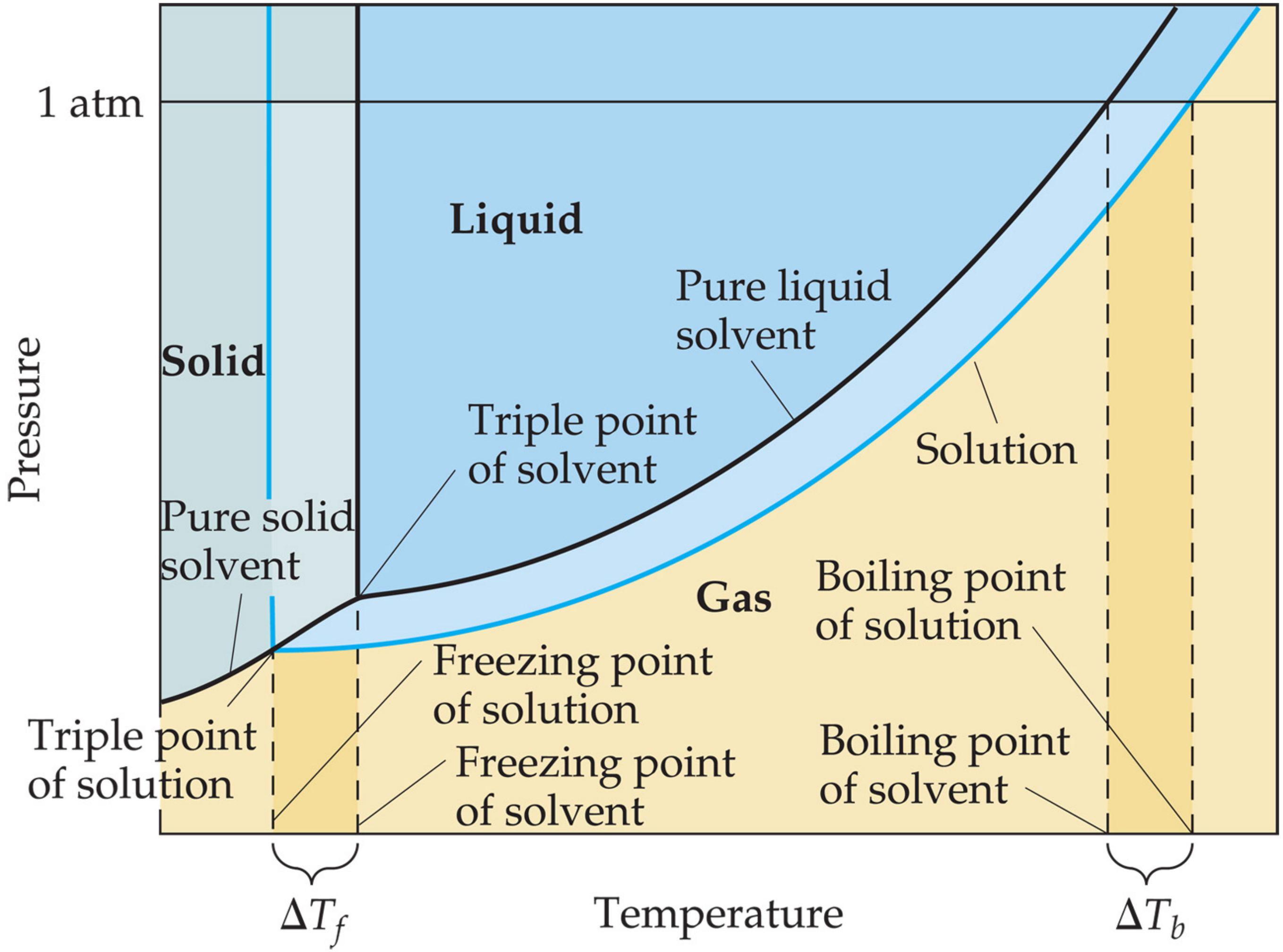
Colligative Properties

Bromfield Honors Chemistry

Colligative Properties

- Addition of a solute changes the properties of the system:
- These changes depend ONLY on the number of solute particles added—not the identity of the solute particles


1 atm
Pressure
Liquid
Solid
Pure liquid solvent
Triple point of solvent
Solution
Pure solid solvent
Gas
Boiling point of solution
Freezing point of solution
Triple point of solution
Freezing point of solvent
Boiling point of solvent
ΔT_f
Temperature
ΔT_b

Adding solute to a solvent

- Presence of solute-solvent interactions
  - Have to break more attractions to get solvent into gas phase

Colligative Properties

- Addition of a solute changes the properties of the system:
  - The solution will have different properties than the pure solvent

Colligative Properties

- Addition of a solute changes the properties of the system:
  - Adding solute changes the freezing point, boiling point, vapor pressure

Colligative Properties

- Addition of a solute changes the properties of the system:
  - These changes depend only on the number of particles added (NOT the identity of the particles)

Colligative Properties

- Freezing Point Depression
  - The solution will freeze at a lower temperature than the pure solvent

Colligative Properties

- Freezing Point Depression
  - The solution will freeze at a lower temperature than the pure solvent
    - Why we put salt on sidewalks during winter
    - Antifreeze in cars

Colligative Properties

- Boiling Point Elevation
  - The solution will boil at a higher temperature than the pure solvent

van’t Hoff Factor

- Some substances (electrolytes)dissociate into ions, resulting in more solute particles dissolving

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  - Acids, bases, ionic compounds (salts)

van't Hoff Factor

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- van’t Hoff Factor = the theoretical (maximum) number of particles formed when a substance dissociates
  - The real degree of ionization is typically slightly less than predicted by the van’t Hoff factor

Predicting van't Hoff factors

- For all covalently bonded substances, (i.e., nonelectrolytes)
  - i = 1
- For ionic substances, acids, & bases
  - i = number of ions present in formula

Predicting van’t Hoff factors

- Ex.
  - NaCl
  - $C_6H_{12}O_6$
  - $Al(NO_3)_3$
  - $MgCl_2$

Calculating the new boiling point

- $\Delta T_{bp} = k_{bp} \bullet i \bullet m$ where k_{bp} is a constant for each solvent

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  - Calculate the new boiling point by adding ΔT_{bp} to the boiling point of the pure solvent

Calculating the new freezing point

- $\Delta T_{fp} = k_{fp} \bullet i \bullet m$ where k_{fp} is a constant for each solvent

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- $\Delta T_{fp} = k_{fp} \bullet i \bullet m$ where k_{fp} is a constant for each solvent
  - Calculate the new freezing point by subtracting ΔT_{fp} from the freezing point of the pure solvent

Practice Problem 1

- If 67.7 g of urea (CH_4N_2O) is dissolved in 833 g of chloroform, what is the elevation in the boiling point?
    - K_{bp} for chloroform is 3.85 C^o/m

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- Answer: 5.21^{o}C

Practice Problem 2

- Ethylene glycol ($C_2H_6O_2$) is the principal ingredient in antifreeze. How many grams of ethylene glycol will be needed to lower the freezing point of 2100 g of water to -20.0°C?
  - K_f for water is 1.86°C/m

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  - K_f for water is 1.86$^oC/m$
- Answer = 1400 g ethylene glycol

Practice Problem 3

- A 15.0 g sample of an unknown compound is dissolved in 100. g of benzene (C_6H_6). The boiling point is raised 2.67°C above the boiling point of pure benzene. What is the molar mass of the unknown? (K_b for benzene is 2.67 C°/m.)

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- Answer: 150. g/mol