Chemistry

Name
Period ________

Heat and Chemical Change Problems

1. How much heat is required to raise the temperature of 32.4 g of mercury from 20.0ºC to 98.0ºC? The specific heat of mercury is 0.13950 J/g x ºC.

$C_p = \frac{q}{m \times \Delta T}$ $\quad 0.13950 \frac{J}{g \times C} = \frac{q}{(32.4g)(98-20)}$ $\quad \boxed{353\ J}$

$352.5J = q$

2. Find the final temperature if 1932.7 J of energy is added to 27.5 g of water at 21.1ºC.

$\Delta T = \frac{q}{C_p \times m} = \frac{1932.7J}{4.18\frac{J}{g \cdot C} \times 27.5} = 16.8°C$ $\quad \boxed{37.9°C}$

$\Delta T = T_F - T_I = 16.8 = T_F - 21.1 \quad T_F = 37.9°C$

3. 4490 J is absorbed by 258 g of water at 22.5ºC. What is the final temperature of the water?

$C_p = \frac{q}{m \cdot \Delta T}$ $\quad 4.18 \frac{J}{g \cdot C} = \frac{4490\ J}{258 \times \Delta T}$ $\quad \boxed{26.7°C}$

$\Delta T = 4.16°C = T_F - T_I = T_F - 22.5°C \quad T_F = 26.66$

4. A rectangular aquarium, 20.3 cm by 47.7 cm by 84.7 cm, is filled with water at 15.4ºC. How much energy in Joules is required to raise the temperature of the water to 24.9ºC? (density of water at 15.4 ºC = 0.999g/cm^3)

$\boxed{3.25 \times 10^6\ J}$

$q = m \cdot C_p \cdot \Delta T$ $\quad d \cdot V = m$

$= 81933.8 \times 4.18 \times (24.9-15.4)$ $\quad (0.999)(20.3cm \times 47.7cm \times 84.7cm) = m$

$q = 3.25 \times 10^6\ J$ $\quad 81933.8g = m$

5. A lead mass is heated and placed in a foam cup calorimeter containing 40.0 ml of water at 17.0ºC. The temperature increases to 20.0ºC. How many joules of heat are released?

$q = C_p \times m \times \Delta T$ $\quad m = 40.0 \times .999$ $\quad \boxed{501\ J}$

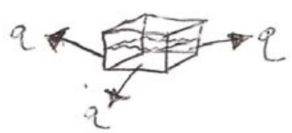
$= 4.18 \frac{J}{g \cdot C} \times 39.96g \times (20-17)$ $\quad m = 39.96g$

$q = 501\ J$

6. What is the specific heat of a substance if 250 ~~cal~~ J are required to raise the temperature of 2.5 g from 10.0ºC to 22.5ºC?

$C_p = \frac{q}{m \times \Delta T} = \frac{250\ J}{2.5 \cdot (22.5-10.0)} = 8.0 \frac{J}{g \cdot C°}$ $\quad \boxed{8.0 \frac{J}{g \cdot C°}}$

7. Draw a diagram showing the heat flow when hot water is poured into an ice cube tray and placed in the freezer. Is this endothermic process or exothermic process relative to the water?



EXOTHERMIC

-103.85 8. Find the enthalpy of reaction for the combustion of propane (C_3H_8).

$C_3H_{8(g)} + 5O_{2(g)} \rightarrow 3CO_{2(g)} + 4H_2O_{(l)}$

$\Delta H = \Sigma prod - \Sigma react.$

$= [(3 \cdot -393.5) + (4 \times -285.8)] - [(1 \times -103.85) + (5 \times 0)] = \boxed{\cancel{-665kJ}}$ -2219.85kJ

a. How much energy is used or created if the 34.8g of Oxygen react with excess propane.

$34.8g\ O_2 \times \frac{1 mol\ O_2}{32.0g} \times \frac{\cancel{-665kJ}\ -2219.85kJ}{5 mol\ O_2} = \boxed{\cancel{14.5g\ O_2}}\ \boxed{\cancel{-294\ kJ}}\ \boxed{-482.8kJ}$

9. What is the change in enthalpy for the reaction of Aluminum metal when it reacts with hydrochloric acid? Is this an exothermic or endothermic reaction?

-705.63
-167.2

$2Al_{(s)} + \cancel{3}\,6HCl_{(aq)} \rightarrow 3H_{2(g)} + 2AlCl_{3\,(aq)}$

$\Delta H = \Sigma prod - \Sigma react.$

$= [(3 \times 0) + (2 \times -705.63)] - [(1 \times 0) + 6(-167.2)] = \cancel{297.57}\ -408.06\ kJ$

a. Mow many grams of aluminum react to produce 500kJ of energy?

$-500kJ \times \frac{2 mol\ Al}{\cancel{297.57kJ}\ -408.06} \times \frac{26.98g}{1 mol\ Al} = \boxed{\cancel{45.33g}}\ \boxed{\cancel{32.06g}}\ \boxed{66.01g}$

10. The molar enthalpy of vaporization of water if 40.79 kJ/mol, and the molar enthalpy of fusion of ice is 6.009 kJ/mol. How much energy is absorbed when 30.3 g of liquid water boils?

30.3g boils → vaporization

convert to moles

$30.3g \times \frac{1 mol}{18.02g} = 1.68 mol$

$\Delta H = \frac{q}{mol}$

$40.79 \frac{kJ}{mol} = \frac{q}{1.68}$ $\boxed{q = 68.5kJ}$

11. How much energy is needed to convert 10.0 grams of ice into steam? Use the enthalpies of H_2O given problem 10. (hint this is a three step process)

$10g\ H_2O \times \frac{1 mol}{18.02g} = .555 moles$

(1) melt ice fusion $\Delta H_f = \frac{q}{mol}$ $6.009 \frac{kJ}{mol} = \frac{x}{.555}$ $3.33kJ = q$ (1)	(2) WATER 0°C → 100°C $q = C_p \times m \times \Delta T$ $= 4.18 \frac{J}{g \cdot °C} \times (10.0g) \times (100-0)$ $q = 4180J \times \frac{1kJ}{1000J}$ $q = 4.18kJ$ (2)	(3) vaporize H_2O $\Delta H_v = \frac{q}{mol}$ $40.09 \frac{kJ}{mol} = \frac{q}{.555 mol}$ $22.2kJ = q$ (3)	TOTAL ENERGY 1+2+3= 3.33kJ 4.18kJ 22.2kJ $\boxed{29.71kJ}$

Hess's Law of Summation Worksheet

1. Find $\Delta H°$ for the following equation,

$$2\ Na_2O_{2(s)} + 4\ HCl_{(g)} \longrightarrow 4\ NaCl_{(s)} + O_{2(g)} + 2\ H_2O_{(l)}$$

given the following equations:

$\checkmark$ $2\ Na_2O_{2(s)} + 2\ H_2O_{(l)} \longrightarrow 4\ NaOH_{(s)} + O_{2(g)}$ $\Delta H° = -126.4$ kJ

4 $NaOH_{(s)} + \cancel{4}HCl_{(aq)} \longrightarrow 4NaCl_{(s)} + \cancel{4}H_2O_{(l)}$ $\Delta H° = (-179.2$ kJ$)4$

-843.2

$\boxed{-843.2\ kJ}$

2. Use the equations:

$\frac{1}{2}(\cancel{2}\ C_2H_{2(g)} + \overset{5/2}{\cancel{5}}\ O_{2(g)} \longrightarrow \overset{2}{\cancel{4}}\ CO_{2(g)} + \cancel{2}\ H_2O_{(g)})$ $\Delta H° = -2512$ kJ$/2$

$N_{2(g)} + ½\ O_{2(g)} \longrightarrow N_2O_{(g)}$ $\Delta H° = (104$ kJ$)5$

$5N_2O_{(g)} \rightarrow 5N_2 + 5/2\ O_2$ -1776 kJ

to obtain $\Delta H°$ for this reaction:

$$C_2H_{2(g)} + 5\ N_2O_{(g)} \longrightarrow 2\ CO_{2(g)} + H_2O_{(g)} + 5\ N_{2(g)}$$

$\boxed{-1776\ kJ}$

3. Predict the Heat of Reaction for the combustion of ammonia gas:

$$NH_{3(g)} + 7/4\ O_{2(g)} \longrightarrow NO_{2(g)} + 3/2\ H_2O_{(g)}$$

$\checkmark$ $NH_{3(g)} \longrightarrow ½\cancel{N_{2(g)}} + 3/2\cancel{H_{2(g)}}$ $\Delta H° = +11.0$ kcal

$\checkmark$ $\cancel{½N_{2(g)}} + O_{2(g)} \longrightarrow NO_{2(g)}$ $\Delta H° = +8.1$ kcal

$\checkmark$ $\cancel{3/2H_{2(g)}} + ¾\ O_{2(g)} \longrightarrow 3/2\ H_2O_{(g)}$ $\Delta H° = -87.7$ kcal

-68.6 kcal

$\boxed{-68.6\ kcal}$

4. Calculate the $\Delta H°$ for the following reaction:

$$P_4O_{10(s)} + 6\ PCl_{5(g)} \longrightarrow 10\ Cl_3PO_{(g)}$$

given the following:

$\cancel{P_{4(s)}} + \cancel{6Cl_{2(g)}} \longrightarrow 4\cancel{PCl_{3(g)}}$ $\Delta H° = -1225.6$ kJ

$\cancel{P_{4(s)} + 5\ O_{2(g)} \longrightarrow P_4O_{10(s)}}$ $P_4O_{10} \rightarrow \cancel{P_4} + \cancel{5O_2}$ $\Delta H° = -2967.3$ kJ x -1

$\cancel{PCl_{3(g)} + Cl_{2(g)} \longrightarrow PCl_{5(g)}}$ $6PCl_5 \rightarrow \cancel{6PCl_3} + \cancel{6Cl_2}$ $\Delta H° = -84.2$ kJ x -6

$PCl_{3(g)} + ½\ O_{2(g)} \longrightarrow Cl_3PO_{(g)}$ $10\cancel{PCl_3} + \cancel{5O_2} \rightarrow 10Cl_3PO$ $\Delta H° = -285.7$ kJ x 10

$\boxed{-610.1\ kJ}$