

Atomic Structure 2

Name: _____

Class: _____

Date: _____

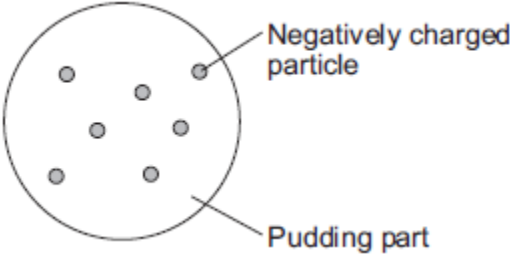
Time: **81 minutes**

Marks: **81 marks**

Comments:

1.

(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)

(b) Nuclear **fusion** also releases energy.
Nuclear fusion happens at very high temperatures. A high temperature is needed to overcome the repulsion force between the nuclei.

(i) Why is there a repulsion force between the nuclei of atoms?

(1)

(ii) Where does nuclear fusion happen naturally?

(1)

(c) In 1991, scientists produced the first controlled release of energy from an experimental nuclear **fusion** reactor. This was achieved by fusing the hydrogen isotopes, deuterium and tritium.

Deuterium is naturally occurring and can easily be extracted from seawater. Tritium can be produced from lithium. Lithium is also found in seawater.

The table gives the energy released from 1 kg of fusion fuel and from 1 kg of fission fuel.

Type of fuel	Energy released from 1 kg of fuel in joules
Fusion fuel	3.4×10^{14}
Fission fuel	8.8×10^{13}

(i) Suggest **two** advantages of the fuel used in a fusion reactor compared with plutonium and the other substances used as fuel in a fission reactor.

1. _____

2. _____

(2)

- (ii) Some scientists think that by the year 2050 a nuclear fusion power station capable of generating electricity on a large scale will have been developed.

Suggest **one** important consequence of developing nuclear fusion power stations to generate electricity.

(1)

- (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.

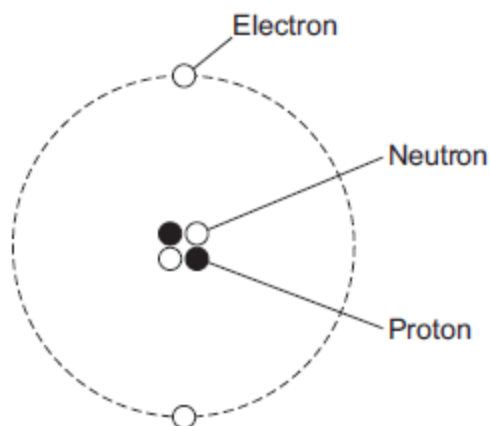
Half-life = _____ years

(2)

(Total 9 marks)

3.

- (a) The figure below shows a helium atom.



- (i) Which **one** of the particles in the atom is **not** charged?

Draw a ring around the correct answer.

electron **neutron** **proton**

(1)

(ii) Which **two** types of particle in the atom have the same mass?

_____ and _____

(1)

(iii) What is the atomic number of a helium atom?

Draw a ring around the correct answer.

2 **4** **6**

Give a reason for your answer.

(2)

(b) Alpha particles are one type of nuclear radiation.

(i) Name **one** other type of nuclear radiation.

(1)

(ii) Use the correct answer from the box to complete the sentence.

electrons	neutrons	protons
------------------	-----------------	----------------

The difference between an alpha particle and a helium atom is that the alpha particle does **not** have any _____ .

(1)

(iii) Which **one** of the following is a property of alpha particles?

Tick (✓) **one** box.

Have a long range in air

Are highly ionising

Will pass through metals

(1)

(c) Doctors may use nuclear radiation to treat certain types of illness.

Treating an illness with radiation may also harm a patient.

(i) Complete the following sentence.

The risk from treating a patient with radiation is that the radiation may _____ healthy body cells.

(1)

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

Radiation may be used to treat a patient if the risk from the

radiation is

much bigger than
about the same as
much smaller than

 the possible benefit of having the treatment.

(1)

(Total 9 marks)

4.

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)

5.

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

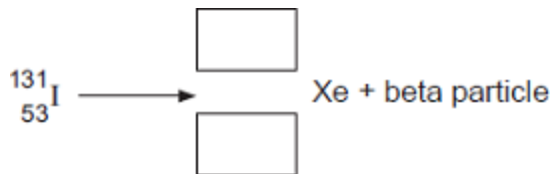
the _____ number.

(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.



(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)

6.

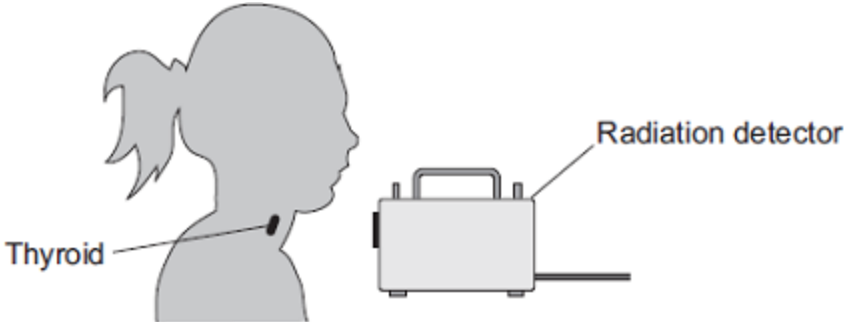
(a) The names of three types of radiation are given in **List A**. Some properties of these three types of radiation are given in **List B**.

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
alpha	will pass through paper but is stopped by thin metal
beta	has the shortest range in air
gamma	will not harm human cells
	is very weakly ionising

(3)

(b) The radioactive isotope iodine-123 can be used by a doctor to examine the thyroid gland of a patient. The iodine, taken as a tablet, is absorbed by the thyroid gland. The gamma radiation emitted as the iodine atoms decay is detected outside the body.



The doctor uses an isotope emitting gamma radiation to examine the thyroid gland rather than an isotope emitting alpha or beta radiation.

Which **one** of the following gives a reason why gamma radiation is used?

Tick (✓) **one** box.

Gamma radiation will pass through the body.

Gamma radiation is not deflected by a magnet.

Gamma radiation has a long range in air.

(1)

(c) Iodine-123 has a half-life of 13 hours.

Use a word from the box to complete the sentence.

all	half	most
-----	------	------

After 13 hours _____ of the iodine-123 atoms the thyroid absorbed have decayed.

(1)

(d) Iodine-123 and iodine-131 are two of the isotopes of iodine.

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

The nucleus of an iodine-123 atom has the same number of

electrons

neutrons

as the

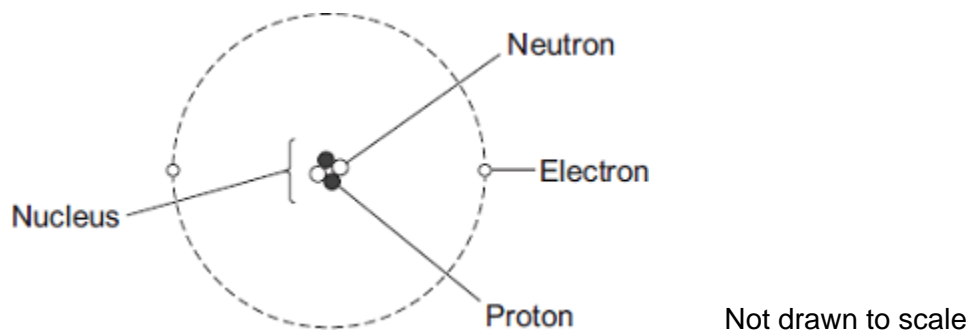
protons

nucleus of an iodine-131 atom.

(1)

(Total 6 marks)

7. The diagram shows the structure of an atom.



(a) In 1931 scientists thought that atoms contained **only** protons and electrons.

Suggest what happened in 1932 to change the idea that atoms contained only protons and electrons.

(1)

(b) The table gives information about the particles in an atom.

Complete the table by adding the names of the particles.

Particle	Relative Mass	Relative Charge
	1	0
	very small	-1
	1	+1

(2)

(Total 3 marks)

8. Certain types of atom emit alpha, beta or gamma radiation. The radiation is emitted from the centre of the atom.

(a) What name is given to the centre of an atom?

(1)




- (b) The sign below is used to warn people that a radiation source is being used in a laboratory.



Why is it important to warn people that a radiation source is being used?

(1)

- (c) Before using a radiation source, a teacher asked her class whether there was any way that she could reduce the amount of radiation that the source emitted. Three students each gave an answer to the teacher.

Keep the source in a freezer. It will emit less radiation.  Put it in acid. It will destroy the radiation.  You can't do anything to change the amount of radiation emitted. 

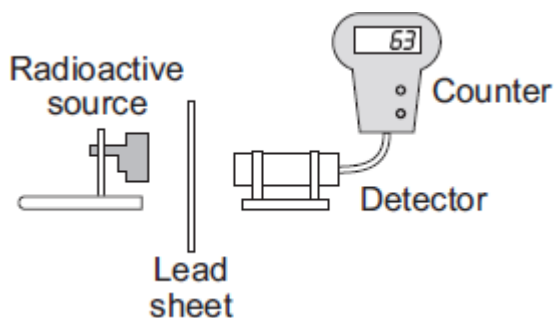
A **B** **C**

Which **one** of the students, **A**, **B** or **C**, is correct?

Write your answer in the box.

(1)

- (d) The diagram shows the apparatus used by the teacher to demonstrate how one type of radiation is able to pass through lead.



One lead sheet, 2 mm thick, was placed between the source and the detector and a count rate was taken. Extra lead sheets were added. For each extra lead sheet, a new count rate was taken and recorded in the table.

Number of lead sheets	Count rate in counts per minute
1	226
2	220
3	210
4	190
5	185

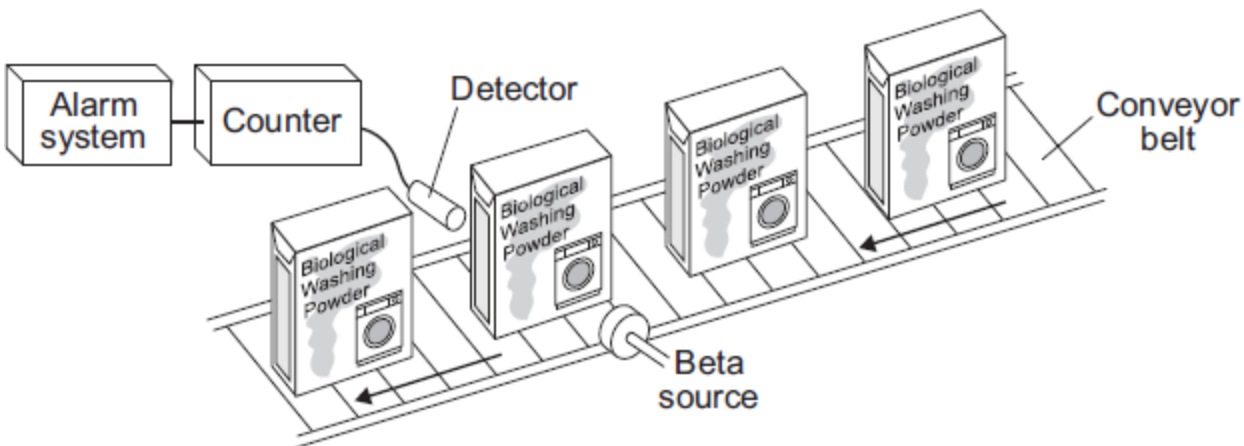
Which type of radiation was the source emitting: alpha, beta or gamma?

Give the reason for your answer.

(2)

(e) The diagram shows how a company detects any boxes left empty by an automatic filler.

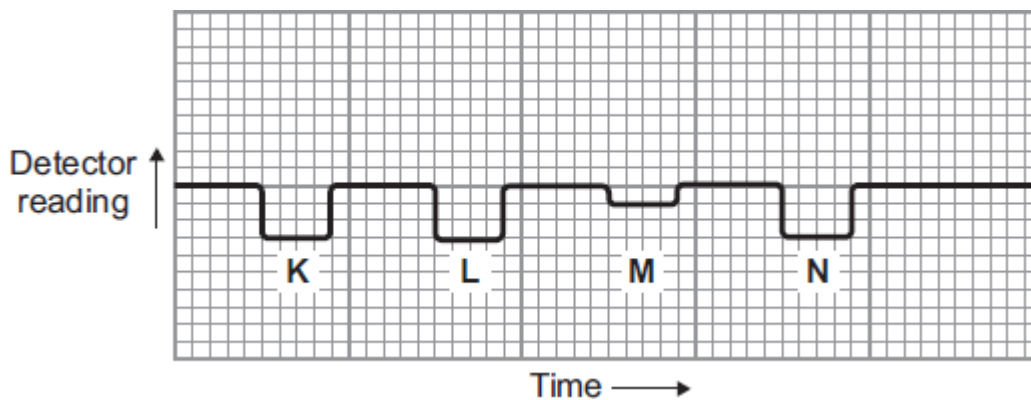
When an empty box passes between the beta source and the detector, a buzzer sounds. A worker then removes the box from the conveyor belt.



(i) Why would this system **not** work if an alpha source were used instead of the beta source?

(1)

(ii) The chart shows how the detector reading changes as boxes pass along the conveyor belt.



Which part of the chart, **K**, **L**, **M** or **N**, shows that an empty box is passing between the beta source and the detector?

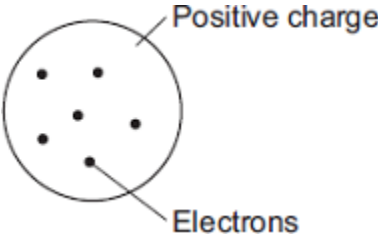
Give a reason for your answer.

(2)

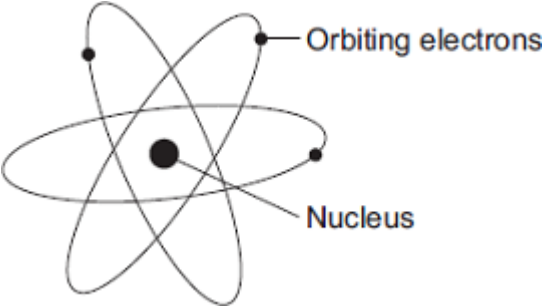
(Total 8 marks)

9.

In the early part of the 20th century, scientists used the 'plum pudding' model to explain the structure of the atom.



Following work by Rutherford and Marsden, a new model of the atom, called the 'nuclear' model, was suggested.

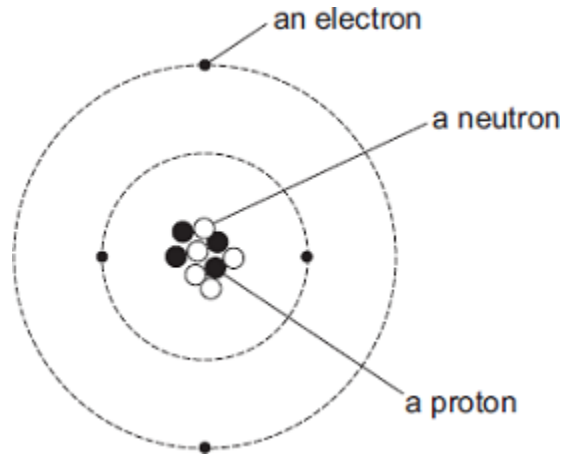


Describe the differences between the two models of the atom.

(Total 4 marks)

10.

The diagram represents an atom of beryllium. The three types of particle that make up the atom have been labelled.



(a) Use the labels from the diagram to complete the following statements.

Each label should be used once.

The particle with a positive charge is _____.

The particle with the smallest mass is _____.

The particle with no charge is _____.

(2)

(b) What is the mass number of a beryllium atom?

Draw a ring around your answer.

4	5	9	13
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Give a reason for your answer.

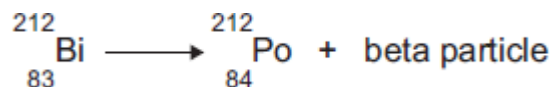
(2)

(Total 4 marks)

11.

- (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.



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

What is the *mass number* of an atom?

(1)

- (ii) Beta decay does **not** cause the mass number of an atom to change.

Explain why not.

(2)

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

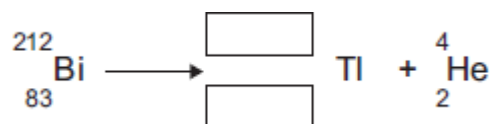
An alpha particle is the same as a helium nucleus.

The symbol below represents an alpha particle.



- (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.



(2)

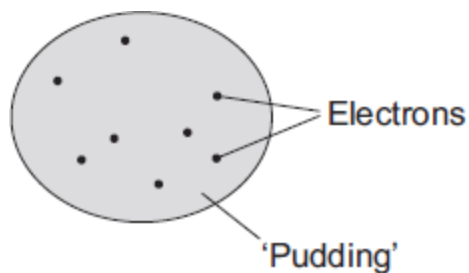
- (ii) It is impossible for the alpha decay of bismuth-212 to produce the same element as the beta decay of bismuth-212.

Explain why.

(2)
(Total 7 marks)

12.

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

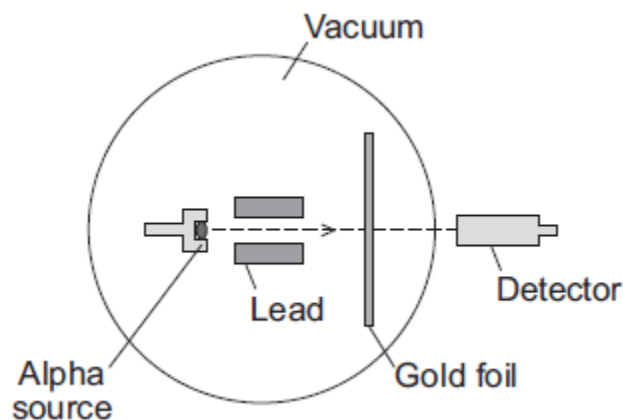


- (a) Those scientists knew that atoms contained electrons and that the electrons had a negative charge. They also knew that an atom was electrically neutral overall.

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.



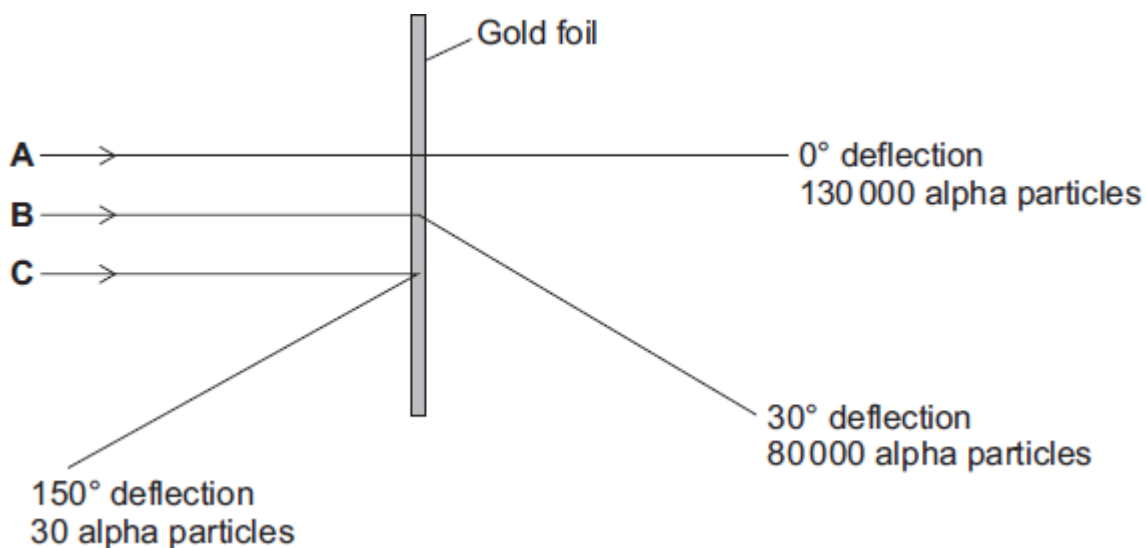
If the 'plum pudding' model was correct, then most of the alpha particles would go straight through the gold foil. A few would be deflected, but by less than 4° .

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)

Mark schemes

1.

- (a) (an equal amount of) positive charge

*do **not** accept charge on the atom / nucleus is positive*

1

- (b) (i) a (significant) number of alpha particles were scattered by more than 4°

or

alpha particles deflected backwards

accept (some) measurements / results were unexpected

1

measurements / results could not be explained by 'plum pudding' model

or

measurements / results did not support predictions

can be explained by the nuclear model is insufficient

accept measurements / results did not support hypothesis

1

- (ii) many / (over)100 000 measurements / results taken

accept Rutherford(and Marsden) were respected scientists

or

scientists were respected

accept measurements / results taken over several months

the experiment was repeated many times is insufficient

1

- (c) Marks awarded for this answer will be determined by the Quality of Written Communication (QWC) as well as the standard of the scientific response. Examiners should also refer to the information on page 5 and apply a 'best-fit' approach to the marking.

0 marks

no relevant content

Level 1 (1–2 marks)

A brief description is given with some particles correctly named

Level 2 (3–4 marks)

A description is given with all three particles named

plus either

the polarity of charge associated with the three particles

or

the relative mass of the three particles

or

the relative mass for one particle and the relative charge for one particle given

Level 3 (5–6 marks)

A more detailed description is given, naming the particles and polarity of charge

and either

the relative mass is given for at least two particles

or

the relative charge is given for at least two particles

Examples of the points made in the response

brief description

contains protons, neutrons and electrons

protons are positive

electrons are negative

neutrons are uncharged

has a nucleus

relative charge

proton +1

electron – 1

neutron 0

relative mass

proton 1

neutron 1

electron (about) $1 / 2000$

accept protons and neutrons have the same mass

accept electrons have tiny / negligible mass

zero mass is neutral

more detailed description

protons and neutrons make up the nucleus

electrons orbit the nucleus

electrons are in shells

most of the atom is empty space

nucleus occupies a very small fraction of the volume of the atom

electrons orbit at a relatively large distance from the nucleus

most of the mass of the atom is contained in the nucleus

the nucleus as a whole is positively charged total number of protons in the nucleus

equals the total number of electrons orbiting it in an atom

6

[10]

2.

- (a) (i) splitting of a(n atomic) nucleus
do not accept splitting an atom

1

- (ii) Neutron

1

- (b) (i) nuclei have the same charge
or
nuclei are positive
accept protons have the same charge

1

- (ii) (main sequence) star
accept Sun or any correctly named star
accept red (super) giant

1

- (c) (i) any **two** from:
- easy to obtain / extract
 - available in (very) large amounts
 - releases more energy (per kg)
do not accept figures only
 - produces little / no radioactive waste.
naturally occurring is insufficient
seawater is renewable is insufficient
less cost is insufficient

2

- (ii) any **one** from:
- makes another source of energy available
 - increases supply of electricity
 - able to meet global demand
 - less environmental damage
 - reduces amount of other fuels used.
accept any sensible suggestion
accept a specific example
accept a specific example

1

(d) 12

allow 1 mark for obtaining 3 half-lives

2

[9]

3.

(a) (i) neutron

1

(ii) neutron
proton

both required, either order

1

(iii) 2

1

number of protons

do not accept number of electrons

1

(b) (i) any **one** from:

- beta
 - gamma
- accept correct symbols*
accept positron / neutrino / neutron
cosmic rays is insufficient

1

(ii) electrons

1

(iii) are highly ionising

1

(c) (i) mutate / destroy / kill / damage / change / ionise

Harm is insufficient

1

(ii) much smaller than

1

[9]

4.

(a) neutrons and protons

1

(b) 0

1

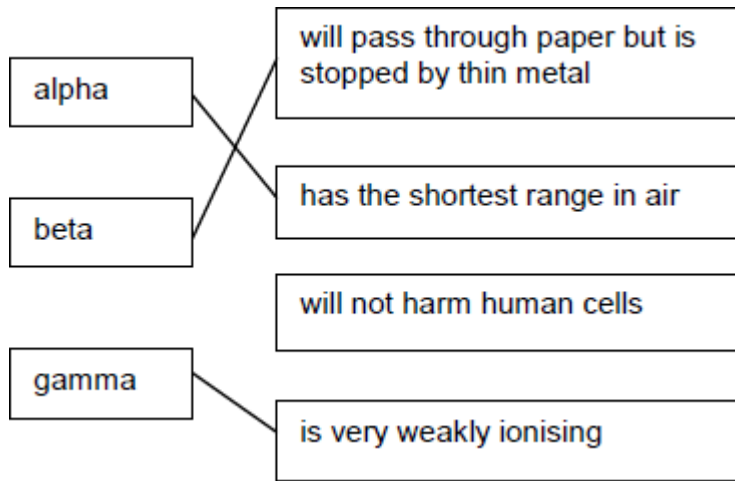
(+)¹

1

- (c) (i) total positive charge = total negative charge
accept protons and electrons have an equal opposite charge 1
- (because) no of protons = no of electrons 1
- (ii) ion 1
- positive 1
- [7]**

- 5.** (a) 78 1
- (b) atomic 1
- (c) (i) 131
correct order only 1
- 54 1
- (ii) 32 (days)
allow 1 mark for showing 4 half-lives provided no subsequent step 2
- (iii) limits amount of iodine-131 / radioactive iodine that can be absorbed
accept increases level of non-radioactive iodine in thyroid
*do **not** accept cancels out iodine-131* 1
- so reducing risk of cancer (of the thyroid)
accept stops risk of cancer (of the thyroid) 1
- [8]**

6. (a) 3 lines correct



allow 1 mark for each correct line
if more than one line is drawn from any type of radiation box then all of those lines are wrong

(b) Gamma radiation will pass through the body

(c) half

(d) protons

3

1

1

1

[6]

7. (a) neutron discovered

(b) neutron

all 3 in correct order

electron

allow 1 mark for 1 correct

proton

1

2

[3]

8. (a) nucleus

do not accept core / centre / middle

1

- (b) radiation damages our cells
accept radiation is dangerous / poisonous / harmful / toxic
accept radiation can cause cancer / kills cells / change DNA / cause mutations / harm health
accept so precautions can be taken
accept so they know they may be exposed to / harmed by radiation
it refers to radiation (source)
to stop people being harmed is insufficient 1
- (c) **C** 1
- (d) gamma 1
- gamma will pass through the lead
reason only scores if gamma chosen
or
 alpha and beta will not pass through lead
accept correct symbols for alpha, beta and gamma 1
- (e) (i) range of alpha too short
accept alpha would not reach detector
or
 alpha absorbed whether box is full or empty
accept alpha (always) absorbed by box / card
accept alpha will not pass through the box / card
alphas cannot pass through objects / solids is insufficient
alpha not strong enough is insufficient 1
- (ii) **M**
*reason only scores if **M** chosen* 1
- less radiation / beta (particles) absorbed
accept more radiation / beta particles pass through
or
 more radiation absorbed by full boxes
accept reading is higher 1

[8]

- 9.** any **two** pairs from:
- to gain credit it must be clear which model is being described*
do **not** accept simple descriptions of the diagram without comparison
- nuclear model mass is concentrated at the centre / nucleus (1)
 accept the nuclear model has a nucleus / the plum pudding model does not have a nucleus for 1 mark
 - plum pudding model mass is evenly distributed (1)
 - nuclear model positive charge occupies only a small part of the atom (1)
 plum pudding model positive charge spread throughout the atom (1)
 - nuclear model electrons orbit some distance from the centre (1)
 accept electrons in shells / orbits provided a valid comparison is made with the plum pudding model
 - plum pudding electrons embedded in the (mass) of positive (charge) (1)
 do **not** accept electrons at edge of plum pudding
 - nuclear model the atom mainly empty space (1)
 plum pudding model is a 'solid' mass (1)
- [4]**
- 10.** (a) proton
 all 3 in correct order
- electron
 allow 1 mark for 1 correct do not
- neutron
 accept letters p, e, n
- 2
- (b) 9
 reason only scores if 9 is chosen
- 1
- number of neutrons and protons
 1
- [4]**
- 11.** (a) (i) (total) number of protons plus neutrons
 accept number of nucleons
 accept amount for number
 do not accept number of particles in the nucleus
- 1

(ii) number of neutrons decreases by one 1

number of protons increases by one
accept for both marks a neutron changes into a proton 1

(b) (i) ${}_{81}^{208}\text{Th}$ 1
correct order only 1

(ii) the number of protons determines the element
accept atomic number for number of protons 1

alpha and beta decay produce different changes to the number of protons
there must be a comparison between alpha and beta which is more than a description of alpha and beta decay alone

or
alpha and beta decay produce different atomic numbers
ignore correct reference to mass number 1

[7]

12.

(a) has an equal amount of positive charge
accept pudding/it is positive 1

(b) (experimental) results could not be explained using 'plum pudding' model
or
(experimental) results did not support plum pudding model
accept (experimental) results disproved plum pudding model 1

(c) (i) **A** – most of atom is empty space **or** most of atom concentrated at the centre 1

B – nucleus is positive (so repels alpha particles)
accept nucleus has the same charge as alpha 1

C – nucleus is very small
accept nucleus is positive if not scored for B
or
nucleus is a concentrated mass
accept nucleus has a very concentrated charge 1

- (ii) (if predictions correct, this) supports the new model
answers should be in terms of the nuclear model
accept supports his/new/nuclear theory
accept proves for supports
accept shows predictions/ Rutherford was correct

1

[6]