



Nuclear Radiation and Half Life

Mark Scheme

Name: _____

Class: _____

Date: _____

Time: **101 minutes**

Marks: **101 marks**

Comments:

Mark schemes

1	(a) (i) two protons	1	
	2 neutrons <i>if neither point gained allow 1 mark for helium nucleus</i>	1	
	(ii) electron	1	
	(b) neutron splits (to form proton and electron)	1	[4]
2	(i) 7 or 8	1	
	correct data extracted from graph e.g. takes 8 days to drop from 50 to 25 <i>allow appropriate annotation of graph</i>	1	
	(ii) long enough to destroy cancer cells <i>do not accept dangerous unqualified</i>	1	
	but short enough to minimise damage to surrounding tissues	1	[4]
3	(a) 78	1	
	(b) atomic	1	
	(c) (i) 131 <i>correct order only</i>	1	
	54	1	
	(ii) 32 (days) <i>allow 1 mark for showing 4 half-lives provided no subsequent step</i>	2	
	(iii) limits amount of iodine-131 / radioactive iodine that can be absorbed <i>accept increases level of non-radioactive iodine in thyroid</i> <i>do not accept cancels out iodine-131</i>	1	

so reducing risk of cancer (of the thyroid)
accept stops risk of cancer (of the thyroid)

1

[8]

4

(a) (i) number of protons are the same
accept atomic number / number of electrons for number of protons

1

number of neutrons are different
accept mass numbers are different – only if the first mark is awarded

1

(ii) an electron from the nucleus
both parts needed

1

(b) decays at the same rate as it is made
accept decays as fast as it is made
accept absorbed / used by plants (in CO₂) at same rate as it is being made

1

(c) (i) 3500
no tolerance

1

(ii) adjusted age correctly obtained from the graph
accept values between 3700–3800 inclusive
accept their (c)(i) used correctly to obtain an adjusted age from the graph

1

adjusted age +50
second mark can only be scored if first mark awarded
if no working shown an answer between 3750–3850 inclusive scores both marks
note: any line or mark made on the graph counts as working out

1

[7]

5

- (a) sensible scales
full use of y axis 1
- completely accurate plotting 1
- a smooth curve going through all but 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]

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- (a) (i) beta and gamma
both answers required
accept correct symbols 1
- (ii) alpha and beta
both answers required
accept correct symbols 1
- (iii) gamma
accept correct symbol 1

- (b) nothing (you do to a radioactive substance / source) changes the count rate / activity / rate of decay / radiation (emitted)

accept it = radiation emitted

or (reducing) the temperature does not change the activity / count rate / rate of decay / radiation (emitted)

1

- (c) (i) has one more neutron

correct answer only

1

- (ii) 14 days

no tolerance

allow 1 mark for showing a correct method on the graph

2

- (iii) any **two** from:

- beta particles / radiation can be detected externally
- beta particles / radiation can pass out of / through the plant
- long half-life gives time for phosphorus to move through the plant / be detected / get results
- phosphorus-32 is chemically identical to phosphorus-31
- phosphorus-32 is used in the same way by a plant as phosphorus-31

2

[9]

7

- (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

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]

8

(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) $\frac{3}{4}$ **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 $\frac{1}{4}$ has decayed **or** $\frac{3}{4}$ 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]**9**

- (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 $\frac{0}{-1} e$

1

- (ii) electromagnetic 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 1 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]

10

- (a) (i) (atoms / elements with) the same number of protons but different numbers of neutrons

accept (atoms / elements with) different mass number but same atomic number

1

- (ii) substances that give out radiation

accept alpha, beta or gamma for radiation

accept an unstable nucleus that decays

radioactive decay takes place is insufficient

1

- (b) 85 years

± 2 years

allow 1 mark for showing correct method on the graph

2

- (c) (i) a helium nucleus

accept 2 neutrons and 2 protons

accept ${}_2^4\text{He}$

*do **not** accept helium atom*

1

- (ii) the rate of decay (of plutonium) decreases

accept fewer (plutonium) nuclei (to decay)

accept radioactivity decreases

1

less heat produced

*do **not** accept energy for heat*

1

- (d) (i) (outside the body)

alpha (particles) cannot penetrate into the body

(inside the body)

1

(heat produced from decay) damages / kills cells / tissues

accept causes cancer for damages / kills cells / tissues

*accept **highly** toxic*

1

(ii) any **one** from:

- worried same could happen again
 - an accident may cause radiation to be spread around the Earth / atmosphere
 - idea of soil contamination resulting from accident / release of radioactive material
 - idea of negative effect on health resulting from accident / release of radioactive material
- accept any sensible suggestion*

1

[10]

11

(a) cobalt-(60)

1

gamma (radiation) will pass through food / packaging

this can score if technetium chosen

1

long half-life so level of radiation (fairly) constant for (a number) of years

this can score if strontium / caesium is chosen

accept long half-life so source does not need frequent replacement

accept answers in terms of why alpha and beta cannot be used

gamma kills bacteria is insufficient

1

(b) (i) people may link the use of radiation with illness / cancer

accept (they think) food becomes radioactive

accept (they think) it is harmful to them

'it' refers to irradiated food

1

(ii) not biased / influenced (by government views)

1

(iii) any **two** from:

- data refers only to (cooked) chicken
 - data may not generalise to other foods
 - the content of some vitamins increases when food / chicken is irradiated
 - no vitamins are (completely) destroyed
 - (only) two vitamins decrease (but not significantly)
- accept irradiated chicken / food contains a higher level of vitamins*
marks are for the explanation only

2

- (iv) so can choose to eat / not eat that (particular) food
*accept irradiated food may cause health problems
 (for some people)
 accept people may have ethical issues
 (over eating irradiated food)*

1

- (c) (i) electron
 from nucleus / neutron
both parts required

1

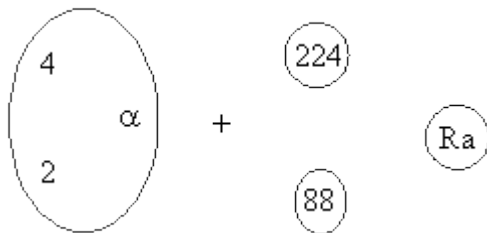
- (ii) 90 years
allow 1 mark for showing 3 half-lives

2

[11]

12

(a)

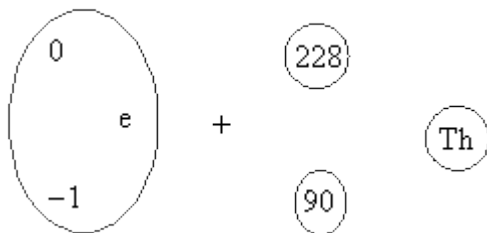


[Accept He²⁺ for α]

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

(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
- 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

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