19 A pacemaker is a device used to regulate a person's heart rate.

Some of the first electronic pacemakers used an isotope of plutonium, Pu-238, as the power source.

(a) Pu-238 decays by alpha emission.

Show that the energy released when a nucleus of Pu-238 decays into a nucleus of uranium is about 5.6 MeV.

	Mass / u
Plutonium nucleus	237.999089
Uranium nucleus	233.991578
α-particle	4.001506

(5)

(b) In one pacemaker, the activity of the plutonium source was measured to be 6.75×10^{10} Bq in 2020.

Calculate the power of the source, in W, when it was fitted 40 years ago.

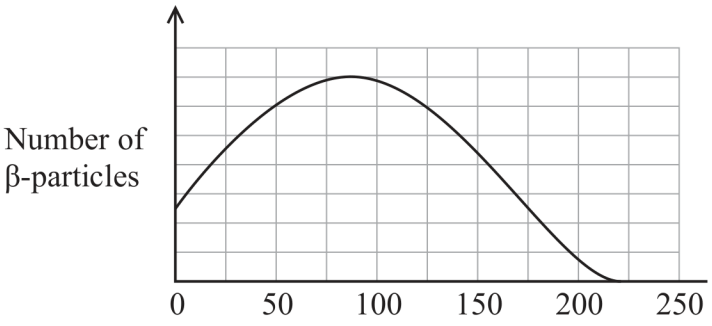
half-life of Pu-238 = 87.7 years

energy of α-particle = 5.6 MeV

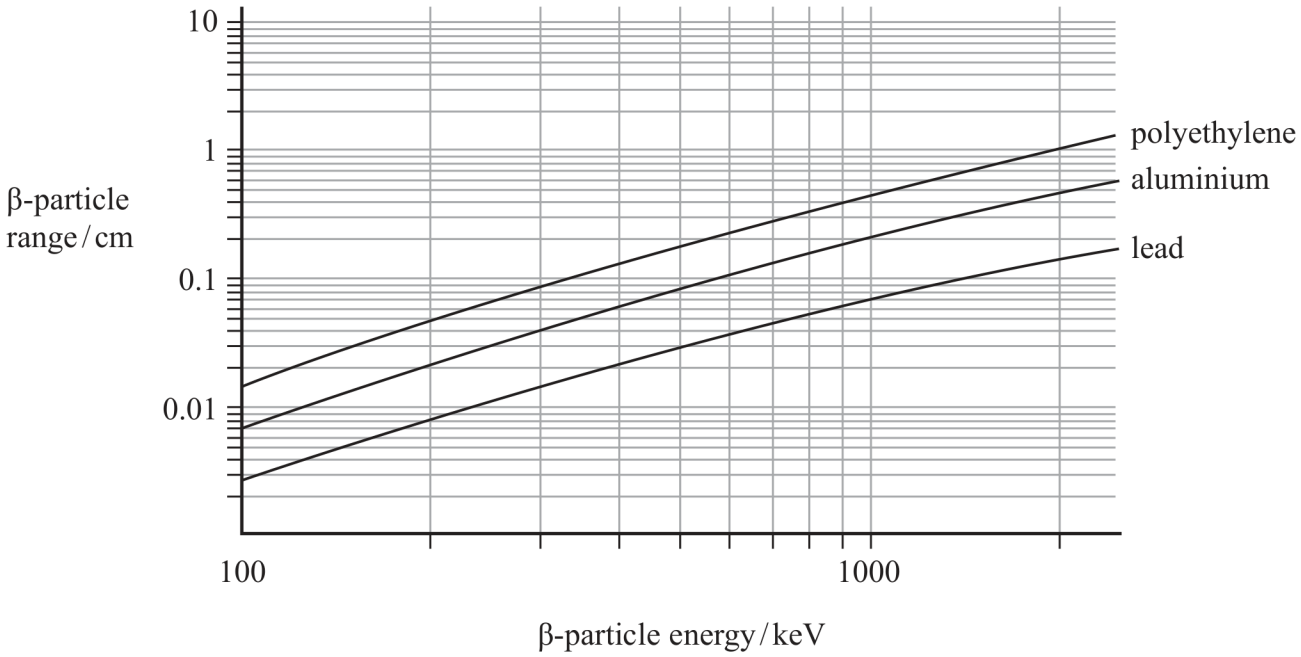
(5)

Power of source = ... W

(c) Another source that was used in early pacemakers was promethium-147. This emits β-particles. The energy spectrum for the β-particles is shown.



The graphs below show how the range of beta particles depends on the beta particle energy, for different materials.



It is suggested that a layer of polyethylene, of thickness 0.5 cm, would be able to absorb all the beta particles emitted from a promethium-147 source.

Comment on this suggestion.

(3)

(Total for Question 19 = 13 marks)