

Physical Chemistry

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Preface

This is an example of a \LaTeX document that is being converted to DocBook. It demonstrates how you might customise DB2 \LaTeX to retain the style of custom \LaTeX class. It does *not* demonstrate how to convert your mathematics to MathML.

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Introduction

This is another introductory preface.

States of Matter

Chapter 1

This Chapter covers the kinetics of intermolecular interactions with a particular focus on gases.

1.1 Kinetic Theory of Gases

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$$\left. \begin{array}{ll} \text{Boyle's Law} & V \propto P^{-1} \\ \text{Charles' Law} & V \propto T \\ \text{Avogadro's Law} & V \propto n \end{array} \right\} \text{Explicable using the Kinetic Theory of Gases}$$

The above can be combined by the Ideal Gas Equation:

$$PV = nRT \quad (1.1)$$

1.1.1 The Postulates

- Large distances between very small particles,
- Continual, rapid, random, straight-line motion,
- Negligible inter-particle forces,
- Elastic collisions,
- $E_{\overline{K}} \propto T$ (is the same for all gases).

Example: Ideal Gas Law

$$\begin{array}{ll} m &= 0.100 \text{ g} \\ &= 0.0001 \text{ kg} \\ P &= 0.0928 \text{ mm} \\ V &= 250 \text{ mL} \\ &= 0.25 \text{ L} \\ T &= 23^\circ\text{C} \\ &= 300 \text{ K} \\ R &= 0.0821 \text{ L mm mol}^{-1} \text{ K}^{-1} \end{array} \quad \begin{array}{l} PV = nRT \\ n = \frac{PV}{RT} \\ \approx 106 \text{ g/mol} \end{array}$$

1.1.2 Non-ideal Gases

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Gases become non-ideal at:

- High pressures, or

- Low temperatures.

This is because in these circumstances, molecules occupy appreciable volume and intermolecular forces are no longer negligible. The latter means that collisions are weaker against any container, and may arise because slow moving, low temperature particles are more easily affected by intermolecular forces and because at high pressures the molecules are closer.

Van der Waals Equation

This equation is important as a conceptual reminder, because it is used to account for deviations from the ideal gas law. The equation is:

$$\left(P + \frac{\alpha n^2}{V^2}\right)(V - \beta n) = nRT \quad (1.2)$$

where the α accounts for intermolecular forces and the β accounts for the volumes of molecules.

1.2 Effusion and Diffusion

Effusion is the movement of particles through a tiny opening (aperture, pore) into another container region of lower pressure. Molecules of low weight (higher speed) elements strike barrier more frequently and therefore effuse quicker.

Diffusion is the mixing of substances by one spreading throughout the other substance.

1.3 Intermolecular Forces

- are electrostatic forces (attraction);
- are weaker than ionic or covalent bonds;
- are directly related to fusion and vapourisation points.

See §9.8 of Kotz and Treichel for more on polar molecules and dipole moments.

Solutions & Colloids

Chapter 2

Definition

A *solute* dissolves into a *solvent*. $V_{\text{solvent}} > V_{\text{solute}}$

For dissolution to occur:

1. Solute particles must be separate from one another;
2. Solvent particles must be separate from one another;
3. The particles of both substances must mix together.

Definition

Miscible substances mix together without interface.

Miscibility is determined by the intermolecular bonds types in the solvent and solute and how these compare with each other. That is, the relative strengths of all the intermolecular bonds involved.

Dissolution occurs when the intermolecular forces between the solvent and solute are similar and strong enough to compete with the forces within the solvent itself and the solute itself.

Ways of Expressing Concentration

Molarity (M)	(moles solute)/(litres solution)
Molality	(moles solute)/(kg solvent)
Mole Fraction (X)	(moles solute)/(moles solvent + moles solute)
\%w/v	(grams solute)/(100 ml solution)
\%w/w	(grams solute)/(100 g solution)
ppm	(mg of solute)/(litre of solution)

When diluting, more solvent is added to a solution. This increases the solution volume, decreases the concentration, but does *not* affect the amount of solute.

2.1 Factors Affecting Solubility

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You should be familiar information in the following sections.

2.1.1 Pressure

For gas into liquid, the solubility increase as gas pressure increases. There is a mathematical relationship called Henry's Law, which states

$$S_g = k_H \times P_g \quad (2.1)$$

$$\text{where } S_g = \text{gas solubility} \quad (2.2)$$

$$P_g = \text{gas pressure} \quad (2.3)$$

$$k_H = \text{Henry's coefficient} \quad (2.4)$$

For an explanation of this relationship, consider the comparative rates of vaporisation and condensation which occur at the interface of the liquid and atmosphere, and what must happen to the gas to reach equilibrium.

2.1.2 Temperature

For gases into liquids, the solubility decreases as temperature increases. This is because at higher temperatures, more energy is present to overcome intermolecular forces and therefore a phase change from liquid to gas is more likely than at lower temperatures.

For solids in liquids, it is most common that solubility increases as temperature increases, though the relationship is not necessarily linear. Some compounds are *less* soluble at higher temperatures.

Colligative Properties

Chapter 3

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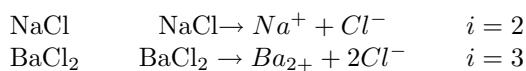
Colligative properties of a solution depend on *how many* solute particle there are, not *what* they are. That is, colligative properties depend on the dissociation of substances in solution.

How many solute particles?

Moles when pure	Substance	Moles of particles when in water
0.01	ethanol	0.01 mol
0.01	NaCl	0.02 mol
0.01	BaCl ₂	0.03 mol

3.1 van't Hoff Factor (i)

The van't Hoff factor relates the number of moles of a substance to the number of particles in solution.



Definition

Non-volatile electrolytes ("non-electrolytes") have a unity van't Hoff factor. Examples include alcohols, ethylene glycol and urea.

3.2 Freezing Point Depression

Molar Mass Calculations

Some colligative properties can be used to calculate molar masses for non-volatile ($i = 1$) solvents. For example:

Step 1. Calculate ΔT_F from given information.

Step 2. Find the molality $\frac{\Delta T_F}{K_F}$.

Step 3. Calculate the moles (molality \times given mass).

Step 4. Find the molar mass $M = \frac{m}{n}$.