1. Consider dissolving 50 mol of a non-volatile solute in 100 mol of liquid water at 100 °C.

(a) What is the vapor pressure of this solution? Assume ideal behavior.

$$\chi_{\text{water}} = \frac{100\text{ mol}}{100\text{ mol} + 50\text{ mol}} = 0.667$$

$$P_{\text{solution}} = \chi_{\text{water}} P^{\text{o}}_{\text{water}} = (0.667)(1.00\text{ atm}) = 0.667\text{ atm}$$

(b) How would the vapor pressure in part (a) change if the solute-solvent interactions became more favorable?

Vapor pressure would decrease as the solute-solvent interactions become stronger.

2. Consider the following information.

$\Delta H^{\text{o}}_{\text{f}}[\text{CaCl}_2\ (s)] = -795.4\text{ kJ/mol}$ $\Delta H_{\text{sub}}[\text{Ca}\ (s)] = 154\text{ kJ/mol}$ $\Delta H_{\text{BE}}[\text{Cl}_2] = 240\text{ kJ/mol}$

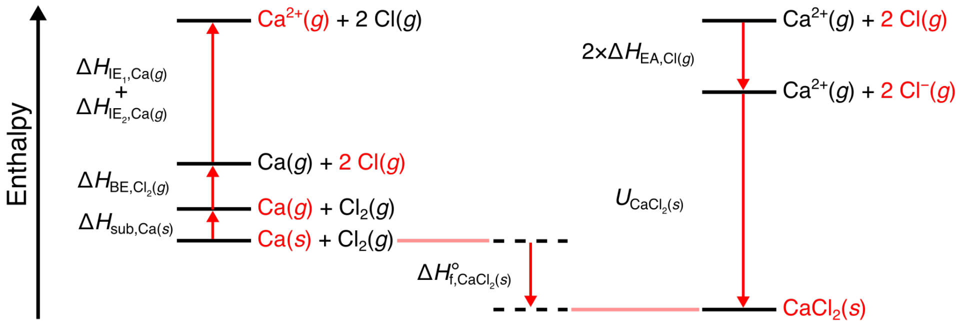
$\text{IE}_1[\text{Ca}] = 590\text{ kJ/mol}$ $\text{IE}_2[\text{Ca}] = 1145\text{ kJ/mol}$ $\text{EA}[\text{Cl}] = -349\text{ kJ/mol}$

(a) Calculate the lattice energy (U) of $CaCl_2$. Draw an energy diagram, with energy on the y-axis, of the Born-Haber cycle that enables you to calculate the lattice energy (U).

$$\Delta H^{\text{o}}_{\text{f,CaCl}_2(s)} = \Delta H_{\text{sub,Ca}(s)} + \Delta H_{\text{BE,Cl}_2(g)} + \Delta H_{\text{IE}_1\text{,Ca}(g)} + \Delta H_{\text{IE}_2\text{,Ca}(g)} + 2\Delta H_{\text{EA,Cl}(g)} + U_{\text{CaCl}_2(s)}$$

$$-795.4\frac{\text{kJ}}{\text{mol}} = 154\frac{\text{kJ}}{\text{mol}} + 240\frac{\text{kJ}}{\text{mol}} + 590\frac{\text{kJ}}{\text{mol}} + 1145\frac{\text{kJ}}{\text{mol}} + 2\left(-349\frac{\text{kJ}}{\text{mol}}\right) + U_{\text{CaCl}_2(s)}$$

$$U_{\text{CaCl}_2(s)} = -2226\frac{\text{kJ}}{\text{mol}}$$



(b) Would you expect the lattice energy of $MgCl_2$ to larger or smaller than that of $CaCl_2$?

$$U_{\text{CaCl}_2(s)} < U_{\text{MgCl}_2(s)}$$

3. The osmotic pressure of a 0.0100 M $CaCl_2$ solution at 298 K is 0.605 atm. How many moles of ions are dissociated for every mole of $CaCl_2$ dissolved in solution.

$$\Pi = iMRT$$

$$0.605\ \text{atm} = i \times (0.0100\ \text{M})\left(0.08206 \frac{\text{L} \cdot \text{atm}}{\text{mol} \cdot \text{K}}\right)(298\ \text{K})$$

$$i = 2.47$$

2.47 mol ions are dissociated for every 1 mole of $CaCl_2$ dissolved.

4. The wasp, *Bracon cephi*, survives in sub-freezing climates by elevating levels of glycerol, a compound composed of only C, H, and O atoms, in their blood as high as 5.00 mol/kg to depress the freezing point of blood. If typical blood (K_f = 1.853 °C/m) freezes at −1.50 °C, what is freezing point of wasp blood?

Determine the *freezing point depression* (ΔT_f). Glycerol is a molecular compound, so i = 1.

$$\Delta \text{T}_\text{f} = i\text{K}_\text{f}m$$

$$= (1)\left(1.853 \frac{°\text{C}}{m}\right)(5.00\ m)$$

$$\Delta \text{T}_\text{f} = 9.26_5\ °\text{C}$$

Now, calculate the new freezing point:

$$\text{T}_{\text{f,wasp}} = -1.50\ °\text{C} - 9.26_5\ °\text{C} = -10.76\ °\text{C}$$