Chapter 4·1 and 4·2 Exam Q Year 11

Question 1

(3 marks)

The fusion of deuterium and tritium to form helium can be represented by the equation:

$$^{2}_{1}H + ^{3}_{1}H \rightarrow ^{4}_{2}He + ^{1}_{0}n.$$

If the mass defect for this reaction is 0.0189 u, calculate the energy released, in joules, in one such fusion reaction.

Question 2

(4 marks)

State whether each of the following statements is true or false.

	Statement	**True or False**
A	When a nucleus is unstable, it decays to emit alpha, beta and gamma radiation all at the same time.	
B	Ionising radiation causes an atom to lose a proton and thus become charged.	
C	Solar energy is produced by nuclear fusion reactions.	
D	Binding energy is the energy needed to bind atoms to each other.	

Question 3

(13 marks)

Between 1917 and 1926 the U.S. Radium Corporation used radium-228 to produce paint that glowed in the dark. This paint was used by female workers to paint the hands and numbers on clocks and other instruments in aircraft. This enabled military pilots to read these instruments without turning on a light and giving the position of their aircraft away.

(a) An isotope of thorium decays to form radium-228 and an alpha particle.

(i) Write the nuclear equation to represent this decay. (2 marks)

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(ii) State the atomic number and mass number of the thorium isotope. (2 marks)

Atomic number: ____________

Mass number: ____________

(b) Radium-228 is an isotope of radium. Define the term 'isotope'. (2 marks)

Question 3 continued

(c) The radium-228 paint on a pilot's instruments had an initial activity of 140 kBq. If the half-life of radium-228 is 5.80 years determine the activity in kBq of the radium on the instruments, 52.2 years later. Show **all** workings. (3 marks)

(d) Alpha particles, ${}^{4}_{2}\alpha$, are often emitted during the decay of radium. An alpha particle is similar in structure to a helium nucleus. Determine the binding energy, in MeV, of a helium nucleus. Use the information in your **Formulae and Data Booklet**, and show **all** workings. (4 marks)

Question 4

(7 marks)

Calculate the average binding energy per nucleon (in joules) for carbon-14.

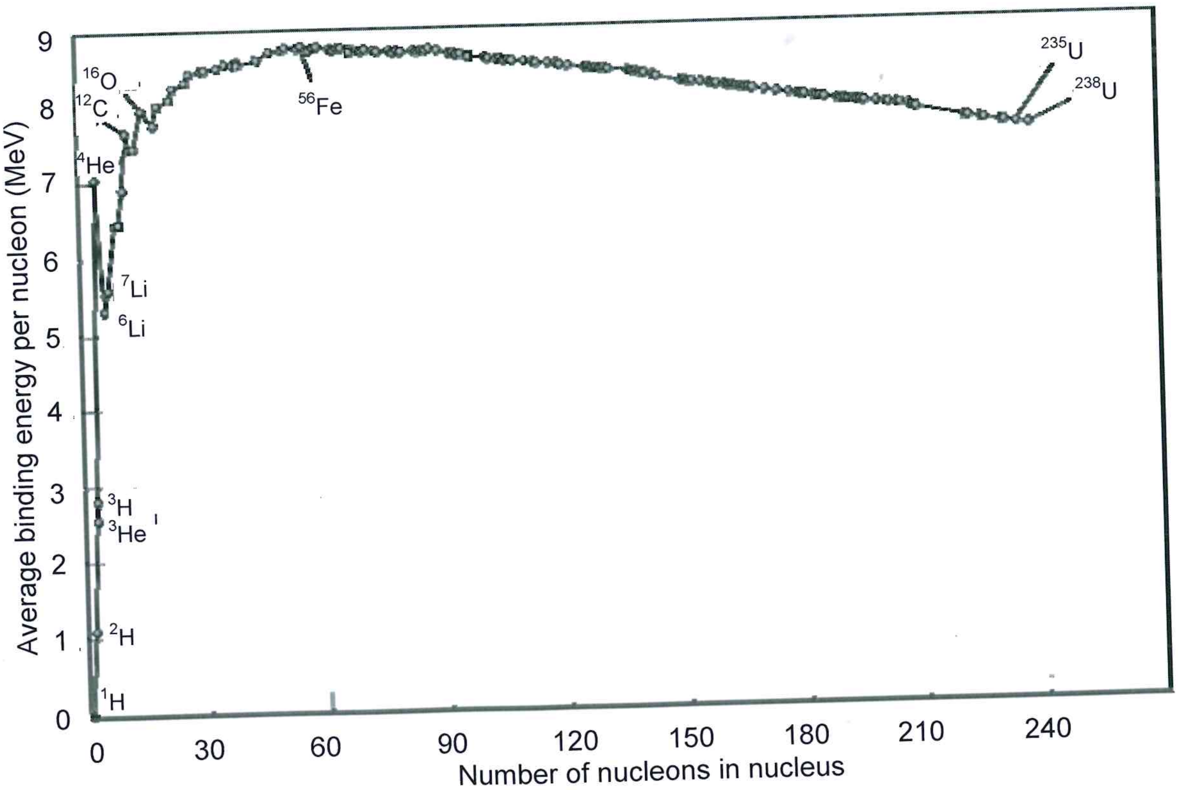
Use the mass of carbon-14 = 2.32478×10^{-26} kg.

Use the **Formulae and Constants sheet** for the masses of the neutron and the proton.

Question 5

(3 marks)

Below is a binding energy curve for common isotopes.



(a) Which element listed is considered to be the most stable? (1 mark)

Circle the correct answer: ^{3}He ^{4}He ^{56}Fe ^{235}U

(b) Explain your choice, using information from the graph. (2 marks)

Question 6

(13 marks)

When a uranium-235 nucleus absorbs a neutron, many fission products are possible. One such reaction in a nuclear power plant results in the formation of lanthanum-148 (La), bromine-85 (Br) and neutrons.

(a) Write an equation for this reaction and identify clearly the number of neutrons produced. (2 marks)

(b) How do the neutrons released in this reaction differ from those that took part in the initial fission reaction? (1 mark)

Many of the products of such fission reactions are themselves radioactive but are not able to be used as an energy source for the reactor. This waste is taken from the site and stored permanently in a safe and secure place where its activity can be monitored. The measured activity from some radioactive waste when it was first removed from the reactor was 128 Bq above the background count of 2.00 Bq.

(c) Explain what is meant by the term 'background count' and give an example of a source that contributes to it. (2 marks)

(d) If the average half-life of the waste in part (c) is taken as being 7.00×10^5 years, calculate how long it will take for its activity to reach the same level as the background count. (4 marks)

The safety device worn by an 85.0 kg nuclear power plant worker indicated that they absorbed 24.0 J of energy overall when exposed to this waste fuel during one work period.

(e) Calculate the dose they absorbed. (2 marks)

(f) Determine the dose equivalent for the worker, assuming all of the absorbed radiation is from gamma rays. (2 marks)

Question 7

(4 marks)

Consider the following nuclear reaction for uranium:

$$^{235}_{92}\text{U} + {}^{1}_{0}\text{n} \rightarrow {}^{143}_{56}\text{Ba} + {}^{91}_{36}\text{Kr} + ?\,{}^{1}_{0}\text{n}$$

(a) Determine the number of neutrons released. (1 mark)

Number of neutrons = ______________

(b) Uranium-235 is commonly used to produce a self-sustaining neutron-induced chain reaction. Using U-235 as the example, draw a labelled diagram that illustrates a self-sustaining neutron-induced chain reaction. (3 marks)