Atomic Structure

Paper 1

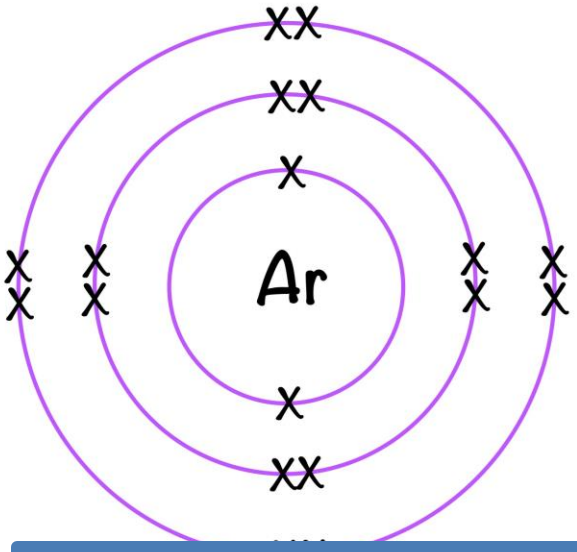
4.1.1 Structure of an Atom

Think
Pair
Share

What is the structure of an atom?

Atoms are very small, having a radius of about 1×10^{-10} metres.

It is a positively charged nucleus composed of both protons and neutrons surrounded by negatively charged electrons.



The radius of a nucleus is less than 1/10 000 of that of the atom

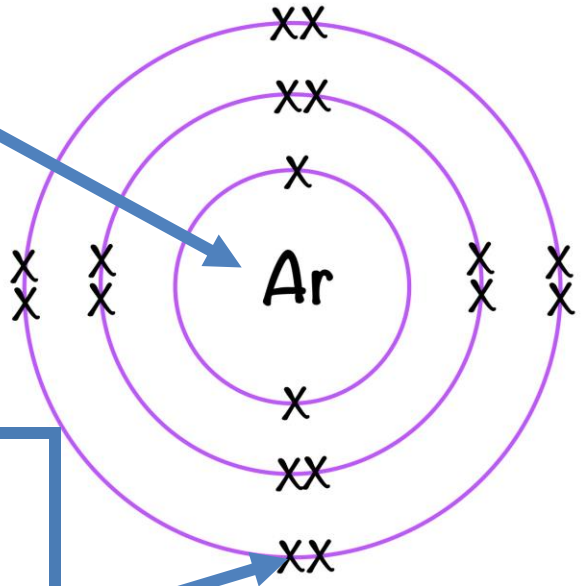
CS/F CS/H SS/F SS/H

4.1.1 Structure of an Atom

Think
Pair
Share

What is the structure of an atom?

Most of the mass is concentrated in the nucleus.



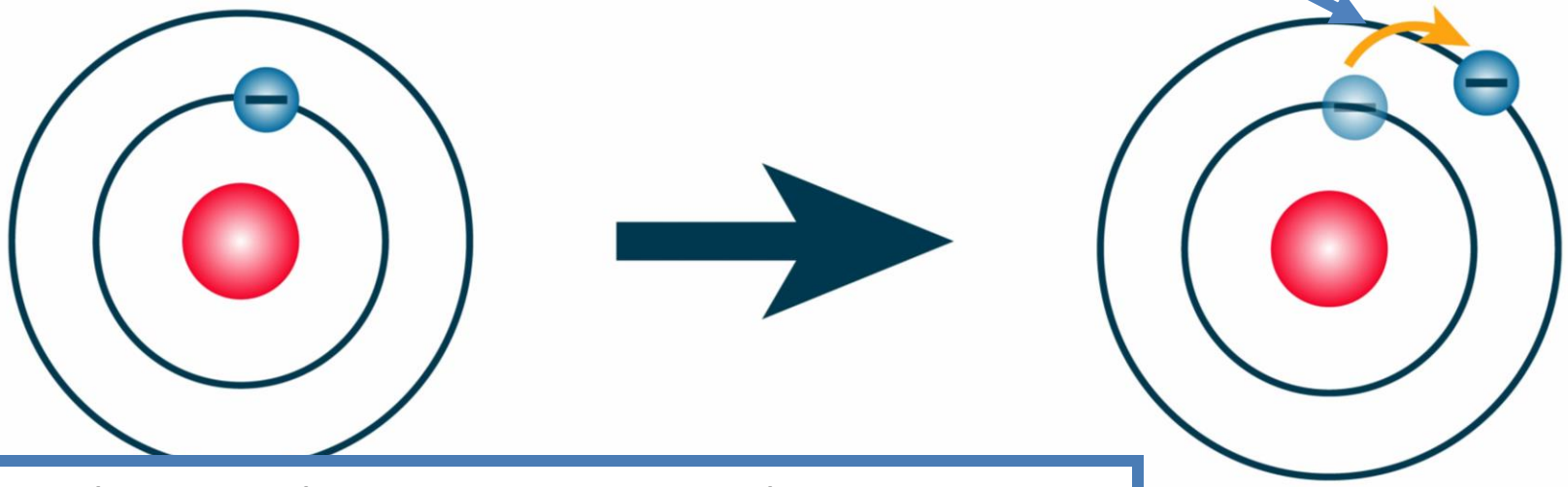
The electrons are arranged at different distances from the nucleus (different energy levels).

CS/F CS/H SS/F SS/H

4.1.1 Structure of an Atom

The electron arrangements may change with the absorption of electromagnetic.

Here electromagnetic radiation has been absorbed and so the electron moves further from the nucleus



When an electron moves to a lower energy level and closer to the nucleus there is emission of electromagnetic radiation.

CS/F CS/H SS/F SS/H

4.1.2 Mass & Atomic Number

Think
Pair
Share

Why are atoms neutral?

In an atom the number of electrons is equal to the number of protons in the nucleus.

This means that atom has no overall electrical charge.

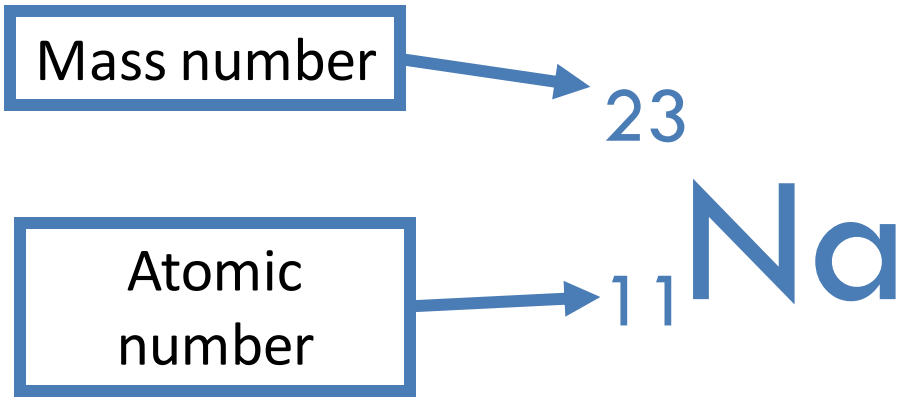
Particle	Relative Charge
Proton	
Neutron	
Electron	

Key Term	Definition
Atomic Number	

All atoms of a particular element have the same number of protons.

CS/F CS/H SS/F SS/H

4.1.2 Mass & Atomic Number



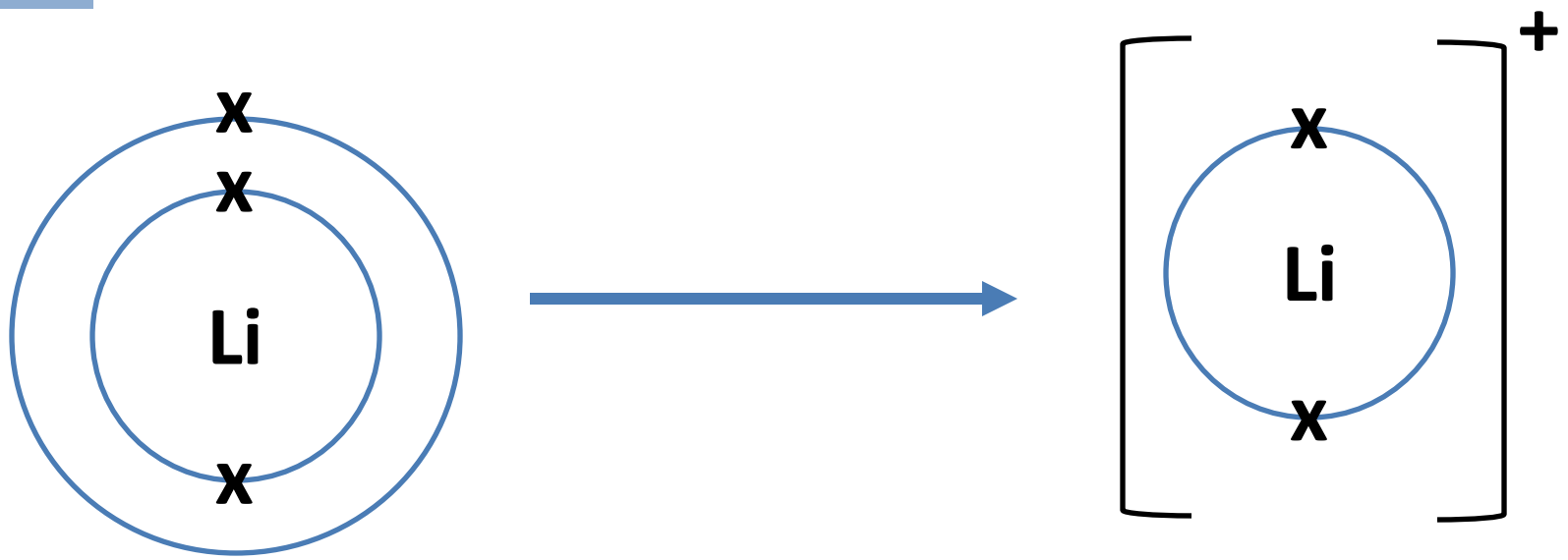
Key Term	Definition
Mass Number	
Isotope	

CS/F CS/H SS/F SS/H

4.1.2 Mass & Atomic Number

Think
Pair
Share

How do positive ions form?



Atoms turn into positive ions if they lose one or more outer electron(s).

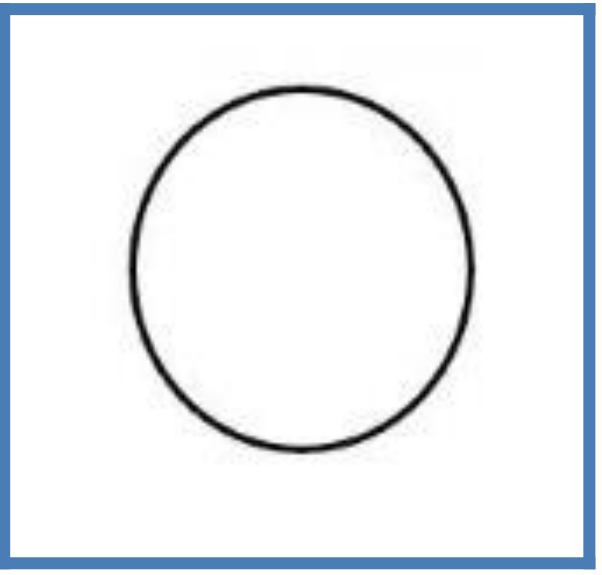
CS/F CS/H SS/F SS/H

4.1.3 Developing Model of the Atom

Ideas about the model of the atom have changed over time.

This is because new experimental evidence leads to scientific models being changed or relaced.

Dalton suggested that atoms were tiny spheres that could not be divided.



Electrons had not been discovered yet!

CS/F CS/H SS/F SS/H

4.1.3 Developing Model of the Atom

Ideas about the model of the atom have changed over time.

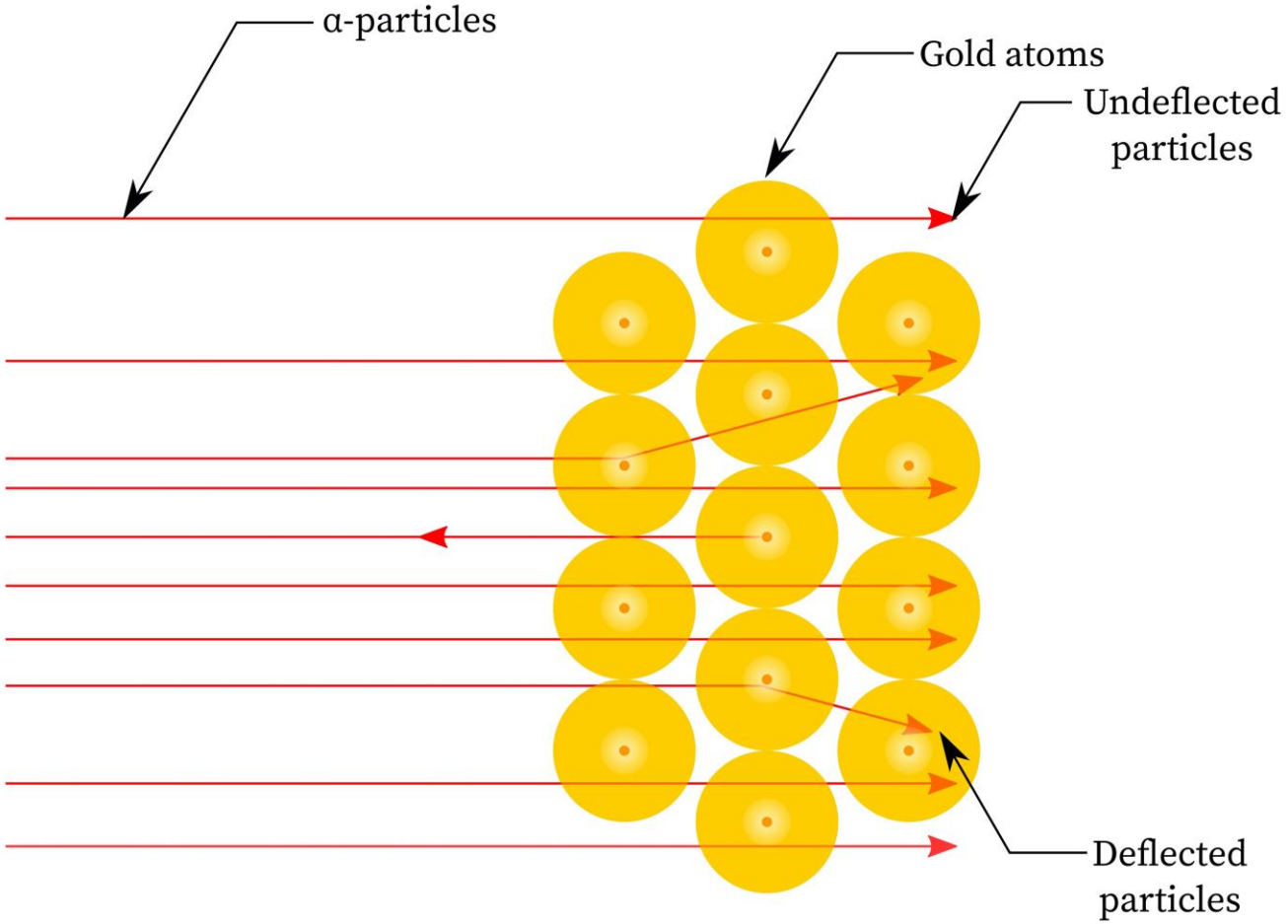
This is because new experimental evidence leads to scientific models being changed or relaced.

JJ Thompson discovered the electron. He then went on to suggest the Plum Pudding Model. This was the idea that the atom was a ball of positive charge with negative electrons embedded in it.

The discovery of the electron led to this new model!

4.1.3 Developing Model of the Atom

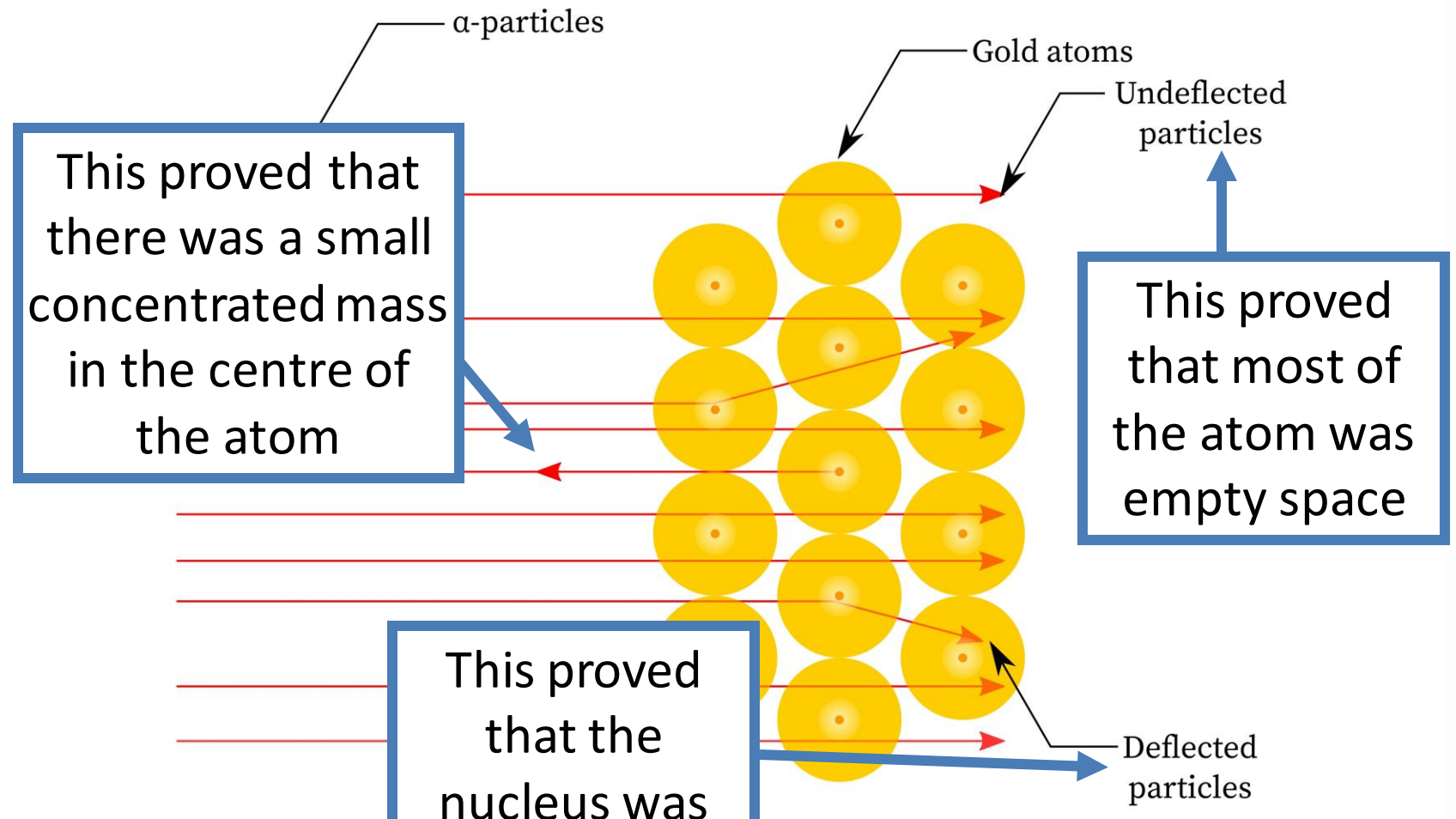
Alpha Particle Scattering Experiment



CS/F CS/H SS/F SS/H

4.1.3 Developing Model of the Atom

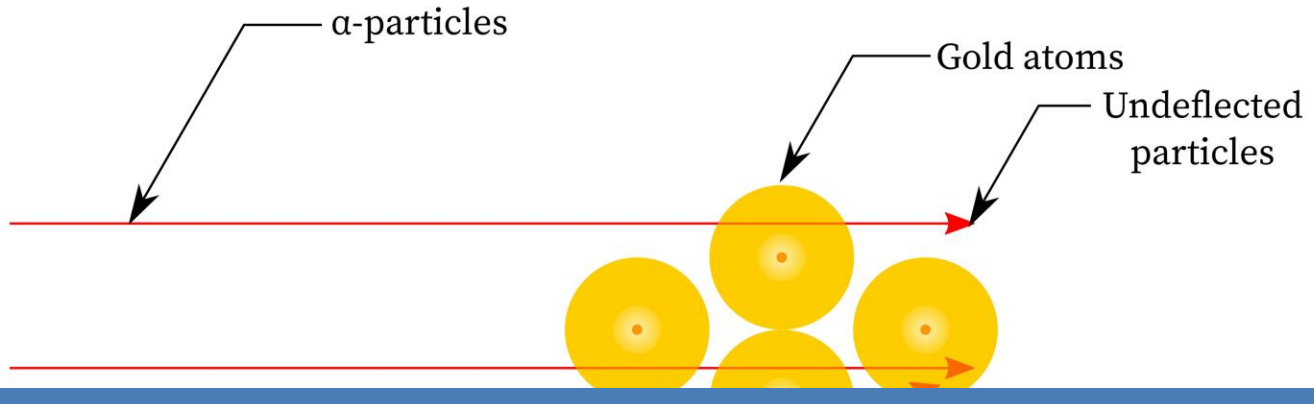
Alpha Particle Scattering Experiment



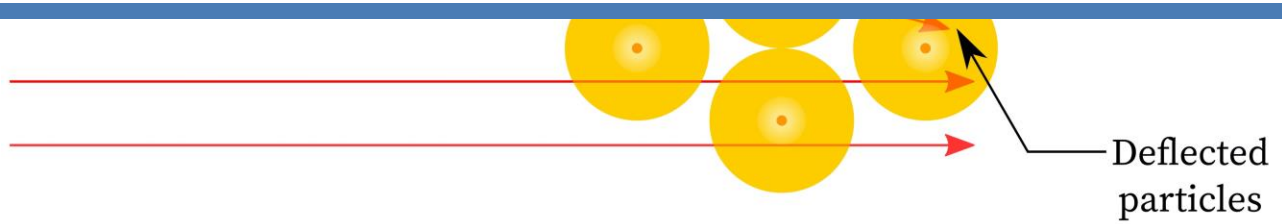
CS/F CS/H SS/F SS/H

4.1.3 Developing Model of the Atom

Alpha Particle Scattering Experiment



The results from the alpha particle scattering experiment led to the conclusion that the mass of an atom was concentrated at the centre (nucleus) and that the nucleus was charged. This nuclear model replaced the plum pudding model.



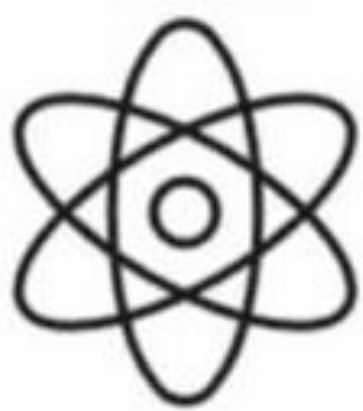
CS/F CS/H SS/F SS/H

4.1.3 Developing Model of the Atom

Ideas about the model of the atom have changed over time.

This is because new experimental evidence leads to scientific models being changed or relaced.

Rutherford carried out an experiment known as the alpha particle scattering experiment. From this the nuclear model of the atom was suggested.

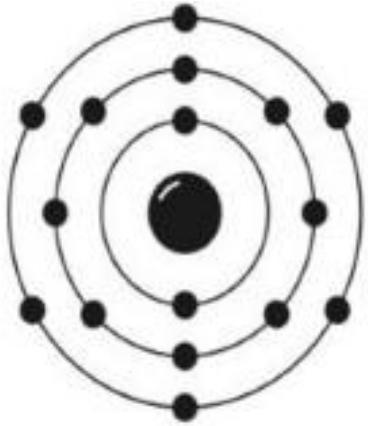


4.1.3 Developing Model of the Atom

Ideas about the model of the atom have changed over time.

This is because new experimental evidence leads to scientific models being changed or relaced.

Niels Bohr then adapted this model by suggesting that electrons orbit the nucleus at specific distance.

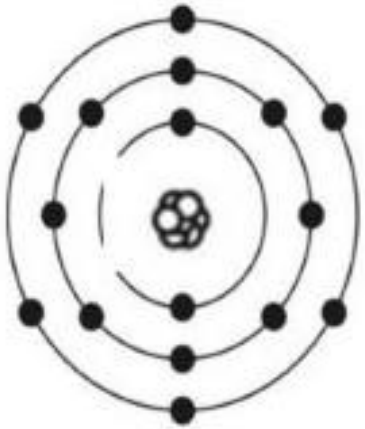


4.1.3 Developing Model of the Atom

Ideas about the model of the atom have changed over time.

This is because new experimental evidence leads to scientific models being changed or relaced.

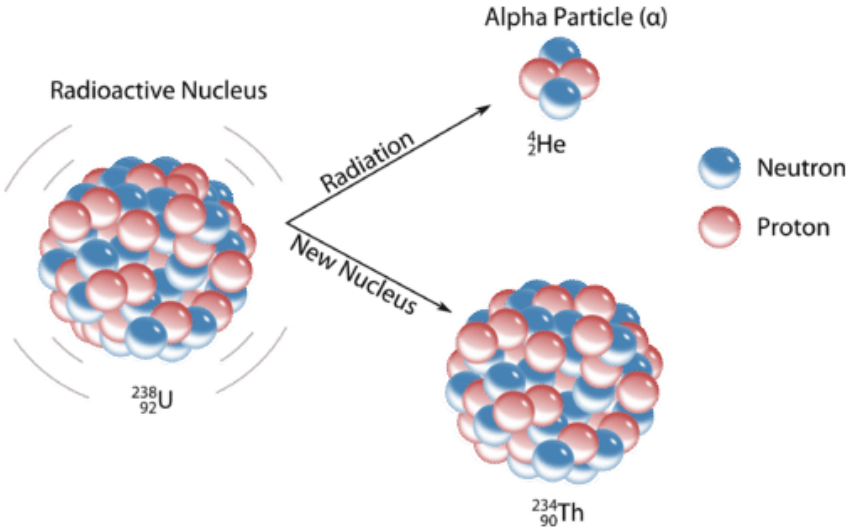
James Chadwick then went on to prove the existence of neutrons.



4.2.1 Radioactive Decay

Think
Pair
Share

What is radioactive decay?



Key Term	Definition
Radioactive Decay	

CS/F CS/H SS/F SS/H

4.2.1 Radioactive Decay

Think
Pair
Share

What is activity and count rate?

Key Term	Definition
Activity	
Count Rate	

CS/F CS/H SS/F SS/H

4.2.1 Radioactive Decay

Think
Pair
Share

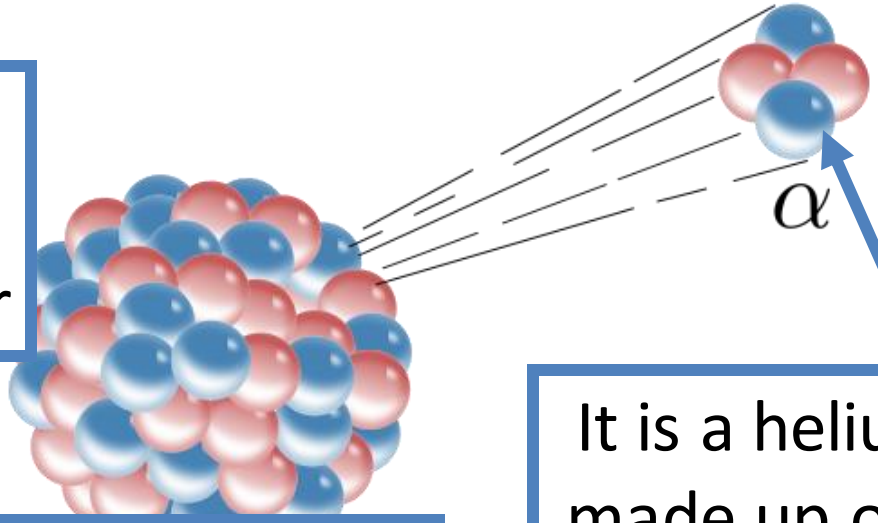
What are the different types of radiation?

Alpha Particle

It has a range of between 3-5cm in air.

Most ionising

Absorbed by the skin and a sheet of paper



It is a helium nucleus made up of 2 protons and neutrons.

Symbol for an alpha particle is α

CS/F CS/H SS/F SS/H

4.2.1 Radioactive Decay

Think
Pair
Share

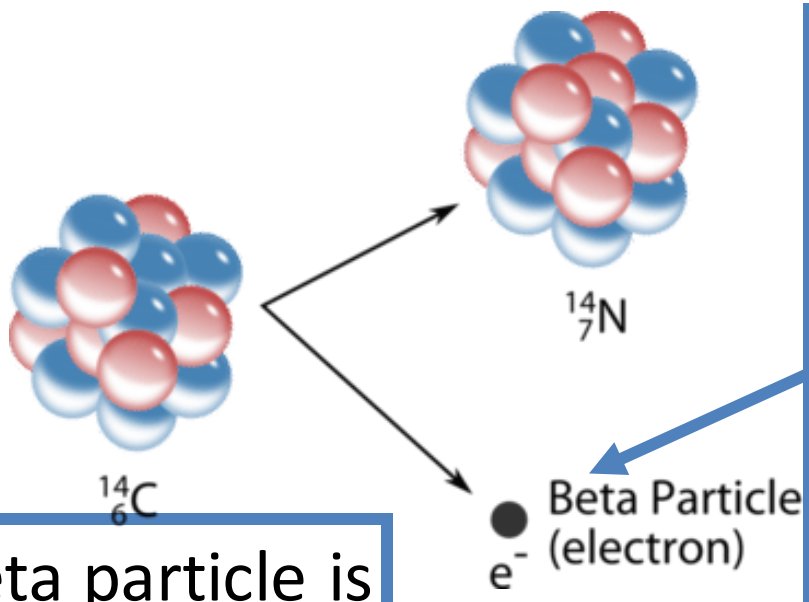
What are the different types of radiation?

Beta Particle

It has a range of 15cm in air.

Less ionising than alpha.

Absorbed by a thin sheet of aluminium



A high-speed electron that is ejected from the nucleus as a neutron turns into a proton.

Symbol for a beta particle is

β

CS/F CS/H SS/F SS/H

4.2.1 Radioactive Decay

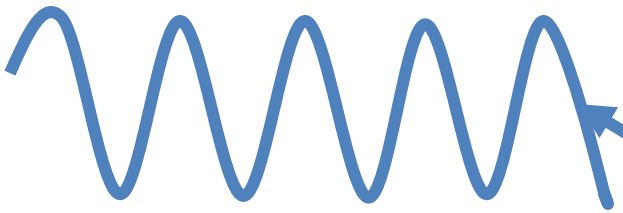
Think
Pair
Share

What are the different types of radiation?

Gamma

Travels large distances in air.

Most penetrating. Can be stopped by thick lead and concrete.



Least ionising

No charge

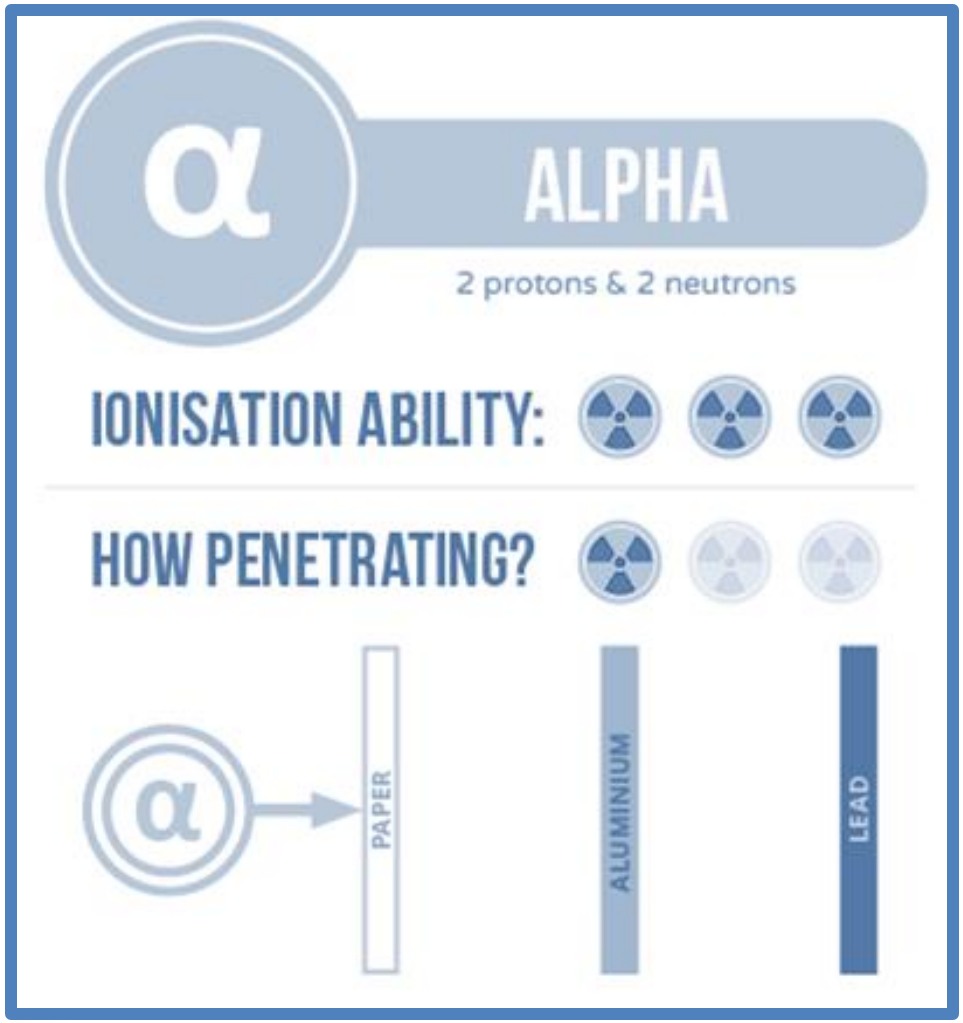
Electromagnetic radiation from the nucleus.

Symbol for gamma radiation is γ

CS/F CS/H SS/F SS/H

4.2.1 Radioactive Decay

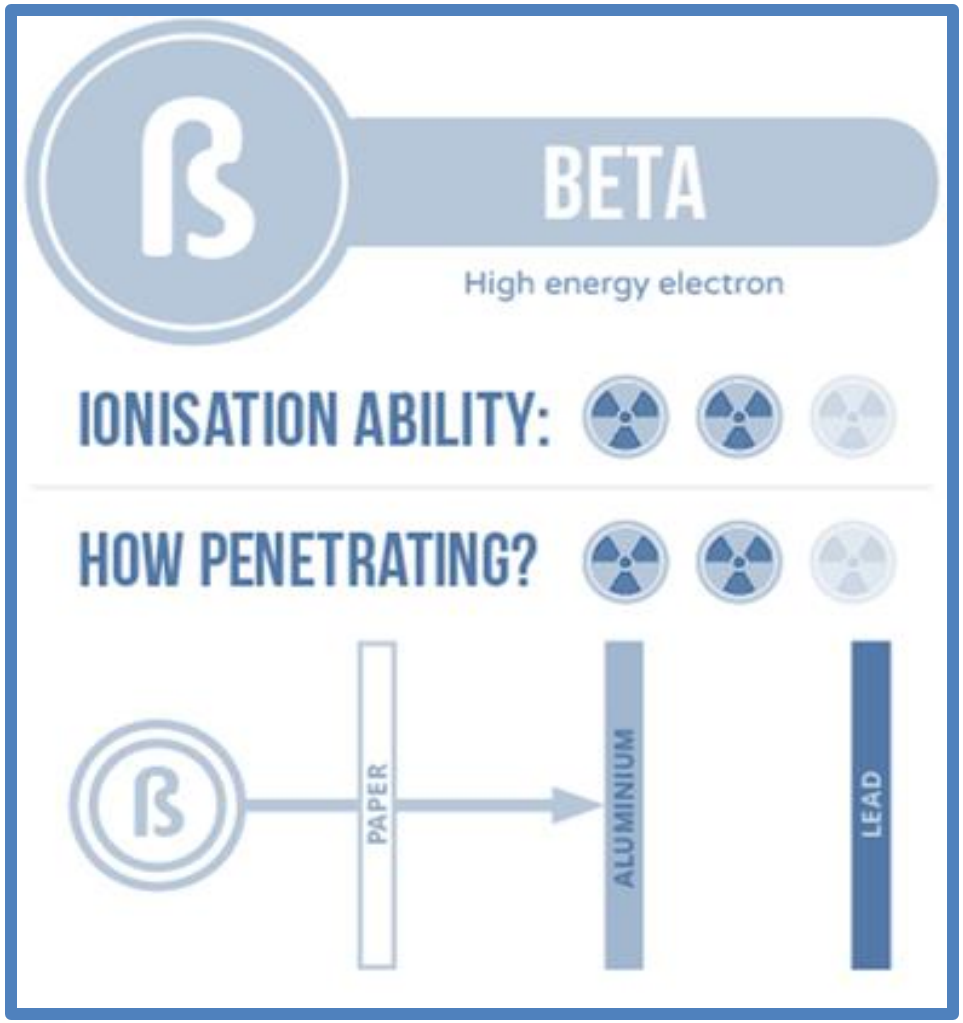
To summarise...



CS/F CS/H SS/F SS/H

4.2.1 Radioactive Decay

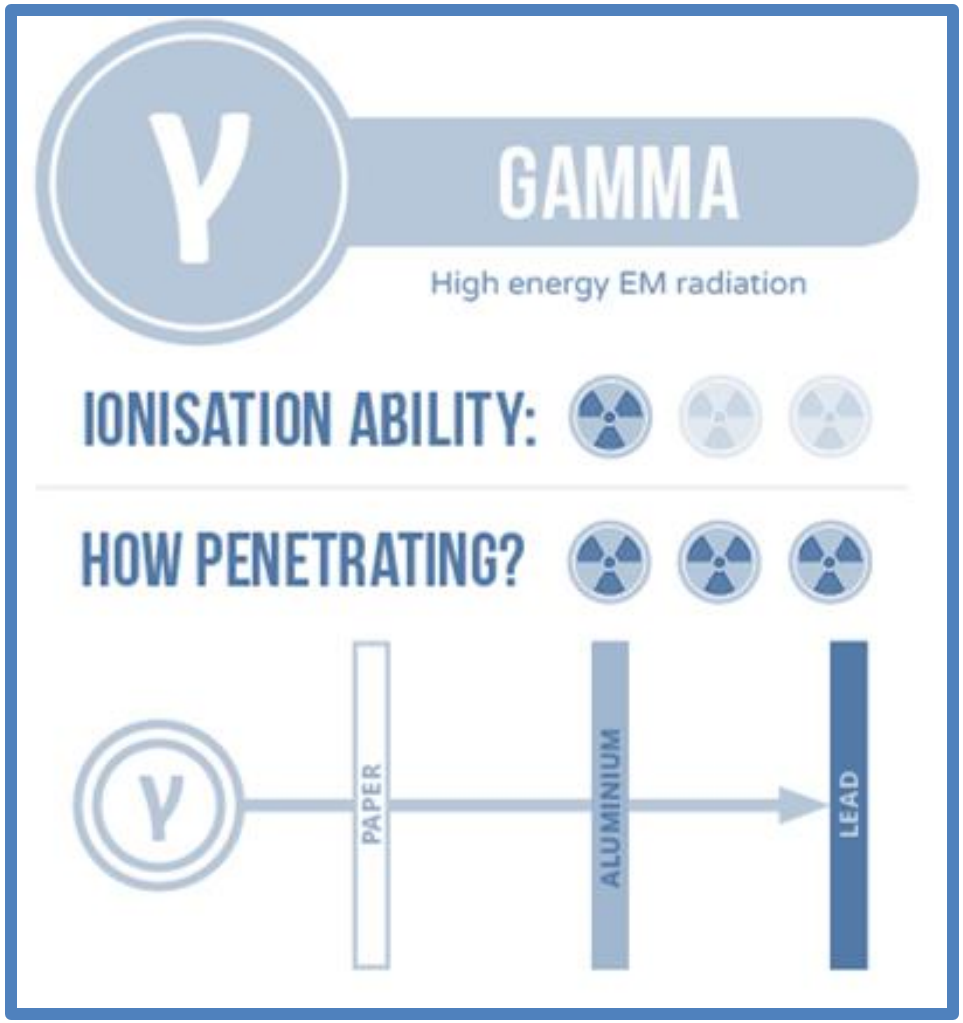
To summarise...



CS/F CS/H SS/F SS/H

4.2.1 Radioactive Decay

To summarise...



CS/F CS/H SS/F SS/H

4.2.1 Radioactive Decay

Radiation	Symbol	Description	Range	Penetrating Power	Ionising Power
Alpha					
Beta					
Gamma					

CS/F CS/H SS/F SS/H

Exam Practice

L3

Explain how the properties of α, β and γ radiation affect the level of the hazard at different distances.

Alpha	Beta	Gamma
Least penetrating	Second most penetrating	Most penetrating
Short Range	Second longest range	Longest Range
Most ionising	Second most ionising	Least ionising
At short range most dangerous	At mid range most dangerous.	At long range most dangerous

Exam Practice

L2

Two isotopes of carbon are $^{12}_{6}C$ and $^{14}_{6}C$.

(a) Describe **two** similarities and **one** difference in the atomic structure of the two isotopes.

You should refer to the **number** and **type** of sub-atomic particles in each isotope.

Similarity 1 Both have 6 protons

Similarity 2 Both have 6 electrons

Difference Carbon 14 has 2 more neutrons

(3)

4.2.2 Nuclear Equations

Think
Pair
Share

What are nuclear equations?

They are ways of representing radioactive decay.

$^{4}_{2}He$

Alpha particle

$^{0}_{-1}e$

Beta particle

The emission of the different types of nuclear radiation may cause a change in the mass and /or the charge of the nucleus.

CS/F CS/H SS/F SS/H

4.2.2 Nuclear Equations

Think
Pair
Share

How can we model alpha decay?

Alpha Decay of Radon

$$^{219}_{86}\text{Radon} \longrightarrow {}^{215}_{84}\text{Polonium} + {}^{4}_{2}\text{He}$$

Alpha decay causes the mass and charge of the nucleus to decrease

CS/F CS/H SS/F SS/H

4.2.2 Nuclear Equations

Think
Pair
Share

How can we model beta decay?

Beta Decay of Carbon

$$^{14}_{6}\text{Carbon} \longrightarrow {}^{14}_{7}\text{Nitrogen} + {}^{0}_{-1}\text{e}$$

Beta decay does not causes the mass of the nucleus to change but does causes the charge of the nucleus to increase.

CS/F CS/H SS/F SS/H

4.2.2 Nuclear Equations

Think
Pair
Share

How we we write nuclear equations for alpha decay?

$$^{210}_{84}Po \longrightarrow {}^{206}_{82}Pb + {}^{4}_{2}He$$

$$^{238}_{92}U \longrightarrow {}^{234}_{90}Th + {}^{4}_{2}He$$

$$^{210}_{82}Pb \longrightarrow {}^{206}_{80}Hg + {}^{4}_{2}He$$

$$^{226}_{88}Ra \longrightarrow {}^{222}_{86}Rn + {}^{4}_{2}He$$

CS/F CS/H SS/F SS/H

4.2.2 Nuclear Equations

Think
Pair
Share

How we we write nuclear equations for beta decay?

$$^{140}_{57}La \longrightarrow ^{140}_{58}Ce + ^{0}_{-1}e$$

$$^{139}_{56}Ba \longrightarrow ^{139}_{57}La + ^{0}_{-1}e$$

$$^{137}_{55}Cs \longrightarrow ^{137}_{56}Ba + ^{0}_{-1}e$$

$$^{3}_{1}H \longrightarrow ^{3}_{2}He + ^{0}_{-1}e$$

CS/F CS/H SS/F SS/H

4.2.2 Nuclear Equations

Type of Decay	Particle Emitted From Nucleus	Mass of Nucleus	Charge of Nucleus
Alpha	$^{4}_{2}He$		
Beta	$^{0}_{-1}e$		

In both alpha and beta decay a new element is made.

CS/F CS/H SS/F SS/H

Exam Practice

L2

Explain why gamma emission does **not** change the atomic number of an element.

Gamma radiation is not a particle

Gamma radiation does not change the number of protons in the nucleus

Beta decay does **not** cause the mass number of an atom to change.

Explain why not.

Neutrons decrease by 1

Protons increase by 1

(2)

Exam Practice

L2

Transmutation is the name given to a process where one element changes into another.

Explain and compare how two different types of radioactive decay can cause transmutation.

Alpha Decay	Beta Decay
Proton number decreases by 2.	Proton number increases by 1.
Both change the proton number	
Atomic number decreases.	Atomic number increases
Emission of 2 protons and 2 neutrons from the nucleus	A neutron decays into a proton

(4)

AQA GCSE Physics Paper 1

Exam Practice

L2

$$^{212}_{83}Bi \longrightarrow \boxed{208}\ \boxed{81}\ Tl + {}^{4}_{2}He$$

(2)

Lead-210 is a radioactive isotope that decays to an isotope of mercury by alpha decay.

Complete the nuclear equation to show the alpha decay of lead-210.

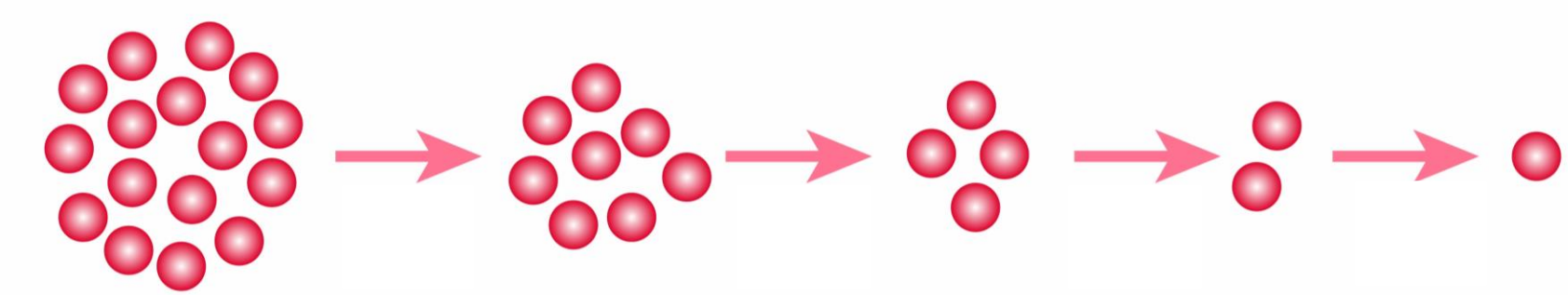
$$^{210}_{82}Pb \longrightarrow {}^{206}_{80}Hg + {}^{4}_{2}He$$

(3)

4.2.3 Half Lives

Think
Pair
Share

What is half life?



Key Term	Definition
Half Life	

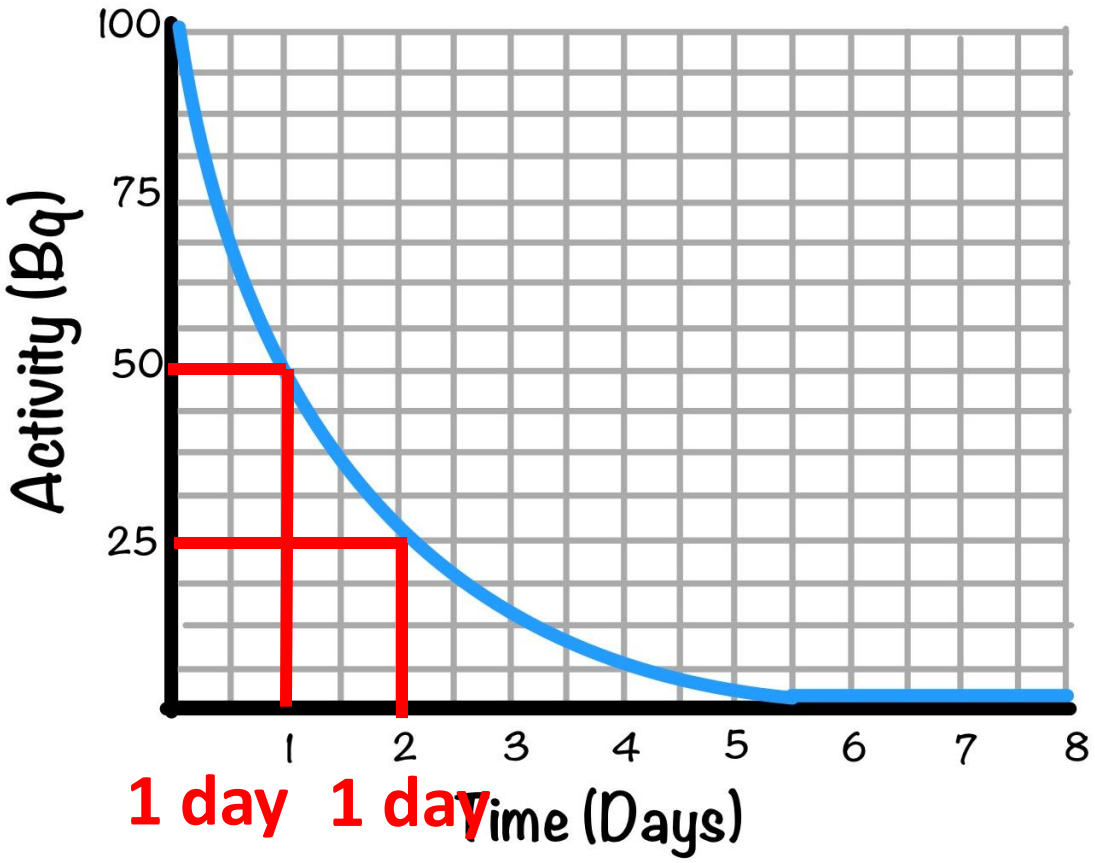
CS/F CS/H SS/F SS/H

4.2.3 Half Lives

Think
Pair
Share

What is half life?

This substance has a half life of 1 day.

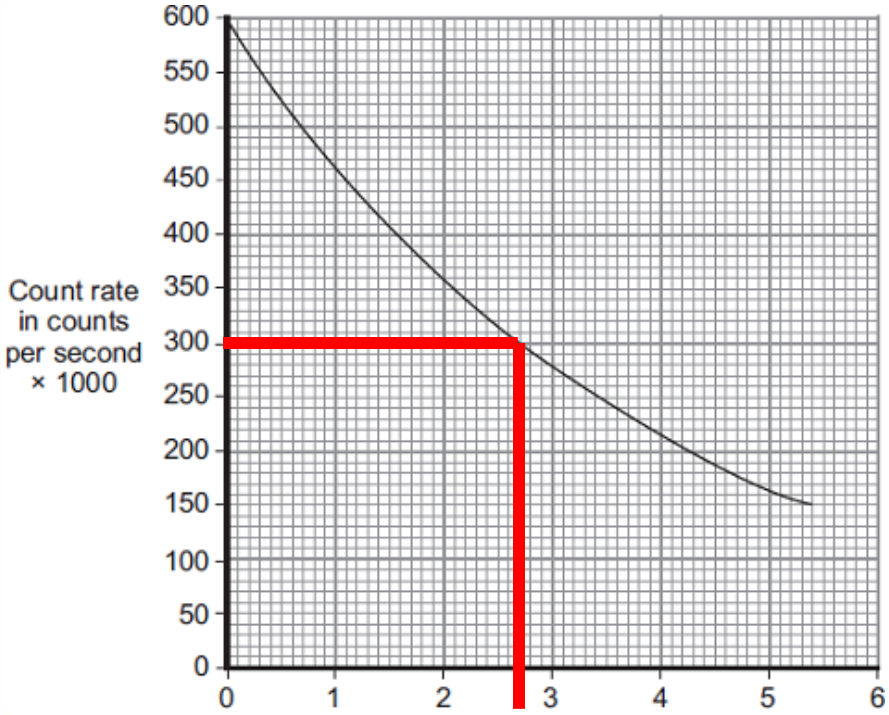


CS/F CS/H SS/F SS/H

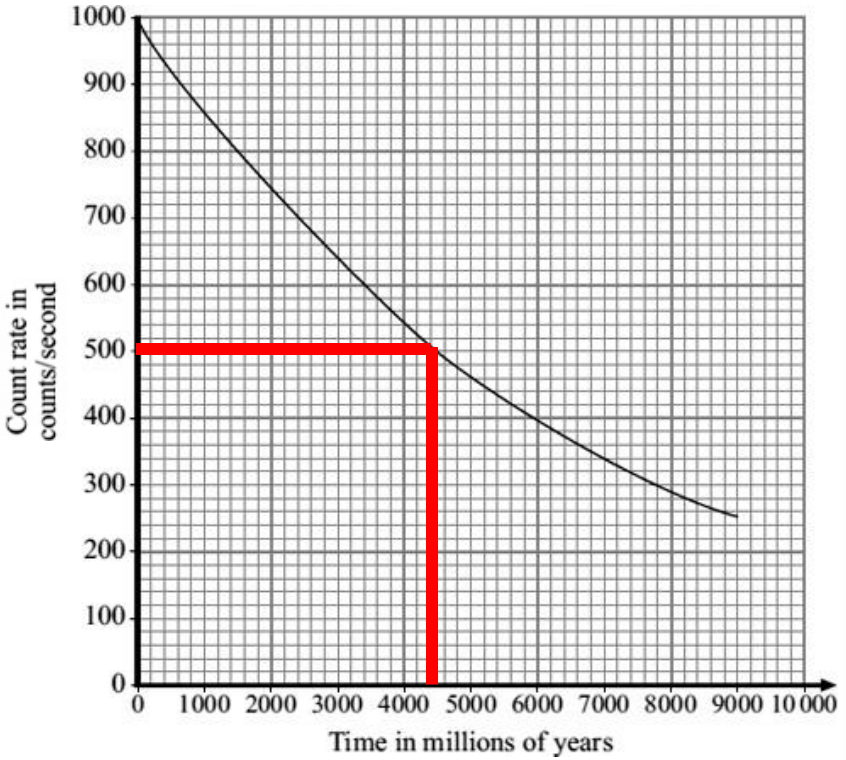
4.2.3 Half Lives

Think
Pair
Share

How can we determine the half lives of these substances?



2.7 days



4500 million years

CS/F CS/H SS/F SS/H

Exam Practice

L2

Tritium is radioactive.

After 36 years, only 10 g of tritium remains from an original sample of 80 g.

Calculate the half-life of tritium.

Show clearly how you work out your answer.

Number of half lives: 3

Half Life Duration = 36 / 3 = 12

Half-life = _____ years

(2)

Exam Practice

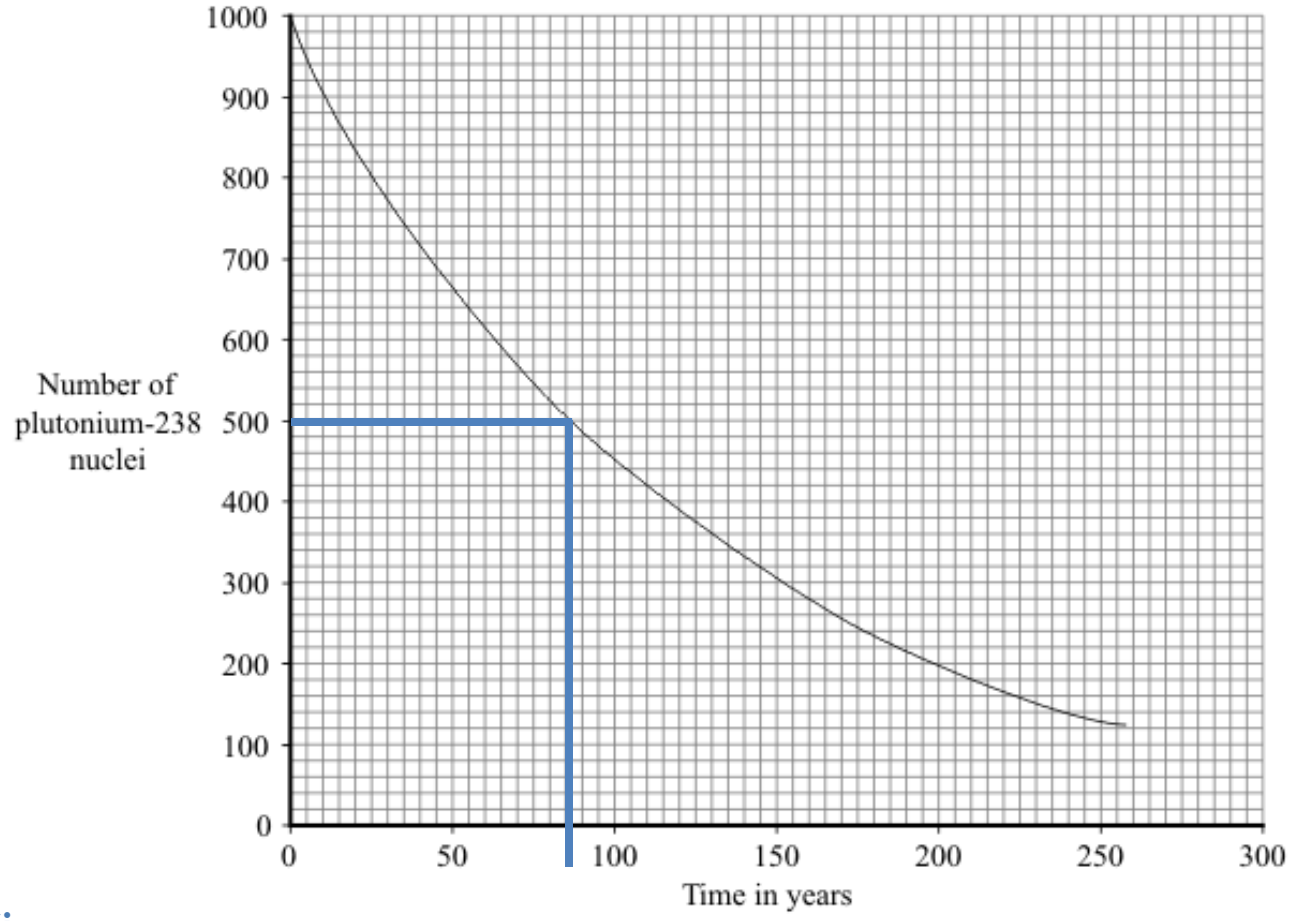
L2

Use the graph to find the half-life of plutonium-238.

Show clearly on the graph how you obtain your answer.

Half-life = 85 years

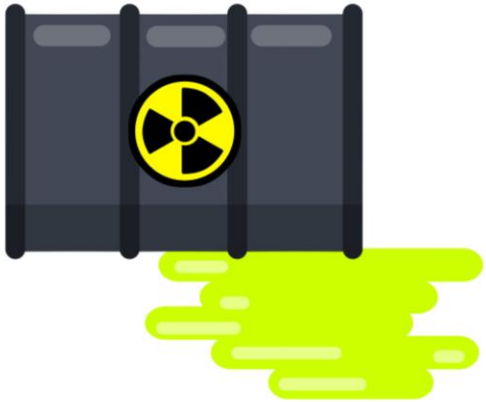
(2)



4.2.4 Radioactive Contamination

Think
Pair
Share

What is contamination and irradiation?



Key Term	Definition
Contamination	
Irradiation	

CS/F CS/H SS/F SS/H

4.2.4 Radioactive Contamination

Think
Pair
Share

What are the differences between contamination and irradiation?

	Contamination	Irradiation
When It Occurs		
Does The Object Become Radioactive?		
Stopping Radiation.		

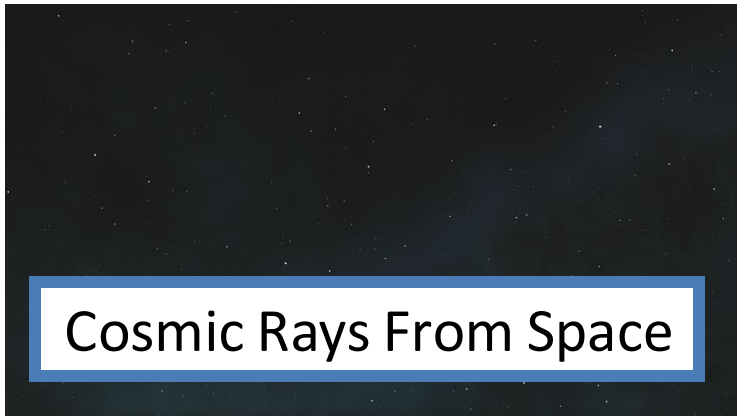
CS/F CS/H SS/F SS/H

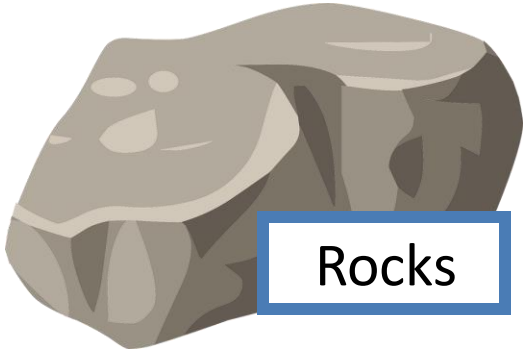
4.3.1 Background Radiation

Think
Pair
Share

What are sources of background radiation?

Natural Sources





CS/F CS/H SS/F SS/H

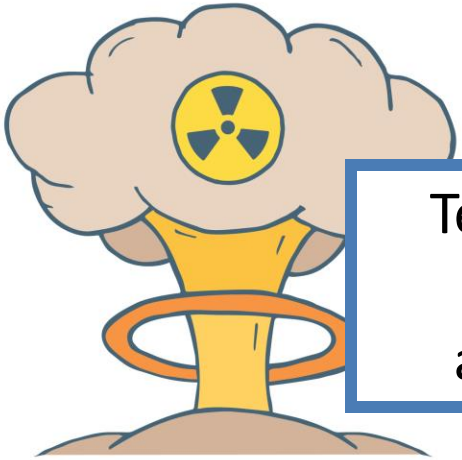
4.3.1 Background Radiation

Think
Pair
Share

What are sources of background radiation?

Man Made Sources

Fallout from nuclear weapons



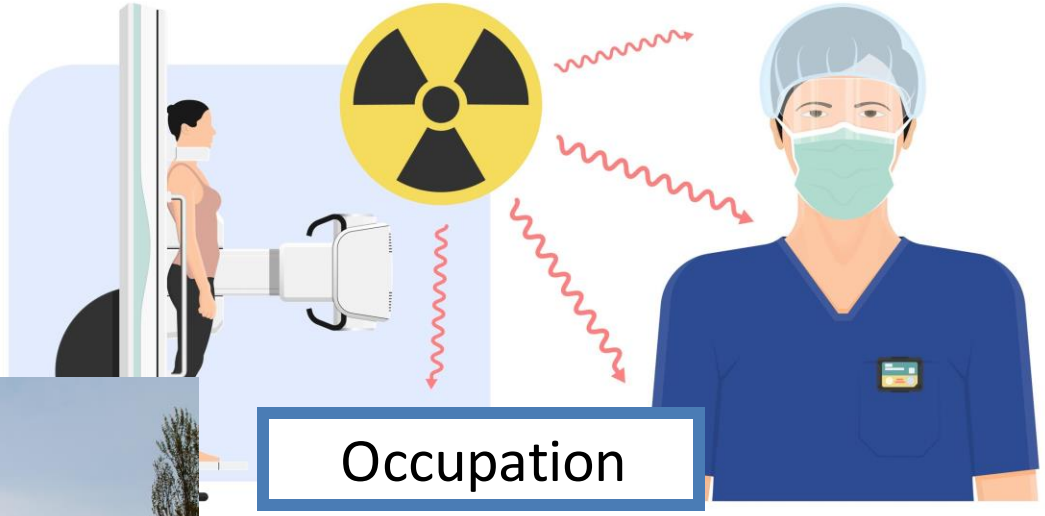
Testing and nuclear accidents

CS/F CS/H SS/F SS/H

4.3.1 Background Radiation

Think
Pair
Share

What can affect the radiation dose a person is exposed to?



Occupation

Location

CS/F CS/H SS/F SS/H

4.3.1 Background Radiation

Think
Pair
Share

How is radiation dose measured?

Radiation dose is measured in **sieverts** (Sv)

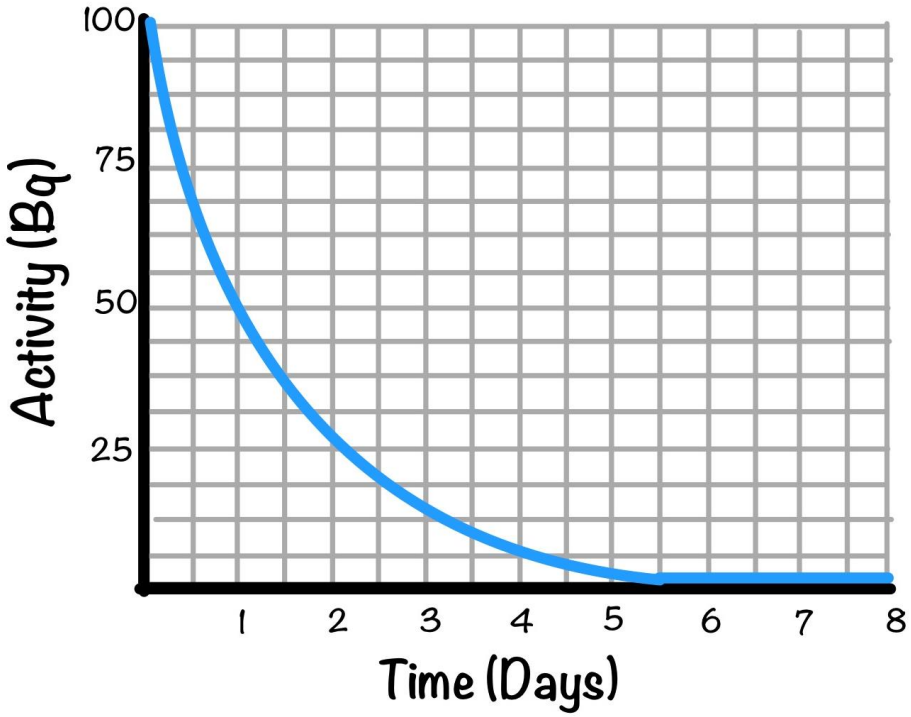
1000 millisieverts (mSv) = 1 sievert (Sv)

CS/F CS/H SS/F SS/H

4.3.2 Half Lives of Isotopes

Radioactive isotopes have a very wide range of half-life values.

If a substance has a short half life, activity decreases quickly and so the risk of harm decreases quickly also.

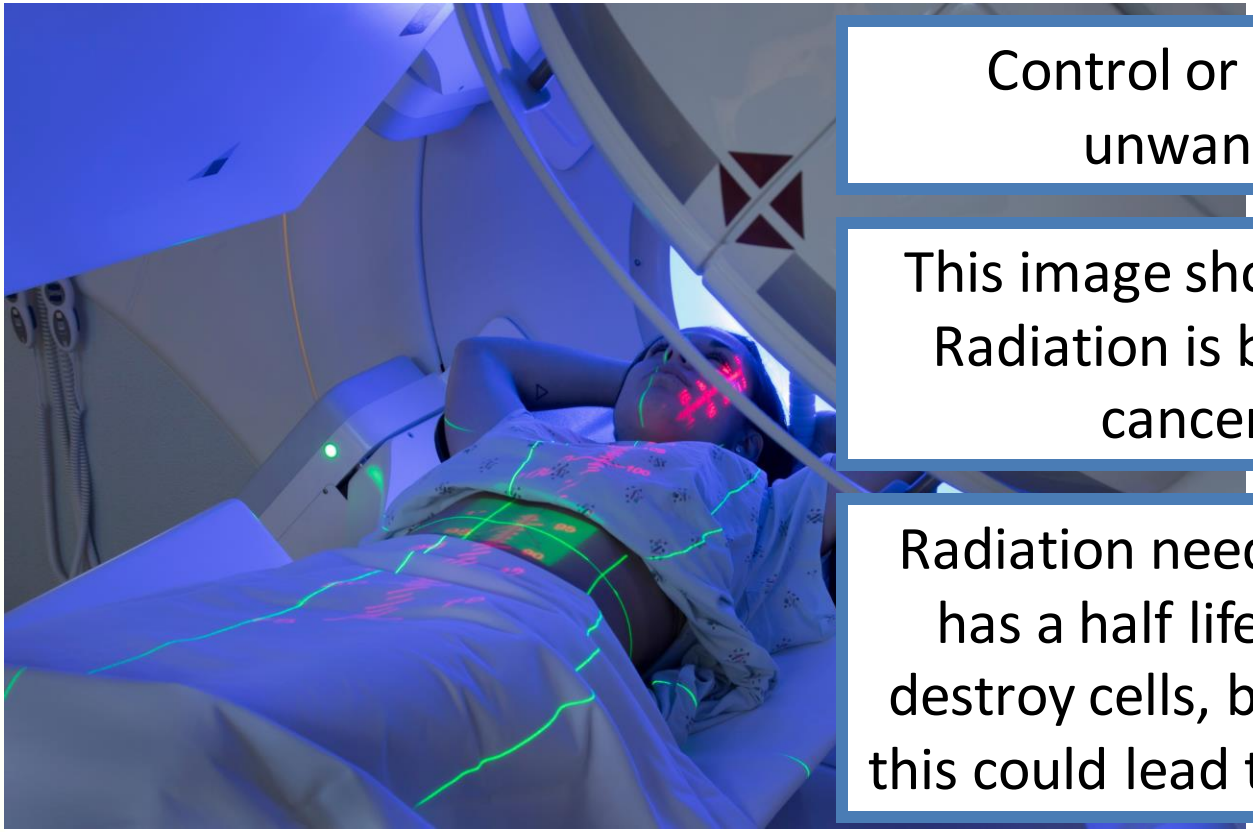


CS/F CS/H SS/F SS/H

4.3.3 Uses of Nuclear Radiation

Think
Pair
Share

What uses to we have for nuclear radiation in medicine?



Control or destruction of unwanted tissue.

This image shows radiotherapy. Radiation is being used to kill cancerous cells.

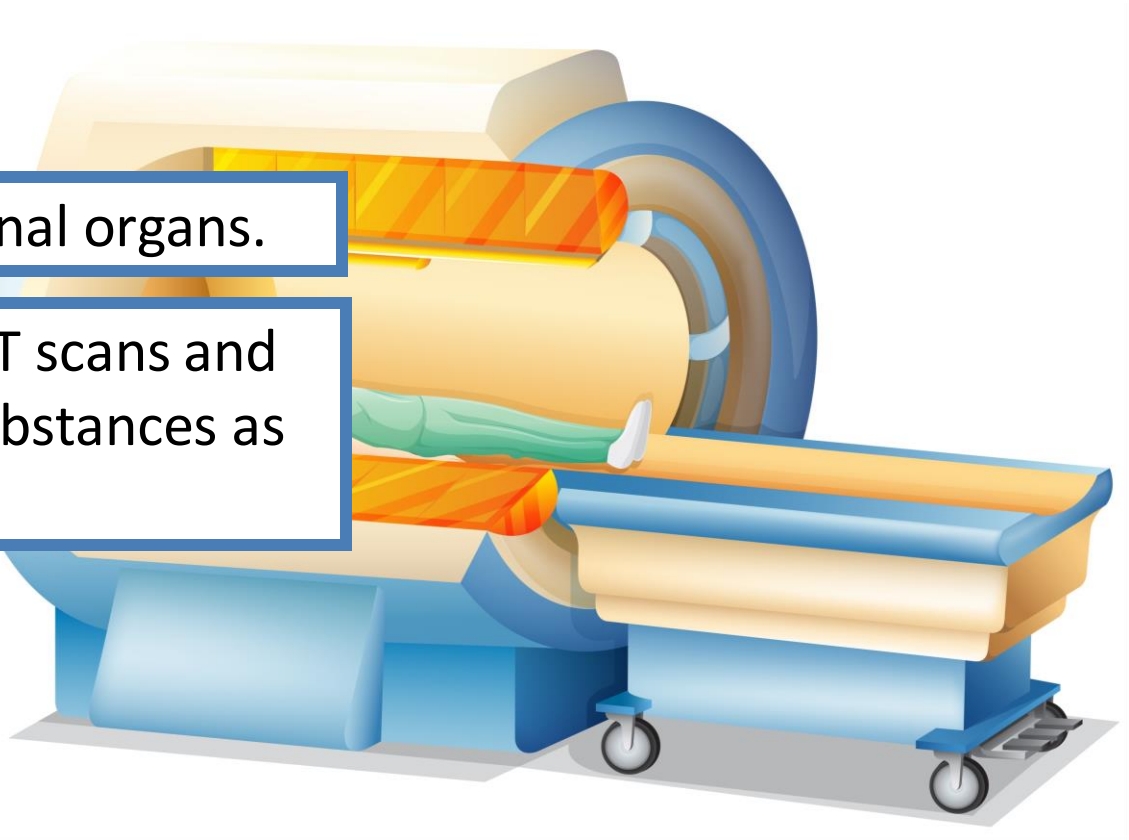
Radiation needs to be used that has a half life long enough to destroy cells, but not too long as this could lead to further damage.

CS/F CS/H SS/F SS/H

4.3.3 Uses of Nuclear Radiation

Think
Pair
Share

What uses to we have for nuclear radiation in medicine?



Exploration of internal organs.

Examples include CT scans and using radioactive substances as tracers.

CS/F CS/H SS/F SS/H

4.4.1 Nuclear Fission

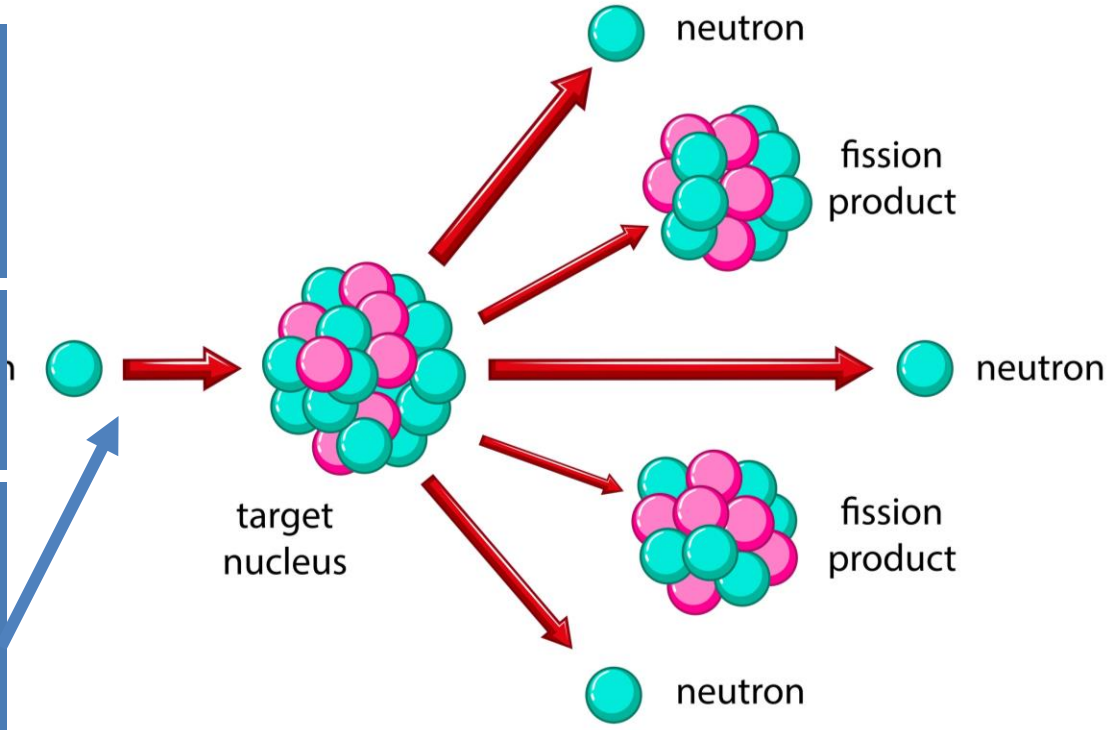
Think
Pair
Share

What is nuclear fission?

Nuclear fission is the splitting of a large and unstable nucleus.

Spontaneous fission is rare.

Usually for fission to occur the unstable nucleus must first absorb a neutron.



CS/F CS/H SS/F SS/H

4.4.1 Nuclear Fission

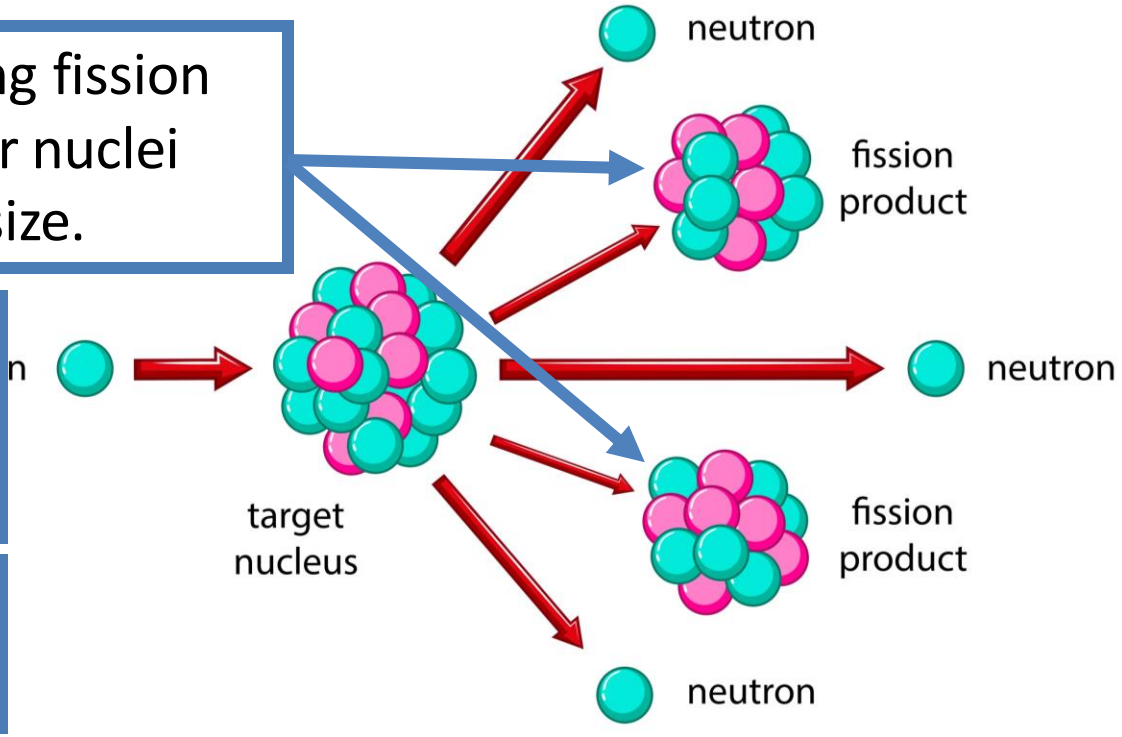
Think
Pair
Share

What is nuclear fission?

The nucleus undergoing fission splits into two smaller nuclei roughly equal in size.

Two or three neutrons plus gamma rays are also emitted.

Energy is released by the fission reaction.



CS/F CS/H SS/F SS/H

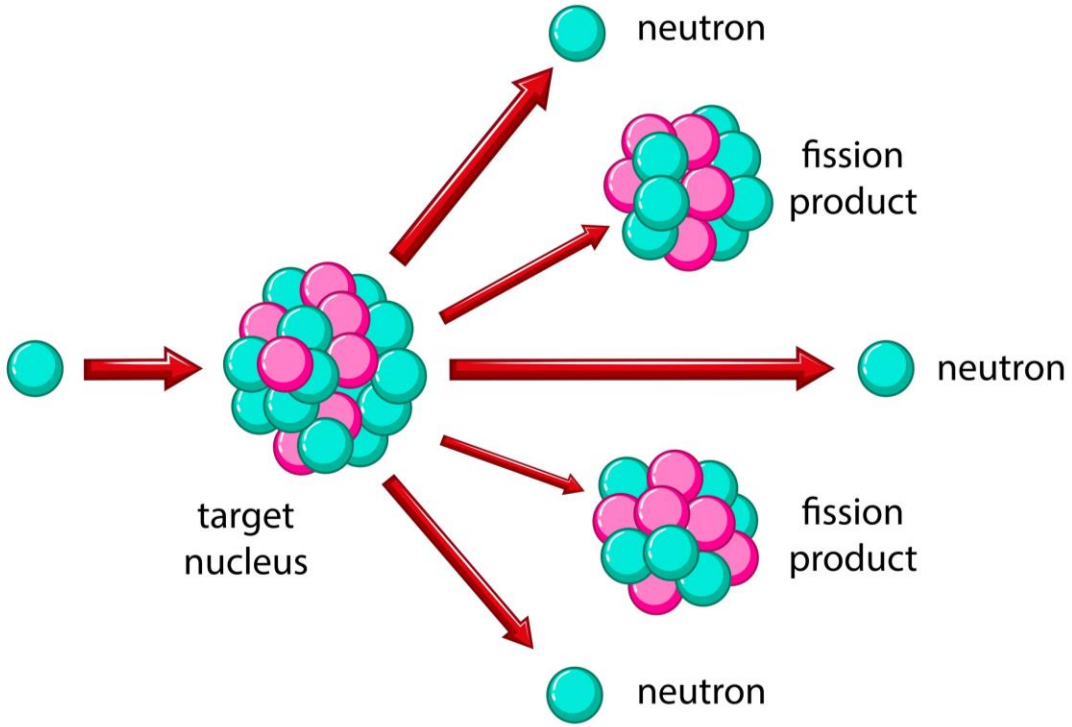
4.4.1 Nuclear Fission

Think
Pair
Share

What is nuclear fission?

All of the fission products have kinetic energy.

The neutrons may go on to start a chemical reaction.



CS/F CS/H SS/F SS/H

4.4.1 Nuclear Fission

Think
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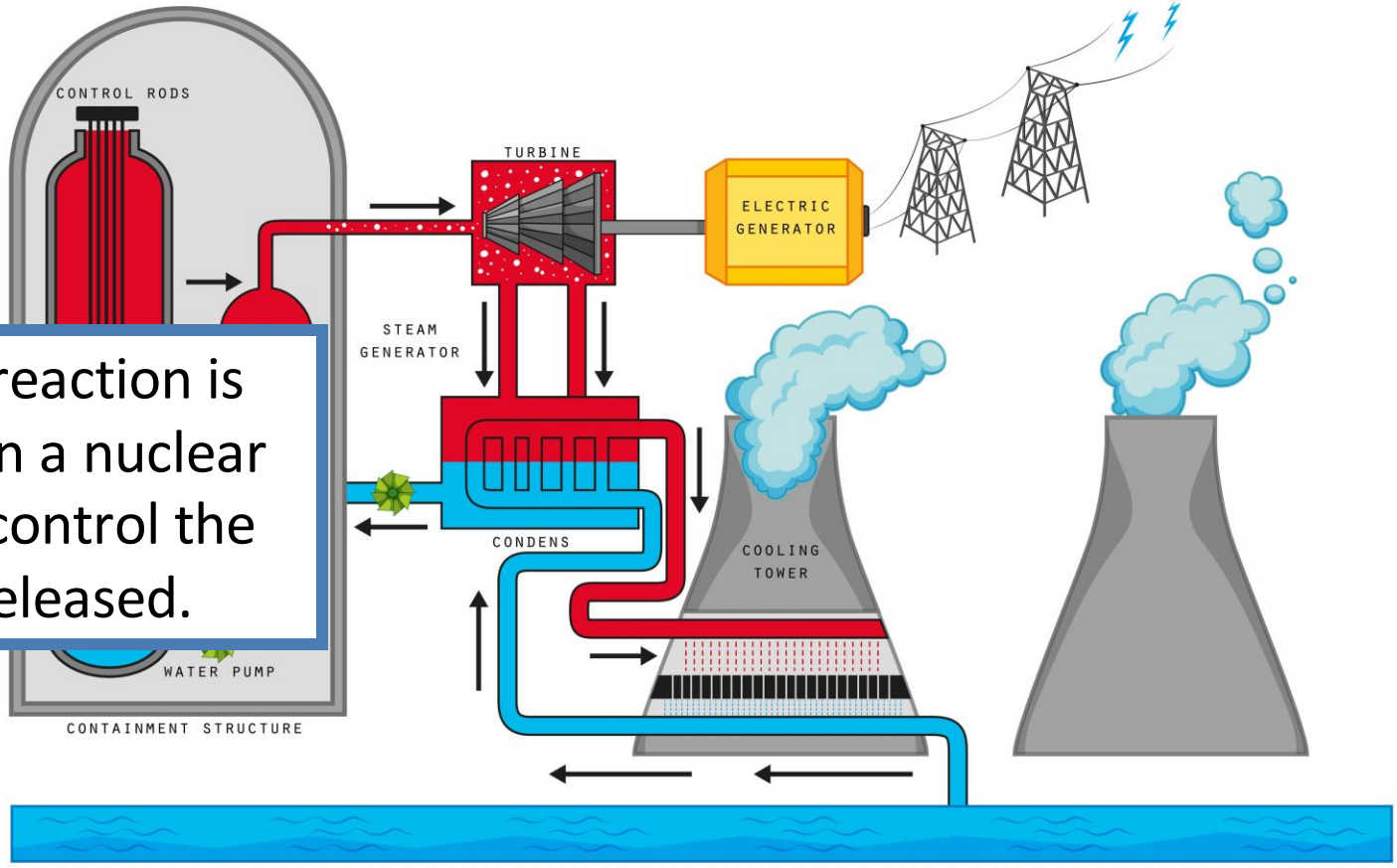
What is nuclear fission?



The chain reaction is controlled in a nuclear reactor to control the energy released.

CS/F CS/H SS/F SS/H

4.4.1 Nuclear Fission

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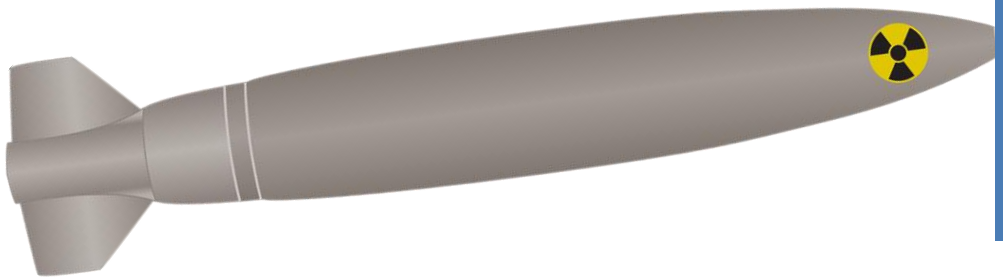
What is nuclear fission?



The explosion caused by a nuclear weapon is caused by an uncontrollable chain reaction.

CS/F CS/H SS/F SS/H

4.4.2 Nuclear Fusion

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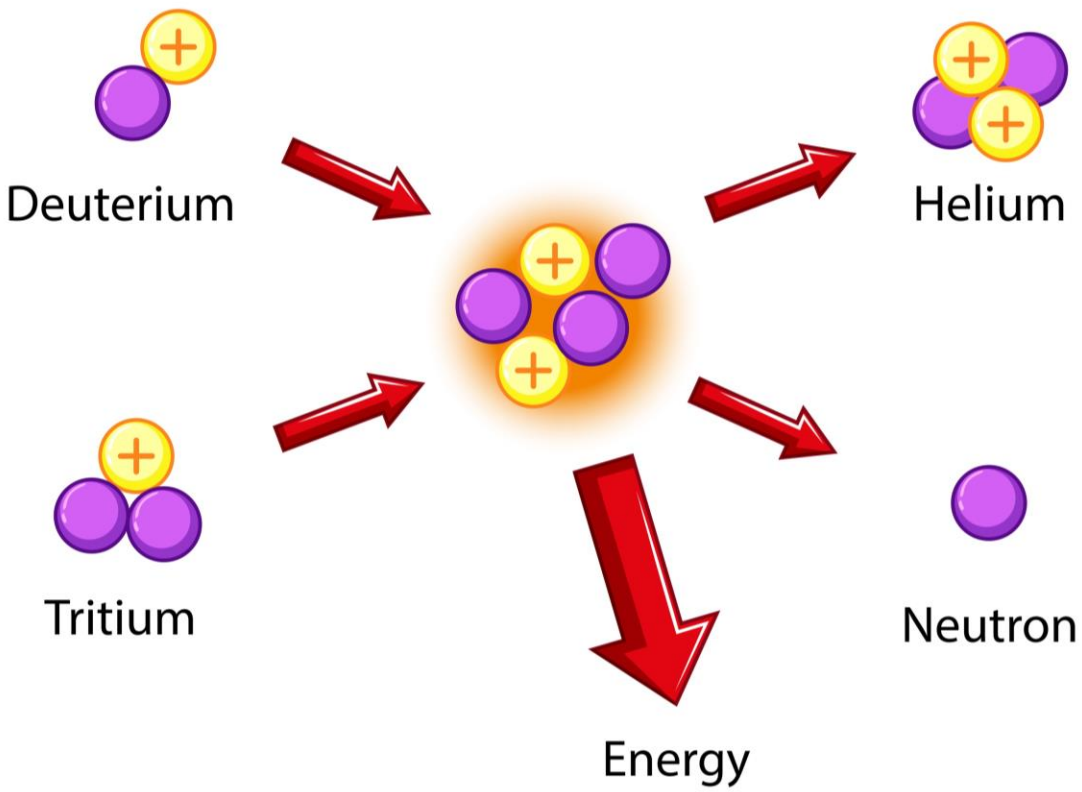
What is nuclear fusion?



Nuclear fusion is the joining of two light nuclei to form a heavier nucleus.

In the process some of the mass may be converted into the energy of radiation.

CS/F CS/H SS/F SS/H