AQA GCSE PHYSICS (HIGHER) · 8463

PHYSICS



MARK SCHEME

4.4.2 ATOMS AND NUCLEAR RADIATION (PACK 3)

SCORE	PERCENTAGE
/146	%

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Q1.

(a) gamma

1

(b) alpha

1

(c) gamma

1

(d)

isotope	number of neutrons	number of protons
uranium-238	146	**92**
thorium-234	**144**	90

1

1

(e) Δθ = 80 °C

1

E = 150 × 4200 × 80

1

E = 50 400 000 (J)

allow 50 000 000 (J)

1

*allow **max 2** marks for correct calculation using incorrect value of Δθ*

*allow **1** mark for correct calculation using θ = 20 **or** θ = 100*

*an answer of 50 400 000 scores **3** marks*

[8]

Q2.

(a) 2 charged particles and 2 neutral particles

1

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

1

(c) it has a very long range in air

1

(d) risk / activity associated with iodine-131 has decreased by a large amount

1

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

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point

1

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

allow activity has halved

1

because of long half-life

allow only one half-life has passed

4th marking point dependent on 3rd marking point

1

(e) 5 half-lives

allow any correct method
e.g. ½ × ½ × ½ × ½ × ½ = 1/32

1

5 × 30 = 150

1

1986 + 150 = 2136

1

any calculation using a value of 137 scores zero

*an answer of 2136 scores **3** marks*

[10]

Q3.

(a) a type of electromagnetic radiation

1

(b) a thick sheet of lead

1

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

1

to prevent food poisoning

1

(d) gamma rays cause mutations

1

(e) decrease the distance between the food and the radioactive source

1

increase the time for which the food is close to the radioactive source

1

(f) (because) the source of radiation is not in the food

allow source of radiation is / remains outside food

1

[8]

Q4.

(a) (gamma emission) does not change the number of protons

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1

(because gamma emission) is not a particle

allow (gamma emission) is an (electromagnetic) wave

1

(b) prevents food poisoning

1

(by) killing the bacteria / microorganisms / moulds

1

that produce toxins

ignore references to decay

1

(c) (only) gamma rays can pass (all the way) through packaging (to reach the food / bacteria)

allow converse

1

(and also) gamma rays pass all the way through the food without damaging / ionising the food

allow converse

1

ignore contamination
ignore no damage to food unqualified

(d) radioactive food contains a source of radiation
or
radioactive food is emitting radiation

1

(whereas)
irradiated food has been exposed to (an external source of nuclear) radiation

1

[9]

Q5.

(a) atoms / electrons gain energy

1

(some) electrons move to a higher energy level

allow (sub) shell for energy level

1

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

allow (sub) shell for energy level

1

(EM) radiation with a frequency / wavelength within the visible region of the spectrum is emitted

1

(b) there should be two electrons on the inner shell (not three)

1

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

1

there should be one more proton

allow should be six protons

1

there should be one fewer neutron

allow should be seven neutrons

1

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

(c) $^{0}_{-1}e$

1

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

allow beta particle for electron

1

so there is an extra proton (in the nucleus)

1

(e) 12.5% is 3 half lives
or
5730 × 3

1

17 190 (years old)

1

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

[13]

Q6.

(a) horizontal line drawn from
92 000 Bq

allow 90 000–94 000

1

1600 years

allow 1500–1700

1

(b) only (119) years have passed

1

activity has not dropped by much

1

(c)

Level 3: Relevant points (reasons/causes) are identified, given in detail and logically linked to form a clear account.	5-6

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Level 2: Relevant points (reasons/causes) are identified, and there are attempts at logically linking. The resulting account is not fully clear.	3-4
Level 1: Points are identified and stated simply, but their relevance is not clear and there is no attempt at logical linking.	1-2
No relevant content	0
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	

6

[10]

Q7.

(a) atoms with the same number of protons

allow atoms of the same element

1

but with a different number of neutrons

1

(b) protons = 11

1

neutrons = 12

1

(c) electrons falling to a lower energy level

1

(d)

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Level 2: Scientifically relevant facts, events or processes are identified and given in detail to form an accurate account.	3-4
Level 1: Facts, events or processes are identified and simply stated but their relevance is not clear.	1-2
No relevant content	0
Indicative content **solid** • atoms closely packed • atoms in a regular arrangement • atoms vibrate about a fixed position **liquid** • atoms are close together • atoms are not in regular arrangement • atoms can move past each other **gas** • atoms are well separated • atoms are not in regular arrangement • atoms move randomly at high speeds	

4

(e) 60 × 60

1

E = 150 × 3600

1

E = 540 000 (J)

*an answer of 540 000 (J) scores **3** marks*

1

(f) less energy transferred

1

not as bright

1

[14]

Q8.

(a) any **one** from:

- heating
- electricity
- electromagnetic radiation

1

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(b) electromagnetic radiation is emitted

1

in the (visible) region of the spectrum

allow as light

1

(c) $(3.0 \times 10^{-2} =) 0.03$

1

(2.7 / 0.03 =) 90

*an answer of 90 scores **2** marks*

1

(d) any **one** from:

- can't see X-rays
- not common experience
- experience of cancer / severity of consequence
- lack of understanding of probability

allow people are scared of X-rays / radiation

1

(e)

Level 3: Relevant points (reasons/causes) are identified, given in detail and logically linked to form a clear account.	5-6
Level 2: Relevant points (reasons/causes) are identified, and there are attempts at logically linking. The resulting account is not fully clear.	3-4
Level 1: Points are identified and stated simply, but their relevance is not clear and there is no attempt at logical linking.	1-2
No relevant content	0
Indicative content **uses** • used to diagnose problems • X-rays and CT scans • sterilising instruments • because it kills bacteria • radiotherapy • to treat cancer • used to kill cancer cells • medical tracers • gamma knives **harm**	

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• can change / mutate DNA • causing cells to grow uncontrollably • causing tumours / cancer • from regular exposure causing increased dose • to eggs / sperm / embryos	

6

[12]

Q9.

(a) both have 6 electrons

1

both have 6 protons

1

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

allow carbon-14 has 2 more neutrons

1

(b) $\frac{17\,190}{5730} = 3$ (half lives)

1

(20 × 2 × 2 × 2 =) 160

*an answer of 160 scores **2** marks*

1

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

1

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

1

becomes part of glucose / starch / carbohydrate

1

plant eaten by humans / herbivores / passed up food chain

allow carbon compounds passed up food chain

1

starch is digested
or
glucose diffuses into cells
or
glucose stored as glycogen in cells

1

[10]

Q10.

(a) The nucleus will emit a neutron.

1

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(b) **Similarity**

same mass number

allow same number of nucleons (protons + neutrons)

1

difference

different atomic number

allow different number of protons

1

(c) Radioactive decay is random.

1

(d) 1.3 (billion years)

allow 1.2-1.4 (billion years)

2

*allow **1** mark for horizontal line drawn from ~ 550*

(e) alpha

1

[7]

Q11.

(a) electromagnetic radiation from the nucleus

'electromagnetic radiation' is insufficient

1

(b) (Gamma is the most penetrating) so a large proportion of the emitted radiation will leave the body

1

more easily detected outside the body

1

(c) (average) time it takes for the number of nuclei of the isotope in a sample to halve

or

(average) time it takes for the count rate from a sample containing the isotope to fall to half its initial level

1

(d) initially there is a high level of hazard.

1

level of hazard drops to a low level quickly

1

answer must imply short period of time

(activity initially high) due to short half-life

or

(drops to safe level quickly) due to short half-life

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1

(e) it is exposed to ionising radiation

1

(f) does not become radioactive

1

[9]

Q12.

(a) 10 000

1

(b) **Increase**

absorb electromagnetic radiation

1

Decrease

emit electromagnetic radiation

1

(c) atomic number is the number of protons

1

mass number is the number of protons and neutrons

1

(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.

4

[9]

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Q13.

(a) (mass number) 231

1

(protons) 92

1

(neutrons) 141

1

(b) 2 / two (hours)

1

(because) count rate halves in that time

1

(c) A high-speed electron

1

(d) uncontrolled

1

benign

1

[8]

Q14.

(a) half-life read from graph = 2 hours

1

time to fall to 1.56 is six half lives = 6 × 2 = 12 (hours)

1

(b) $^{210}_{82}Pb \longrightarrow {}^{206}_{80}Hg + {}^{4}_{2}He$

one mark for each correct element in the equation

3

(c) ionising radiation turns atoms into ions

1

which can break up molecules

1

this can change DNA

1

causing mutations to genes

1

which can cause cancer

1

[10]

Q15.

(a) gamma

*allow **1** mark for 1 or 2 correct*

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beta

alpha

2

(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

2

(c) as time increases count rate decreases

1

count rate halves every 80 seconds

1

(d) half-life is 80 seconds

1

so after 200 seconds count rate = 113

1

(e) because a very small amount of radiation will be emitted **or** will be similar to / same as background radiation

1

[9]

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Q1.

(a) In the first of three multiple choice questions about radiation the majority of students chose the correct answer for the most penetrating.

(b) Just 51% knew the most ionising radiation.

(c) 46% knew which radiation has the longest range.

(d) 77% of students scored at least 1 mark and 66% scored both for correctly determining the number of protons and neutrons in the nuclei.

(e) In this calculation, students were asked to choose the appropriate equation from the Physics Equations Sheet and most did so successfully. The majority of students gained all 3 marks. Some students did not use the correct temperature change. As in other questions, students should check the number of zeros in their workings and final answer.

Q2.

(a) 51% of students knew what an alpha particle consists of.

(b) 70% of students knew that a particle of beta radiation has a negative charge.

(c) 63% of students knew that gamma radiation has a very long range in air.

(d) 45% of students scored marks on this question. Students who failed to score often understood there is a risk associated with nuclear radiation but were unable to relate that to the changing levels of radiation with time. There were lots of misconceptions about half-life, the most common being that iodine-131 would not emit any radiation after two half-lives.

Q3.

(a) 77% of students knew gamma rays are a type of electromagnetic radiation.

(b) 66% of students knew that a thick sheet of lead would be the best absorber of gamma radiation.

(c) Over half of students knew that bacteria on food are killed to decrease the rate of decay of food. Fewer knew that this helps prevent food poisoning, with many believing it removes dirt from food.

(d) 19% of students knew that gamma rays kill bacteria by causing mutations. Most students responded that gamma rays decrease the size of bacterial cells.

(e) 34% of students could select both choices describing how food producers could increase the level of radiation that the food is exposed to.

(f) 3% of students understand that for food to be radioactive, the source needs to be within the food itself. Common misconceptions and incorrect answers seen include:

- bacteria / viruses / pathogens are affected by the gamma radiation, but the food itself isn't

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- irradiation is the opposite of radioactivity
- it is impossible for food to be radioactive
- the food was not exposed to the gamma rays for long enough to become radioactive.

Q4.

(a) 26% of students could identify that gamma emission is an electromagnetic wave. 2% of students could explain that gamma emission does not change the number of protons.

(b) The most common mark awarded was for the idea that irradiating food kills microorganisms. Answers were often too vague regarding preventing food poisoning, with more students referring to best before dates, which was insufficient.

Misconceptions referring to the half-life of the food being extended were seen. There were also misconceptions regarding food that has been irradiated becoming radioactive.

(c) Some students could relate their knowledge of properties of gamma radiation to being able to pass through packaging. Recall of penetration properties needed to be applied to the situation given in the question.

(d) Some students could state that irradiated food has been exposed to a source of radiation, or that radioactive food emits radiation, however, 6% of students did both to give a full answer. The most common misconception was that the term irradiated means removing a source of radiation from food.

Q5.

(a) 84% of students did not gain any marks in this high demand question. 3% of students achieved three or four marks. The most common mark given was for electrons / atoms gaining energy.

(b) This question discriminated between students very well with almost equal proportions of students spread across the mark range. Students would appear to have a sound understanding of atomic structure, with 85% achieving at least one mark, and 20% achieving full marks.

Common misconceptions were that ‘electrons must be drawn in pairs’ and ‘neutrons should equal protons’. Some stated that the number of protons, electrons and neutrons was wrong without stating details.

(c) 69% of all students answered this question correctly. The fourth option was the most common incorrect choice.

(d) A significant number of students gave answers in term of nitrogen changing into carbon. Few answers offered the complete story of a neutron splitting to produce a proton and an electron.

There was considerable confusion about the meaning of the subscripted and superscripted numbers preceding the atomic symbols. The subscripted number was taken to be the number of electrons. As a result many answers were in terms of atomic number increasing because an electron had been gained. 16% of students achieved one or two marks for this question.

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(e) 13% of students understood the idea of half-life sufficiently to achieve both marks. Otherwise students attempted to calculate 12.5% of 5730. The most common reasonable error was to use the calculation for 4 half-lives.

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