Particles and Waves

Nuclear Reactions

1) A uranium - 235 nucleus undergoes induced fission. The equation for the reaction is shown below:

$$^{235}_{92}U + ^{1}_{0}n \longrightarrow ^{140}_{58}Ce + ^{94}_{40}Zr + 2^{1}_{0}n + 6^{0}_{-1}e$$

The total mass of the particles on the LHS is 391.848 x 10^{-27} kg and the total mass of the particles on the RHS is 391.476 x 10^{-27} kg.

a) Determine the mass defect.
b) Calculate the energy released in this nuclear reaction.

2) A nuclear reaction is represented by the equation below:

$$^{240}_{94}Pu \longrightarrow ^{236}_{92}U + ^{4}_{2}He$$

a) Pu has a mass of 398.626 x 10^{-27} kg. The total mass of the particles on the RHS of the nuclear equation is 398.615 x 10^{-27} kg
Determine the mass defect.

b) Calculate the energy released in this nuclear reaction.

c) How many of the above reactions would have to take place each second to produce a power of 1kW.

3) A nuclear reaction is represented below:

$$^{2}_{1}H + ^{2}_{1}H \longrightarrow ^{3}_{1}H + ^{1}_{1}H$$

a) State the type of nuclear reaction shown above.

b) The mass of the nuclei on the LHS amounts to 6.689 x 10^{-27}kg and the mass of the nuclei on the RHS amounts to 6.682 x 10^{-27}kg. Determine the mass defect and calculate the energy released in the nuclear reaction.

4) A nuclear reaction is shown below:

$$^{235}_{92}U + {}^{1}_{0}n \longrightarrow {}^{140}_{54}Xe + {}^{94}_{q}Sr + 2{}^{1}_{0}n$$

a) Determine the value of q

b) Physicists use the value of the *atomic mass unit (amu)* to stand for nuclear masses. 1 amu = 1.660 539 x 10^{-27} kg.
Use the table below to determine the mass defect of the above nuclear reaction. The numbers represent the masses of the nuclei in amu.

$^{235}_{92}U$	$^{1}_{0}n$	$^{140}_{54}Xe$	$^{94}_{q}Sr$	$^{1}_{0}n$
235.043 923	1.008 665	139.921 647	93.915 361	1.008 665

c) Calculate the energy released by this nuclear reaction.

d) Determine the number of the above reactions that must take place each second to provide a power of 800 MW

5) Which of the following statements correctly describes nuclear fission

i) Two nuclei combine to form a large nucleus releasing several neutrons

ii) A large nucleus splits into two smaller nuclei releasing three electrons

iii) A large nucleus splits into two smaller nuclei releasing several protons

iv) A large nucleus splits into two smaller nuclei releasing several neutrons.

6) The nuclear reaction represented below gives off 9.9 x 10^{-13} J.
Determine the total mass of the product nuclei given that the mass of the Pu - 240 is 398.626 x 10^{-27} kg

$$^{240}_{94}Pu \longrightarrow {}^{236}_{92}U + {}^{4}_{2}He$$

Answers and solutions.

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1) a) mass defect = 0.372×10^{-27} kg
   b) Energy = 3.348×10^{-11} J

2) a) mass defect = 1.1×10^{-29} kg
   b) Energy = 9.9×10^{-13} J
   c) 1.01×10^{15} reactions per second.

3) a) Fusion reaction
   b) mass defect = 7.0×10^{-30} kg
   Energy = 6.3×10^{-13} J

4) a) q = 38
   b) mass defect = 3.29×10^{-28} kg
   c) Energy = 2.96×10^{-11} J
   d) 2.7×10^{19} reactions per second

5) Statement iv is correct

6) Total mass of products = 3.98615×10^{-25} kg