6 The isotope Radium-224 undergoes spontaneous decay and as a result, ionising radiation is produced. A stationary Radium- 224 nucleus decays to a Radon (Rn) nucleus by emitting an α-particle with no gamma emission as shown in the equation below. The daughter nucleus is an isotope of Radon (Rn).

$$^{224}_{88}\mathrm{Ra} \rightarrow \, ^{A}_{Z}\mathrm{Rn} + \alpha$$

(a) A deuterium nucleus has half the mass number and charge of the α-particle. Explain why a helium nucleus is more likely to be produced in the decay rather than two deuterium nuclei.

……………………………………………………………………………..…………

……………………………………………………………………………..…….. [1]

(b) Determine the number of neutrons and protons in a nucleus of Rn.

Number of neutrons = ………..……..

Number of protons = ………….. [1]

(c) The mass of the Radium nucleus is greater than the combined mass of the nuclei of Radon and the α-particle. Use a conservation law to explain how this decay is possible.

……………………………………………………………………………..…………

……………………………………………………………………………..…….. [1]

(d) The kinetic energy of the Rn nucleus is 0.1037 MeV. Determine the energy of the α-particle given the following information:

rest mass of $^{224}_{88}\mathrm{Ra}$ = 224.0202 u

rest mass of Rn = 220.0114 u

rest mass of α-particle = 4.0026 u

Energy of α-particle = ……………………… MeV [4]

(e) As the α-particle travels in air, ionisation of air occurs. A neutral molecule becomes an ion-electron pair. The energy required to produce an ion-electron pair from a neutral molecule at atmospheric pressure is 31 eV.

By estimating the range of an α-particle in air, calculate to two significant figures, the number of ion-electron pairs produced per unit length as the α-particle is stopped in air at atmospheric pressure.

Number of ion-electron pairs produced per unit length = …………………….. m^{-1} [3]