



Atoms and Radiation 2

Name: _____

Class: _____

Date: _____

Time: **332 minutes**

Marks: **332 marks**

Comments:

Mark schemes

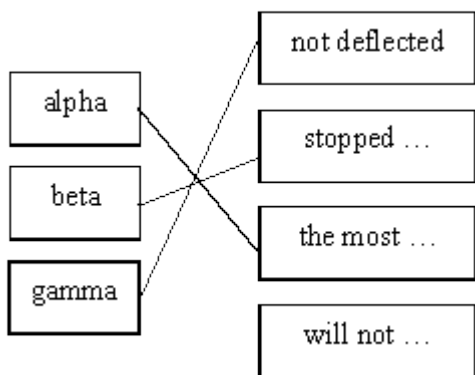
1

- (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]

2

(a) 3 lines correctly drawn



1 mark for each correct line if more than one line is drawn from a box in List A all lines from that box are wrong

3

(b) nucleus

accept nuclei
do **not** accept nuclear

1

(c) Y

do **not** accept gamma

any **two** from:

do **not** accept other properties of gamma

- least dangerous (inside the body)
do **not** accept not dangerous
accept not as harmful as alpha
(inside the body)
- least ionising
- penetrates through the body
do **not** accept can be detected externally
- is a gas / can be breathed in
accept it is not a solid
(cannot score if Z chosen)
if X chosen can score this gas mark
if Z chosen can score **both** gamma marks

1

2

(d) any **one** from:

*do **not** accept kills bacteria*

- longer shelf life
accept stays fresh longer / stops it going bad / mouldy
- food can be supplied from around the world
- wider market for farmers
- cost to consumers (may be) lower
- less likely to / will not get food poisoning
accept infection / disease / ill for food poisoning

1

[8]

3

(i) 50 ± 5

1

(ii) 50 ± 5

accept their (b)(i)

1

(iii) less

accept any way of indicating the correct answer

1

[3]

4

answers must be comparative

accept converse answers throughout

alpha: the count rate is (greatly) reduced
by the card **or** the card absorbs alphas but not betas

accept paper for the card

1

beta: the count rate is (greatly) reduced by the metal **or** the thin metal absorbs alphas and betas **or** the thin metal absorbs all of the radiation (from the source)

accept aluminium for the metal

1

gamma: would pass through the thin

accept aluminium for the metal

metal but count rate is background **or** no radiation passing through **or** a higher reading would be recorded **or** to reduce the count to 2 would require much more than 3 mm of metal

accept lead / aluminium for the metal

1

[3]

5

(a) (i) two protons and two neutrons **or** the nucleus of a helium atom

1

(ii) different numbers of neutrons **or** one has (3) more or less neutrons than the other

accept different mass (numbers)

if give a number as a difference it must be 3

1

(iii)

if polonium or hydrogen chosen gets 0 marks

technetium (99) or none

1

any **two** from:

*do **not** accept gamma rays are less dangerous*

gamma rays less dangerous inside the body

gamma radiation less likely to be absorbed by cells **or** gamma rays do not ionise cells

gamma rays can penetrate the body (to be detected externally)

first 3 points valid if either technetium or iridium or none is given

2

short half-life so safe levels inside body soon reached

half-life long enough to obtain measurements

half-life short enough not to cause long term damage

last 3 points valid if either technetium or uranium or none is given

(b) 2200 ± 200

allow 1 mark for attempted use of 70% on the graph

2

[7]

6

(a) 95

1

(b) alpha

1

accept correct symbol

(c) any **two** from:

- radiation is outside the body

accept detector is on ceiling or high up the wall

- radiation will not reach (living) cells

accept radiation cannot pass through the body / skin

- radiation absorbed by the air

accept cannot pass through the plastic casing

*do **not** accept because it is alpha radiation – unless qualified*

*do **not** accept does not give off harmful substance*

*do **not** accept cannot pass through building materials etc*

2

(d) less (than)

1

[5]

7

(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]

8

(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]

9

(a) all points correctly plotted

tolerance $\pm \frac{1}{2}$ 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

*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]

10

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

accept 0.25 or 25%

1

(ii) 2600

if answer to (c)(i) is $\frac{1}{2}$ then accept 1300

1

[2]

11

(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]

12

- (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 \pm 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]

13

(a) (i) helium nuclei 1

or

two protons and two neutrons or $\frac{4}{2}$ He

*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]

14

(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

1

[3]

15

(a) (i) it is random
*do **not** accept unpredictable*
*do **not** accept irregular*

1

(ii) source adds nothing **or** little to the count
 continues to record background level
accept a clear explanation of background

1

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]

16

- (a) suitable arrangement of source and GM tube ie fixed distance apart
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

*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 labelled 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]

17

- (a) (i) a helium nucleus

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

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 \pm 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]

18

(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) $1 \rightarrow 1/2 \rightarrow 1/4 \rightarrow 1/8$

for 1 mark

3 half lives/ 3×433

for 1 mark

1299 years

gains 3 marks

3

[8]

19

- (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
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
 $8000 \rightarrow 4000 \rightarrow 2000 \rightarrow 1000$ 1

time elapsed is $3 \times \text{half life} = 31.8 \text{ hr}$

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

[7]

20

- (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]

21

(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

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]

22

- (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]

23

- (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

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]

24

beta

1

alpha absorbed by paper

allow beta and 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]

25

(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 all / most (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]

26

- (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]

27

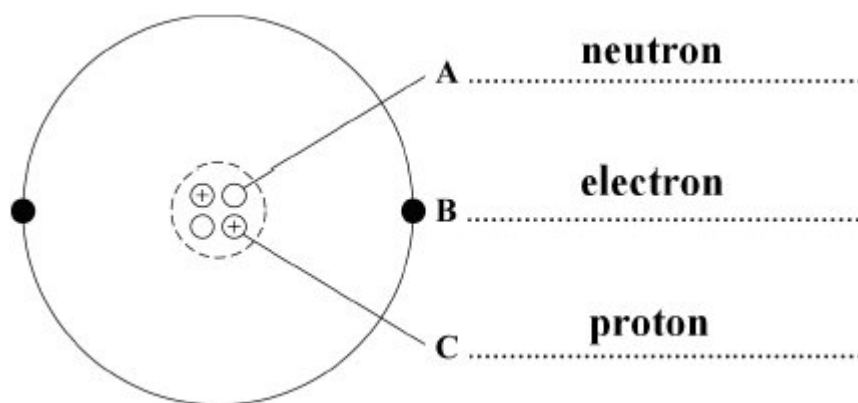
- (i) 7 or 8 1
- correct data extracted from graph e.g. takes 8 days to drop from 50 to 25
allow appropriate annotation of graph 1
- (ii) long enough to destroy cancer cells
do not accept dangerous unqualified 1
- but short enough to minimise damage to surrounding tissues 1
- [4]

- 28** (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]**

- 29** (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]**

30

(a) (i)



all 3 labels correct
allow 1 mark for 1 correct label

2

(ii) has no electrons

it = alpha

allow alpha has a positive(charge)

allow a helium (atom) has no (charge)

*do **not** accept general properties of alpha*

*do **not** accept general answers in terms of size / density / mass etc*

1

(b) (i) 15 (hours)

accept any answer between 14.8 and 15.2 inclusive

1

(ii) 15 (hours) or their (b) (i)

1

(c) (i) americium-241 has a long half life

1

(ii) any **one** from:

- alpha (particles) are harmful to ...
accept radiation / radioactive material is harmful to ...
accept specific example of harm
eg can cause cancer
accept radiation is poisonous if ingested / inhaled
*do **not** accept it is poisonous / in case of leakage*
- so they dispose of it safely / appropriately
- so they don't break it open / open it
*accept do **not** touch the radioactive source*
- so they can make a choice about having a radioactive source (in the house)
it = radioactive material

1

[7]

31

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]

32

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

gains proton neutral

[1]

33

(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]

34

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

1

(i) alpha
accept Greek symbol (α)

1

He^{2+} **or** ${}^4_2\text{He}$

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
- (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 α or β because a spark counter only measures α or β* 1

[8]

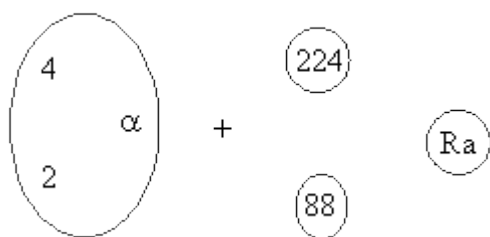
35

- (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
- (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]

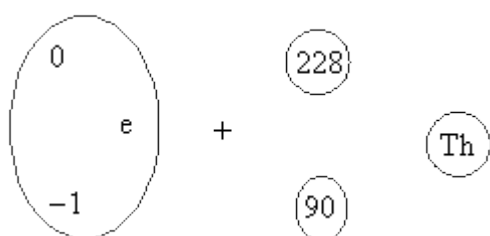

36

(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
- 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]

37

(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]

38

- A β / beta
B γ / gamma
C α / alpha

for 1 mark each

[3]

39

- (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]

- 40** (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]**

- 41** (a) (i) gamma hardly ionises the air
accept does not ionise
accept gamma radiation is not charged
do not accept answers in terms of danger of gamma or other properties 1
- (ii) half-life (too) short
accept need frequent replacement 'it' refers to curium-242 1
- (iii) (two) fewer neutrons
accept different numbers of neutrons if a number is specified it must be correct
do not accept more neutrons unless curium-244 is specified 1
- (b) (i) gamma
accept correct symbol 1
- (ii) both absorbed by the metal / steel / weld
only scores if (b)(i) is correct
accept cannot pass through the metal / steel / weld 1
- (c) (i) put source into water at **one** point on bank
accept the idea of testing different parts of the river bank at different times 1
- see if radiation is detected in polluted area
accept idea of tracing 1

(ii) 2.7 (days)

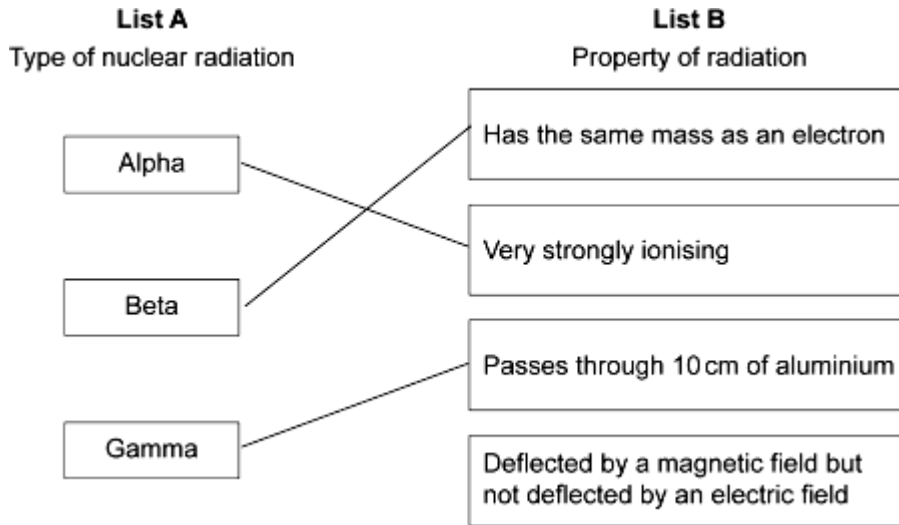
allow 1 mark for showing correct use of the graph

2

[9]

42

(a) 1 mark for each correct line



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

3

(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*

1

more beta (particles / radiation) is being absorbed / stopped

accept radiation for beta particles / radiation

accept fewer particles being detected

1

(ii) six years

1

- (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

1

[7]

43

- (a) beta

1

alpha: would not pass through (the aluminium / foil)

1

gamma: no change in count rate when thickness changes

must be a connection between detection / count rate / passing through and change in thickness

1

- (b) foil thickness increases then decreases (then back to normal / correct thickness)
a description of count rate changes is insufficient

1

gap between rollers decreases, then increases (then back to correct size)

or

pressure from rollers increases then decreases

accept tightness for pressure

answers may link change in thickness and gap width for full credit

ie:

foil thickness increases so gap between rollers decreases (1)

foil thickness decreases so gap between rollers increases (1)

1

- (c) 56 (years)

accept any value between 55-57 inclusive

allow 1 mark for correct calculation of mass remaining as 1.5 (micrograms)

allow 1 mark for a mass of 4.5 micrograms plus correct use of graph with an answer of 12

maximum of 1 compensation mark can be awarded

2

[7]

44

- (a) (i) L

1

(ii) **M**

1

(b) To make a smoke detector work.

1

(c) **40**

no tolerance

1

[4]

45

(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]

46

- (a) alpha particles **cannot** pass through...
do not accept gamma particles...

or

alpha particles can pass through a very thin sheet of **paper / card**
credit answers where correct amendments are made to boxed statement

1

- (b) (i) horizontal and vertical line drawn at correct positions on the graph
accept a cross drawn at 4500 / 500 on the curve

or

two pairs of lines drawn, for example, at 600 and 300

accept a horizontal line drawn at 500 on its own

do not accept vertical lines only

1

- (ii) 4500 million years

1

- (iii) half-life too long

do not accept simply its half-life is 4500 million years

1

no (measurable) change in count rate

do not accept have not got the equipment

do not accept it's harmful (to children)

if neither of the above points scored, accept not enough time to measure it for 1 mark

1

[5]

47

- (a) (i) alpha (particle)

1

- (ii) (unstable) nucleus

accept (unstable) nuclei

do not accept middle

do not accept helium nucleus

1

- (iii) same number of protons

accept same number of electrons

accept same atomic / proton number

accept they both have 92 protons

same number of neutrons negates answer

1

- (b) (i) 4500 million years
do not accept 4500 years 1
- (ii) curve starting at 100 000 with a correct general shape 1
- passing through (4500, 50 000) and (9000, 25 000)
allow 1 mark for points plotted
- or**
- line passing through (4500, 50 000) and (9000, 25 000)* 1

[6]

48

- (a) (i) **K and L**
both answers required either order 1
- (ii) (1) same number of protons
accept same number of electrons
accept same atomic number 1
- (2) different numbers of neutrons 1
- (b) (i) 90 1
- (ii) 140 1
- (c) alpha (particle)
reason may score even if beta or gamma is chosen 1
- mass number goes down by 4
or
number of protons and neutrons goes down by 4
or
number of neutrons goes down by 2
*candidates that answer correctly in terms of why gamma
and beta decay are not possible gain full credit* 1

atomic / proton number goes down by 2

or

number of protons goes down by 2

accept an alpha particle consists of 2 neutrons and 2 protons for 1 mark

accept alpha equals ${}^4_2\text{He}$ or ${}^4_2\alpha$ for 1 mark

an alpha particle is a helium nucleus is insufficient for this mark

1

[8]

49

(a) C

1

(b) beta

accept gamma

if answer alpha can still gain marks for saying why not beta or gamma

1

any **two** from:

must have at least one quantitative statement to get 2 marks

- range in air for beta is (at least) 50cm
- count-rate does not drop (much) in first 40cm
- count-rate does not fall much until distance is 60cm
- alphas cannot travel more than 5cm in air / alphas could not travel 100cm in air

accept alphas cannot travel that far

- alphas would not be detected
- gammas not absorbed by 100cm of air

accept gammas not stopped by air

accept gammas travel further than alphas and betas

strength of source is neutral

references to penetrating power is neutral

2

- (c) (i) increases 1
- (ii) Group **A** think that (even a very small level of exposure) gives some risk
accept there is always a risk, no matter how small the level of exposure 1
- Group **B** think that there is no risk (from a very low level of exposure)
accept below a certain level of exposure there is no risk
no marks for a simple graph description 1

[7]

50

- (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]

51

(a) 146 1

(b) atomic number 1

(c) (i) alpha 1

(ii) number of protons changes
accept atomic number changes
accept loses or gains protons
*do **not** accept protons with any other particle e.g. number of protons and neutrons changes incorrect*
*do **not** accept any reference to mass number* 1

[4]

52

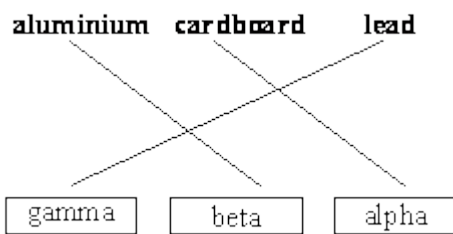
(a) (i) P

1

(ii) Q

1

(b) 3 lines correct



allow 1 mark for 1 correct line

two lines drawn from any source or box – both incorrect

2

(c) (i) K

1

(ii) 56

accept 50 – 60 inclusive

1

(iii) K

1

(iv) to inject... tracer

1

[8]