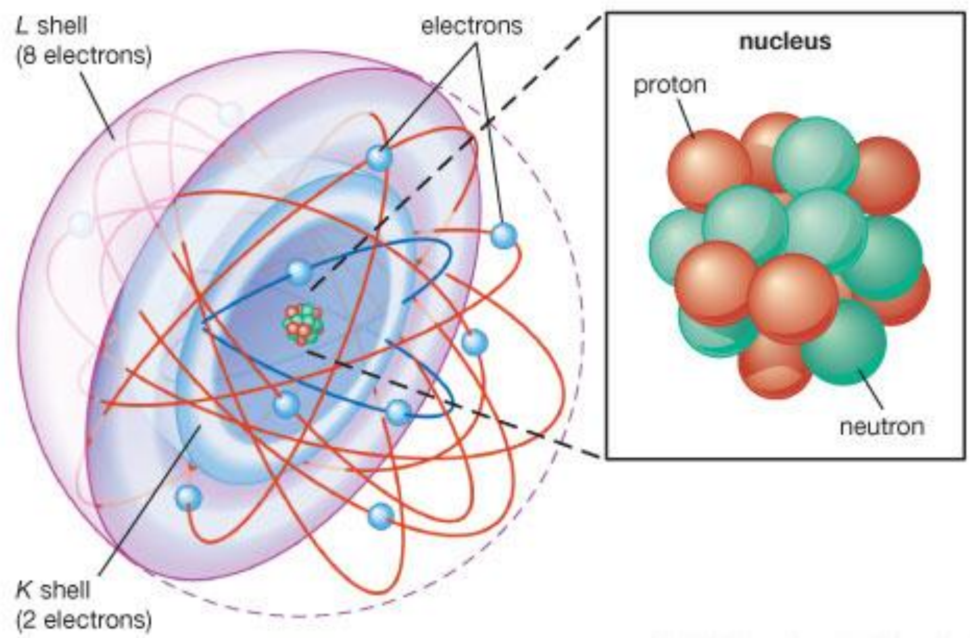
SALTUS
Prepare to meet the world.

IGCSE Physics



Unit 8 – Nuclear Physics

Name: ……………………………………………………………………………

Class: ……………… **Date:**…………………………

Summary

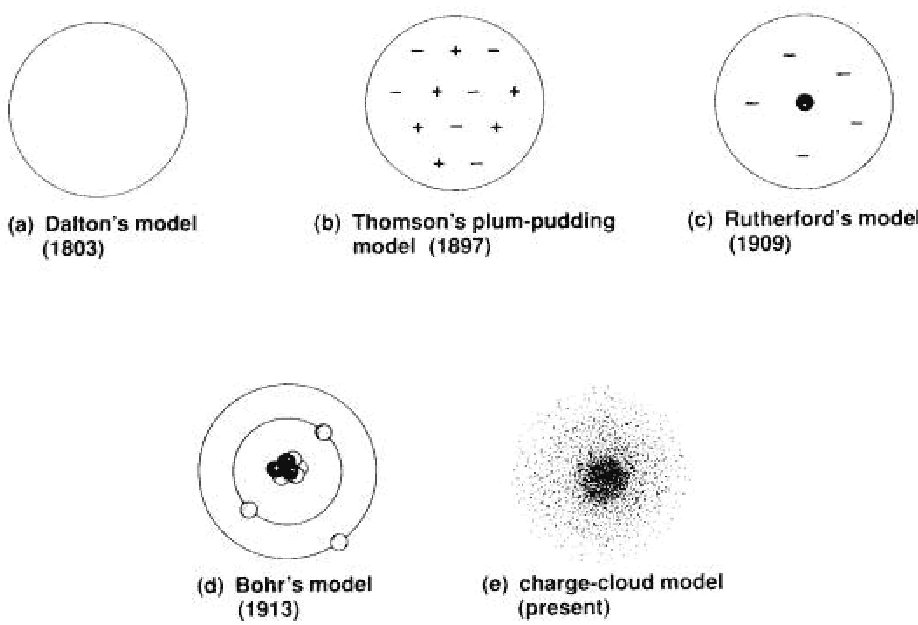
Lesson	Objectives : Students will be assessed on their ability to
Discovery of the Nucleus	• describe the results of Geiger and Marsden's experiments with gold foil and alpha particles • describe Rutherford's nuclear model of the atom and how it accounts for the results of Geiger and Marsden's experiment and understand the factors (charge and speed) which affect the deflection of alpha particles by a nucleus
Nuclear Structure	• describe the structure of an atom in terms of protons, neutrons and electrons and use symbols such as C^{14} to describe particular nuclei • understand the terms atomic (proton) number, mass (nucleon) number and isotope • understand that alpha and beta particles and gamma rays are ionising radiations emitted from unstable nuclei in a random process
Nuclear Radiation	• describe the nature of alpha and beta particles and gamma rays and recall that they may be distinguished in terms of penetrating power • understand that ionising radiations can be detected using a photographic film or a Geiger-Muller detector • describe the dangers of ionising radiations, including radiation can cause mutations in living organisms and radiation can damage cells and tissue
Nuclear Equations	• recall the sources of background radiation • describe how the atomic and mass numbers of a nucleus change following a radiation emission • understand how to complete balanced nuclear equations
Half-Life	• understand that the activity of a radioactive source decreases over a period of time and is measured in becquerels • recall the term 'half-life' and understand that it is different for different radioactive isotopes • use the concept of half-life to carry out simple calculations on activity
Applications of Nuclear Physics	• describe the uses of radioactivity in medical and non-medical tracers, in radiotherapy and in the radioactive dating of archaeological specimens and rocks
Nuclear Fission	• understand that a nucleus of U-235 can be split (the process of fission) by collision with a neutron, and that this process releases energy in the form of kinetic energy of the fission products • recall that the fission of U-235 produces two daughter nuclei and a small number of neutrons • understand that a chain reaction can be set up if the neutrons produced by one fission strike other U-235 nuclei
Nuclear Power	• understand the role played by the control rods and moderator when the fission process is used as an energy source to generate electricity • describe the dangers of ionising radiations, including the problems arising in the disposal of radioactive waste

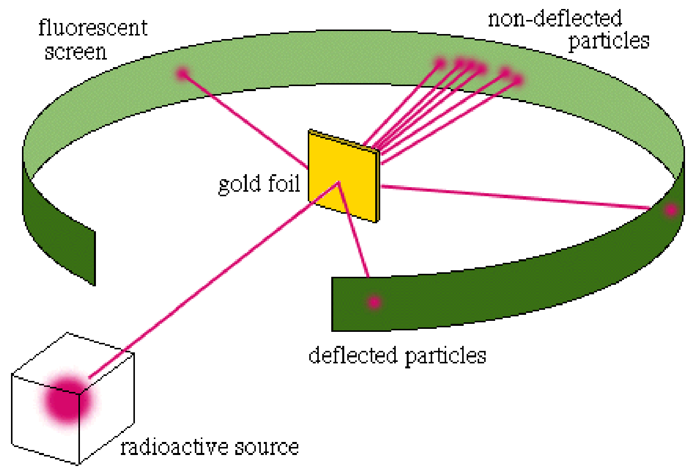
1 – Discovery of the Nucleus

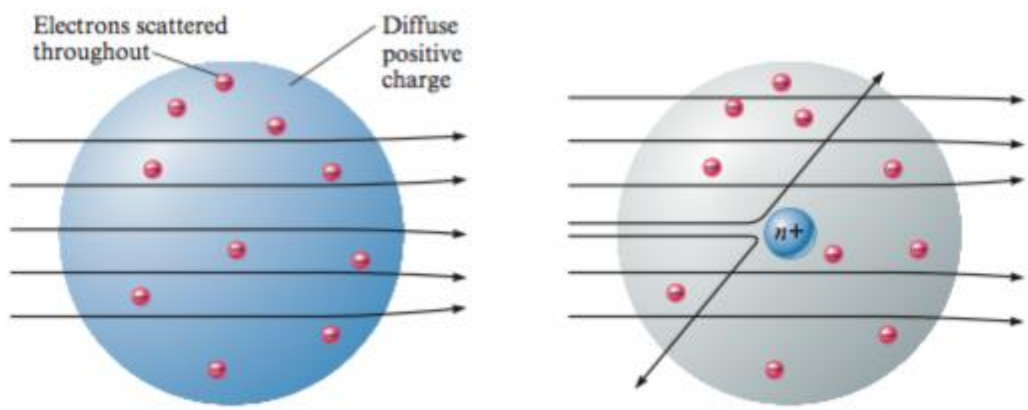
Objectives:

- describe the results of Geiger and Marsden's experiments with gold foil and alpha particles
- describe Rutherford's nuclear model of the atom and how it accounts for the results of Geiger and Marsden's experiment and understand the factors (charge and speed) which affect the deflection of alpha particles by a nucleus

Notes:




fluorescent screen
non-deflected particles
gold foil
deflected particles
radioactive source


Electrons scattered throughout
Diffuse positive charge
n+

CW 8.1 - The Nucleus of the Atom

Q1. Complete the following sentences (4).

a) Neutral atoms have ……………………… charge.
b) A charged atom is called an …………………………. .
c) A neutral atom has the same number of ……………………………. and …………………………………. .
d) If an electron is removed from a neutral atom, the atom becomes …………………………. charged.

Q2. Complete this table (3):

Particle	Mass	Charge
Proton	1	
	1	0
Electron		-1

Q3. In the early 1900s the "plum pudding" model of the atom was replaced by Rutherford's "nuclear" model.

a) Briefly describe the experiment that Geiger and Marsden carried out. (1)

………

……….

b) What did they EXPECT to happen in the experiment? (1)

………

……….

c) Rutherford used the results from the experiment to disprove the plum pudding model and come up with the nuclear model of the atom. Describe the results of their experiment and what it showed about the structure of the atom. (3)

………

……….

………

……….

………

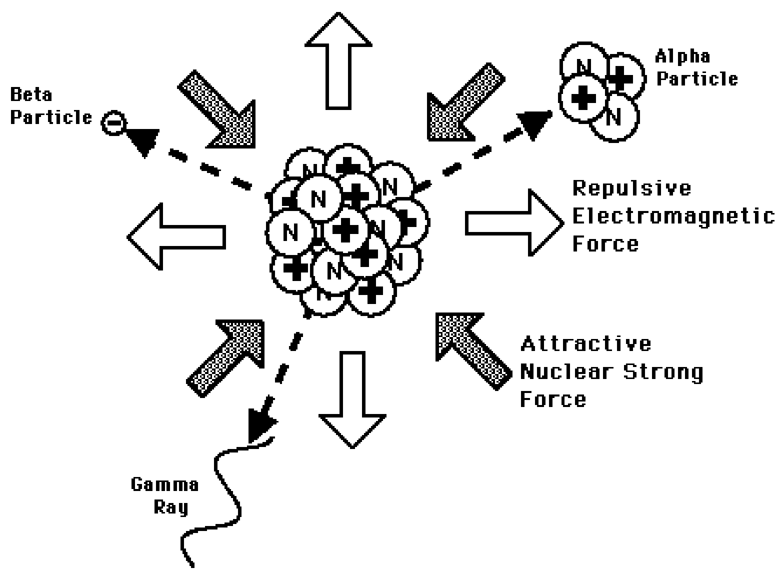
……….

2 – Nuclear Structure

Objectives:

- describe the structure of an atom in terms of protons, neutrons and electrons and use symbols such as ${}^{14}_{6}C$ to describe particular nuclei
- understand the terms atomic (proton) number, mass (nucleon) number and isotope
- understand that alpha and beta particles and gamma rays are ionising radiations emitted from unstable nuclei in a random process

Notes:

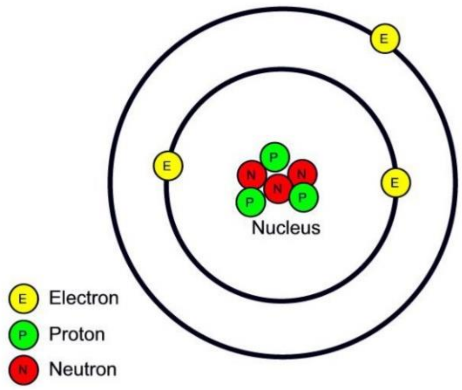


Name	Symbol	Mass	Charge
Proton			
Neutron			
Electron			

Complete the table (10)

Isotope	Protons	Neutrons	Electrons
Hydrogen-1			
Hydrogen-2			
Helium-4			
Lithium-7			
Carbon-12			
Carbon-14			
Uranium-235			
Uranium-238			
Technicium-99			
Potassium-39			

Name and write the full symbol for the isotope depicted below. (2)

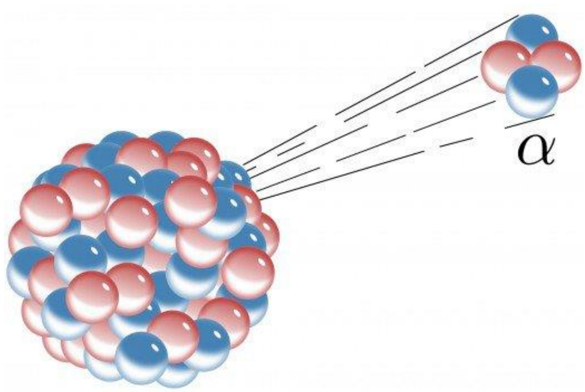


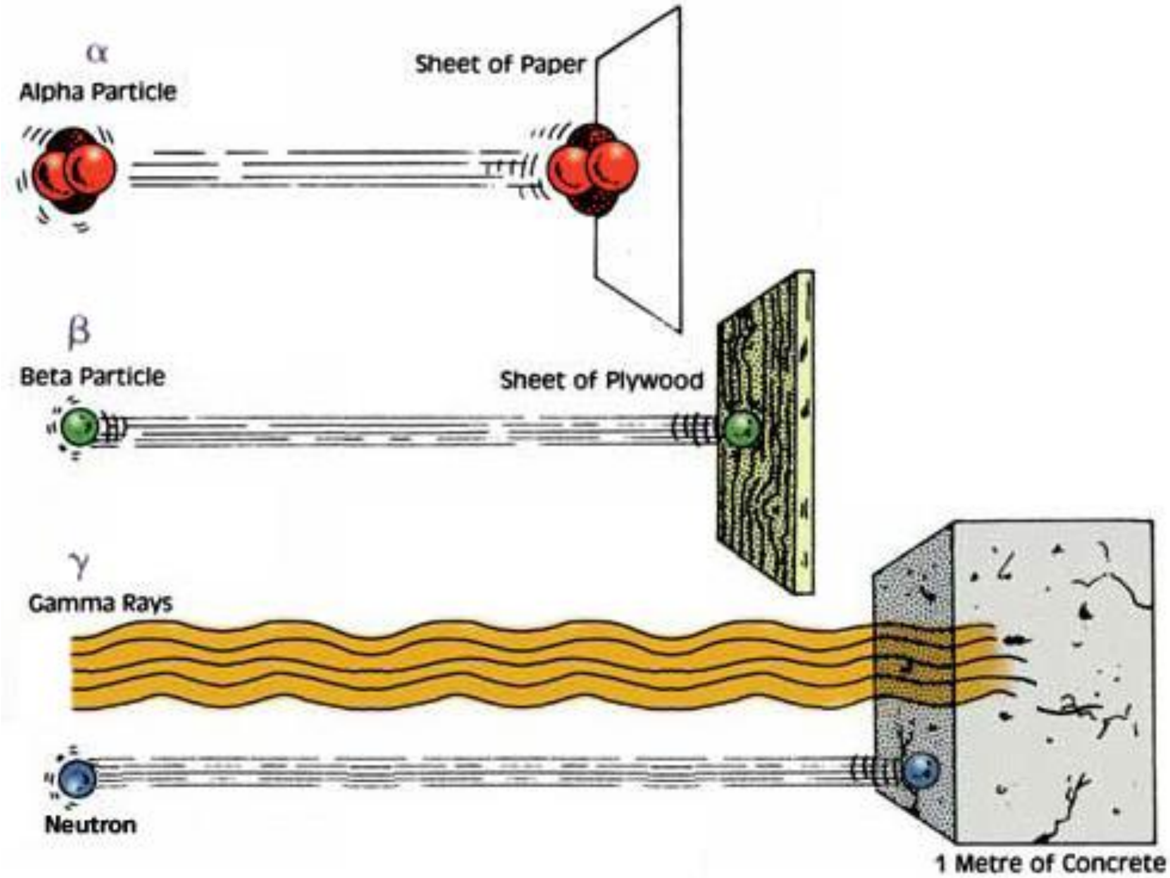
3 – Nuclear Radiation

Objectives:

- describe the nature of alpha and beta particles and gamma rays and recall that they may be distinguished in terms of penetrating power
- understand that ionising radiations can be detected using a photographic film or a Geiger-Muller detector
- describe the dangers of ionising radiations, including radiation can cause mutations in living organisms and radiation can damage cells and tissue

Notes:





Complete the table below by choosing the correct word from each column. (5)

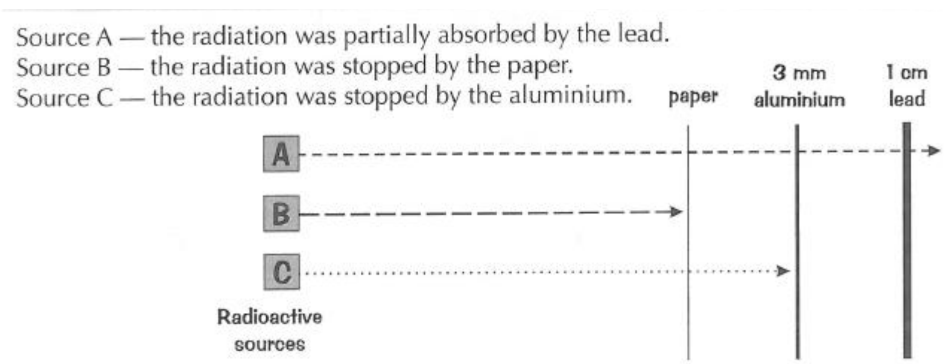
Radiation Type	Ionising power weak/ moderate/ strong	Charge positive/ none/ negative	Relative mass no mass/ small/large	Penetrating power low/moderate/ high	Range in air short/long/ very long
alpha					
beta					
gamma					

CW 8.2 - Ionising Radiation Questions

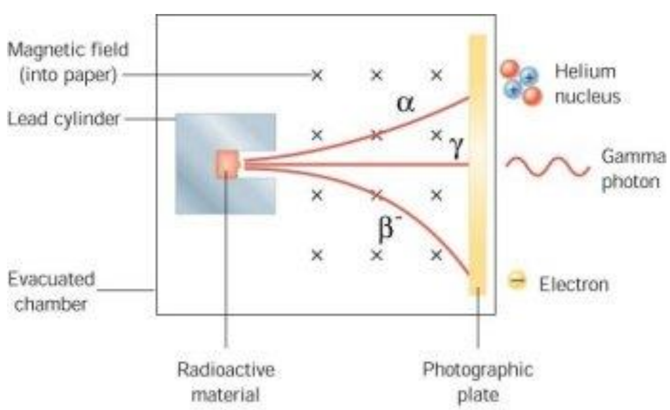
1. Match the descriptions of the radiation: (1)

Alpha	2 neutrons and 2 protons
Beta	An electromagnetic wave
gamma	A fast moving electron

2. Label the three types of radiation based on their penetrating power. (1)



3. The diagram below shows the paths of an alpha particle and a beta particle in a B-field. Explain the difference in their paths. Hint: consider both Newton's Laws and Fleming's Left Hand Rule. (2)



....

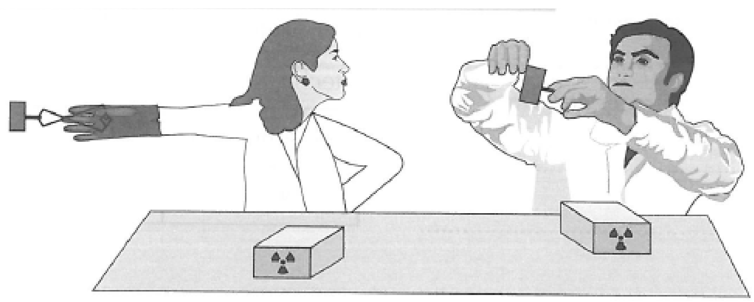
....

....

...

CW 8.3 - Radioactivity Safety

Q1. Two scientists are handling samples of radioactive material.



a) One of the scientists is taking sensible safety precautions, but the other is not. Describe THREE things which the careless scientist is doing wrong. (3)

....

....

....

b) Describe another way the scienntists can reduce their exposure to the radiation without using special apparatus or clothing. (1)

....

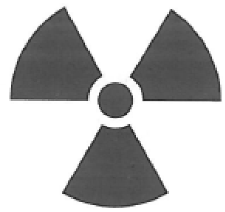
....

c) How should radioactive samples be stored when they are not in use? (2)

....

....

Q2. The three different types of radiation can all be dangerous.



a) Which TWO types can pass through the human body? (1)

....

....

b) Which type of radiation is usually the most dangerous if it is swallowed or inhaled? (1)

....

....

c) What effects can this type of radiation have on the human body? (1)

....

....

d) The international symbol for nuclear radiation is pictured above. Explain what this symbol is trying to show. (1)

....

....

CW 8.4 - Natural Radiation

1. Explain the following:

   a) Radioactivity is present inside your body as well as around it. (1)

   ....

   ....

   b) A regular air traveller recieves a higher dose of radiation than someone who does not travel by air. (1)

   ....

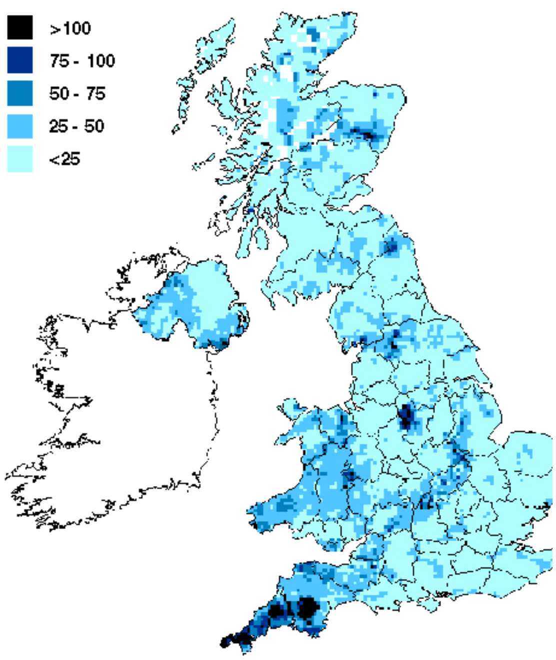
   ....

   c) Where you live may affect the radiation dose that you receive. (1)

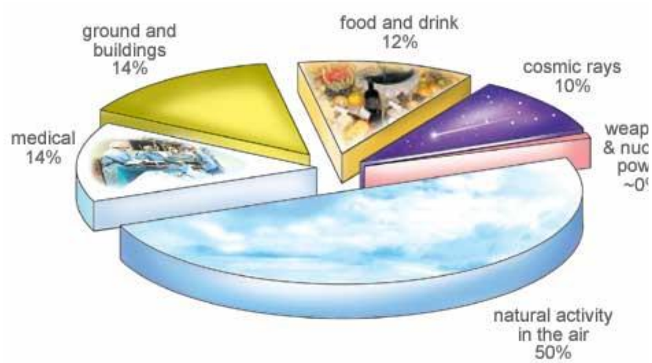
   ....

   ....

2. The pie chart shows the sources of the average radiation dose received in one year by someone living in the UK. The map shows how the levels of radon gas vary in different parts of the UK.



Geometric mean radon, Bq m^{-3}



a) Where is the concentration of radon gas the highest? Use your knowledge of UK geography (or research it!) to explain why this is the case. (2)

....

....

b) Radon is more likely to cause problems in homes that are poorly ventilated, especially in the parts of the country where the levels are high. Suggest why ventilatation helps. (1)

....

....

c) The average annual radiation dose in the UK is 2.20 units. Using the pie chart above, calcuate the dosage received from i) rocks and ii) cosmic rays. (2)

....

....

Q4. Background radiation varies and can be random. It is essential that it is montiored. Explain how and why scientists monitor this background radiation. (2)

....

....

....

....

Q5. How can we account for the errors that background radiation can cause in our experiments in the laboratory? (2)

....

....

....

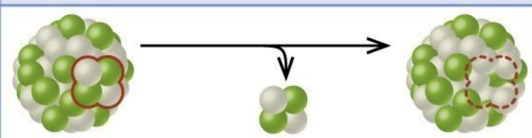
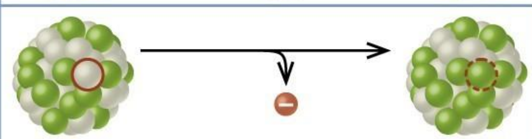
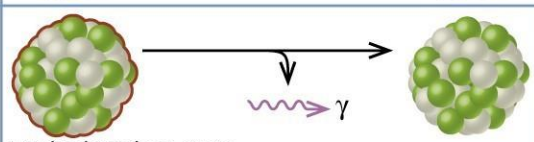
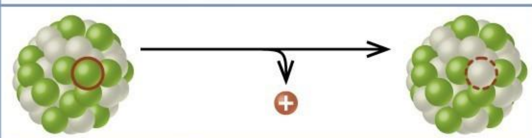
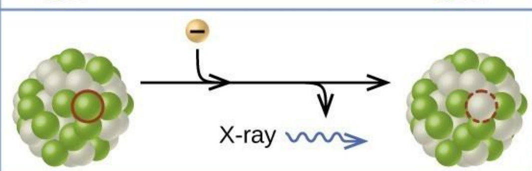
....

4 – Nuclear Equations

Objectives:

- recall the sources of background radiation
- describe how the atomic and mass numbers of a nucleus change following a radiation emission
- understand how to complete balanced nuclear equations

Notes:

Type	Nuclear equation	Representation	Change in mass/atomic numbers
Alpha decay	${}^{A}_{Z}X \quad {}^{4}_{2}He + {}^{A-4}_{Z-2}Y$		A: decrease by 4 Z: decrease by 2
Beta decay	${}^{A}_{Z}X \quad {}^{0}_{-1}e + {}^{A}_{Z+1}Y$		A: unchanged Z: increase by 1
Gamma decay	${}^{A}_{Z}X \quad {}^{0}_{0}\gamma + {}^{A}_{Z}Y$	 Excited nuclear state	A: unchanged Z: unchanged
Positron emission	${}^{A}_{Z}X \quad {}^{0}_{+1}e + {}^{A}_{Y-1}Y$		A: unchanged Z: decrease by 1
Electron capture	${}^{A}_{Z}X \quad {}^{0}_{-1}e + {}^{A}_{Y-1}Y$		A: unchanged Z: decrease by 1

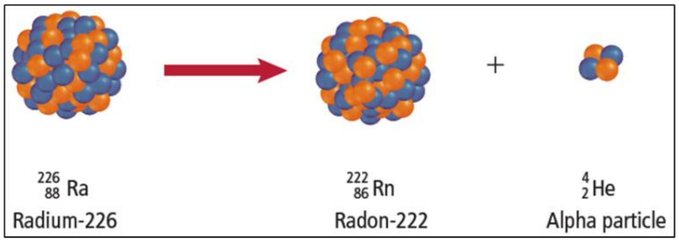
CW 8.5 - A Full Decay Series

The following decay chain shows how U-235 decays over a series of steps to a stable isotope. Fill in the empty boxes, moving the daughter product to the left side of the next equation.

Parent					**Daughter**
${}^{235}_{92}U$	$\rightarrow$	${}^{231}_{90}\boldsymbol{Th}$	+	${}^{4}_{2}\alpha$	Thorium
${}^{231}_{90}\boldsymbol{Th}$	$\rightarrow$		+	${}^{0}_{-1}e$	
	$\rightarrow$		+	${}^{4}_{2}\alpha$	
	$\rightarrow$		+	${}^{4}_{2}\alpha$	
	$\rightarrow$		+	${}^{0}_{-1}e$	
	$\rightarrow$		+	${}^{4}_{2}\alpha$	
	$\rightarrow$		+	${}^{4}_{2}\alpha$	
	$\rightarrow$		+	${}^{4}_{2}\alpha$	
	$\rightarrow$		+	${}^{0}_{-1}e$	
	$\rightarrow$		+	${}^{4}_{2}\alpha$	
	$\rightarrow$		+	${}^{0}_{-1}e$	

CW 8.6 - Decay Equations

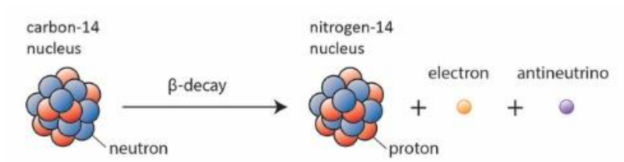
Q1 The alpha decay of radium-226 is illustrated below:



All the following nuclei decay by alpha emission. Add the names of the daughter nuclei produced.

Parent						Daughter
a) Radium	$^{226}_{88}Ra$	→		+	$^{4}_{2}\alpha$	
b) Thorium	$^{232}_{90}Th$	→		+	$^{4}_{2}\alpha$	
c) Thorium	$^{228}_{90}Th$	→		+	$^{4}_{2}\alpha$	
d) Radium	$^{224}_{88}Ra$	→		+	$^{4}_{2}\alpha$	
e) Polonium	$^{216}_{84}Po$	→		+	$^{4}_{2}\alpha$	
f) Radon	$^{220}_{86}Rn$	→		+	$^{4}_{2}\alpha$	
g) Bismuth	$^{126}_{83}Bi$	→		+	$^{4}_{2}\alpha$	
h) Polonium	$^{212}_{84}Po$	→		+	$^{4}_{2}\alpha$	
i) Astatine	$^{217}_{85}At$	→		+	$^{4}_{2}\alpha$	

Q2. The beta decay of carbon-14 is illustrated below:



All the following nuclei decay by beta emission. Add the names of the daughter nuclei produced.

Parent						Daughter
a) Carbon	${}^{14}_{6}C$	→		+	${}^{0}_{-1}e$	
b) Uranium	${}^{237}_{92}U$	→		+	${}^{0}_{-1}e$	
c) Plutonium	${}^{241}_{94}Pu$	→		+	${}^{0}_{-1}e$	
d) Protactinium	${}^{233}_{91}Pa$	→		+	${}^{0}_{-1}e$	
e) Bismuth	${}^{213}_{83}Bi$	→		+	${}^{0}_{-1}e$	
f) Lead	${}^{209}_{82}Pb$	→		+	${}^{0}_{-1}e$	
g) Thallium	${}^{209}_{81}Tl$	→		+	${}^{0}_{-1}e$	
h) Radium	${}^{225}_{88}Ra$	→		+	${}^{0}_{-1}e$	
i) Francium	${}^{223}_{87}Fr$	→		+	${}^{0}_{-1}e$	

Q3. For the following isotopes, write the nuclear equation that represents their decay modes.

a) Thorium-234 decays to form Protactinium-234.

....

b) Thorium-230 decays to form Radium-226

....

c) Protactinium-234 decays to form Uranium-234

....

d) Thorium-232 decays to form Radium-228.

....

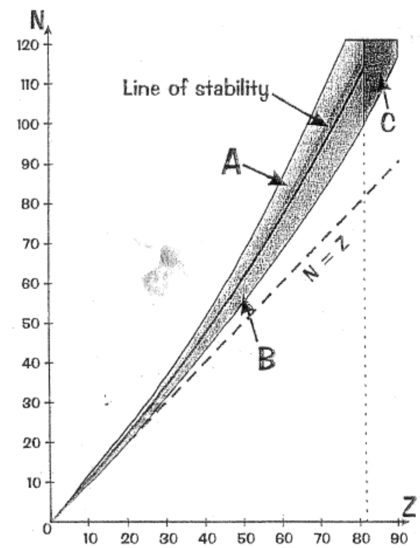
CW 8.7 – More Decay Equations

Complete the following nuclear reactions:

${}^{90}_{38}Sr$	→	${}^{90}_{39}Y$	+			
${}^{239}_{94}Pu$	→	${}^{235}_{92}U$	+			
${}^{58}_{27}Co$	→	${}^{58}_{26}Fe$	+			
${}^{42m}_{20}Ca$	→	${}^{42}_{20}Ca$	+			
${}^{2}_{1}H$	+	${}^{63}_{29}Cu$	→	${}^{64}_{30}Zn$	+	
${}^{239}_{92}U$	→	${}^{239}_{93}Np$	+			
${}^{239}_{93}Np$	→	${}^{239}_{94}Pu$	+			
${}^{239}_{94}Pu$	→	${}^{235}_{92}U$	+			
${}^{99m}_{43}Tc$	→	${}^{99}_{43}Tc$	+			

Question: What are the particles produced by reactions #3 and #5?

CW 8.8 - The Line of Stability



Q1. The graph on the right of the relative numbers of protons, *Z*, and neutrons, *N*, that make up nuclei shows the line of stability. Nuclei that lie on this line are stable and do not decay. Ones to either the left or right of the line are unstable and decay in order to move themselves closer to the line.

a) What are isotopes of an element?

....

b) Would you describe isotopes in region A as stable or unstable?

....

c) Are isotopes in region A neutron-rich or proton-rich?

....

d) Isotopes in region B are unstable. Suggest a reason for this.

....

....

e) In order of stability, what type of decay will isotopes in region B undergo?

....

f) What type of decay will isotopes in region C undergo to achieve stability?

....

Q2. Copy and complete the sentences below:

a) During alpha decay the nucleus loses ………………… protons and …………………. neutrons.

Therefore, its mass number decreases by ……………………. and its atomic number decreases by ………………….

b) During β^- decay a ………………………….. becomes a ……………………………….. The atomic number …………………………………. and the mass number ……………………………………..

c) During β^+ decay a ……………………………. becomes a ………………………………. . The atomic number ……………………. and the mass number ……………………………..

d) Alpha decay and beta decay results in the formation of a different ………………………….. because the …………………………. number changes.

e) Beta decay is often accompanied by the emission of more energy in the form of a ……………………………. as the nucleus undergoes rearrangement.

Q3. There are two forms of beta radiation. β^- is the more common and involves the transformation of a neutron into a proton and an electron. It is fairly easy to visualize the neutron as being made from a proton and an electron. *(This is not the whole story as a strange particle/wave (we are not sure yet…) known as a neutrino is also emitted.)*

a) Sketch a diagram to represent β^- decay:

Somewhat rarer, but it has been observed and is useful in hospitals, is the β^+ decay. Here a neutron decays into the anti-matter forms of the proton and the electron. This are named the anti-proton and positron respectively. They have the same mass but opposite electrical charge.

b) Sketch a diagram to represent β^+ decay:

The anti-matter particles do not exist for very long, as when they encounter the matter versions of themselves, they are mutually annihilated in a flash of gamma-rays. These gamma rays have specific wavelengths and are detectable.

c) Sketch a diagram to represent the mutual annihilation of a positron and an electron:

5 – Half-Life

Objectives:

- understand that the activity of a radioactive source decreases over a period of time and is measured in becquerels
- recall the term ‘half-life’ and understand that it is different for different radioactive isotopes
- use the concept of half-life to carry out simple calculations on activity

Number of Throws	Number of dice remaining	Number of Throws	Number of dice remaining
0		11	
1		12	
2		13	
3		14	
4		15	
5		16	
6		17	
7		18	
8		19	
9		20	
10		21	

The number required to decrease the number of dice by 50% (100 → 50) = ...

The number required to decrease the number of dice by 50% (50 → 25) = ...

CW 8.9 - Half-life

1. A certain radioactive isotope has an activity of 800 Bq with a half-life of 60 years.

   a) What does all this mean? (2)

   ....

   ....

   b) How long will it take to decrease to an activity of 100 Bq? (2)

   ....

   ....

2. The half-life of strontium-90 is 29 years. If you started with 1000 atoms of strontium-90, how many would you expect there to be after 87 years? (2)

   ....

   ....

3. The activity of a radioactive sample is 1440 Bq. Five hours later it has fallen to 45 Bq. What is the half-life? (2)

   ....

   ....

4. A student records the following count rate data from a radioactive isotope.

Time (mins)	0	10	20	30	40	80	160
Count rate (per min)	740	553	420	326	260	140	103

   a) Plot the graph of the data. (2)

   b) The count rate will never fall below 100 cpm. Suggest a reason for this. (1)

   ....

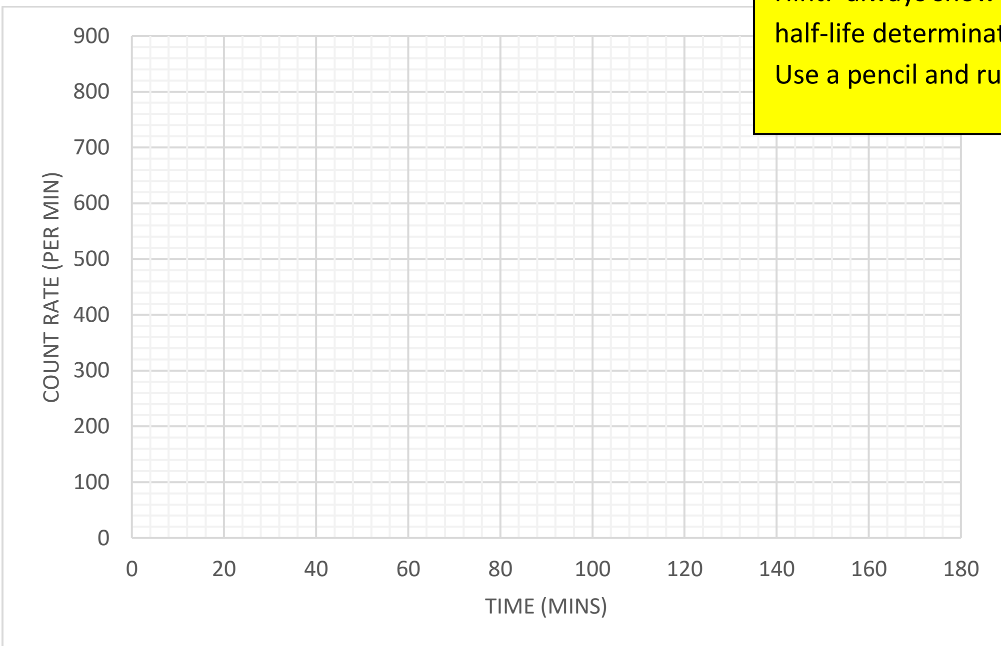
   ....

   c) Determine the half-life of the sample. (Hint: recall 4b) (2)

   ....

   ....

Hint: always show the lines for the half-life determination on the graph. Use a pencil and ruler obviously….

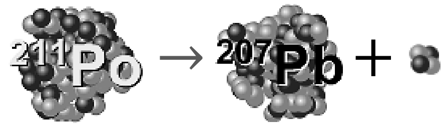


5. The range of radioactive half-lives are vast! Some are shorter than a blink of an eye, others are on the same sort of time scales as the life of the stars. Big question: assuming that all the elements were created at the creation of the universe, and the universe is infinitely old, how can unstable isotopes exist? Discuss… (4)

Isotope	Half-life
Boron-12	0.02 sec
Radon-220	52 sec
Iodine-131	25 min
Radon-222	3.8 days
Strontium-90	28 years
Radium-226	1602 years
Carbon-14	5730 years
Plutonium-239	24,400 years
Uranium-235	7.1×10^8 years
Uranium-238	4.5×10^9 years
Carbon-12	Stable (infinite half-life)

PhET LAB: Alpha Decay

OBJECTIVES:



- explain the alpha decay process and radioactive decay equations
- define and analyze half-life through applying the PhET “Alpha Decay”

Run “Alpha Decay” http://phet.colorado.edu.

<u>Investigating Alpha Decay</u>

1. Start on the **SINGLE ATOM** tab. Observe the decay of Polonium-211. After each decay, press the RESET NUCLEUS button to watch the process again. Write a description of alpha decay for Po-211. (1)

Complete the following alpha decay equations (5):

2. Polonium-211: ${}^{211}_{84}Po \rightarrow {}^{207}_{82}Pb +$

3. Radium-226: ${}^{226}_{88}Ra \rightarrow \quad + {}^{4}_{2}\alpha$

4. Uranium-238: $\quad \rightarrow {}^{234}_{90}Th + {}^{4}_{2}\alpha$

5. Plutonium-240: ${}^{240}_{94}Pu \rightarrow \quad + {}^{4}_{2}\alpha$

6. Americium-241: ${}^{241}_{95}Am \rightarrow {}^{237}_{93}Np +$

7. How is alpha decay used in everyday life? (2)

Investigating Half-Life of Alpha Decay

8. Click the **MULTIPLE ATOMS** tab. Execute five trials to determine the number of parent and daughter nuclei at one half-life. Complete the table below. (2)

Parent Nuclei Po-211	**Parent Nuclei (remaining nuclei) [yellow]**	**Daughter Nuclei (decayed nuclei) [black]**
100		
80		
60		
40		
20		

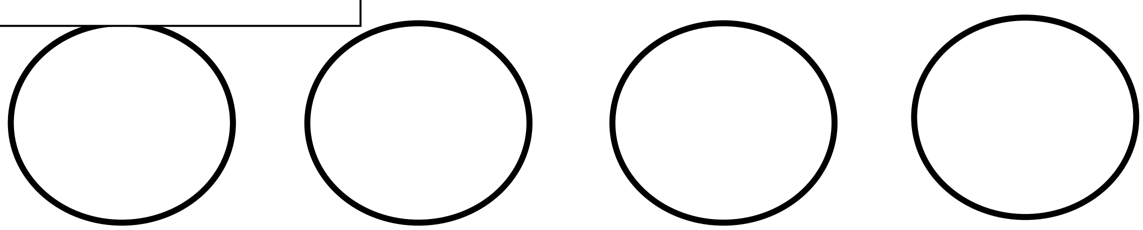
9. Define half-life. (1)

....

....

10. Suppose a substance has a half-life of 0.52 s. Create accurate pie charts *showing the number* of remaining parent nuclei and decayed daughter nuclei (shade slightly) starting with 40 total nuclei. (2)

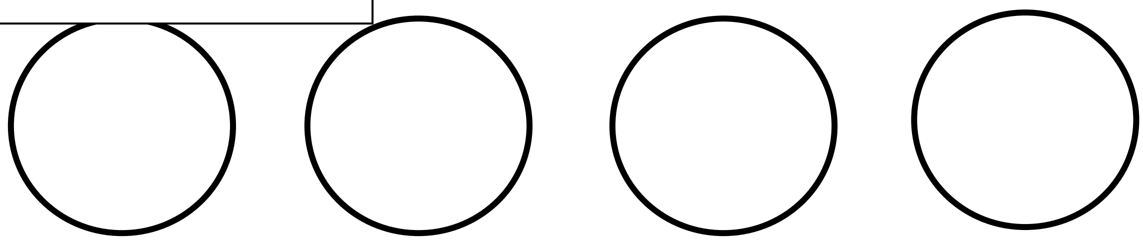
PREDICTION with VALUES:



$t = 0.52\ s$ $t = 1.04\ s$ $t = 1.56\ s$ $t = 2.08\ s$

11. Use the PhET alpha decay simulation to test your scenario copying each pie chart. (2)

SIMULATION with VALUES:



$t = 0.52\ s$ $t = 1.04\ s$ $t = 1.56\ s$ $t = 2.08\ s$

12. How does your prediction match with the results of the simulation? Convey with actual values from the simulation and a calculation of percent difference on 0.52 seconds. (1)

....

....

....

13. Run three trials and complete the data table below. (2)

Time (s)	Number of Decayed Daughter Nuclei (n/nuclei)			
	Trial 1	Trial 2	Trial 3	Average
0.52				
1.04				
1.56				
2.08				
2.60				

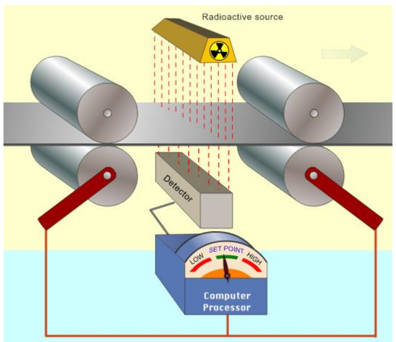
14. Draw a graph of **average decays v. time**. Staple this to this graph into your booklet. (4)

6 – Applications of Nuclear Physics

Objectives:

- describe the uses of radioactivity in medical and non-medical tracers, in radiotherapy and in the radioactive dating of archaeological specimens and rocks

Industry



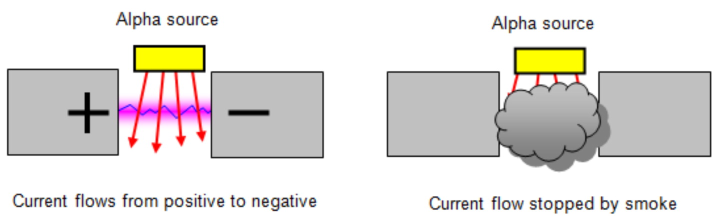
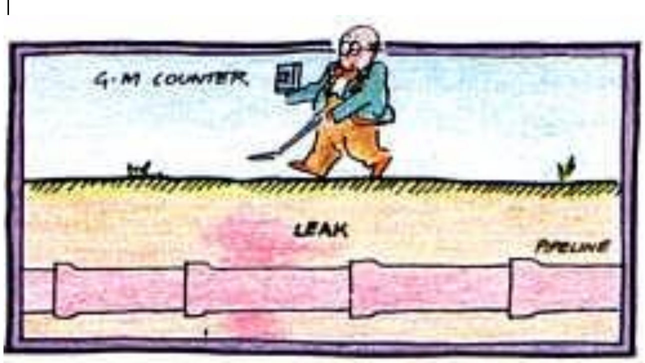
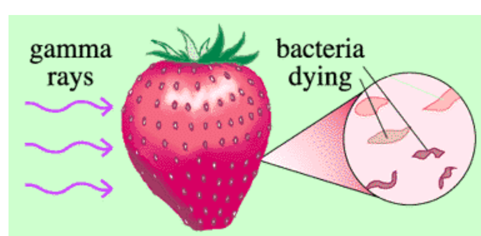


Figure 3





Medicine

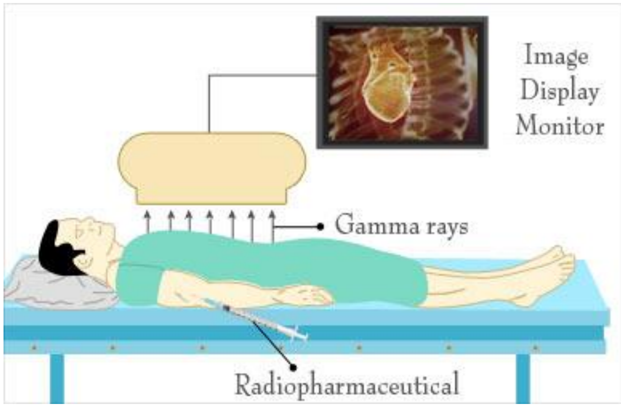
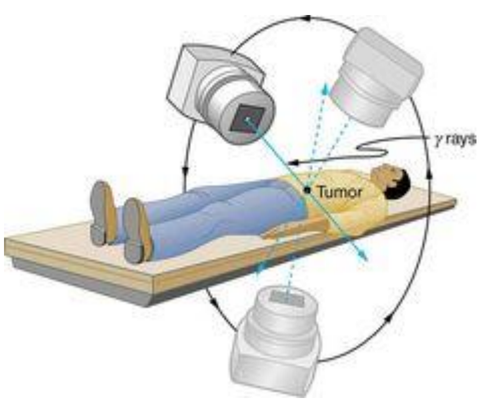


Image
Display
Monitor
Gamma rays
Radiopharmaceutical


Radiation
therapy
Sterilization


γ rays
Tumor

CW 8.10 - Uses of Radiation

1. Complete the follwing paragraph (7)

High doses of gamma radiation will ………… living cells. Because of this, gamma radiation is used to traet ………… However, an unwanted side effect is that ……………………… cells can get damaged too. This can make a patient feel very ……………. The goal of ……………………………………………… is to kill the ………………………………… cells whilst mininising damage to the ……………………………… cells.

2. As radiation kill cells it is used to sterilise medical equipment.
   a) Why is it necessary to sterilise medical equipment. (1)
   ……………………………………………………………………………………………………
   b) What other methods could be used to sterilise?
   Scaplels and scissors (1) ……………………………………………………………………………
   Bandages and dressings. (1) ……………………………………………………………………
   How could these be kept sterile? (1) ……………………………………………………………

   What type of radiation should be used and why? (2)
   ……
   ……
   ……

   An advantage of radiation sterilization is that the item can be sealed in a plastic container before hand. Explain the advantages of this and how it works. (2)
   ……
   ……
   ……
3. Why must the equipment be surrounded by thick lead? (1)
   ……
4. The table below shows three radioactive isotopes.

Isotope	Half-life	Emission
Technetium-99	6 hrs	Beta/gamma
Phosphorus-32	14 days	Beta
Cobalt-60	5 years	Beta/gamma

a) Which isotope would be the best to use as a tracer and why? (2)

....

....

....

b) Which isotope would be best for a hostipal to treat cancer patients and why? (2)

....

....

....

5. Another use of radiation is to control the thickness of materials – such as paper or aluminium foil.
   a. Why would beta radiation be used rather than either alpha or gamma? (1)

   ....

   b. What would happen to the count rate at the detector if a) the paper is to thick or b) too thin? (2)

   ....

   ....

   ....

6. Iodine-131 is commonly used as a tracer.
   a) Stable iodine isotope has a mass number of 127. Is I-131 neutron or proton rich? (1)

   ....

   b) The thyroid gland normally absorbs iodine. What are the usual sources of iodine? What does the thyroid do and where is it located? (1)

   ....

   ....

   ....

   c) How does using the I-131 isotope help doctors know if the thyroid is working properly? (1)

   ....

   ....

   ....

   d) What type of radiation do you think is emitted by I-131 and explain how you decided this? (2)

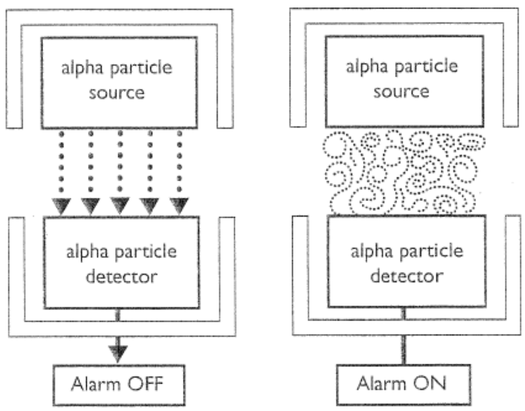
   ....

   ....

   ....

CW 8.11 - The Best Radiation for the Job

Q1. Look at the diagram below and use it to explain how a smoke alarm works. (1)



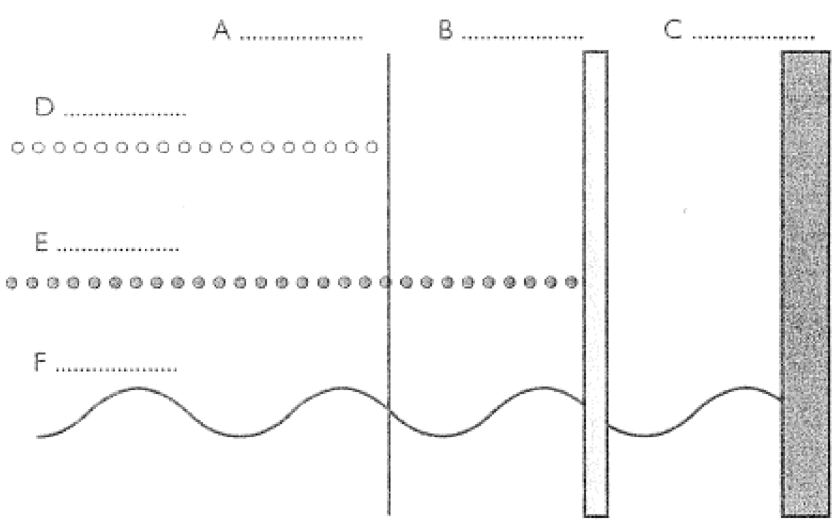
....

....

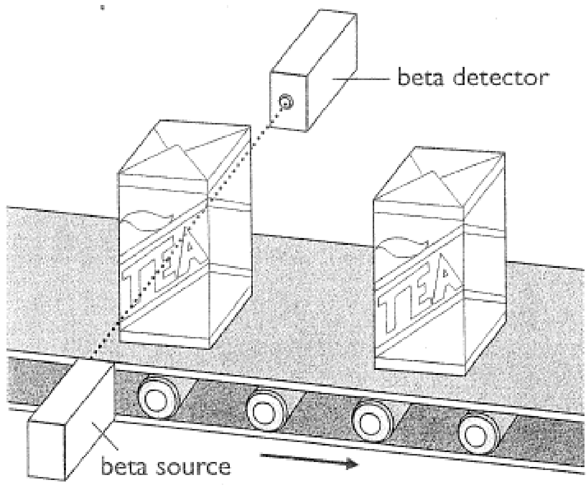
....

....

Q2. Complete the diagram below to show the penetrating power of alpha, beta and gamma radiation. (2)



Q3. The diagram below shows packets of tea passing along a conveyor belt. As the belt moves along, the packets pass through a beam of beta particles.



a) Explain how this can be used to count the packets of tea passing along the belt? (1)

....

....

....

b) Explain how this also provides a way of indicating if a packet is not filled all the way to the top? (1)

....

....

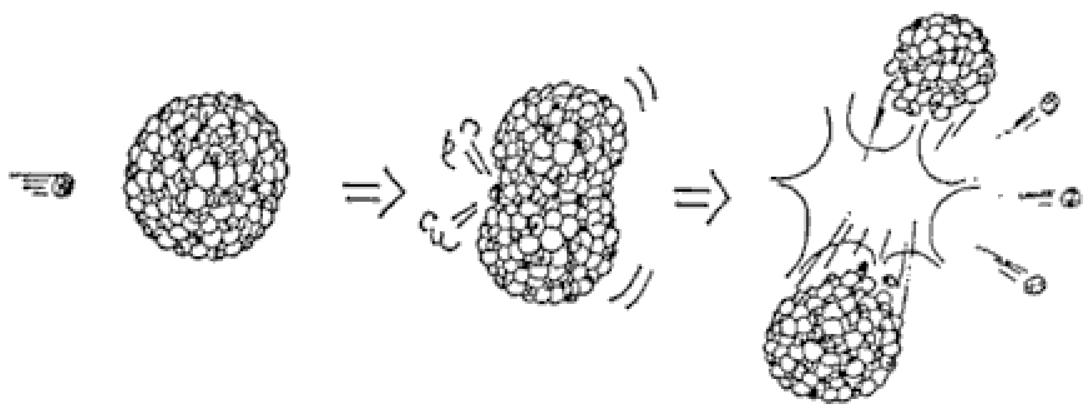
....

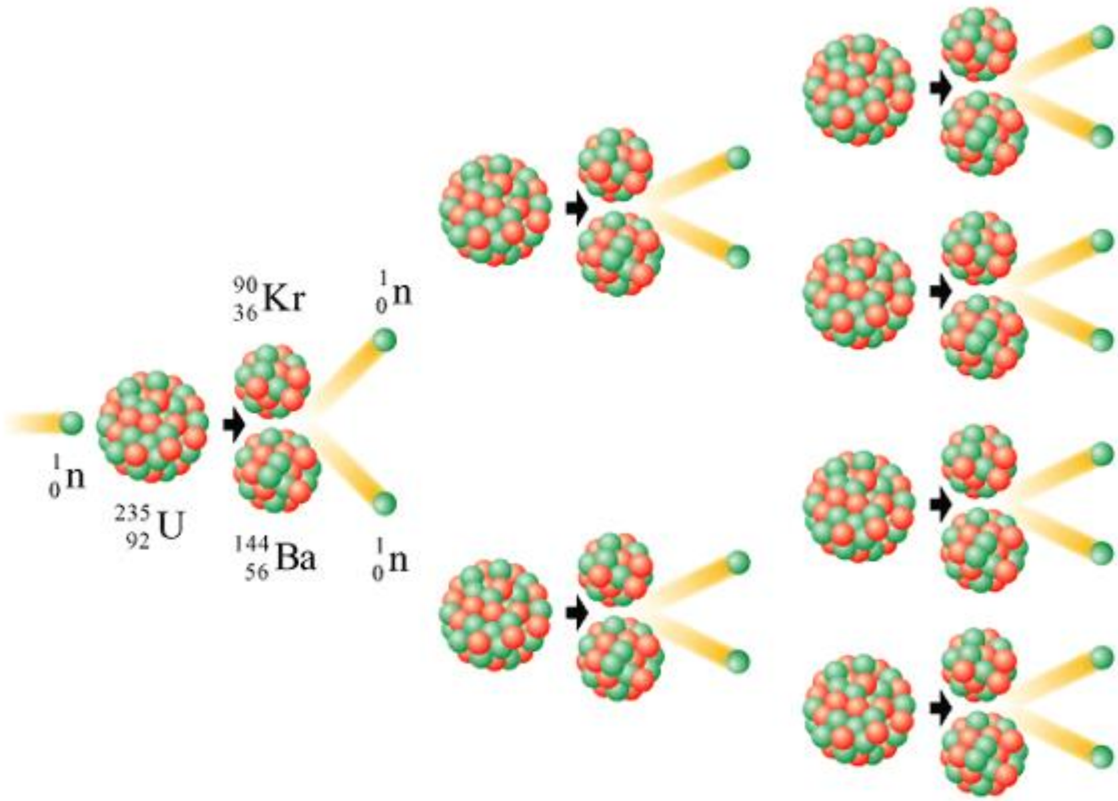
8 – Nuclear Fission

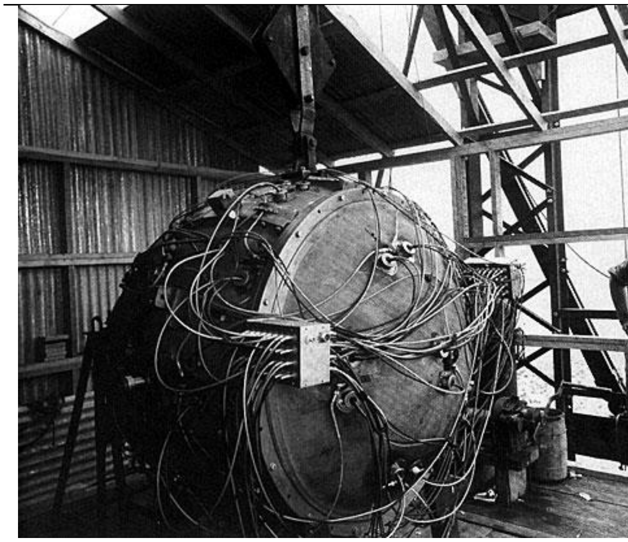
Objectives:

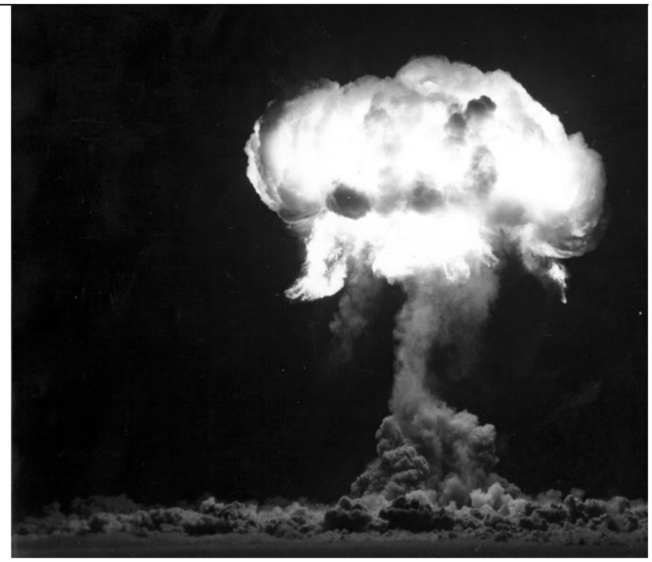
- understand that a nucleus of U-235 can be split (the process of fission) by collision with a neutron, and that this process releases energy in the form of kinetic energy of the fission products
- recall that the fission of U-235 produces two daughter nuclei and a small number of neutrons
- understand that a chain reaction can be set up if the neutrons produced by one fission strike other U-235 nuclei

Notes:




$^{90}_{36}Kr$
$^{1}_{0}n$
$^{1}_{0}n$
$^{235}_{92}U$
$^{144}_{56}Ba$
$^{1}_{0}n$





CW 8.12 - Nuclear Weapons

1. What was the “Manhattan Project”? (1)

....

2. What were the two cities that the US destroyed in 1945? (2)

....

....

3. What were some of the consequences of using these bombs? (4)

....

....

....

....

4. The newer “H-bombs” are many times more powerful than the early bombs. Explain why. (2)

....

....

....

....

5. Currently only the US, France, UK, Russia and China are known to have large nuclear stockpiles. It is suspected that Israel, India and Pakistan have them too. What other countries either have them or are actively developing them? (2)

....

....

6. What does the acronym MAD stand for? (1)

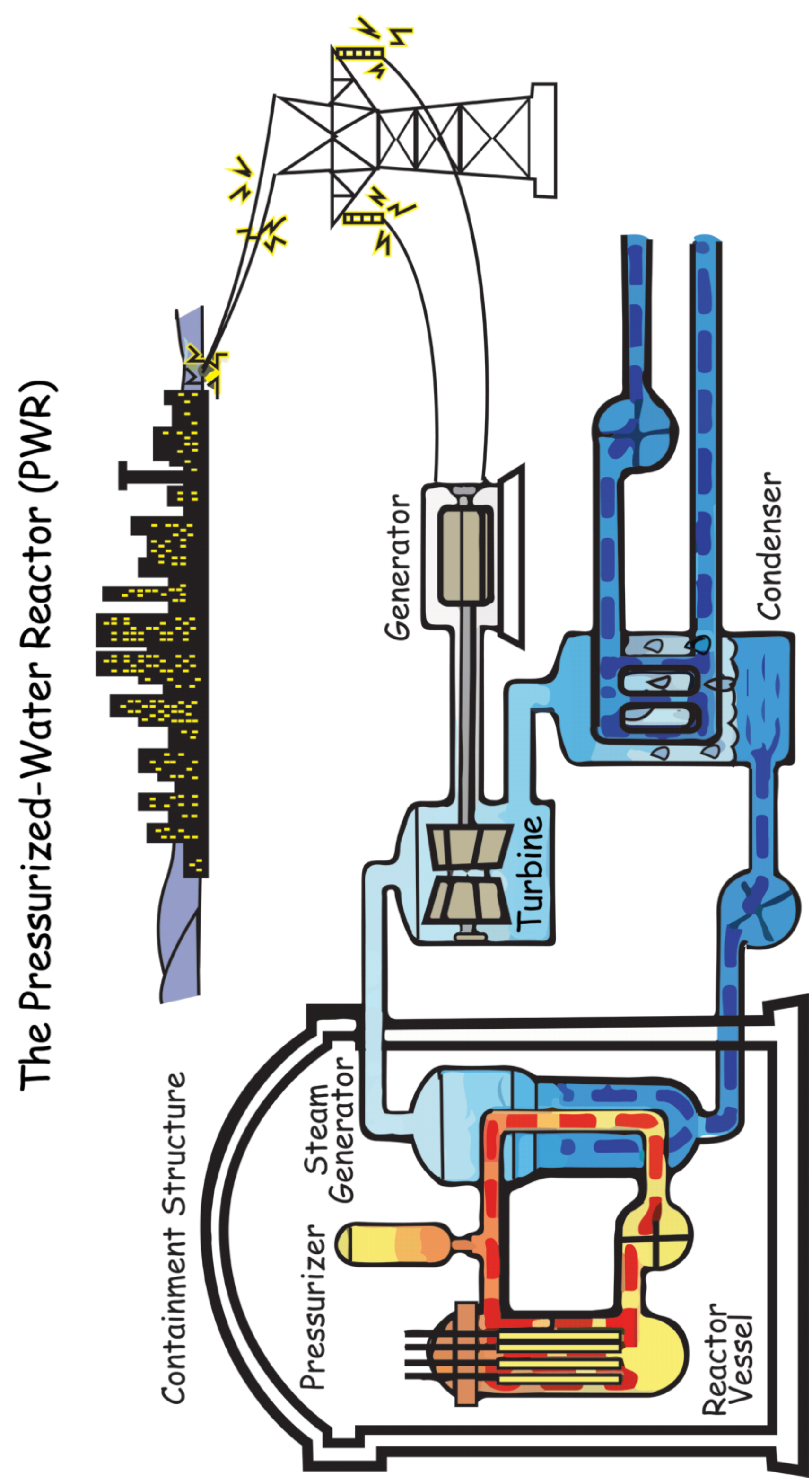
....

9 – Nuclear Power

Objectives:

- understand the role played by the control rods and moderator when the fission process is used as an energy source to generate electricity
- describe the dangers of ionising radiations, including the problems arising in the disposal of radioactive waste

Notes:


The Pressurized-Water Reactor (PWR)
Containment Structure
Pressurizer
Steam Generator
Reactor Vessel
Turbine
Generator
Condenser

CW 8.13 - Particles and Power

Q1. A coal-fired power station burns coal at a rate of 30 tonnes each minute. 1 kg of uranium when fissioned releases as much energy as 2700 tonnes of coal.

a) How much uranium would have to be fissioned each minute to produce the same amount of electricity as coal? (2)

....

....

....

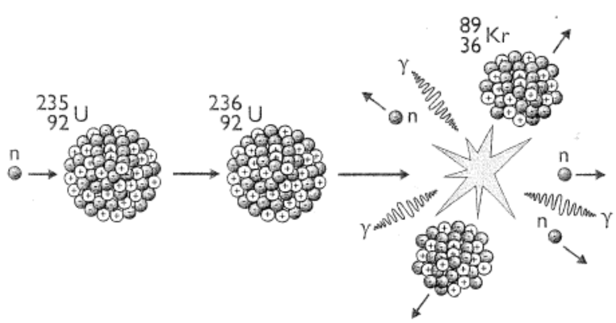
b) How much fuel would each type of power station use over a year? (2)

....

....

....

Q2. The diagram below shows a neutron colliding with the nucleus of uranium-235, splitting the nucleus and producing three more neutrons.



a) What is the name given to this process? (1)

....

b) What is the form of energy released in this process? (1)

....

c) Explain how this process can lead to a chain reaction. (1)

....

....

....

Q3. If each atom of U-235 that fissions produces two neutrons, one atom may cause two further atoms to be fissioned. These two may fission four more atoms and so on. How many atoms may be fissioned in total after:

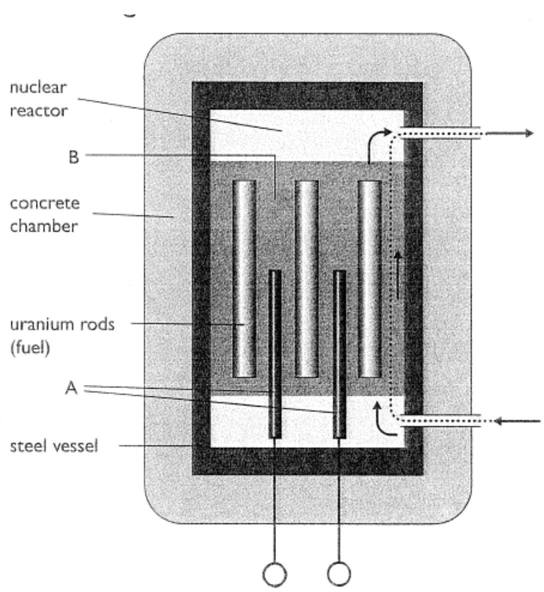
a) Five such steps? (1)

....

b) Ten steps? (1)

....

Q4. The digram below shows a nuclear reactor.



a) Name the parts labeled A and B. (2)

The part of the reactor labeled A can be moved in and out of the reactor core.

b) Describe the effect of moving A out of the reactor. (1)

....

....

....

c) Why does moving A out of the reactor have this effect? (1)

....

....

....

d) What role is played by the part of the reactor labeled B? (1)

....

....

....

e) The reactor produces a large amount of heat. How is this heat removed and transferred to the electricity generator? Label the diagram to assist your explanation. (2)

....

....

....

f) What is likely to be the consequence if this heat transfer system fails? (1)

....

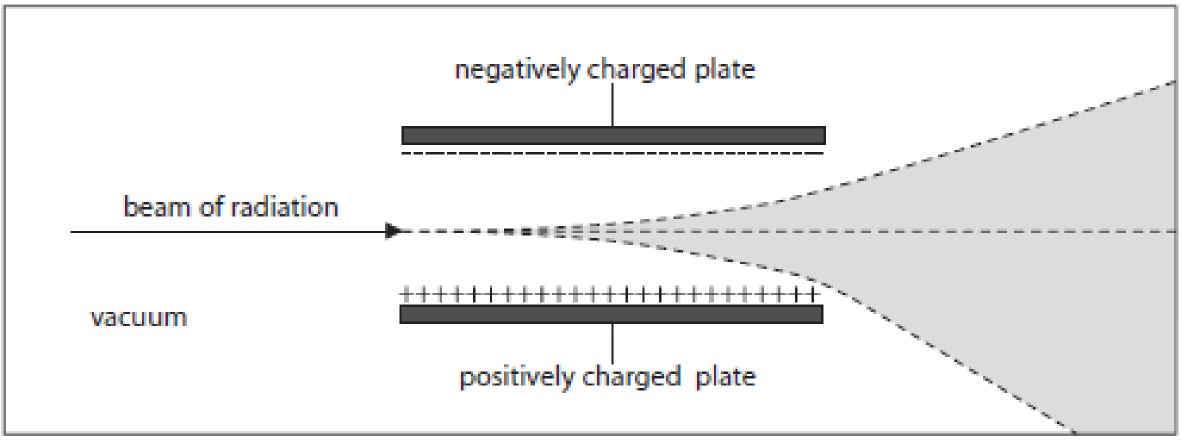
CW 8.14 - PAST IGCSE QUESTIONS

2 (a) Scientists use deflection in an electric field to help distinguish between different radiations.

The diagram shows a beam containing several types of radiation. This beam travels in a vacuum between two charged plates.

Some of the radiations are deflected upwards, some are deflected downwards and some are not deflected at all.

Hint: think of their charges and mass



Put one tick in each row to show the correct deflection for each type of radiation.

One has been done for you.

(4)

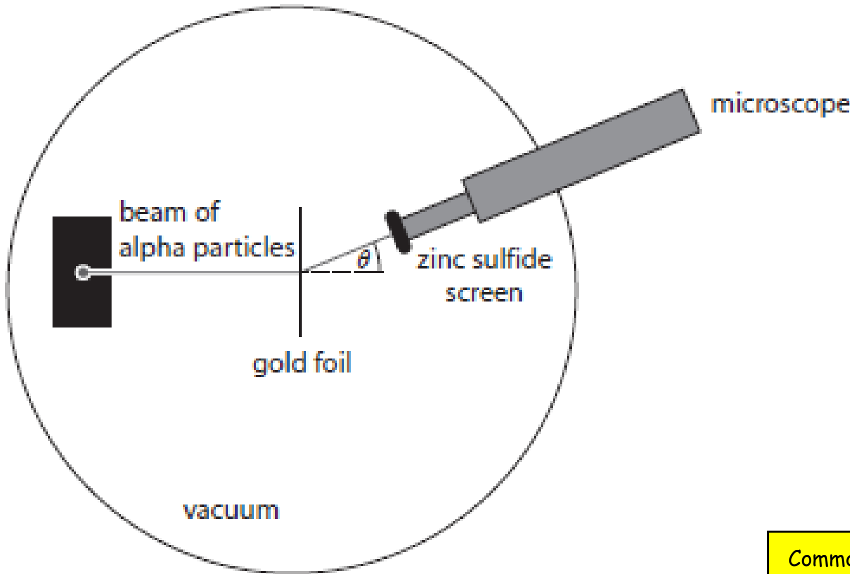
Type of radiation	Deflected upwards	Deflected downwards	Not deflected
alpha	✓		
beta			
gamma			
neutrons			
protons			

(b) The diagram shows the apparatus Geiger and Marsden used to investigate the structure of an atom.

They aimed a beam of alpha particles at a very thin sheet of gold foil.

They used a zinc sulfide screen to detect the alpha particles.

The gold foil experiment is a very common question – become an expert in it!



Common question in a variety of contexts.

(i) Suggest why Geiger and Marsden removed the air from the apparatus.

(1)

....

....

....

(ii) Describe Geiger and Marsden's results.

(2)

....

....

....

....

....

....

Hint: Don't be fooled. The word "may" actually means **DRAW A WELL-LABELED DIAGRAM!**

(c) Rutherford produced a model of the atom.

Describe how Rutherford's model explains Geiger and Marsden's results.

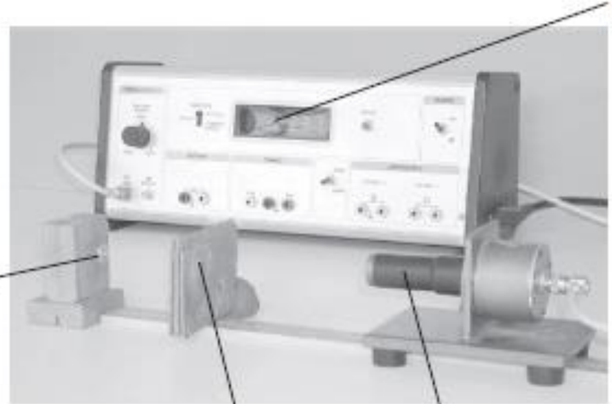
You may draw a diagram to help your answer.

(4)

(Total for Question 2 = 11 marks)

Bullet pointed sentences that are clear and succinct are the best way to answer this question.

12 A teacher uses this apparatus to demonstrate radioactivity to his students.



(a) The teacher needs to take some safety precautions.

Put one tick (✓) on each row to show whether the safety precaution is needed or not.

Two have been done for you.

(2)

safety precaution	needed	not needed
not touch the source with bare hands	✓	
use tongs		
wear gloves		✓
wear goggles		
students sit at least two metres away		
wear a lead apron		
store source in a lead box		

(b) The teacher uses this method to investigate radioactivity.

- place the detector 10 cm from the radioactive source
- record the count with different absorbent materials between the source and the detector
- repeat the investigation using a different radioactive source
- also repeat the investigation without a source

The table shows his results.

Source used	**Counts in 30 s for each material**					
	5 mm of aluminium	**5 mm of lead**	**0.2 mm of paper**	**5 mm of plastic**	**5 mm of stone**	**5 mm of wood**
barium-133	3 843	1 989	not taken	4 551	10 408	4 557
strontium-90	14	15	42 770	182	13	331
none	15	15	14	15	14	15

(i) State why the teacher keeps the distance constant between the source and the detector.

(1)

....

....

(ii) Explain why there is a reading when no source is used.

(2)

....

....

....

....

(iii) Explain which of the materials the teacher used is the best absorber of radiation.

(3)

....

....

....

....

....

....

(iv) A student makes this conclusion.

'Stone is the worst absorber of radiation.'

Evaluate this conclusion.

(3)

....

....

....

....

....

....

....

....

....

It is very common for students to misunderstand this type of question and then waffle.....
EXAMINE and USE the data in your answer.

12 The table shows information about three isotopes of uranium.

Isotope	Proton number	Neutron number	Half-life	Amount in natural uranium
Uranium-234	92	142	0.0002 billion years	0.005%
Uranium-235		143	0.7 billion years	0.7%
Uranium-238	92		4.5 billion years	99%

(a) (i) Complete the table by filling in the missing numbers. **(2)**

(ii) Explain what is meant by the term **half-life**. **(2)**

....

....

....

....

(iii) Suggest why uranium-238 is the most common isotope of uranium. **(1)**

....

....

....

(b) Nuclear power stations use a uranium isotope as fuel.

What are the products of the fission of uranium nuclei? **(3)**

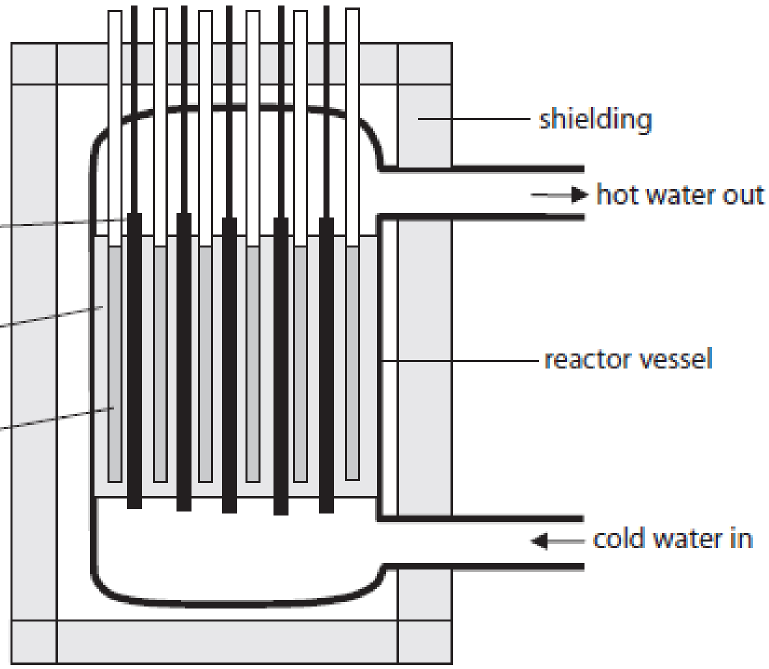
....

....

....

....

(c) The diagram shows the reactor in a nuclear power station.



(i) What is the purpose of the moderator?

(1)

....

(ii) Describe what happens in the reactor when a control rod is removed.

(2)

....

....

....

....

Nuclear reactors have been very common on IGCSE papers over recent years. Make sure that you are CLEAR about the differences between: a) fuel rods, b) control rods and c) the moderator and their roles.

They also often ask about the PROS and CONS of nuclear power. Have clear answers ready and avoid references to "cheap', 'jobs'. Keep it sciency.

Make sure that you know the two really big accidents: Chernobyl and Fukushima.

(d) There have been several accidents at nuclear power stations.

The most serious accident caused an explosion in the reactor.

This explosion spread material from inside the reactor to the surrounding area.

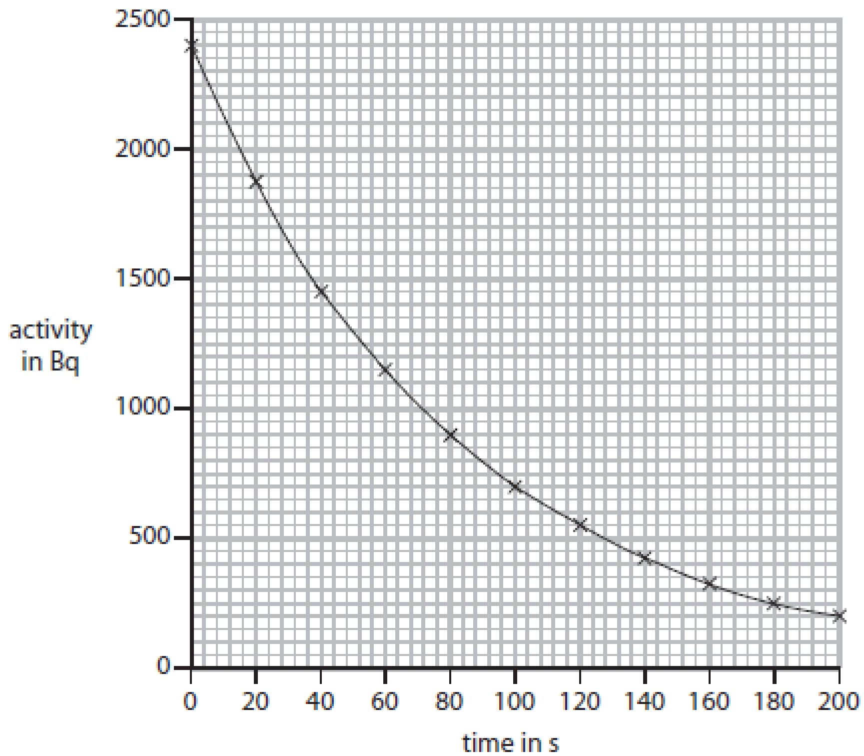
Explain why it is difficult to make the surrounding area safe again after a serious nuclear accident.

(5)

(Total for Question 12 = 16 marks)

(half a question….)

(c) The graph shows how the activity of a sample of the radioactive isotope changes with time.



2 marks – one is for clearly showing how you USED THE GRAPH to determine the half-life.

(i) Use the graph to find the half-life of the isotope.

(2)

half-life = ... s

(ii) The teacher takes a new reading every 20 s.

Suggest why the teacher measures the activity so frequently.

(1)

....

....

....

(Total for Question 6 = 6 marks)

10 Emissions from a radioactive source pass through a hole in a lead screen and into a magnetic field, as shown in Fig. 10.1.

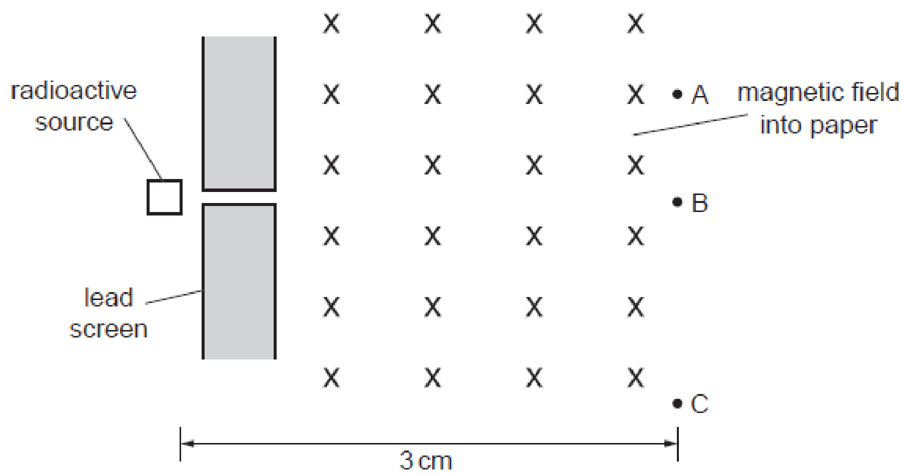


Fig. 10.1

Radiation detectors are placed at A, B and C. They give the following readings:

A	B	C
32 counts / min	543 counts / min	396 counts / min

The radioactive source is then completely removed, and the readings become:

A	B	C
33 counts / min	30 counts / min	31 counts / min

(a) Explain why there are still counts being recorded at A, B and C, even when the radioactive source has been removed, and give the reason for them being slightly different.

....

....

....

.... [2]

(b) From the data given, deduce the type of emission being detected, if any, at A, at B and at C when the radiation source is present.

State the reasons for your answers.

detector at A ....

....

.... [2]

detector at B ....

....

.... [3]

detector at C ....

....

.... [3]

[Total: 10]

Lots of marks here - so they want DETAIL. Think about the charges and masses of the various types of radiation. Fleming's left hand rule (magnetism) and Newton's second law (mechanics) are really relevant. Examiners love this type of question as there is lots of good physics from a range of units all combined!