



Atoms and Nuclear Radiation 1

Name: _____

Class: _____

Date: _____

Time: **160 minutes**

Marks: **159 marks**

Comments:

Mark schemes

| | | | |
|-----|--|---|---|
| 1 | (a) | Alpha – two protons and two neutrons | 1 |
| | | Beta – electron from the nucleus | 1 |
| | | Gamma – electromagnetic radiation | 1 |
| | (b) | Gamma | |
| | | Beta | |
| | | Alpha | |
| | | <i>allow 1 mark for 1 or 2 correct</i> | 2 |
| | (c) | any two from: | |
| | | <ul style="list-style-type: none">• (radioactive) source not pointed at students• (radioactive) source outside the box for minimum time necessary• safety glasses or eye protection or do not look at source• gloves• (radioactive) source held away from body• (radioactive) source held with tongs / forceps | |
| | | <i>accept any other sensible and practical suggestion</i> | 2 |
| (d) | half-life = 80 s | 1 | |
| | counts / s after 200 s = 71 | | |
| | <i>accept an answer of 70</i> | 1 | |
| (e) | very small amount of radiation emitted | | |
| | <i>accept similar / same level as background radiation</i> | 1 | |
| | | [10] | |
| 2 | (a) | 2 protons and 2 neutrons | |
| | | <i>accept 2p and 2n</i> | |
| | | <i>accept (the same as a) helium <u>nucleus</u></i> | |
| | | <i>symbol is insufficient</i> | |
| | <i>do not accept 2 protons and neutrons</i> | 1 | |
| (b) | (i) | gamma rays | 1 |
| | (ii) | loses/gains (one or more) <u>electron(s)</u> | 1 |

(c) any **one** from:

- wear protective clothing
- work behind lead/concrete/glass shielding
- limit time of exposure
- use remote handling

accept wear mask/gloves

wear goggles is insufficient

wear protective equipment/gear is insufficient

accept wear a film badge

accept handle with (long) tongs

accept maintain a safe distance

accept avoid direct contact

1

(d) Marks awarded for this answer will be determined by the Quality of Written Communication (QWC) as well as the standard of the scientific response. Examiners should apply a 'best-fit' approach to the marking.

Level 3 (5 – 6 marks):

There is a description of all three types of radiation in terms of at least two of their properties

or

a full description of two types of radiation in terms of all three properties.

Level 2 (3 – 4 marks):

There is a description of at least two types of radiation in terms of some properties

or

a full description of one type of radiation in terms of all three properties

or

the same property is described for all three radiations

Level 1 (1 – 2 marks):

There is a description of at least one type of radiation in terms of one or more properties.

Level 0 (0 marks):

No relevant information

examples of physics points made in the response

alpha particles

- are least penetrating
- are stopped by paper / card

- have the shortest range
- can travel (about) 5cm in air

- are (slightly) deflected by a magnetic field
- alpha particles are deflected in the opposite direction to beta particles by a magnetic field

beta particles

- (some are) stopped by (about) 2mm (or more) of aluminium/metal
- can travel (about) 1 metre in air
- are deflected by a magnetic field
- beta particles are deflected in the opposite direction to alpha particles by a magnetic field

accept (some are) stopped by aluminium foil

gamma rays

- are the most penetrating
- are stopped by (about) 10cm of lead
- have the longest range
- can travel at least 1 km in air
- are not deflected by a magnetic field

6
[10]

3

- (a) cell damage or cancer

accept kills / mutates cells
radiation poisoning is insufficient
ionising is insufficient

1

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

- use tongs to pick up source
- wear gloves
- use (lead) shielding
- minimise time (of exposure)
- maximise distance (between source and teacher).

accept any other sensible and practical suggestion
ignore reference to increasing / decreasing the number / thickness of lead sheets

1

- (ii) background

1

- (c) (i) curve drawn *from point 2, 160*
do not accept straight lines drawn from dot to dot 1
- (ii) (also) increases
less radiation passes through is insufficient 1
- (iii) 50
accept any value from 40 to 56 inclusive 1
- (d) gamma 1
- only gamma (radiation) can pass through lead
*accept alpha **and** beta cannot pass through lead*
a general property of gamma radiation is insufficient 1

[8]

- 4** (a) (i) splitting of a(n atomic) nucleus
do not accept splitting an atom 1
- (ii) Neutron 1
- (b) (i) nuclei have the same charge
or
 nuclei are positive
accept protons have the same charge 1
- (ii) (main sequence) star
accept Sun or any correctly named star
accept red (super) giant 1

- (c) (i) any **two** from:
- easy to obtain / extract
 - available in (very) large amounts
 - releases more energy (per kg)
- do not accept figures only*
- produces little / no radioactive waste.
- naturally occurring is insufficient*
seawater is renewable is insufficient
less cost is insufficient

2

- (ii) any **one** from:
- makes another source of energy available
 - increases supply of electricity
 - able to meet global demand
 - less environmental damage
 - reduces amount of other fuels used.
- accept any sensible suggestion*
accept a specific example
accept a specific example

1

(d) 12

allow 1 mark for obtaining 3 half-lives

2

[9]

5

(a) neutrons and protons

1

(b) 0

1

(+)1

1

(c) (i) total positive charge = total negative charge

accept protons and electrons have an equal opposite charge

1

(because) no of protons = no of electrons

1

(ii) ion

1

positive

1

- (d) Marks awarded for this answer will be determined by the quality of communication as well as the standard of the scientific response. Examiners should apply a best-fit approach to the marking.

0 marks

No relevant content

Level 1 (1 – 2 marks)

There is a basic description of at least **one** of the particles in terms of its characteristics.

Level 2 (3 – 4 marks)

There is a clear description of the characteristics of **both** particles

or

a full description of either alpha **or** beta particles in terms of their characteristics.

Level 3 (5 – 6 marks)

There is a clear and detailed description of **both** alpha and beta particles in terms of their characteristics.

examples of the physics points made in the response:

structure

- alpha particle consists of a helium nucleus
- alpha particle consists of 2 protons and 2 neutrons
- a beta particle is an electron
- a beta particle comes from the nucleus

penetration

- alpha particles are very poorly penetrating
- alpha particles can penetrate a few cm in air
- alpha particles are absorbed by skin
- alpha particles are absorbed by thin paper
- beta particles can penetrate several metres of air
- beta particles can pass through thin metal plate / foil
- beta particles can travel further than alpha particles in air
- beta particles can travel further than alpha particles in materials eg metals

deflection

- alpha particles and beta particles are deflected in opposite directions in an electric field
 - beta particles are deflected more than alpha particles
 - alpha particles have a greater charge than beta particles but beta particles have much less mass
- or**
- beta particles have a greater specific charge than alpha particles

6

[13]

6

- (a) (i) nuclear reactor

1

star

1

(ii) nuclei are joined (not split)

accept converse in reference to nuclear fission

*do **not** accept atoms are joined*

1

(b) (i) any **four** from:

- neutron
- (neutron) absorbed by U (nucleus)
ignore atom
*do **not** accept reacts*
*do **not** accept added to*
- forms a larger nucleus
- (this larger nucleus is) unstable
- (larger nucleus) splits into two (smaller) nuclei / into Ba and Kr
- releasing three neutrons and energy
accept fast-moving for energy

4

(ii) 56 (Ba)

1

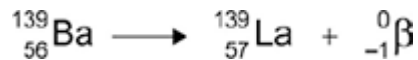
57 (La)

if proton number of Ba is incorrect allow 1 mark if that of La is 1 greater

1



accept e for β

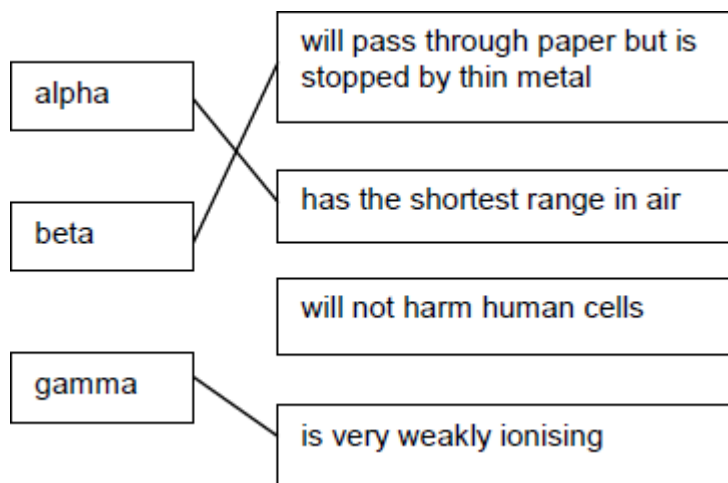


scores **3** marks

1

[10]

7 (a) 3 lines correct



allow 1 mark for each correct line
if more than one line is drawn from any type of radiation box then all of those lines are wrong

(b) Gamma radiation will pass through the body

(c) half

(d) protons

3

1

1

1

[6]

8 (a) 78

(b) atomic

(c) (i) 131

correct order only

54

(ii) 32 (days)

allow 1 mark for showing 4 half-lives provided no subsequent step

(iii) limits amount of iodine-131 / radioactive iodine that can be absorbed

accept increases level of non-radioactive iodine in thyroid

*do **not** accept cancels out iodine-131*

1

1

1

1

2

1

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

1

[8]

9

(a) (i) any **one** from:

- nuclear power (stations)
accept nuclear waste
accept coal power stations
- nuclear weapons (testing)
accept nuclear bombs / fallout
- nuclear accidents
accept named accident, eg Chernobyl or Fukushima
accept named medical procedure which involves a radioactive source
accept radiotherapy
accept X-rays
accept specific industrial examples that involve a radioactive source
nuclear activity / radiation is insufficient
smoke detectors is insufficient

1

(ii) (radioactive decay) is a random process

accept an answer in terms of background / radiation varies (from one point in time to another)

1

(b) any **one** from:

- (maybe) other factors involved
accept a named 'sensible' factor, eg smoking
- evidence may not be valid
accept not enough data
- may not have (a complete) understanding of the process (involved)

1

(c) (i) 2

1

2

1

(ii) 218

correct order only

1

84

1

(d) 3.8 (days)

*allow 1 mark for showing correct method using the graph provided
no subsequent steps*

*correct answers obtained using numbers other than 800 and 400
gain 2 marks provided the method is shown*

2

[9]

10

(a) nucleus

*do **not** accept core / centre / middle*

1

(b) radiation damages our cells

accept radiation is dangerous / poisonous / harmful / toxic

accept radiation can cause cancer / kills cells / change DNA / cause mutations / harm health

accept so precautions can be taken

*accept so they know they may be exposed to / harmed by radiation
it refers to radiation (source)*

to stop people being harmed is insufficient

1

(c) **C**

1

(d) gamma

1

gamma will pass through the lead

reason only scores if gamma chosen

or

alpha and beta will not pass through lead

accept correct symbols for alpha, beta and gamma

1

(e) (i) range of alpha too short

accept alpha would not reach detector

or

alpha absorbed whether box is full or empty

accept alpha (always) absorbed by box / card

accept alpha will not pass through the box / card

alphas cannot pass through objects / solids is insufficient

alpha not strong enough is insufficient

1

(ii) **M**

*reason only scores if **M** chosen*

1

less radiation / beta (particles) absorbed
accept more radiation / beta particles pass through
or
more radiation absorbed by full boxes
accept reading is higher

1

[8]

11

(a) (i) 200 to 50
accept either order

1

(ii) 5.3
accept values between 5.2 and 5.4 inclusive

1

(iii) 5.3
accept values between 5.2 and 5.4 inclusive
or
their (a)(ii)

1

(b) (i) Make the conveyor belt move more slowly

1

(ii) lead

1

(c) Exposure increased the content of some types of vitamin.

1

[6]

12

(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]

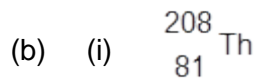
13

- (a) (i) (total) number of protons plus neutrons
accept number of nucleons
accept amount for number
do not accept number of particles in the nucleus 1
- (ii) number of neutrons decreases by one 1

number of protons increases by one

accept for both marks a neutron changes into a proton

1



1

correct order only

1

(ii) the number of protons determines the element

accept atomic number for number of protons

1

alpha and beta decay produce different changes to the number of protons

there must be a comparison between alpha and beta which is more than a description of alpha and beta decay alone

or

alpha and beta decay produce different atomic numbers

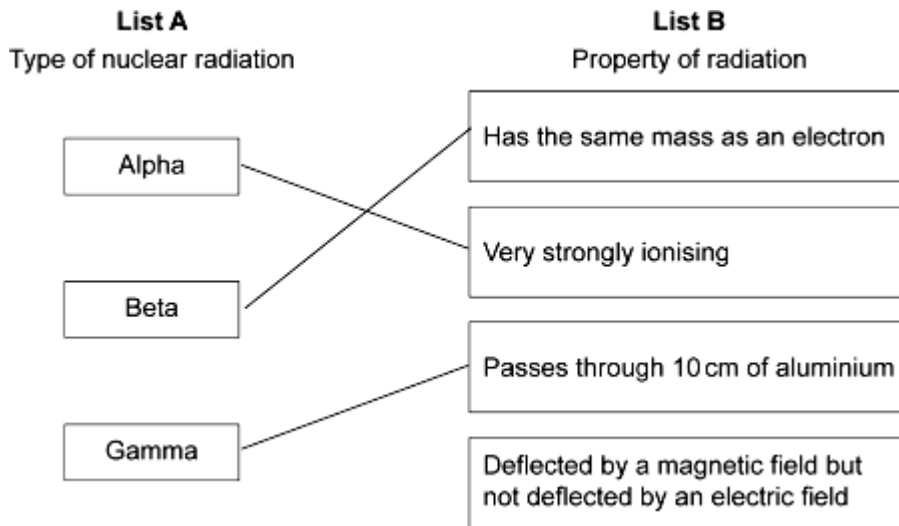
ignore correct reference to mass number

1

[7]

14

(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]

15

- (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]

16

(a) (i) L

1

(ii) M

1

(b) To make a smoke detector work.

1

(c) 40

no tolerance

1

[4]

17

(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]

18

- (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]

- 19** (a) (i) alpha (particle) 1
- (ii) (unstable) nucleus 1
accept (unstable) nuclei
*do **not** accept middle*
*do **not** accept helium nucleus*
- (iii) same number of protons 1
accept same number of electrons
accept same atomic / proton number
accept they both have 92 protons
same number of neutrons negates answer
- (b) (i) 4500 million years 1
*do **not** accept 4500 years*
- (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]

- 20** (a) (i) **K and L** 1
both answers required either order
- (ii) (1) same number of protons 1
accept same number of electrons
accept same atomic number
- (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]