HEAT TRANSFER- STUDY PROBLEMS

1. A 18.5 g piece of metal with an initial temperature of 100.9°C is added to 75.3 g of water with an initial temperature of 22.9°C. The final temperature is 27.0°C. Calculate the specific heat of the metal.

metal — water

$m \Delta T \; C_p = m \Delta T \; C_p$

$(18.5g)(73.9°C)(x) = (75.3g)(4.10°C)(4.184 \frac{J}{g°C})$

$x = 0.945 \frac{J}{g°C}$

2. A 10.4 g piece of metal with an initial temperature of 99.9°C is added to 35.3 g of water with an initial temperature of 25.0°C. The specific heat of the metal is 0.593J/g°C. Calculate the final temperature. (C_p for water is 4.184 J/g°C)

metal — water

$(10.4g)(99.9 - x)(0.593 \frac{J}{g°C}) = (35.3g)(x - 25.0°C)(4.184 \frac{J}{g°C})$

$616.4 - 6.167x = 147.7x - 3692.4$

$4308.8 = 153.87x$

$x = 28.1°C$

3. What is the enthalpy of solution in J/g if 5.45 g of NaOH is dissolved into 124 g of water. The temperature of the water changes from 23°C to 26°C. Is this exothermic or endothermic?

Solute — water

$m \Delta H_{sol} = m \Delta T \; C_p$

$(5.45g)(x) = (124 + 5.45g)(3°C)(4.184 \frac{J}{g°C})$

$x = ^{-}298 \frac{J}{g}$ exothermic

4. What is the enthalpy of solution if 7.82g of $NaNO_3$ is dissolved in 195.34 g of water. The temperature of the water changes from 25°C to 19.5°C. Is this exothermic or endothermic?

Solute — water

$m \Delta H_{sol} = m \Delta T \; C_p$

$(7.82g)(x) = (195.34 + 7.82g)(5.5°C)(4.184 \frac{J}{g°C})$

$x = ^{+}598 \frac{J}{g}$ endothermic

5. How much energy would be produced if 50.0g of SO_3 reacts with an excess of H_2O?

$SO_3 + H_2O \rightarrow H_2SO_4 + 78.2kJ$

50.0g SO_3 | 1 mole SO_3 / 80.06g SO_3 | 78.2 kJ / 1 mole SO_3 = 48.8 kJ released

6. How much energy is required to synthesize 10.0g of NO_2?

$68\ kJ + N_2 + 2O_2 \rightarrow 2NO_2$

10.0g NO_2 | 1 mole NO_2 / 46.01g NO_2 | 68 kJ / 2 mole NO_2 = 7.39 kJ absorbed

7. Consider the following reaction:

$CH_{4(g)} + 2O_{2(g)} \rightarrow CO_{2(g)} + 2H_2O_{(l)} \quad \Delta H = -891\ kJ$

How much energy is produced with 1.00 x 10^3 L methane gas at 740. Torr and 25°C is burned in excess oxygen?

PV = nRT

(740 torr)(1.00 × 10^3 L) = x (62.4 torr L / mol K)(298 K)

x = 39.8 mole CH_4

39.8 mole CH_4 | 891 kJ / 1 mole CH_4 = 35 500 kJ released or 3.55 × 10^4 kJ

8. Consider the reaction between hydrochloric acid and barium hydroxide.

Write the balanced equation for the reaction:

If ΔH = -188 kJ, calculate the heat when 100.0 mL of 0.500M HCl is mixed with 300.0 mL of 0.500 M $Ba(OH)_2$. Assume that the temperature of both solutions was initially 25.0°C and that the final mixture has a mass of 400.0 g and the specific heat capacity is 4.184 J/g°C, calculate the final temperature of the mixture.

2 HCl + Ba(OH)$_2$ → BaCl$_2$ + 2 H$_2$O + 188 kJ

100.0 mL, 0.500M (HCl) ; 300.0 mL, 0.500 M (Ba(OH)$_2$)

HCl
(0.500M)(0.1000 L) = 0.0500 mole

Ba(OH)$_2$
(0.500M)(0.3000 L) = 0.150 mole

0.0500 mole HCl | 118 kJ / 2 mole HCl = 2.95 kJ = 2950 J

q = m ΔT Cp

2950 J = (400.0g)(x)(4.184 J/g°C)

ΔT = 1.8°C

25.0 + 1.8 = 26.8°C

9. The standard enthalpy of combustion of ethane gas, $C_2H_{4(g)}$, is -1411.1 kJ/mole at 298K. Given the following enthalpies of formation, calculate the ΔH^o_f for $C_2H_{4(g)}$.

$CO_{2(g)}$ -393.5 kJ/mol
$H_2O_{(l)}$ -285.9 kJ/mol

$C_2H_{4(g)} + 3O_2 \rightarrow 2CO_2 + 2H_2O$
-393.5 kJ/mol   -285.9 kJ/mol

$\Delta H_{rxn} = \Sigma \Delta H_{f\,prod} - \Sigma \Delta H_{f\,react}$

$-1411.1\ \frac{kJ}{mol} = [2(-393.5\ \frac{kJ}{mol}) + 2(-285.9\ \frac{kJ}{mol})] - [1(x\ \frac{kJ}{mol})]$

$-1411.1\ kJ = -1358.8 - x$ $x = 52.3\ \frac{kJ}{mol}$

10. Using Hess's Law, calculate the heat of reaction for the following reaction

$2H_3BO_{3(aq)} \rightarrow B_2O_{3(s)} + 3H_2O_{(l)}$

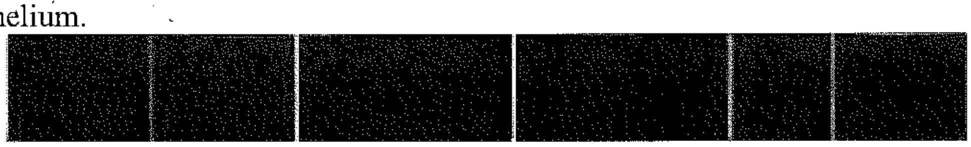
Given the following equations

$H_3BO_{3(aq)} \rightarrow HBO_{2(aq)} + H_2O_{(l)}$ ΔHrxn = -0.02 kJ
$H_2B_4O_{7(aq)} + H2O_{(l)} \rightarrow 4HBO_{2(aq)}$ ΔHrxn = -11.3 kJ
$H_2B_4O_{7(aq)} \rightarrow 2B_2O_{3(s)} + H_2O_{(l)}$ ΔHrxn = 17.5 kJ

$(H_3BO_3 \rightarrow HBO_2 + H_2O)\,4$ $(-0.02)\,4$
$H_2B_4O_7 \rightarrow 2B_2O_3 + H_2O$ 17.5
$4HBO_2 \rightarrow H_2B_4O_7 + H_2O$ 11.3

$\frac{4}{2}H_3BO_3 \rightarrow \frac{2}{2}B_2O_3 + \frac{6}{2}H_2O$ $\frac{28.72}{2} = 14.39\ kJ$

11. Calculate the frequency and energy per photon of the following emission lines for helium.

He

450 nm   515 nm   600 nm   690 nm   715 nm

450 nm

$\nu = \frac{c}{\lambda} = \frac{3.0\times10^8\ \frac{m}{s}}{4.50\times10^{-7}\ m} = 6.67\times10^{14}\ Hz$ $E = h\nu$
$= (6.626\times10^{-34}\ J\cdot s)(6.67\times10^{14}\ Hz)$
$= 4.42\times10^{-19}\ J$

515 nm

$= \frac{3.0\times10^8\ \frac{m}{s}}{5.15\times10^{-7}\ m} = 5.83\times10^{14}\ Hz$ $= (6.626\times10^{-34}\ J\cdot s)(5.83\times10^{14}\ Hz)$
$= 3.86\times10^{-19}\ J$