Semester One

Examination 2019

Question/Answer booklet

PHYSICS UNIT 1

Student Name: _____

Teacher 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 provides by the supervisor
This Question/Answer Booklet
Formulae and Data Booklet

To be provided by the candidate
Standard items: pens, pencils (including coloured), sharpener, correction fluid, eraser, ruler, highlighters.
Special items: up to three non-programmable calculators approved for use in the WACE examinations, drawing templates, drawing compass and a protractor.

STRUCTURE OF THIS PAPER

Section	No. of Questions	No. of questions to be attempted	Suggested working time (minutes)	Marks available	Percentage of exam
Section one Short Response	11	ALL	55	54	30
Section two Problem Solving	6	ALL	95	90	50
Section three Comprehension	2	ALL	30	36	20
			Total	**180**	**100**

INSTRUCTIONS TO CANDIDATES

Write your answers in the spaces provided beneath each question. The value of each question (out of 180) is shown following each question.

Answers to questions involving calculations should be evaluated and given in decimal form. Final answers should be given up to three significant figures and include appropriate units.

Questions containing the instruction "**estimate**" may give insufficient numerical data for their solution. Give final answers to a maximum of two significant figures and include appropriate units.

Despite an incorrect final result, credit may be obtained for method and working providing these are 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.

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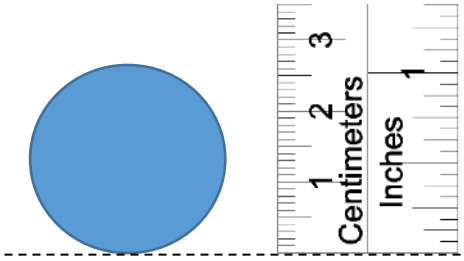
Section One: Short Response **30% (54 marks)**

This section has 11 questions. Answer **all** questions. Answer the questions in the spaces provided. Suggested working time: 50 minutes.

Question 1 **(3 marks)**

Aiden is measuring the following shaded perfect circle and he puts a ruler next to it, as shown on the right.



Write the absolute and relative uncertainties of the diameter of the circle below.

a) Diameter with absolute uncertainty:

b) Diameter with relative uncertainty:

Space for working out:

Question 2 **(3 marks)**

A glider, as shown on the right, is a light aircraft that is designed to fly without using an engine over a large plain field. As the field is heated by the sun, it is able to operate more effectively. Explain the reasons using Physics concepts.

Question 3 **(5 marks)**

Sodium-24 has a half-life of 15.0 hours. It has applications in medicine and engineering.

a) How much of a 34.0 g sample of Sodium-24 will remain undecayed after two days? Show clear working. (3 marks)

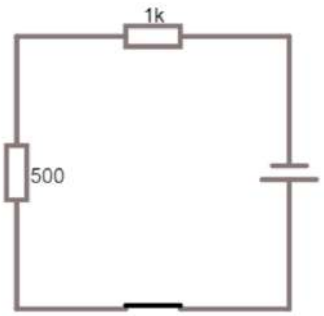
b) If Iodine-131 (half-life = 8.00 days) of the same amount were to replace Sodium-24, would more of the original sample be left over or less compared to Sodium-24? Explain without calculations. (2 marks)

Question 4 **(4 marks)**

The circuit on the right consists of a switch, two resistors (1.00 kΩ and 500 Ω) and a 12.0 V battery.

a) In the diagram, label the direction of the flow of electrons. (1 mark)

b) A student is about to measure the voltage drop of across the 1.00 kΩ resistor using a voltmeter. What is the expected reading? Show your calculation. (3 marks)



Closed Switch

Question 5 **(7 marks)**

A food shop sells hot beef soup. A number of slices of beef are put into a bowl, followed by pouring in a hot liquid vegetable stock. The soup is then ready to serve to customers.

Use the following information to answer the questions:

- Mass of vegetable stock: 0.800 kg
- Initial temperature of the stock: 96.0 ^{o}C
- Specific heat capacity of the stock: 4000 J kg^{-1} K^{-1}
- Mass of each beef slice: 50.0 g
- Initial temperature of beef: 6.00 ^{o}C
- Specific heat capacity of beef: 3000 J kg^{-1} K^{-1}

a) According to safety regulations, the serving temperature of the soup should be below 60.0 ^{o}C. Estimate the minimum number of beef slices required to add to the stock to achieve this.

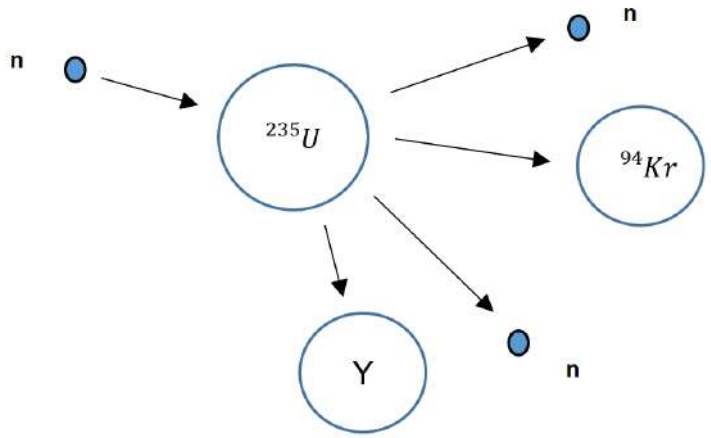
(6 marks)

b) State one assumption in the calculation in part a). (1 mark)

See Next Page

Question 6 **(7 marks)**

The diagram below shows a neutron, **n**, being absorbed by a Uranium-235 atom. The remaining neutrons then continue to react with other Uranium-235 atoms.



a) Complete the following table by writing the correct terminologies: (3 marks)

Descriptions	Terminologies
A neutron collides with a Uranium nucleus and is absorbed.	
The atom splits into different two atoms and two neutrons.	
The released neutrons continue to be absorbed by other Uranium-235 nuclei.	

b) Predict what substance **Y** be. Write the symbol of the substance, its atomic number and mass number in a correct format. (2 marks)

c) If the Krypton-94 continues to decay and release a beta negative particle. Write the full nuclear equation for this decay. (2 marks)

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Question 7 **(5 marks)**

The diagram below is a simple schematic diagram of a fridge. It consists of one long coil that goes through the inside compartment of the fridge and then flows outside. Fluid refrigerant is sealed inside this coil. The arrow, in the diagram below, shows the direction of the refrigerant. Part C is called an expansion valve. The pressure inside the pipe is reduced by the expansion valve, causing the refrigerant to evaporate.

a) Explain how this helps to cool the fridge. (3 marks)

b) When there is a power outage, a fridge can still keep the contents cold for as long as 2 hours. Describe the features of a fridge which help to keep the fridge cold. (2 marks)

Question 8 **(6 marks)**

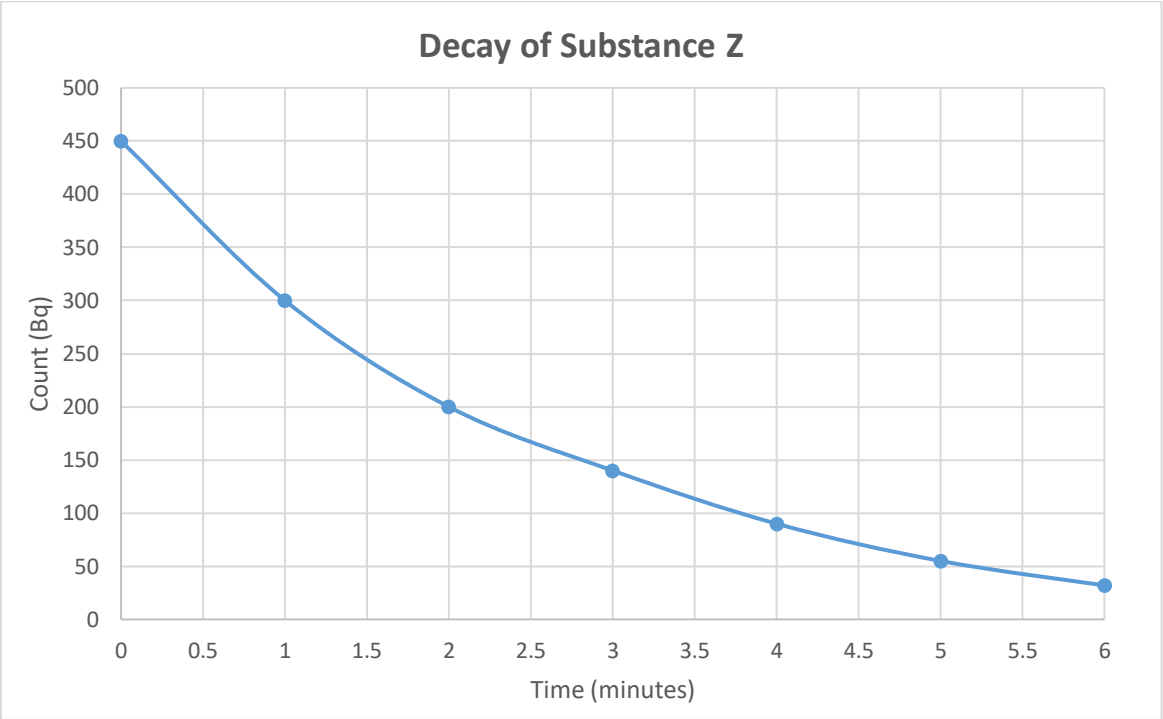
A heating coil is rated at 2.00 kW when 8.00 A flows through it. When the heater has been turned on for 1.00 hour. Calculate:

a) the potential difference across the heater. (2 marks)

b) the total amount of charge that has flown through the heater during its operation. (4 marks)

Question 9 **(5 marks)**

The graph below shows the decay of radiative substance **Z**.



a) Use the graph above to estimate the half-life of substance **Z**. Show your working on the graph above. (2 marks)

b) Hence, estimate how long it would take for substance **Z** to decrease to 10.0 Bq of activity. (3 marks)

Question 10 **(5 marks)**

Find the binding energy, per nucleon in, MeV, for Uranium-236.

Use the following data:

Mass of proton	=	1.00727 u
Mass of neutron	=	1.00867 u
Mass of Uranium-236	=	236.045568 u

Question 11 **(4 marks)**

Calculate how much energy needs to be removed to convert 500 g of water from 24.0 ^{o}C into ice at –4.00 ^{o}C ice.

END OF SECTION ONE

Section Two: Problem-solving **50% (90 marks)**

This section contains 6 questions. Answer **all** questions. Answer the questions in the spaces provided. Suggested working time 90 minutes.

Question 12 **(16 marks)**

John carries out an experiment to investigate the cooling properties of Octadecan-1-ol. Octadecan-1-ol is one type of alcohol that can be used in anti-freeze products and lubricants. Its latent heat of fusion is 331 J kg^{-1}.

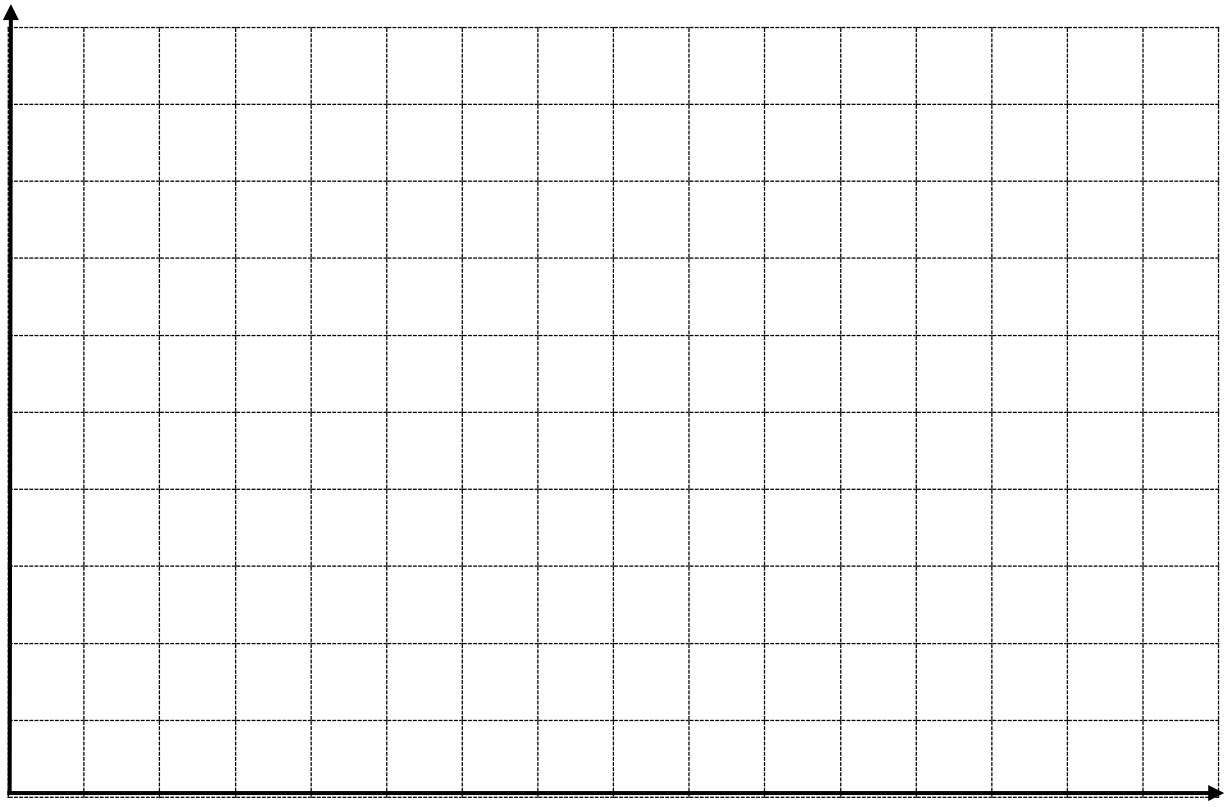
John heats a test tube containing of 250 g solid Octadecan-1-ol in a water bath at 80.0 ^{o}C. He then puts the test tube immediately into a beaker of iced water.

The temperature of the Octadecan-1-ol is then recorded over a time interval of 5.00 minutes. The results are shown below:

Time (s)	0	30	60	90	120	150	180	210	240	270	300
Temperature (^{o}C)	71	63	57	55	55	55	55	55	50	44	35

a) Plot a cooling curve of Octadecan-1-ol in the graph below. A spare graph paper can be found on page 31.

(2 marks)



b) Estimate the melting point of Octadecan-1-ol, in Kelvin. (2 marks)

c) Use kinetic theory to explain the shape of the curve between 90 seconds and 210 seconds. (3 marks)

d) Use the given information to calculate the rate of heat loss of the 250 g of Octadencan-1-ol in between 90 seconds and 210 seconds. (4 marks)

e) If the experiment was to be done in thermally insulated conditions, would your answer for part d) be higher or lower? Explain your answer. (3 marks)

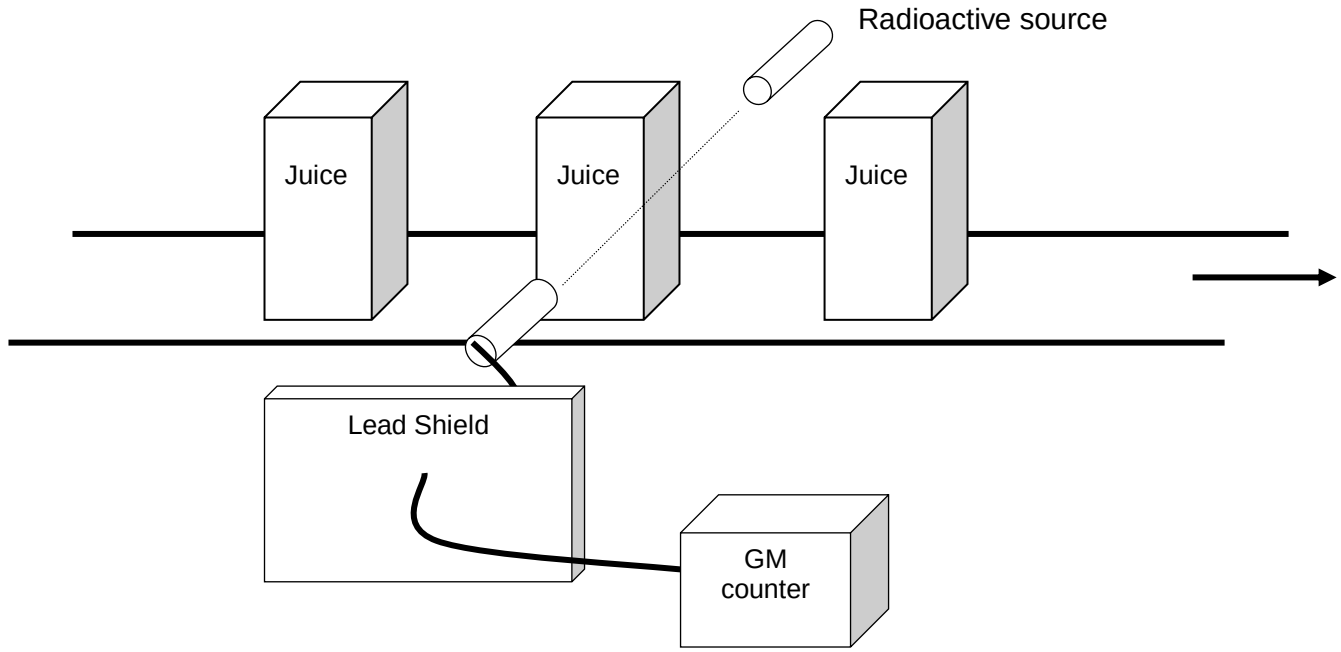
f) List one possible example of random error and one possible example of systematic error in this experiment. (2 marks)

Random error: _____

Systematic error: _____

Question 13 **(13 marks)**

In a juice factory, a radioactive source and a Geiger-Muller (GM) counter are used to ensure each box of juice is full before delivering to the shops. The radiation emitted by the source penetrate through the top section part of each box and are then detected by the GM counter as shown in the following diagram.



The following table shows a sample of results recorded by the GM counter:

Box Number	**1**	**2**	**3**	**4**	**5**
Measured count rate (Bq)	645	652	648	729	654

a) What type of radiation (alpha, beta or gamma) should be used for the radioactive source? Explain. (2 marks)

b) Why was there an increase in the measured count rate when the fourth box of juice passes through the detector? Explain your reason. (2 marks)

c) It is claimed that as long as the radiation penetrate through the top part of the juice box and are detected by the GM counter, the distance between the source and the detector is **NOT** critical. Comment on this statement. (2 marks)

d)

i) If you were the manager of the factory and had a choice of half-lives of the radioactive source shown below. Which one would you choose? Circle your answer. (1 mark)

10 seconds **10 hours** **10 years**

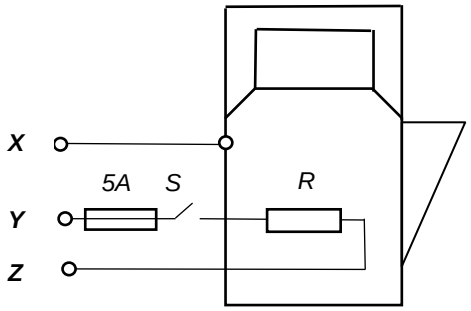
ii) Briefly explain your answer of your above choice. (1 mark)

e) Comment on the purpose of the lead shield. (1 mark)

f) All factory workers who work in this juice factory must wear radiation monitoring badges. These badges monitor the radiation exposure to a factor worker. A person whose mass is 75.0 kg receives an average of 3.00 J a day according to the badge. Estimate the dose equivalent this person receives every day. Use your answer in part a) for the calculation. (4 marks)

Question 14 **(18 marks)**

The schematic diagram on the right shows how wires are connected to an electric kettle. A 5 A fuse is connected to the kettle. The main source of resistance in the kettle is the heating element. The rating of this kettle is "240V, 2000 W". Note: **S** is a switch and **R** is the resistance. Also, the wire **X** is attached to the casing of the kettle.



a) Describe the main energy transformation taking place in the kettle. (1 mark)

b) Referring to the diagram above.

i) Which wire would be the earth wire? Circle the correct answer below. (1 mark)

X ***Y*** ***Z***

ii) Explain the purpose of the earth wire and how it is important for the safety of this appliance. (2 marks)

c) An electrician inspects the wiring and explains that the Fuse is not suitable. Explain. (3 marks)

d) Discuss one other safety feature, other than those shown in the diagram, for electrical appliances you can install for your home. Explain how it works to prevent electric shock. (3 marks)

e) This kettle is now filled with 1.50 L of water. If the kettle has an efficiency of 40% and is turned on for 2.00 minutes, calculate the temperature rise of the water. Note: density of water is 1.00 kg L^{-1}. (5 marks)

f) When boiling water, placing the lid on the top of the kettle allows it to bring water to the boil faster than without a lid on. Explain, using kinetic theory, why using the lid increases the effectiveness of the kettle. (3 marks)

Question 15 **(13 marks)**

On average, a person, through perspiration, loses up to 400 mL of water every hour even sitting in an comfortable office. The latent heat of vaporisation of water at a comfortable temperature is 2.42×10^6 J kg^{-1}. Note: density of water is 1.00 kg L^{-1}

a) Explain how water assists heat loss for human bodies to prevent hyperthermia, a scientific term to describe a body temperature above 40.0 ^oC. (3 marks)

b) Jane, whose mass is 55.0 kg, has been at work for 8.00 hours.

i) How much heat energy does Jane's body lose at work, through the evaporation of water? Assume the evaporating perspiration does not absorb heat from anywhere else. (3 marks)

ii) By how much would Jane's body temperature rise if the same amount of water in part i) did not evaporate from her skin? Assume the specific heat capacity of a human body is 3500 J kg^{-1} K^{-1}. (2 marks)

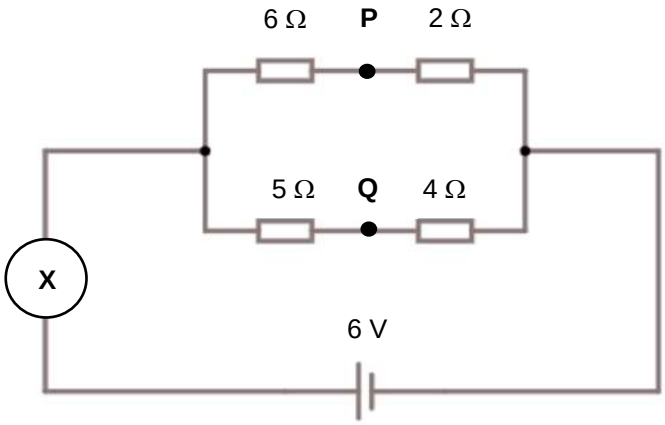
See Next Page

c) Jane finds that using a fan which blows air across her skin helps her feel more comfortable while working in a hot office. Explain why. (3 marks)

d) After work, Jane goes to a swimming pool. Explain why she often feels colder when she gets out of the water, even if the temperature of the air and the water are the same. (2 marks)

Question 16 **(14 marks)**

The following circuit includes four resistors which are shown in the diagram below. This circuit is powered by a 6.00 V battery. Assume no internal resistance in the battery.



a) Calculate the total resistance of the circuit. (3 marks)

b) A device **X** is connected to the circuit in series as shown in the diagram.

i) For the circuit to remain operational, should the device be an ammeter or a voltmeter? Circle the correct answer below. (1 mark)

Ammeter **Voltmeter**

ii) What would be the reading of the device **X**? (2 marks)

c) Calculate the current through point P. (3 marks)

d) A student connects points P and Q using a copper wire.

i) Calculate the new total resistance of the circuit. (3 marks)

ii) Would the reading of **X** increase or decrease as a result of the change? Explain, without the use of calculations. (2 marks)

Question 17 **(16 marks)**

The Sun constantly undergoes a series of fusion reactions to produce a large amount of energy. A common series of reactions that occurs within the sun is outlined in the steps below.

1. Two protons fuse together, producing Deuterium and other particles plus energy;
2. Deuterium and a proton fuse, producing Helium-3 and energy;
3. Two Helium-3 nuclei fuse together, producing Helium-4, two protons, and energy;
4. Helium-3 fuses with Helium-4, producing Beryllium-7, which decays and then fuses with another proton to yield two Helium-4 nuclei plus energy.

Use the following data to answer the questions below:

Element	Scientific name	Mass (u)
${}_{1}^{1}H$ or ${}_{1}^{1}p$	Protium/Proton	1.008
${}_{1}^{2}H$	Deuterium	2.015
${}_{1}^{3}H$	Tritium	3.015
${}_{2}^{3}He$	Helium-3 (Helion)	3.016
${}_{2}^{4}He$	Helium-4	4.003
${}_{0}^{1}n$	Neutron	1.008

a)

i) For step 3, write the full nuclear equation for the process. (2 marks)

ii) Use the information above to calculate the energy released, in MeV, for step 3 (part i)). Correct the answer to two significant figures. (5 marks)

iii) Calculate the total energy, in Joules, that would be produced from 50.0 Tonnes of Helium-3 undergoing the reaction in Step 3. Correct your answer to two significant figures. (5 marks)

b) Helium-4 is more stable than Tritium. Comment on this statement. (2 marks)

c) The Sun's life span is about 5 billion years. Would the mass of the sun have increased or decreased by then? Explain. (2 marks)

END OF SECTION TWO

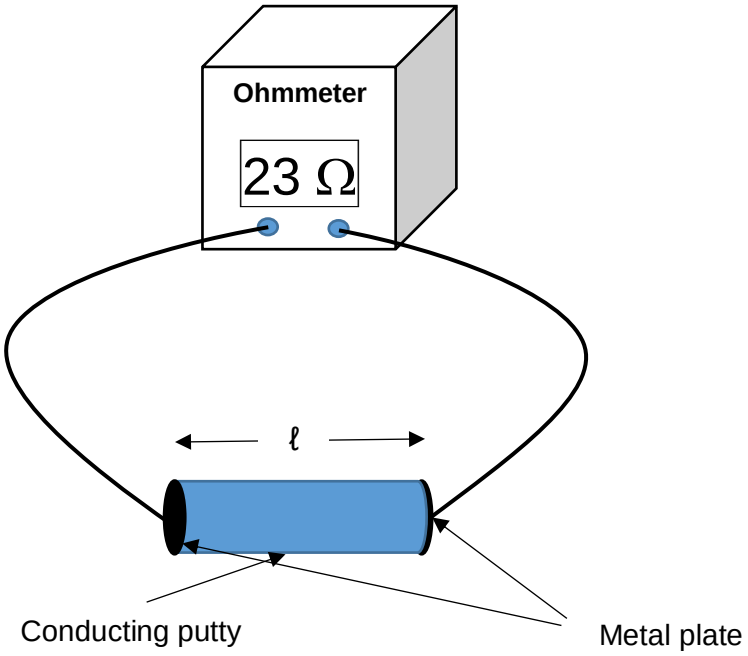
Section Three: Comprehension **15% (36 marks)**

This section has two questions. Answer **both** questions. Answer the questions in the spaces provided. Suggested working time: 40 minutes.

Question 18 **(24 marks)**

An experiment is carried by Jamie to investigate how the resistance of a fixed volume of conducting putty varied with its length. This conducting putty is a soft material that be easily shaped into different lengths.

The experiment apparatus is shown below.



Jamie conducts the experiment and records the result in the table below. Note that one column is deliberately left blank for further analysis.

ℓ (cm)	***R*** (Ω)	____ (____)
6.0	25	
11.0	60	
13.5	110	
17.0	180	
22.5	280	
25.0	370	

Jamie discovered that the suggested resistivity of the conducting putty, ρ (pronounced *rho*), is given by the formula:

$$\rho = \frac{(\boldsymbol{R} - R_o)V}{\boldsymbol{\ell}^2}$$

where $\boldsymbol{R_o}$ is the resistance of the connecting wires and $\boldsymbol{V}$ is the volume, in cm^3, of the conducting putty.

a) For this experiment, state: (2 marks)

i) Dependent variable: _____

ii) One controlled variable: _____

b) Show that the formula can be rearranged as:

$$\boldsymbol{R} = \frac{\rho}{V}\boldsymbol{\ell}^2 + R_o$$

Show clear working to show how you establish the formula. (3 marks)

c) Explain why plotting a graph of $\boldsymbol{R}$ against $\boldsymbol{\ell}$ would not enable you to obtain the linear relationship. (1 mark)

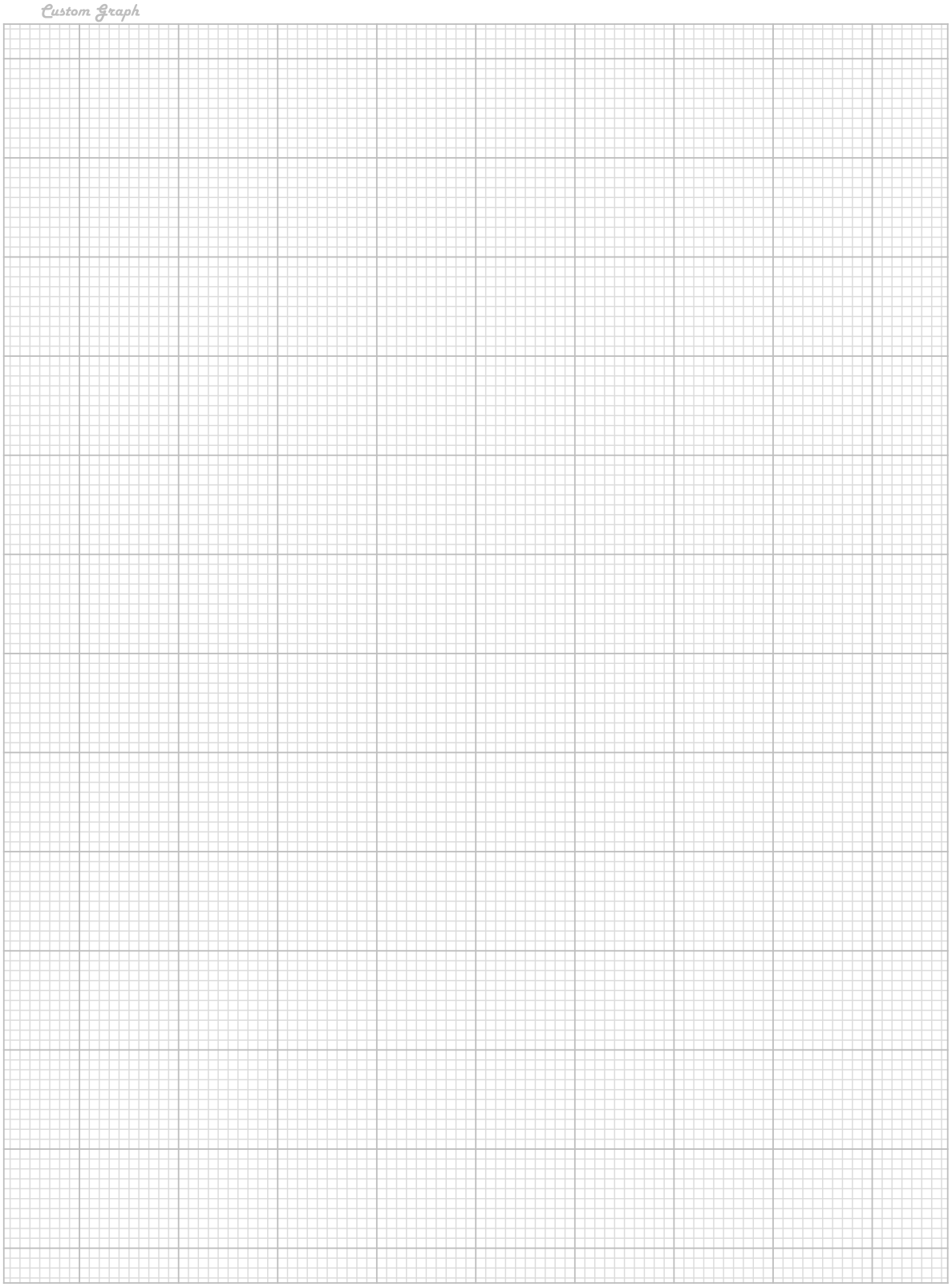
d) Calculate and record values of $\boldsymbol{\ell^2}$ in the table on the previous page. Correct your answer to appropriate number of significant figures. (3 marks)

e)

i) Plot a graph of $\boldsymbol{R}$ vs $\boldsymbol{\ell^2}$ on the next page. If you have made a mistake, spare graph paper is on page 31. (5 marks)

ii) Use your date to obtain the line of best fit. (1 mark)

Graph for Question 18



f) Hence, calculate the gradient of the line of best fit. Include the unit. (4 marks)

g) Assume the volume of the putty is 15.0 cm^3. Use your gradient in part f) to calculate resistivity of the conducting putty, ρ. The unit of the conductivity is not required. (3 marks)

h) Describe and explain one possible source of error for this experiment.. (2 marks)

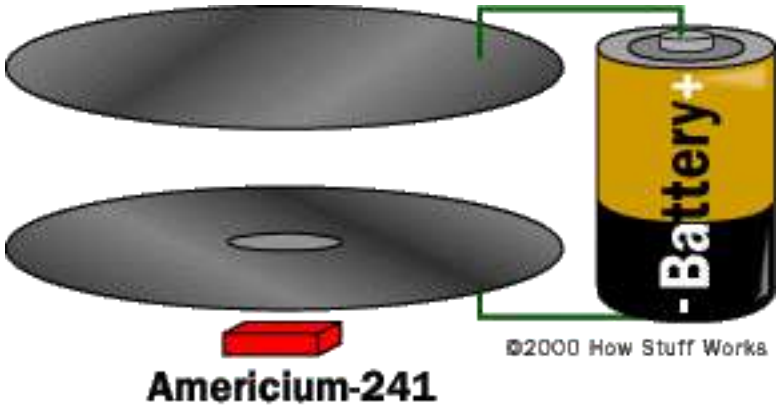
Question 19 **(12 marks)**

Smoke Detectors

Many smoke detectors use an ionisation chamber and a source of ionising radiation to detect smoke. This type of smoke detector is more common because it is inexpensive and more effective in detecting the smaller amounts of smoke produced by flaming fires.

Inside an ionisation detector is a small amount (0.000200 grams) of Americium-241. The radioactive element americium has a half-life of 432 years.

Another way to talk about the amount of americium in the detector is to say that a typical detector contains 0.9 micro-curie of Americium-241. A curie is a unit of measure for nuclear material. If you are holding a curie of something in your hand, you are holding an amount of material that undergoes 37,000,000,000 nuclear transformations per second.



Generally, that means that 37 billion atoms in the sample are decaying and emitting a particle of nuclear radiation per second.
One gram of the element radium generates approximately 1 curie of activity. Marie Curie, the woman after whom the curie is named, did much of her research using radium.

An ionisation chamber is very simple. It consists of two plates with a voltage applied across them, along with a radioactive source of ionising radiation. (See diagram)

The positively charged particles generated by the americium ionise the oxygen and nitrogen atoms of the air in the chamber. Once these atoms have been ionised, free electrons and positively charged atoms are attracted to the positive and negative plates respectively. The electronics in the smoke detector sense the small amount of electrical current that these electrons and ions moving toward the plates create.

When smoke enters the ionisation chamber, it disrupts this current, the smoke particles attach to the ions and neutralise them. The smoke detector senses the drop in current between the plates and sets off the alarm.

Speaking of alarms, whenever the words "nuclear radiation" are used an alarm goes off in many people's minds. The americium in the smoke detector could only pose a danger if you were to inhale it. Therefore, you do not want to be playing with the americium in a smoke detector, poking at it, or disturbing it in any way, because you don't want it to become airborne.

Questions

a) In the text, it repeatedly uses the word “ionisation”. What does this mean? (1 mark)

See Next Page

b)

i) The text describes that the americium is used as a substance to emit particles in the smoke detector. What type of radioactive decay would mostly likely be emitted? Explain your answer. (2 marks)

ii) Hence, express the decay equation for the reaction. (2 marks)

c) During a very humid day, a smoke detector might trigger false alarm. Explain why this might occur. (2 marks)

d) In the text, it states that “a typical detector contains 0.9 micro-curie (μ-curie) of Americium-241”. How many nuclear decays are there in one second? (2 marks)

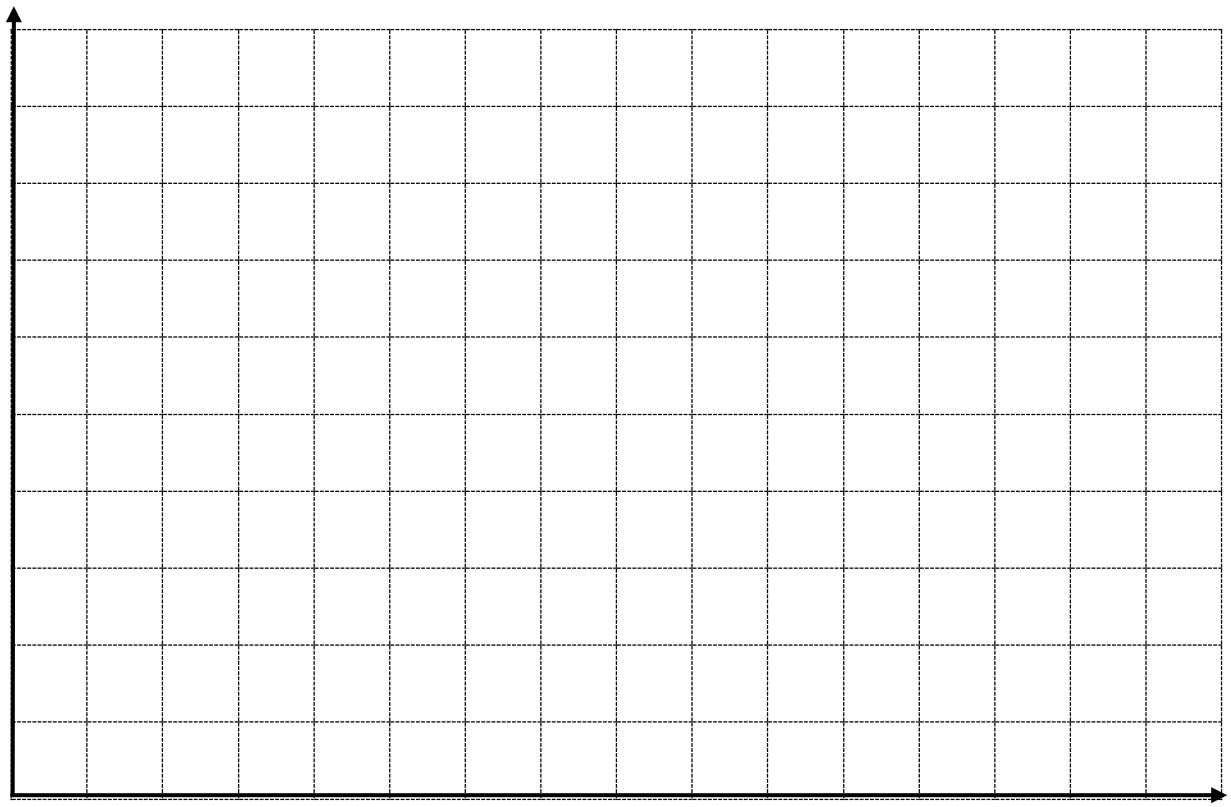
e) Use the information in the text to calculate the remaining mass, in grams, of Americium-241 used in a smoke detector after 2 000 years. Show all working out clearly. (3 marks)

END OF SECTION THREE

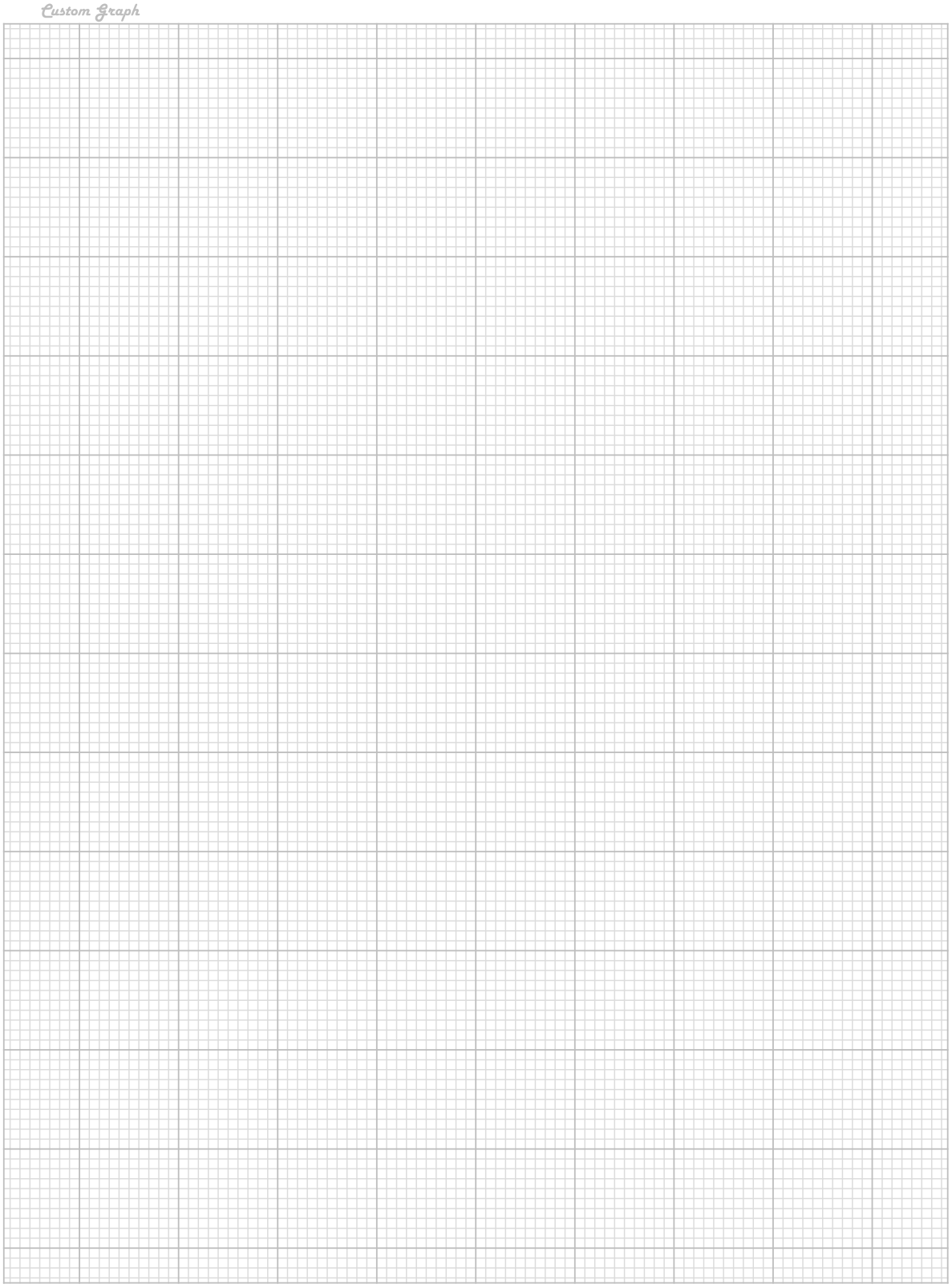
END OF THE EXAMINATION

Extra Space

Extra Graph for question 12



Extra Graph for question 18



Acknowledgements

Question 7

Brain, M. and Elliott, S. (2019). *How Refrigerators Work*. [online] HowStuffWorks. Available at: https://home.howstuffworks.com/refrigerator.htm [Accessed 1 Feb. 2019].

Question 19

Brain, M. (2019). *How Smoke Detectors Work*. [online] HowStuffWorks. Available at: https://home.howstuffworks.com/home-improvement/household-safety/smoke.htm [Accessed 12 Jan. 2019].

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