come from this dishwasher? Explain your answer, using the energy consumption figure shown. (3 marks)



Question 15**(13 marks)**

The first few steps of the natural decay series of the nuclide uranium-238, via the radioactive elements thorium-234 and protactinium-234m ($^{234}_{91}\text{Pa}^*$), are shown below.



(a) Write balanced nuclear equations for

(i) the first decay in the series, uranium-238 into thorium-234 (1 mark)

(ii) the third decay in the series, protactinium-234m into protactinium-234 (1 mark)

(iii) the fourth decay in the series, protactinium-234 into uranium-234 (1 mark)

A radiation detector is used to measure the level of radioactivity near a sample of protactinium-234m over a period of several minutes. The results obtained are shown in the following table:

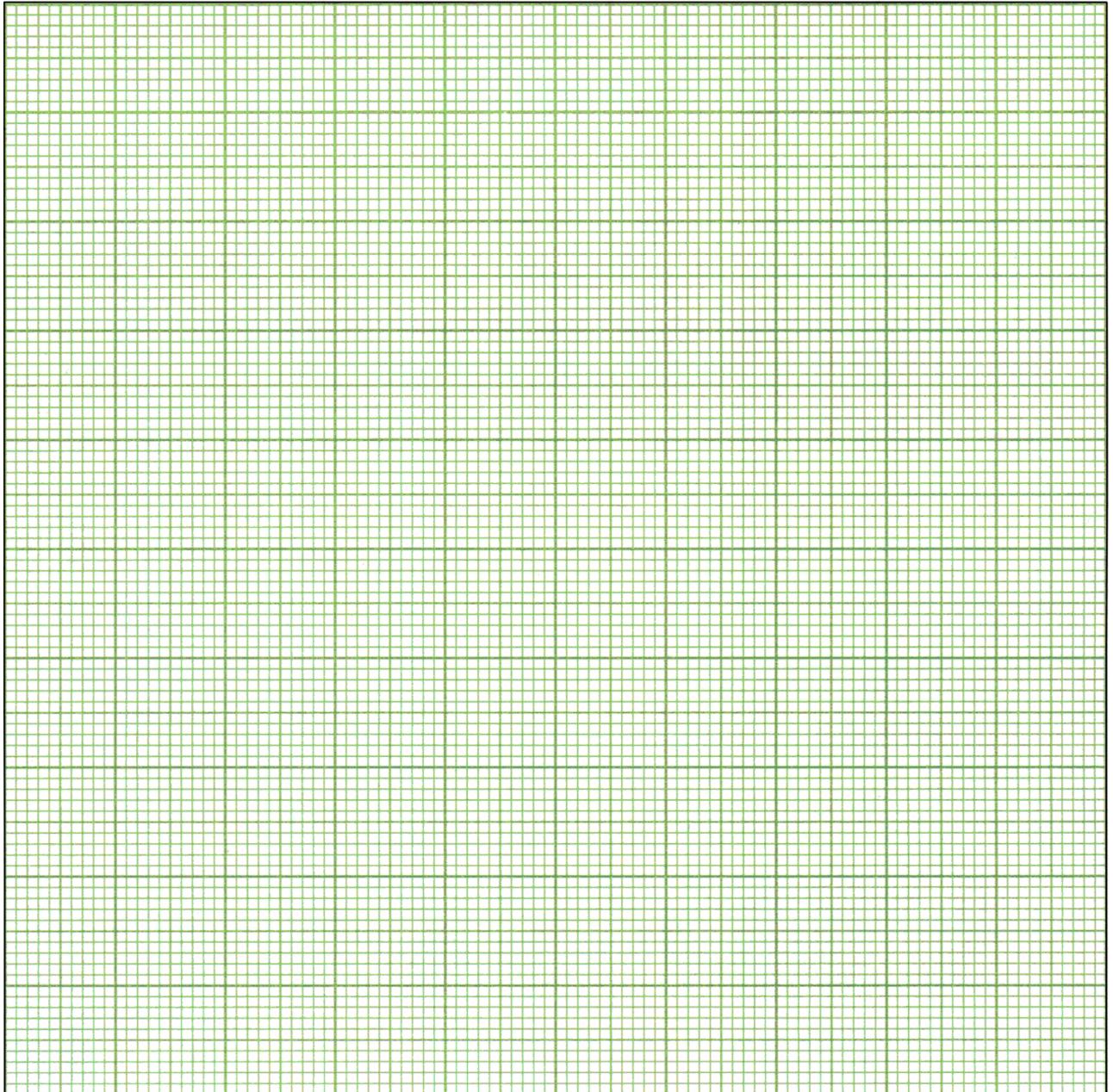
Activity A (Bq)	360	302	256	216	184	158	138	121	106	84	56	46	42
Time t (s)	0	20	40	60	80	100	120	140	160	200	300	400	500

(b) Use these results to plot a graph of activity against time on the graph paper supplied on the next page. (4 marks)

(c) From this graph:

(i) estimate the level of background radiation. (1 mark)

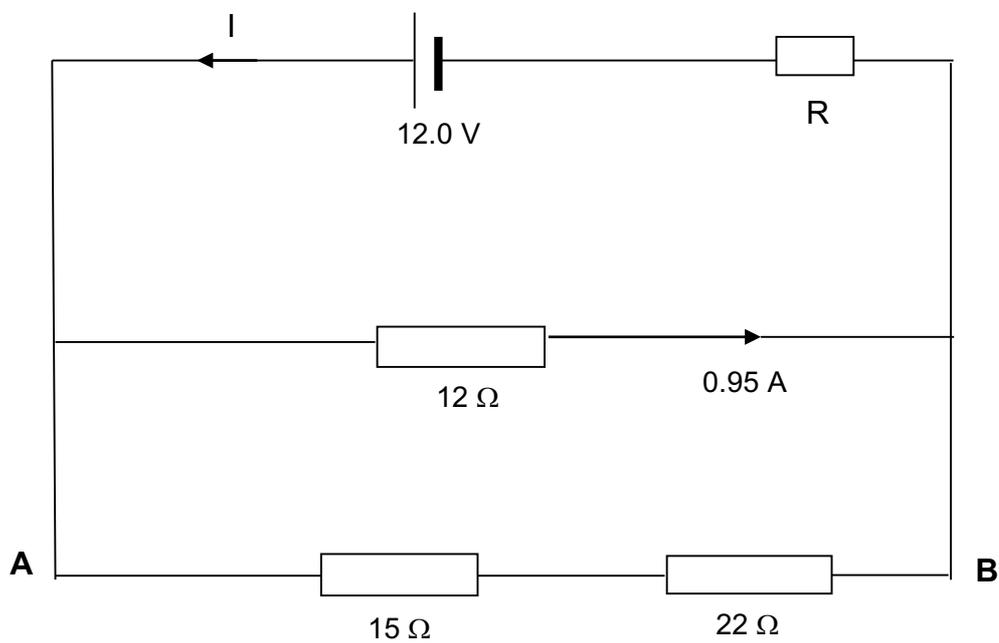
(ii) calculate the half-life of Pa-234m. (2 marks)



- (d) Using your value of half-life from above, calculate the expected level of activity after 580 seconds. (3 marks)

Question 16**(9 marks)**

A 12.0 V battery is connected to a circuit with four resistors as shown in the diagram below. A current of 0.95 A flows through the 12 Ω resistor.



(a) Calculate the potential difference (voltage) between points A and B. (2 marks)

(b) Find the current flowing through the 15 Ω resistor. (2 marks)

(c) Determine the rate at which heat is being produced in the $22\ \Omega$ resistor. (2 marks)

(d) What is the current I from the battery? (1 mark)

(e) Find the value of the resistance R in series with the battery. (2 marks)

Question 17

(15 Marks)

The clarinet, pictured at right, is a wind instrument that behaves like a closed pipe with a fundamental frequency of 130 Hz in air at a room temperature of 25°C.



(a) What are the frequencies of the next two higher harmonics? (2 marks)

(b) Sketch the particle displacement vs distance envelopes for the fundamental frequency and for the next harmonic frequency above the fundamental for this instrument. (2 marks)

fundamental
frequency

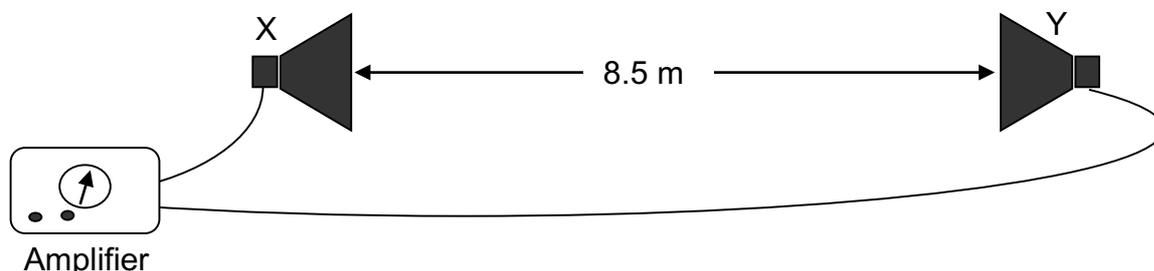
A large, empty rectangular box with a black border, intended for sketching the particle displacement vs distance envelope for the fundamental frequency.

next harmonic
frequency

A large, empty rectangular box with a black border, intended for sketching the particle displacement vs distance envelope for the next harmonic frequency.

(c) Calculate the length of the clarinet. (3 marks)

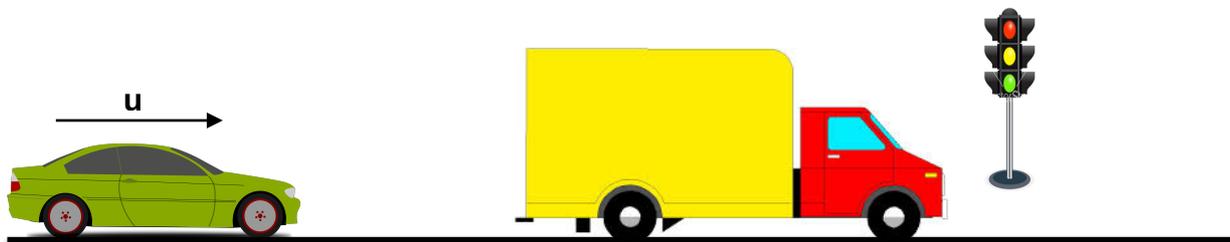
The clarinet is played so as to produce its fundamental frequency, and the sound is captured by a microphone and feed into an amplifier. Two loudspeakers X and Y are connected in phase to the amplifier and set up facing each other a distance of 8.5 m apart. A person walking from one of the loudspeakers towards the other hears points where the sound is extremely soft, alternating with points where it is loud.



- (d) Why will the person hear a series of soft and loud points as they walk from one loudspeaker towards the other? (2 marks)
- (e) Calculate whether the sound is loud or soft when the person walking between the loudspeakers is 2.92 m from speaker X. (3 marks)
- (e) What is the distance between a soft and a loud point? (1 mark)
- (f) Determine the number of soft points between the loudspeakers. (2 marks)

Question 18**(15 marks)**

A car of mass 1200 kg is being driven along a busy road at a steady speed when the driver, distracted by answering their phone, fails to notice that the lights ahead are red and runs into the back of a stationary 3.5 tonne van waiting at the lights. The car and van lock together after collision and slide to a halt in the middle of the intersection, leaving skid marks measured by the police to be 3.2 m long. The police also estimate that the frictional force acting on the tyres of the skidding vehicles was equivalent to 60% of their combined weight.



- (a) Calculate a value for the frictional force acting on the tyres of the skidding vehicles, and hence find the work done by friction in bringing the vehicles to a halt. (3 marks)
- (b) State the energy transformation that occurs as the two vehicles skid to a halt. (1 mark)
- (c) Hence find the speed of the two vehicles immediately after the car runs into the van (at the beginning of their skid). (3 marks)

- (d) Given that momentum is conserved during the collision of the car with the van, determine the speed of the car before hitting the van. (2 marks)
- (e) Compare the kinetic energy of the car before collision with the kinetic energy of the car plus van after collision. Account for any difference between the two values. (3 marks)
- (f) Compare the force experienced by each vehicle during the collision. Explain why the car driver is more likely to suffer injuries as a result of the collision than the van driver. (3 marks)

Question 19

A water-cooled nuclear reactor is shown in the sketch at right. The fuel rods in the nuclear reactor contain the fissile isotope uranium-235, which releases large amounts of energy when it undergoes fission.

The heat produced by the reactor core is removed by the coolant flowing through it, in this case pressurised liquid water, which remains in the liquid state despite **increasing in temperature by 160 K** after passing through the reactor core.

The masses of various particles involved in a typical fission reaction are given below

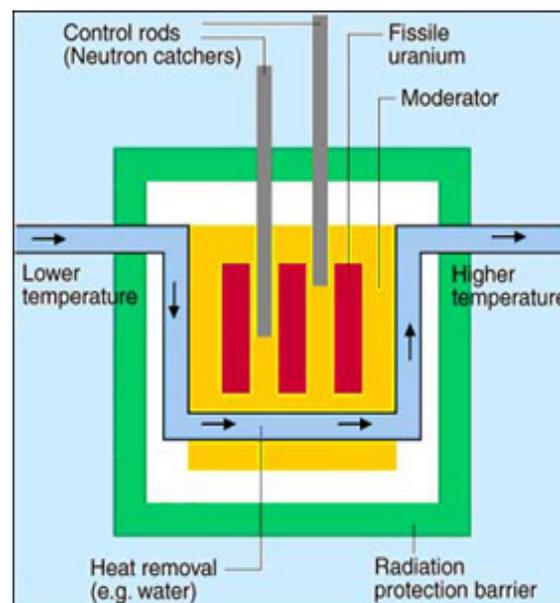
$$\text{mass (uranium-235)} = 3.90314 \times 10^{-25} \text{ kg}$$

$$\text{mass (barium-141)} = 2.34002 \times 10^{-25} \text{ kg}$$

$$\text{mass (krypton-92)} = 1.52653 \times 10^{-25} \text{ kg}$$

$$\text{mass (neutron)} = 1.6750 \times 10^{-27} \text{ kg}$$

(13 marks)



- (a) Write a balanced nuclear equation for the fission of a uranium-235 nucleus, after the absorption of a neutron, into barium-141 and krypton-92 nuclei along with the release of more neutrons. (2 marks)

- (b) Given the masses listed above, calculate the energy released per fission of a uranium-235 nucleus. (3 marks)

(c) The power output of the nuclear reactor is 250 MW. Calculate the rate at which the fuel rods lose mass in order to provide this amount of power. (2 marks)

(d) Calculate the mass of coolant that must pass through the reactor core every second to maintain it at a stable temperature when it has a power output of 250 MW. (2 marks)

(e) Explain the function of the following components of the nuclear reactor.

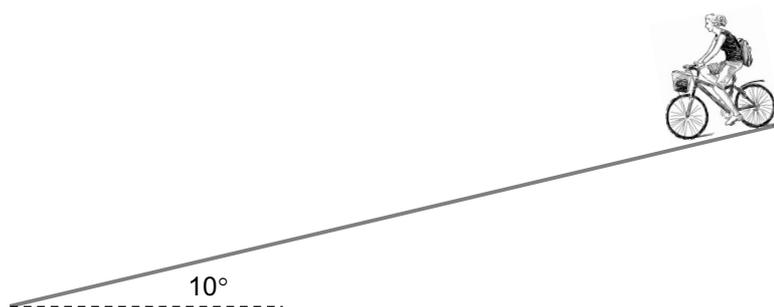
(i) the control rods (2 marks)

(ii) the moderator (2 marks)

Question 20**(12 marks)**

A girl riding on her bike starts rolling from rest at the top of a steep 10° slope, as shown in the diagram below. The girl and her bike have a combined mass of 65 kg, and the friction force of the road against her tyres as she rolls down the slope is a constant 15 N.

- (a) On the diagram, draw in and label the three forces acting on the girl (and her bike) as she starts rolling down the slope. (3 marks)



- (b) How large is the normal reaction force of the road pushing on the tyres? (2 marks)
- (c) Calculate the size of the net force on the girl as she starts rolling down the slope, and her initial acceleration. (4 marks)

In addition to the 15 N friction force, there is an air resistance force opposing her motion down the slope, which increases quadratically with speed according to the formula

$$F = 1.2 v^2, \text{ where } F = \text{air resistance force (in N)} \text{ and } v = \text{her speed (in m/s)}.$$

- (d) Calculate the maximum speed she will reach rolling down the slope on her bike. (3 marks)

END OF SECTION TWO

Section Three: Comprehension

(36 Marks)

This section has **two (2)** questions. Write your answers in the spaces provided.

Suggested working time: 36 minutes.

Question 21

ELECTRICITY IN THE CAR

(20 marks)

(Paragraph 1)

Modern cars use electricity for a variety of tasks, including initiating the burning of fuel (in a petrol engine). The amount of electricity used to generate sparks in the spark plugs is quite low, so the power to propel the car clearly comes, not from the electricity, but from the fuel itself. It is possible, however, to use electricity to provide all the necessary power, using rechargeable batteries, or using energy directly from the sun via solar cells.

(Paragraph 2)

The idea of using electricity to power a car directly is not new. More than a hundred years ago, electric cars such as the Victoria electric carriage were built. This had a top speed of 18 km/hr and could carry four passengers a distance of 30 miles (approximately 48 km). The motor drew an average current of 26 amperes on a hard, flat road. As the internal combustion engine became more efficient, the electric car fell out of favour and has only recently again captured the public's attention, as concern over the effects of fossil fuels on the environment has grown.



(Paragraph 3)

Table 1 below shows how the frictional force on a typical modern car varies with its speed. The power (in watts) needed by the car, at a particular speed, can be calculated by multiplying the frictional force on the car at that speed by the value of the speed.

Table 1

Frictional force F (N)	Speed v (m/s)
0	0
19	5
74	10
167	15
296	20
463	25
666	30
907	35
1184	40

(Paragraph 4)

A major problem with the direct use of electricity to drive a car is the limited energy-storage capacity of the batteries. Petrol, diesel and LPG are very energy efficient as they store a large amount of energy in a relatively small volume. There is enough energy stored in petrol, for example, to carry the initial weight of fuel more than 1500 kilometres. A lead-acid battery, in contrast, only stores enough energy to carry its own weight 15 kilometres, one-hundredth this distance. New battery designs have improved on this figure but, so far only by a factor of 5 or 6.

(Paragraph 5)

An alternative to batteries to power an electric vehicle is to make use of the sun's energy directly using solar cells. When light falls on a solar cell, it generates an EMF at the terminals of the solar cell, which can be used to produce a current in a circuit. Sunlight is converted directly to electrical energy by a solar cell.

(Paragraph 6)

Each square metre of a surface exposed to sunlight has about 1000 watts of energy per second falling on it, under the best conditions. Even if all of this energy arriving per second could be converted to useful electricity, it would be of limited value in driving an electric vehicle directly. One kilowatt of electrical power is a fraction of that produced by a modern petrol engine. In practice, the amount of energy available may be as low as 10% of this value on a very overcast day - typically rising only as high as 85% on a clear day.

(Paragraph 7)

Even then, not all the energy is usable. Theoretically, a solar cell can only reach an efficiency of 28%; that is, it can convert only 28% of the sunlight falling on it into electricity. Standard mass-produced solar cells are only 14% efficient, but specialised high-efficiency types have achieved efficiency as high as 26%. The energy available is also reduced because the solar cells will not always be oriented to receive the maximum amount of solar energy, as the vehicle turns or moves into a shady area, or when the sun is low in the sky. And, of course, no solar energy is available at night.



(a) In paragraph one it says, "The amount of electricity used to generate sparks in spark plugs is quite low..."

(i) What is meant by the phrase "the amount of electricity"? (1 mark)

(ii) Why is the amount of electricity in a spark quite low given that a voltage of several thousand volts is used to produce sparks? (2 marks)

- (d) A solar car is fitted with standard mass-produced solar cells, which cover a total surface area of 6.20 m^2 .
- (i) How much power is available to this solar car on a clear day? (hint: state the values from the article that you need to use for this calculation) (3 marks)
- (ii) Assuming that Table 1 applies to this solar car, estimate the maximum speed of the solar car on a clear day. (2 marks)
- (e) State two major problems with solar vehicles that have prevented their commercial use. (2 marks)

Question 22

OMHIC/NONOHMIC CIRCUIT COMPONENTS

(16 marks)

A Year 11 student carried out an experiment that measured the current through a particular circuit component, identified only as component A, as the voltage across it was successively increased. She then repeated the experiment for a second circuit component, identified only as component B. The tables below show the data collected in the experiment by the student.

Component A

current (Amps)	voltage (Volts)
0.00	0.00
0.93	0.99
1.23	2.00
1.49	2.93
1.68	3.76
1.99	5.20
2.12	5.82
2.24	6.41
2.32	6.94

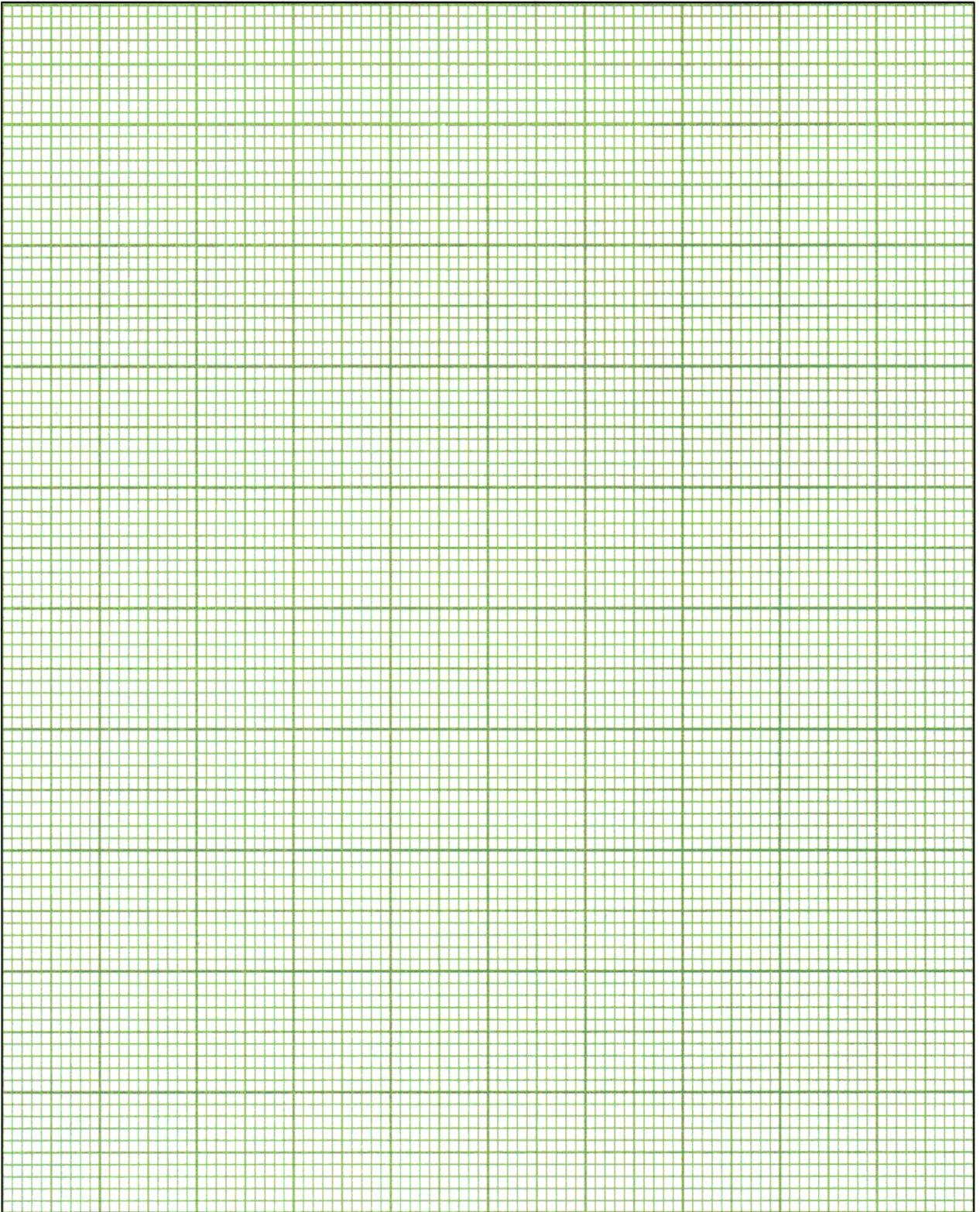
Component B

current (Amps)	voltage (Volts)
0.00	0.00
0.13	1.37
0.26	2.66
0.40	3.94
0.51	5.05
0.63	6.23
0.73	7.19
0.84	8.26
0.95	9.25

- (a) On the graph paper supplied on the next page, draw a graph of voltage versus current for each component, using the same set of axes. (5 marks)

- (b) Which of the two components is an **ohmic** conductor? Calculate its resistance from your graph. (3 marks)

- (c) What is the appropriate number of significant figures for your calculated value of resistance for the **ohmic** conductor? Briefly state why this is the appropriate number of significant figures. (2 marks)



- (d) Could you use your calculated value of resistance to predict the current through the **ohmic** conductor if a voltage of 25.00 V was applied across it? Briefly explain. (2 marks)
- (e) From the graph, find the resistance of the **nonohmic** conductor when the voltage across it is
- (i) 4.5 V (1 mark)
- (ii) 7.5 V (1 mark)
- (f) Which of these estimated values of the resistance of the **nonohmic** conductor do you think is more reliable? Briefly explain your reasoning. (2 marks)

END OF PAPER

EXTRA WORKING SPACE