GCSE
PHYSICS
AQA - COMBINED SCIENCE
MARK SCHEME

P4
ATOMIC STRUCTURE
TEST 3
Mark schemes

(a) \(1 \times 10^{-10} \text{ m}\)

(b) (a helium atom) has 2 electrons
    \textit{accept it has more mass}
    \textit{allow it is not charged}

(c) 2

(d) neutral
    \textit{accept 0 or 'no charge'}

(because) protons have positive charge and electrons have negative charge

(and) there are equal numbers of protons and electrons

(e) helium will one day run out
    
    there will be none left for medical uses so balloons waste helium

(a) (mass number) 231
(protons) 92
(neutrons) 141

(b) 2 / two (hours)

(because) count rate halves in that time

(c) A high-speed electron

(d) uncontrolled

benign
(a) gamma

*allow 1 mark for 1 or 2 correct*

beta

alpha

(b) any two from:

- do not point (radioactive) source at students
- keep (radioactive) source outside the box for minimum time necessary
- wear safety glasses or eye protection or do not look at source
- wear gloves
- hold (radioactive) source away from body
- hold (radioactive) source with tongs / forceps

(c) as time increases count rate decreases

count rate halves every 80 seconds

(d) half-life is 80 seconds

so after 200 seconds count rate = 113

(e) because a very small amount of radiation will be emitted or will be similar to / same as background radiation
(a) 1 mark for each correct line

<table>
<thead>
<tr>
<th>List A</th>
<th>List B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of nuclear radiation</td>
<td>Property of radiation</td>
</tr>
<tr>
<td>Alpha</td>
<td>Has the same mass as an electron</td>
</tr>
<tr>
<td>Beta</td>
<td>Very strongly ionising</td>
</tr>
<tr>
<td>Gamma</td>
<td>Passes through 10cm of aluminium</td>
</tr>
<tr>
<td></td>
<td>Deflected by a magnetic field but not deflected by an electric field</td>
</tr>
</tbody>
</table>

if more than 1 line is drawn from any box in List A, none of those lines gain any credit

(b) (i) (the detector) reading had gone down

‘it’ equals detector reading
accept the reading in the table is the smallest
accept 101 is (much) lower than other readings / a specific value eg 150

do not accept this answer if it indicates the readings are the thickness

more beta (particles / radiation) is being absorbed / stopped
accept radiation for beta particles / radiation
accept fewer particles being detected

(ii) six years

(iii) alpha would not penetrate the cardboard

accept the basic property – alpha (particles) cannot pass through paper / card
accept alpha (particles) are less penetrating (than beta)
range in air is neutral

[7]

5 (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 $4^\circ$

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

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

(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

(ii) number of neutrons decreases by one

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

6

[10]
(b) (i) \[ \frac{208}{81} \text{ Th} \]  

Correct order only  

(ii) the number of protons determines the element  

Accept atomic number for number of protons  

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  

7  

(a) 78  

(b) atomic  

(c) (i) 131  

Correct order only  

54  

(ii) 32 (days)  

*Allow 1 mark for showing 4 half-lives provided no subsequent step*  

(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  

So reducing risk of cancer (of the thyroid)  

Accept stops risk of cancer (of the thyroid)  

8  

(a) 2 charged particles and 2 neutral particles  

(b) it is the type of radiation with a negative charge  

(c) it has a very long range in air
(d) risk / activity associated with iodine-131 has decreased by a large amount
   because of short half-life
   allow many half-lives have passed
   allow half-life is only 8 days
   2nd marking point dependent on 1st marking point

   risk / activity associated with caesium-137 will not have decreased by much
   allow activity has halved

   because of long half-life
   allow only one half-life has passed
   4th marking point dependent on 3rd marking point

(e) 5 half-lives
   allow any correct method
   e.g. \( \frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} = \frac{1}{32} \)

   5 \times 30 = 150

   1986 + 150 = 2136

   any calculation using a value of 137 scores zero
   an answer of 2136 scores 3 marks