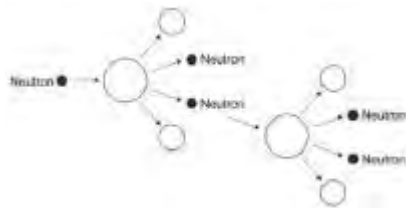


**M1.** (a) Nucleus splitting into two fragments and releasing two or three neutrons 1

(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]

- M2.** (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]

- M3.** (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 **much** 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]

M4. (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]

- M5. (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  $\frac{1}{2}$  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]**

- M6.** (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]**