Atomic structure revision pack

Content will be tested on physics paper 1

Atoms and Nuclear Physics	☺	☹
Label the parts of an atom and state approximate sizes of the atom and the nucleus		
Explain what might cause changes in distance of electrons from the nucleus		
Describe the changes to the atomic model over time, and why those changes were made		
Describe what is meant by an isotope and describe some of their uses		
Describe the properties and origins of alpha, beta and gamma radiation		
Complete nuclear equations for alpha and beta decay		
Describe what is meant by the half-life of a radioactive isotope and obtain values for this from a decay curve		
Choose an appropriate source for a particular purpose		
Explain the difference between contamination and irradiation and compare the hazards of each		

4.4.1 Atoms and isotopes

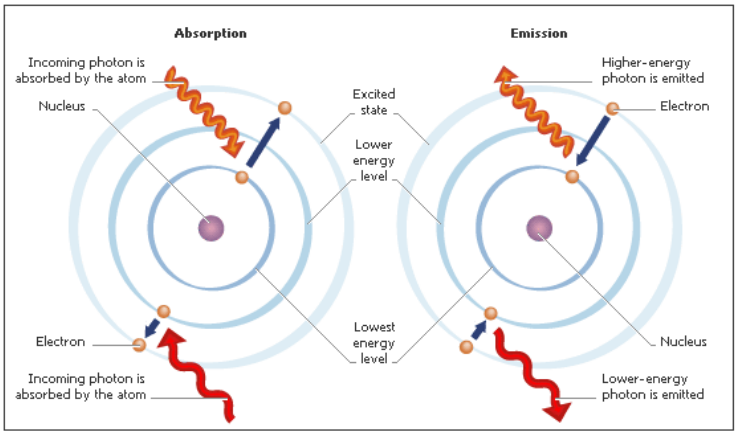
Positively charged nucleus (which contains neutrons and protons) surrounded by negatively charged electrons.

Subatomic Particle	Relative Mass	Relative Charge
Proton	1	+1
Neutron	1	0
Electron	0 (0.0005)	-1

Typical radius of an atom: 1×10^{-10} metres
- And the radius of the nucleus is 10 000 times smaller
- Most (nearly all) the mass of the atom is concentrated at the nucleus

Electron Arrangement:
- Electrons lie at different distances from the nucleus (different energy levels). The electron arrangements may change with the interaction with EM radiation.

- **Absorption** of electromagnetic radiation – move further from the nucleus; higher energy level
- **Emission** of electromagnetic radiation – move close to the nucleus; a lower energy level.



Isotopes and Elements

- All atoms of the same element have the same number of protons
- Neutral atoms have the same number of electrons and protons
- Isotopes are atoms of the same element, but with different masses, which have the same number of protons but different number of neutrons.
- For example Carbon-12, Carbon-13 and Carbon-14

$$^{A}_{Z}X^{\pm n}$$

- X is the letter of their element
- A is the mass number (number of neutrons and protons)
- Z is the proton number
- N is the charge
    - On a normal neutral atom, electrons = protons, so cancels out
    - If N more electrons than protons, then –N charge
    - If N fewer electrons than protons, then +N charge
    - The number of protons does not change for a certain element

E.g. Chlorine has two isotopes

18 neutrons
17 protons
17 electrons

$^{35}_{17}Cl$

20 neutrons
17 protons
17 electrons

$^{37}_{17}Cl$

Exam practice 1

Q1. Atoms contain three types of particle.

(a) Draw a ring around the correct answer to complete the sentence.

The particles in the nucleus of the atom are

electrons and neutrons.
electrons and protons.
neutrons and protons.

(1)

(b) Complete the table to show the relative charges of the atomic particles.

Particle	Relative charge
Electron	–1
Neutron	
Proton	

(2)

(c) (i) A neutral atom has no overall charge.

Explain this in terms of its particles.

_____

_____

_____

_____

(2)

(ii) Complete the sentence.

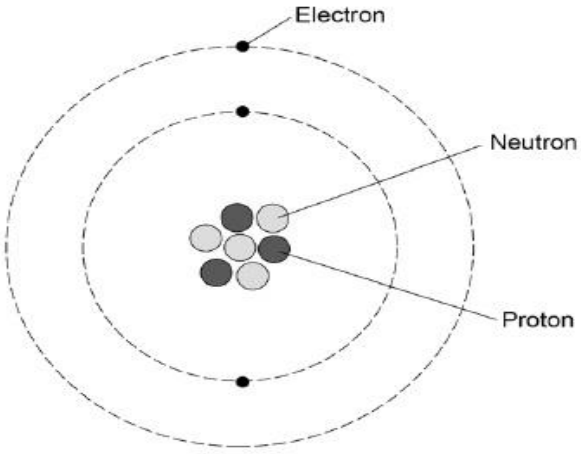
An atom that loses an electron is called an _____

and has an overall _____ charge.

(2)

(Total 7 marks)

Q2. The diagram shows a lithium atom.



(a) What is the mass number of this lithium atom?

Tick **one** box.

3 ☐ 4 ☐ 7 ☐ 10 ☐

(1)

(b) What is the atomic number of a lithium atom?

Tick **one** box.

3 ☐ 4 ☐ 7 ☐ 10 ☐

Give a reason for your answer.

_____

_____

(2)

(c) Complete the sentence.

Choose the answer from the box.

circles	**levels**	**rings**

The electrons in an atom orbit in different energy _____ .

(1)

Q3. Americium-241 ($^{241}_{95}Am$) is an isotope of americium.

(a) Which of the isotopes given in the table below is **not** an isotope of americium?

Isotope	**Mass number**	**Atomic number**
A	243	95
B	243	94
C	242	95

Isotope _____

Give a reason for your answer.

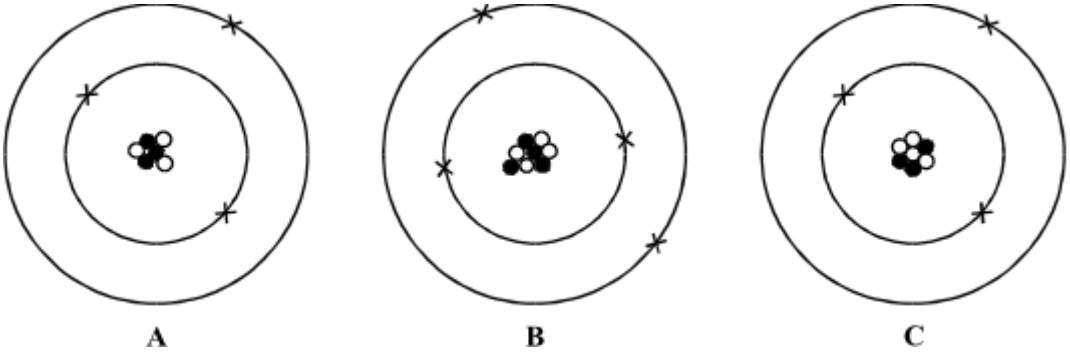
_____

_____

_____

(2)

Q4. The diagrams below represent three atoms, **A**, **B** and **C**.



(a) Two of the atoms are from the **same** element.

(i) Which of **A**, **B** and **C** is an atom of a different element? _____

(ii) Give **one** reason for your answer.

_____

_____

(2)

(b) Two of these atoms are isotopes of the same element.

(i) Which **two** are isotopes of the same element? _____ and _____

(ii) Explain your answer.

_____

_____

(3)

(Total 5 marks)

Q5. Atoms are different sizes.

One of the heaviest naturally occurring stable elements is lead.

Two of its isotopes are lead-206 ($^{206}_{82}Pb$) and lead-208 ($^{208}_{82}Pb$).

(a) (i) What is meant by 'isotopes'?

_____

_____

(2)

(ii) How many protons are in the nucleus of a $^{206}_{82}Pb$ atom?

_____

(1)

(iii) How many neutrons are in the nucleus of a $^{206}_{82}Pb$ atom?

(1)

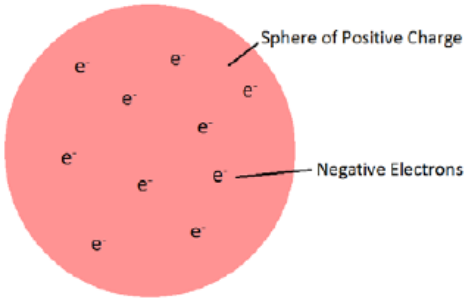
4.4.1.3 The development of the model of the atom (common content with chemistry)

How and why the atomic model has changed over time

1800 - Dalton said everything was made of tiny spheres (atoms) that could not be divided

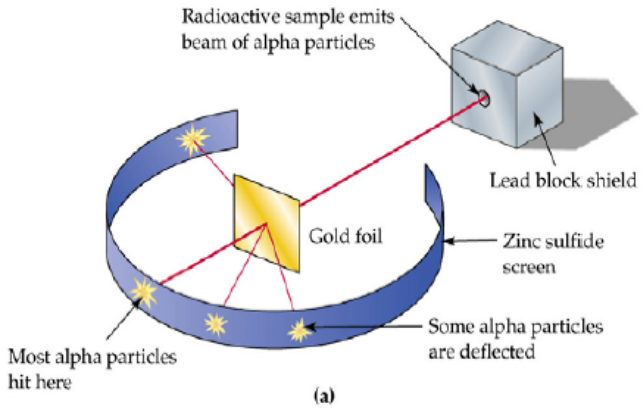
1897 - JJ Thomson discovered the electron

The Plum Pudding Model was formed



The overall charge of an atom is neutral, so the negative electrons were dispersed through the positive "pudding" to cancel out the charges.

1911 - Rutherford realised most of the atom was empty space



kcmcgann.tripod.com/goldfoil.jpg

Gold Foil Experiment

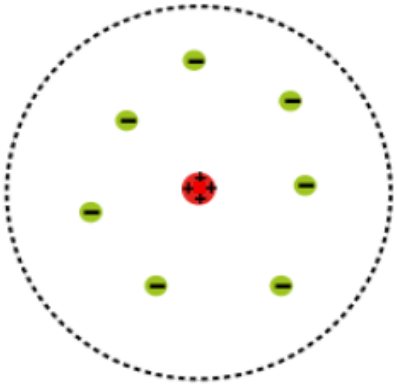
Most α particles went straight through
- So most of atom is empty space

Some α particles were slightly deflected
- So nucleus must be charged, deflecting positive α

Few α particles were deflected by >90°
- So nucleus contained most of the mass

This experiment was carried out by Geiger and Marsden, specifics not needed

1913 - Rutherford Model



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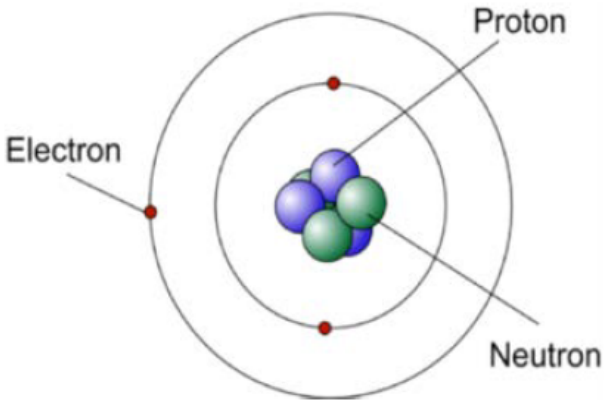
Now there is a positive nucleus at the centre of the atom, and negative electrons existing in a cloud around the nucleus

1913 – Bohr produced the final model of the atom



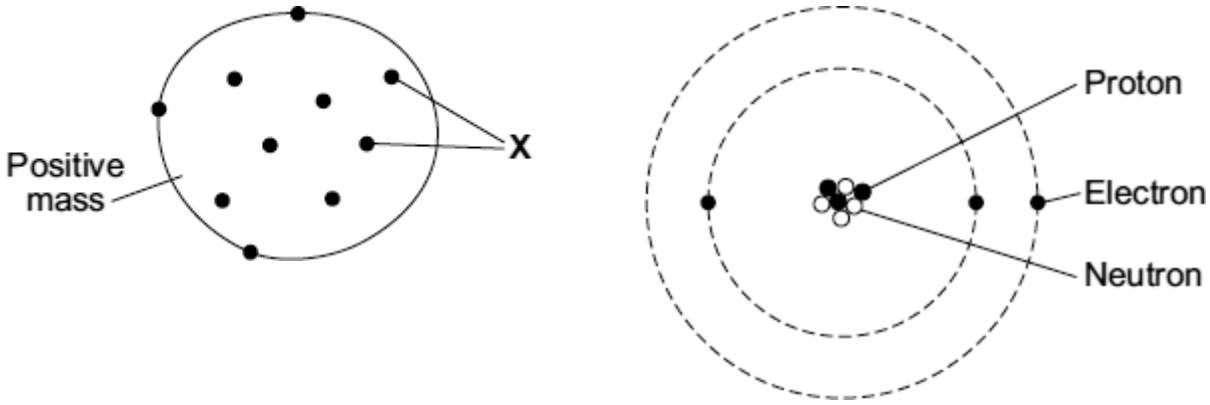
If Rutherford was right, the electrons in the cloud close to the nucleus would get attracted, and cause the atom to collapse. So now the electrons exist in fixed 'orbitals'

Later on:

- Positive charge of nucleus could be subdivided into smaller particles, each with the same amount of charge – the proton
- 20 years after the 'nucleus' was an accepted scientific idea, James Chadwick provided evidence to prove neutrons existed (don't need specifics)

Exam practice 2

Q1. The diagrams show two different models of an atom.



'Plum pudding' model **Model used today**

(a) The particles labelled '**X**' in the plum pudding model are also included in the model of the atom used today.

What are the particles labelled '**X**' ?

_____

(1)

(b) Scientists decided that the 'plum pudding' model was wrong and needed replacing.

Which **one** of the following statements gives a reason for deciding that a scientific model needs replacing?

Tick (✓) **one** box.

The model is too simple. ☐

The model has been used by scientists for a long time. ☐

The model cannot explain the results from a new experiment. ☐

(1)

(c) The table gives information about the three types of particle that are in the model of the atom used today.

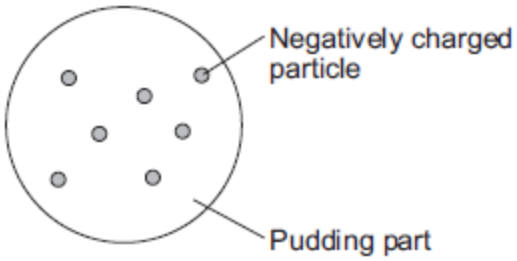
Particle	Relative mass	Relative charge
	1	+1
	very small	–1

	1	0

Complete the table by adding the names of the particles.

(2)

Q2.(a) Over 100 years ago, scientists thought the atom was like a 'plum pudding'.
The diagram below shows the plum pudding model of the atom.



The scientists knew that an atom has negatively charged particles. They also knew that an atom has no overall charge.

What did the scientists conclude about the **charge** on the 'pudding part' of the atom?

_____

_____

(1)

(b) Two scientists named Rutherford and Marsden devised an experiment to investigate the plum pudding model of the atom. The experiment involved firing alpha particles at a thin sheet of gold. The scientists measured how many of the alpha particles were scattered.

Using the plum pudding model, the scientists predicted that only a few of the alpha particles would be scattered by more than 4°.

Over several months, more than 100 000 measurements were made.

(i) The results from this experiment caused the plum pudding model to be replaced by a new model of the atom.

Explain why.

_____

_____

_____

_____

_____

(2)

(ii) Suggest **one** reason why other scientists thought this experiment provided valid evidence for a new model of the atom.

_____

_____

_____

(1)

(c) **In this question you will be assessed on using good English, organising information clearly and using specialist terms where appropriate.**

Describe the model now used for the structure of an atom.

In your answer you should:
- give details of the individual particles that make up an atom
- include the relative masses and relative charges of these particles.

Do **not** include a diagram in your answer.

_____

_____

_____

_____

_____

_____

_____

_____

_____

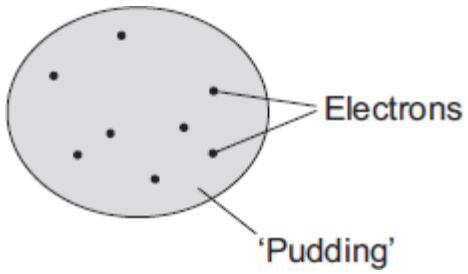
_____

(6)

(Total 10 marks)

Higher question:

Q4. The 'plum pudding' model of the atom was used by scientists in the early part of the 20th century to explain atomic structure.



(a) Those scientists knew that atoms contained electrons and that the electrons had a negative charge. They also knew that an atom was electrically neutral overall.

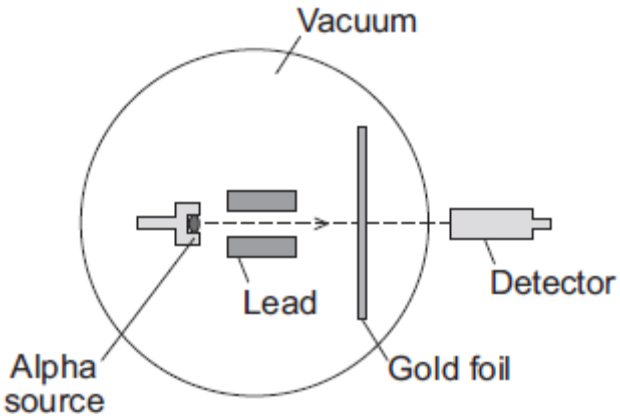
What did this allow the scientists to deduce about the 'pudding' part of the atom?

_____

_____

(1)

(b) An experiment, designed to investigate the 'plum pudding' model, involved firing alpha particles at a thin gold foil.



If the 'plum pudding' model was correct, then most of the alpha particles would go straight through the gold foil. A few would be deflected, but by less than 4°.

The results of the experiment were unexpected. Although most of the alpha particles did go straight through the gold foil, about 1 in every 8 000 was deflected by more than 90°.

Why did this experiment lead to a new model of the atom, called the nuclear model, replacing the 'plum pudding' model?

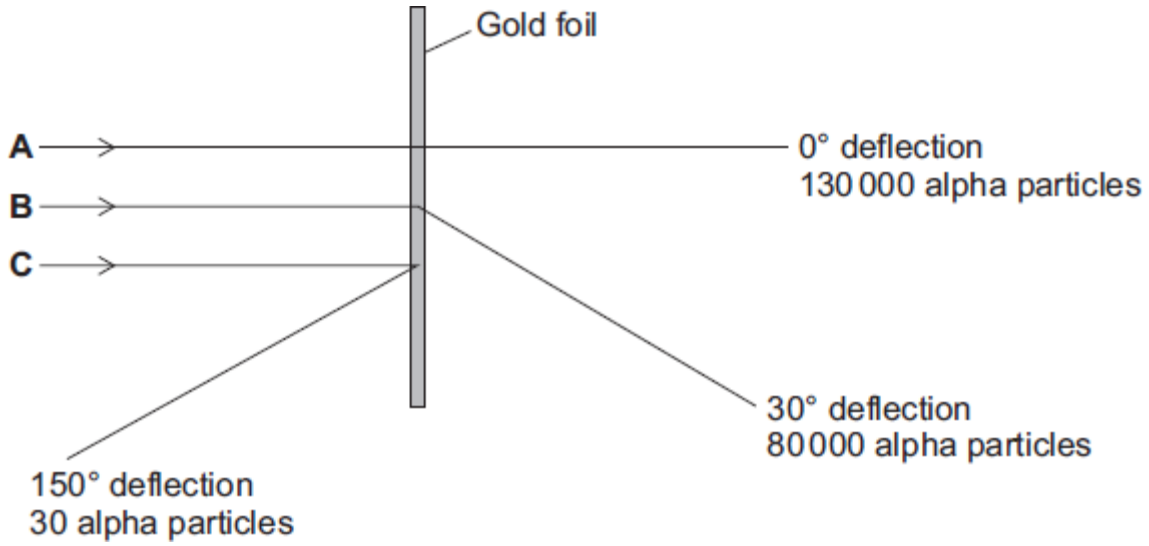
_____

_____

_____

(1)

(c) The diagram shows the paths, **A**, **B** and **C**, of three alpha particles. The total number of alpha particles deflected through each angle is also given.



(i) Using the nuclear model of the atom, explain the three paths, **A**, **B** and **C**.

A _____

_____

B _____

_____

C _____

_____

(3)

(ii) Using the nuclear model, the scientist E. Rutherford devised an equation to predict the proportion of alpha particles that would be deflected through various angles.

The results of the experiment were the same as the predictions made by Rutherford.

What was the importance of the experimental results and the predictions being the same?

_____

_____

(1)

(Total 6 marks)

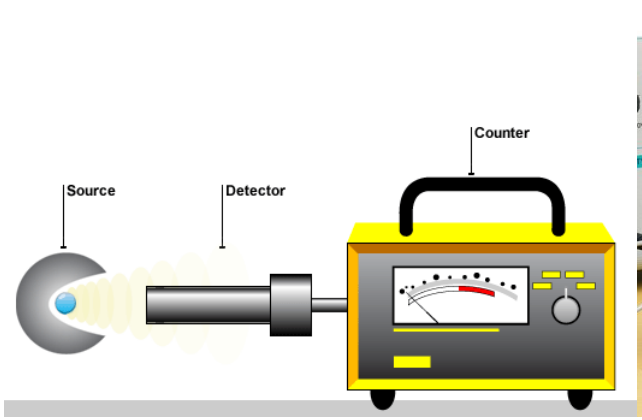
4.4.2 Atoms and nuclear radiation

Some atomic nuclei are unstable. The nucleus gives out radiation as it changes to become more stable. This is a random process called radioactive decay.

Activity is the rate at which a source of unstable nuclei decays.

- Sa sample with high activity has a fast rate of decay
- Measured in Becquerel, Bq

Count-rate is the number of decays recorded by a detector per second. E.g. a Geiger=Muller tube.



People can protect themselves from radiation in 2 ways

1: Using shielding to block the radiation

2: Limiting how much time we spend exposed to it

People can use radiation detectors to make sure they are safe. We can use a Geiger counter, or photographic film to detect radiation

By knowing the penetration distances, range in air and the ionising power of alpha particles, beta particle, and gamma rays – you can work out which source you have. In addition, you should be able to apply this knowledge to the uses of radiation and evaluate the best sources of radiation to use in a given situation.

	What is it	How ionising is it	How can it be blocked	Uses
Alpha	**2 protons + 2 neutrons: Helium nucleus**	**Very. It has +2 charge**	**10cm of air. Paper. Skin**	**Smoke detectors**
Beta -	**An electron**	**Medium**	**Aluminium**	**Thickness of materials**
Gamma	**Electrom agnetic wave**	**Usually low. Depends on frequency and intensity**	**Lots of lead, concrete, etc.**	**Sterilisation, Tracers, Radiotherapy (treating cancer)**

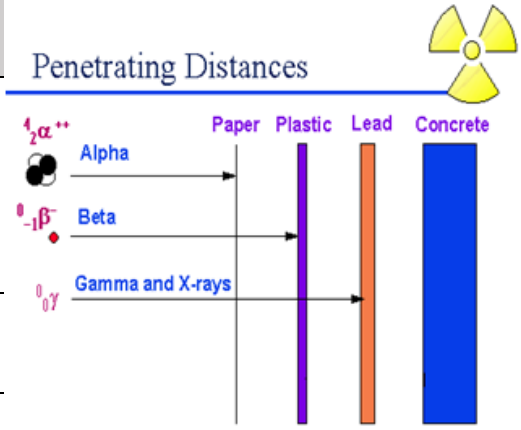
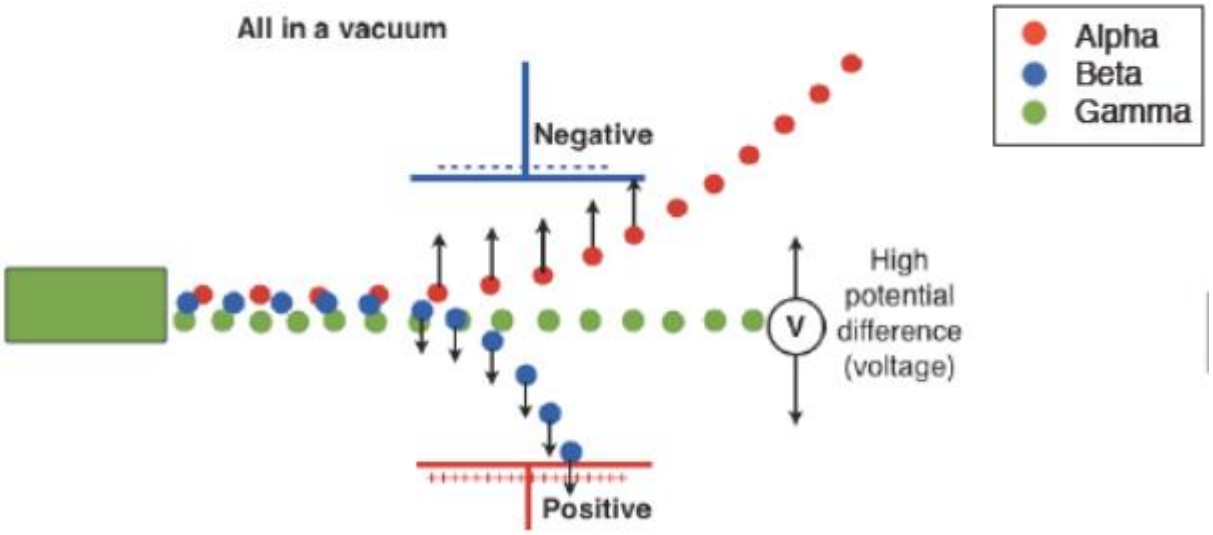


Diagram showing the effect of an electric field has on alpha radiation, beta radiation and gamma rays.



Exam practice 3

Q1.(a) The names of three types of radiation are given in **List A**. Some properties of these three types of radiation are given in **List B**.

Draw **one** line from each type of radiation in **List A** to its correct property in **List B**.

List A Type of radiation	**List B Property of radiation**
	will pass through paper but is stopped by thin metal
alpha	
	has the shortest range in air
beta	
	will not harm human cells
gamma	
	is very weakly ionising

(3)

Q2. Alpha particles, beta particles and gamma rays are types of nuclear radiation.

(a) Describe the structure of an alpha particle.

_____

_____

(1)

(b) Nuclear radiation can change atoms into ions by the process of ionisation.

(i) Which type of nuclear radiation is the least ionising?

Tick (✔) **one** box.

alpha particles ☐

beta particles ☐

gamma rays ☐

(1)

(ii) What happens to the structure of an atom when the atom is ionised?

_____

_____

(1)

(c) People working with sources of nuclear radiation risk damaging their health.

State **one** precaution these people should take to reduce the risk to their health.

_____

_____

(1)

(Total 4 marks)

Q3.(a) Radioactive sources that emit alpha, beta or gamma radiation can be dangerous.

What is a possible risk to health caused by using a radioactive source?

_____

_____

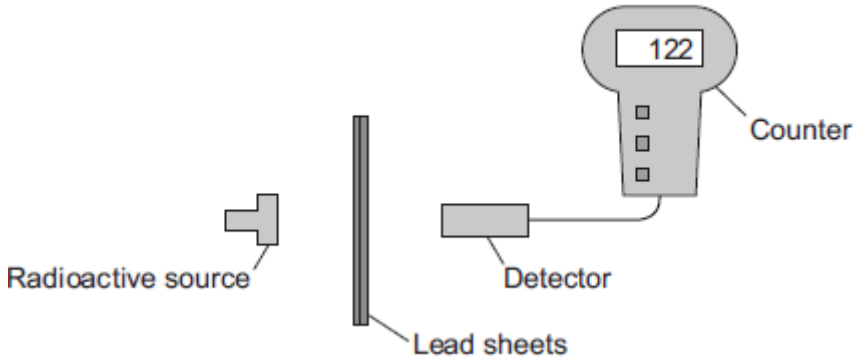
(1)

(b) In an experiment, a teacher put a 2 mm thick lead sheet in front of a radioactive source. She used a detector and counter to measure the radiation passing through the lead sheet in one minute.

She then put different numbers of lead sheets, each 2 mm thick, in front of the radioactive source and measured the radiation passing through in one minute.

The apparatus the teacher used is shown in **Figure 1**.

Figure 1



(i) When using a radioactive source in an experiment, how could the teacher reduce the risk to her health?

Suggest **one** way.

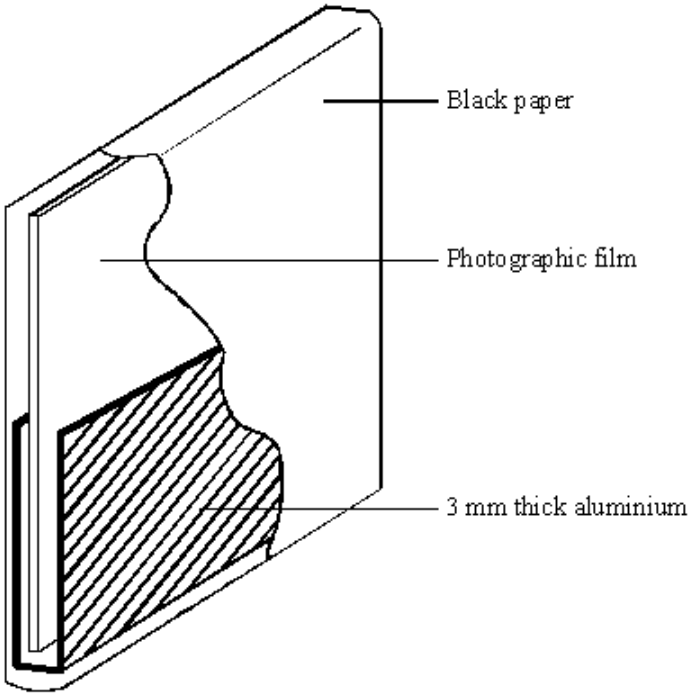
_____

_____

(1)

Q4. The diagram shows a badge worn by a worker at a nuclear power station.

Part of the outer black paper has been removed so that you can see the inside of the badge.



Scientists examined the worker's badge at the end of a day's work.

They found that the top part of the badge had been affected by radiation, but the bottom half had not.

What type of radiation had the worker been exposed to? Explain the reasons for your answer.

_____

_____

_____

_____

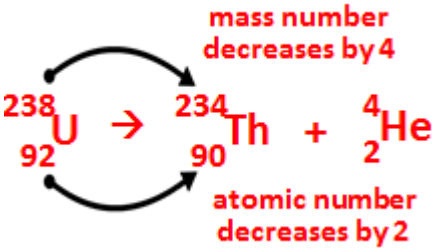
(Total 2 marks)

4.4.2.2 Nuclear equations

A nucleus changes into a new element by emitting alpha or beta particles. These changes are described using nuclear equations.

- **Alpha decay** (two protons and two neutrons) changes the mass number of the element by -4 and the atomic number by -2. An alpha particle is the same as a helium-4 nucleus.

Example

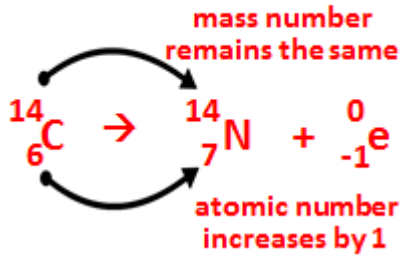


Alpha decay Rule:
Mass – 4
Atomic -2

$$^{219}_{86}Rn \rightarrow ^{215}_{84}Po + ^{4}_{2}He$$

- **Beta decay** changes the atomic number by +1 (the nucleus gains a proton) but the mass number remains unchanged (it gains a proton but loses a neutron by ejecting an electron, so a beta particle is an electron).

Example



Beta decay Rule:
Mass – stay the same
Atomic - +1

$$^{14}_{6}C \rightarrow ^{14}_{7}N + ^{0}_{-1}e$$

- **Gamma** is pure energy and will not change the structure of the nucleus in any way.

Nuclear / Decay equations practice

Alpha decay:

Mass number decreases by 4

Atomic number decreases by 2

$$^{A}_{Z}X \rightarrow ^{A-4}_{Z-2}Y + ^{4}_{2}He$$

$$^{222}_{86}Rn \rightarrow ^{218}_{84}Po + ^{4}_{2}He$$

$$^{210}_{84}Po \rightarrow \_\!\!^{\_}_{\_}Pb + ^{4}_{2}He$$

$$^{238}_{92}U \rightarrow \_\!\!^{\_}_{\_}Pb + ^{4}_{2}He$$

$$^{242}_{94}Pu \rightarrow \_\!\!^{\_}_{\_}U + ^{4}_{2}He$$

$$^{226}_{88}Ra \rightarrow \_\!\!^{\_}_{\_}Rn + ^{4}_{2}He$$

$$^{185}_{79}Au \rightarrow \_\!\!^{\_}_{\_}Ir + ^{4}_{2}He$$

$$^{211}_{87}Fr \rightarrow \_\!\!^{\_\_}_{\_\_}\_\_ + ^{4}_{2}He$$

Beta minus decay:

Mass number stays the same

Atomic number increases by 1

$$^{A}_{Z}X \rightarrow ^{A}_{Z+1}Y + ^{0}_{-1}e$$

$$^{1}_{0}n \rightarrow ^{1}_{1}p + ^{0}_{-1}e$$

$$^{14}_{6}C \rightarrow ^{14}_{7}N + ^{0}_{-1}e$$

$$^{234}_{90}Th \rightarrow \_\!\!^{\_}_{\_}Pa + ^{0}_{-1}e$$

$$^{6}_{2}He \rightarrow \_\!\!^{\_}_{\_}Li + ^{0}_{-1}e$$

$$^{235}_{93}Np \rightarrow \_\!\!^{\_}_{\_}Pu + ^{0}_{-1}e$$

$$^{228}_{88}Ra \rightarrow \_\!\!^{\_}_{\_}Ac + ^{0}_{-1}e$$

$$\_\!\!^{\_}_{\_}K \rightarrow ^{40}_{20}Ca + ^{0}_{-1}e$$

$$^{82}_{35}Br \rightarrow \_\!\!^{\_}_{\_}\_\_ + ^{0}_{-1}e$$

Exam practice 4

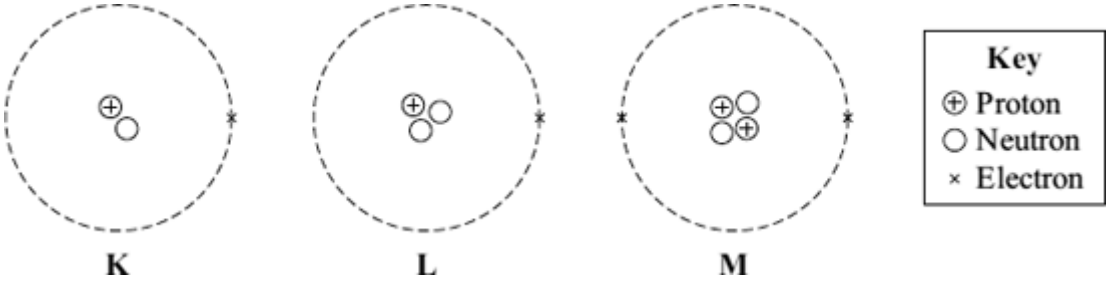
Q1. (b) (ii) An isotope of barium is Ba-139.
Ba-139 decays by beta decay to lanthanum-139 (La-139).

Complete the nuclear equation that represents the decay of Ba-139 to La-139.

$$^{139}Ba \longrightarrow \ldots\ldots\ ^{139}La + \ldots\ldots$$

(3)

Q2.(a) The diagram represents 3 atoms, **K**, **L** and **M**.



(i) Which **two** of the atoms are isotopes of the same element?

_____ and _____

(1)

(ii) Give a reason why the **two** atoms that you chose in part (a)(i) are:

(1) atoms of the same element _____

_____

(2) different isotopes of the same element. _____

_____

_____

(2)

(b) The table gives some information about the radioactive isotope thorium-230.

mass number	230
atomic number	90

(i) How many electrons are there in an atom of thorium-230?

_____

(1)

(ii) How many neutrons are there in an atom of thorium-230?

_____

(1)

(c) When a thorium-230 nucleus decays, it emits radiation and changes into radium-226.

$$^{230}_{90}\text{Th} \longrightarrow {}^{226}_{88}\text{Ra} + \boxed{\text{Radiation}}$$

What type of radiation, alpha, beta or gamma, is emitted by thorium-230?

_____

Explain the reason for your answer.

_____

_____

_____

_____

_____

(3)

(Total 8 marks)

Q3. In 2011 an earthquake caused severe damage to a nuclear power station in Japan.

The damage led to the release of large amounts of radioactive iodine-131 ($^{131}_{53}\text{I}$) into the atmosphere.

(a) The table gives some information about an atom of iodine-131 ($^{131}_{53}\text{I}$).

Complete the table.

mass number	131
number of protons	53
number of neutrons	

(1)

(b) Complete the sentence.

The number of protons in an atom is called the proton number or

the _____ number.

(1)

(c) An atom of iodine-131 decays into an atom of xenon (Xe) by emitting a beta particle.

(i) The decay of iodine-131 can be represented by the equation below.

Complete the equation by writing the correct number in each of the **two** boxes.

$$^{131}_{53}\text{I} \longrightarrow \square \quad \text{Xe + beta particle}$$

$$\square$$

(2)

Q4. (c) An atom of the isotope radon-222 emits an alpha particle and decays into an atom of polonium.

An alpha particle is the same as a helium nucleus. The symbol below represents an alpha particle.

$$^{4}_{2}\mathrm{He}$$

(i) How many protons and how many neutrons are there in an alpha particle?

Number of protons = _____

Number of neutrons = _____

(2)

(ii) The decay of radon-222 can be represented by the equation below.

Complete the equation by writing the correct number in each of the **two** boxes.

$$^{222}_{86}\mathrm{Rn} \longrightarrow \square \quad \square \;\; \mathrm{Po} + \text{alpha particle}$$

(2)

Q5.(a) Atoms of the isotope bismuth-212 decay by emitting either an alpha particle or a beta particle. The equation represents what happens when an atom of bismuth-212 decays by beta emission into an atom of polonium-212.

$$^{212}_{83}\mathrm{Bi} \longrightarrow {}^{212}_{84}\mathrm{Po} + \text{beta particle}$$

(i) The bismuth atom and the polonium atom have the same mass number (212).

What is the *mass number* of an atom?

_____

(1)

(b) When an atom of bismuth-212 emits an alpha particle, the atom decays into an atom of thallium.

An alpha particle is the same as a helium nucleus.
The symbol below represents an alpha particle.

$$^{4}_{2}\mathrm{He}$$

(i) The equation below represents the alpha decay of bismuth-212.

Complete the equation by writing the correct number in each of the two boxes.

$$^{212}_{83}\mathrm{Bi} \longrightarrow \square \quad \square \;\; \mathrm{Tl} + {}^{4}_{2}\mathrm{He}$$

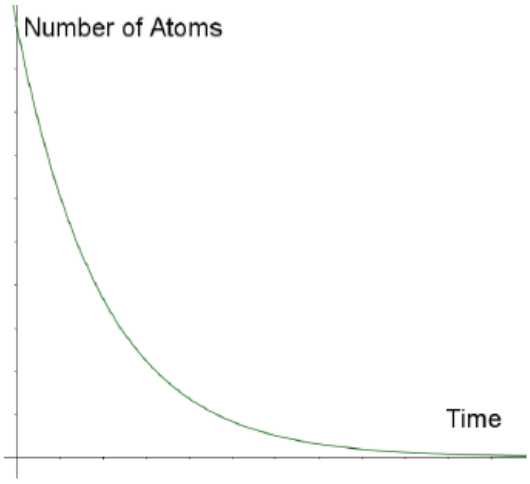
(2)

4.4.2.3 Half lives and the random nature of radioactive decay.

Half Life

- The half-life of an isotope is the time taken for half the nuclei in a sample to decay or the time taken for the activity or count rate of a sample to decay by half.
- It cannot be predicted when any one nucleus will decay, but the half-life is a constant that enables the activity of a very large number of nuclei to be predicted during the decay.
- So if 80 atoms falls to 20 over 10mins, the half-life?
    - 80/2 = 40
    - 40/2 = 20 – so two half lives in 10mins
        - So half-life is 5mins

- A short half-life
    - The source presents less of a risk, as it does not remain strongly radioactive
    - This means initially it is very radioactive, but quickly dies down
    - So presents less of a long-term risk
- Long half-life
    - The source remains weakly radioactive for a long period of time
    - Americium has a half-life of 432 years
        - It is an alpha emitter, and used in smoke alarms
        - It is emitted into the air around the alarm, and does not reach far because alpha is weakly penetrating
        - If smoke reaches the alarm, the amount of alpha particles in the surrounding air drops
        - This causes the alarm to sound
    - It is suitable because it will not need to be replenished, and its weak activity means it won't be harmful to anyone.



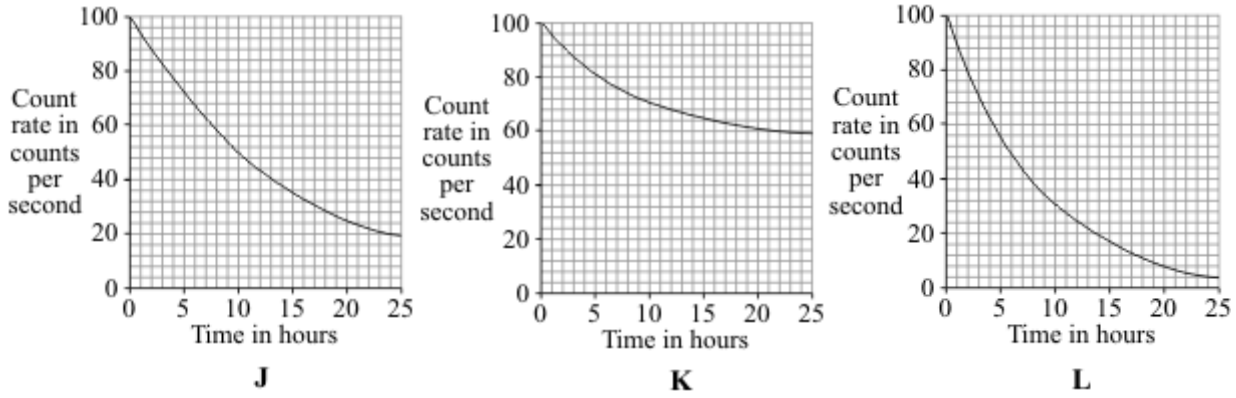
The number of atoms over time tends to 0.

Net Decline

- **Calculate the ratio of net decline of radioactive nuclei after X half-lives**
    - **Half the initial number of nuclei, and keep doing so X number of times**
    - $$\textbf{Net Decline} = \frac{\textbf{initial number} - \textbf{number after X half lives}}{\textbf{initial number}}$$

Exam Practice 5

Q1.(c) The graphs show how the count rates from three different radioactive sources, **J**, **K**, and **L**, change with time.



(i) Which source, **J, K**, or **L**, has the highest count rate after 24 hours?

_____

(1)

(ii) For source **L**, what is the count rate after 5 hours?

_____ counts per second

(1)

(iii) Which source, **J, K,** or **L**, has the longest half-life?

_____

(1)

(iv) A radioactive source has a half-life of 6 hours.

What might this source be used for?

Put a tick (✓) in the box next to your choice.

To monitor the thickness of paper as it is made in a factory ☐

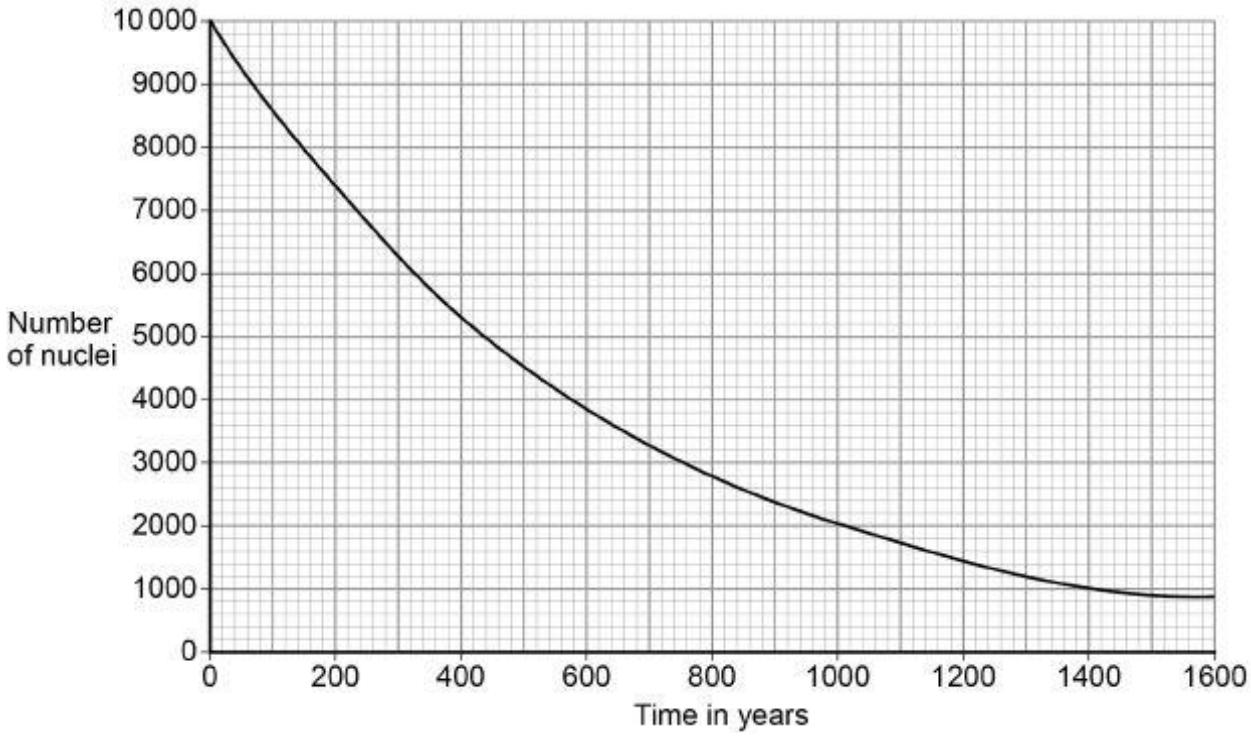
To inject into a person as a medical tracer ☐

To make a smoke alarm work ☐

(1)

(Total 8 marks)

Q2. The graph below shows how the number of americium-241 nuclei in a sample changes with time.



(b) How many years does it take for the number of americium-241 nuclei to decrease from 10 000 to 5000?

Time = _____ years

(1)

(c) What is the half-life of americium-241?

Half-life = _____ years

(1)

(Total 4 marks)

Q5. (d) 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.

_____

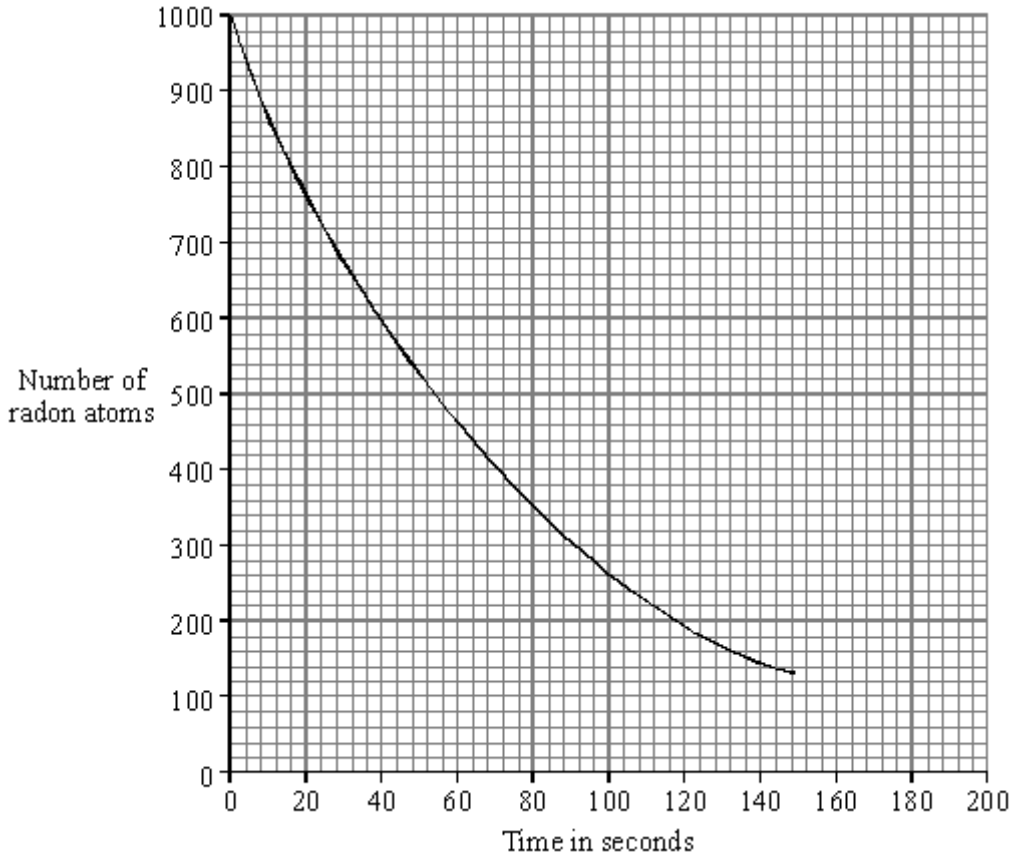
_____

Half-life = _____ years

(2)

(Total 9 marks)

Q3. Radon is a radioactive element. The graph shows how the number of radon atoms in a sample of air changes with time.



(i) How long did it take the number of radon atoms in the sample of air to fall from 1000 to 500?

Time = _____ seconds

(1)

(ii) How long is the half-life of radon?

Half-life = _____ seconds

(1)

(iii) Complete this sentence by crossing out the **two** lines in the box that are wrong.

As a radioactive material gets older, it emits

less
a constant level of
more

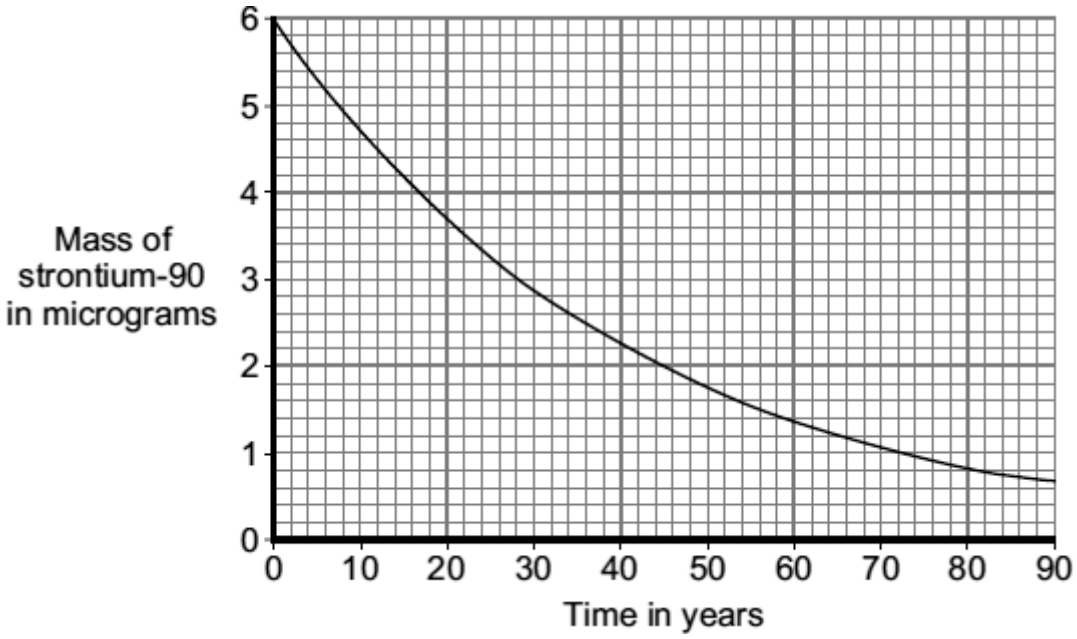
radiation per second.

(1)

(Total 3 marks)

Q6.

(c) When first used, the radiation source contains 6 micrograms of strontium-90.
The graph shows how the mass of the strontium-90 will decrease as the nuclei decay.



The control system will continue to work with the same source until 75 % of the original strontium-90 nuclei have decayed.

After how many years will the source need replacing?

Show clearly your calculation and how you use the graph to obtain your answer.

_____

_____

_____

Number of years = _____

(2)

(Total 7 marks)

4.4.2.4 Radioactive contamination

Contamination

- Contamination
  - Lasts for a long period of time
  - The source of the radiation is transferred to an object
    - Radioactive contamination is the unwanted presence of radioactive atoms on other materials – the hazard is the decaying of the contaminated atoms releasing radiation
  - E.g. radioactive dust settling on your skin (your skin becomes contaminated)
- Irradiation
  - Lasts only for a short period of time
  - The source emits radiation, which reaches the object
    - Exposing an object to nuclear radiation, but does **not** make it radioactive
  - E.g. radioactive dust emitting beta radiation, which "irradiates" your skin
  - Medical items are irradiated sometimes to kill bacteria on its surface, but not to make the medical tools themselves radioactive

Scientific Reports Published need to be peer reviewed

- If they are on the effects of radiation on humans, peer review is essential
  - If initial studies got measurements wrong, safety levels based on the study may cause people to die.

Exam practice 6

Q1. Gamma radiation is emitted from the nuclei of some atoms.

(a) What is a gamma ray?

Tick **one** box.

A helium nucleus ☐

A high speed electron ☐

A neutron ☐

A type of electromagnetic radiation ☐

(1)

(b) Which would be the best absorber of gamma radiation?

Tick **one** box.

A few mm of air ☐

A thick sheet of cardboard ☐

A thick sheet of lead ☐

A thin sheet of paper ☐

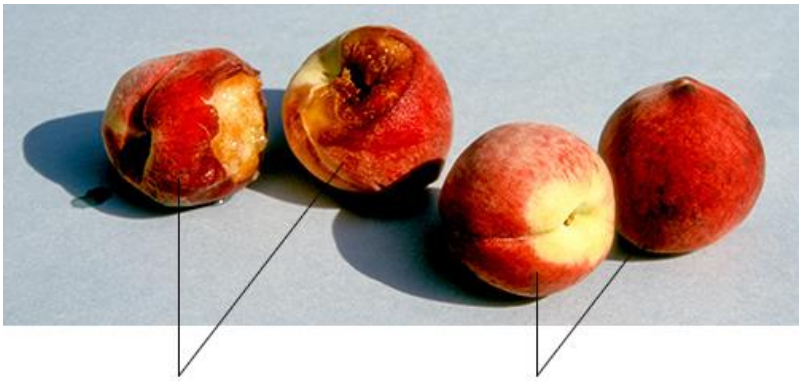
(1)

Food can be irradiated with gamma rays to kill bacteria.

Below is a photograph of peaches.

Two of the peaches were irradiated.

The photograph was taken one week after irradiation.



(c) Why do food producers need to kill bacteria on food?

Tick **two** boxes.

To change the colour of the food ☐

To decrease the rate of decay of the food ☐

To decrease the shelf life of the food ☐

To prevent food poisoning ☐

To remove dirt from food ☐

(2)

(d) How do gamma rays kill bacteria?

Tick **one** box.

Gamma rays cause meiosis to occur ☐

Gamma rays cause mutations ☐

Gamma rays decrease the size of bacterial cells ☐

Gamma rays destroy the food source for bacteria ☐

(1)

(e) Food producers can irradiate food by passing it close to a radioactive source.

How can food producers increase the level of radiation that the food is exposed to?

Tick **two** boxes.

Boil the food before passing it close to the radioactive source ☐

Decrease the distance between the food and the radioactive source ☐

Increase the time for which the food is close to the radioactive source ☐

Put the radioactive source in a box ☐

Reduce the temperature of the radioactive source ☐

(2)

(f) A student said:

'The irradiated food would become radioactive.'

Give **one** reason why the student is **not** correct.

_____

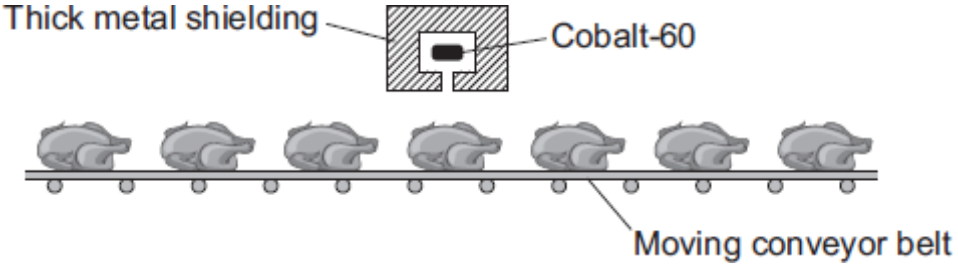
_____

(1)

(Total 8 marks)

Q2.(b) The gamma radiation emitted from a source of cobalt-60 can be used to kill the bacteria on fresh, cooked and frozen foods. Killing the bacteria reduces the risk of food poisoning.

The diagram shows how a conveyor belt can be used to move food past a cobalt-60 source.



(i) Which **one** of the following gives a way of increasing the amount of gamma radiation the food receives?
Put a tick (✓) in the box next to your answer.

Increase the temperature of the cobalt-60 source. ☐

Make the conveyor belt move more slowly. ☐

Move the cobalt-60 source away from the conveyor belt. ☐

(1)

(ii) To protect people from the harmful effects of the gamma radiation, the cobalt-60 source has thick metal shielding.

Which **one** of the following metals should be used?

Draw a ring around your answer.

aluminium **copper** **lead**

(1)

(c) A scientist has compared the vitamin content of food exposed to gamma radiation with food that has not been exposed.

The table gives the data the scientist obtained when she tested 1 kg of cooked chicken.

Vitamin	**Food not exposed to gamma radiation**	**Food exposed to gamma radiation**
	Mass in milligrams	**Mass in milligrams**
B6	1.22	1.35
B12	21.00	28.00
E	3.30	2.15
Niacin	58.00	55.50
Riboflavin	2.10	2.25

Considering only this data, which **one** of the following is a correct conclusion?

Put a tick (✓) in the box next to your answer.

Vitamin content is not affected by gamma radiation. ☐

Gamma radiation completely destroys some types of vitamin. ☐

Exposure increased the content of some types of vitamin. ☐

(1)

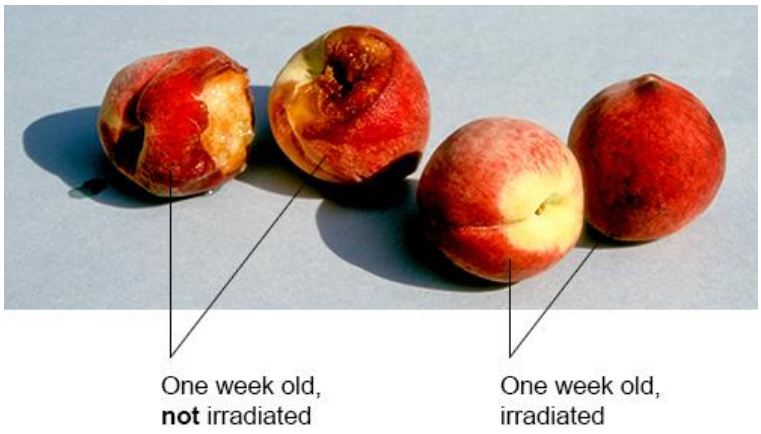
(Total 6 marks)

Q3. Food can be irradiated to make it safer to eat.

Below is a photograph of peaches.

Two of the peaches were irradiated.

The photograph was taken one week after irradiation.



(b) Explain why irradiating food makes it safer to eat.

_____

_____

_____

_____

_____

_____

(3)

(c) Food is packaged and then irradiated.

Explain why food is irradiated using gamma radiation rather than alpha or beta radiation.

_____

_____

_____

_____

(2)

(d) Some people are concerned that irradiated food could be radioactive.

Describe how irradiated food is different from food that is radioactive.

_____

_____

_____

_____

(2)

(Total 9 marks)

Q4. In 2011 an earthquake caused severe damage to a nuclear power station in Japan.

The damage led to the release of large amounts of radioactive iodine-131 ($^{131}_{53}I$) into the atmosphere.

(a) The table gives some information about an atom of iodine-131 ($^{131}_{53}I$).

Complete the table.

mass number	131
number of protons	53
number of neutrons	

(1)

(b) Complete the sentence.

The number of protons in an atom is called the proton number or

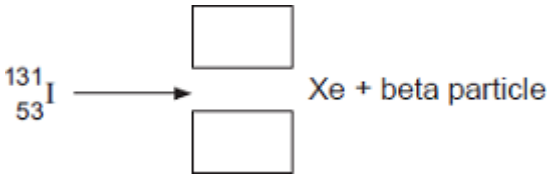
the _____ number.

(1)

(c) An atom of iodine-131 decays into an atom of xenon (Xe) by emitting a beta particle.

(i) The decay of iodine-131 can be represented by the equation below.

Complete the equation by writing the correct number in each of the **two** boxes.



(2)

(ii) A sample of rainwater contaminated with iodine-131 gives a count rate of 1200 counts per second.

Calculate how many days it will take for the count rate from the sample of rainwater to fall to 75 counts per second.

Half-life of iodine-131 = 8 days

Show clearly how you work out your answer.

_____

_____

_____ days

(2)

(iii) If people drink water contaminated with iodine-131, the iodine-131 builds up in the thyroid gland. This continues until the thyroid is saturated with iodine-131 and cannot absorb any more. The radiation emitted from the iodine-131 could cause cancer of the thyroid.

In Japan, people likely to be drinking water contaminated with iodine-131 were advised to take tablets containing a non-radioactive isotope of iodine.

Suggest why this advice was given.

_____

_____

_____

_____

(2)

(Total 8 marks)