GCSE
PHYSICS
AQA - COMBINED SCIENCE
MARK SCHEME

P4
ATOMIC STRUCTURE
TEST 1
Mark schemes

(a) gamma

(b) alpha

(c) gamma

(d) isotope number of neutrons number of protons

<table>
<thead>
<tr>
<th>isotope</th>
<th>number of neutrons</th>
<th>number of protons</th>
</tr>
</thead>
<tbody>
<tr>
<td>uranium-238</td>
<td>146</td>
<td>92</td>
</tr>
<tr>
<td>thorium-234</td>
<td>144</td>
<td>90</td>
</tr>
</tbody>
</table>

(e) $\Delta \theta = 80 \, ^\circ\text{C}$

$$E = 150 \times 4200 \times 80$$

$$E = 50\,400\,000 \, (\text{J})$$

allow $50\,400\,000 \, (\text{J})$

allow max 2 marks for correct calculation using incorrect value of $\Delta \theta$

allow 1 mark for correct calculation using $\theta = 20$
or $\theta = 100$

an answer of 50 400 000 scores 3 marks

2 (a) The nucleus will emit a neutron.

(b) Similarity

same mass number

allow same number of nucleons (protons + neutrons)

difference

different atomic number

allow different number of protons

(c) Radioactive decay is random.
(d) 1.3 (billion years) 
allow 1.2-1.4 (billion years) 

allow 1 mark for horizontal line drawn from ~ 550

(e) alpha

(a) a type of electromagnetic radiation

(b) a thick sheet of lead

(c) to decrease the rate of decay of the food
to prevent food poisoning

(d) gamma rays cause mutations

(e) decrease the distance between the food and the radioactive source
increase the time for which the food is close to the radioactive source

(f) (because) the source of radiation is not in the food
allow source of radiation is / remains outside food

(a) electron

atom

nucleus

orbit

(b) positive charge is provided by protons

(every atom of the same element contain the) same number of protons 

*do not accept same number of protons and neutrons*

*ignore reference to electrons*
(c) \( v = 300 000 000 \times \left(\frac{7}{100}\right) \)

allow any correct method of determining 7% of 
300 000 000

\( v = 21 000 000 \) (m/s)

allow 2.1 \( \times 10^7 \) (m/s)

an answer of 21 000 000 scores 2 marks

(d) \( r = 6 \times 2.5 \times 10^{-11} \)

allow a ratio in the range of 5.7–6.3 or measurements
that would give this range, correctly substituted

\( r = 1.5 \times 10^{-10} \) (m)

allow 1.4 \( \times 10^{-10} \) to 1.6 \( \times 10^{-10} \)

their ratio \( \times 2.5 \times 10^{-11} \) correctly calculated scores 1 mark

an answer in the range 1.4 \( \times 10^{-10} \) to 1.6 \( \times 10^{-10} \) scores 
2 marks

5

(a) horizontal line drawn from
92 000 Bq

allow 90 000–94 000

1600 years

allow 1500–1700

(b) only (119) years have passed

activity has not dropped by much
<table>
<thead>
<tr>
<th><strong>Level 3:</strong> Relevant points (reasons/causes) are identified, given in detail and logically linked to form a clear account.</th>
</tr>
</thead>
<tbody>
<tr>
<td>5-6</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th><strong>Level 2:</strong> Relevant points (reasons/causes) are identified, and there are attempts at logically linking. The resulting account is not fully clear.</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Level 1:</strong> Points are identified and stated simply, but their relevance is not clear and there is no attempt at logical linking.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>No relevant content</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
</tr>
</tbody>
</table>

**Indicative content**

**properties**
- alpha is the least penetrating
- alpha is the most ionising
- alpha has least range in air
- beta is the second most penetrating
- beta is the second most ionising
- beta has the second longest range in air
- gamma is the most penetrating
- gamma is the least ionising
- gamma has the greatest range in air

**hazard** (linked to correct property)
- short-range alpha most dangerous
- mid-range beta most dangerous
- long range gamma most dangerous

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(a) atoms / electrons gain energy

(some) electrons move to a higher energy level

*allow (sub) shell for energy level*

(so) as the electrons fall to a lower / original energy level

*allow (sub) shell for energy level*

(EM) radiation with a frequency / wavelength within the visible region of the spectrum is emitted
(b) there should be two electrons on the inner shell (not three)

there should only be four electrons in the outer shell
or
there should only be six electrons in total

there should be one more proton

allow should be six protons

there should be one fewer neutron

allow should be seven neutrons

allow 2 marks for one of the neutrons should be a proton

(c) \[ \begin{array}{c}
  0 \\
  -1 \\
\end{array} \]

(d) a neutron splits into a proton and an electron

allow beta particle for electron

so there is an extra proton (in the nucleus)

(e) 12.5% is 3 half lives
or
5730 \times 3

17 190 (years old)

an answer of 17 190 (years old) scores 2 marks

(a) both have 6 electrons

both have 6 protons

carbon-12 contains 6 neutrons but carbon-14 contains 8 neutrons

allow carbon-14 has 2 more neutrons
(b) \[ \frac{17190}{5730} = 3 \text{ (half lives)} \]

\[(20 \times 2 \times 2 \times 2 =) 160\]

*an answer of 160 scores 2 marks*

(c) carbon-14 is in (some) carbon dioxide (in air)

carbon-14 / carbon dioxide taken in (by plants) in photosynthesis

becomes part of glucose / starch / carbohydrate

plant eaten by humans / herbivores / passed up food chain

*allow carbon compounds passed up food chain*

starch is digested

or

glucose diffuses into cells

or

glucose stored as glycogen in cells

(a) 10 000

(b) *Increase*

absorb electromagnetic radiation

*Decrease*

emit electromagnetic radiation

(c) atomic number is the number of protons

mass number is the number of protons and neutrons
(d) **Level 2 (3–4 marks):**
A clear comparison, with logical structure.

**Level 1 (1–2 marks):**
Fragmented points, with no logical structure.

**0 marks:**
No relevant content

**Indicative content**

**Beta decay**
- Atomic number increases by one
- When a neutron decays into a proton

**Alpha decay**
- Atomic number decreases by two
- When an alpha particle is emitted

**Comparison**
Both change number of protons (hence new element / transmutation)
Beta decay increases atomic number and alpha decay decreases (explicit)

NB No credit is given for different number of protons = new element.