AQA GCSE PHYSICS (HIGHER) · 8463

PHYSICS



MARK SCHEME

4.4.1 ATOMS AND ISOTOPES (PACK 1)

SCORE	PERCENTAGE
/244	%

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Q1.

(a) B

reason only scores if B is chosen

1

americium has an atomic number of 95

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

1

(b) 430 (years)

allow an answer between 420 and 440 (years)

1

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

allow an answer between 420 and 440 (years)

1

[4]

Q2.

(a) 7

1

(b) 3

1

number of <u>protons</u>

reason only scores if 3 chosen

1

(c) levels

1

(d) $^{4}_{2}He$

correct order only

1
1

$^{0}_{-1}e$

1

(e) shorter half-life (than the other sources)

1

exposure time to radiation is shorter

1

[9]

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Q3.

(a) most alpha particles pass straight through the atom

1

which shows that the atom is mostly empty space

1

very few alpha particles are deflected through a large angle

1

which shows the atom contains a nucleus where the mass / charge of the atom is concentrated

1

(b) electron may absorb electromagnetic radiation

full credit may be scored for a description of an electron emitting electromagnetic radiation

1

(and) move further from the nucleus

1

to a higher energy level

1

[7]

Q4.

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]

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Q5.

(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]

Q6.

(a) (i) (atoms with the) same number of protons

allow same atomic number

***or** same proton number*

1

(atoms with) different number of neutrons

allow different mass number

1

(ii) 82

1

(iii) 124

1

(b) (i) $^{58}_{26}Fe + ^{208}_{82}Pb$

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***1** mark for each correct box*

3

(ii) (a) neutron

1

(iii) 4.0×10^{-4} (s)
or
0.0004

$3.00 \times 10^{8} \times 0.1 = 12\,000 / t$
*gains **1** mark*

2

(iv) particles need to travel a large distance

1

equipment would have to be very long

1

with circular paths long distances can be accommodated in a smaller space

1

(c) (i) the average time for the number of nuclei to halve

1

the time for count rate to halve

1

(ii) $^{261}_{106}Sg + {}^{4}_{2}\alpha$

***1** mark if top boxes total = 265*
***and** bottom boxes total = 108*
***1** mark for 4 and 2 for alpha*

2

(d) (i) 3 plotted points
± ½ small square

1

best line through points

1

(ii) 190−205 (pm)
or correct from student's line

1

[20]

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Q7.

(a) (an equal amount of) positive charge

*do **not** accept charge on the atom / nucleus is positive*

1

(b) (i) a (significant) number of alpha particles were scattered by more than 4°
or
alpha particles deflected backwards

accept (some) measurements / results were unexpected

1

measurements / results could not be explained by 'plum pudding' model
or
measurements / results did not support predictions

can be explained by the nuclear model is insufficient

accept measurements / results did not support hypothesis

1

(ii) many / (over)100 000 measurements / results taken

accept Rutherford(and Marsden) were respected scientists
or
scientists were respected

accept measurements / results taken over several months

the experiment was repeated many times is insufficient

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 on page 5 and apply a 'best-fit' approach to the marking.

0 marks
no relevant content

Level 1 (1−2 marks)
A brief description is given with some particles correctly named

Level 2 (3−4 marks)
A description is given with all three particles named
plus either
the polarity of charge associated with the
three particles
or
the relative mass of the three particles
or
the relative mass for one particle and the relative charge for one particle given

Level 3 (5−6 marks)
A more detailed description is given, naming the particles and polarity of charge
and either
the relative mass is given for at least two particles
or
the relative charge is given for at least two particles

Examples of the points made in the response

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brief description

contains protons, neutrons and electrons

protons are positive
electrons are negative
neutrons are uncharged

has a nucleus

relative charge

proton +1
electron − 1
neutron 0

relative mass

proton 1
neutron 1
electron (about) 1 / 2000

accept protons and neutrons have the same mass
accept electrons have tiny / negligible mass
zero mass is neutral

more detailed description

protons and neutrons make up the nucleus
electrons orbit the nucleus
electrons are in shells
most of the atom is empty space
nucleus occupies a very small fraction of the volume of the atom
electrons orbit at a relatively large distance from the nucleus
most of the mass of the atom is contained in the nucleus
the nucleus as a whole is positively charged total number of protons in the nucleus equals the total number of electrons orbiting it in an atom

6

[10]

Q8.

(a) neutrons and protons

1

(b) 0

1

(+)1

1

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

accept protons and electrons have an equal opposite charge

1

(because) no of protons = no of electrons

1

(ii) ion

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1

positive

1

[7]

Q9.

(a) (i) neutron

1

(ii) neutron
proton
both required, either order

1

(iii) 2

1

number of protons
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]

Q10.

(a) neutron discovered

1

(b) neutron

all 3 in correct order

electron

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

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proton

2

[3]

Q11.

(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]

Q12.

(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]

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Q13.

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]

Q14.

(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

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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]

Q15.

(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

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[6]

Q16.

(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]

Q17.

(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]

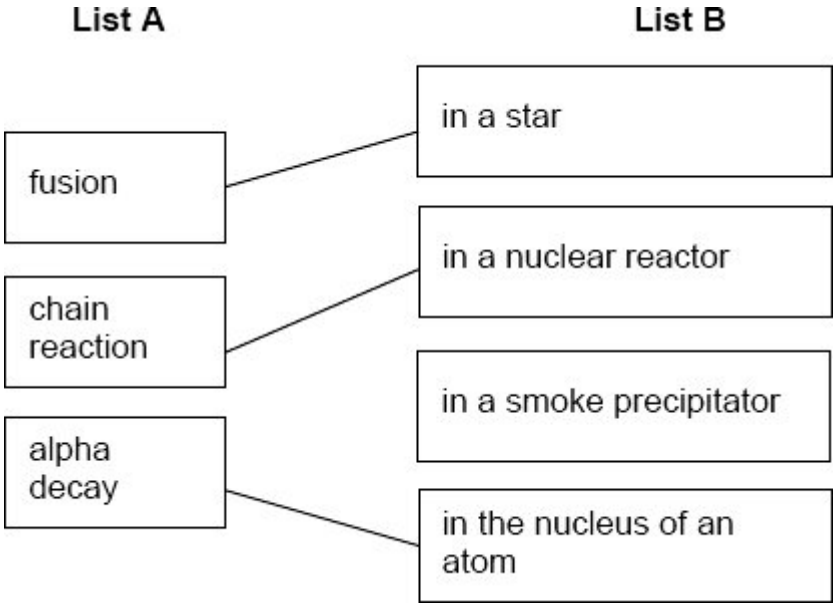
Q18.

three lines correct

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

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



[3]

Q19.

(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]

Q20.

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

- food / drink
- rocks / building materials
- cosmic rays / rays from space

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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

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(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]

Q21.

(a) (i) **L**

1

(ii) **M**

1

(b) To make a smoke detector work.

1

(c) **40**

no tolerance

1

[4]

Q22.

(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]

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Q23.

(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]

Q24.

(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

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(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]

Q25.

(a) (i) **K** and **L**
both answers required either order

1

(ii) (1) same number of protons
accept same number of electrons
accept same atomic number

1

(2) different numbers of neutrons

1

(b) (i) 90

1

(ii) 140

1

(c) alpha (particle)
reason may score even if beta or gamma is chosen

1

mass number goes down by 4
or
number of protons and neutrons goes down by 4
or
number of neutrons goes down by 2
*candidates that answer correctly in terms of why gamma **and** beta decay are not possible gain full credit*

1

atomic / proton number goes down by 2
or
number of protons goes down by 2
*accept an alpha particle consists of 2 neutrons and 2 protons for **1** mark*
*accept alpha equals $^{4}_{2}He$ or $^{42}\alpha$ for **1** mark*
an alpha particle is a helium nucleus is insufficient for this mark

1

[8]

Q26.

(a) (i) (atoms / elements with) the same number of protons but different numbers of neutrons

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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

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[10]

Q27.

(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]

Q28.

(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 positive to deflect/ repel alpha particles

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

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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

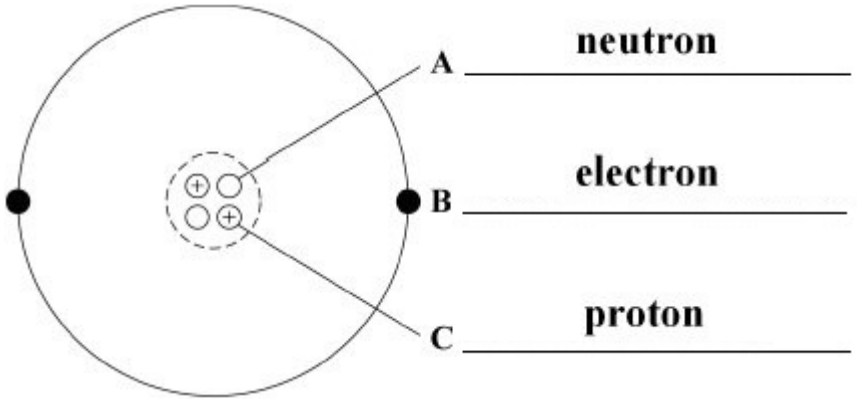
accept a specific finding that could not be explained
eg some alpha particles were deflected backwards

1

[8]

Q29.

(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

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(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]

Q30.

(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

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(ii) 2.7 (days)

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

2

[9]

Q31.

(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]

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Q32.

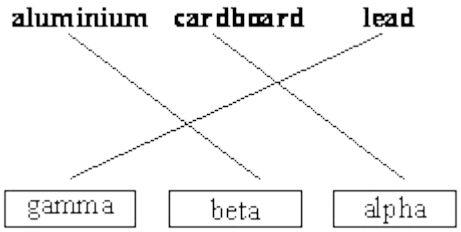
(a) (i) **P**

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

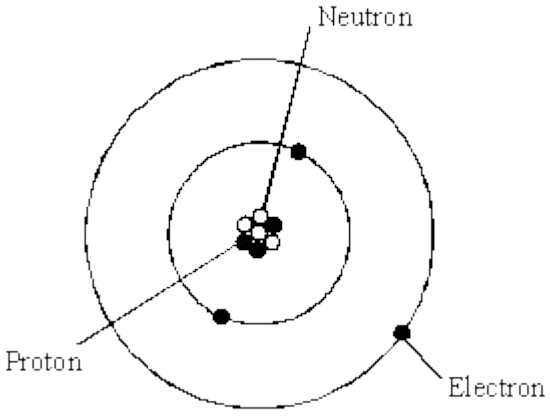
(iv) to inject... tracer

1

[8]

Q33.

(i) each correct label scores 1 mark



3

(ii) neutron

1

(iii) 7

1

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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]

Q34.

(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]

Q35.

(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

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(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]

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