Mark schemes

1.

(a) 148

1

(b) D and E

1

(c) line between B and 86 protons

1

same line between B and 222 mass number

1

(d) can't predict which nucleus will decay next

or

can't predict when a (particular) nucleus will decay

1

(e) one alpha decay would decrease proton number by 2

1

two beta decays would increase proton number by 2

1

so the proton / atomic number of the final nucleus is the same as the proton / atomic number of the original nucleus

this mark is dependent on scoring the first two marks

1

[8]

2.

(a) Any **one** from:

- (medical) x-rays

  allow CT scans
- radiotherapy
- nuclear weapons (testing)

  allow nuclear fallout
- named nuclear disaster e.g. Chernobyl / Fukushima / Three Mile Island.

  ignore radioactive / nuclear waste

1

(b) uranium / plutonium

ignore any number given

allow thorium

1

(c) neutron absorbed by a uranium nucleus **1**

nucleus splits into two parts

allow an atom splits into two parts if 1st marking point doesn't score **1**

and (2/3) neutrons (are released) **1**

and gamma rays (are emitted) **1**

(d) lighter nuclei join to form heavier nuclei

allow specific examples **1**

some of the mass (of the nuclei) is converted to energy (of radiation) **1**

(e) activity decreases quickly

allow nuclei / waste will decay at a greater rate
ignore waste is radioactive for less time **1**

risk of harm decreases quickly

allow burial site doesn't need to be monitored for as long
or
doesn't need to be buried underground for as long
or
may not need to be buried underground **1**

[10]

3. (a) $^{206}_{82}Pb$ **2**

(b) alpha radiation is highly ionising

1

causing an increased risk of cancer
or
organ failure
or
radiation sickness / poisoning
or
mutation of genes / DNA
or
damage to cells / tissues / organs

allow kill cells

1

until the radioactive material is removed / excreted

allow all the alpha radiation is absorbed by the body

or

activity of radioactive material reaches / approaches background radiation levels

ignore references to half-life

1

(c)

*an answer of 1.16 × 10^{-3} (g) scores **3** marks*

$\frac{414}{138} = 3$ (half-lives)

1

$1.45 \times 10^{-4} \times 2 \times 2 \times 2$

1

$= 1.16 \times 10^{-3}$ (g)
or
= 0.00116 (g)

1

[8]

4. (a) smoke absorbs / stops alpha radiation

allow alpha particles for alpha radiation

alpha radiation does not reach the detector is insufficient

1

(b) alpha radiation is not very penetrating

allow alpha particles for alpha radiation

or

alpha radiation does not penetrate skin

allow alpha radiation does not travel very far (in air)

1

(c) beta and gamma radiation will penetrate smoke

allow beta and gamma radiation will not be stopped by smoke

1

no change (in the count rate) would be detected

allow the change detected (in the count rate) would be too small

1

(d) (a long half-life means) the count rate is (approximately) constant

allow activity of source is (approximately) constant

or

a short half-life means the count rate decreases quickly

1

until 1.3 half-lives the count rate is above 80 per second

allow after 1.3 half-lives the count rate is below 80 per second

or

until 1.3 half-lives the count rate is above the threshold for the smoke alarm to be activated

or

after 1.3 half-lives the smoke alarm will be activated all the time

so don't have to replace source or smoke detector is insufficient

1

(e) **Level 2:** Relevant points (reasons / causes) are identified, given in detail and logically linked to form a clear account.

3–4

Level 1: Relevant points (reasons / causes) are identified, and there are attempts at logically linking. The resulting account is not fully clear.

1–2

No relevant content

0

Indicative content

- short half-life or half-life of a few hours
- (short half-life means) less damage to cells / tissues / organs / body
- low ionising power
- (low ionising power means) less damage to cells / tissues / organs / body
- highly penetrating
- (highly penetrating means) it can be detected outside the body
- emits gamma radiation

[10]

5. (a) any **three** from:

- no carbon dioxide emitted (to produce electricity)
  no greenhouse gases is insufficient
- doesn't cause global warming
  allow climate change or greenhouse effect for global warming
- nuclear power doesn't cause earthquakes
- more energy released per kg of fuel (compared to shale gas)

3

(b) uranium
or
plutonium
ignore any numbers given

1

(c) a neutron is absorbed by a (large) nucleus
a description in terms of only atoms negates first two marking points

1

the nucleus splits into two (smaller) nuclei

1

releasing energy (and gamma rays)

1

and (two / three) neutrons

1

[8]

6. (a) a uranium nucleus

1

absorbs a neutron

1

(uranium-236 nucleus) splits into two smaller nuclei
or
Kr and Ba nuclei
or
krypton and barium nuclei

1

and releases 3 neutrons and energy

1

(b) light nuclei

1

join to form a heavier nucleus

allow hydrogen nuclei for light nuclei

allow helium nucleus for heavier nucleus

1

(some of the) mass of the nuclei is converted to energy

allow particles for nuclei

1

(c) any **two** from:

- easy to obtain / extract
- available in (very) large amounts
- releases more energy (per kg)

*do **not** accept figures **only***

naturally occurring is insufficient

seawater is renewable is insufficient

less cost is insufficient

allow produces little / no radioactive waste

2

[9]

7. (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]

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

1

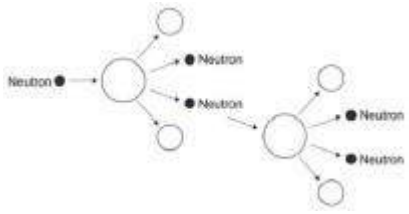
(at least one) fission neutron shown to be absorbed by additional large nucleus and causing fission

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]