M1. (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]

M2. (a) (i) number of protons are the same

accept atomic number / number of electrons for number of protons

1

number of neutrons are different

accept mass numbers are different – only if the first mark is awarded

1

(ii) an electron from the nucleus

both parts needed

1

(b) decays at the same rate as it is made

accept decays as fast as it is made

accept absorbed / used by plants (in CO_2) at same rate as it is being made

1

(c) (i) 3500

no tolerance

1

(ii) adjusted age correctly obtained from the graph

accept values between 3700–3800 inclusive

accept their (c)(i) used correctly to obtain an adjusted age from the graph

1

adjusted age +50

second mark can only be scored if first mark awarded

if no working shown an answer between 3750–3850 inclusive scores both marks

note: any line or mark made on the graph counts as working out

1

[7]

M3. *(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]

M4. *(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]

M5. *(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]

M6. *(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]

M7. *(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]