Period 9 Exercise Answers

E.1 In chemical reactions, the amount of mass that might be converted into energy is very small. In nuclear reactions this is not the case. This is because the binding energy in chemical bonds

a) is much larger than the binding energy in nuclear bonds.

b) is almost the same as the binding energy in nuclear bonds, except for light nuclei that fuse.

c) is much smaller than the binding energy in nuclear bonds.

d) is about the same as in nuclear bonds, but many more chemical reactions take place.

e) depends on the catalyst present, while nuclear bonds are the same for all nuclei.

The binding energy in nuclear bonds is much greater than the binding energy in chemical bonds.

E.1 = c

E.2 Protons are held in an atomic nucleus by the strong nuclear force. The attraction of the nuclear force is opposed by which of the following?

a) the repulsive nuclear force between neutrons

b) the attractive nuclear force between electrons

c) the mutual repulsion between like positive charges

d) random molecular collisions

e) the gravitational force

E.2 = c

E.3 **A deuterium nucleus consists of one proton and one neutron. The mass of a deuterium nucleus = 3.3435×10^{-27} kg. What is the binding energy of deuterium in joules? The mass of a proton = 1.6726×10^{-27} kg and the mass of a neutron = 1.6749×10^{-27} kg.**

1) Find the total mass of the nucleons making up the nucleus (1 proton and 1 neutron)

$$\begin{array}{r} 1.6726 \times 10^{-27} \text{ kg} \\ + \underline{\quad 1.6749 \times 10^{-27} \text{ kg}} \\ 3.3475 \times 10^{-27} \text{ kg} \end{array}$$

2) Subtract the known mass of the nucleus.

$$\begin{array}{r} 3.3475 \times 10^{-27} \text{ kg} \\ - \underline{\quad 3.3435 \times 10^{-27} \text{ kg}} \\ 0.004 \times 10^{-27} \text{ kg} \end{array} \quad = 4 \times 10^{-30} \text{ kg}$$

3) Use $E = M c^2$ to convert this mass into energy

$E = M c^2 = (4 \times 10^{-30} \text{ kg}) \times (3 \times 10^{8} \text{ m/s})^2$

$= (4 \times 10^{-30} \text{ kg}) \times (9 \times 10^{16} \text{ m}^2/\text{s}^2)$

$= 36 \times 10^{-14} \text{ J} = 3.6 \times 10^{-13} \text{ J}$

E.3 = b

E.4 Which one of the following isotopes would you expect to be stable? Why might each of the others be unstable?

a) $^{232}_{90}\mathrm{Th}$ **(Thorium-232): unstable because it is a large nucleus with more than 83 protons**

b) $^{40}_{19}\mathrm{K}$ **(Potassium-40): unstable because it is a small nucleus with more neutrons (21) than protons (19)**

c) $^{12}_{6}\mathrm{C}$ **(Carbon-12) stable because it is a small nucleus with equal numbers of neutrons and protons**

d) $^{14}_{8}\mathrm{O}$ **(Oxygen-14) unstable because it is a small nucleus with more protons (8) than neutrons (6)**

e) $^{14}_{7}\mathrm{N}$ **(Nitrogen-14) stable because it is a small nucleus with equal numbers of neutrons and protons**

E.4 = c and e are stable

E.5 **The binding energy of an H_2 molecule is 4.5 eV. Two grams of H_2 contain 6.0×10^{23} molecules. How many joules of energy are released when 2 grams of H atoms combine to form molecules of H_2? (Hint: 1 eV = 1.6×10^{-19} joules.)**

a) 7.2×10^{-19} J
b) 2.2×10^{5} J
c) 4.3×10^{5} J
d) 1.4×10^{24} J
e) 2.7×10^{24} J

Use ratios to convert the binding energy per molecule in electron volts (eV) into joules.

$$\frac{4.5\ \cancel{\text{eV}}}{\text{molecule}} \times \frac{1.6 \times 10^{-19}\ \text{J}}{\cancel{\text{eV}}} = \frac{7.2 \times 10^{-19}\ \text{J}}{\text{molecule}}$$

Then use ratios to find the amount of binding energy in 6.0×10^{23} molecules.

$$\frac{7.2 \times 10^{-19}\ \text{J}}{\cancel{\text{molecule}}} \times 6.0 \times 10^{23}\ \cancel{\text{molecules}} = 4.3 \times 10^{5}\ \text{J}$$

E.5 = c

E.6 **The binding energy of a deuterium nucleus, which consists of a proton and a neutron bound together by the nuclear force, is 2.2 MeV. Two grams of deuterium contain 6.0 x 10^{23} molecules. How many joules of energy are released in the formation of 2 grams of deuterium from free protons and neutrons?**

a) **3.5 x 10^{-13} J**
b) **1.05 x 10^{11} J**
c) **2.1 x 10^{11} J**
d) **1.3 x 10^{30} J**
e) **2.6 x 10^{30} J**

Convert MeV into eV using 1 MeV = 1 x 10^6 eV

$$2.2\ \cancel{\text{MeV}} \times \frac{1 \times 10^{6}\ \text{eV}}{\cancel{\text{MeV}}} = 2.2 \times 10^{6}\ \text{eV}$$

Next, use ratios to convert the binding energy per nucleus in electron volts (eV) into joules.

$$\frac{2.2 \times 10^{6}\ \cancel{\text{eV}}}{\text{deuterium}} \times \frac{1.6 \times 10^{-19}\ \text{J}}{\cancel{\text{eV}}} = \frac{3.5 \times 10^{-13}\ \text{J}}{\text{deuterium}}$$

Then use ratios to find the amount of binding energy in 6.0 x 10^{23} molecules.

$$\frac{3.5 \times 10^{-13}\ \text{J}}{\cancel{\text{molecule}}} \times 6.0 \times 10^{23}\ \cancel{\text{molecules}} = 2.1 \times 10^{11}\ \text{J}$$

E.6 = c

E.7 How much energy would be released if 3 kilograms of mass were completely changed into energy?

a) 3×10^{8} J
b) 1.33×10^{16} J
c) 9×10^{16} J
d) 2.7×10^{17} J
e) 27×10^{24} J

$$E = M c^2 = 3 \text{ kg} \times (3 \times 10^{8} \text{ m/s})^2$$

$$= 3 \text{ kg} \times (9 \times 10^{16} \text{ m}^2/\text{s}^2)$$

$$= 27 \times 10^{16} \text{ J} = 2.7 \times 10^{17} \text{ J}$$

E.7 = d

Period 9 Answers

E.1 = c

E.2 = c

E.3 = b

E.4 = c and e

E.5 = c

E.6 = c

E.7 = d