Mark schemes

Q1.

(a) B

reason only scores if B is chosen

1

americium has an atomic number of 95

allow proton number for atomic number
allow B has a different atomic number
allow B has an atomic number of 94

1

(b) 430 (years)

allow an answer between 420 and 440 (years)

1

(c) 430 (years)
or
their answer to part **(b)**

allow an answer between 420 and 440 (years)

1

[4]

Q2.

(a) $\text{count rate} = \frac{819}{60}$

1

count rate = 13.65

1

corrected count rate = 13.35 (per second)

allow an answer of
background = 0.30 × 60
= 18 (per minute)
corrected count rate
= 819 – 18
corrected count rate
= 801 <u>per minute</u>

1

*an answer of 13.35 (per second) scores **3** marks*
*an answer of 13.95 (per second) scores **2** marks*
*an answer of 801 (per second) scores **2** marks*

(b) activity = 1250 × 180

1

activity = 225 000 (Bq)

1

*an answer of 225 000 (Bq) scores **2** marks*

(c) yearly dose = 0.003 × 365

allow yearly dose = 1.095 (mSv)

1

which is << 100 (mSv)

or

(well) below the lowest dose with evidence of causing cancer / harm

1

(d) people are able to compare a radiation risk / dose / hazard to the radiation dose from (eating) bananas

1

[8]

Q3.

(a) smoke absorbs / stops alpha radiation

allow alpha particles for alpha radiation

alpha radiation does not reach the detector is insufficient

1

(b) alpha radiation is not very penetrating

allow alpha particles for alpha radiation

or

alpha radiation does not penetrate skin

allow alpha radiation does not travel very far (in air)

1

(c) beta and gamma radiation will penetrate smoke

allow beta and gamma radiation will not be stopped by smoke

1

no change (in the count rate) would be detected

allow the change detected (in the count rate) would be too small

1

(d) (a long half-life means) the count rate is (approximately) constant

allow activity of source is (approximately) constant

or

a short half-life means the count rate decreases quickly

1

until 1.3 half-lives the count rate is above 80 per second

allow after 1.3 half-lives the count rate is below 80 per second

or

until 1.3 half-lives the count rate is above the threshold for the smoke alarm to be activated

or

after 1.3 half-lives the smoke alarm will be activated all the time

so don't have to replace source or smoke detector is insufficient

1

(e) **Level 2:** Relevant points (reasons / causes) are identified, given in detail and

logically linked to form a clear account.

3–4

Level 1: Relevant points (reasons / causes) are identified, and there are attempts at logically linking. The resulting account is not fully clear.

1–2

No relevant content

0

Indicative content

- short half-life or half-life of a few hours
- (short half-life means) less damage to cells / tissues / organs / body
- low ionising power
- (low ionising power means) less damage to cells / tissues / organs / body
- highly penetrating
- (highly penetrating means) it can be detected outside the body
- emits gamma radiation

[10]

Q4.

(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]

Q5.

(a) 2 protons and 2 neutrons

accept 2p and 2n

accept (the same as a) helium <u>nucleus</u>

symbol is insufficient

do not accept 2 protons and neutrons

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

[4]

Q6.

(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]

Q7.

(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]

Q8.

(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

[7]

Q9.

(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

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

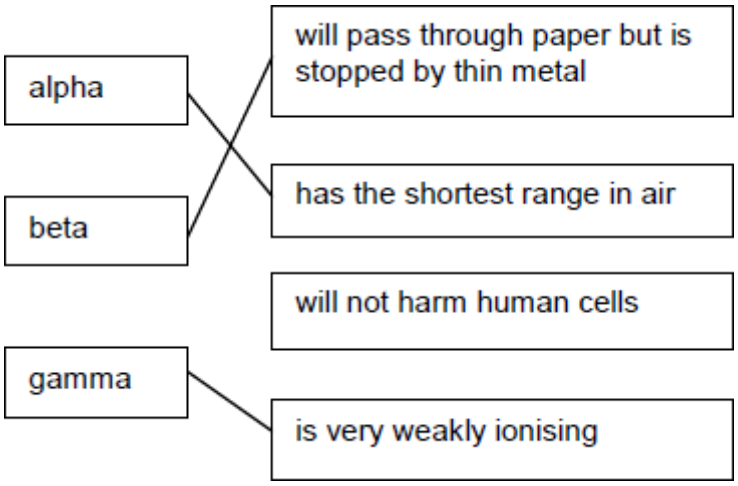
*scores **3** marks*

1

[10]

Q10.

(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]

Q11.

(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]

Q12.

(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]

Q13.

(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]

Q14.

(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]

Q15.

(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]

Q16.

(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

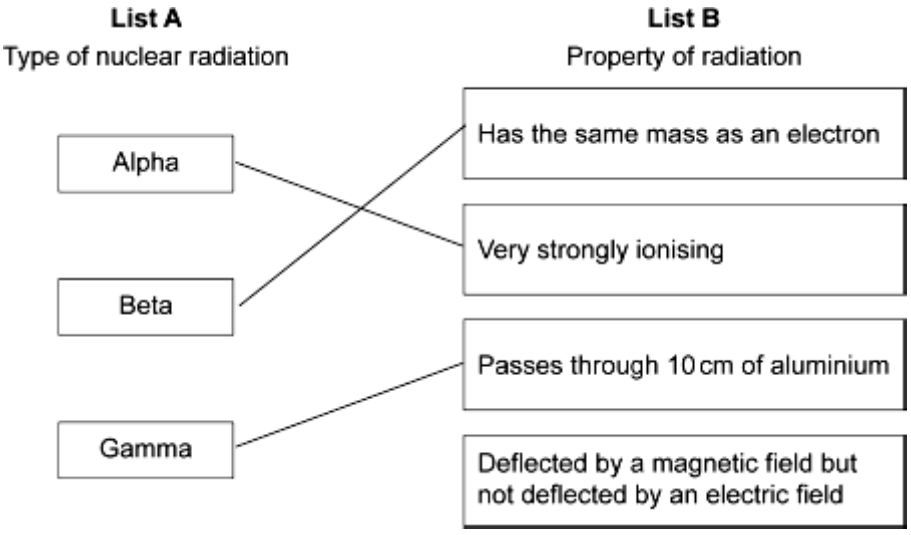
ignore correct reference to mass number

1

[7]

Q17.

(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]

Q18.

(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]

Q19.

(a) (i) **L**

1

(ii) **M**

1

(b) To make a smoke detector work.

1

(c) **40**

no tolerance

1

[4]

Q20.

(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]

Q21.

*(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]

Q22.

(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]

Q23.

*(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 $^{4}_{2}He$ or $^{4}_{2}\alpha$ for **1** mark*

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

1

[8]

Q24.

(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]

Q25.

(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]

Q26.

(a) *146*

1

(b) *atomic number*

1

(c) (i) *alpha*

1

(ii) *number of protons changes*

accept atomic number changes

accept <u>loses or gains</u> protons

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

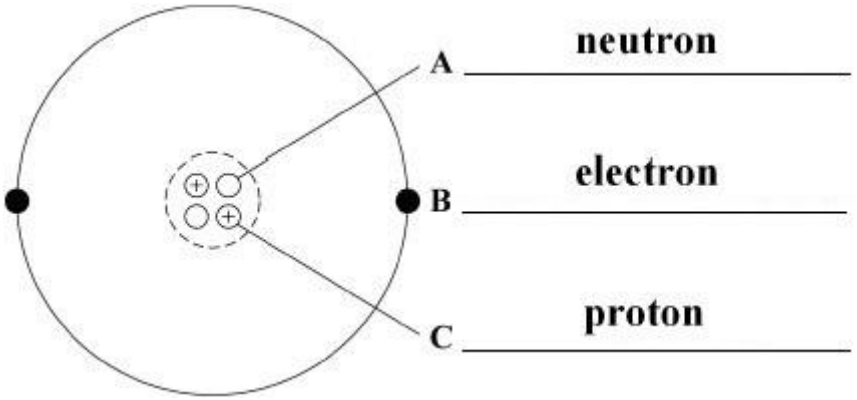
*do **not** accept any reference to mass number*

1

[4]

Q27.

(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]

Q28.

(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]

Q29.

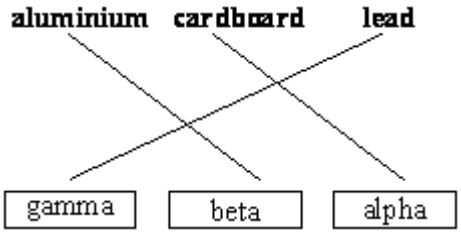
(a) *(i)* ***P***

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]

Q30.

(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:*

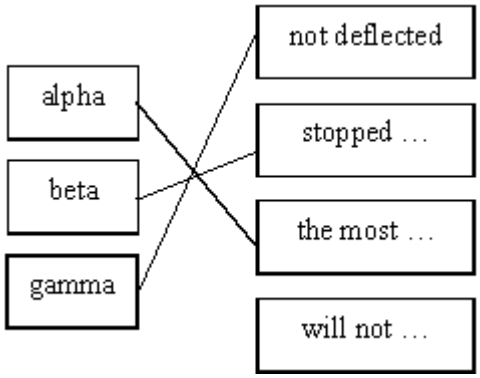
- *beta particles / radiation can be detected externally*
- *beta particles / radiation can pass out of / through the plant*
- *long half-life gives time for phosphorus to move through the plant / be detected / get results*
- *phosphorus-32 is chemically identical to phosphorus-31*
- *phosphorus-32 is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

2

[9]

Q31.

(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]

Q32.

(i) 50 ± 5

1

(ii) 50 ± 5

accept their (b)(i)

1

(iii) less

accept any way of indicating the correct answer

1

[3]

Q33.

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 <u>and</u> 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* <u>*much more*</u> *than 3 mm of metal*

accept lead / aluminium for the metal

1

[3]

Q34.

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

1

(ii) <u>*different*</u> *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]

Q35.

(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]