1. $P^\circ_{\text{vap}}(H_2O) = 0.0317\,\text{bar}$. Circle all the conditions that will cause water to condense spontaneously.

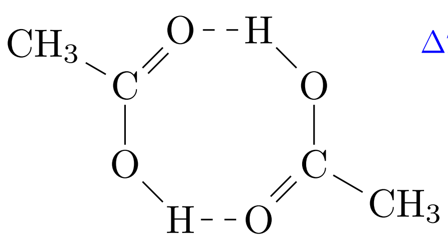
   - ■ Partial pressure of water = 1 bar
   - ■ Partial pressure of water = 0.1 bar
   - □ Partial pressure of water = 0.01 bar
   - □ Partial pressure of water = 0.0317 bar, temperature increases
   - ■ Partial pressure of water = 0.0317 bar, volume decreases

2. The vapor pressure of a liquid is 0.92 atm at 60 °C. Circle all the temperatures that could correspond to the boiling point of the liquid.

   □ 35 °C □ 45 °C □ 55 °C □ 60 °C ■ 65 °C

3. When acetic acid (CH_3COOH) dissolves in benzene, it forms dimers. A solution of acetic acid in benzene has a freezing point of 5.40 °C. What is the molality of the acetic acid/benzene solution?

$$T_{f,\text{benzene}} = 5.53\,^\circ\text{C} \qquad k_{f,\text{benzene}} = 5.12\,\frac{^\circ\text{C}\cdot\text{kg}}{\text{mol}}$$



$$\Delta T_f = T_f^{\text{pure}} - T_f^{\text{soln}} = 5.53\,^\circ\text{C} - 5.40\,^\circ\text{C} = 0.13\,^\circ\text{C}$$

$$\Delta T_f = i \cdot k_f \cdot m$$

$$m = \frac{\Delta T_f}{i \cdot k_f} = \frac{0.13\,^\circ\text{C}}{\frac{1}{2}\cdot 5.12\,\frac{^\circ\text{C}\cdot\text{kg}}{\text{mol}}} = \boxed{0.051\,\frac{\text{mol}}{\text{kg}}}$$

4. Consider two gases, iodine chloride (ICl (g)) and iodine bromide (IBr (g))

   (a) Circle the one with greater k_H in water at 25 °C?

   ■ k_H(ICl) □ k_H(IBr)

   Two separate systems are prepared at the same initial temperature and pressure:

   - System 1: ICl (g) at 2 bar in 250 mL of water
   - System 2: IBr (g) at 2 bar in 250 mL of water

   (b) Suppose you want the systems to have equal concentrations of ICl (aq) and IBr (aq). Which system would you compress to achieve this goal?

   □ ICl ■ IBr □ Cannot be determined

   (c) Suppose you want the systems to have equal concentrations of ICl (aq) and IBr (aq). Which system would you heat at constant pressure to achieve this goal?

   ■ ICl □ IBr □ Cannot be determined

5. Two aqueous solutions are placed in a U-tube separated by a semipermeable membrane. One solution is 1.00 L of 0.05 M urea (a molecular solute). The other is 1.00 L of 0.02 M Na_2SO_4. Assume ideal solutions at the same temperature.

   (a) Which solution has the higher osmotic pressure?

$$\Pi_{\text{urea}} = iMRT = (1)(0.05\,\tfrac{\text{mol}}{\text{L}})RT = 0.05\,\text{M}\,RT$$
$$\Pi_{\text{Na}_2\text{SO}_4} = iMRT = (3)(0.02\,\tfrac{\text{mol}}{\text{L}})RT = 0.06\,\text{M}\,RT \implies \boxed{\text{Na}_2\text{SO}_4}$$

   (b) In order to stop water from flowing, pressure must be applied to which side?

   Na_2SO_4, the side with higher osmotic pressure

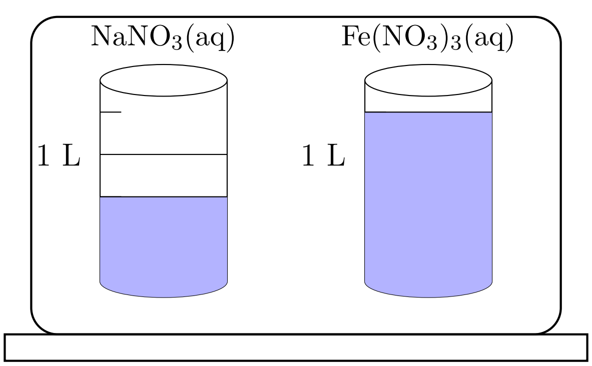
   (c) Water is allowed to flow through the semipermeable membrane until the osmotic pressure of both solutions equalize. What is the concentration of Na_2SO_4 when this occurs?

$$i_{\text{urea}}RTc_{\text{urea}} = i_{\text{Na}_2\text{SO}_4}RTc_{\text{Na}_2\text{SO}_4}$$
$$(1)\left(\frac{0.05\,\text{mol}}{(1-x)\,\text{L}}\right) = (3)\left(\frac{0.02\,\text{mol}}{(1+x)\,\text{L}}\right)$$
$$\frac{0.05}{1-x} = \frac{0.06}{1+x}$$
$$0.05(1+x) = 0.06(1-x)$$
$$0.11x = 0.01 \implies x = 0.0909$$

   Then calculate volume and concentration

$$1 + x = 1.0909\,\text{L}$$
$$[\text{Na}_2\text{SO}_4] = \frac{0.02\,\text{mol}}{1.0909\,\text{L}} = \boxed{0.0183\,\text{M}}$$

6. Two beakers are placed together in a sealed container. One beaker contains 1.00 L 0.01 m $NaNO_3(aq)$, the other contains 1.00 L 0.01 m $Fe(NO_3)_3(aq)$. After some time, the system reaches equilibrium as the water vapor causes redistribution between the beakers. Sketch the water levels below.



$$i_{\text{NaNO}_3}m_{\text{NaNO}_3} = i_{\text{Fe(NO}_3)_3}m_{\text{Fe(NO}_3)_3}$$
$$(2)\left(\frac{0.0100\,\text{mol}}{(1-x)\,\text{kg}}\right) = (4)\left(\frac{0.0100\,\text{mol}}{(1+x)\,\text{kg}}\right)$$
$$\frac{2}{1-x} = \frac{4}{1+x}$$
$$2(1+x) = 4(1-x)$$
$$6x = 2 \implies x = 0.333$$
$$V_{\text{NaNO}_3} = 1 - x = \boxed{0.667\,\text{L}}$$
$$V_{\text{Fe(NO}_3)_3} = 1 + x = \boxed{1.333\,\text{L}}$$

Homework Problem 29

1. The standard (1 bar) boiling point of ethanol (C_2H_6O) is 78.4 °C. 9.15 g of a molecular solute is dissolved in 100.0 g of ethanol. The vapor pressure of the resulting solution is 0.97 at 78.4 °C.
   (a) What is the mol fraction of ethanol in the solution?

   (b) What is the molar mass of the solute?

   (c) What is the boiling point of the solution? (k_b for ethanol = 1.07 $\frac{\mathrm{K\cdot kg}}{\mathrm{mol}}$)