

Worksheet # 15

Energy

1. Define kinetic and potential energy and state the difference between them.
2. What is the first law of thermodynamics?
3. Define system and surroundings.
4. Define exothermic and endothermic.
5. The nutritional Calorie is the equivalent of 1 kcal. One pound of body fat is equivalent to about 4.1×10^3 Calories. Convert this to Joules and kJ.
6. Thermal decomposition of 5.0 metric tons of limestone to lime and carbon dioxide requires 9.0×10^6 kJ of heat. Convert this energy to joules and calories.

Energy and Chemical Change

7. "Hot packs" used by skiers, climbers, and others for warmth are based on the crystallization of sodium acetate from a highly concentrated solution. What is the sign of ΔH for this crystallization? Is the reaction exothermic or endothermic?
8. Classify the following processes as exothermic or endothermic: (a) freezing of water; (b) boiling of water; (c) digestion of food; (d) a person running; (e) a person growing; (f) wood being chopped; (g) heating with a furnace.
9. Draw an enthalpy diagram for a general exothermic reaction; label axis, reactants, products, and ΔH with its sign.
10. Draw an enthalpy diagram for a general endothermic reaction; label axis, reactants, products, and ΔH with its sign.
11. Write a balanced equation and draw an approximate enthalpy diagram for each of the following: (a) the combustion of 1 mol of methane in oxygen; (b) the freezing of liquid water.
12. Write a balanced equation and draw an approximate enthalpy diagram for each of the following: (a) the formation of 1 mol of sodium chloride from its elements (heat is released); (b) the vaporization of liquid benzene.
13. Write balanced equation and draw an approximate enthalpy diagram for each of the following changes: (a) the combustion of 1 mol of liquid ethanol (C_2H_5OH); (b) the formation of 1 mol of nitrogen dioxide from its elements (heat is absorbed).

14. Write a balanced equation and draw an approximate enthalpy diagram for each of the following changes: (a) the sublimation of dry ice [conversion of $\text{CO}_2(\text{s})$ directly to $\text{CO}_2(\text{g})$]; (b) the reaction of 1 mol of sulfur dioxide with oxygen.

Answers to Worksheet # 15

Energy

1. Kinetic energy is the energy associated with motion, while potential energy is energy that results from an object's position. Kinetic energy would be the energy of a rock rolling down a hill, while potential energy would be the energy the rock had when positioned on top of the hill.
2. The first law of thermodynamics is that energy can't be created or destroyed (similar to the law of conservation of matter).
3. The system is the object being studied, while the surroundings are everything outside the system.
4. In an exothermic process, heat is transferred from a system to the surroundings. In an endothermic process, heat is transferred to a system from the surroundings.

$$5. \quad J = 4.1 \times 10^3 \text{ Cal} \left| \frac{1 \text{ kcal}}{1 \text{ Cal}} \right| \left| \frac{1000 \text{ cal}}{1 \text{ kcal}} \right| \left| \frac{4.184 \text{ J}}{1 \text{ cal}} \right| = 1.7 \times 10^7 \text{ J}$$

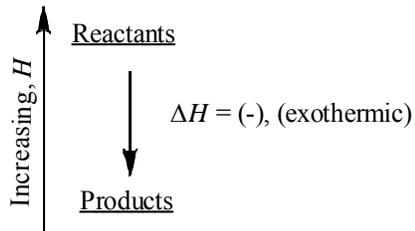
$$kJ = 1.7 \times 10^7 \text{ J} \left| \frac{1 \text{ kJ}}{1000 \text{ J}} \right| = 1.7 \times 10^4 \text{ kJ}$$

$$6. \quad J = 9.0 \times 10^6 \text{ kJ} \left| \frac{1000 \text{ J}}{1 \text{ kJ}} \right| = 9.0 \times 10^9 \text{ J} \quad \text{cal} = 9.0 \times 10^9 \text{ J} \left| \frac{1 \text{ cal}}{4.184 \text{ J}} \right| = 2.2 \times 10^9 \text{ cal}$$

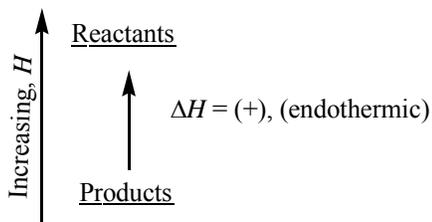
7. The hot pack is releasing (producing) heat, thus ΔH is **negative**, and the process is **exothermic**.
8.
 - a) **Exothermic**, the system (water) is releasing heat in changing from liquid to solid.
 - b) **Endothermic**, the system (water) is absorbing heat in changing from liquid to gas.
 - c) **Exothermic**, the process of digestion breaks down food and releases energy.
 - d) **Exothermic**, heat is released as a person runs and muscles perform work.
 - e) **Endothermic**, heat is absorbed as food calories are converted to body tissue.
 - f) **Endothermic**, the wood being chopped absorbs heat (and work).
 - g) **Exothermic**, the furnace releases heat from fuel combustion. Alternatively, if the system is defined as the air in the house, the change is endothermic since the air's temperature is increasing by the input of heat energy from the furnace.

9. An exothermic reaction releases heat, so the reactants have greater H (H_{initial}) than the products (H_{final}).

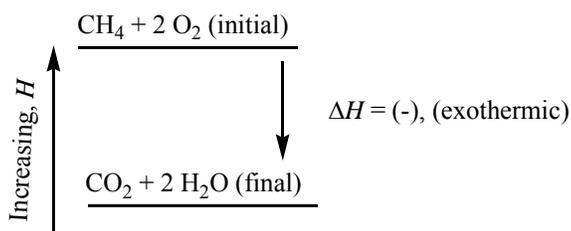
$$\Delta H = H_{\text{final}} - H_{\text{initial}} < 0.$$



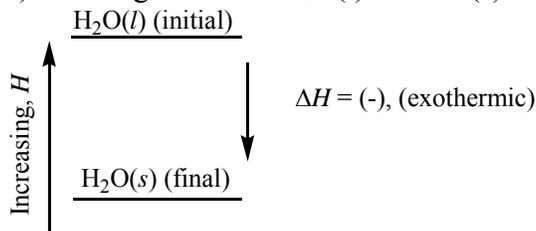
10. Endothermic reaction:



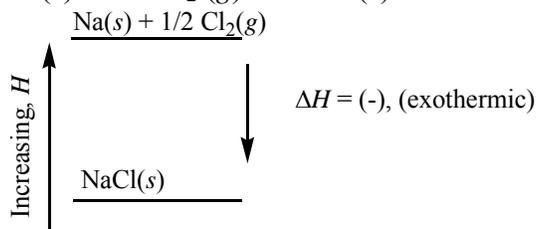
11. a) Combustion of methane: $\text{CH}_4(g) + 2 \text{O}_2(g) \rightarrow \text{CO}_2(g) + 2 \text{H}_2\text{O}(g) + \text{heat}$



- b) Freezing of water: $\text{H}_2\text{O}(l) \rightarrow \text{H}_2\text{O}(s) + \text{heat}$



12. $\text{Na}(s) + 1/2 \text{Cl}_2(g) \rightarrow \text{NaCl}(s) + \text{heat}$



- b) $\text{C}_6\text{H}_6(l) + \text{heat} \rightarrow \text{C}_6\text{H}_6(g)$

