**Mark schemes**

Q1.

(a) Nucleus splitting into two fragments and releasing two or three neutrons

1

(at least one) fission neutron shown to be absorbed by additional large nucleus and causing fission

1

two or three additional neutrons released from fission reaction

1

This diagram would gain all 3 marks:

(b) lowering the control rods increases the number of neutrons absorbed

accept converse description

1

(so) energy released decreases

1

allow changing the position of the control rods affects the number of neutrons absorbed for 1 mark

(c) rate of increase between 240 and 276 (MW / min)

2

allow 1 mark for attempt to calculate gradient of line at 10 minutes

[7]

Q2.

(a) 2 protons and 2 neutrons

accept 2p and 2n

accept (the same as a) helium nucleus

symbol is insufficient

do not accept 2 protons and neutrons

1

(b) (i) gamma rays

1

(ii) loses/gains (one or more) electron(s)

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]

Q3.

(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]

Q4.

(a) (average) time taken for the amount / number of nuclei / atoms (of the isotope in a sample) to halve

or

time taken for the count rate (from a sample containing the isotope) to fall to half

accept (radio)activity for count rate

1

(b) 60 ±3 (days)

1

indication on graph how value was obtained

1

(c) (i) cobalt(-60)

1

gamma not deflected by a magnetic field

or

gamma have no charge

dependent on first marking point

accept (only) emits gamma

gamma has no mass is insufficient

do not accept any reference to half-life

1

(ii) strontium(-90)

1

any two from:

• only has beta

• alpha would be absorbed

• gamma unaffected

• beta penetration / absorption depends on thickness of paper

if thorium(-232) or radium(-226) given, max 2 marks can be awarded

2

(iii) cobalt(-60)

1

shortest half-life

accept half-life is 5 years

dependent on first marking point

1

so activity / count rate will decrease quickest

1

(iv) americium(-241) / cobalt(-60) / radium(-226)

1

gamma emitter

1

(only gamma) can penetrate lead (of this box)

do not allow lead fully absorbs gamma

1

[14]

Q5.

(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]

Q6.

(a) (i) 18

1

(ii) the count rate for the source

1

(iii) the alpha radiation would not cover such a distance

1

(iv) plots correct to within ½ small square

allow 1 mark for 4 correct points plotted

2

correct curve through points as judged by eye

1

(v) two attempts at finding ‘half-distance’ using the table

20 to 10 cpm d = 0.4 m

125 to 56 cpm d = 0.2 m

31 to 14 cpm d = 0.4 m

allow 1 mark for one attempted comparison

2

obeyed or not obeyed

dependent on previous two marks

1

(b) (i) there is no effect on the count rate in experiment 1 because the field is parallel or beta particles are not deflected or there is no force

1

count rate is reduced in experiment 2 because field is perpendicular or beta particles are deflected or there is a force

1

(ii) only background radiation (as beta do not travel as far)

1

slightly different values show the random nature of radioactive decay

1

[13]

Q7.

(a) cosmic rays

1

radon gas

1

(b) (i) Radioactive decay is a random process

1

(ii) 19

1

(iii) 140

accept 159 – their (b)(i) correctly calculated

1

(iv) gamma

1

the count stayed the same

1

or

gamma does not have a charge

accept gamma is an electromagnetic wave

(so) gamma is not deflected / affected by the magnetic field

accept magnet for magnetic field

do not accept is not attracted to the magnet

last two marks may be scored for an answer in terms of why it cannot be alpha or beta

only answer simply in terms of general properties of gamma are insufficient

1

(c) lead absorbs (some of the) radiation

accept radiation cannot pass through (the lead)

or

less radiation emitted into the (storage) room

1

(d) Should radioactive waste be dumped in the oceans

1

[10]

Q8.

(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]

Q9.

(a) (both graphs show an initial) increase in count rate

accept both show an increase

1

(b) only the right kidney is working correctly

1

any two from:

if incorrect box chosen maximum of 1 mark can be awarded

reference to named kidney can be inferred from the tick box

• count-rate / level / line for right kidney decreases (rapidly)

it decreases is insufficient

• count-rate / level / line for left kidney does not change

it does not change is insufficient

• radiation is being passed out into urine – if referring to right kidney

• radiation is not being passed out – if referring to the left kidney

• left kidney does not initially absorb as much technetium-99

2

[4]

Q10.

(a) 1 mark for each correct line

if more than 1 line has been drawn from a box in List A then all those lines are marked incorrect

3

(b) higher in village B

1

by 6 units

allow 1 mark for correctly obtaining a height difference of 180 (m) / 4 times higher – this refers to height not radiation levels

accept for 3 marks in village A it is 2 units (extra) and in village B it is 8 units (extra) allow 1 mark for a correct radiation calculation based on incorrect height readings

2

[6]

Q11.

(a) (i) 2.5

1

(ii) The radiation dose from natural sources is much greater than from artificial sources

1

(b) (i) any one from:

• different concentrations in different rooms

• to average out daily fluctuations

accept to find an average

accept to make the result (more) reliable / valid

do not accept to make more accurate on its own

1

(ii) average level (much) higher (in C and D)

accept converse

1

some homes have very high level (in C and D)

accept maximum level in A and B is low

1

or

maximum level in some homes (in C and D) is very high

accept higher radiation levels (in C and D) for 1 mark

[5]

Q12.

(a) (i) on average, cosmic rays produce less background radiation than rocks.

1

having no X-rays reduces a person's radiation dose.

1

(ii) 4

allow 1 mark for 350 / 4

allow 1 mark for an answer 3.5

2

(b) (i) (risk) increases

1

(ii) C

reason only scores if C chosen

1

shows a lower risk for low doses (than for zero exposure)

accept risk reduces when you go from low to moderate (doses)

1

(c) (i) no mark for YES or NO, marks are for the explanation

YES

fewer mice exposed first to a low dose

1

get cancer (than those only exposed to a high dose)

only scores if first marking point scores

NO

the results are for mice (1)

and may not be applicable to people (1)

1

(ii) ethical

1

[10]

Q13.

(a) (i) 1.25 (mSv)

1

(ii) any two from:

• (frequent) flying

accept stated occupation that involves flying

• living at altitude

• living in areas with high radon concentrations

accept a specific area, eg Cornwall

• living in a building made from granite (blocks)

• having more than the average number of X-rays

or

having a CT scan

accept more medical treatments

• working in a nuclear power station

accept any suggestion that could reasonably increase the level from a specific source

2

(b) (i) to be able to see the effect of exposure (to radon gas)

or

as a control

accept to compare (the effect of) exposure (with no exposure)

1

(ii) increased levels of exposure increases the risk (of developing cancer)

accept exposure (to radon gas) increases the risk

1

smoking increases the (harmful) effect of radon

answers that simply reproduce statistics are insufficient

1

(c) LNT model – risk increases with increasing radiation (dose) level

accept in (direct) proportion

accept low doses increase the risk

1

Radiation hormesis - low radiation (dose) levels reduce the risk

1

(d) two valid points made – examples:

• animals have no choice and so should not be used

• should not make animals suffer

• better to experiment on animals than humans

• experiments lead to a better understanding / new knowledge

• experiments may lead to health improvement / cures for humans

results for animals may not apply to humans is insufficient

2

[10]

Q14.

(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]

Q15.

(a) (i) half / 50 %

1

(ii) Measure the radon gas level in more homes in this area

1

(b) (i) 86

1

(ii) 222

1

[4]

Q16.

(a) (i) any one from:

• food / drink

• rocks / building materials

• cosmic rays / rays from space

accept correctly named example

1

(ii) any one from:

• nuclear power / coal power (stations)

accept nuclear waste

• nuclear accidents

accept named accident eg Chernobyl

• nuclear weapons testing

accept named medical procedure which involves a radioactive source

accept radiotherapy

nuclear activity / radiation is insufficient

do not accept CT scans

1

(iii) different number of / fewer protons

accept does not have 86 protons

accept only has 84 protons

or

different atomic number

do not accept bottom number different

reference to mass number negates this mark

1

(b) 168

accept 169 if clear, correct method is shown

allow 1 mark for a correct dose ratio involving the spine

eg 2:140 etc

or ratio of days to dose is 1.2

or ratio of dose to days is 0.83

2

(c) (i)

Group A Group

B

J M O K L N

all correct

any order within each group

1

(ii) similar (number) / same (number) / large (number)

accept the same specific number in each group eg three

reference to other factors such as age is neutral

1

(iii) how many people in each group developed cancer

a clear comparison is required

1

(iv) there are no marks for Yes or No the

mark is for the reason

Yes

the benefit of having the scan is greater than the risk

or

the risk is (very) small (compared to the chance from natural causes)

accept the risk is much greater from natural causes

No

no additional risk is acceptable

1

[9]

Q17.

1 mark for each correct line

If more than 1 line has been drawn from a box in List A then all those lines are marked incorrect.

[3]

Q18.

(a) gamma will pass through the body

it refers to gamma

or

alpha will not pass through the body

answers must relate to the body

accept skin for body

1

gamma is only slightly ionising

accept gamma causes less damage to cells / tissue

or

alpha is heavily ionising

do not accept gamma causes no damage to cells

less harmful is insufficient

1

(b) (i) (both graphs show an initial) increase in count-rate

accept both show an increase

1

(ii) only the right kidney is working correctly

1

any two from:

if incorrect box chosen maximum of 1 mark can be awarded

reference to named kidney can be inferred from the tick box

• count-rate / level / line for right kidney decreases (rapidly)

it decreases is insufficient

• count-rate / level / line for left kidney does not change

it does not change is insufficient

• radiation is being passed out / into urine - if referring to right kidney

• radiation is not being passed out - if referring to the left kidney

2

(c) (i) time taken for number of nuclei to halve

or

time taken for the count-rate to halve

1

(ii) short half-life – the level of radiation (in the body) decreases rapidly

it refers to short life isotope

1

to a safe / very small level

or

a long half-life – the radiation remains in the body / for a long time

level of radiation remains high

answers in terms of damage eg cancer are insufficient

1

[9]

Q19.

(a) (i) 2.5

1

(ii) The radiation dose from natural sources is much greater

than from artificial sources.

1

(b) (i) other factors may be involved

accept a specific suggestion

eg they may be exposed to other types of radiation

accept cannot be sure (in many cases) that the cause of death is radon (poisoning)

1

(ii) any one from:

• different concentrations in different rooms

• to average out daily fluctuations

accept to find an average

accept to make the result (more) reliable / valid

do not accept to make more accurate on its own

1

(iii) average level (much) higher (in C and D)

accept converse

1

some homes have very high level (in C and D)

accept maximum level in A and B is low

or

maximum level in some homes (in C and D) is very high

accept higher radiation levels (in C and D) for 1 mark

1

[6]

Q20.

(a) (i) half / ½ / 50%

accept 1 (part) in 2 (parts) 1

1

(ii) (the) food (we eat) is radioactive

accept because of the food (we eat)

accept we breathe in radon

radon in the air is neutral

1

(b) higher in village B

1

 by 6 units

allow 1 mark for correctly obtaining a height

difference of 180(m)/ 4 times higher – this refers

to height and not radiation levels

accept for 3 marks in village A it is 2 units (extra)

and in village be it is 8 units (extra)

allow 1 mark for a correct radiation calculation based on incorrect height readings

2

[5]

Q21.

(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]

Q22.

(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]

Q23.

(a) top and bottom boxes identified

1

(b) Medical (treatment)

 or X-rays

answer must be in table

accept treatment for medical treatment

1

(c) 15

allow 1 mark for correctly identifying 300 as the average dose

2

[4]

Q24.

(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]

Q25.

(a) (i) 3 fewer neutrons

accept fewer neutrons

accept different number of neutrons

do not accept different number of electrons

1

(ii) electron from the nucleus

both points needed

1

(iii) 32 (days)

allow 1 mark for clearly obtaining 4 half-lives

2

(iv) has a much longer half-life

accept converse answers in terms of iodine-131

accept it has not reached one half-life yet

1

 little decay happened / still in the atmosphere

accept it is still decaying

1

(b) any two from:

marks are for reasons

• some children developed TC before 1986

• some children (after 1986) that developed TC did not live

in highly contaminated areas

• the (large) increase can (only) be explained by (a large

increase in) radiation as caused by Chernobyl

• all areas would be contaminated (and raise the risk of TC)

• no evidence (of effect) of other variables

2

(c) People not exposed (to the radiation but who were otherwise similar)

accept people not affected (by the radiation)

1

(d) any two from:

answers should be in terms of nuclear power and not why we should not use other fuels

• produce no pollutant / harmful gases

accept named gas or greenhouse gases

do not accept no pollution

• produces a lot of energy for a small mass (of fuel) or

is a concentrated energy source

accept amount for mass

accept high energy density

• it is reliable or

it can generate all of the time

• produces only a small volume of (solid) waste

accept amount for volume

2

[11]

Q26.

(a) (i) protons

1

 neutrons

answers may be in either order

1

(ii) 86

1

(iii) two fewer protons and two fewer neutrons

do not accept two fewer protons and neutrons

 or 84 protons 134 neutrons

do not accept 218 protons and neutrons

1

(b) (i) 0.4

accept / accept 40 % for 2 marks

allow 1 mark for correct totalling = 1.8

allow 1 mark for a clearly correct method with a clearly incorrect total

2

(ii) any one from:

• nuclear weapon testing

do not accept nuclear

• nuclear power (stations)

accept nuclear/ radioactive waste

• nuclear accidents

• medical

accept X-rays

1

(c) (i) 2

accept 2:1

accept twice as big

ignore units

1

(ii) No with a reasonable reason explained

 only going for two weeks so

 or even staying for a year

 total exposure well under lowest limit for causing cancer

1 mark is for a time frame

1 mark is for correctly relating to a dose

1

 or Yes with a reasonable reason explained

 all levels of radiation are (potentially) hazardous (1)

accept low doses could still cause cancer

accept all levels affect you

do not accept radiation dose is high(er)

do not accept level of background radiation is higher in Germany

 harm caused by lower doses may not have been recorded (1)

 or evidence may not be complete

 or insufficient research into effect of small doses

1

[10]

Q27.

(a) 3 correct lines drawn

any box in list A with 2 or more lines,

all lines for that box do not score

3

(b) radiation damages our cells

accept radiation can cause cancer

accept kills cells

accept changes DNA / causes mutations

accept dangerous / poisonous / harmful / toxic

accept so precautions can be taken

1

(c) it can pass through the human body

1

(d) (i) 6 (hours)

no tolerance

1

(ii) 6 (hours)

accept their (d)(i)

1

[7]

Q28.

(a) (i) alpha

1

(ii) damages them / changes DNA

accept kills them / destroys

accept causes cancer

accept causes cell mutations

do not accept they ionise cells on its own

1

(b) count is (roughly) the same

1

gamma is not affected by magnetic field

accept magnet for magnetic field

1

or

 alpha and beta are deflected by a magnetic field (1)

count would go down significantly (1)

(c) time taken for number of nuclei to halve

do not accept time for radioactivity to halve

or

time taken for count rate to fall to half

(its initial value)

do not accept time for nuclei to halve

1

(d) not enough time to take measurements / make observations

1

before level of radiation became insignificant

1

[7]

Q29.

(a) (i) electromagnetic (wave / radiation)

accept em (wave / radiation)

ignore reference to frequency

1

(ii) gamma can penetrate the crate / box / packaging

accept converse (but must relate to both alpha and beta)

ignore just gamma radiation kills bacteria

accept can get through to food

1

(iii) neutrons

1

(b) (i) absorb gamma / radiation

accept it stops / reduces the radiation

1

(ii) any one from:

• slow down the conveyor belt

• food does more than one circuit

• stay on the conveyor belt longer

• food closer to the source / radiation

ignore larger doses / use more of the source

ignore thinner packaging

1

(c) (i) idea of testing food on humans / animals

1

no (measured) ill effects or monitor their health

accept monitor people that have eaten the food

accept a measurement / comparison for 1 mark

eg measure the amount of radiation in treated food

comparison plus a reason for the comparison would get 2 marks

eg idea of measuring level of radiation in treated food with no

measurable increase in level = 2 marks or comparing it to

untreated food = 2 marks

1

(ii) so can make own decision about eating or not eating treated food

accept may be against their religious / moral views

accept some people prefer food that hasn’t been tampered with

ignore in case they don’t like the idea of eating treated food

accept don’t want to eat treated food

ignore might be allergic to the food

eg think it will give them cancer = 0 marks

think it will give you cancer so I need to know so that I can choose = 1 mark1

1

[8]

Q30.

(i) any one from:

 the ground

the air

radon (gas)

building materials

buildings

rocks / granite

food

cosmic rays or solar rays

do not accept mobile phones

 X-rays

nuclear weapons testing

nuclear power stations / accidents

accept from outer space

accept sun but not sunlight

accept medical uses

1

(ii) 2

allow

2

[3]

Q31.

(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]

Q32.

(i) photographic film / paper

accept X-ray film

1

(ii) (when developed) the film is darker

must have a comparison

1

(iii) to prevent them receiving / being exposed to too much radiation or

so they know how much radiation they have been exposed to

accept if he gets too much radiation there may be something wrong with the plant

any statement making reference to a need for preventive or corrective action gains 1 mark

an isolated statement of fact of the effect of radiation gains 0 marks

1

[3]

Q33.

(i) radon (gas)

do not accept gas

1

(ii) background

1

[2]

Q34.

(a) all points correctly plotted

tolerance ± 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 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]

Q35.

(i) any one from

 cosmic rays

 rocks

 food

 air

1

(ii) any one from

 medical

 nuclear power stations

 nuclear weapons testing

 food

but do not accept food in both (1) and (ii)

1

[2]

Q36.

(a) X emits beta

accept β

1

Y emits alpha, beta, gamma

must have all three accept α, β, γ

1

(b) gamma

accept beta and gamma

any mention of alpha loses first mark

1

radiation can penetrate (the plastic)

1

 kills bacteria or microbes or micro-organisms or viruses

not germs

1

[5]

Q37.

(i) radiation (received by the body) due to our environment

not naturally occurring radiation

accept radiation all around us

accept radiation that is always there

1

(ii) larger than average dose of cosmic rays

must have idea of comparison

1

 when flying less air to absorb or shield from radiation

1

[3]

Q38.

(a) all 3 correct

Gamma source Beta source Alpha source

allow 1 mark for one or two possible links

no marks for more than one line from a source or to a box

2

(b) (i) geiger-müller (tube)

accept G-M (tube)

accept geiger tube or geiger counter

1

(ii) steady line rising then falling at leak

must be one peak only

1

 (c) (i) can penetrate (skull or head)

accept goes through body

accept most penetrating

do not accept strongest

do not accept can penetrate skin

1

(ii) cancer cells receive full dose or more radiation

accept healthy cells not damaged

1

 healthy or other cells receive low dose only

do not accept it is safer

1

(iii) any two properties from:

• travel through a vacuum

do not accept they are an energy form

• travel at same speed in air or

vacuum

• can be diffracted

treat as a list ignoring 1 and 2

• can be reflected

• can be refracted

• travel in straight lines

• all transverse

• can be polarised

• transfer energy

2

[9]

Q39.

(a) (i) an unstable nucleus or atom or isotope

accept nucleus has too much energy

 an atom or nucleus or isotope which decays

1

(ii) sodium – 24

if Mg-27 chosen can get third mark if explained

 sufficiently long to allow circulation and take readings

 short enough that levels of radiation in the body will become insignificant

quickly

3

(iii) each axis is given a linear scale

1

curve concave to axes drawn

1

 (curve) shows correct half-life of five years

must show two half lives check first two plotted points correct to half square

1

(b) any three points from the following:

• waste remains radioactive for a long time or waste has to be disposed of

• waste may leak from its storage point

• possibility of accident at power station or in transport of fuel

• contamination of the local environment

• people living close to a power station may have a greater risk of

developing cancer or leukaemia

accept harmful to people

• high cost to decommission power station

do not accept expensive

3

[10]

Q40.

(a) (i) cosmic rays

1

(ii) any two from:

rocks

cosmic rays

food

radon

2

 (b) (i) 15

1

(ii) 450

e.c.f. 465 – (d)(i)

do not accept negative number

1

(iii) beta

count (greatly) reduced by aluminium

or alpha not reach GM tube and gamma would pass

(unaffected) through the aluminium

accept aluminium stops beta

2

[7]

Q41.

(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 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 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]

Q42.

(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]

Q43.

(a) two from:

internal/bodies

thoron

building materials

soil

food

rocks

radon

gamma rays

cosmic rays/outer space

any 2 for 1 mark each

2

(b) only a very small amount of the background

radioactivity comes from nuclear power owtte.

accept any sensible response for 1 mark

1

(c) use G.M. tube/meter/counter or film

‘count’ higher than or compare with background/normal/control or film is blacker

for 1 mark each

2

(d) more neutrons/different number

gains 1 mark

 but I-131 has 4 extra neutrons = 2

or I-131 has 78 neutrons I-127 has 74 (2)

gains 2 marks

2

(e) (i) emits radiation

ionises

molecules

in cells

radiation damages cells/mutation/kills cells

may cause cancer

β / /radiation is penetrating

half-life is long enough for damage to be caused

any 4 for 1 mark each (4 from above)

4

(ii) e.g. replace I-127 in body/body cannot tell the difference/causes thyroid

cancer/causes cancer (but not if already given in (i))

for 1 mark

1

(iii) Either No

half-life = 8 days many half lives have passed/attempts to calculate number of half-lives or explains meaning of half-life so very little left/become harmless

for 1 mark each

or Yes half-life = 8 days such a large quantity was released although little left it is still harmful

for 1 mark each

3

[15]

Q44.

Quality of written communication

The answer to this question requires ideas in good English in a sensible order with correct use of scientific terms. Quality of written communication should be considered in crediting points in the mark scheme

 Any three from

 radon releases (alpha) radiation

accept radon is radioactive

1

 (radon or radiation causes) harm or damage to body or cells

accept cause cancer / mutations /

radiation sickness

1

 idea that living near radiation over long period will lead to large ‘dose’ of radiation

 radon (is a gas) that can be breathed in

1

[3]

Q45.

Quality of written communication

 correct use of three scientific terms e.g. radiation / or or / cells /

ionisation / mutation (not cells or body) / chromosomes / DNA /

genes / cancer

1

 any three from:

 (materials emit) radiation

 named type of radiation ( or or )

 damage / harm / kill

dangerous is neutral

 cells / chromosomes / DNA / genes

 cancer

 mutations

 ionisation

 gloves or glass absorb radiation / prevent radiation reaching body or cells

3

[4]

Q46.

(i) (strontium-90)

beta rays partly absorbed by aluminium

accept gamma rays not absorbed and alpha all absorbed

if phosphorus -32 then one mark max for beta ray explanation

1

 long half life means it can be used for a long time

1

(ii) (technetium-99)

(gamma) rays will pass out of body / less likely to be absorbed

accept (gamma) less damaging or alpha / beta will damage cells if cobalt -60 then one mark max for gamma ray explanation

1

 short half life means it will not affect body over a long period

1

[4]

Q47.

(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]

Q48.

(a) evidence of

gains 1 mark

but

490

gains 2 marks

but

4900

gains 3 marks

units cm3

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]

Q49.

(a) γ/gamma

• because more penetrating

• so can reach/damage cells from outside body/through skin

 but

α/alpha

• does more damage/more likely to cause cancer

• can only do this if inside the body/cells

each • for 1 mark

[credit same ideas expressed conversely]

4

(b) • must emit alpha / α radiation

• idea that half-life must be just long enough to kill cancer cells

each for 1 mark

[do not credit simply short half-life]

(allow ‘must be liquid / in solution)

2

(c) evidence of repeated halving then

n × 3.6

gains 1 mark

 but

answer in range

22 – 25.2 days

(ie >6 and up to 7 half lives)

gains 2 marks

2

[8]