Freezing Point Depression
Boiling Point Elevation

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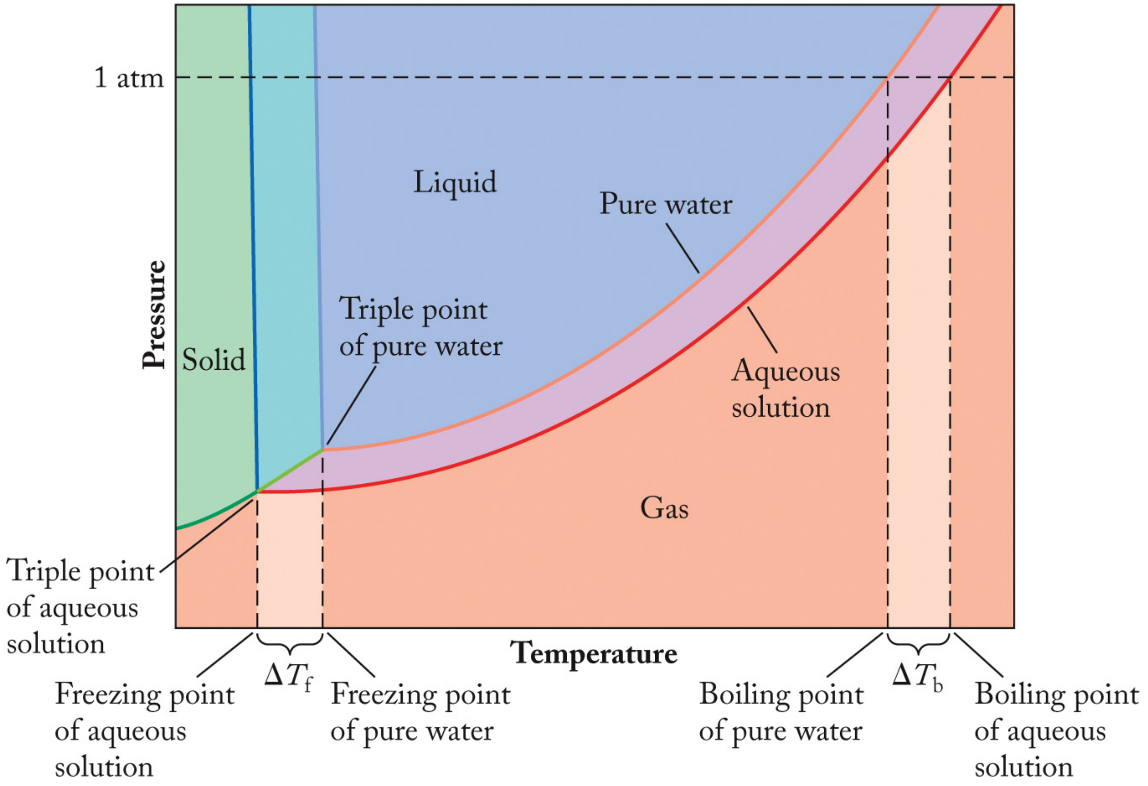
In general, adding solute to a solvent (i.e., creating a solution) has two effects:

1. Elevates the boiling point
2. Depresses the melting point



QUANTIFYING COLLIGATIVE PROPERTIES

To determine the change in freezing point or boiling point of a solution, we use the following two equations, respectively:

FREEZING POINT DEPRESSION

$$\Delta \mathrm{T_f} = i\mathrm{K_f}m$$

BOILING POINT ELEVATION

$$\Delta \mathrm{T_b} = i\mathrm{K_b}m$$

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$$\Delta T_b = iK_b m$$

ΔT_f or ΔT_b = change in temperature (°C)
i = number of dissociated particles per mole of solute
K_f or K_b = constant values (°C/*m*)
m = molality (mol/kg or *m*)

$$m = \frac{n_{solute}}{\text{kg solvent}}$$

Determine the change in boiling point of a solution made by dissolving 125 mg of $C_{10}H_{14}O$ in 1.50 g of CS_2 (K_b = 2.34 °C/*m*).

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Your first actual step in these types of problem is to determine what kind of compound you have! Because:

- Molecular compounds that dissolve have an i = 1 since they do not dissociate.
- Insoluble ionic compounds do **not** dissociate in water, so **no changes** are observed!
- Soluble ionic compounds have theoretical i values equal to the number of ions per mole compound.

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Step two is to find the molality of your solution:

$$m = \frac{\mathrm{n_{solute}}}{\mathrm{kg\ solvent}} = \frac{125\ \mathrm{mg}\ \mathrm{C_{10}H_{14}O} \times \frac{1\ \mathrm{g}}{1000\ \mathrm{mg}} \times \frac{1\ \mathrm{mol}\ \mathrm{C_{10}H_{14}O}}{150.21\ \mathrm{g}}}{1.50\ \mathrm{g}\ \mathrm{CS_2} \times \frac{1\ \mathrm{kg}}{1000\ \mathrm{g}}} = 0.555\ m$$

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And finally solve for the change in boiling point:

$$\begin{aligned}\Delta \mathrm{T_b} &= i\mathrm{K_b}m \\ &= (1)\left(2.34\ \frac{^\circ\mathrm{C}}{m}\right)(0.555\ m) \\ &= 1.30\ ^\circ\mathrm{C}\end{aligned}$$

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$$\Delta T_f = iK_f m$$

$$-0.322\ °C = i\left(1.86\ \frac{°C}{m}\right)(0.0935\ m)$$

$$i = 1.85$$

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We can then extract the mass from the molality:

$$0.0378\ m = \frac{\mathrm{n_{solute}}}{10.0\ \mathrm{L\ H_2O} \times \frac{1000\ \mathrm{mL}}{1\ \mathrm{L}} \times \frac{1\ \mathrm{g}}{1\ \mathrm{mL}} \times \frac{1\ \mathrm{kg}}{1000\ \mathrm{g}}}$$

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$$m_{solute} = 0.378\ \mathrm{mol\ (NH_4)_2SO_4} \times \frac{132.144\ \mathrm{g}}{1\ \mathrm{mol\ (NH_4)_2SO_4}} = 5.00\ \mathrm{g (NH_4)_2SO_4}$$