AQA GCSE PHYSICS (HIGHER) · 8463

PHYSICS



MARK SCHEME

4.4.2 ATOMS AND NUCLEAR RADIATION (PACK 2)

SCORE	PERCENTAGE
/208	%

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Q1.

(i) nucleus / neutron

*do **not** accept shells or orbits*

1

(ii) neutron changes to a proton **or** number of neutrons goes down 1 and the number of protons goes up by 1

*do **not** accept becomes positive*

1

[2]

Q2.

(a) bigger

accept any word which means bigger

1

(b) **Z**

if Z is not given, the reason does not score

1

alpha will not pass through aluminium or lead

accept alpha cannot go through metals / dense material
accept there is nothing to stop the radiation
accept alpha will not pass through aluminium
*do **not** accept alpha will not pass through lead*
*do **not** accept alpha stopped by air*

1

[3]

Q3.

(a) all points correctly plotted

tolerance ± $\frac{1}{2}$ square on y axis only

*allow **1** mark for 3 correctly plotted points*

2

attempt made to draw a smooth curve

*do **not** accept dot-to-dot line*

1

(b) (i) 3 days $\pm$ 0.2
or any value correctly obtained using their graph line

if no line drawn in (a), answer must be exactly 3

1

(ii) 3 days or their (b)(i)

1

(c) radon-222

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*accept radon **or** 222*
accept alpha or 3.8
correct isotope required for reason to score

1

has the shortest half-life

accept the others have longer half-lives

1

[7]

Q4.

(i) $\frac{1}{4}$

accept 0.25 or 25%

1

(ii) 2600

if answer to (c)(i) is ½ then accept 1300

1

[2]

Q5.

(a) (i) element with equal number of protons, different number neutrons
or
same atomic/proton number different mass/nuclear number

1

(ii) time taken for activity **or** count rate **or** number of nuclei to decrease to half

*accept parents atoms **or** radioactive isotope*

do not accept time taken for radioactivity/substance/ material to halve

1

(iii) 12 (s)

1

(b) (i) 22800 (years)

*allow 1 mark for iterative steps 80-40-20-10-5 **or** statement of 4 half-lives*

2

(ii) decay (of carbon 14) over 150 years is insignificant

accept very little decay

accept change is too small

1

(c) either argument gains full credit

accept any 3 valid points from for and/or against arguments

FOR

– massive dilution of waste
– reduces concentration (within a given volume) to insignificant levels
– distant from habitation

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AGAINST

– pollution (of the sea/beach)
– mutation **or** harm caused to living things (animals/plants)
– effect on food chain
– long period of time necessary

3

[9]

Q6.

(a) electron

accept e

1

(b) 5400 – 7000

horizontal line drawn corresponding to their halving

1

or

a cross in the correct position on the line

1

(c) count rate converted to 14.5/min for 1g mass

accept 14.5 clearly marked on graph

1

decay time taken as 750 years ± 100 years

accept 750 years clearly marked on graph

1

refer their answer to 837 years (or approximately 800 **or** a value 837 - 937 years)

no the shirt was made after he died (if numbers justify)

or

yes it could have been his shirt (if numbers justify)

allow an alternative answer working backwards from 837 years

1

[6]

Q7.

(a) (i) helium nuclei

1

or

two protons and two neutrons or $^{4}_{2}$He

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*do **not** accept it is a particle emitted by an unstable nucleus of Californium -241*

(ii) time taken for the activity **or** count rate **or** number of nuclei **or** number of atoms **or** number of radioactive particles to decrease to half

1

(iii) Technetium-99

*this mark **cannot** score without Technetium- 99*

1

any **two** of the following:

- suitable short half-life or activity quickly reduced to a safe level or it doesn't stay in the body long

  *this mark **can** score if Cobalt -60 is given*

- (gamma emitter so) it can be detected outside the body

- less (ionising) damage to cells **or** tissue

  *this mark **can** score if Cobalt -60 is given*

2

(b) any **three** of the following:

- transport of waste into the area
- possibility of accident or leakage from transport
- safe levels not reached for hundreds or thousands of years
- Possible leakage **or** contamination of land **or** water **or** increase in background radiation
- increased risk of (radiation linked) illness **or** cancer

3

[8]

Q8.

(a) presence of a radioactive source

*accept radioactivity **or** radioactive or radiation*

accept a named source

accept a named type of radiation ignore reference to relative levels

*do **not** accept thermal **or** heat radiation*

*do **not** accept nuclear waste*

1

(b) (i) gamma

accept correct symbol

1

(ii) alpha

accept correct symbol

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1

[3]

Q9.

(a) (i) it is random

*do **not** accept unpredictable*

*do **not** accept irregular*

1

(ii) source adds nothing **or** little to the count

1

continues to record background level

accept a clear explanation of background

1

(b) (i) an electron

accept $\overset{0}{\underset{-1}{}}e$

1

(ii) <u>electromagnetic</u> wave with **high frequency** or short wavelength

*must have high frequency **or** short wavelength*

1

(iii) 15

*allow **1** mark for **3** iterative steps 584/2 292/2 146/2*

allow I mark for 45/3

3

(iv) [A] a safe level of radiation reached much quicker

could answer in terms of isotope but answer must be clear whether it refers to isotope or sodium-24

1

[B] long enough to obtain measurements

1

[10]

Q10.

(a) suitable arrangement of source and GM tube ie <u>fixed distance apart</u>

accept 'detector' for GM tube and counter

1

suitable test

*eg introduce absorbing material **or** increase distance between source and GM tube*

1

suitable conclusion

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*alpha that which gives a greatly reduced count with a paper absorber **or** alpha if count decreases rapidly when distance between source and GM tube exceeds 5 cm (approx)*

the first two marks could be scored from a <u>labelled</u> diagram

1

(b) (i) (changes to) background radiation

*do **not** accept the source is decaying if it is their only answer*

or

(beta) decay is random

accept decay is not constant

1

(ii) thickness decreasing

accept it is thin

1

increased count rate

1

(means) less (beta) radiation absorbed

accept more (beta) radiation passes through

1

(iii) changing thickness will not change count rate (significantly)

accept insufficient absorption of gamma radiation irrespective of thickness

*do **not** accept gamma rays too penetrating*

*do **not** accept answers in terms of speed*

1

[8]

Q11.

(a) (i) a helium nucleus

accept $^{4}_{2}He$

accept 2 protons + 2 neutrons

*do **not** accept He*

*do **not** accept helium atom*

1

(ii) nucleus

only answer, no alternative

1

(b) (i) each axis given a linear scale

time axis must go up to 12 days

y-axis must go up to 40 000

1

curve concave to axis drawn

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1

curve shows correct half-life of four days

*do **not** accept a straight line must show one half-life*

check first two plotted points correct to ± half square

*a curve drawn dot-to-dot scores a maximum of **1**mark*

1

(ii) 38 750

no tolerance

*allow **1** mark for 5 half-lives*

*allow **1** mark for showing that 1 250 are undecayed*

3

(c) (i) more radon enters shaft (through cracks in the rock face)

accept radon emitted from surroundings

1

(ii) (alpha) radiation will damage cell structure or ionise cells

accept kill cells

1

causing cancerous growth

*an answer in terms of the daughter product polonium being a solid **or** lodging in the throat and also emitting alpha gains full credit*

1

[11]

Q12.

(a) decrease

for 1 mark

1

(b) (i) none would go through paper

for 1 mark

1

(ii) all would go through paper

for 1 mark

1

(iii) only some absorbed/amount absorbed
depends on thickness of paper

for 1 mark each

2

(c) 1 → 1/2 → 1/4 → 1/8

for 1 mark

3 half lives/3 × 433

for 1 mark

1299 years

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gains 3 marks

3

[8]

Q13.

(a) (i) electron
neutron
proton
nucleus

1 mark for each correct label

4

(ii) H-1 has no neutrons
H-3 has 2 neutrons

more neutrons gets 1 mark

2

(iii) nucleus unstable

2

(b) lead/concrete
lead/concrete needed to stop gamma rays

2

[10]

Q14.

(a) 1.
-1

2

for 1 mark each

(b) (i) 19p,
20n,
19e

all correct for 2 marks
2 correct for 1 mark

2

(ii) K40 has an extra neutron/different number of neutrons/
it has more neutrons/21 neutrons

for 1 mark
NOT fewer neutrons

1

(iii) radioactive/unstable nucleus/ nucleus disintegrates/
emits radiation/it has too many neutrons

for 1 mark

1

(iv) calcium/Ca

for 1 mark

1

(v) 1 (e) in outer shell/same number of electrons/outer electron
same distance from the nucleus

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for 1 mark

1

(c) (i) Geiger-Muller tube (photographic) film

for 1 mark

1

(ii) cancer, leukaemia, radiation sickness etc.

for 1 mark

1

[10]

Q15.

(a) two half lives

gains 1 mark

but
20 minutes

gains 2 marks

2

(b) alphas will be stopped by skin / air **or** do not penetrate betas and gammas can reach / damage organs / cells

for 1 mark each

2

[4]

Q16.

(a) (i) beta and gamma (*any* order)

for one mark

1

(ii) gamma

for one mark

1

(b) (i) particles / atoms / molecules become charged / gain / lose electrons

for one mark

1

(ii) e.g. to kill cancer cells (*allow* any use of alpha, beta or gamma or X^- radiation)

for one mark

1

(c) (i) time taken for no. of atoms / no. of nuclei / mass of U238 / activity to halve – ***not*** radioactivity
or
time taken for count rate to halve

for one mark

1

(ii) atoms with unstable nuclei which emit radiation
(*not* definition of isotope but isotope which is radioactive gets 1 mark)

for 1 mark each

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2

(d) (i) 1 / 4 *accept* 25% or 0.25

for one mark

1

(ii) 2 × half life or 2 × 4500 million years (independent of (i))
gains *1 mark*
but

9000 million years ecf only if answer to (i) is $\frac{1}{2}, \frac{1}{8}, \frac{1}{16}$, etc.

gains 2 marks

2

[10]

Q17.

beta

1

alpha absorbed by paper

allow beta <u>and</u> alpha
second mark is linked to first

1

or beta absorbed by aluminium allow beta can penetrate paper
or gamma would affect all of film

i.e. cannot obtain second mark unless first mark is correct

[2]

Q18.

(a) (i) cannot penetrate aluminium

allow can only pass through air / paper too weak is neutral

1

(ii) gamma rays not affected (by aluminium)

allow <u>all</u> / <u>most</u> (gamma rays) to pass through
too strong is neutral
danger is neutral

1

(b) (i) (nuclei) unstable

1

(ii) causes harm / damage to body / cells

allow radiation sickness

1

detail e.g., causes mutations / causes cancer / damages DNA / damages chromosomes

allow two effects for 2 marks

1

[5]

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Q19.

(a) (i) two protons

1

2 neutrons

if neither point gained allow 1 mark for helium nucleus

1

(ii) electron

1

(b) neutron splits (to form proton and electron)

1

[4]

Q20.

(i) 7 **or** 8

1

correct data extracted from graph e.g. takes 8 days to drop from 50 to 25

allow appropriate annotation of graph

1

(ii) long enough to destroy cancer cells

do not accept dangerous unqualified

1

but short enough to minimise damage to surrounding tissues

1

[4]

Q21.

(a) (i) two protons

1

2 neutrons

if neither point gained allow 1 mark for helium nucleus

1

(ii) electron

1

(b) neutron splits (to form proton and electron)

1

[4]

Q22.

2 weeks

if answer is incorrect 2 gains two marks weeks gains one mark
half of 68 or 34 gains one mark / allow working shown on graph

[3]

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Q23.

neutron becomes proton / neutron emits electron / neutron emits beta particle

gains proton neutral

[1]

Q24.

(a) sensible scales

full use of y axis

1

completely accurate plotting

1

a smooth curve going through all bar one of the points

do not accept a dot-to-dot graph if two parts shown for curves accept the more correct

1

at least one line or a clear mark showing how to obtain the half life from the graph and obtaining between 13 and 15

at the bottom of the page cross or ticks in the order of the mark scheme

1

(b) (i) to let the beta particles get through

accept must be there to let the radiation through ***or*** *if thick they may be stopped*

1

(ii) alpha particles would be stopped by the glass **or** cannot penetrate glass

do not accept alphas are weak

1

(c) (i) it will give more counts per minute for a small quantity **or** it does not last so long so may not be as dangerous

accept answers in terms of 5 years assume it refers appropriately

1

(ii) it will not be there long enough to act as a tracer **or** it could cause radiation damage as all its activity will be in the first place it enters the system

accept answer in terms of 5 seconds

accept not there long enough to work assume it refers appropriately

1

[8]

Q25.

(a) (i) alpha particles cannot penetrate covering

do not credit any answer not relating to film badge or its case

1

(ii) film gets fogged **or** blackened

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accept film gets exposed
*do not credit film changes colour **or** goes white **or** blotchy*

1

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

may cause cancer may damage cells **or** cell nucleii causes mutations changes DNA

*accept (causes) burns **or** kills cells*

1

(ii) any **two** from

treating cancers
tracers in body
sterilising instruments **or** bandages

accept two descriptions of named treatments, eg thyroid check and circulation monitoring

*accept is a source of X-rays, eg for dentistry **or** taking X-rays of bones*

2

(c) calculation that 1000 is 3 half lives on

8000 → 4000 → 2000 → 1000

1

time elapsed is 3 × half life = 31.8 hr

award both marks for 31.8 hr or 1 day 7.8 hr with no working shown

1

[7]

Q26.

(a) (i) and (ii) in any order

1

(i) alpha

accept Greek symbol (α)

1

He^{2+} **or** $^{4}_{2}He$

1

(ii) beta

*accept Greek symbol (β) **or** electron*

1

e^{-} or $^{0}_{-1}e$

mass and automatic numbers are not required

accept e

1

(b) (i) alpha

accept symbol

1

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(ii) decreases

then stops (entirely) **or** after a few cm

accept stops because α can only travel a few cm in air

1

(c) it's gamma

*accept its not ionising **or** it is not charged **or** it's not a or β because a spark counter only measures α or β*

1

[8]

Q27.

(a) at least **6** points correctly plotted

gains 1 mark

(to better than half a square) **but all** points correctly plotted

gains 2 marks

2

any **line** graph related to plotted points;
point (3,29) discounted;
best fit smooth curve

each for 1 mark

3

(b) radiation decreases with time

gains 1 mark

but decreases quickly at first then more slowly

gains 2 marks

but *idea that* it (about) halves every 2 weeks **or** half-life is (about) 2 weeks

gains 3 marks

3

[8]

Q28.

(a) one relevant point correctly plotted

gains 1 mark

but two relevant points correctly plotted

gains 2 marks

but three relevant points correctly plotted

gains 3 marks

curved line drawn accurately through the points

for 1 further mark

4

(b) age of igneous rock = 400 ± 100 million years

1

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(c) sandstone is a sedimentary rock

for 1 mark

there is likely to be some lead-207 present
or from the rocks from which the sandstone was formed

for 1 mark

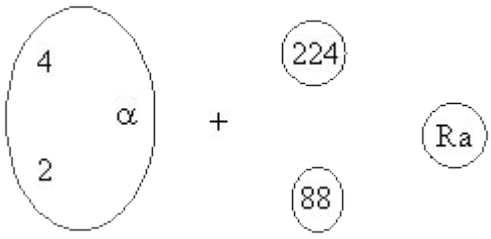
(*allow* ^{207}Pb may not have come from this ^{235}U)

2

[7]

Q29.

(a)

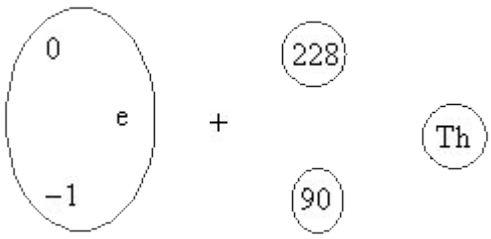


[Accept He^{2+} for α]

each ◯ *for 1 mark*

4

(b)



[Accept β for e]

each ◯ *for 1 mark*

4

(c) (i)

beta/ β		alpha/ α
alpha/ α		beta/ β
beta/ β	but	alpha/ α
alpha/ α		beta/ β

[i.e. consistent for 1; consistent and correct for 2]

gains 2 marks

2

(ii) *ideas that*

- many thorium atoms because they take so long to decay*
- (many lead atoms because) the thorium has been decaying for so long/for billions of years

or (because) the rock is so/very/billions of years of years old

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- many lead atoms because this is the stable end product [of the decay series]
- few atoms of other isotopes because they decay so quickly*

[*N.B. credit answers in terms of half-life]

any three for 1 mark each

3

[13]

Q30.

(a) evidence of $\frac{7350}{15}$

gains 1 mark

but

490

gains 2 marks

but

4900

gains 3 marks

units cm^3

for 1 further mark

4

(b) some of radioactive solution gets into cells/body organs
some of radioactive solution gets into urine (in the kidney)
the radioactive solution becomes less radioactive during the test
variability in readings

in any order for 1 mark each

3

(c) *ideas that*

- won't lose (too) much radioactivity during the test
- won't stay radioactive/harm cells for too long after test is over

for 1 mark each

2

[9]

Q31.

A β / beta
B γ / gamma
C α / alpha

for 1 mark each

[3]

Q32.

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(a) indication (in writing or on graph) of finding point where radiation is halved (e.g. to 24 [from an initial 48]) and relating to the time difference between the two points

gains 1 mark

but
4.2-4.8*
(*i.e. in this range, including extremes)

gains 2 marks

units billions of years

for 1 mark

3

(b) ¾ **or** 75%
[allow ecf from (a)]

for 1 mark

1

(c) (i) *idea that* the intermediate nuclides are relatively short-lived

for 1 mark

1

(ii) *idea that* ¼ has decayed **or** ¾ remains

gains 1 mark

but
read graph for radiation level of 36 (stated or shown on graph itself)

gains 2 marks

but
1.6-1.8* (billion years)
(* i.e. in this range, including extremes)

gains 3 marks

3

[8]

Q33.

(i) (fast moving) electrons (from the nucleus)
(*allow* negatively charged particles)

for 1 mark

1

(ii) protactinium has one neutron fewer
protactinium has one proton more
(*credit* has different numbers of neutrons / protons *with one mark*)

for 1 mark each

2

[3]

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