

# Chemistry 2740 Spring 2018 Test 1 solutions

1. (a)  $q = (120 \text{ g})(2427 \text{ J g}^{-1}) = 291 \text{ kJ}$   
(b)

$$q = mc_p \Delta T$$
$$\therefore \Delta T = \frac{q}{mc_p} = \frac{291 \text{ kJ}}{(74 \text{ kg})(3.47 \text{ kJ K}^{-1} \text{ kg}^{-1})} = 1.1 \text{ K}$$

2. (a)

$$S(\text{l, mp}) = S(\text{ice, mp}) + \Delta_{\text{fus}} S$$
$$\Delta_{\text{fus}} S = \frac{\Delta_{\text{fus}} H}{T_{\text{fus}}} = \frac{6.132 \times 10^3 \text{ J mol}^{-1}}{276.83 \text{ K}} = 22.15 \text{ J K}^{-1} \text{ mol}^{-1}$$
$$\therefore S(\text{l, mp}) = 43.37 + 22.15 \text{ J K}^{-1} \text{ mol}^{-1}$$
$$= 65.52 \text{ J K}^{-1} \text{ mol}^{-1}$$

- (b)

$$S(\text{l, 298.15 K}) = S(\text{l, mp}) + \Delta S(\text{mp} \rightarrow 298.15 \text{ K})$$
$$\Delta S(\text{mp} \rightarrow 298.15 \text{ K}) = \int_{T_{\text{mp}}}^{298.15 \text{ K}} \frac{dq_{\text{rev}}}{T} = \int_{T_{\text{mp}}}^{298.15 \text{ K}} \frac{C_{p,m} dT}{T}$$
$$= \int_{T_{\text{mp}}}^{298.15 \text{ K}} \frac{A + BT + C/T}{T} dT$$
$$= \int_{T_{\text{mp}}}^{298.15 \text{ K}} \left( \frac{A}{T} + B + \frac{C}{T^2} \right) dT$$
$$= \left[ A \ln T + BT - \frac{C}{T} \right]_{T_{\text{mp}}}^{298.15 \text{ K}}$$
$$= (-91.35 \text{ J K}^{-1} \text{ mol}^{-1}) \ln \left( \frac{298.15 \text{ K}}{276.83 \text{ K}} \right)$$
$$+ (0.2628 \text{ J K}^{-2} \text{ mol}^{-1})(298.15 - 276.83 \text{ K})$$
$$- (28777 \text{ J mol}^{-1}) \left( \frac{1}{298.15} - \frac{1}{276.83 \text{ K}} \right)$$
$$= 6.26 \text{ J K}^{-1} \text{ mol}^{-1}$$
$$\therefore S(\text{l, 298.15 K}) = 65.52 + 6.26 \text{ J K}^{-1} \text{ mol}^{-1}$$
$$= 71.78 \text{ J K}^{-1} \text{ mol}^{-1}$$

3. Start by setting up the heat balance:

$$q = 0 = \left\{ \begin{array}{l} \text{combustion} \\ \text{of sample} \end{array} \right\} + \left\{ \begin{array}{l} \text{combustion} \\ \text{of wire} \end{array} \right\} + \left\{ \begin{array}{l} \text{calorimeter} \\ \text{warming} \end{array} \right\}$$

$$= n_{\text{acid}} \Delta_c U_m(\text{acid}) + \ell \Delta_c u_{\text{wire}} + C_V \Delta T$$

In this case, the unknown is  $\Delta_c U_m(\text{acid})$ .

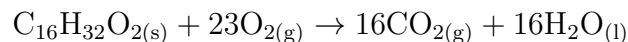
$$n_{\text{acid}} = \frac{1.1041 \text{ g}}{256.428 \text{ g mol}^{-1}} = 0.0043057 \text{ mol}$$

$$\Delta_c U_m = -\frac{1}{n} (\ell \Delta_c u_{\text{wire}} + C_V \Delta T)$$

$$= -\frac{1}{0.0043057 \text{ mol}} [(9.8 \text{ cm})(-9.6 \times 10^{-3} \text{ kJ cm}^{-1}) + (11.08 \text{ kJ K}^{-1})(3.879 \text{ K})]$$

$$= -9960 \text{ kJ mol}^{-1}.$$

To go further, I need a balanced reaction:



From this reaction, we have

$$\Delta_c \nu_{\text{gas}} = 16 - 23 = -7$$

$$\Delta_c H_m = \Delta_c U_m + RT \Delta_c \nu_{\text{gas}}$$

$$= -9960 \text{ kJ mol}^{-1} + (8.314472 \times 10^{-3} \text{ kJ K}^{-1} \text{ mol}^{-1})(298.15 \text{ K})(-7)$$

$$= -9977 \text{ kJ mol}^{-1}$$

Also,

$$\Delta_c H_m = 16\Delta_f H^\circ(\text{CO}_2) + 16\Delta_f H^\circ(\text{H}_2\text{O}, \text{l}) - [\Delta_f H^\circ(\text{C}_{16}\text{H}_{32}\text{O}_2) + 23\Delta_f H^\circ(\text{O}_2)]$$

$$\therefore \Delta_f H^\circ(\text{C}_{16}\text{H}_{32}\text{O}_2) = 16\Delta_f H^\circ(\text{CO}_2) + 16\Delta_f H^\circ(\text{H}_2\text{O}, \text{l}) - \Delta_c H_m$$

$$= 16(-393.51) + 16(-285.830) - (-9977) \text{ kJ mol}^{-1}$$

$$= -892 \text{ kJ mol}^{-1}$$