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

1

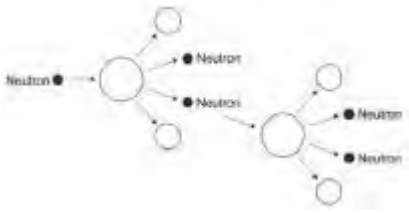
(at least one) fission neutron shown to be absorbed by additional large nucleus and causing fission

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 <u>one</u> 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 ½ 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]