Mark schemes

(a) Alpha – two protons and two neutrons

Beta – electron from the nucleus

Gamma – electromagnetic radiation

(b) Gamma

Beta

Alpha

allow 1 mark for 1 or 2 correct

(c) any two from:

• (radioactive) source not pointed at students
• (radioactive) source outside the box for minimum time necessary
• safety glasses or eye protection or do not look at source
• gloves
• (radioactive) source held away from body
• (radioactive) source held with tongs / forceps

accept any other sensible and practical suggestion

(d) half-life = 80 s

counts / s after 200 s = 71

accept an answer of 70

(e) very small amount of radiation emitted

accept similar / same level as background radiation

[10]
Indicative content
- alpha particle scattering experiment
- alpha particles directed at gold foil
- most alpha particles pass straight through
- (so) most of atom is empty space
- a few alpha particles deflected through large angles
- (so) mass is concentrated at centre of atom
- (and) nucleus is (positively) charged
- plum pudding model has mass spread throughout atom
- plum pudding model has charge spread throughout atom

3

(a) cannot predict which dice / atom will ‘decay’

accept answers given in terms of ‘roll a 6’

1

cannot predict when a dice / atom will ‘decay’

1

(b) 3.6 to 3.7 (rolls)

allow 1 mark for attempt to read graph when number of dice = 50

2

(c) 90

1

(d) uranium

1

(e) beta

1

proton number has gone up (as neutron decays to proton and e−)

1
(f) prevents contamination

or

prevents transfer of radioactive material to teacher’s hands

which would cause damage / irradiation over a longer time period.

(a) Nucleus splitting into two fragments and releasing two or three neutrons

(at least one) fission neutron shown to be absorbed by additional large nucleus and causing fission

two or three additional neutrons released from fission reaction

_This diagram would gain all 3 marks:_

(b) lowering the control rods increases the number of neutrons absorbed

_\text{accept converse description}_

(so) energy released decreases

_allow changing the position of the control rods affects the number of neutrons absorbed for 1 mark_

(c) rate of increase between 240 and 276 (MW / min)

_allow 1 mark for attempt to calculate gradient of line at 10 minutes_

5

(a) neutrons

(b) generate electricity

_\text{accept produce electricity} \_

_\text{accept heat water} \_

_\text{accept produce steam} \_

_\text{turns turbines is insufficient}_

(c) (i) a neutron
(ii) two particles \(\text{X}\) released from the uranium-235

uranium-235 shown splitting into two fragments

or

each particle \(\text{X}\) shown colliding with a uranium-235 and producing 2 further particles \(\text{X}\)

one uranium-235 shown splitting is sufficient, provided no contradiction shown

(a) 2 protons and 2 neutrons

accept 2p and 2n

accept (the same as a) helium nucleus

symbol is insufficient

do not accept 2 protons and neutrons

(b) (i) gamma rays

(ii) loses/gains (one or more) electron(s)

(c) any one from:

- wear protective clothing
- work behind lead/concrete/glass shielding
- limit time of exposure
- use remote handling

accept wear mask/gloves

wear goggles is insufficient

wear protective equipment/gear is insufficient

accept wear a film badge

accept handle with (long) tongs

accept maintain a safe distance

accept avoid direct contact
(d) 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 apply a ‘best-fit’ approach to the marking.

**Level 3 (5 – 6 marks):**
There is a description of all three types of radiation in terms of at least two of their properties

or

a full description of two types of radiation in terms of all three properties.

**Level 2 (3 – 4 marks):**
There is a description of at least two types of radiation in terms of some properties

or

a full description of one type of radiation in terms of all three properties

or

the same property is described for all three radiations

**Level 1 (1 – 2 marks):**
There is a description of at least one type of radiation in terms of one or more properties.

**Level 0 (0 marks):**
No relevant information

**examples of physics points made in the response**

**alpha particles**
- are least penetrating
- are stopped by paper / card
- have the shortest range
- can travel (about) 5cm in air
- are (slightly) deflected by a magnetic field
- alpha particles are deflected in the opposite direction to beta particles by a magnetic field

**beta particles**
- (some are) stopped by (about) 2mm (or more) of aluminium/metal
- can travel (about) 1 metre in air
- are deflected by a magnetic field
- beta particles are deflected in the opposite direction to alpha particles by a magnetic field

  accept (some are) stopped by aluminium foil

**gamma rays**
- are the most penetrating
- are stopped by (about) 10cm of lead
- have the longest range
- can travel at least 1 km in air
- are not deflected by a magnetic field
(a) (i) (enough) dust and gas (from space) is pulled together
   
   *accept nebula for dust and gas*
   *accept hydrogen for gas*
   *accept gas on its own*
   *dust on its own is insufficient*
   *mention of air negates this mark*

   by:
   gravitational attraction
   or
   gravitational forces
   or
   gravity

   *ignore any (correct) stages beyond this*

(ii) joining of two (atomic) nuclei (to form a larger one)

   *do not accept atoms for nuclei*

(iii) more sensitive astronomical instruments / telescopes

   or

   infrared telescopes developed

   *accept better technology*

   *more knowledge is insufficient*

(b) (i) (other) planets / solar systems

   *do not accept galaxy*

   *moons is insufficient*

(ii) provided evidence to support theory

   *accept proves the theory*

(c) elements heavier than iron are formed only when a (massive) star explodes

   *accept materials for elements*

   *accept supernova for star explodes*

   *accept stars can only fuse elements up to (and including) iron*
(a) (i) (atoms with the) same number of protons

*allow same atomic number*

*or same proton number*

(atomic with) different number of neutrons

*allow different mass number*

(ii) 82

(iii) 124

(b) (i)

\[ ^{58}\text{Fe} + ^{208}\text{Pb} \]

1 mark for each correct box

(ii) (a) neutron

(iii) \(4.0 \times 10^{-4} \text{ (s)}\)

*or*

0.0004

\[ 3.00 \times 10^8 \times 0.1 = 12 000 \text{ / t} \]

gains 1 mark

(iv) particles need to travel a large distance

equipment would have to be very long

with circular paths long distances can be accommodated in a smaller space
(c) (i) the average time for the number of nuclei to halve
the time for count rate to halve

(ii) \[
\begin{array}{c}
261 \\
106 \\
\end{array} \quad \begin{array}{c}
4 \\
2 \\
\end{array} \\
\text{Sg} + \alpha
\]

1 mark if top boxes total = 265
and bottom boxes total = 108
1 mark for 4 and 2 for alpha

(d) (i) 3 plotted points
\[ \pm \frac{1}{2} \text{ small square} \]
best line through points

(ii) 190–205 (pm)
or correct from student’s line

(a) inside the Sun

(b) fusion

(c) energy

(a) cell damage or cancer
accept kills / mutates cells
radiation poisoning is insufficient
ionising is insufficient

10
(b) (i) any one from:
- use tongs to pick up source
- wear gloves
- use (lead) shielding
- minimise time (of exposure)
- maximise distance (between source and teacher).

accept any other sensible and practical suggestion
ignore reference to increasing / decreasing the number / thickness of lead sheets

(ii) background

(c) (i) curve drawn from point 2,160
do not accept straight lines drawn from dot to dot

(ii) (also) increases
less radiation passes through is insufficient

(iii) 50
accept any value from 40 to 56 inclusive

(d) gamma

only gamma (radiation) can pass through lead
accept alpha and beta cannot pass through lead
a general property of gamma radiation is insufficient

(a) (an equal amount of) positive charge
do not accept charge on the atom / nucleus is positive
(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

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

(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
(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