Questions

1. Boron undergoes fission via thermal neutron capture to produce lithium-7, an alpha particle and energy in the following reaction:

$$n + {}^{10}_{5}B \rightarrow {}^{7}_{3}Li + {}^{4}_{2}He$$

Using the data below, calculate the energy released (in MeV) for this reaction.

mass of a neutral boron atom	10.013 u
mass of a neutral lithium-7 atom	7.016 u
mass of a neutral helium-4 atom	4.003 u
mass of a neutron	1.01 u

2. Thorium-228 undergoes fission according to the equation:

$${}^{228}_{90}Th \rightarrow {}^{224}_{88}Ra + {}^{4}_{2}He$$

Use the data below to calculate the energy released for this reaction.

mass of a neutral thorium-228 atom	228.029u
mass of a neutral radium-224 atom	224.020u
mass of a neutral helium-4 atom	4.003u

3. Consider the following fission reaction of uranium-235:
$${}^{1}_{0}n + {}^{235}_{92}U \rightarrow {}^{141}_{55}Cs + {}^{93}_{37}Rb + 2{}^{1}_{0}n$$
During this reaction there is a mass defect of 4.99×10^{-28} kg. How much energy in joules is produced per reaction?

4. Uranium – 235 can fission according to the following equation:

$$ {}^{1}_{0}n + {}^{235}_{92}U \rightarrow {}^{148}_{57}La + {}^{85}_{35}Br + x\,{}^{1}_{0}n + Energy $$

a) Balance the equation and determine a value for x **[1 mark]**

x = _____

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The masses of the various nuclei are:

Neutron = 1.00867 u;	Uranium-235 = 235.03854 u;
Lanthanum-148 = 147.95736 u;	Bromine-85 = 84.93617 u

b) Explain the term **mass defect** related to this fission reaction **[1 mark]**

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c) What causes a mass defect in a nuclear reaction? **[1 mark]**

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d) Calculate the energy that would be released from the reaction given above. **[2 marks]**

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e) 1 kg of uranium-235 contains about 2.55×10^{24} atoms. Calculate the energy (in MeV) that the total fission of 1 kg of uranium-235 could produce. **[2 marks]**

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5. Plutonium-239 is a fissile material. When a plutonium-239 nucleus is struck by and absorbs a neutron, it can split in many different ways. Consider the example of a nucleus that splits into lanthanum-143 and rubidium-94 and releases some neutrons.

The nuclear equation for this is:

$$ {}^{1}_{0}n + {}^{239}_{94}Pu \rightarrow {}^{143}_{57}La + {}^{94}_{37}Rb + a\,{}^{1}_{0}n + \text{energy} $$

a How many neutrons are released during this fission process, i.e. what is the value of *a*?

b During this single fission reaction, there is a loss of mass (a mass defect) of 4.58×10^{-28} kg. Calculate the amount of energy that is released during fission of a single plutonium-239 nucleus. Give your answer in both MeV and joules to two significant figures.

c The combined mass of the plutonium nucleus and bombarding neutron is 2.86×10^{-25} kg. What percentage of this initial mass is converted into the energy produced during the fission process?