**Name\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Date\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Chemistry**

**Practice Problems– Heat of Reaction and Chemical Equations**

1. Draw an energy diagram for an exothermic reaction where ΔH = − 20 kJ.
2. If ∆H is a negative number of kJ, is the reaction endothermic or exothermic?
3. When dissolving NaOH pellets in water, the beaker containing the solution gets warmer. Is dissolving the NaOH pellets an endothermic or exothermic reaction? Justify your answer.
4. A coffee cup calorimeter is used to calculate the heat change when NH4Cl is dissolved in water. Use the data table below to calculate the ***heat change*** when 1.00 mole of NH4Cl is dissolved in water. (Assume that the heat change for the solution is the same as that of water alone and that you can ignore the mass of solid in the water, so use only the mass of water and the specific heat of water, 4.18 J/g °C, in calculating the heat change.)

 Mass of NH4Cl = 5.03 g

 Mass of water in the coffee cup = 60.0 g

 Initial temperature of the water = 24.78 °C

 Final temperature of the water = 19.23 °C

Is this process endothermic or exothermic?\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1. Given the following reaction: **2 P(*s*) + 3 Cl2(*g*) → 2 PCl3(*g*) H = −574 kJ**

 a) How many moles of phosphorus are needed to produce 488 kJ?

 b) How much heat is released when 122 g of PCl3 are produced?

 c) How many grams of Cl2 are needed to produce 27.0 kJ?

1. Calculate the enthalpy change when 5.00g of propane are burned with excess oxygen according to the reaction:

**C3H8(g) +5O2🡪3CO2(g) + 4H2O**

Is this an endothermic or exothermic process?\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1. Important reactions in the production of ozone, O3, in polluted air are:

 (1) 2 NO(g) + O2(g) → 2 NO2(g)

(2) NO2(g) + O2(g) → O3(g) + NO(g)

(3) O2(g) + O(g) → O3(g)

Use the data of ∆Hf˚ in your textbook’s appendix to calculate ∆H˚ (in kilojoules) for reactions (1), (2), and (3). (The ∆Hf˚ for O(g) is +249 kJ/mol)

1. When 1 mole of sulfur dioxide reacts with excess oxygen to form sulfur trioxide at constant pressure, 198.2kJ of energy is released as heat. Calculate ∆H for a process in which 12.8-gram sample of sulfur dioxide reacts with excess oxygen at constant pressure.
2. How much heat will be absorbed when 13.7 g of Nitrogen reacts with excess O2 according to the following equation?

**N2 + O2 → 2NO ∆H° = -180kJ**

1. How much heat will be released when 11.8 g of Iron reacts with excess O2 according to the following equation?

**3Fe + 2O2 → Fe3O4 ∆H° = -1120.5kJ**

1. How much heat will be released when 18.6 g of Hydrogen reacts with excess O2 according to the following equation?

**2H2 + O2 → H2O ∆H° = -571.6kJ**

1. How much heat will be transferred when 14.9 g of ammonia reacts with excess O2 according to the following equation?

**4NH3 + 5O2 → 4NO + 6H2O ∆H° = -1170kJ**

1. How much heat will be transferred when 5.81 g of graphite reacts with excess H2 according to the following equation?

**6C(graphite) + 3H2 → C6H6 ∆H° = 49.03kJ**

**Using ∆H=mC∆T to calculate the following:**

1. How many kilojoules of heat energy are required to heat all the aluminum (Cp of Al = .902J/g•°C) in a roll of aluminum foil (500.0 g) from room temperature (25.0 °C) to the temperature of a hot oven (250.0°C)?
2. One way to cool down your cup of coffee is to plunge an ice-cold piece of aluminum into it. Suppose you store a 20.0 g piece of aluminum (Cp of Al = .902J/g•°C) in the refrigerator at 4.40 °C and then drop it into your coffee. The coffee temperature drops from 90.0 °C to 55.0 °C. How many joules of heat energy did the aluminum block absorb? (Ignore the cooling of the cup)

**Solution Key**

1. Draw an energy diagram for an exothermic reaction where ΔH = − 20 kJ.

reactants

 20

 ΔH = −20 kJ products

 0

1. If ∆H is a negative number of kJ, is the reaction endothermic or exothermic? exothermic
2. When dissolving NaOH pellets in water, the beaker containing the solution gets warmer. Is dissolving the NaOH pellets an endothermic or exothermic reaction? Justify your answer. Exothermic. Heat is being liberated, which is why the temperature is warmer.
3. A coffee cup calorimeter is used to calculate the heat change when NH4Cl is dissolved in water. Use the data table below to calculate the ***heat change*** when 1.00 mole of NH4Cl is dissolved in water. (Assume that the heat change for the solution is the same as that of water alone and that you can ignore the mass of solid in the water, so use only the mass of water and the specific heat of water, 4.18 J/g °C, in calculating the heat change.)

 Mass of NH4Cl = 5.03 g

 Mass of water in the coffee cup = 60.0 g

 Initial temperature of the water = 24.78 °C

 Final temperature of the water = 19.23 °C

Is this process endothermic or exothermic?

Q (J) = specific heat (J/g °C) x mass (g) x ΔT (°C); ΔT = 19.23 − 24.78 = −5.55 °C

 Q = 4.18 J/g °C x 60.0 g x −5.55 °C = 1390 J

 1 mole NH4Cl x  = 14,800 J = 14.8 kJ/mole

 Endothermic

1. Given the following reaction: 2 P(*s*) + 3 Cl2(*g*) → 2 PCl3(*g*) H = −574 kJ

 a) How many moles of phosphorus are needed to produce 488 kJ?

 b) How much heat is released when 122 g of PCl3 are produced?

 c) How many grams of Cl2 are needed to produce 27.0 kJ?

1. 488 kJ x  = 1.70 moles P

 b) 122 g PCl3 x  = 255 kJ

 c) 27.0 kJ x  = 10.0 g Cl2

1. Calculate the enthalpy change when 5.00g of propane are burned with excess oxygen according to the reaction:

**C3H8(g) +5O2🡪3CO2(g) + 4H2O**

**Answer: ∆H=-252kJ**

1. Important reactions in the production of ozone, O3, in polluted air are:

 (1) 2 NO(g) + O2(g) → 2 NO2(g)

(2) NO2(g) + O2(g) → O3(g) + NO(g)

(3) O2(g) + O(g) → O3(g)

Use the data of ∆Hf˚ in your textbook’s appendix to calculate ∆H˚ (in kilojoules) for reactions (1), (2), and (3). (The ∆Hf˚ for O(g) is +249 kJ/mol)

Answer:

(1) ∆Hrxn = ∑∆Hf(products) – ∑∆Hf(reactants)

 ∆Hrxn = [2(+33.9)] – [2(+90.4) + 0] = –113 kJ

(2) ∆Hrxn = ∑∆Hf(products) – ∑∆Hf(reactants)

 ∆Hrxn = [90.4 + 143] – [33.9 + 0] = +199.5 kJ

(3) ∆Hrxn = ∑∆Hf(products) – ∑∆Hf(reactants)

 ∆Hrxn = [143)] – [0 + 249] = –106 kJ

1. When 1 mole of sulfur dioxide reacts with excess oxygen to form sulfur trioxide at constant pressure, 198.2kJ of energy is released as heat. Calculate ∆H for a process in which 12.8-gram sample of sulfur dioxide reacts with excess oxygen at constant pressure. **∆H=39.6kJ**
2. How much heat will be absorbed when 13.7 g of Nitrogen reacts with excess O2 according to the following equation?

**N2 + O2 → 2NO ∆H° = -180kJ**

**Answer: ∆H=-88.1kJ**

1. How much heat will be released when 11.8 g of Iron reacts with excess O2 according to the following equation?

**3Fe + 2O2 → Fe3O4 ∆H° = -1120.5kJ**

**Answer: ∆H= -78.7kJ**

1. How much heat will be released when 18.6 g of Hydrogen reacts with excess O2 according to the following equation?

**2H2 + O2 → H2O ∆H° = -571.6kJ**

**Answer: ∆H=-2660kJ**

1. How much heat will be transferred when 14.9 g of ammonia reacts with excess O2 according to the following equation?

**4NH3 + 5O2 → 4NO + 6H2O ∆H° = -1170kJ**

**Answer: ∆H= -256kJ**

1. How much heat will be transferred when 5.81 g of graphite reacts with excess H2 according to the following equation?

**6C(graphite) + 3H2 → C6H6 ∆H° = 49.03kJ**

**Answer: ∆H= 3.96kJ**

**Using ∆H=mC∆T to calculate the following:**

1. How many kilojoules of heat energy are required to heat all the aluminum (Cp of Al = .902J/g•°C) in a roll of aluminum foil (500.0 g) from room temperature (25.0 °C) to the temperature of a hot oven (250.0°C)?

**Answer: Q =101kJ**

1. One way to cool down your cup of coffee is to plunge an ice-cold piece of aluminum into it. Suppose you store a 20.0 g piece of aluminum (Cp of Al = .902J/g•°C) in the refrigerator at 4.40 °C and then drop it into your coffee. The coffee temperature drops from 90.0 °C to 55.0 °C. How many joules of heat energy did the aluminum block absorb? (Ignore the cooling of the cup)

**Answer: Q= 912J**