**M1.**          (a)     (i)      (atoms / elements with) the same number of protons but different numbers  
of neutrons

*accept (atoms / elements with) different mass number but same atomic number*

**1**

(ii)     substances that give out radiation

*accept alpha, beta or gamma for radiation*

*accept an unstable nucleus that decays*

*radioactive decay takes place is insufficient*

**1**

(b)     85 years

*± 2 years*

*allow* ***1*** *mark for showing correct method on the graph*

**2**

(c)     (i)      a helium nucleus

*accept 2 neutrons and 2 protons*

*accept 2 4He*

*do* ***not*** *accept helium atom*

**1**

(ii)     the rate of decay (of plutonium) decreases

*accept fewer (plutonium) nuclei (to decay)*

*accept radioactivity decreases*

**1**

         less heat produced

*do* ***not*** *accept energy for heat*

**1**

(d)     (i)      (outside the body)

         alpha (particles) cannot penetrate into the body

         (inside the body)

**1**

         (heat produced from decay) damages / kills cells */* tissues

*accept causes cancer for damages / kills cells / tissues*

*accept* ***highly*** *toxic*

**1**

(ii)     any **one** from:

•        worried same could happen again

•        an accident may cause radiation to be spread around the Earth / atmosphere

•        idea of soil contamination resulting from accident / release of radioactive material

•        idea of negative effect on health resulting from accident / release of radioactive material

*accept any sensible suggestion*

**1**

**[10]**

**M2.**          (a)     (i)      (nuclear) fission

*accept fision providing clearly* ***not*** *fusion*

**1**

(ii)     (released) neutrons are absorbed by further (uranium) nuclei

*accept hit nuclei for absorbed / hit  
do* ***not*** *accept atom for nuclei*

**1**

         more neutrons are released (when new nuclei split)

*accept for* ***both*** *marks a correctly drawn diagram*

**1**

(iii)     increases by 1

**or** goes up to 236

**1**

(b)     any **two** from:

•        (more) neutrons are absorbed

*accept there are fewer neutrons*

•        (chain) reaction slows down / stops

*accept keeping the (chain) reaction controlled*

•        less energy released

*accept heat for energy  
accept gases (from reactor) are not as hot*

**2**

**[6]**

**M3.**          (a)     (i)      centre

**1**

(ii)     protons and neutrons

**2**

(iii)     different number of neutrons

*gets 1 mark*

heavier

*gets 1 mark*

3 more neutrons or specified numbers

*gets 2 marks*

**2**

(b)     atom hit by neutron;  
splits into smaller nuclei;  
further neutrons released;  
neutrons released when one atom splits  
cause further fission;  
energy released.

*any 4 for 1 mark each*

**4**

**[9]**

**M4.**          (a)     (i)      a helium nucleus

*accept He*



*accept 2 protons + 2 neutrons*

*do* ***not*** *accept He*

*do* ***not*** *accept helium atom*

**1**

(ii)     nucleus

*only answer, no alternative*

**1**

(b)     (i)      each axis given a linear scale

*time axis must go up to 12 days*

*y-axis must go up to 40 000*

**1**

curve concave to axis drawn

**1**

curve shows correct half-life of four days

*do* ***not*** *accept a straight line must show one half-life*

*check first two plotted points correct to  half square*



*a curve drawn dot-to-dot scores a maximum of* ***1****mark*

**1**

(ii)     38 750

*no tolerance*

*allow* ***1*** *mark for 5 half-lives*

*allow* ***1*** *mark for showing that 1 250 are undecayed*

**3**

(c)     (i)      more radon enters shaft (through cracks in the rock face)

*accept radon emitted from surroundings*

**1**

(ii)     (alpha) radiation will damage cell structure or ionise cells

*accept kill cells*

**1**

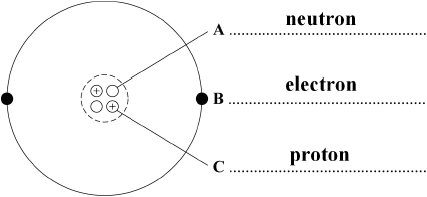
causing cancerous growth

*an answer in terms of the daughter product polonium being a solid* ***or*** *lodging in the throat and also emitting alpha gains full credit*

**1**

**[11]**

**M5.**          (a)     (i)



*all 3 labels correct*

*allow* ***1*** *mark for 1 correct label*

**2**

(ii)     has no electrons

*it = alpha*

*allow alpha has a positive(charge)  
allow a helium (atom) has no (charge)*

*do* ***not*** *accept general properties of alpha  
do* ***not*** *accept general answers in terms of size / density / mass etc*

**1**

(b)     (i)      15 (hours)

*accept any answer between 14.8 and 15.2 inclusive*

**1**

(ii)     15 (hours) or their (b) (i)

**1**

(c)     (i)      americium-241 has a long half life

**1**

(ii)     any **one** from:

•        alpha (particles) are harmful to …

*accept radiation / radioactive material is harmful to …  
accept specific example of harm  
eg can cause cancer  
accept radiation is poisonous if ingested / inhaled*

*do* ***not*** *accept it is poisonous / in case of leakage*

•        so they dispose of it safely / appropriately

•        so they don’t break it open / open it

*accept do* ***not*** *touch the radioactive source*

•        so they can make a choice about having a radioactive source (in the house)

*it = radioactive material*

**1**

**[7]**

**M6.**          (a)     146

**1**

(b)     atomic number

**1**

(c)     (i)      alpha

**1**

(ii)     number of protons changes

*accept atomic number changes*

*accept loses or gains protons*

*do* ***not*** *accept protons with any other particle e.g. number of protons and neutrons changes incorrect*

*do* ***not*** *accept any reference to mass number*

**1**

**[4]**

**M7.**          (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]**