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

Explain what is meant by

(i) *radioactive decay*,

………………………………………………………….…………………………..

………………………………………………………….…………………………..

………………………………………………………….………………………… [2]

(ii) *random* decay,

………………………………………………………….…………………………..

………………………………………………………….………………………… [2]

(iii) *spontaneous* decay.

………………………………………………………….…………………………..

………………………………………………………….………………………… [1]

(b) The three most common types of radioactive decay are alpha, beta and gamma decay, which results in the emission of α, β and γ radiation respectively.

(i) Distinguish between the three types of radiation in term of their relative charges and masses.

………………………………………………………….…………………………..

………………………………………………………….…………………………..

………………………………………………………….………………………… [3]

(ii) Explain the use of a uniform magnetic field to differentiate the three types of radiation. You may draw a diagram if you need.

………………………………………………………….…………………………..

………………………………………………………….…………………………..

………………………………………………………….………………………… [2]

(c) Carbon-14 (^{14}C) is an unstable isotope that decays into nitrogen-14 (^{14}N).

The rest masses of the nuclei of carbon-14 and nitrogen-14 are

^{14}C, 13.999950 u

^{14}N, 13.999234 u

(i) State the type of radioactive decay that carbon-14 undergoes.

…………………………………………………………….………………….… [1]

(ii) Hence calculate the energy released in the decay of a carbon-14 nucleus.

energy released = ………………… MeV   [2]

(d) The ratio of the amount of carbon-14 (^{14}C) to carbon-12 (^{12}C) atoms in a living organism is a constant value of 1.3×10^{-12}.

However, when an organism dies, the ratio changes as the carbon-14 decays.

(i) The half-life of carbon-14 is 5730 years. Explain what this means.

……………………………………………………….…………………………..

…………………………………………………………….………………….… [1]

(ii) Calculate the decay constant of carbon-14.

decay constant = …………………….year^{-1} [2]

(iii) A sample is taken from an ancient bone fragment and analysed for its carbon content. It is found that there is a total number of 1.0×10^{20} carbon atoms in the sample, 6.0×10^5 of them being ^{14}C atoms.

Assume that the carbon atoms only consist of ^{14}C and ^{12}C atoms.

Detemine the age of the bone fragment.

age = ………………… years   [3]

(e) Besides counting the number of ^{14}C atoms in an object, another method of determining its age is to measure the count rate due to the ^{14}C in the object.

However, this method can only be used for objects up to about 35000 years old.

Suggest why this is so.

…………………………………………………………………………………………...........

…………………………………………………….…………………………………...

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

End of Section B

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