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

Level 3 (5–6 marks):
A detailed and coherent explanation is provided. The student gives examples that argue a strong case and demonstrate deep knowledge. The student makes logical links between clearly identified, relevant points.

Level 2 (3–4 marks):
An attempt to link the description of the experiment and the results with differences between the two models. The student gives examples of where the plum pudding model does not explain observations. The logic used may not be clear.

Level 1 (1–2 marks):
Simple statements are made that the nuclear model is a better model. The response may fail to make logical links between the points raised.

0 marks:
No relevant content.

Indicative content
- alpha particle scattering experiment
- alpha particles directed at gold foil
- most alpha particles pass straight through
- (so) most of atom is empty space
- a few alpha particles deflected through large angles
- (so) mass is concentrated at centre of atom
- (and) nucleus is (positively) charged
- plum pudding model has mass spread throughout atom
- plum pudding model has charge spread throughout atom

[6]

3   (a)   cannot predict <u>which</u> dice / atom will 'decay'

accept answers given in terms of 'roll a 6'

1

cannot predict <u>when</u> a dice / atom will 'decay'

1

(b)   3.6 to 3.7 (rolls)

*allow **1** mark for attempt to read graph when number of dice = 50*

2

(c)   90

1

(d)   uranium

1

(e)   beta

1

proton number has gone up (as neutron decays to proton and e⁻)

1

(f)   prevents contamination

     or

     prevents transfer of radioactive material to teacher's hands

                                     1

     which would cause damage / irradiation over a longer time period.

                                     1

                                   [10]

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

                                   1

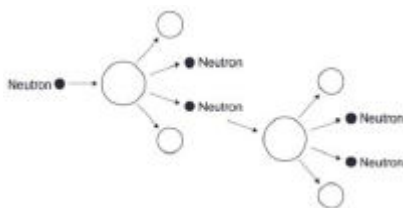   (at least one) fission neutron shown to be absorbed by additional large nucleus and causing fission

                                   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]

5   (a)   neutrons and protons

                                   1

    (b)   0

                                   1

       (+)1

                                   1

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

               accept protons and electrons have an equal opposite charge

                                   1

(because) no of protons = no of electrons

1

(ii)   ion

1

positive

1

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

0 marks
No relevant content

Level 1 (1 – 2 marks)
There is a basic description of at least **one** of the particles in terms of its characteristics.

Level 2 (3 – 4 marks)
There is a clear description of the characteristics of **both** particles
or
a full description of either alpha **or** beta particles in terms of their characteristics.

Level 3 (5 – 6 marks)
There is a clear and detailed description of **both** alpha and beta particles in terms of their characteristics.

examples of the physics points made in the response:

structure

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

penetration

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

deflection

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

6

[13]

6   (a)   (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]

7 (a) (i) neutron

1

   (ii) neutron
         proton
               both required, either order

1

   (iii) 2

1

         number of <u>protons</u>
               do not accept number of electrons

1

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

   •   beta

   •   gamma
       accept correct symbols
       accept positron / neutrino / neutron
       cosmic rays is insufficient

1

   (ii) electrons

1

   (iii) are highly ionising

1

(c) (i) mutate / destroy / kill / damage / change / ionise
           Harm is insufficient

1

   (ii) much smaller than

1

[9]

8 (a) J
               reason only scores if J is chosen

1

(only) stars (about) the same / smaller size / mass as the Sun become black dwarfs
               accept smaller than the Sun
               accept it is the smallest
               accept (only) small stars become black dwarfs

1

(b) (i) become a supernova
or
it will explode
ignore subsequent correct stages

1

(ii) cannot take measurements needed
or
do not have the technology
*do **not** accept cannot measure mass*

1

(iii) advances in (measuring) techniques / technology / knowledge

1

(c) any **five** from:
ignore any information up to the end of the main sequence
Apply the list rule if more than 5 points are made
• star expands (to become)
• a red giant
red supergiant is incorrect
• heavier elements are formed (by fusion)
elements heavier than iron are formed is incorrect
• star shrinks (to become)
• a white dwarf
supernova, neutron star, black hole are incorrect
• star cools / fades
• star stops emitting energy / radiation
star loses all energy is insufficient

5
[10]

9   (a)   (same) number of protons

same atomic number is insufficient

1

(b)   (i)   nuclei split

*do **not** accept atom for nuclei / nucleus*

1

(ii)   (nuclear) <u>reactor</u>

1

(c)   beta

1

any **one** from:
* atomic / proton number increases (by 1)

accept atomic / proton number changes by 1
* number of neutrons decreases / changes by 1
* mass number does not change

(total) number of protons and neutrons does not change
* a neutron becomes a proton

1

(d)   (average) time taken for number of nuclei to halve
or
(average) time taken for count-rate / activity to halve

1

(e)   (i)   6.2 (days)

Accept 6.2 to 6.3 inclusive
*allow **1** mark for correctly calculating number remaining as 20 000*
or
*allow **1** mark for number of*
80 000 plus correct use of the graph (gives an answer of 0.8 days)

2

(ii)   radiation causes ionisation

allow radiation can be ionising

1

that may then harm / kill healthy cells

accept specific examples of harm, eg alter DNA / cause cancer

1

(iii)   benefit (of diagnosis / treatment) greater than risk (of radiation)

accept may be the only procedure available

1

[11]

10   (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) <u>nuclei</u> / into Ba and Kr
- releasing <u>three</u> neutrons and energy

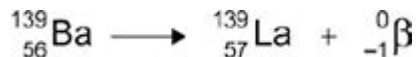   *accept fast-moving for energy*

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

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

     accept e for β

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

     *scores **3** marks*

1

[10]

11 (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

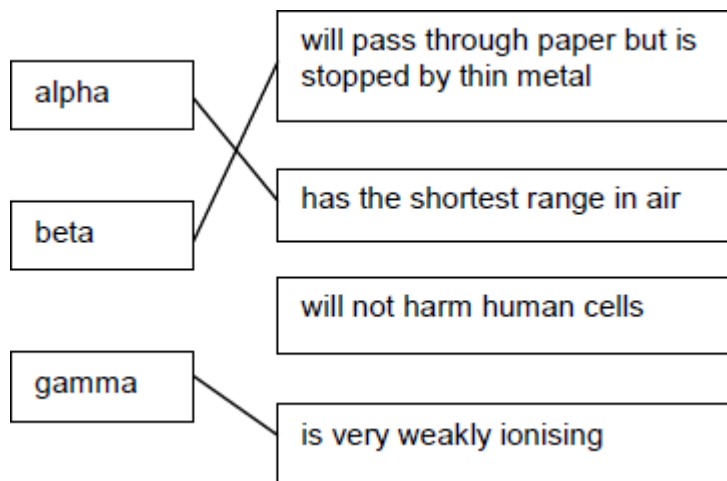(ii) only background radiation (as beta do not travel as far)

1

slightly different values show the random nature of radioactive decay

1

[13]

12 (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]

13   (a)   uranium-235

accept any correct indication

1

(b)   splits / breaks (into two smaller parts)

nucleus is separated is insufficient

*do **not** accept atom splits – on its own*

1

and (two / three) neutrons

1

(c)   steam

correct order only

1

turbine

1

generator

1

[6]

14   (a)   (i)   plutonium (239)

accept Pu / Thorium / MOX (mixed oxide)

*do **not** accept uranium-238 **or** hydrogen*

1

(ii)   (energy) used to heat water and

1

produce (high pressure) steam

1

the steam drives a turbine (which turns a generator)

1

(b)   Neutron(s) shown 'hitting' other U-235 nuclei

one uranium nucleus is sufficient

1

U-235 nuclei (splitting) producing 2 or more neutrons

1

(c)   any **two** from:

- neutrons are absorbed (by boron / control rods)

- there are fewer neutrons

- chain reaction slows down / stops
    accept fewer reactions occur

2

[8]

15 (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]

16 (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]

17   (a)   neutron discovered

1

(b)   neutron
all 3 in correct order

electron
*allow **1** mark for 1 correct*

proton

2

[3]

18   (a)   forces (within the star) are balanced
if specific forces are mentioned they must be appropriate

1

(b)   (i)   bigger the mass (of the star) the shorter the 'main sequence' period
accept bigger the star the shorter the time

1

(ii)   any **one** from:

- insufficient evidence

- do not know (exact) amount of hydrogen in star
  accept do not know (exact) mass of star

- time too long (to measure directly)

- may be other factors (not yet known) that determine length of 'main sequence' period

- values are based on theory / calculation

1

(iii)   faster than

1

larger stars have a shorter 'main sequence' period so they must have the faster (rate of) nuclear fusion
   there must be a link between shorter 'main sequence' and nuclear fusion, this may be implied from the first marking point

1

the end of 'main sequence' happens as the hydrogen in (the core of) a star is used up
or
(since) they use up hydrogen at a faster (rate)
   accept more massive stars (are brighter so) release energy faster

1

(c)   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 also refer to the information in the Marking guidance, and apply a
'best-fit' approach to the marking.

0 marks
No relevant content.

Level 1 (1-2 marks)
There is a basic description of what happens to a star much larger than the Sun after
the 'main sequence' period.
OR
Two stages are correctly named and are in the correct sequence.

Level 2 (3-4 marks)
There is a clear description of what happens to a star much larger than the Sun after
the 'main sequence' period.
AND
At least two stages are correctly named and are in the correct sequence.

Level 3 (5-6 marks)
There is a detailed description of what happens to a star much larger than the Sun
after the 'main sequence' period.
AND
At least three stages are named, in the correct sequence. There are no additional
incorrect stages given.

Examples of the points made in the response:
            extra information

•   (the core of the) star runs out of hydrogen

•   (the star) expands (to form)

•   (the star) cools (to form)
            •   *the core shrinks*
            •   *helium starts to fuse to form other elements*

•   a red supergiant
            accept super red giant
            *do **not** accept red giant*

    •   (outer layers) explode
            •   *fusion of lighter elements to form heavier elements (up to iron)*

•   as a supernova

    •   elements heavier than iron are formed
            accept heaviest elements are formed

    •   core shrinks

•   becoming a neutron star

- if mass large enough (core collapses)

- (to form) a black hole

    if a correct description and sequence for a star the same size as the Sun and much bigger than the Sun given without clearly indicating which is which is limited to Level 2

6

[12]

19 (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]

20   (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 <u>right</u> kidney decreases (rapidly)

  it decreases is insufficient

- count-rate / level / line for <u>left</u> 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

- <u>left</u> kidney does not initially absorb as much technetium-99

2

[4]

21   (a)   protons, electrons

both required, either order

1

neutrons

1

electron, nucleus

both required, this order

1

(b)   2.7 (days)

*allow **1** mark for showing correct use of the graph*

2

(c)   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

or

put source into water at three points on bank (1)
see if radiation is detected downstream of factory **or** farmland **or** sewage treatment works (1)

1

[7]

22 (a)   proton

all 3 in correct order

electron

*allow **1** mark for 1 correct do **not***

neutron

accept letters p, e, n

2

(b)   9
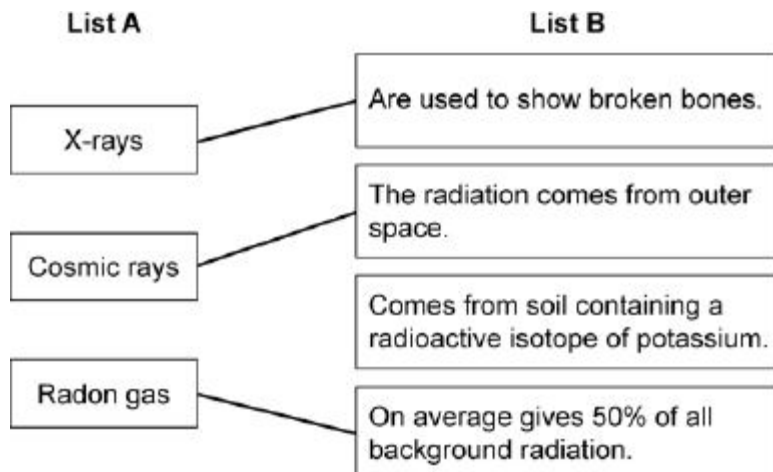
reason only scores if 9 is chosen

1

number of neutrons and protons

1

[4]

23 (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]

24 (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]

25 any **two** pairs from:

> *to gain credit it must be clear which model is being described*
>
> *do **not** accept simple descriptions of the diagram without comparison*

- nuclear model mass is concentrated at the centre / nucleus (1)

  > *accept the nuclear model has a nucleus / the plum pudding model does not have a nucleus for **1** mark*

  plum pudding model mass is evenly distributed (1)

- nuclear model positive charge occupies only a small part of the atom (1)

  plum pudding model positive charge spread throughout the atom (1)

- nuclear model electrons orbit some distance from the centre (1)

  > *accept electrons in shells / orbits provided a valid comparison is made with the plum pudding model*

  plum pudding electrons embedded in the (mass) of positive (charge) (1)

  > *do **not** accept electrons at edge of plum pudding*

- nuclear model the atom mainly empty space (1)

  plum pudding model is a 'solid' mass (1)

  [4]

26 (a) fusion

  > *do **not** credit any response which looks like 'fission'*

  1

  of hydrogen / H (atoms)

  > *credit only if 1ˢᵗ mark point scores*

  1

(b) fusion of other / lighter atoms / elements

  > *reference to big bang nullifies both marks*

  1

  during supernova / explosion of star(s)

  1

(c) the (available) evidence: supports this idea
  or
  does not contradict this idea
  or
  can be extrapolated to this idea
  or
  (electromagnetic) spectrum from other stars is similar to sun

  1
  [5]

27 (a) *answers must be in terms of nuclear fuels*

concentrated source of energy

     idea of a small mass of fuel able to generate a lot of electricity

     1

that is able to generate continuously

     accept it is reliable

     or *can control / increase / decrease electricity generation*

     idea of available all of the time / not dependent on the weather

     ignore reference to pollutant gases

     1

the energy from (nuclear) <u>fission</u>

     1

is used to heat water to steam to turn turbine linked to a generator

     1

(b) <u>carbon dioxide</u> is not released (into the atmosphere)

     1

but is (caught and) stored (in huge natural containers)

     1

     [6]

28 (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 <u>lead</u>

> *reason only scores if gamma chosen*

or

alpha <u>and</u> beta will not pass through <u>lead</u>

> *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]

29 (a) **B E G**

> *all 3 required and no other*
> *any order*

1

same number of / 88 protons (and different numbers of neutrons)

> *same number of electrons is insufficient*

1

(b) (i) 222

1

86

1

(ii) 4800

> *allow **1** mark for obtaining 3 half-lives*

2

(c) ethical

1

deceived / lied to (about safety of working conditions)

    accept (women) not warned of the dangers

    given no protection is insufficient

or

value own / scientists' lives more than women

or

did not treat women humanely

        1

(d)   accept any sensible suggestion

eg

too many interests in continued use of radium

evidence may cause public unrest

    *do **not** accept not enough evidence*

doctors not want to be blamed for illnesses (caused by radium)

    accept doctors not wanting to be sued (for harm caused by using radium)

doctors thought (possible) benefits outweighed (possible) risks

    *do **not** accept did not know radium could be harmful*

    believe radium could treat illnesses is insufficient

        1

        [9]

30   (a)   (i)   (nuclear) fission is the splitting of a (large atomic) nucleus

    *do **not** accept particle/atom for nucleus*

        1

(nuclear) fusion is the joining of (two atomic) nuclei (to form a larger one)

    do not accept particles/atoms for nuclei

        1

   (ii)   energy

    accept heat/radiation/nuclear energy

    accept gamma (radiation)

    do not accept neutrons/neutrinos

        1

(b)   (i)   uranium (–235)

    accept U (–235)

    ignore any numbers given with uranium

    accept thorium

    accept MOX (mixed oxide)

    *do **not** accept hydrogen*

        1

(ii)   (same) number of protons

accept (same) atomic number

accept (same) positive charge

ignore reference to number of electrons

1

[5]

31 (a)   has an equal amount of positive charge

accept pudding/it is positive

1

(b)   (experimental) results could not be explained using 'plum pudding' model
or
(experimental) results did not support plum pudding model

accept (experimental) results disproved plum pudding model

1

(c)   (i)   **A** – most of atom is empty space**or**most of atom concentrated at the centre

1

B – nucleus is positive (so repels alpha particles)

accept nucleus has the same charge as alpha

1

C – nucleus is very small

accept nucleus is positive if not scored for B
or
nucleus is a concentrated mass

accept nucleus has a very concentrated charge

1

(ii)   (if predictions correct, this) supports the new model

answers should be in terms of the nuclear model

accept supports his/new/nuclear theory

accept proves for supports

accept shows predictions/ Rutherford was correct

1

[6]

32 (a)   (i)   protostar

correct order only

1

red giant

1

black dwarf

1

(ii)   Alpha Centauri A
accept any correct indication, eg alpha, centauri, A
reason only scores if Alpha Centauri A is chosen

1

stars (about) same size as Sun form white / black dwarfs
or
very large stars form red super giants / supernova/black hole
it is the same size as the Sun is insufficient
same life cycle as the Sun is insufficient

1

(b)   Atomic nuclei inside the star join together

1

[6]

33   (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 low<u>er</u> 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]

34 (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]

35 (a) a protostar is at a lower temperature
or
a protostar does not emit radiation /energy

1

as (nuclear) fusion reactions have not started

accept heat or light for energy

1

(b) by (nuclear) fusion

accept nuclei fuse (together)

nuclear fusion and fission negates this mark

1

of hydrogen to helium

1

elements heavier than <u>iron</u> are formed in a <u>supernova</u>

accept a specific example e.g. heavier elements such as gold are formed in a supernova

accept heavier elements (up to iron) formed in red giant/red super giant

reference to burning (hydrogen) negates the first 2 marks

1

[5]

36 (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]

37 (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]

38   (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]

39 (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

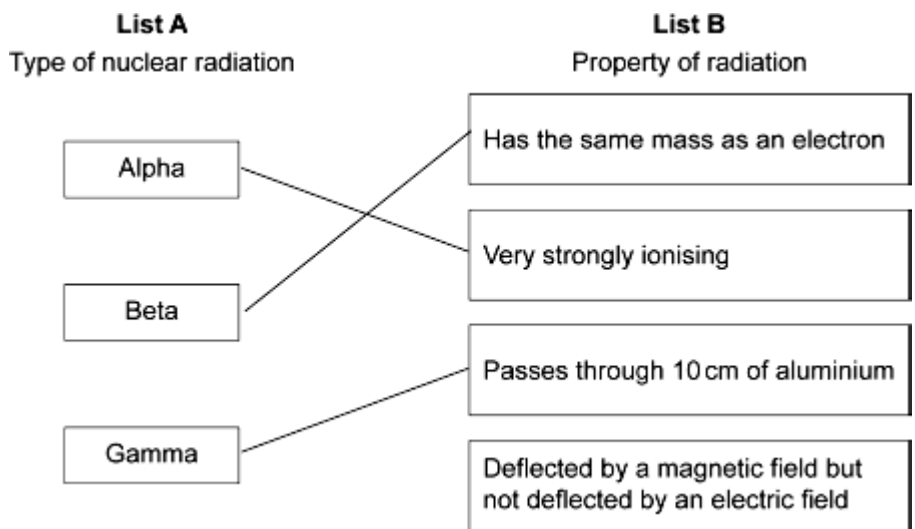**or**

alpha and beta decay produce different atomic numbers

ignore correct reference to mass number

1

[7]

40　(a)　**1** mark for each correct line

List A Type of nuclear radiation	**List B** Property of radiation

Alpha   Has the same mass as an electron

    Very strongly ionising

Beta

    Passes through 10 cm of aluminium

Gamma   Deflected by a magnetic field but not deflected by an electric field

*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]

41　(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

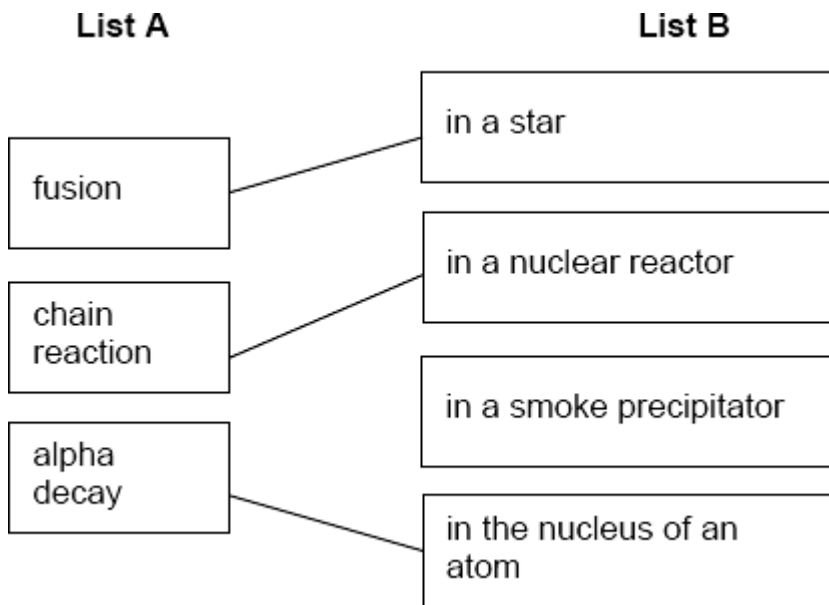*maximum of 1 compensation mark can be awarded*

2

[7]

42 **three** lines correct

*allow **1** mark for each correct line*

*if more than 1 line is drawn from a box in **List A**, mark each line incorrect*

List A   **List B**

fusion ────────────── in a star

chain reaction ─────── in a nuclear reactor

                        in a smoke precipitator

alpha decay ────────── in the nucleus of an atom

[3]

43 (a) electron(s)

1

(b) 3rd box ticked

The model cannot explain the results from a new experiment

1

(c) all three correct

Particle
Proton
Electron
Neutron

*allow **1** mark for 1 correct*

2

[4]

44 (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]

45 (a) gravitational attraction

accept 'gravity'

accept (nuclear) fusion

1

(b) radiation 'pressure' and gravity / gravitational attraction

must be in correct context

1

are balanced / in equilibrium

        accept are equal <u>and opposite</u>

        *do **not** accept 'equal'*

or

there is sufficient / a lot of hydrogen / fuel

        *do **not** accept constant supply of hydrogen*

to last a very long time / for (nuclear) fusion

        this mark only scores if linked to the supply of hydrogen / fuel

        reference to burning negates both marks

        1

(c) (i) (conversion of) hydrogen <u>to</u> helium

        accept (conversion of) lighter elements to heavier elements

        1

        by (nuclear) <u>fusion</u>

        *note do **not** credit spelling of 'fusion' which could be 'fission'*

        reference to burning negates both marks

        1

  (ii) massive supply / lots of <u>hydrogen</u>

        1

(d) distributed throughout the Universe / space

        *do **not** accept Solar System for Universe*

        1

        [7]

46 (a) (i) **L**

        1

    (ii) **M**

        1

(b) To make a smoke detector work.

        1

(c) **40**

        no tolerance

        1

        [4]

47 (a) (i) number of protons are the same

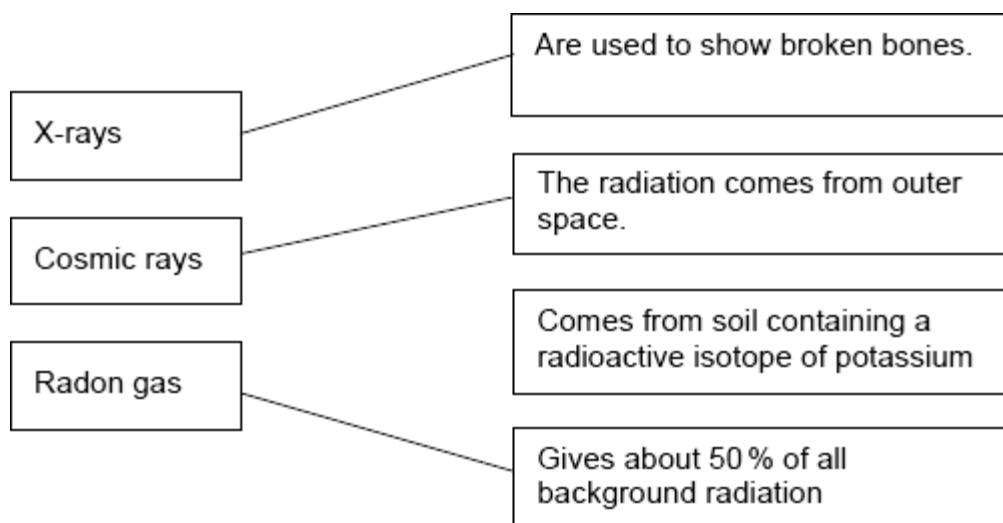   *accept atomic number / number of electrons for number of protons*

        1

48

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.*

| X-rays | Are used to show broken bones. |

| Cosmic rays | The radiation comes from outer space. |

| | Comes from soil containing a radioactive isotope of potassium |

| Radon gas | Gives about 50 % of all background radiation |

[3]

49

(a)   proton

electron

neutron

all 3 in correct order
*allow **1** mark for 1 correct*
*do **not** accept letters p, e, n*

2

(b)   4

reason only scores if 4 is chosen

1

number of protons

accept number of electrons
accept there are 4 protons and 4 electrons
*do **not** accept there are 4 protons and electrons*

1

(c)   The atom loses an electron.

1

[5]

50 (a) **L**

J

K

all 3 in correct order
allow 1 mark for 1 correct

2

(b) number of electrons = number of protons
accept amount for number

1

(c) neutrons
this answer only

1

(d) loses / gains electron(s)

1

[5]

51 beta
reason may score even if alpha or gamma given

1

any **two** from:

• mass number does not change
  or
  total number of protons and neutrons does not change

• atomic / proton number increases by 1
  or
  number of protons increases by 1

• number of neutrons goes down by 1

allow for 2 marks a neutron splits / changes into a proton and electron / beta

*candidates that answer correctly in terms of why alpha **and** gamma are not possible, gain both marks*

2

[3]

52 (a) (forces due to) <u>gravity</u> and <u>radiation pressure</u>

1

correct direction of forces

1

(forces) are balanced / equilibrium / equal

> *accept for **3** marks an answer in terms of*
> *sufficient hydrogen (1)*
> *to keep fusion reaction (1)*
> *reference to burn / burning negates this mark*
> *going at a continuous /steady rate (1)*
> *if fuel is used instead of hydrogen maximum of **2** marks*

1

(b)   the Sun will remain stable (for several billion years)

1

based on evidence

> *accept a specific example of evidence*
> *eg that the Sun has remained stable during the life of our planet /*
> *for 4.5 billion years*
> ***or***
> *still contains more than 50 % hydrogen*
> ***or***
> *by comparison with the lifecycle of (similar) stars*
> *allow a refutation*
> *eg not based on prejudice / whim / hearsay / folk law / historical or*
> *religious authority*

1

[5]

53   (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]

54	(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]

55 (a) (i) all correct

accept presented as a tally chart

Number of protons	3
Number of electrons	3
Number of neutrons	4

*allow **1** mark for **1** correct*

2

(ii) 7

reason may score even if 7 not chosen

1

number of protons and neutrons

accept number of particles in the nucleus

accept number of nucleons

*do **not** accept number of electrons and neutrons*

1

(b) an ion

1

(c) (i) smaller than

1

(ii) radon loses an alpha (particle)
or
radon loses an (alpha) particle
or
(mass of) polonium plus an alpha = (mass) radon
or
radon loses 2 protons and 2 neutrons (to become polonium)

accept radon has less protons and neutrons

1

[7]

56 (a) (i) (two) <u>nuclei</u> (of light elements) join

accept <u>hydrogen atoms</u> for nuclei

1

forming a larger / heavier nucleus / one

accept comparative term equivalent to larger

accept forms a helium (nucleus / atom) this mark only scores if fusion is in terms of hydrogen atoms

1

(ii)   stars

   accept a named star

   e.g. the Sun

   accept nebula

   mention of planets negates answer

1

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

•   (currently) only experimental

•   <u>reaction</u> does not last long enough

•   use more energy than they produce

   allow difficult to control

   *do **not** allow inefficient on its own*

1

(ii)   any **one** from:

•   will give another source of energy

•   unlimited fuel supplies / energy

   accept unlimited hydrogen

•   would not produce any radioactive waste

   accept less radioactive waste

   accept nuclear for radioactive

   *do **not** accept toxic waste*

•   want to show that it can be done

   accept any sensible suggestion

   *do **not** accept answers only in terms of fossil fuels or carbon dioxide*

1

[5]

57   (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 $^4_2α$ for ***1*** *mark*

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

1

[8]

58 (a) gravitational force(s) (1)
accept 'gravity'

balanced by (force(s) due to) <u>radiation</u> pressure (1)
accept equal

2

(b)   by (nuclear) <u>fusion</u> (1)

of hydrogen to helium (other light elements) (1)

allow 'low density' for light

accept hydrogen nuclei / atoms form helium

response must clearly link one element(s) producing others

fusion to produce helium (2)

heavy element / elements heavier than iron are only produced (by fusion) in a <u>supernova</u> (1)

allow dense for heavy

ignore any reference to elements undergoing radioactive decay (to form other elements)

3

[5]

59   (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 <u>left</u> 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]

60　(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]