

**M1.** (a) (i) alpha (particle) 1

(ii) (unstable) nucleus 1  
*accept (unstable) nuclei*  
*do **not** accept middle*  
*do **not** accept helium nucleus*

(iii) same number of protons 1  
*accept same number of electrons*  
*accept same atomic / proton number*  
*accept they both have 92 protons*  
*same number of neutrons negates answer*

(b) (i) 4500 million years 1  
*do **not** accept 4500 years*

(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<sub>2</sub>) 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

- 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)  ${}_{81}^{208}\text{Th}$  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  
 alpha and beta decay produce different atomic numbers  
 ignore correct reference to mass number 1

**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]**