8 **(a)** Radioactive decay is a random and a spontaneous process.

Explain what is meant by

(i) *radioactive decay*,

.....

.....

..... [2]

(ii) a *random process*,

.....

..... [1]

(iii) a *spontaneous process*.

.....

..... [1]

(b) In a Voyager spacecraft, electrical power is provided using plutonium-238 ($^{238}_{94}Pu$).

Plutonium-238 nuclei emit α-particles of energy 5.48 MeV. The half-life of plutonium-238 is 86.4 years.

Some of the energy of the emitted α-particles is converted into thermal energy and then into electrical energy.

Calculate

(i) the probability per second of the decay of a plutonium-238 nucleus,

probability = ... s^{-1} [3]

(ii) the mass of plutonium-238 required for the energy per unit time of the emitted α-particles to be 2400 W. Explain your working.

mass = ... kg [6]

(c) Initially, of the 2400 J of energy produced per second by the decay of the plutonium-238, 160 J of electrical energy is generated per second.

(i) Calculate the efficiency of the conversion process.

efficiency = ...% [1]

(ii) Use data in **(b)** to determine the electrical power that is generated after 3.2 years.

power = ... W [2]

(d) Some data for three radioactive isotopes are given in Fig. 8.1.

isotope	half-life	principal radiation
plutonium-238	86.4 years	α-particles
polonium-210	138 days	α-particles
strontium-90	27.7 years	β-particles

Fig. 8.1

Suggest and explain, for a space flight lasting several years, one advantage of plutonium-238 as compared with

(i) polonium-210,

.....

.....

..... [2]

(ii) strontium-90.

.....

.....

..... [2]