12 (a) A sample of a radioactive isotope contains N nuclei of the isotope at time T.
At time $(T + \Delta T)$, the sample contains $(N - \Delta N)$ nuclei of the isotope. The time interval ΔT is short.

Use the symbols N, ΔN, T and ΔT to give expressions for:

(i) the average activity of the sample during the time ΔT

.... [1]

(ii) the probability of decay of a nucleus in the time ΔT

.... [1]

(iii) the decay constant λ of the isotope.

.... [1]

(b) The isotope polonium-208 ($^{208}_{84}$Po) is radioactive and decays to form lead-204 ($^{204}_{82}$Pb).
The nuclear equation for this decay is

$$^{208}_{84}\text{Po} \longrightarrow\ ^{204}_{82}\text{Pb} +\ ^{4}_{2}\text{He}.$$

Data for nuclear masses are given in Fig. 12.1.

	mass / u
$^{4}_{2}$He	4.002 603
$^{204}_{82}$Pb	203.973 043
$^{208}_{84}$Po	207.981 245

Fig. 12.1

(i) Determine, for the decay of one nucleus of polonium-208:

1. the change, in u, of the mass

mass change = ... u [1]

2. the total energy, in pJ, released.

energy = ... pJ [3]

(ii) The polonium-208 nucleus is initially stationary. The initial kinetic energy of the $^{4}_{2}$He nucleus (α-particle) is found to be less than the energy calculated in **(i) part 2**.

Suggest **two** possible reasons for this difference.

1. ....

....

2. ....

....

[2]

[Total: 9]

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