Christ Church Grammar School

Science Department
Year 11 Physics

Semester 1 Examination, 2020

Question/Answer booklet

PHYSICS UNIT 1

SECTION ONE

SHORT ANSWER

Fix student label here

Student Name: ____________________________

Teacher: CJO JRM PCW SGA

Time allowed for this paper

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

Materials required/recommended for this paper

To be provided by the supervisor

Three Question/Answer booklets
Formulae and Data booklet

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 ATAR examinations

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		Percentage of exam	Percentage achieved
Section One: Short Answer	10	10	40		42	32	
Section Two: Problem Solving	5	5	60		67	50	
Section Three: Comprehension	1	1	20		24	18	
						100	

Instructions to candidates

1. The rules of conduct of Christ Church Grammar School assessments are detailed in the Reporting and Assessment Policy. Sitting this examination implies that you agree to abide by these rules.

2. Write your answers in this Question/Answer booklet preferably using a blue/black pen. Do not use erasable or gel pens.

3. 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.

4. Supplementary pages for planning/continuing your answers to questions are provided at the end of this Question/Answer booklet. If you use these pages to continue an answer, indicate at the original answer where the answer is continued, i.e. give the page number.

5. Information for questions has been repeated on the removable Information Booklet which has been inserted inside the front cover of this booklet so that you can refer more easily to it while answering the questions. Do not write your answers in the Information Booklet.

6. Provide all answers to three significant figures unless otherwise instructed.

YEAR 11
PHYSICS ATAR
SEMESTER 1 EXAMINATION 2020

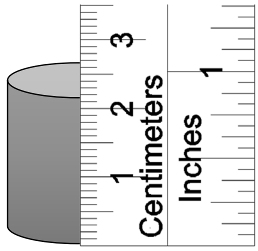
Section One: Short Response **(32% 40 marks)**

This section has **ten (10)** questions. Answer **all** questions. Write your answers in the space provided.

Suggested working time for this section is **40 minutes**.

Question 1 **(2 marks)**

A student is measuring a cylinder shown in the diagram. He places a ruler over the front edge of the cylinder.



(a) State the height with absolute uncertainty:

(1 mark)

(b) Calculate percentage uncertainty in the height:

(1 mark)

Question 2 **(4 marks)**

A 0.0450 kg aluminium pellet is heated to 98.5°C and then dropped into an 80.0 g glass beaker containing 0.200 kg of water at 20.0°C. The final maximum equilibrium temperature is 23.5°C. Calculate the specific heat capacity of the aluminium. Assume any heat lost from the calorimeter is negligible. (c_{glass} = 670.0 J kg^{-1} K^{-1})

Question 3 **(5 marks)**

Complete the following nuclear equations.

(a) $^{14}_{6}C \rightarrow {}^{14}_{7}N + \square + \square$

(b) $^{27}_{13}Al + {}^{4}_{2}\alpha \rightarrow \square + {}^{1}_{0}n$

(c) $^{217}_{85}At \rightarrow {}^{213}_{83}Bi + \square$

(d) $^{10}_{5}B + {}^{1}_{0}n \rightarrow {}^{4}_{2}\alpha + \square$

Question 4 **(3 marks)**

Multimeters can function as voltmeters (with very high resistance) and as ammeters (with very low resistance). Students who place a multimeter across an electrical component, but accidentally have it set as an ammeter instead of voltmeter, find that it breaks the multimeter. Explain how this error can damage the multimeter.

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Question 5 **(5 marks)**

Given the following data, calculate the binding energy per nucleon in, MeV, for a neutral Manganese-55 atom.

Mass of proton	=	1.007276 u
Mass of neutron	=	1.008665 u
Mass of electron	=	0.000548 u
Mass of Hydrogen-1	=	1.007825 u
Mass of Manganese 55 atom	=	54.93800 u

Question 6 **(4 marks)**

Complete the table to show the relative magnitude of various properties of the radioactive particles. Use the bolded words provided for the magnitude of each property.

Particle	Alpha	Beta	Gamma
Mass **zero small medium large**			
Electric charge			
Distance travelled in air **zero small medium large**			
Emission speeds **zero small medium large**			

Question 7 **(3 marks)**

Gallium-68 has a half-life of 68.3 minutes. Calculate the percentage of a sample of gallium remaining at the end of 3.00 hours.

Question 8 **(5 marks)**

The label on a rechargeable Lithium-Polymer (LiPo) battery reads: "11.1 volt, 1850 mAh". The battery is being used to operate a remote-control vehicle.

(a) The term "1800 mAh" refers to which quantity below? Circle your answer.

(1 mark)

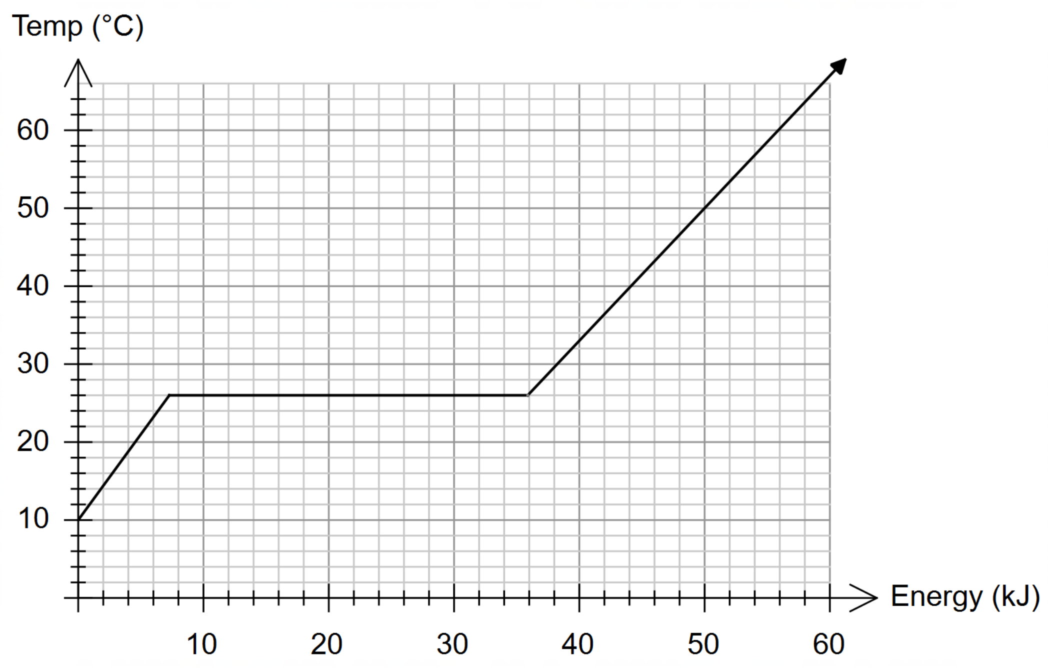
Current Time Energy Charge

(b) Given that the electric motor of the vehicle draws a constant current of 12.0 A from the battery during an operating time of 9.00 minutes, calculate the efficiency of the motor, if the motor produces 5.80×10^4 J of useful energy.

(4 marks)

Question 9 **(8 marks)**

The heating curve below shows the temperature change of a 285 g sample of solid coconut oil as it is heated, with a small 40.0 W heating element, from an initial temperature of 10.0 °C.



(a) Calculate the time taken for the coconut oil to completely melt.

(3 marks)

(b) Use the graph to estimate the specific heat capacity of liquid coconut oil.

(5 marks)

Question 10 **(3 marks)**

In cold climates wind chill factor and hypothermia can pose a real threat to the health of an individual. Wind chill is when cooler, moving air replaces relatively still air near the skin, giving the person the sensation that the effective temperature has decreased. Explain why the wind chill is worsened when the person is wet or wearing wet clothes.

End of Section One

Supplementary page

Question number: ___________________

Supplementary page

Question number: ___________________

Christ Church
Grammar School

Science Department
Year 11 Physics

PHYSICS UNIT 1

SECTION TWO

PROBLEM SOLVING

Semester 1 Examination, 2020

Question/Answer booklet

Section Two: Problem Solving **50% (67 marks)**

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

Suggested working time for this section is **60 minutes**.

NAME:_______________________________________

TEACHER: CJO JRM PCW SGA
(please circle)

Question 11 **(10 marks)**

A portable radio is rated at 9.00 V and draws an operating current of 0.800 A while operating. The radio's battery can provide a total energy of 45.0 kJ at 9.00 V until the batteries are depleted of charge and can no longer operate the radio

(a) Calculate the power of the radio when it is operating.

(2 marks)

(b) Calculate the number of electrons that flow through radio every second.

(3 marks)

(c) Calculate the time, in minutes that the radio can operate before all of the total charge has been depleted from the battery.

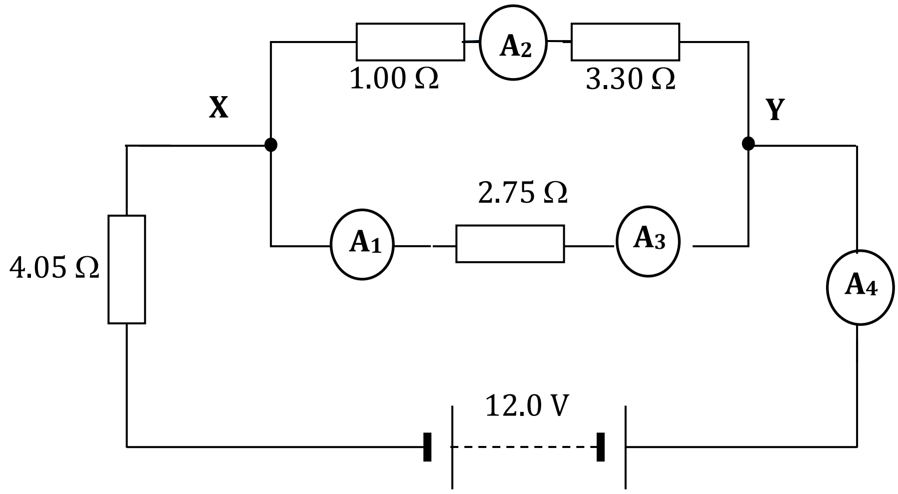
(3 marks)

(d) Calculate the energy each electron loses as it passes through the radio.

(2 marks)

Question 12 **(12 marks)**

Consider the complex circuit below.



(a) Calculate the total resistance of the circuit.

(4 marks)

(b) Calculate the total current that flows through the circuit. (If you could not complete part (a), use R_T = 7.00 Ω)

(2 marks)

(c) State and explain which ammeters, if any that would show the same readings.

(2 marks)

(d) Calculate the reading on ammeter 2.

(4 marks)

Question 13 **(11 marks)**

In an experiment to calculate the latent heat of ice, 24.0 grams of ice at 0.00 °C was placed into an insulated calorimeter containing 0.240 kg of water at 36.0 °C. The ice completely melted and the final mixture temperature was measured to be 23.6 °C.

(a) Calculate the heat energy lost by the water in the calorimeter.

(2 marks)

(b) Write an equation for the total heat energy gained by the ice.

(1 mark)

(c) Hence, by equating the heat lost from (a) to the heat gained in (b), calculate the latent heat of fusion for ice.

(3 marks)

(d) Calculate the percentage difference between the calculated value of L_f and the accepted value. (if you could not complete part (c), use $L_f = 3.80 \times 10^5$)

(2 marks)

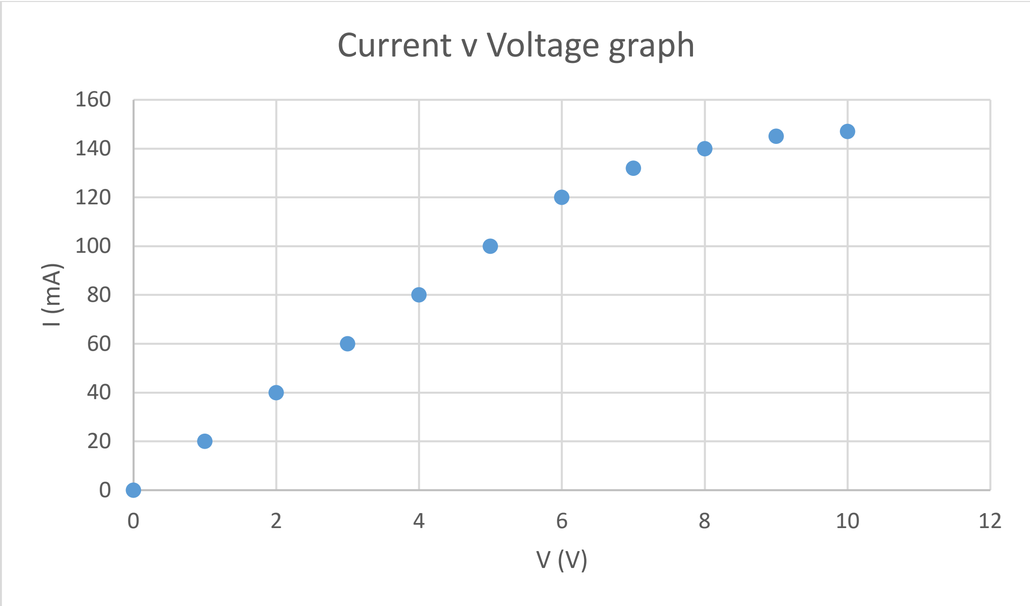
In reality, as the calorimeter was in an environment that was colder than the final temperature some heat would have been removed from the system.

(e) Explain the effect that this loss of energy would have on the measured value of the latent heat of fusion of ice.

(3 marks)

Question 14 **(10 marks)**

A voltage source is connected across a filament light bulb and the current is measured for different voltages. The graph is shown below.



(a) Draw a line of best fit for the data shown in the graph above.

(1 mark)

(b) State the range of voltages where the light bulb is behaving as an ohmic conductor.

(1 mark)

Range: ____

(c) Using the gradient of the graph above, calculate the average resistance of the light bulb when it is behaving as an ohmic conductor.

(3 marks)

(d) Calculate the resistance of the filament light bulb when the voltage is at 8.00 V.

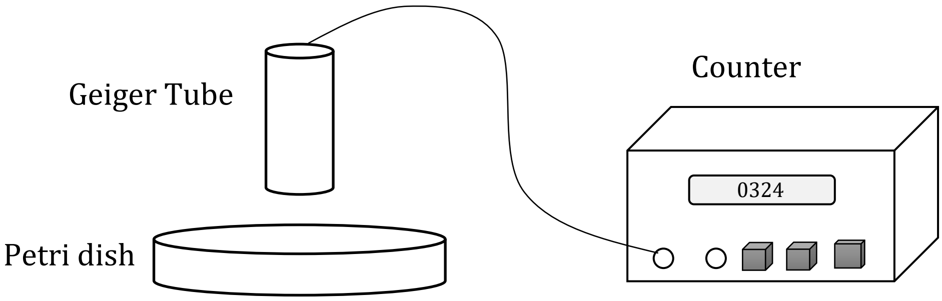
(2 marks)

(e) Explain and account for the difference in calculated resistances for parts (c) and (d).

(3 marks)

Question 15 **(24 marks)**

In an experiment to determine the half-life of the element barium-137, a small amount of barium nitrate solution was dispensed into a petri dish and the β^- particle emission from the liquid was measured using a Geiger Counter.



The counter displays the total number of counts of β^- particles coming from the barium source, measured at 20 second intervals. The experimental results for the experiment are shown below in the table (the first 120 seconds have been calculated).

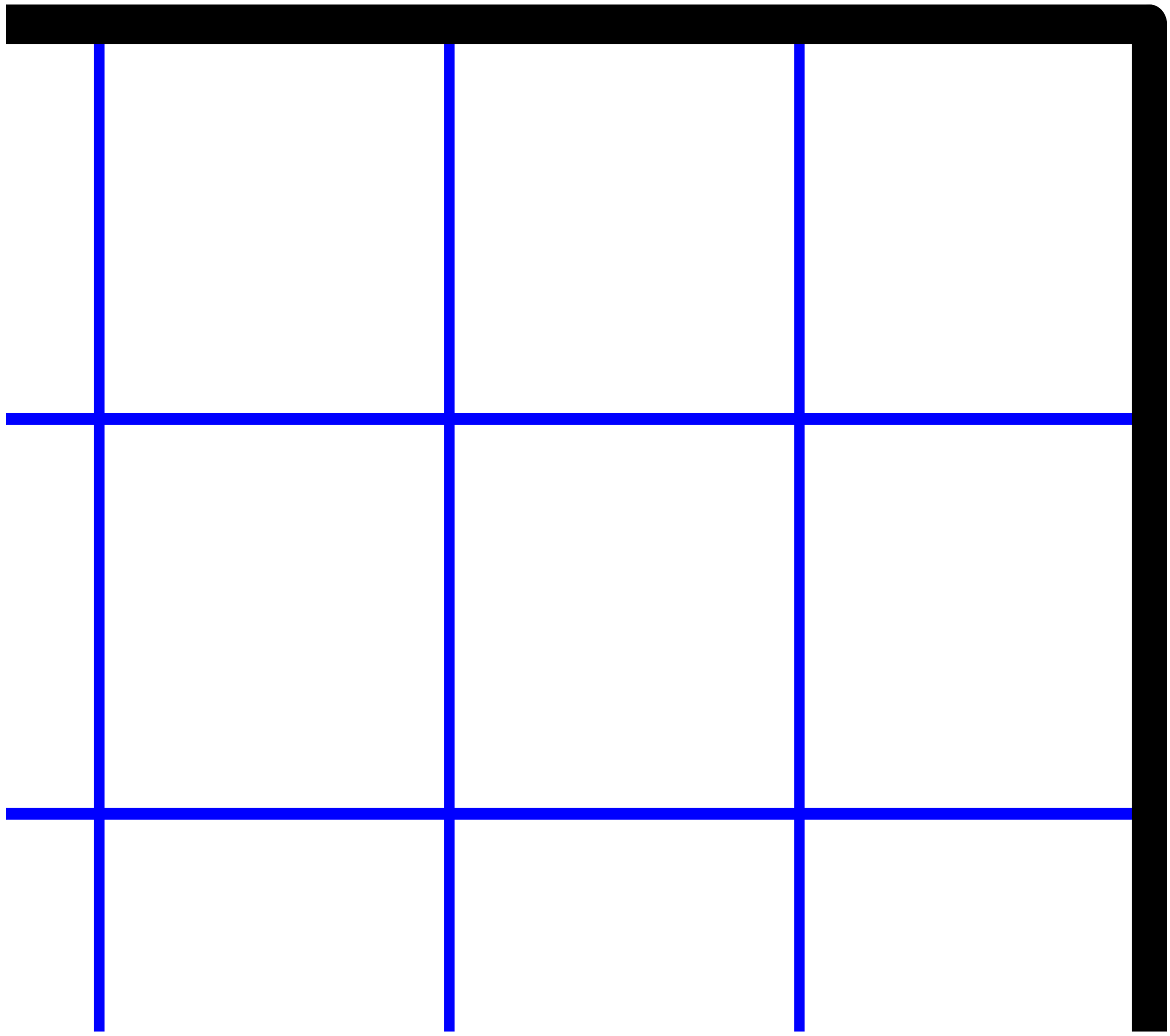
Time (s)	Total Count	Counts for each 20 s interval	Average rate per second
20	126	126	6.3
40	229	103	5.2
60	324	95	4.8
80	411	87	4.4
100	491	80	4.0
120	563	72	3.6
140	634		
160	698		
180	754		
200	803		
220	850		
240	895		
260	938		
280	980		
300	1020		
320	1057		

(a) Complete the final two columns in the table so that it shows the counts recorded in **each** 20 second interval. The right column shows the average count rate i.e. the average number of counts per second over that 20 second interval.

(4 marks)

(b) On the graph below, plot a graph of “Average rate per second” vs time. A spare grid is provided on the end of this Question/Answer booklet. If you need to use it, cross out this attempt and clearly indicate that you have redrawn it on the spare page.

(5 marks)



(c) Using the graph, determine the half life of Barium 137 and write your value below,

(3 marks)

Question 15 continued

Another sample of barium-137 initially is recorded as having an activity of 12.0 kBq.

(d) Calculate the measured activity after a time of 8.00 minutes. (If you could not complete (c), use a value of 150.0 seconds)

(4 marks)

(e) Write a balanced nuclear equation of barium-137 into its daughter nuclei.

(2 marks)

The decay particle is released with an emission energy of 1.60 $\times 10^{-13}$ J. Suppose a scientist of mass 65.5 kg was to accidentally ingest a sample of barium-137 which undergoes a total of 5.20 $\times 10^{14}$ decay events in a duration of 3.00 days.

(f) Calculate the absorbed dose received by the scientist.

(3 marks)

(g) Calculate the equivalent dose received by the scientist. (If you could not do (f), use an absorbed dose of 1.00 Gy)

(3 marks)

End of Section Two

Spare grid

Supplementary page

Question number: ___________________

Christ Church Grammar School

Science Department
Year 11 Physics

PHYSICS UNIT 1

SECTION THREE

COMPREHENSION

Semester 1 Examination, 2020

Question/Answer booklet

Section Three: Comprehension **18% (24 marks)**

This section has **one (1)** question. Write your answers in the space provided.

Suggested working time for this section is **20 minutes.**

NAME:____

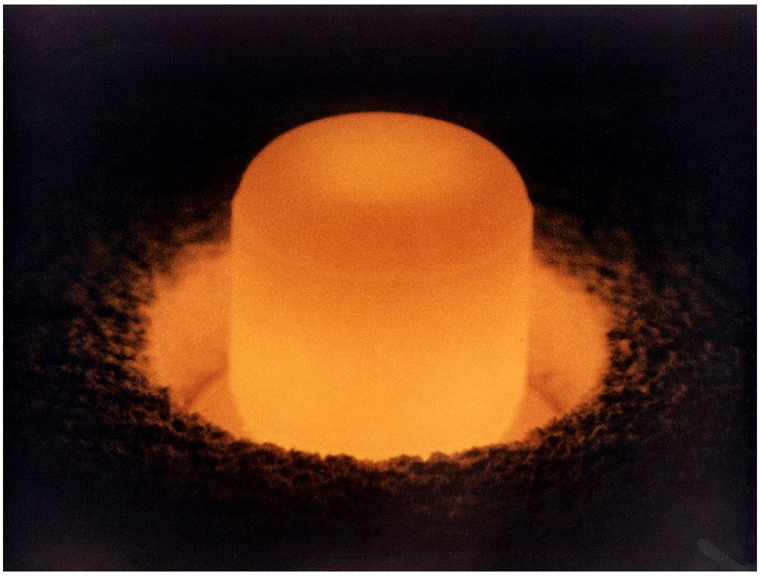
TEACHER: CJO JRM PCW SGA
(please circle)

Question 16 **(24 marks)**

The secretive Element 94

You might have heard in chemistry class that there are 92 naturally occurring elements existing on Earth and, up until 79 years ago, that was all the building blocks we had to play with. In the mid-1930s, Enrico Fermi reported that his team of scientists had produced a mysterious *Element 94*, but it wasn't until 1941, midway through World War II that it was chemically identified and confirmed as a new element at the University of California, Berkley. Wartime secrecy prevented the University of California team from publishing its discovery until 1948, so much investigation and testing went on in secrecy by the American and Allied nations during the early 1940s. Since uranium had been named after the planet Uranus and neptunium after the planet Neptune, element 94 was named after Pluto (which at the time was considered to be a planet as well).

Plutonium was first produced by a neutron bombardment of uranium-238; producing unranium-239 (half-life 23.5 minutes) which beta-decayed into neptunium-239 (half-life 2.35 days) which subsequently beta-decayed to form this new element with atomic number 94 and atomic weight 239 (half-life 24,100 years).



Further investigation from the team at the Cavendish Laboratory in Cambridge, realised that a slow neutron reactor fuelled with uranium would theoretically produce substantial amounts of plutonium-239 as a by-product. They calculated that element 94 would be fissile and had the added advantage of being chemically different from uranium and could easily be separated from it.

(a) Complete the 3 separate nuclear equations that show the synthesis of plutonium through the neutron bombardment of uranium.

(3 marks)

(b) If 212 g of U–239 was synthesised in a lab, calculate the mass of uranium remaining after a time of 3.40 hours.

(4 marks)

(c) The decayed mass of U-239 should be roughly equal to the synthesized mass of Np-239. Explain why the mass of neptunium is less than the predicted value they assumed would be present by subtracting the value from part (b) from the initial 212 grams.

(2 marks)

When plutonium-239 was first synthesised into macroscopic pieces, scientists marveled that the sample of heavy silver metal was warm to touch. When isotope samples undergo radioactive decay, internal interactions are absorbed and produces “decay heat”. Different isotopes produce different amounts of heat per mass. The decay heat is usually listed as watt/kilogram, or milliwatt/gram.

Radioisotope	Decay Heat (W/kg)
Pu-238	560
Pu-240	6.8
Am-241	114
Po-210	141
U-235	3.0

A 5.00 kg mass of pure Pu-239 contains about 12.5 $\times 10^{24}$ atoms. With a half-life of 24,100 years, about 11.5 $\times 10^{12}$ of its atoms decay each second by emitting a 5.16 MeV alpha particle. This amounts to 9.49 W of power released. Heat produced by the deceleration of these alpha particles makes it warm to the touch.

(d) Calculate the decay heat for Pu-239.

(2 marks)

(e) Show that the energy per emission and decay rate of Pu-239 amounts to 9.49 W of power.

(3 marks)

With all fission reactors, the removal of the decay heat is a significant reactor safety concern, especially shortly after normal shutdown or following a loss-of-coolant accident. Failure to remove decay heat may cause the reactor core temperature to rise to dangerous levels and has caused nuclear accidents, including the nuclear accidents at Three Mile Island and Fukushima I. The heat removal is usually achieved through several redundant systems, from which heat is removed via heat exchangers. Water is passed through the secondary side of the heat exchanger via the essential service water system which dissipates the heat into the 'ultimate heat sink', often a sea, river or large lake. In locations without a suitable body of water, the heat is dissipated into the air by recirculating the water via a cooling tower.

Consider a nuclear reactor initially containing fuel rods of Pu-239 of mass 53.5 kg. A loss of coolant event sees no thermal energy removed in a period of 12.5 minutes.

(f) Calculate the energy released via decay heat of the fuel rods in this time period. (If you could not answer (d), use a decay heat of 2.00 W/kg)

(3 minutes)

Nuclear fission power stations that produce plutonium (known as "fast breeder reactors") are controversial, as the Pu-239 produced can be used as a fuel source for nuclear weapons. Pu-239 is efficient at capturing fast moving neutrons, produces a large amount of energy per event and emits on average 2.89 neutrons during each fission event.

(g) Explain why Pu-239 is an ideal fuel source for a weapon, but not required for a power station. (Your answer should refer to the differences in the desired rate of reaction)

(4 marks)

In order to detonate a nuclear weapon, a critical mass of a fuel source, such as Pu – 239 must be assembled, typically the fuel is in a spherical shape and often detonated using conventional explosives.

(h) Explain the purpose of the conventional explosives and the spherical shape

(3 marks)

End of Section Three

Supplementary page

Question number: ___________________

Supplementary page

Question number: ___________________