HW 4 Chem 1151 12 pts

30. $H_2O(g) \rightarrow H_2O(l)$; $\Delta E = q + w$; $q = -40.66$ kJ; $w = -P\Delta V$

Volume of 1 mol $H_2O(l)$ = 1 mol $H_2O(l) \times \frac{18.02\text{ g}}{\text{mol}} \times \frac{1\text{ cm}^3}{0.996\text{ g}} = 18.1\text{ cm}^3 = 18.1\text{ mL}$

$w = -P\Delta V = -1.00\text{ atm} \times (0.0181\text{ L} - 30.6\text{ L}) = 30.6\text{ L atm} \times \frac{101.3\text{ J}}{\text{L atm}} = 3.10 \times 10^3\text{ J}$

$\Delta E = q + w = -40.66\text{ kJ} + 3.10\text{ kJ} = -37.56\text{ kJ}$ $= 3.10$ kJ

38. a. $1.00\text{ g } CH_4 \times \frac{1\text{ mol } CH_4}{16.04\text{ g } CH_4} \times \frac{-891\text{ kJ}}{\text{mol } CH_4} = -55.5\text{ kJ}$

b. $n = \frac{PV}{RT}, \frac{\frac{740.}{760}\text{ atm} \times 1.00 \times 10^3\text{ L}}{\frac{0.08206\text{ L atm}}{\text{mol K}} \times 298\text{ K}} = 39.8\text{ mol } CH_4$

$39.8\text{ mol} \times \frac{-891\text{ kJ}}{\text{mol}} = -3.55 \times 10^4\text{ kJ}$

C. This is a Limiting Reactant Problem. From 38b, we have 39.8 mol CH_4 and will need

$$39.8\text{ mol } CH_4 \left(\frac{2\text{ mol } O_2}{1\text{ mol } CH_4}\right) = 79.6\text{ mol } O_2$$

But we have $\frac{2240\text{ g}}{\frac{32\text{ g}}{\text{mol}}} = 70$ mol O_2 on hand

So O_2 = LR

Start w/ $70\text{ mol } O_2 \left(\frac{-891\text{ kJ}}{2\text{ mol } O_2}\right)$

$= -31,185$ kJ

52. $NH_4NO_3(s) \rightarrow NH_4^+(aq) + NO_3^-(aq)$ $\Delta H = ?$; mass of solution = 75.0 g + 1.60 g = 76.6 g

Heat lost by solution = Heat gained as NH_4NO_3 dissolves. To help eliminate sign errors, we will keep all quantities positive (q and ΔT), then deduce the correct sign for ΔH at the end of the problem. Here, since temperature decreases as NH_4NO_3 dissolves, heat is absorbed as NH_4NO_3 dissolves, so it is an endothermic process (ΔH is positive).

$$\text{Heat loss by solution} = \frac{4.18\ \text{J}}{\text{g °C}} \times 76.6\ \text{g} \times (25.00 - 23.34)\text{°C} = 532\ \text{J} = \text{heat gain as } NH_4NO_3 \text{ dissolves}$$

$$\Delta H = \frac{532\ \text{J}}{1.60\ \text{g } NH_4NO_3} \times \frac{80.05\ \text{g } NH_4NO_3}{\text{mol } NH_4NO_3} \times \frac{1\ \text{kJ}}{1000\ \text{J}} = 26.6\ \text{kJ/mol } NH_4NO_3 \text{ dissolving}$$

62.

$C_6H_4(OH)_2 \rightarrow C_6H_4O_2 + H_2$	$\Delta H = 177.4$ kJ
$H_2O_2 \rightarrow H_2 + O_2$	$\Delta H = -(-191.2$ kJ)
$2\ H_2 + O_2 \rightarrow 2\ H_2O(g)$	$\Delta H = 2(-241.8$ kJ)
$2\ H_2O(g) \rightarrow 2\ H_2O(l)$	$\Delta H = 2(-43.8$ kJ)
$C_6H_4(OH)_2(aq) + H_2O_2(aq) \rightarrow C_6H_4O_2(aq) + 2\ H_2O(l)$	$\Delta H = -202.6$ kJ

74. $C_2H_4(g) + 3\ O_2(g) \rightarrow 2\ CO_2(g) + 2\ H_2O(l)$ $\Delta H° = -1411.1$ kJ

$$\Delta H° = -1411.1\ \text{kJ} = 2(-393.5)\ \text{kJ} + 2(-285.8)\ \text{kJ} - \Delta H°_{f,C_2H_4}$$

$$-1411.1\ \text{kJ} = -1358.6\ \text{kJ} - \Delta H°_{f,C_2H_4},\ \Delta H°_{f,C_2H_4} = 52.5\ \text{kJ/mol}$$

86. $Na_2SO_4(aq)_2 + Ba(NO_3)_2(aq) \rightarrow BaSO_4(s) + 2\ NaNO_3(aq)$ $\Delta H = ?$

$$1.00\ \text{L} \times \frac{2.00\ \text{mol}}{\text{L}} = 2.00\ \text{mol } Na_2SO_4;\ 2.00\ \text{L} \times \frac{0.750\ \text{mol}}{\text{L}} = 1.50\ \text{mol } Ba(NO_3)_2$$

The balanced equation requires a 1:1 mole ratio between Na_2SO_4 and $Ba(NO_3)_2$. Because we have fewer moles of $Ba(NO_3)_2$ present, it is limiting and 1.50 mol $BaSO_4$ will be produced [there is a 1:1 mole ratio between $Ba(NO_3)_2$ and $BaSO_4$].

heat gain by solution = heat loss by reaction

$$\text{mass of solution} = 3.00\ \text{L} \times \frac{1000\ \text{mol}}{1\ \text{L}} \times \frac{2.00\ \text{g}}{\text{mL}} = 6.00 \times 10^3\ \text{g}$$

$$\text{heat gain by solution} = \frac{6.37\ \text{J}}{\text{g °C}} \times 6.00 \times 10^3\ \text{g} \times (42.0 - 30.0)\text{°C} = 4.59 \times 10^5\ \text{J}$$

Because the solution gained heat, the reaction is exothermic; $q = -4.59 \times 10^5$ J for the reaction.

$$\Delta H = \frac{-4.59 \times 10^5\ \text{J}}{1.50\ \text{mol } BaSO_4} = -3.06 \times 10^5\ \text{J/mol} = -306\ \text{kJ/mol}$$