Nuclear Physics

1. (*no single correct answer, but must be clear that isotopes are different versions of the same thing*)

2.
   (a)
       (i) helium nucleus
       (ii) electron
       (iii) positron
       (iv) photon
   (b)
       (i) Excess neutrons
       (ii) Excess protons
       (iii) Nucleus too large
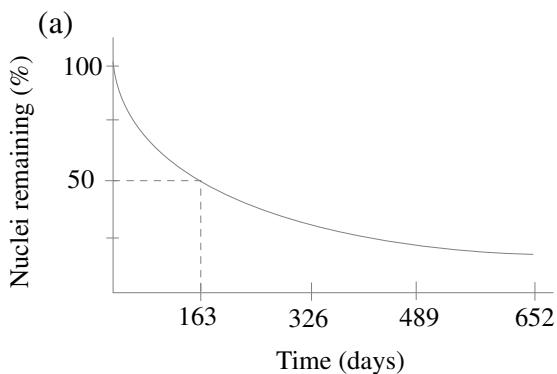   (iv) Nucleus left with excess energy after decay

3.
   (a) $^{1}_{0}n$

   (b) $^{27}_{12}X$ (Mg)

   (c) $^{1}_{0}n$

   (d) $^{4}_{2}He$

4.
   (a)

   (b) (*could use graph for this*)

   $$n = \frac{500}{163} = 3.07 \text{ half-lives}$$

   $$N = N_0 \left(\tfrac{1}{2}\right)^n$$

   $$= 4.2{\times}10^{24} \left(\tfrac{1}{2}\right)^{3.07}$$

   $$= 5.0{\times}10^{23} \text{ nuclei}$$

5.
   (a) Fission splits big nuclei, fusion joins small nuclei.
   (b) Hydrogen nuclei have much fewer protons and therefore substantially less repulsion.

6.
    (a) Uranium splits releasing neutrons which are absorbed by uranium nuclei causing them to split, etc...

    (b) To slow the neutrons so they can be absorbed.

    (c) By an absorber of neutrons.

7.

    (a) $\Delta m = m_f - m_i$

$$= 5.00824\times10^{-27} - \left(1.67262\times10^{-27} + 3.34358\times10^{-27}\right)$$

$$= -7.96\times10^{-30} \text{ kg}$$

$$\therefore 7.96\times10^{-30} \text{ kg lost}$$

    (b) $E = mc^2$

$$= 7.96\times10^{-30} \times\left(3.00\times10^{8}\right)^2$$

$$= 7.16\times10^{-13} \text{ J}$$