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

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

2

(c) any **two** from:

- (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

accept any other sensible and practical suggestion

2

(d) half-life = 80 s

1

counts / s after 200 s = 71

accept an answer of 70

1

(e) very small amount of radiation emitted

accept similar / same level as background radiation

1

[10]

2

(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]

3 (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

$^{0}_{-1}\beta$

accept e for β

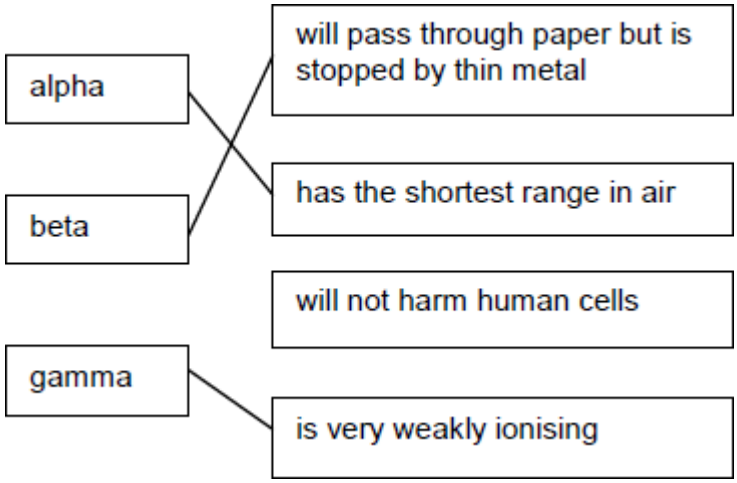
$^{139}_{56}Ba \longrightarrow {}^{139}_{57}La + {}^{0}_{-1}\beta$

*scores **3** marks*

1

[10]

4 (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

3

(b) Gamma radiation will pass through the body

1

(c) half

1

(d) protons

1

[6]

5 (a) 78

1

(b) atomic

1

(c) (i) 131

correct order only

1

54

1

(ii) 32 (days)

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

2

(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

so reducing risk of cancer (of the thyroid)

accept stops risk of cancer (of the thyroid)

1

[8]

6 (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]

7 (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]

8 (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]

9 (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]

10 (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

(b) (i) $^{208}_{81}Th$

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

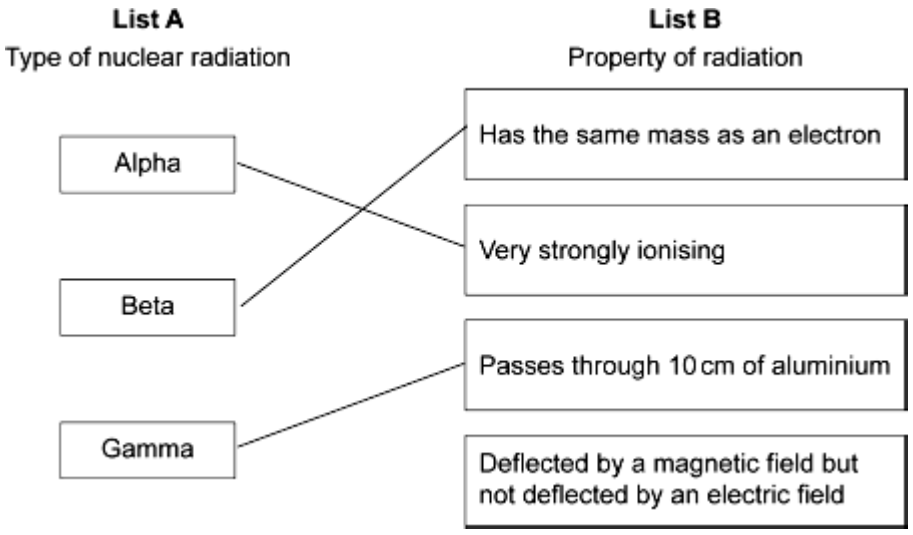
alpha and beta decay produce different atomic numbers

ignore correct reference to mass number

1

[7]

11 (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]

12 (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]

13 (a) (i) **L**

1

(ii) **M**

1

(b) To make a smoke detector work.

1

(c) **40**

no tolerance

1

[4]

14 (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 CO_2) 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]

15 (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]

16 (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]

17 (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_2He or $^4_2\alpha$ for **1** mark*

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

1

[8]

18 (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]

19 (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 $_2{}^4He$

*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]

20 (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

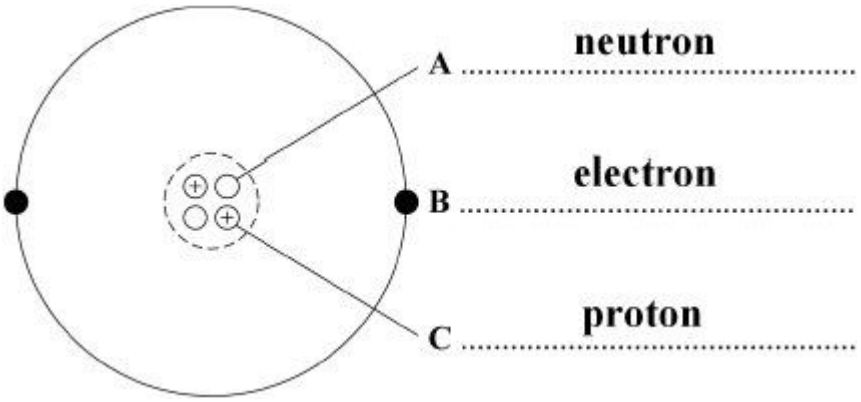
*do **not** accept protons with any other particle e.g. number of protons and neutrons changes incorrect*

*do **not** accept any reference to mass number*

1

[4]

21 (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]

22 (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]

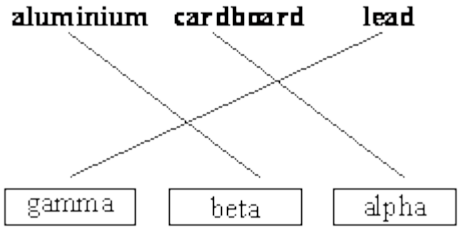
23 (a) (i) **P**

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]

24 (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 <u>one</u> more neutron

correct answer only

1

(ii) 14 days

no tolerance

*allow **1** mark for showing a correct method on the graph*

2

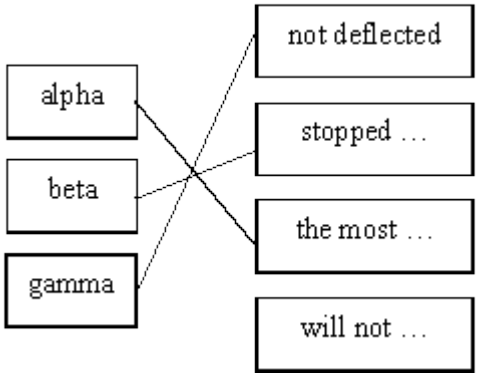
(iii) any **two** from:

- 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]

25 (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*

1

- 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*

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]

26 (i) 50 ± 5

1

(ii) 50 ± 5

accept their (b)(i)

1

(iii) less

accept any way of indicating the correct answer

1

[3]

27 *answers must be comparative*
accept converse answers throughout

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

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]

28 (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]

29 (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]

30 (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]

31 (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]

32 (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

*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]

33

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

accept 0.25 or 25%

1

(ii) 2600

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

1

[2]

34

(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]

35 (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]

36 (a) (i) helium nuclei

1

or

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

*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]

37 (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]

38 (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) <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]

39 (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]

40 (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

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]

41 (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

gains 3 marks

3

[8]

42 (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]

43 (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]

44 (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]

45 (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]

46 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]

47 (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]

48 (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]

49 (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]

50 (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]

51 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]

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

gains proton neutral

[1]

53 (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]

54 (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 → 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]

55 (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

(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]

56 (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]

57 (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

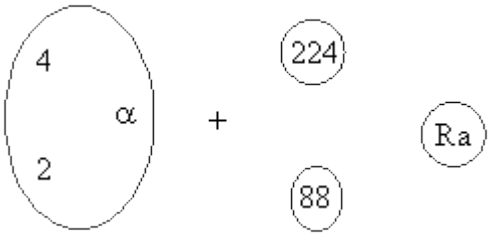
for 1 mark

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

2

[7]

58 (a)

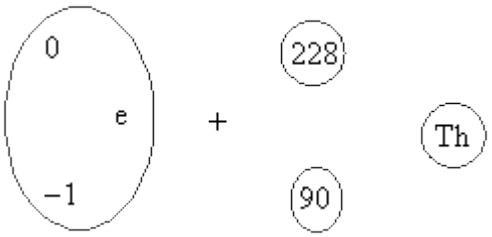


[Accept He^{2+} for α]

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]

59

(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]

60 A β / beta
B γ / gamma
C α / alpha

for 1 mark each

[3]