Mark schemes

1

(a) isotopes

1

(b) $^{231}_{90}Th$

1

correct order only

1

(c) (i) (nuclear) fission

accept fision

*do **not** accept any spelling that may be confused with fusion*

1

(ii) neutron / neutrons

1

(d) plutonium (239)

accept MOX (mixed oxide)

accept Pu

*do **not** accept uranium 238 / hydrogen*

1

[6]

2

(a) (enough) <u>dust and gas</u> (from space)

accept nebula for dust and gas

accept hydrogen for gas

mention of air negates this mark

1

pulled together by:

- gravitational attraction
  or
- gravitational forces
  or
- gravity

1

(b) forces (in the star) are <u>balanced</u>

accept equal and opposite for balanced

accept in equilibrium for balanced

1

forces identified as gravity and radiation pressure

both forces are required

*gravitational forces inwards balance / equal radiation pressure outwards for **2** marks*

*accept for **2** marks an answer in terms of sufficient hydrogen to keep the fusion reactions going*

*accept for **1** mark an answer in terms of sufficient fuel to keep the fusion reactions going*

1

(c) (explodes as) a supernova

1

any **one** from:

- outer layer(s) thrown into space

  *do **not** accept just 'thrown into space'*

- scatters dust and gas into space (for the formation of new stars)

  *do **not** accept just 'dust and gas'*

- elements distributed throughout space

  *do **not** accept just 'distributed'*

- matter left behind / core may form a neutron star

  *do **not** accept just 'neutron star'*

- a black hole will form if the gravitational forces are enormous / sufficient mass is left behind

  *do **not** accept just 'black hole'*

  *do **not** accept any references to 'dark bodies' or 'black dwarfs'*

  black hole forms if star is large enough is insufficient

1

[6]

3 (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]

4

(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

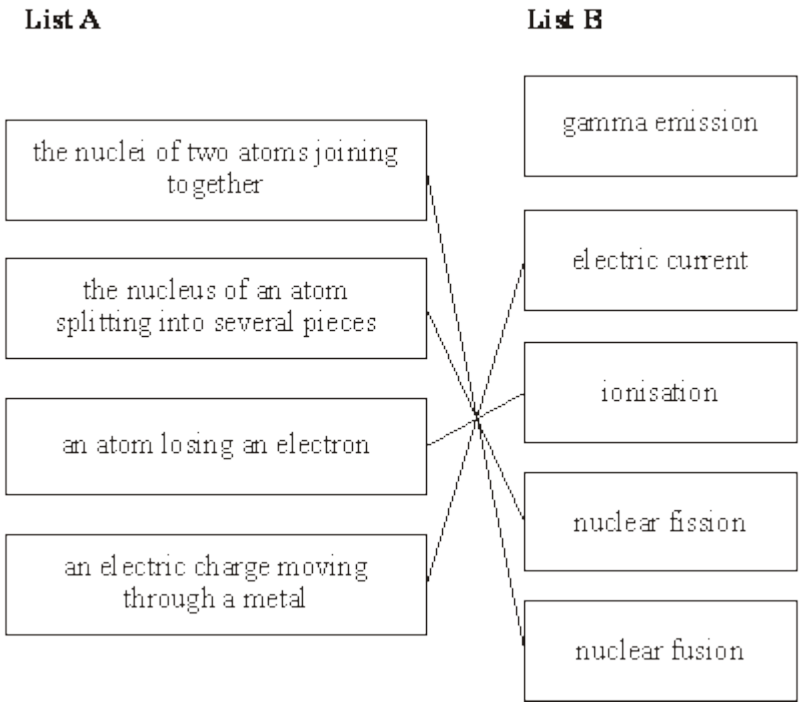
1

[10]

5 **four** 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



[4]

6 (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]

7 (a) 146

1

(b) atomic number

1

(c) (i) alpha

1

(ii) number of protons changes

accept atomic number changes

accept loses or gains protons

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

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

1

[4]

8 (a) any **two** pairs from:

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

  plum pudding model mass is evenly distributed (1)

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

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

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

  accept electrons in shells/ orbits provided a valid comparison is made with the plum pudding model
  *do **not** accept on its own*
  *do **not** accept electrons at edge of plum pudding*

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

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

- nuclear model the atom mainly empty space (1)

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

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

4

(b) nucleus must be <u>positive</u> to deflect/ repel alpha particles

answers in terms of electrons/negative charge causing deflection negates mark answers in terms of reflection negates mark

1

nucleus (very) small so few alpha particles deflected backwards

accept most of atom empty space so <u>most</u> pass through

1

(c) many/ 100 000 measurements taken

accept results for measurements accept data valid / reliable

1

findings could not be explained by plum pudding model

accept a specific finding that could not be explained
eg some alpha particles were deflected backwards

1

[8]

9 (a) fusion (1)

of hydrogen/H (atoms)(1)

*do **not** credit any response which looks like 'fission' **or** the 'word' 'fussion'*

credit only if a nuclear reaction

2

(b) fusion of other/lighter atoms/elements (1)

reference to big bang nullifies both marks

during super nova/explosion of star(s) (1)

2

(c) explosion of star(s)/super nova (1)

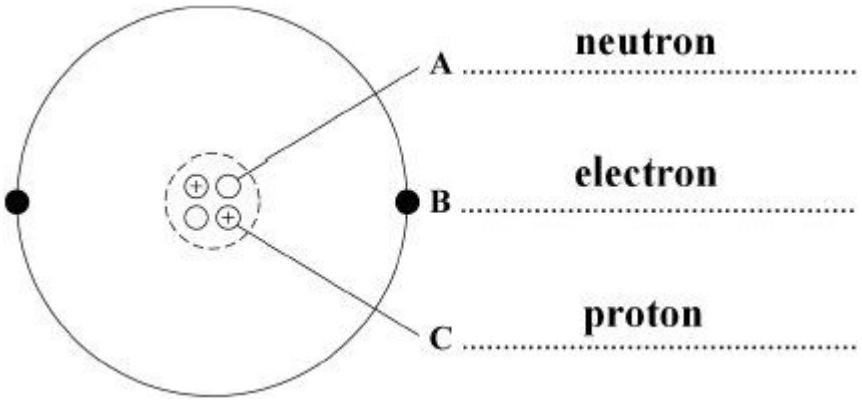
reference to big bang nullifies both marks reference to the star running out of energy/material nullifies both marks

at the end of the 'life' of star(s) / when they 'die' (1)

2

[6]

10 (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]

11 (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]

12 (a)

Particle	Relative Mass	Relative charge
Proton	1	
Neutron		0

accept one, accept +1
*do **not** accept –1*

1

accept zero

*do **not** accept no charge/ nothing/neutral unless given with 0*

1

(b) equal numbers/amounts of protons and electrons

1

protons and electrons have equal but opposite charge

accept protons charge +1 and electron charge –1

accept (charge) on proton
cancels/balances (charge) on electron

accept positive (charges) cancel out the negative(charges)

neutrons have no charge is neutral

*do **not** accept total charge of protons, electrons (and neutrons) is 0 unless qualified*

1

(c) (i) (3) fewer neutrons

accept lower/ smaller mass number

*do **not** accept different numbers of neutrons*

any mention of fewer/more protons/electrons negates mark

accept answers in terms of U-238 providing U-238 is specifically stated i.e. U-238 has (3) more neutrons

1

(ii) neutron

1

(iii) (nuclear) fission

accept fision

*do **not** accept any spelling that may be taken as fusion*

1

[7]

13 (a) gravitational

accept gravity

*do **not** accept weight*

1

(b) (i) planet(s)

accept comet(s)

accept asteroid(s)

*do **not** accept moon(s)*

1

(ii) balanced

accept equal / the same / are in equilibrium

1

(iii) Milky Way

accept milky way

1

[4]

14 (a) (i) the bigger the masses (of the dust and gases then) the bigger the force / gravity (between them)

accept the converse

1

(ii) the greater the distance (between the dust and gases then) the smaller the force / gravity (between them)

accept the converse

1

(b) radiation 'pressure' and gravity / gravitational attraction these are balanced / in equilibrium

1

must be in correct context
*do **not** accept are equal*

or there is sufficient / a lot of hydrogen / fuel to last a very long time

second mark consequent on first

1

(c) any **two** from:

- hydrogen runs out / is used up
- nuclei larger than helium nuclei formed

  *accept bigger atoms are formed however do **not** accept any specific mention of an atom with a mass greater than that of iron*
- (star expands to) / become(s) a red giant

2

[6]

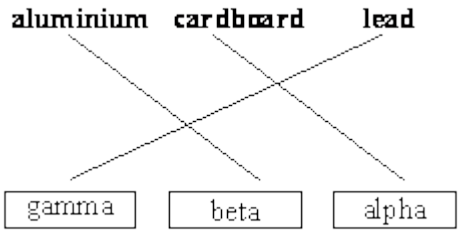
15 (a) (i) **P**

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]

16 (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]

17 (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]

18 (a) (i) (nuclear) fission

*accept fision providing clearly **not** fusion*

1

(ii) (released) neutrons are absorbed by further (uranium) nuclei

accept hit nuclei for absorbed / hit
*do **not** accept atom for nuclei*

1

more neutrons are released (when new nuclei split)

*accept for **both** marks a correctly drawn diagram*

1

(iii) increases by 1

or goes up to 236

1

(b) any **two** from:

- (more) neutrons are absorbed

  accept there are fewer neutrons

- (chain) reaction slows down / stops

  accept keeping the (chain) reaction controlled

- less energy released

  accept heat for energy
  accept gases (from reactor) are not as hot

2

[6]

19 (a) (a) supernova (explosion)

1

(b) solar system contains heavy elements / elements heavier than hydrogen and helium (1)

these (heavy) elements are / were formed by (nuclear) fusion (1)

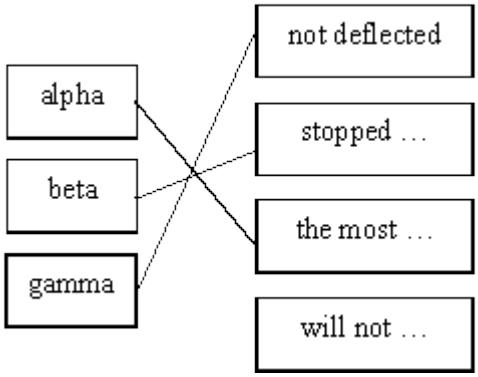
accept minor misspellings for 'fusion'
*but **not** anything which could also be 'fission'*

(at the very high temperature(s)) in a super nova / when stars explode (1)

3

[4]

20 (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]

21 (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 **<u>much</u>** 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]

22 (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 $\frac{2}{5}$ */ 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]

23 (a) dust

accept 'solid (s)'

1

space

accept 'from supernova / supernovum / supernovas'

1

(b) By atoms joining together

only one ticked or otherwise unambiguously identified

1

(c) Milky Way (galaxy)

1

(d) The answer depends on beliefs and opinions, not scientific evidence.

only one ticked or otherwise unambiguously identified

1

[5]

24 (a) (i) (nuclear) fusion

*allow minor misspellings but do **not** credit any response which could be fission*

1

(ii) (in) stars

accept supernova / red giants / white dwarves

*do **not** allow the Sun*

1

(iii) (by) supernova / explosion of star

*do **not** credit just 'explosion(s)'*

1

(b) the (available) evidence:
supports this idea
or does not contradict this idea
or can be extrapolated to this idea

1

[4]

26 (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]

27 (a) (i) <u>electromagnetic</u> (wave / radiation)

accept <u>em</u> (wave / radiation)
ignore reference to frequency

1

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

accept converse (but must relate to both alpha <u>and</u> 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

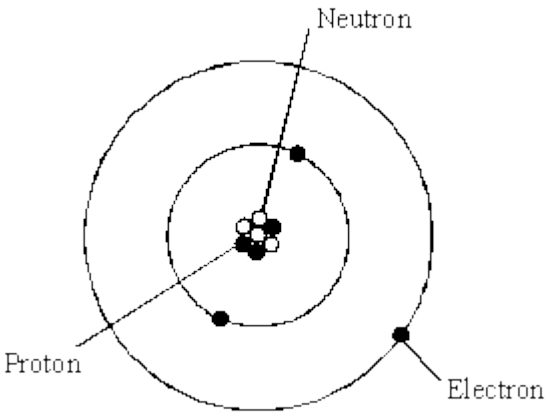
*eg think it will give them cancer = **0** marks*

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

1

[8]

28 (i) each correct label scores 1 mark



3

(ii) neutron

1

(iii) 7

1

number of protons and neutrons **or** number of nucleons or number of particles in the nucleus

accept number of particles in the centre only if first answer = 7

1

[6]

29 (i) 50 ± 5

1

(ii) 50 ± 5

accept their (b)(i)

1

(iii) less

accept any way of indicating the correct answer

1

[3]

30 (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 $\frac{1200}{60 \times 10}$ **or** $\frac{120}{600}$ **or** 120

2

[3]

31 *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]

32 *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.*

*Maximum of **1** mark if ideas not well expressed*

any **two** from:

dust <u>and</u> gas **or** remnants of a super nova

accept hydrogen for dust and gas
*do **not** accept hydrogen burns*

pulled together by (force of) gravity

nuclear fusion starts

although candidates may include more detail these points are essential to score the credit

[2]

33 (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]

34 (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]

35 (a) **Y** and **Z**

1

they have the same number of protons **or** same atomic number

*accept they have the same number of electrons **or** same number of protons **and** electrons*
allow only different in number of neutrons N.B. independent marks

1

(b) **Quality of written communication**

*for correct use of terms underlined in B **or** C*

Q ✓ Q ✗

1

A – alpha particle passes straight through the empty space of the atom
or it is a long way from the nucleus

*describes 3 tracks correctly for **2** marks*
*describes 2 or 1 track correctly for **1** mark*

B – alpha particle deflected / repelled / repulsed by the (positive) nucleus

C – alpha particle heading straight for the nucleus is deflected / repelled / repulsed backwards

*do **not** accept hits the nucleus*
*do **not** accept answers referring to refraction*
*do **not** accept answers in terms of reflected backwards unless qualified in terms of repulsion*

mention of difference in charge on nucleus negates that track

max 2

[5]

36 (a) (i) (large) nucleus hit by a neutron

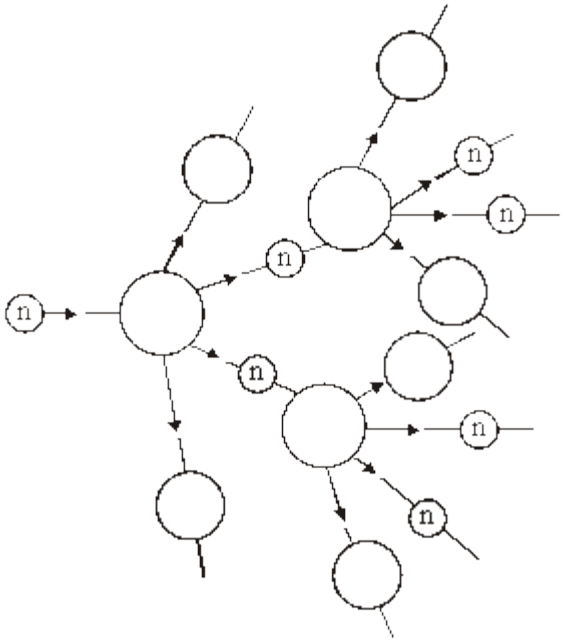
1

splits into (smaller) nuclei **and** neutron(s) (+ energy)

1

(ii) additional neutrons collide with nuclei causing further fission

allow full credit for a correct labelled diagram
accept 2 or more neutrons given out at each fission reaction
diagram shows 3 discernible sizes, with smaller nuclei and neutrons at same stage



1

(b) cost of (building and) de-commissioning is very high **or**
cost of building is higher

accept a correct description of de-commissioning
accept high cost to keep the power station safe / secure
accept high cost of reprocessing / storage of nuclear waste

1

(c) less pollution from transport carrying the fuel

accept coal produces more pollutant gases
accept correct named gases
accept more radiation pollution from coal than nuclear
accept more waste from coal than nuclear
*do **not** accept any reference to burning uranium*
*do **not** accept answers in terms of global warming **or** acid rain unless developed*

1

[5]

37 (a) any **two** from:

- nuclei / atoms of light elements fuse

  accept hydrogen or helium for light elements
  accept join for fuse
  *accept for **1** mark, by nuclear fusion*
  answers about fission negates a mark

- each (fusion) reaction releases energy / heat / light

- lots of reactions occur

2

(b) presence of nuclei of the heaviest / heavy / heavier elements

accept atom for nuclei

1

(c) (i) (matter / mass) with such a high density / strong gravitational (field)

1

electromagnetic radiation / light is pulled in

accept nothing can escape
*do **not** accept answers in terms of an empty void*

1

(ii) X-rays

accept e-m radiation / e-m waves

1

[6]

38 (i) nucleus / neutron

*do **not** accept shells or orbits*

1

(ii) neutron changes to a proton **or** number of neutrons goes down 1 and the number of protons goes up by 1

*do **not** accept becomes positive*

1

[2]

39 (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]

40 (i) radon (gas)

*do **not** accept gas*

1

(ii) background

1

[2]

41 (a) bigger

accept any word which means bigger

1

(b) **Z**

if Z is not given, the reason does not score

1

alpha will not pass through aluminium or lead

accept alpha cannot go through metals / dense material
accept there is nothing to stop the radiation
accept alpha will not pass through aluminium
*do **not** accept alpha will not pass through lead*
*do **not** accept alpha stopped by air*

1

[3]

42 (a) all points correctly plotted

tolerance ± $\frac{1}{2}$ square on y axis only

*allow **1** mark for 3 correctly plotted points*

2

attempt made to draw a smooth curve

*do **not** accept dot-to-dot line*

1

(b) (i) 3 days $\pm$ 0.2
or any value correctly obtained using their graph line

if no line drawn in (a), answer must be exactly 3

1

(ii) 3 days or their (b)(i)

1

(c) radon-222

*accept radon **or** 222*
accept alpha or 3.8
correct isotope required for reason to score

1

has the shortest half-life

accept the others have longer half-lives

1

[7]

43 (a) (i) both lose 2 protons and (2) neutrons

accept changes by 2 protons and 2 neutrons

1

(ii) different number of protons (in the nucleus)

accept different atomic number
*do **not** accept different number of protons and neutrons or different mass number*
ignore electrons

1

(iii) gamma involves no change in the number of protons (in the nucleus)
or gamma is a wave (not a particle)

*do **not** accept number of neutrons*
and / or protons
ignore electrons

1

(b) (i) water because

*both material **and** reason required*

for all energy values the thickness
of water needed to absorb (90% of)
the radiation is more than the other materials

accept thickness of water required is always more than the other materials

1

(ii) 6

*allow **1** mark for obtaining both correct values 72 **and** 12 from graph*
*allow **1** mark for incorrect values 71 and / or 11 from graph evaluated correctly*

2

(c) any **three** from:

may be scored on annotated diagram provided not negated elsewhere

- most (alpha) particles passed undeflected / straight through the gold
- suggesting most of the atom is empty (space)
- a few (alpha) particles scattered / deflected through (very) large angles

  accept repelled
  *do **not** accept reflected / rebound / bounce back*
- suggesting a concentrated / small nucleus
- nucleus is positive because it repels the positive (alpha) particles

  *no reference to experiment, maximum **1** mark*

3

[9]

44

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

accept 0.25 or 25%

1

(ii) 2600

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

1

[2]

45

(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]

46 (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]

47 (a) (i) element with equal number of protons, different number neutrons
or
same atomic/proton number different mass/nuclear number

1

(ii) time taken for activity **or** count rate **or** number of nuclei to decrease to half

*accept parents atoms **or** radioactive isotope*

do not accept time taken for radioactivity/substance/ material to halve

1

(iii) 12 (s)

1

(b) (i) 22800 (years)

allow 1 mark for iterative steps 80-40-20-10-5 ***or*** *statement of 4 half-lives*

2

(ii) decay (of carbon 14) over 150 years is insignificant

accept very little decay

accept change is too small

1

(c) either argument gains full credit

accept any 3 valid points from for and/or against arguments

FOR

– massive dilution of waste
– reduces concentration (within a given volume) to insignificant levels
– distant from habitation

AGAINST

– pollution (of the sea/beach)
– mutation **or** harm caused to living things (animals/plants)
– effect on food chain
– long period of time necessary

3

[9]

48 (a) electron

accept e

1

(b) 5400 – 7000

horizontal line drawn corresponding to their halving

1

or

a cross in the correct position on the line

1

(c) count rate converted to 14.5/min for 1g mass

accept 14.5 clearly marked on graph

1

decay time taken as 750 years ± 100 years

accept 750 years clearly marked on graph

1

refer their answer to 837 years (or approximately 800 **or** a value 837 - 937 years)

no the shirt was made after he died (if numbers justify)

or

yes it could have been his shirt (if numbers justify)

allow an alternative answer working backwards from 837 years

1

[6]

49 (a) (i) helium nuclei

1

or

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

*do **not** accept it is a particle emitted by an unstable nucleus of Californium -241*

(ii) time taken for the activity **or** count rate **or** number of nuclei **or** number of atoms **or** number of radioactive particles to decrease to half

1

(iii) Technetium-99

*this mark **cannot** score without Technetium- 99*

1

any **two** of the following:

- suitable short half-life or activity quickly reduced to a safe level or it doesn't stay in the body long

  *this mark **can** score if Cobalt -60 is given*

- (gamma emitter so) it can be <u>detected</u> outside the body

- less (ionising) damage to cells **or** tissue

  *this mark **can** score if Cobalt -60 is given*

2

(b) any **three** of the following:

- transport of waste into the area
- possibility of accident or leakage from transport
- safe levels not reached for hundreds or thousands of years
- Possible leakage **or** contamination of land **or** water **or** increase in background radiation
- increased risk of (radiation linked) illness **or** cancer

3

[8]

50 (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 <u>cosmic rays</u>

must have idea of comparison

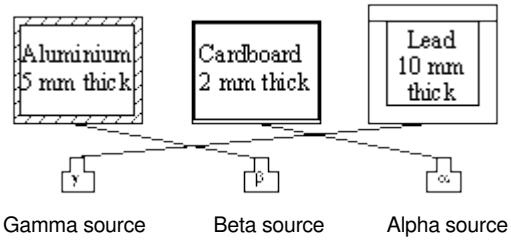
1

when flying less air to absorb **or** shield from radiation

1

[3]

51 (a) all **3** correct



*allow **1** mark for **one or two** possible links*
no marks for more than one line from a source or to a box

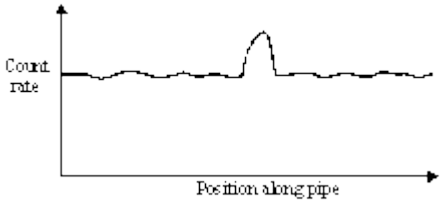
2

(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]

52 (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]

53 (a) presence of a radioactive source

*accept radioactivity **or** radioactive or radiation*

accept a named source

accept a named type of radiation ignore reference to relative levels

*do **not** accept thermal **or** heat radiation*

*do **not** accept nuclear waste*

1

(b) (i) gamma

accept correct symbol

1

(ii) alpha

accept correct symbol

1

[3]

54 (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]

55 (a) (i) it is random

*do **not** accept unpredictable*

*do **not** accept irregular*

1

(ii) source adds nothing **or** little to the count

1

continues to record background level

accept a clear explanation of background

1

(b) (i) an electron

accept $\frac{0}{-1}e$

1

(ii) <u>electromagnetic</u> wave with **high frequency** or short wavelength

*must have high frequency **or** short wavelength*

1

(iii) 15

*allow **1** mark for **3** iterative steps 584/2 292/2 146/2*

allow I mark for 45/3

3

(iv) [A] a safe level of radiation reached much quicker

could answer in terms of isotope but answer must be clear whether it refers to isotope or sodium-24

1

[B] long enough to obtain measurements

1

[10]

56 (a) suitable arrangement of source and GM tube ie <u>fixed distance apart</u>

accept 'detector' for GM tube and counter

1

suitable test

*eg introduce absorbing material **or** increase distance between source and GM tube*

1

suitable conclusion

*alpha that which gives a greatly reduced count with a paper absorber **or** alpha if count decreases rapidly when distance between source and GM tube exceeds 5 cm (approx)*

the first two marks could be scored from a <u>labelled</u> diagram

1

(b) (i) (changes to) background radiation

*do **not** accept the source is decaying if it is their only answer*

or

(beta) decay is random

accept decay is not constant

1

(ii) thickness decreasing

accept it is thin

1

increased count rate

1

(means) less (beta) radiation absorbed

accept more (beta) radiation passes through

1

(iii) changing thickness will not change count rate (significantly)

accept insufficient absorption of gamma radiation irrespective of thickness

*do **not** accept gamma rays too penetrating*

*do **not** accept answers in terms of speed*

1

[8]

57 (a) fusion

accept fussion

1

energy producing process

accept heat and/or light for energy

accept fussion

1

(b) up to **2** points from:

***3** marks for 3 points in sequence with no contradiction*

- expands

***2** marks for 2 points in sequence with no contradiction*

- cools
- forms a red giant

***1** mark for a correct point which is not contradicted*

up to **2** points from:

*do **not** accept 'it turns red'*

- contracts
- increases in temperature
- forms a white dwarf

ignore further reference to black dwarfs, black holes, nebulae, supernovae

3

[5]

58 (a) (i) a helium nucleus

accept $^{4}_{2}He$
accept 2 protons + 2 neutrons
*do **not** accept He*
*do **not** accept helium atom*

1

(ii) nucleus

only answer, no alternative

1

(b) (i) each axis given a linear scale

time axis must go up to 12 days
y-axis must go up to 40 000

1

curve concave to axis drawn

1

curve shows correct half-life of four days

*do **not** accept a straight line must show one half-life*
check first two plotted points correct to ± half square
*a curve drawn dot-to-dot scores a maximum of **1** mark*

1

(ii) 38 750

no tolerance
*allow **1** mark for 5 half-lives*
*allow **1** mark for showing that 1 250 are undecayed*

3

(c) (i) more radon enters shaft (through cracks in the rock face)

accept radon emitted from surroundings

1

(ii) (alpha) radiation will damage cell structure or ionise cells

accept kill cells

1

causing cancerous growth

*an answer in terms of the daughter product polonium being a solid **or** lodging in the throat and also emitting alpha gains full credit*

1

[11]

59 (a) (i) centre

1

(ii) protons and neutrons

2

(iii) different number of neutrons

gets 1 mark

heavier

gets 1 mark

3 more neutrons or specified numbers

gets 2 marks

2

(b) atom hit by neutron;
splits into smaller nuclei;
further neutrons released;
neutrons released when one atom splits
cause further fission;
energy released.

any 4 for 1 mark each

4

[9]

60 (i) sensible answers e.g. risk of radioactive leak during transport eliminated
cheaper transport

1

(ii) 4 half-lives 4 × 6 = 24 seconds

3

[4]