Kinetic Molecular Theory
Physical States of Matter

BIOB111
CHEMISTRY & BIOCHEMISTRY

Session 5
Key concepts: session 5

From this session you are expected to develop an understanding of the following concepts:

Concept 1: Intermolecular vs intramolecular forces

Concept 2: Strength of intermolecular and intramolecular forces

Concept 3: Kinetic and potential energy

Concept 4: An atom's energy

Concept 5: Boyle's law

Concept 6: Dissolving NaCl (salt) in H₂O

Concept 7: Saturated solutions

Concept 8: Osmosis

These concepts are covered in the Conceptual multiple choice questions of tutorial 5
Session Overview

Part 1: Forces exist within one molecule and between different molecules
- Intramolecular vs intermolecular forces
- Intramolecular forces
- Intermolecular forces

Part 2: Investigating the properties of matter
- Atoms possess energy
- Energetic differences between the states of matter
- Properties of gases
- Boyle’s law

Part 3: Solutions
- Solutions
- Solubility of a solution
- Solution formation
- Osmosis
Part 1: Forces exist within one molecule and between different molecules

- Intramolecular vs intermolecular forces
- Intramolecular forces
- Intermolecular forces
**Intramolecular forces**
- Intramolecular means within one molecule
- Intramolecular forces are the strong chemical bonds that form within a single molecule
  - Examples of intramolecular forces: Covalent bonds, ionic bonds
- Intramolecular forces are responsible for holding a single molecule together
  - Example: The covalent bonds that hold together a single H_2O molecule are intramolecular forces

**Intermolecular forces**
- Intermolecular means between two different molecules
- Intermolecular forces are the attractive forces between two different molecules
  - Weaker than intramolecular forces
  - Not true chemical bonds
  - Examples of intermolecular forces:
    - Hydrogen bonds
    - Dipole-dipole interactions
    - Van der Waals interactions
- Intermolecular forces are the attractive forces that hold together molecules that are close to each other
  - Example: The many H_2O molecules within a drop of water on a leaf are more attracted to each other (via intermolecular forces) than to the leaf (causes beading)

[Image of a water molecule with covalent bonds]
Intramolecular forces

- Atoms “want” to connect to other atoms via chemical bonds (intramolecular forces) to become more stable
  - Stable atoms have full valence (outer) electron shells

- Electrons, around the outside of the nucleus, are the subatomic particles that allow an atom to form chemical bonds (intramolecular forces) with other atoms

Chemical bonds (intramolecular forces) allow atoms to form groups called molecules
- Molecules that contain more than one type of atom are compounds
A CHEMICAL BOND (INTRAMOLECULAR FORCE) IS A CONNECTION BETWEEN TWO ATOMS

The basis of the connection between atoms is either:

TWO ATOMS SHARING ELECTRONS

Is called COVALENT BONDING

ONE ATOM DONATING ELECTRON(S) TO ANOTHER ATOM

Through this process BOTH ATOMS BECOME IONS

Is called IONIC BONDING
Covalent bonding

**Definition**: Allows two atoms to connect via sharing a pair of electrons.

**Example**: \( \text{H}_2\text{O} \)

**Type of Force**: Intramolecular force

**Simplified representation**:

- **Oxygen**: Has 8 valence electrons.
- **Each hydrogen**: Has 2 valence electrons.
- Shared pairs of electrons count towards the electron total for both atoms.
- All atoms in the compound have full valence electron shells and are stable.
Ionic bonding

Ionic bond:
One metal atom gives away electron(s) (loses electrons) which are accepted by one non-metal atom (gains electrons)

- Both atoms involved in the ionic bond become ions
  - Metal is a positive ion (cation)
  - Non-metal is a negative ion (anion)
    - Both ions have full valence shells and are stable

Ionic compound: sodium chloride

\[ \text{Na}^+ \text{Cl}^- \]
Intermolecular forces

Intermolecular forces:
The attractive forces that exist between two different molecules

• Intermolecular forces are also known as electrostatic forces
  – Involve positive and negative attraction

• Intermolecular forces are not true chemical bonds like intramolecular forces (covalent and ionic bonds)
  – Intermolecular forces are much weaker than intramolecular forces

https://www.freeimages.com/photo/water-leaf-1396069
Intermolecular forces:
The attractive forces that exist between two different molecules

- Intermolecular forces are responsible for holding different molecules close together
  - There are many intermolecular forces in solids and liquids that contribute to keeping the atoms or molecules close together
  - There are few intermolecular forces in gases where the atoms or molecules are far apart

- 3 Types of Intermolecular Forces:
  - Hydrogen bonds (investigated further)
  - Dipole-dipole interactions
  - Van der Waals interactions
**Definition**

Type of intermolecular force

**HYDROGEN BOND**

- **Definition:** Attraction between a partially positive hydrogen (H$^{δ+}$) and a non-bonded pair of electrons within the valence shell of an electronegative atom (O, N, F, Cl).

**Requirement for a hydrogen bond:**

- Hydrogen becomes partially positive (H$^{δ+}$) when the hydrogen is in a polar covalent bond with an electronegative atom such as O, N, F, Cl.

**Common electronegative atoms with non-bonding electrons pairs include O, N, F, Cl.**
Polar covalent bond

Polar covalent bonds present in H₂O

- Shared electrons are more attracted to oxygen than hydrogen, as oxygen has a higher electronegativity than hydrogen.
- With the shared pair of negative electrons being more attracted to oxygen, oxygen has a partial negative charge ($\delta^-$).
- With the shared pair of negative electrons being less attracted to hydrogen, hydrogen has a partial positive charge ($\delta^+$).
Multiple H₂O molecules come together to form multiple hydrogen bonds.

- **Polar covalent bond** shared electrons are more attracted to O than H.
- **Partial negative charge** on O.
- **Partial positive charge** on H.
- **Non-bonding pair of electrons** on O.
- **Hydrogen bond** occurs between a partially positive hydrogen (H⁺) and the non-bonding electrons within an electronegative atom (O⁻).

Multiple H₂O molecules come together to form multiple hydrogen bonds.
Many hydrogen bonds form within a collection of individual water molecules

- These hydrogen bonds are the attractive forces that allow separate water molecules to stay close together

**Hydrogen bond**

Occurs between a partially positive hydrogen ($H^{\delta^+}$) and the non-bonding electrons within an electronegative atom.
A hydrogen bond occurs between two compounds when:

- One compound that contains a partially positive hydrogen ($H^{\delta+}$) is close to a second compound that contains an electronegative atom (O, N, F, Cl) with a non-bonded pair of electrons in its valence shell.

**Intermolecular forces**

- Hydrogen fluoride–hydrogen fluoride
- Ammonia–ammonia
- Hydrogen fluoride–water
- Ammonia–water
- Water–hydrogen fluoride
- Water–ammonia
Key concept: inter and intramolecular forces

What is the difference between an intermolecular and an intramolecular force? Which is stronger?

What are the intramolecular forces present within an \( \text{H}_2\text{O} \) molecule? How are these formed?

What are the intermolecular forces present between two \( \text{H}_2\text{O} \) molecules? How are these formed?
Attempt Socrative questions: 1 to 4

Google Socrative and go to the student login

Room name:

City name followed by 1 or 2 (e.g. PERTH1)

1 for 1st session of the week and 2 for 2nd session of the week
Part 1: Forces exist within one molecule and between different molecules

- **Intramolecular vs intermolecular forces**
  - Intramolecular forces are the true chemical bonds that form within a molecule
    - **Examples:** covalent bonds, ionic bonds
  - Intermolecular forces are the attractive forces that exist between two different molecules
    - **Example:** hydrogen bonds

- **Intramolecular forces**
  - Intramolecular means within one molecule
  - Intramolecular forces are stronger than intermolecular forces
Part 1: Forces exist within one molecule and between different molecules

- **Intermolecular forces**
  - Intermolecular means between two separate molecules
  - Intermolecular forces are weaker than intramolecular forces
  - A hydrogen bond is the intermolecular force that occurs between multiple H$_2$O molecules
    - A hydrogen bond occurs between a partially positive hydrogen (H$^{\delta+}$) and the non-bonding electrons within an electronegative atom (e.g. O, N, F or Cl)
  - Intermolecular forces are responsible for holding different molecules close together
    - Allows the H$_2$O molecules within a drop of water to be held close together
Part 2: Investigating the properties of matter

- Atoms possess energy
- Energetic differences between the states of matter
- Properties of gases
- Boyle’s law
Atoms possess energy

- **Energy** is the ability of matter to do work and/or cause other matter to change
  - Does not occupy space and has no mass

- **Law of conservation of energy**
  - Energy can neither be created nor destroyed
    - Energy can be released (exothermic) or consumed (endothermic) in a chemical reaction
    - One form of energy can be converted into another form of energy

**Kinetic energy** is the energy of motion

**Potential energy** is stored energy that matter possesses due to its capacity to attract or repel other matter
ALL ATOMS

KINETIC ENERGY

Energy of Motion

Potential Energy

Definition

Example

Possess

All atoms possess kinetic energy.

stored energy that matter contains due to its capacity to attract and repel other matter. The capacity of an atom to attract or repel a second atom means that the first atom possesses potential energy.

All atoms are constantly moving, so they possess kinetic energy.

Example

Definition

Possess
Atoms possess energy

Which type of energy is described in the scenarios below?

A molecule moves through space and eventually collides with another molecule by chance

**Kinetic energy**

A molecule that contains a partially positive hydrogen has the capacity to attract an electronegative atom, which has a non-bonded pair of electrons in its valence shell

**Potential energy**
Atoms possess energy

Potential energy is converted into kinetic energy as soon as attraction or repulsion actually occurs

For example:

A H₂O molecule that contains a partially positive hydrogen has the capacity to attract an electronegative atom, which has a non-bonded pair of electrons in its valence shell.

A NH₃ molecule that contains the electronegative nitrogen moves into the path of a H₂O molecule by chance.

NH₃ molecule has potential energy

Electrostatic attraction between the NH₃ molecule and the H₂O molecule causes them to move closer together, before a hydrogen bond is formed.

When the molecules move closer together due to electrostatic attraction, the molecules potential energy is converted into kinetic energy.
Atoms possess energy

Units commonly used to measure energy

- cal = a calorie (used in the metric system)
  - 1 cal = the amount of energy needed to raise the temperature of 1 gram of water by 1°C

- J = a joule (used in the SI System)
  - 1 kcal = 1,000 cal
  - 1 cal = 4.184 J

<table>
<thead>
<tr>
<th>Macronutrient</th>
<th>Energy Value [kcal/g]</th>
<th>Energy Value [kJ/g]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbohydrate</td>
<td>4</td>
<td>17</td>
</tr>
<tr>
<td>Protein</td>
<td>4</td>
<td>17</td>
</tr>
<tr>
<td>Fat</td>
<td>9</td>
<td>38</td>
</tr>
</tbody>
</table>
Energetic differences between states of matter

**Solids**
- Atoms/molecules are packed very close together
  - Close packing allows many intermolecular interactions to form between different atoms/molecules
- Very high potential energy
- Low kinetic energy

**Liquids**
- Atoms/molecules are packed close together but can still move about
  - Close packing allows many intermolecular interactions between different atoms/molecules
- High potential energy
- Moderate kinetic energy

**Gases**
- Atoms/molecules are very far apart and move quickly
  - With atoms/molecules far apart, intermolecular interactions are minimal
- Very low potential energy
- Very high kinetic energy

Adapted from Stoker 2014, Figure 7-3a p175
Energetic differences between states of matter

• The different states of matter are characterised by the amount of kinetic and potential energy that they possess

• High amounts of kinetic energy causes atoms/molecules to be far apart

• High amounts of potential energy means that the atoms/molecules are close enough to each other to form intermolecular interactions (such as hydrogen bonds)
  – The higher the potential energy of the matter, the more intermolecular forces the matter will possess
Energetic differences between states of matter

Changing the physical state of matter involves heating or cooling a substance

**Endothermic Change**
- A change of state where heat energy is absorbed to speed up atoms/molecules
  - Requires energy
  - **Examples**: melting, evaporation

**Exothermic Change**
- A change of state where heat energy is released to slow down atoms/molecules
  - Releases energy
  - **Examples**: condensation, freezing
## Properties of gases

<table>
<thead>
<tr>
<th>Property</th>
<th>Description</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pressure (P)</td>
<td>The force that gas exerts against the walls of its container</td>
<td>Atmosphere [atm]</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Millimeters of mercury [mmHg]</td>
</tr>
<tr>
<td>Volume (V)</td>
<td>The space that the gas occupies</td>
<td>Litre [L]</td>
</tr>
<tr>
<td>Temperature (T)</td>
<td>Determines the kinetic energy of the gas = the motion of gas particles</td>
<td>Degree Celsius [°C]</td>
</tr>
</tbody>
</table>

Adapted from Stoker 2014, Figure 7-3a p175
Properties of gases

- **Pressure** is the force that a gas exerts against the walls of its container.

  $$\text{Pressure} = \frac{\text{force}}{\text{area}}$$

- Units of measurement:
  - Atmosphere [atm]
  - Millimeter of mercury [mmHg]

- Pressure can be measured with a barometer.
Properties of gases

- Gases expand to occupy the volume of their container
Properties of gases

- Kinetic energy of the gas particles is dependent on the temperature
  - High temperature = high kinetic energy of the gas atoms/molecules
  - Low temperature = lower kinetic energy of the gas atoms/molecules

Movement of gas particles in a container

High Temperature

Lower temperature
Boyle’s law

- Boyle’s law explains the relationship between:
  - The pressure that a gas exerts on a container
  - The volume that the gas occupies within a container

- Boyle’s law:

  \[ P_1 V_1 = P_2 V_2 \]

  The volume of a gas is inversely proportional to the pressure exerted by the gas

  - As pressure is increased, volume decreases
  - As pressure is decreased, volume increases

Stoker 2014, Figure 7.8, p.180
Boyle’s law \( P_1 \times V_1 = P_2 \times V_2 \)

- A sample of Helium gas occupies a 12.4 litre container and the pressure exerted by the gas is 0.956 atm.
- What volume will the helium occupy once the gas is transferred to a new container where the pressure exerted by the gas is 1.20 atm?

\( P_1 = 0.956 \text{ atm} \) (initial pressure)
\( V_1 = 12.4 \text{ L} \) (initial volume)
\( P_2 = 1.20 \text{ atm} \) (final pressure)
\( V_2 = ? \text{ L} \) (final volume volume)

\[
P_1 \times V_1 = P_2 \times V_2
\]
\[
(0.956 \text{ atm}) \times (12.4 \text{ L}) = (1.20 \text{ atm}) \times V_2
\]
\[
V_2 = \frac{(0.956 \text{ atm}) \times (12.4 \text{ L})}{1.20 \text{ atm}}
\]
\[
V_2 = 9.88 \text{ Litres}
\]
Boyle’s law

Boyle’s law helps to explain how air is inhaled and exhaled from the lungs

Inhalation
- The lungs expand to occupy a larger volume of air
- As the volume of the lungs increases, the pressure in the lungs decreases
  - Air flows from the area of higher pressure (atmosphere) to the area of lower pressure (lungs)

Exhalation
- The lungs contract, meaning there is less space for the air
- As the volume of the lungs decreases, the pressure in the lungs increases
  - Air flows from the area of higher pressure (lungs) to the area of lower pressure (atmosphere)

Gases move from a high pressure environment to a lower pressure environment via diffusion
After inhaling air, the pressure of O\textsubscript{2} is higher in the lungs than in the blood: Allows O\textsubscript{2} to enter the blood.

The pressure of O\textsubscript{2} is higher in the blood than in the cells within the tissues: Allows O\textsubscript{2} to enter the cell to be used in metabolism (generates ATP).

CO\textsubscript{2} is produced as a byproduct of metabolism, which means that the pressure of CO\textsubscript{2} is higher in the cells than in the blood: Allows CO\textsubscript{2} to enter the blood.

Pressure of CO\textsubscript{2} in the lungs is higher than the pressure of CO\textsubscript{2} in the atmosphere: Allows CO\textsubscript{2} to be exhaled into the atmosphere.

Once the blood rich in CO\textsubscript{2} returns to the lungs, the pressure of CO\textsubscript{2} in the blood is higher than in the lungs: Allows CO\textsubscript{2} to enter the lungs.

Gases move from a high pressure environment to a lower pressure environment via diffusion.
Attempt Socrative questions: 5 to 8

Google Socrative and go to the student login

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Part 2: Investigating the properties of matter

- **Atoms possess energy**
  - Atoms and molecules are always moving, which means they possess kinetic energy
  - Atoms and molecules have the capacity to attract and repel other atoms/molecules, which means they possess potential energy

- **Energetic differences between the states of matter**
  - Gases are made up of atoms that possess very high kinetic energy and very low potential energy
    - The atoms within a gas are usually far apart, which means few intermolecular interactions are formed
  - Liquids are made up of atoms that possess moderate kinetic energy and high potential energy
    - The atoms within a liquid are close together, which means many intermolecular interactions are formed
  - Solids are made up of atoms that possess very low kinetic energy and very high potential energy
    - The atoms within a solid are packed very close together, which means a very large number of intermolecular interactions are formed
Part 2: Investigating the properties of matter

• **Properties of gases**
  – Pressure is the force that a gas exerts against the walls of its container
  – Gases expand to occupy the volume of their container
  – The kinetic energy of gas particles increases as temperature increases

• **Boyle’s law**
  – $P_1 \times V_1 = P_2 \times V_2$
  – As the pressure of a gas increases, the volume of the gas decreases
  – As the pressure of a gas decreases, the volume of the gas increases
  – Boyle’s law explains how air moves into and out of our lungs as we inhale and exhale
Part 3: Solutions

- Solutions
- Solubility of a solution
- Solution formation
- Osmosis
Solutions

Solution:
A homogeneous mixture that contains one or more solutes dissolved in a solvent

Solvent:
The component present in the greatest amount (highest concentration) in the solution
  – The solvent dissolves the other components of the solution (solute)

Solute:
The component(s) present in smaller amounts (lower concentrations) than the solvent within a solution
  – Solute are dissolved by the solvent within a solution
Solutions

Solvent: H₂O

Solute: NaCl (table salt)

Solution: NaCl dissolved in H₂O
Solutions

Solution:
A homogeneous mixture that contains one or more solutes dissolved in a solvent

Examples of solutions:

- NaCl (solid) solute dissolved in H₂O solvent (liquid)
- CO₂ (gas) solute dissolved in H₂O solvent (liquid)
  - As seen in carbonated beverages
- O₂ (gas) solute dissolved in N₂ solvent (gas)
  - As seen in the air
The concentration (amount) of a specific solute dissolved within a solution can be represented by:

- **Percent Concentration**
  - 10% volume/volume
  - 10% weight/volume
    - **Example:**
      1 gram of NaCl dissolved in 100 mL of H₂O is a 1% weight/volume NaCl solution

- **Molar Concentration (Molarity)**
  - Number of mole of the solute in 1 litre of solvent

- **Parts per million**
  - 1 part of solute per 1,000,000 parts solvent
  - Equal to mg/litre
Solubility of a solution

**Solubility**: The maximum amount of a solute that dissolves in a given amount of solvent

- **Example**: At 20°C, 36 grams of the solute NaCl dissolves in 100 mL of the H$_2$O solvent

**Factors that affect the solubility of a solution**:

- **Temperature**:
  - High temperatures aid dissolving solid solutes in a liquid solvent

- **Amount of solvent (concentration)**:
  - The greater the amount of solvent, the more solute can be dissolved

- **Polarity**:
  - Polar solvents dissolve polar solutes, non-polar solvents dissolve non-polar solutes
    - NaCl (polar) readily dissolves in the polar H$_2$O solvent
Saturated solution: A solution that contains the maximum amount of solute that can be dissolved by the solvent

- If any more solute is added, the solute will not dissolve in the saturated solution
  - The solute will remain as an undissolved solid

- The solubility of a solution can be increased by:
  - Increasing the amount of solvent
  - Increasing temperature

Stoker 2014, Figure 8-3 p207
Solubility of a solution

Saturated solution: Maximum amount of \text{NaCl} has dissolved in $\text{H}_2\text{O}$

Solvent: $\text{H}_2\text{O}$

Solute: \text{NaCl} (table salt)

Solution: NaCl dissolved in $\text{H}_2\text{O}$

Solute remains as an undissolved solid in the saturated solution
Solution formation

Polar covalent bonds present in H$_2$O make H$_2$O a polar compound

- Shared electrons are more attracted to oxygen than hydrogen, as oxygen has a higher electronegativity than hydrogen.
- With the shared pair of negative electrons being more attracted to oxygen, oxygen has a partial negative charge ($\delta^-$).
- With the shared pair of negative electrons being less attracted to hydrogen, hydrogen has a partial positive charge ($\delta^+$).

Partial charges are not as strong as the true positive and negative charges present in ions.
Solution formation

- \( \text{H}_2\text{O} = \text{a polar molecule} \)
  - The hydrogens within \( \text{H}_2\text{O} \) have a partial positive charge (\( \delta^+ \))
  - The oxygen within \( \text{H}_2\text{O} \) has a partial negative charge (\( \delta^- \))

- When an ionic compound, such as \( \text{NaCl} \), dissolves in \( \text{H}_2\text{O} \):
  - The ionic compound will dissociate into individual ions
    - \( \text{Na}^+ \) & \( \text{Cl}^- \)

- The charges within the \( \text{Na}^+ \) and \( \text{Cl}^- \) ions are stabilised by the partial charges within \( \text{H}_2\text{O} \)
  - Allows \( \text{NaCl} \) to dissolve in \( \text{H}_2\text{O} \)
Solution formation

The partial positive charge of the many hydrogen atoms (within H$_2$O) stabilise the negatively charged chloride ion.
The partial negative charge of the many of oxygen atoms (within H₂O) stabilise the positively charged sodium ion.
Solution formation

The partial positive charge of the many hydrogen atoms (within H₂O) stabilises the negatively charged chloride ion

- Multiple H₂O molecules are needed to stabilise the charge of a single chloride ion
- Once all the H₂O molecules in the solution are being used to stabilise ions, the solution becomes saturated
Solution formation

The partial negative charge of the many of oxygen atoms (within \( \text{H}_2\text{O} \)) stabilises the positively charged sodium ion

- Multiple \( \text{H}_2\text{O} \) molecules are needed to stabilise the charge of a single sodium ion
- Once all the \( \text{H}_2\text{O} \) molecules in the solution are being used to stabilise ions, the solution becomes saturated
Osmosis

Osmosis:
The movement of a solvent through a semi-permeable membrane from an area of higher solvent concentration to an area of lower solvent concentration

- The semi-permeable membrane contains small pores that allows only small solvent molecules (e.g. H$_2$O) to pass through

- The cell membrane is a semi-permeable membrane
Osmosis:
The movement of a solvent through a semi-permeable membrane from an area of higher solvent concentration to an area of lower solvent concentration

- **Diffusion allows substances to move from an area of high concentration to an area of low concentration, with or without a membrane present**
  - Diffusion of a gas involves the gas moving from an area of high pressure/concentration to low pressure/concentration
    - Involved in moving oxygen into different parts of the body
  - Diffusion of a solute dissolved in a solution, such as NaCl, allows the dissolved solute to move from an area of high concentration to an area of low concentration

- **Key difference between osmosis and diffusion:**
  - Osmosis must involve a solvent moving through a semi-permeable membrane
Osmosis

Osmosis:
The movement of a solvent through a semi-permeable membrane from an area of higher solvent concentration to an area of lower solvent concentration

- Solvent in human body = water
- Water can enter and exit the body’s cells via osmosis
  - The cell membrane is semi-permeable membrane
- Most water that enters/exits the body’s cells moves through specialised protein channels called aquaporin’s
  - Aquaporin’s are embedded within the cell membrane
    - Aquaporin’s allow water to bypass the cell membrane (lipid bilayer)
      » Not favourable for the polar water to contact the non-polar fatty acid tails (hydrophobic) within the lipid bilayer
Key concept: dissolving ionic compounds in H₂O

Why is H₂O able to dissolve the NaCl ionic compound?

How are the positive and negative ions within NaCl (Na⁺ and Cl⁻) balanced when NaCl dissolves in H₂O?

Is there a limit to the amount of NaCl that will dissolve in a particular volume of H₂O? Why?
Attempt Socrative questions: 9 and 10

Google Socrative and go to the student login

Room name:

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1 for 1st session of the week and 2 for 2nd session of the week
Part 3: Solutions

- **Solution**: A homogeneous mixture that contains one or more solutes dissolved in a solvent

- **Solvent**: The component present in the greatest amount (highest concentration) in the solution

- **Solute**: The component(s) present in smaller amounts (lower concentrations) than the solvent within a solution

- Solutes are dissolved by the solvent within a solution

- **Solubility of a solution**

  - **Solubility**: The maximum amount of a solute that dissolves in a given amount of solvent

  - **Saturated solution**: A solution that contains the maximum amount of solute that can be dissolved by the solvent

  - If any more solute is added to a saturated solution, the solute remains as an undissolved solid
Part 3: Solutions

• Solution formation
  – Polar solvents (such as H₂O) dissolve polar solutes (such as NaCl)
  – When NaCl dissolves in H₂O, the charges within the Na⁺ & Cl⁻ ions are stabilized by the partial charges within H₂O

• Osmosis
  – Osmosis: The movement of a solvent through a semi-permeable membrane from an area of higher solvent concentration to an area of lower solvent concentration
  – Some H₂O can move in and out of the body’s cells via osmosis
Readings & Resources

- Stoker, HS 2004, General, Organic and Biological Chemistry, 3rd edn, Houghton Mifflin, Boston, MA.
- Timberlake, KC 2014, General, organic, and biological chemistry: structures of life, 4th edn, Pearson, Boston, MA.
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