8 **(a)** Define binding energy.

.....

..... [2]

(b) $^{226}_{88}Ra$ is a stationary radioactive isotope which decays to $^{222}_{86}Rn$ with the release of an alpha particle. Given:

Mass of $^{226}_{88}Ra$ = 226.025 *u*

Mass of $^{4}_{2}He$ = 4.00260 *u*

Mass of $^{222}_{86}Rn$ = 222.018 *u*

Mass of proton = 1.00783 *u*

Mass of neutron = 1.00867 *u*

(i) Calculate the binding energy per nucleon of $^{226}_{88}Ra$ in MeV.

binding energy per nucleon = ... MeV [3]

(ii) Calculate the energy released in the above decay reaction in MeV.

energy released = ... MeV [2]

(c) $^{222}_{86}Rn$ is found in atmospheric air and it is also a radioactive element. The radioactive decay of $^{222}_{86}Rn$ is a *random* and *spontaneous* process.

(i) Explain what is meant by *random* and *spontaneous* process.

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.....

..... [2]

(ii) $^{222}_{86}Rn$ is one of the rarest element on Earth. Suggest reasons for this.

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.....

..... [2]

(iii) $^{222}_{86}Rn$ is considered to be an unacceptable health hazard when the activity of $^{222}_{86}Rn$ is greater than 200 Bq in 1.0 m^3 of air. The decay constant of $^{222}_{86}Rn$ is 2.1×10^{-6} s^{-1}.

Calculate the minimum mass of $^{222}_{86}Rn$ in 1.0 m^3 of air above which the health hazard becomes unacceptable.

minimum mass = ... kg [3]

(d) Carbon-14 is a radioactive isotope of carbon and it undergoes beta decay.

An archaeologist found a fragment of an ancient basket made from wood. The carbon-14 activity of the wood in the basket is 8.5 % that of an equal carbon sample from present day wood. Carbon-14 has a half-life of 5700 years.

(i) Calculate the age of the basket

age = ... years [2]

(ii) Calculate the probability of decay per second of a carbon-14 nuclide.

probability of decay per second = ... s^{-1} [1]

(iii) Explain whether Carbon-14 can be used to measure the age of a stone.

.....

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..... [2]

(iv) State and explain what happens to the number of protons and neutrons in the nucleus after it undergoes beta decay.

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..... [1]

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