Name: _____

Class: _____

Date: _____

Atomic Structure part 2 AQA Triple Physics

Time: **76 minutes**

Marks: **73 marks**

Comments:

1. Scientists developed new models of the atom as new particles were discovered.

(a) Draw **one** line from each particle to the year it was discovered.

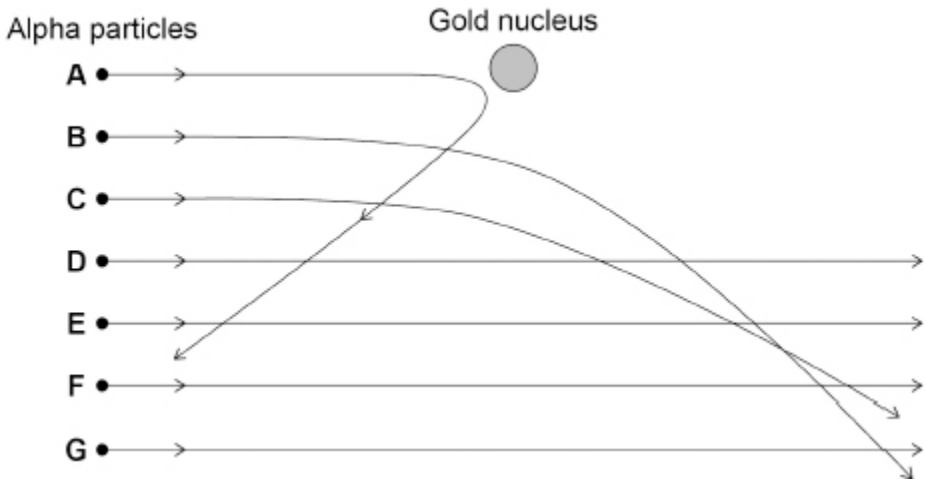
Particle	Year of discovery
Electron	1897
Neutron	1911
Nucleus	1920
Proton	1932

(2)

The nucleus was discovered using an alpha particle scattering experiment.

Alpha particles were directed at a sheet of gold foil.

The figure below shows the paths taken by seven alpha particles, **A**, **B**, **C**, **D**, **E**, **F** and **G**.



(b) Explain why alpha particle **A** takes the path shown in the figure above.

_____

_____

_____

_____

(2)

(c) Explain why the path of alpha particle **B** is more tightly curved than the path of alpha particle **C**.

_____

_____

_____

_____

(2)

(d) What can be deduced about the atom from the paths taken by alpha particles **D**, **E**, **F** and **G** in the figure above?

Tick (✓) **one** box.

The atom contains a nucleus.	☐
The atom contains protons, neutrons and electrons.	☐
The atom is mostly empty space.	☐

(1)

(e) How is the Bohr model of the atom different from the nuclear model of the atom?

_____

_____

_____

(1)

(f) Explain how an electron can move up and down between energy levels in an atom.

_____

_____

_____

_____

(2)

(Total 10 marks)

2. Radioactive isotopes emit different types of nuclear radiation.

(a) What does an alpha particle consist of?

Tick (✓) **one** box.

- 2 protons and 2 electrons ☐
- 2 protons and 2 neutrons ☐
- 4 protons ☐
- 4 neutrons ☐

(1)

(b) What is a beta particle?

Tick (✓) **one** box.

- An electron ☐
- A neutron ☐
- Electromagnetic radiation ☐

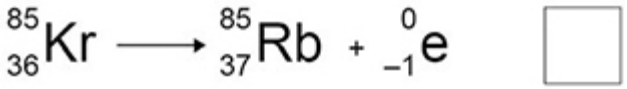
(1)

(c) A krypton (Kr) nucleus decays into a rubidium (Rb) nucleus by emitting a beta particle.

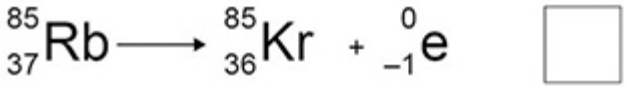
What is the correct equation for this decay?

Tick (✓) **one** box.

☐



☐

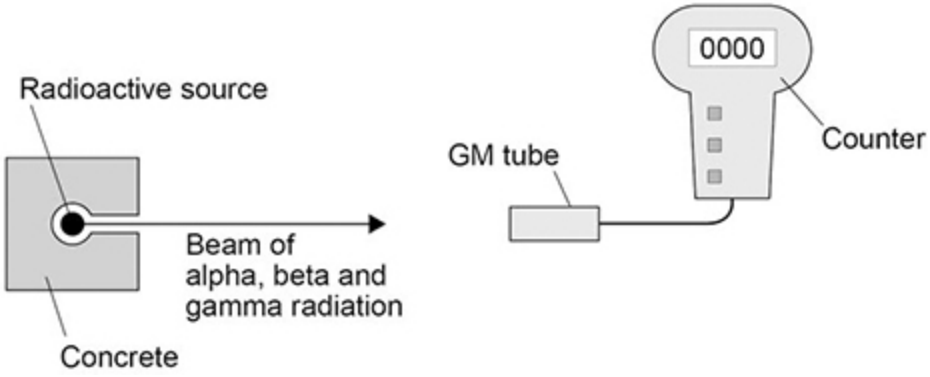


☐

(1)

(d) The figure below shows an experiment to demonstrate how alpha, beta and gamma radiation penetrate different materials.

The experiment takes place in a vacuum.



Three different materials are used:

- a sheet of paper
- a 0.5 cm thick sheet of aluminium
- a 10 cm block of lead.

Each material is placed one at a time between the radioactive source and the GM tube.

The GM tube and counter show whether the material has stopped the radiation.

Complete below table to show how alpha, beta and gamma radiation penetrate the materials in the figure above.

Use the words **Yes** and **No**.

Part of below table has been completed for you.

Type of radiation	**Most radiation is stopped by:**		
	the sheet of paper	**the sheet of aluminium**	**the block of lead**
Alpha			Yes
Beta	No		
Gamma		No	

(3)

(e) Alpha, beta and gamma radiation have different ionising powers.

Draw **one** line from each radiation type to the correct ionising power.

Radiation type	Ionising power
Alpha	Zero
Beta	Low
Gamma	Medium
	High

(3)

(f) Some sources of background radiation are natural and other sources are man-made.

Which of the following is a man-made source of background radiation?

Tick (✓) **one** box.

Cosmic rays ☐

Nuclear accidents ☐

Rocks ☐

(1)

(g) The average background radiation dose per year in the UK is 2.0 millisieverts.

A dental X-ray gives a patient a radiation dose of 0.005 millisieverts.

Calculate how many dental X-rays would be the same as the average background radiation dose per year.

_____

_____

_____

Number of dental X-rays = _____

(2)

(Total 12 marks)

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

(a) What does an alpha particle consist of?

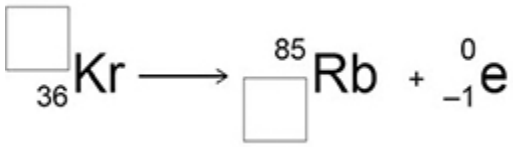
_____

_____

(1)

(b) A krypton (Kr) nucleus decays into a rubidium (Rb) nucleus by emitting a beta particle.

Complete the nuclear equation for this decay by writing the missing number in each box.



(2)

(c) Internal contamination of the human body means radioactive material is inside the human body.

Explain how the risk from internal contamination is different to the risk from external irradiation by a source of alpha radiation.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

(5)

(Total 8 marks)

4. Atoms of different elements have different properties.

(a) Which of the following is the same for all atoms of the same element?

Tick (✓) **one** box.

- Atomic number ☐
- Mass number ☐
- Neutron number ☐

(1)

(b) Which of the following is different for isotopes of the same element?

Tick (✓) **one** box.

- Number of electrons ☐
- Number of neutrons ☐
- Number of protons ☐

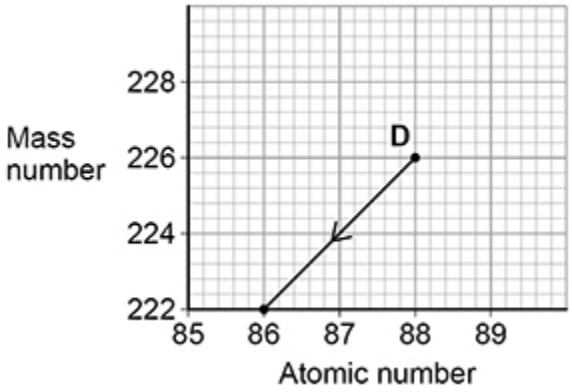
(1)

(c) A nucleus emits radiation.

Figure 1 shows how the mass number and the atomic number change.

The nucleus is labelled **D**.

Figure 1



Which type of radiation is emitted when nucleus **D** decays?

Tick (✓) **one** box.

Alpha ☐

Beta ☐

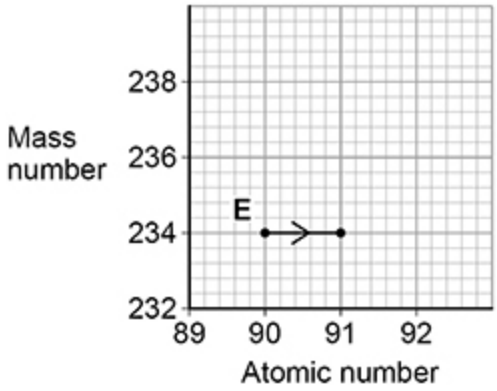
Neutron ☐

(1)

(d) Nucleus **E** also emits radiation.

Figure 2 shows how the mass number and the atomic number change for nucleus **E**.

Figure 2



Which type of radiation is emitted when nucleus **E** decays?

Tick (✓) **one** box.

Alpha ☐

Beta ☐

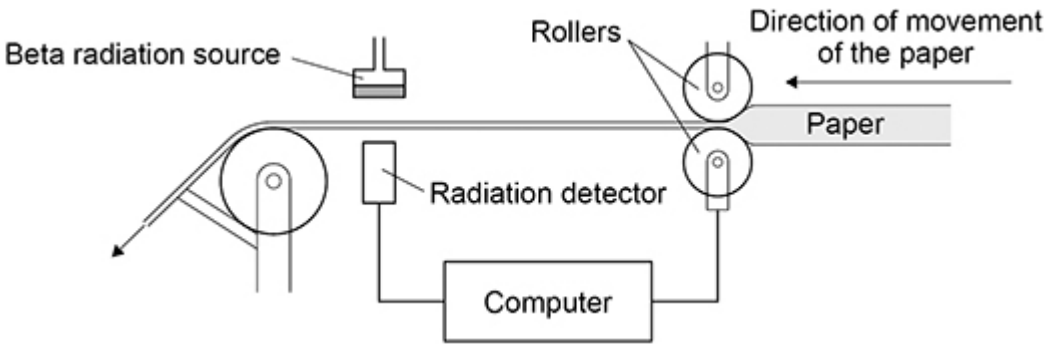
Neutron ☐

(1)

Beta radiation can be used to monitor the thickness of paper during production.

Figure 3 shows how the radiation is used.

Figure 3



The computer uses information from the radiation detector to change the size of the gap between the rollers.

(e) Complete the sentences.

Choose answers from the box.

Each answer can be used once, more than once or not at all.

decrease	stay the same	increase

The thickness of the paper between the beta source and the detector increases.

The reading on the detector will _____.

This is because the amount of radiation absorbed by the paper will _____.

(2)

(f) All radioactive elements have a half-life.

What is meant by 'half-life'?

Tick (✓) **one** box.

The time it takes for all the nuclei in a radioactive sample to split in half. ☐

The time it takes for the count rate of a radioactive sample to halve. ☐

The time it takes for the radiation to travel half of its range in air. ☐

(1)

(g) Why should the radiation source used in **Figure 3** have a long half-life?

Tick (✓) **one** box.

So the activity of the source is approximately constant. ☐

So the amount of radiation decreases quickly. ☐

So the radiation has a long range in air. ☐

(1)

(Total 8 marks)

5. Energy from the Sun is released by nuclear fusion.

(a) Complete the sentences.

Nuclear fusion is the joining together of _____.

During nuclear fusion the total mass of the particles _____.

(2)

(b) Nuclear fusion of deuterium is difficult to achieve on Earth because of the high temperature needed.

Electricity is used to increase the temperature of 4.0 g of deuterium by 50 000 000 °C.

specific heat capacity of deuterium = 5200 J/kg °C

Calculate the energy needed to increase the temperature of the deuterium by 50 000 000 °C.

Use the Physics Equations Sheet.

_____

_____

_____

_____

_____

Energy = _____ J

(3)

(c) The idea of obtaining power from nuclear fusion was investigated using models.

The models were tested before starting to build the first commercial nuclear fusion power station.

Suggest **two** reasons why models were tested.

1 _____

_____

_____

2 _____

_____

_____

(2)

(d) Generating electricity using nuclear fusion will have fewer environmental effects than generating electricity using fossil fuels.

Explain **one** environmental effect of generating electricity using fossil fuels.

_____

_____

_____

_____

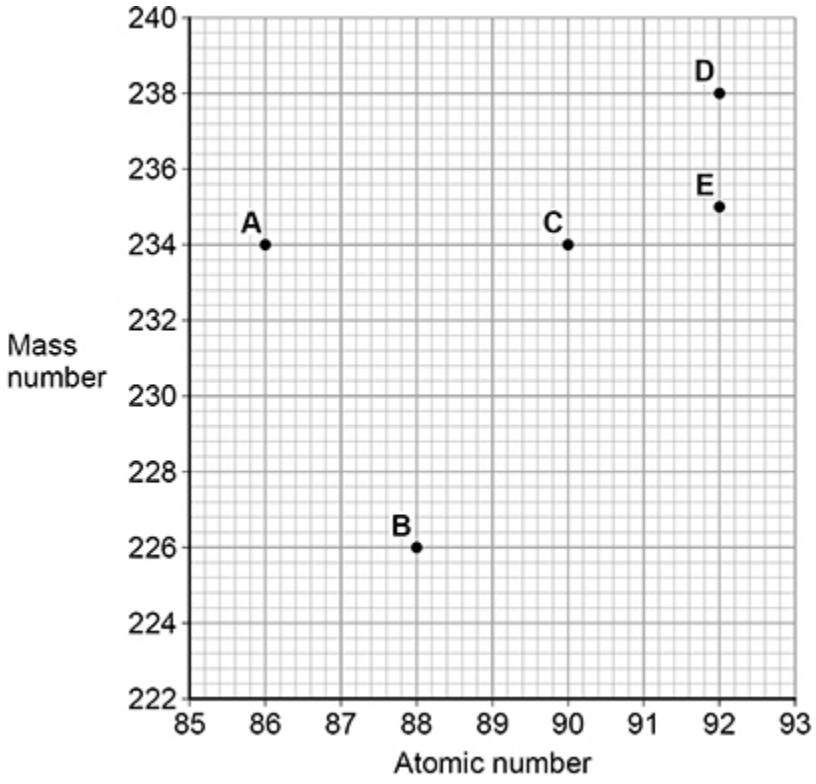
_____

(2)

(Total 9 marks)

6. **Figure 1** shows the mass number and the atomic number for the nuclei of five different atoms.

Figure 1



(a) How many neutrons are there in a nucleus of atom **A**?

_____

(1)

(b) Which **two** atoms in **Figure 1** are the same element?

Tick (✓) **one** box.

A and **B** ☐

A and **C** ☐

C and **D** ☐

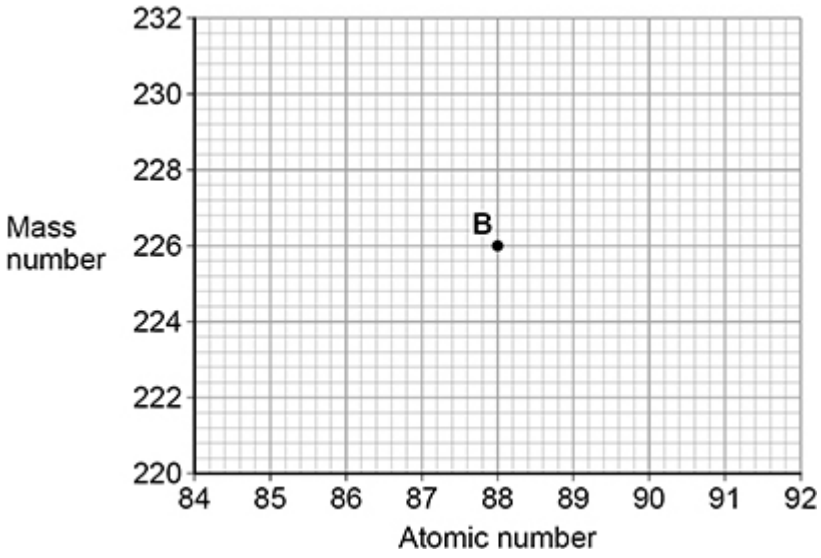
D and **E** ☐

(1)

(c) Nucleus **B** decays by emitting an alpha particle.

Draw an arrow on **Figure 2** to represent the alpha decay.

Figure 2



(2)

(d) What is meant by the 'random nature of radioactive decay'?

_____

_____

_____

(1)

(e) A polonium (Po) nucleus decays by emitting an alpha particle and forming a lead (Pb) nucleus.

$$Po \rightarrow Pb + \alpha$$

The lead (Pb) nucleus then decays by emitting a beta particle and forms a bismuth (Bi) nucleus.

$$Pb \rightarrow Bi + \beta$$

The bismuth (Bi) nucleus then decays by emitting a beta particle and forms a polonium (Po) nucleus.

$$Bi \rightarrow Po + \beta$$

Explain how these three decays result in a nucleus of the original element, polonium.

_____

_____

_____

_____

_____

_____

_____

(3)

(Total 8 marks)

7. Radioactive waste from nuclear power stations is a man-made source of background radiation.

(a) Which of the following is also a man-made source of background radiation?

Tick (✓) **one** box.

cosmic rays ☐

radiotherapy ☐

rocks ☐

stars ☐

(1)

(b) Nuclear power stations use the process of nuclear fission.

Complete the sentences to describe the process of nuclear fission.

Choose answers from the box.

a neutron	**a proton**	**an electron**	
cosmic rays	**energy**	**gamma rays**	**x-rays**

An unstable nucleus absorbs _____ and splits into two parts.

Two or three neutrons are released, as well as _____

and _____.

(3)

(c) Plutonium-239 is one type of radioactive waste from nuclear power stations.

The following nuclear equation represents the decay of plutonium-239 (Pu-239).

$$^{239}_{94}Pu \rightarrow {}^{235}_{92}U + {}^{4}_{2}He$$

How does the nuclear equation show that alpha radiation is emitted when plutonium-239 decays?

Tick (✓) **one** box.

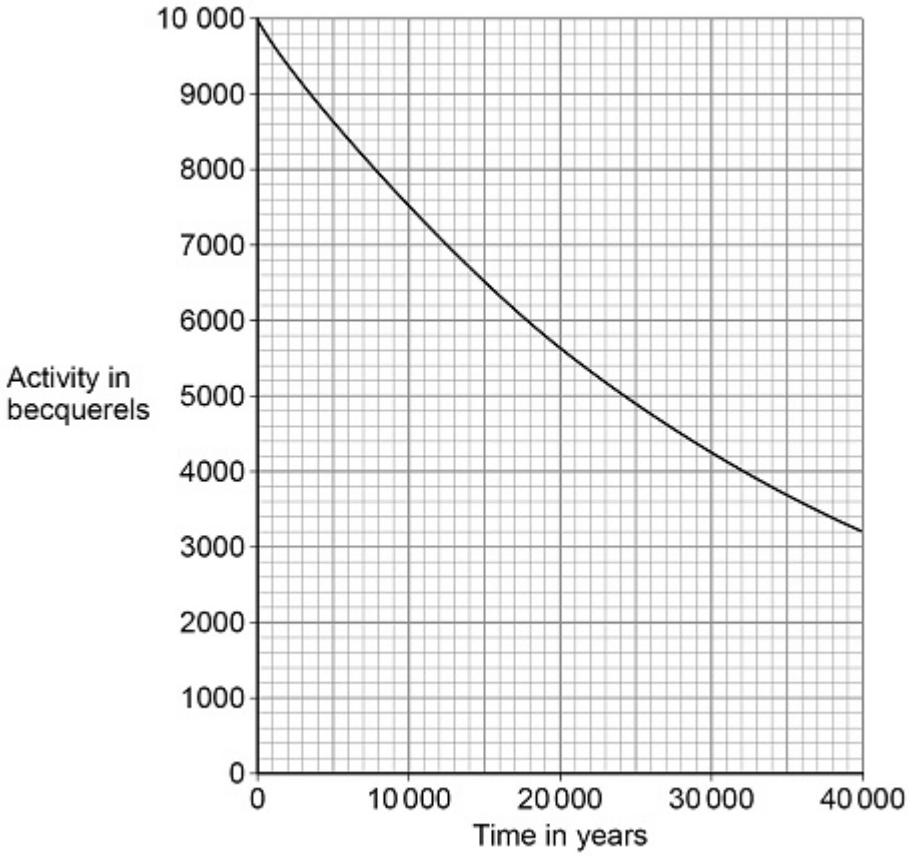
An alpha particle contains 92 protons. ☐

An alpha particle has a mass number of 235. ☐

An alpha particle is the same as a helium nucleus. ☐

(1)

The graph below shows how the activity of a sample of plutonium-239 varies with time.



(d) How much time will it take for the activity of the sample of plutonium-239 to fall to half of its initial activity?

Time = _____ years

(1)

(e) What is the half-life of plutonium-239?

Half-life = _____ years

(1)

(f) The radioactive waste from a nuclear power station is buried underground.

People are warned to stay away from places where radioactive waste is buried.

Suggest **one** risk of going near the place where radioactive waste is buried.

_____

_____

_____

_____

(1)

(Total 8 marks)

8. Radioactive waste from nuclear power stations is a man-made source of background radiation.

(a) Give **one** other man-made source of background radiation.

_____

(1)

Nuclear power stations use the energy released by nuclear fission to generate electricity.

(b) Give the name of **one** nuclear fuel.

_____

(1)

(c) Nuclear fission releases energy.

Describe the process of nuclear fission inside a nuclear reactor.

(4)

(d) A new type of power station is being developed that will generate electricity using nuclear fusion.

Explain how the process of nuclear fusion leads to the release of energy.

(2)

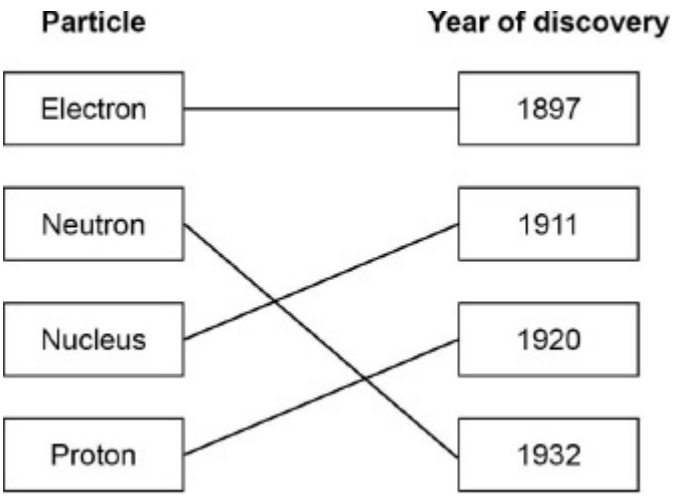
(e) Nuclear fusion power stations will produce radioactive waste. This waste will have a much shorter half-life than the radioactive waste from a nuclear fission power station.

Explain the advantage of the radioactive waste having a shorter half-life.

(2)

(Total 10 marks)

1. (a)



4 correct for 2 marks

2 or 3 correct for 1 mark

additional line from a box on the left negates the mark for that box

2

(b) both the alpha particles and the (gold) nucleus have positive / same charge

*'it' is alpha particle **A***

allow alpha particles and protons have positive / same charge

1

so the alpha particle and the gold nucleus repel each other

allow like charges repel

ignore deflection (this refers to the path taken not the force)

1

(c) particle **B** passes closer to the nucleus

*'it' is particle **B***

1

so experiences a stronger (repulsive) force
or
so experiences a stronger electric field

*any mention of particle **B** colliding with the nucleus scores zero*

1

(d) the atom is mostly empty space

1

(e) in the Bohr model the electrons orbit (the nucleus) at specific distances (whereas in the nuclear model the electrons can orbit at a continuous range of distances)

allow energy levels or shells for specific distances

1

(f) to move to a higher energy level an electron absorbs energy from electromagnetic radiation

allow absorbs energy by collision with another electron
allow EM radiation for electromagnetic radiation

1

to move to a lower energy level an electron emits energy in the form of electromagnetic radiation

1

if no other mark scored allow 1 mark for an electron changes energy level by emitting or absorbing electromagnetic radiation

[10]

2. (a) 2 protons and 2 neutrons

1

(b) an electron

1

(c) $^{85}_{36}Kr \longrightarrow {}^{85}_{37}Rb + {}^{0}_{-1}e$

1

(d)

Type of radiation	**Most radiation is stopped by:**		
	the sheet of paper	**the sheet of aluminium**	**the block of lead**
Alpha	Yes	Yes	Yes
Beta	No	Yes	Yes
Gamma	No	No	Yes

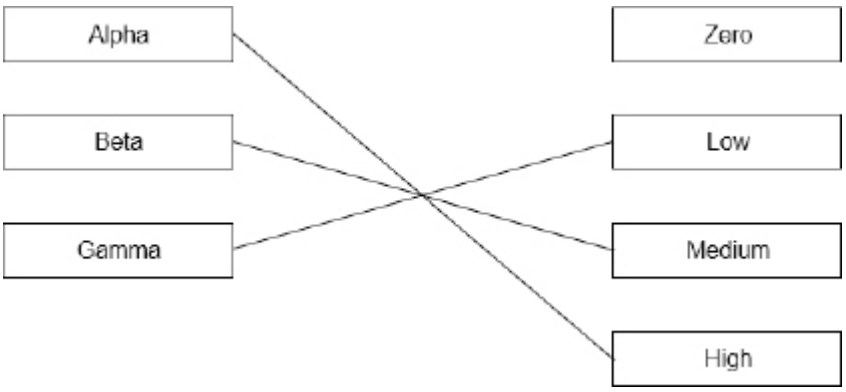
1 *mark for each correct row*

allow ticks and crosses in place of yes and no

any incorrect answer on a row negates the mark for the row

3

(e)



1 *mark for each correct line*

if more than one line drawn from radiation type list principle applies

3

(f) nuclear accidents

1

(g) number = $\frac{2.0}{0.005}$

1

number = 400

1

[12]

3. (a) two protons and two neutrons

allow helium nucleus

ignore symbols

1

(b) 85

1

37

1

this order only

(c) alpha radiation has a low penetrating ability

1

(so externally) alpha radiation is stopped by skin (so is low risk)

allow absorbed for stopped

ignore reference to range of alpha particles through other materials

1

internally, alpha radiation is absorbed by living tissue / organs

allow (internal) contamination will increase the radiation dose

1

(as) alpha radiation is highly ionising

1

(internal) contamination will cause greater (risk of) harm to cells / tissues / organs / DNA / genes

allow contamination causes greater chance of developing cancer

allow greater chance of mutations

1

[8]

4. (a) atomic number

1

(b) number of neutrons

1

(c) Alpha

1

(d) Beta

1

(e) decrease

1

increase

this order only

1

(f) the time it takes for the count rate of a sample to halve

1

(g) so the activity of the source is approximately constant

1

[8]

5. (a) nuclei

do not accept atoms

1

decreases

1

(b) m = 0.004 (kg)

1

E = 0.004 × 5200 × 50 000 000

allow a correct substitution of an incorrectly/not converted value of m

1

E = 1.04 × 10^9 (J)
or
E = 1 040 000 000 (J)

allow a correct calculation using an incorrectly/not converted value of m

1

(c) any **two** from:

- to make sure the fusion process is possible
- to develop an understanding of the process
- to make adaptations to the process
- to assess the efficiency of the process
- to make predictions
- assess safety risks
- to assess environmental impact
- set-up cost is lower (for small scale experiments)

2

(d) releases carbon dioxide

allow releases greenhouse gases

1

which causes global warming

allow which causes climate change

OR
releases particulates
which causes global dimming
or
which cause breathing problems

OR
releases sulfur dioxide
which cause acid rain

OR
releases nitrogen oxides
which cause breathing problems
or
which causes acid rain

1

[9]

6. (a) 148

1

(b) D and E

1

(c) line between B and 86 protons

1

same line between B and 222 mass number

1

(d) can't predict which nucleus will decay next

or

can't predict when a (particular) nucleus will decay

1

(e) one alpha decay would decrease proton number by 2

1

two beta decays would increase proton number by 2

1

so the proton / atomic number of the final nucleus is the same as the proton / atomic number of the original nucleus

this mark is dependent on scoring the first two marks

1

[8]

7. (a) radiotherapy

1

(b) a neutron

1

energy

energy and gamma rays can score in reverse order

1

gamma rays

1

(c) An alpha particle is the same as a helium nucleus.

1

(d) 24 000 (years)

allow an answer between 24 000 and 24 500 (years) inclusive

1

(e) 24 000 (years)
or
their (d)

1

(f) Any **one** from:

- irradiation
- cancer
- genetic damage
- mutations to DNA / genes
- radiation sickness / poisoning

1

[8]

8.

(a) Any **one** from:

- (medical) x-rays

  allow CT scans
- radiotherapy
- nuclear weapons (testing)

  allow nuclear fallout
- named nuclear disaster e.g. Chernobyl / Fukushima / Three Mile Island.

  ignore radioactive / nuclear waste

1

(b) uranium / plutonium

ignore any number given

allow thorium

1

(c) neutron absorbed by a uranium nucleus

1

nucleus splits into two parts

allow an atom splits into two parts if 1st marking point doesn't score

1

and (2/3) neutrons (are released)

1

and gamma rays (are emitted)

1

(d) lighter nuclei join to form heavier nuclei

allow specific examples

1

some of the mass (of the nuclei) is converted to energy (of radiation)

1

(e) activity decreases quickly

allow nuclei / waste will decay at a greater rate
ignore waste is radioactive for less time

1

risk of harm decreases quickly

allow burial site doesn't need to be monitored for as long
or
doesn't need to be buried underground for as long
or
may not need to be buried underground

1

[10]