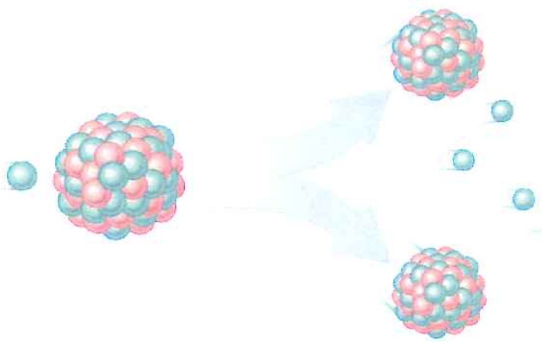
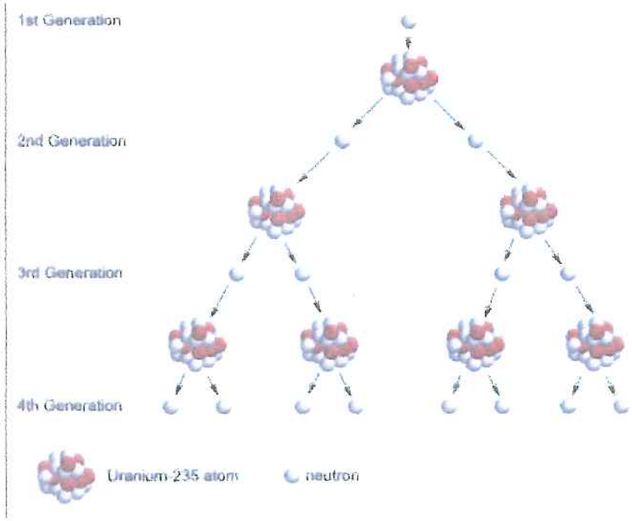
Nuclear Fission

Label the diagram to the right. During this process energy is released. What form of energy is released?

Heat





Explain, using the diagram, what is meant by a 'chain reaction.'

One reaction/fission releases more neutrons. These neutrons are absorbed by other uranium atoms, causing them to undergo fission, releasing more neutrons...

What is the job of the moderator in nuclear reactions?

Absorb some of the kinetic energy of the neutrons.

Why do the neutrons need to be slowed down?

To enable the uranium nuclei to absorb them.

What to the control rods do to the neutrons, and how does this affect the rate of reaction?

Absorbs the neutrons removing them from the fission process - reduces the rate of the reaction.

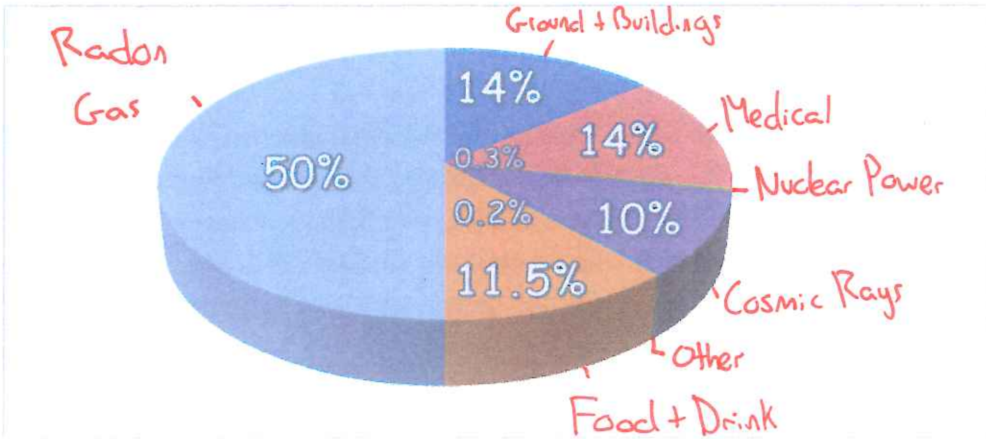
Radioactivity Revision Booklet

Name: **Class:**

Radioactivity is measured in becquerels (Bq). What is the definition of 1 Bq?

1 becquerel is equal to... 1 count per second

Radioactivity is all around us. Complete the pie chart to show the main sources of radioactivity.

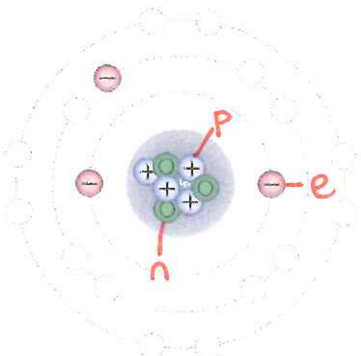


Atoms and Radioactivity

Atoms are made of three different particles; protons, neutrons, and electrons. The protons and neutrons are found in the nucleus. The electrons orbit the nucleus.

Label one of each of the three particles.

This is an atom of lithium. Give the atomic number and mass number below.



$^{7}_{3}Li$

Atomic Particle	Relative Mass	Relative Charge
Electron	1	-1
Proton	2000	+1
Neutron	2000	0

Complete the table to the left.

The number of protons in an atom identifies the element. For example, carbon atoms always have six protons. The number of neutrons can vary. Atoms with the same number of protons, but different numbers of neutrons, are called isotopes.

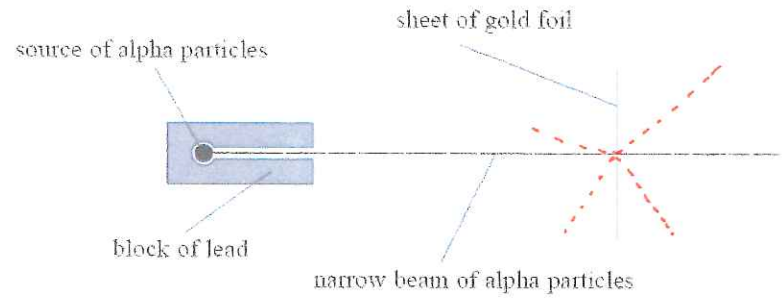
Three different carbon isotopes are shown. Complete the chemical symbols

Carbon-12	Carbon-13	Carbon-14
$^{12}_{6}C$	$^{13}_{6}C$	$^{14}_{6}C$

The nucleus of an atom is held together by the **strong force**. This is strong enough to overcome the **electric force** repelling the protons away from each other. When atoms become too large, or they contain too many or too few neutrons, they become unstable. An unstable nucleus will decay.

Decay splits an atom apart, giving out energy, radiation and fragments of the original nucleus.

Particles



Geiger and Marsden fired alpha particles at very thin gold foil. Most of the alpha particles passed straight through.

Some of the alpha particles were deflected. Draw some deflected particles on the diagram and explain why they were deflected.

The positive charges of the alpha particles and the gold nuclei repel each other, making the alpha particles deviate from their original path.

A small amount of particles seemed to "bounce" back. Why?

They approached the gold nuclei very closely and hence were repelled the most, back the way they came.

What conclusion about the structure of the atom was made from these results?

The nucleus of an atom is very small compared to the full volume. Most of the mass is concentrated at the centre of the atom.

Applications of Radioactivity

Fill in the gaps using the words at the bottom of the page:

Radioactive iodine-123 is absorbed into the thyroid gland in exactly the same way as any stable isotope. Iodine-123 is a gamma emitter. The gamma rays can be detected using a gamma camera, which is used to build up a picture of functioning and non-functioning areas of the thyroid.

Radiation can cause damage to cells and the DNA in cells. These mutations will be copied when a cell divides, and can lead to abnormal growth and cancer. Very high doses can kill cells.

Chemicals can be used to target cancerous cells. They are attached to radioactive isotopes that emit alpha or beta radiation. The radiation kills the cancer cells, and because they have a low degree of penetration they affect only the areas they are delivered to. This avoids killing too many healthy cells.

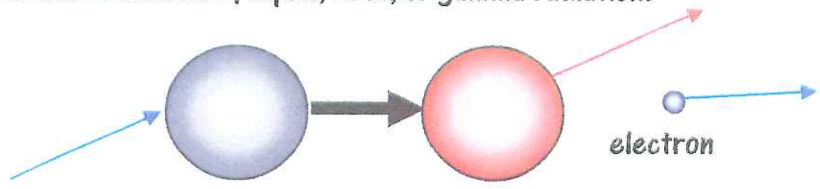
Ionising radiation can also be used in sterilisation. The radiation kills living cells, e.g. Bacteria, without harming the item. Medical tools can be sterilised in this way.

Radiation can also be used to gauge the thickness of a material, tracking the flow of liquids and gases, and in radiocarbon dating.

Words to use:	gamma	healthy	picture	radiocarbon
gamma camera	beta	Medical	flow	penetration
living cells	target	thickness	sterilisation	

Ionising Radiation

A neutral atom can be ionised by alpha, beta, or gamma radiation.



Alpha, Beta, and Gamma

An alpha particle is identical to a helium nucleus - two protons and two neutrons without an orbiting electrons. They have an atomic number of 2 and a mass number of 4. Alpha radiation is the most ionising and least penetrating of the three.

$^{4}_{2}He$ Or $^{4}_{2}\alpha$

A beta particle is a fast-moving electron. They are smaller and carry less charge than alpha particles, so they interact less frequently with matter in their path. They are more penetrating and less ionising than alpha particles.

$^{0}_{-1}\beta$

Gamma rays are electromagnetic waves. They have no mass or charge.

They are the most penetrating and least ionising radiation.

Radiation	Penetrating Power	Ionising Power	Radiation Stopped By
Alpha	Low	High	Paper
Beta	Medium	Medium	Thin aluminium
Gamma	High	Low	Thick lead

Alpha and Beta Decay

During alpha decay a nucleus emits an alpha particle. The atom loses two protons and two neutrons - the atomic number decreases by 2, the mass number decreases by 4.

$^{222}_{88}Ra \rightarrow\ ^{218}_{86}Rn + ^{4}_{2}He$ ...here is an example

Now try this one... $^{234}_{92}U \rightarrow\ ^{230}_{90}Th + ^{4}_{2}He$

During beta decay a neutron turns into a proton and an electron - this electron is emitted from the nucleus. The mass number remains the same, however the atomic number increases by one.

$^{137}_{55}Cs \rightarrow\ ^{137}_{56}Ba + ^{0}_{-1}e$ ...here is an example

Now try this one... $^{14}_{6}C \rightarrow\ ^{14}_{7}N \quad ^{0}_{-1}e$

When alpha or beta decay occurs there is sometimes excess energy in the nucleus. This energy is emitted as gamma radiation. Gamma rays have no mass or charge, so there is no change to the nucleus.

Alpha and Beta Decay Rules:

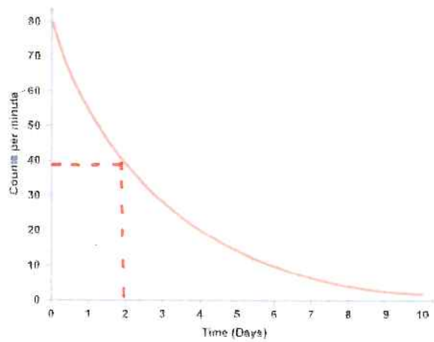
Radiation	Particle Emitted	Change to Atomic Number	Change to Mass Number
Alpha	Helium Nucleus	-2	-4
Beta	Electron	+1	0

Radiation and Half-life

The half-life of a radioactive sample is the average time taken for half the original Mass of the sample to decay.

Different radioactive isotopes have different half-lives, e.g. uranium -238 has a half-life of 4.5 billion years, whereas polonium-218 has a half-life of only 3 minutes.

Calculate the half-life from the following graph:



Half-life: 2 Days

Radon-222 has a half life of 3.825 days. How long will it take for a 10 g sample to decay to:

5 g 3.825 days 2.5 g 7.65 days 1.25 g 11.475 days

A 1 g sample of radium-226 decayed to 0.25 g after 3180 years. How long is the half-life for radium-226?

1g → 0.25g = 2 half lives. 3180 years = 2 half lives (÷2)
1590 years = 1 half life.

What fraction of a sample is left after 5 half-lives?

$1 \rightarrow \frac{1}{2} \rightarrow \frac{1}{4} \rightarrow \frac{1}{8} \rightarrow \frac{1}{16} \rightarrow \frac{1}{32}$ is left after 5 half lives