INTRODUCTION TO NATURAL SCIENCE 2006/07

CHEMISTRY HOMEWORK - WEEK 1 - SPRING

Chapter 6

(7) $28.1 \frac{J}{mol\ K} \times \boxed{\frac{1\ mol\ Hg}{200.59\ g}} = \underline{\underline{0.140\ J\,g^{-1}K^{-1}}}$

(8) $1.74 \frac{J}{g\ K} \times \boxed{\frac{78.114\ g\ C_6H_6}{1\ mol\ C_6H_6}} = \underline{\underline{135.9\ J\ mol^{-1}K^{-1}}}$

(10) mass of water $= 50.00\,mL \times \boxed{\frac{0.9979\,g}{mL}} = 49.85\,g$

$$q = C.M.\Delta T$$
$$= (4.184\ J\,g^{-1}K^{-1})(49.85\,g)(3.23\,K)$$
$$= 673.69\ J = \underline{\underline{673.7\,J}}$$

(11) $q = C.M.\Delta T$

$$\Delta T = \frac{q}{C.M} = \frac{2.25\ kJ}{(0.449\ J\,g^{-1}K^{-1})(344\,g)} \times \left(\frac{10^3\,J}{kJ}\right)$$

$$\Delta T = 14.567\ K = 14.567\,^\circ C$$

$$T_f - T_i = 14.567\,^\circ C \qquad T_f = 37\,^\circ C$$

$$T_i = 37\,^\circ C - 14.567\,^\circ C = 22.43\,^\circ C$$
$$= \underline{\underline{22\,^\circ C}}$$

(17) heat given off by Cu = heat absorbed by H_2O

$$m_{Cu}\, c_{Cu}\, (\Delta T)_{Cu} = m_{H_2O}\, c_{H_2O}\, (\Delta T)_{H_2O}$$

$$(45.5 g)(0.385\ J g^{-1} K^{-1})(372.8 - T_f) = (152 g)(4.184\ J g^{-1} K^{-1})(T_f - 291.5 K)$$

$$17.518\ J K^{-1} (372.8 - T_f) K = 635.96\ J K^{-1} (T_f - 291.5) K$$

$$6.531 \times 10^3 - 17.518\, T_f = 635.96\, T_f - 1.8538 \times 10^5$$

$$1.9191 \times 10^5 = 653.48\, T_f$$

$$T_f = 293.68\ K$$

$$= \underline{\underline{20.7\ ^\circ C}}$$

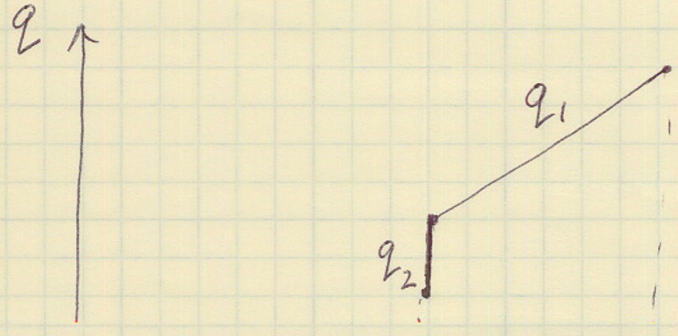
(19) Phase change only. No tempt. change. Assume density = 1 g/mL

$$\text{heat evolved} = \frac{333\ J}{g} \times \frac{1 g\ H_2O}{1 mL\ H_2O} \times \frac{10^3 mL}{L}$$

$$= 3.33 \times 10^3\ J$$

$$= \underline{\underline{3.33\ kJ}}$$

(23)



amount of heat evolved $= q_1 + q_2$

q_1 = heat evolved when cooling Hg from 23.0°C to −38.8°C

q_2 = freezing liq Hg at −38.8°C to solid Hg at −38.8°C (phase change only, no tempt. change)

$q_1 = C \cdot M \cdot \Delta T$

mass of Hg $= 1.00\,mL \times 13.6\,\frac{g}{mL} = 13.6\,g$

$q_1 = (0.140\,J\,g^{-1}K^{-1})(13.6\,g)(61.8\,K)$

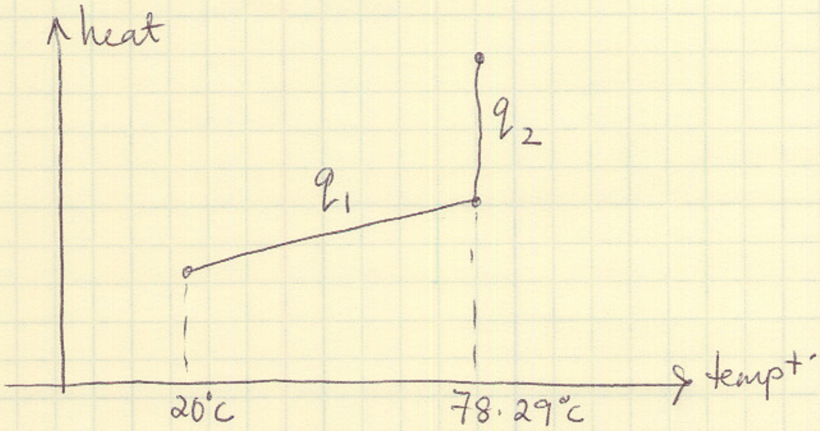
$= 117.67\,J$

$q_2 = 11.4\,\frac{J}{g} \times 13.6\,g = 155.04\,J$

total heat evolved $= q_1 + q_2 = 272.71\,J$

$= \underline{\underline{273\,J}}$

(25)



Amount of heat required = $q_1 + q_2$

q_1 = heat required to raise the tempt from 20°C to 78.29°C

$$= m.c.\Delta T = (1.00\,kg)(2.44\,J\,g^{-1}\,K^{-1})(58.29\,K)\left(\frac{10^3\,g}{kg}\right)$$

$$= 1.4223 \times 10^5\ J$$

q_2 = heat required for the phase change

$$= 855\ J \cdot g^{-1}\ (1.00\,kg) \times \left(\frac{10^3\,g}{kg}\right) = 8.55 \times 10^5\ J$$

$$q_1 + q_2 = 9.972 \times 10^5\ J = \underline{\underline{997.2\ kJ}}$$

(28) The reaction is endothermic since ΔH is positive.

$$10.0\,g\ CaO \times \boxed{\frac{mol}{56.068\,g}} = 0.178\ mol\ CaO$$

ΔH^{θ}_{rn} for 1 mol of CaO = 464.8 kJ

ΔH^{θ}_{rn} for 0.178 mol CaO = (464.8 × 0.178) kJ

= $\underline{\underline{82.7\ kJ}}$

This heat is absorbed.

(30) mass of acetic acid $= 1.00 L \times \left(\frac{1.044 g}{mL}\right) \times \left(\frac{10^3 mL}{L}\right)$

$= 1.044 \times 10^3 g$

moles of acetic acid $= 1.044 \times 10^3 g \times \left(\frac{mol}{~~84.07~~ 60.054 g}\right)$

$= 17.384$ mol acetic acid

Heat evolved when 1 mol acetic acid is produced $= 355.9 kJ$

heat evolved when 17.384 mol of acetic acid is produced $= 6187.09 kJ$

$= \underline{\underline{6.19 \times 10^3 kJ}}$

(31) mol of CsOH $= 0.200 \frac{mol}{L} \times 0.10000 mL$

$= 0.0200$ mol

mol of HCl $= (0.400 M)(0.0500 ~~m~~L) = 0.0200$ mol

molar ratio of CsOH : HCl $= 1:1$

∴ All of the reactants will be used up during the reaction.

total volume ~~Mass of the~~ $= 100.0 mL + 50.0 mL = 150.0 mL$

total mass $= 150.0 mL \times \frac{1.00 g}{mL} = 150.0 g$

$\Delta T = T_f - T_i = (24.28 - 22.50) = 1.78 K$

heat evolved in the reaction } $= m \cdot c \cdot \Delta T$

$= (150.0 g)(4.2 J g^{-1} K)(1.78 K)$

$= 1121.4 J = 1.1214 kJ$

This amount of heat is evolved from 0.0200 mol of CsOH.

Heat evolved per mol of CsOH $= 1.121 kJ \times 0.0200$

$= 0.02242 kJ$

$= \underline{\underline{22.42 J}}$

(33) temp change (ΔT) for Ti metal $= (99.5 - 24.3) K$

$= 75.2 K$

heat given off by Ti $= C \cdot m \cdot \Delta T$

$= C (20.8 g)(75.2 K)$

$= (1564.16 \cdot C) g K$

ΔT for the water $= (24.3 - 21.7) K = 2.6 K$

heat absorbed by water $= C \cdot M \cdot \Delta T$

$= (75.0 g)(4.184 J g^{-1} K^{-1})(2.6 K)$

$= 815.88 J$

heat given off by Ti = heat absorbed by water

$(1564.16) C \; g K = 815.88 J$

$C = 0.5216 J g^{-1} K^{-1} = \underline{\underline{0.522 J g^{-1} K^{-1}}}$

(37) $\Delta T = (26.72 - 21.25)K = 5.47K$

Heat absorbed by bomb $= (923 J K^{-1})(5.47K)$

$= 5.0488 \times 10^{3} J$

Heat absorbed by water $= (815g)(4.184 J K^{-1} g^{-1})(5.47 K)$

$= 1.865 \times 10^{4} J$

Total heat absorbed $= 2.370 \times 10^{4} J$

Total heat released by heating 2.56 g of S_8 $= 2.370 \times 10^{4} J$

~~$2.56 g\ S_8 \times \frac{32.066 g}{mol}$~~

$2.56 g\ S_8 \times \frac{mol\ S_8}{256.53 g} = 9.979 \times 10^{-3}\ mol\ S_8$

∴ Heat evolved per mol of S_8 $= \frac{2.370 \times 10^{4} J}{9.979 \times 10^{-3} mol} \times \frac{kJ}{10^{3} J}$

$= 2374.89\ kJ$

$= \underline{\underline{2375\ kJ}}$

(43) (a)

	$\Delta H^\ominus$ (kJ)
$CH_4(g) + 2O_2(g) \longrightarrow CO_2(g) + 2H_2O(g)$	-802.4
+ $CO_2(g) + 2H_2O(g) \longrightarrow CH_3OH(g) + \frac{3}{2}O_2(g)$	$+676$

$$CH_4(g) + \frac{1}{2}O_2(g) \longrightarrow CH_3OH(g)$$

$$\Delta H_m^\ominus = (-802.4 + 676)\text{ kJ}$$

$$= -126.4\text{ kJ}$$

energy diagram not required.

(45)

	$\Delta H^\ominus$ (kJ)
$\frac{1}{2}[N_2(g) + 3H_2(g) \longrightarrow 2NH_3(g)]$	$-91.8 \times \frac{1}{2}$
$\frac{1}{4}[4NH_3(g) + 5O_2(g) \longrightarrow 4NO(g) + 6H_2O(g)]$	$-906.2 \times \frac{1}{4}$
~~$H_2(g) + \frac{1}{2}O_2(g) \longrightarrow H_2O(g)$~~	
$\frac{3}{2}[H_2O(g) \longrightarrow H_2(g) + \frac{1}{2}O_2(g)]$	$+241.8 \times \frac{3}{2}$

$$\frac{1}{2}N_2(g) + \frac{1}{2}O_2(g) \longrightarrow NO(g)$$

$$\Delta H_m^\ominus = \frac{1}{2}(-91.8) + \frac{1}{4}(-906.2) + \frac{3}{2}(241.8)\text{ kJ}$$

$$= 90.25\text{ kJ}$$

(46)

$$P_4(s) + 10\,Cl_2(g) \longrightarrow 4\,PCl_5(s) \qquad \Delta H_f^\ominus (kJ)\; -1774.0$$

$$+\; 4\,[PCl_5(s) \longrightarrow PCl_3(l) + Cl_2(g)] \qquad +123.8 \times 4$$

$$P_4(s) + 6\,Cl_2(g) \longrightarrow 4\,PCl_3(l)$$

$$\Delta H_{rn}^\ominus = [-1774.0 + 4(123.8)]\,kJ$$

$$= -1278.8\ kJ$$

$\Delta H_{rn}^\ominus$ for 1mol of $PCl_3(l)$ = $\frac{-1278.8\,kJ}{4}$

$$= \underline{\underline{-514.4\,kJ}}$$

(47)

(a) $C\,(\text{graphite}) + 2\,H_2(g) + \frac{1}{2}O_2(g) \longrightarrow CH_3OH\,(l)$

(b) $\Delta H_f^\ominus = \underline{\underline{-238.4\ kJ\,mol^{-1}}}$

(49)

(a) $2\,Cr(s) + \frac{3}{2}O_2(g) \longrightarrow Cr_2O_3(s)$

$$\Delta H_f^\ominus = \underline{\underline{-1134.7\ kJ/mol}}$$

(b) $2.4\,g\ Cr_2O_3 \times \frac{1\,mol\ Cr_2O_3}{151.992\,g} = 1.579 \times 10^{-2}\,mol\ Cr_2O_3$

(51) (a) $P_4(s) + 5O_2(g) \longrightarrow P_4O_{10}(s)$ (white)

$$\Delta H_m^\theta = \Delta H_f^\theta[P_4O_{10}(s)] - \Delta H_f^\theta[P_4(s)] - 5\Delta H_f^\theta[O_2(g)]$$

$$= (-2984.0 - 0 - 0)\ kJ = \underline{-2984.0\ kJ}$$

molar mass of white P_4 = 123.88 g/mol

$$1.0\ g\ P_4 \times \frac{mol}{123.88\ g} = 8.072 \times 10^{-3}\ mol\ P_4$$

ΔH_m^θ per 1.0 g P_4 = ~~$\frac{-2984.0\ kJ}{8.072 \times 10^{-3}}$~~

$$= -2984.0\ \frac{kJ}{mol} \times 8.072 \times 10^{-3}\ mol\ P_4$$

$$= \underline{\underline{-24.09\ kJ}}$$

(b) $2NO(g) \longrightarrow N_2(g) + O_2(g)$

$$\Delta H_m^\theta = \Delta H_f^\theta[N_2(g)] + \Delta H_f^\theta[O_2(g)] - 2\Delta H_f^\theta[NO(g)]$$

$$= 0 + 0 - 2[90.29]\ kJ = -180.58\ kJ$$

$$\Delta H_m^\theta \text{ for } 0.20\ mol\ NO = \frac{-180.58\ kJ}{2\ mol\ NO} \times 0.20\ mol\ NO$$

$$= \underline{\underline{-18.06\ kJ}}$$

(c) $Na(s) + \frac{1}{2} Cl_2(g) \longrightarrow NaCl(s)$

$\Delta H_f^\ominus [NaCl(s)] = -411.12 \text{ kJ/mol}$

$2.40 \text{g NaCl} \times \left(\frac{\text{mol}}{58.44 \text{g}} \right) = 0.04107 \text{ mol NaCl}$

$\Delta H_{rn}^\ominus$ for 0.04107 mol NaCl $= -\frac{411.12 \text{ kJ}}{\text{mol}} \times 0.04107 \text{ mol}$

$= -16.88 \text{ kJ}$

(d) $2 Fe(s) + \frac{3}{2} O_2(g) \longrightarrow Fe_2O_3(s)$

$\Delta H_{rn}^\ominus = \Delta H_f^\ominus [Fe_2O_3(s)] - 2 \Delta H_f^\ominus [Fe(s)] - \frac{3}{2} \Delta H_f^\ominus [O_2(g)]$

$= -825.5 \text{ kJ}$ per 2 mol of Fe

$250 \text{ g Fe} \times \frac{\text{mol}}{55.85 \text{g}} = 4.476 \text{ mol Fe}$

$\Delta H_{rn}^\ominus$ for 250 g Fe $= -\frac{825.5 \text{ kJ}}{2 \text{mol Fe}} \times 4.476 \text{ mol Fe}$

$= -1847.6 \text{ kJ}$

(53) (a) $\Delta H^{\ominus}_{rxn} = 4\,\Delta H^{\ominus}_f[NO(g)] + 6\,\Delta H^{\ominus}_f[H_2O(g)] - 4\,\Delta H^{\ominus}_f[NH_3(g)] - 5\,\Delta H^{\ominus}_f[O_2(g)]$

$= [4(90.29) + 6(-241.83) - 4(-45.90) - 5(0)]$ kJ

$= -906.22$ kJ

(b) $\Delta H^{\ominus}_{rxn}$ for 4 mol NH_3 = -906.22 kJ

$10.0\text{ g } NH_3 \times \left(\frac{\text{mol}}{17.024\text{ g}}\right) = 0.587 \text{ mol } NH_3$

$\Delta H^{\ominus}_{rxn}$ for 10.0 g NH_3 = $\frac{-906.22\text{ kJ}}{4\text{ mol}} \times 0.587\text{ mol}$

$= -133.1$ kJ evolved.

(57) $\Delta H^{\ominus}_{rxn} = 10\,\Delta H^{\ominus}_f[CO_2(g)] + 4\,\Delta H^{\ominus}_f[H_2O(l)] - \Delta H^{\ominus}_f[C_{10}H_8(s)] - 12\,\Delta H^{\ominus}_f[O_2(g)]$

$-4395.0\text{ kJ} = 10[-393.509\text{ kJ}] + 4[-285.83\text{ kJ}] - \{\Delta H^{\ominus}_f[C_{10}H_8(s)]\} - 0$

$=$ ~~-4945.33 kJ~~ $-5078.41\text{ kJ} - \Delta H^{\ominus}_f[C_{10}H_8(s)]$

$\Delta H^{\ominus}_f[C_{10}H_8(s)] = 683.41$ kJ/mol