This lecture will help you understand:

- Most Materials are Mixtures
- The Chemist’s Classification of Matter
- Solutions
- Solubility
- Soaps and Detergents
- Softening Hard Water
- Purifying the Water We Drink
- Wastewater Treatment
Most Materials are Mixtures

• *Pure substance*
  
  A material consisting of only one type of element or compound.
Most Materials are Mixtures

- **Pure substance**
  A material consisting of only one type of element or compound.

- **Mixture**
  A collection of two or more pure substances.
Most Materials are Mixtures

• **Pure substance**
  A material consisting of only one type of element or compound.

• **Mixture**
  A collection of two or more pure substances. —can be separated by physical means
Most Materials are Mixtures

.Symbol for sugar molecule, which is sucrose, C\textsubscript{12}H\textsubscript{22}O\textsubscript{11}.

Sugar

Sugar in water
The Chemist’s Classification of Matter

MATTER

Pure
- Element
  - Gold, Au
  - Sulfur, S₈
  - Nitrogen, N₂
- Compound
  - Salt, NaCl
  - Carbon dioxide, CO₂
  - Ammonia, NH₃

Impure (mixture)
- Homogeneous mixture
  - Solution
    - Air (N₂, O₂)
    - Salt water (NaCl, H₂O)
    - White gold (Au, Pd)
  - Suspension
    - Milk (water, solid proteins)
    - Blood (water, solid proteins)
    - Fog (air, tiny water droplets)
- Heterogeneous mixture
  - Sand in water
  - Oil and water
  - Sand and salt
The Chemist’s Classification of Matter

- Pure materials consist of a single element or compound.
The Chemist’s Classification of Matter

• Pure materials consist of a single element or compound.

• Impure materials consist of two or more elements or compounds.
The Chemist’s Classification of Matter

• Pure materials consist of a single element or compound.
• Impure materials consist of two or more elements or compounds.
• Mixtures may be heterogeneous or homogeneous.
The Chemist’s Classification of Matter

• In heterogeneous mixtures, the different components can be seen as individual substances.
The Chemist’s Classification of Matter

• In heterogeneous mixtures, the different components can be seen as individual substances.

• In homogenous mixtures, the composition is the same throughout.
The Chemist’s Classification of Matter

(a) Heterogeneous mixtures
- Granite
- “Snow” in snow globe
- Pizza

(b) Homogeneous mixtures
- Air
- Clear seawater
- White gold
The Chemist’s Classification of Matter

• Homogeneous mixtures
The Chemist’s Classification of Matter

- Homogeneous mixtures
  - Solution: all components in the same phase.
The Chemist’s Classification of Matter

• Homogeneous mixtures
  – Solution: all components in the same phase.
  – Suspension: different components in different phases.
Is the air in your house a homogeneous or a heterogeneous mixture?

A. Homogeneous, because it is mixed very well.
B. Heterogeneous, because of the dust particles it contains.
C. Homogeneous, because it is all at the same temperature.
D. Heterogeneous, because it consists of different types of molecules.
Is the air in your house a homogeneous or a heterogeneous mixture?

A. Homogeneous, because it is mixed very well.
B. **Heterogeneous, because of the dust particles it contains.**
C. Homogeneous, because it is all at the same temperature.
D. Heterogeneous, because it consists of different types of molecules.
Solutions

• Solution: A homogenous mixture consisting of ions or molecules

• Solvent: The major component of a solution.
Solutions

- **Solution**: A homogenous mixture consisting of ions or molecules.
- **Solvent**: The major component of a solution.
- **Solute**: The minor components of a solution.
Solutions

• Solution: A homogenous mixture consisting of ions or molecules

• Solvent: The major component of a solution.

• Solute: The minor components of a solution.

• Saturated: Said of a solution in which no more solute will dissolve.
Solutions

• Concentration: A measure of the amount of solute dissolved in solution.
Solutions

- Concentration: A measure of the amount of solute dissolved in solution.

\[
\text{Concentration} = \frac{\text{Solute}}{\text{Solution}}
\]
Solutions

• Concentration: A measure of the amount of solute dissolved in solution.

\[
\text{Concentration} = \frac{\text{Solute}}{\text{Solution}}
\]

“concentrated”
Solutions

• Concentration: A measure of the amount of solute dissolved in solution.

\[
\text{Concentration} = \frac{\text{Solute}}{\text{Solution}}
\]
Solutions

• Concentration: A measure of the amount of solute dissolved in solution.

\[
\text{Concentration} = \frac{\text{Solute}}{\text{Solution}}
\]

“dilute”
Solutions

• Concentration: A measure of the amount of solute dissolved in solution.

• Mole: A super-large number, $6.02 \times 10^{23}$, used to measure numbers of atoms or molecules, a.k.a. Avogadro’s number.
Solutions

• Concentration: A measure of the amount of solute dissolved in solution.

• Mole: A super-large number, $6.02 \times 10^{23}$, used to measure numbers of atoms or molecules, a.k.a. Avogadro’s number.

The formula mass of a substance expressed in grams contains one mole.
Solutions

• Concentration: A measure of the amount of solute dissolved in solution.

• Mole: A super-large number, \(6.02 \times 10^{23}\), used to measure numbers of atoms or molecules, a.k.a. Avogadro’s number.

<table>
<thead>
<tr>
<th>Substance</th>
<th>Formula Mass</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon, C</td>
<td>12</td>
</tr>
<tr>
<td>Oxygen, (O_2)</td>
<td>32</td>
</tr>
<tr>
<td>Carbon dioxide, (CO_2)</td>
<td>44</td>
</tr>
<tr>
<td>Sucrose, (C_{12}H_{22}O_{11})</td>
<td>342</td>
</tr>
</tbody>
</table>

The formula mass of a substance expressed in grams contains one mole.
Sucrose, $C_{12}H_{22}O_{11}$ = 342 g/mole
Water, H₂O, has a formula mass of 18. How many moles of water are there in 18 grams of water?

A. 0.5 moles
B. 1 mole
C. 9 moles
D. 18 moles
Water, $\text{H}_2\text{O}$, has a formula mass of 18. How many moles of water are there in 18 grams of water?

A. 0.5 moles  
B. 1 mole  
C. 9 moles  
D. 18 moles
How many grams of water, H₂O, are there in 2 moles of water?

A. 1 gram
B. 9 grams
C. 18 grams
D. 36 grams
How many grams of water, \( \text{H}_2\text{O} \), are there in 2 moles of water?

A. 1 gram  
B. 9 grams  
C. 18 grams  
D. 36 grams
Solutions

• Molarity: A unit of concentration expressed in moles solute per liter of solution.
Solutions

- Molarity: A unit of concentration expressed in moles solute per liter of solution.

\[
\text{Molarity} = \frac{\text{Moles of Solute}}{\text{Liters of Solution}}
\]
Solutions

• Molarity: A unit of concentration expressed in moles solute per liter of solution.

• ppm: A unit of concentration expressed in milligrams solute in liters of solution.
Solutions

• Molarity: A unit of concentration expressed in moles solute per liter of solution.

• ppm: A unit of concentration expressed in milligrams solute in liters of solution.

\[
1 \text{ ppm} = \frac{1 \text{ part solute}}{1,000,000 \text{ parts solution}} = \frac{1 \text{ milligram solute}}{1 \text{ liter solution}}
\]
Solubility

• Solubility: The ability of a solute to dissolve in a solvent.
Solubility

- Solubility: The ability of a solute to dissolve in a solvent.
- Soluble: Said of a solute that has appreciable solubility.
Solubility

- Precipitate: Solute that comes out of solution.

165 g NaNO₃ in 100 mL water

87 g NaNO₃ in 100 mL water
The amount of oxygen, $O_2$, dissolved in the waters of the arctic ocean is greater, about equal to, or less than the amount of oxygen dissolved in warm tropical waters?

A. Greater than  
B. About equal  
C. Less than  
D. It depends
The amount of oxygen, $O_2$, dissolved in the waters of the Arctic Ocean is greater, about equal to, or less than the amount of oxygen dissolved in warm tropical waters?

A. Greater than  
B. About equal  
C. Less than  
D. It depends

*Explanation:*
The solubility of oxygen in water decreases with increasing temperature. As a consequence, cold polar oceans tend to be more fertile than warmer tropical waters.
By mass, water is 88.88 percent oxygen. So why can’t we breathe water?
By mass, water is 88.88 percent oxygen. So why can’t we breathe water?

Hint: What is the elemental formula for the oxygen we breathe and the chemical formula for water?
Soaps and Detergents

- Soaps and detergents have both polar and nonpolar properties.
Soaps and Detergents

• Soaps and detergents have both polar and nonpolar properties.
• Nonpolar part attracts to the “grime”.

Soaps and Detergents

- Soaps and detergents have both polar and nonpolar parts.
- Nonpolar part attracts to the “grime”.
- Polar part attracts to water.
Soaps and Detergents
Soap attracts “grime” by which type of molecular interaction?

A. Dipole–dipole.
B. Induced dipole–induced dipole.
C. Hydrogen bonding.
D. Dipole–induced dipole.
Soap attracts “grime” by which type of molecular interaction?

A. Dipole–dipole.

B. Induced dipole–induced dipole.

C. Hydrogen bonding.

D. Dipole–induced dipole.
Softening Hard Water

- Hard water has high concentrations of calcium and magnesium.
Softening Hard Water

- Hard water has high concentrations of calcium and magnesium.
- Undesirable effects
Softening Hard Water

• Hard water has high concentrations of calcium and magnesium.
• Undesirable effects
  – Clogged pipes
Softening Hard Water

- Hard water has high concentrations of calcium and magnesium.
- Undesirable effects
  - Clogged pipes
  - Lower cleaning action of soaps and detergents
Softening Hard Water

• Hard water has high concentrations of calcium and magnesium.

• Undesirable effects
  – Clogged pipes
  – Lower cleaning action of soaps and detergents
  – Soap scum
Softening Hard Water

• Detergent additives attract the $\text{Ca}^{2+}$ and $\text{Mg}^{2+}$ ions in hard water.
Softening Hard Water

- Detergent additives attract the Ca\(^{2+}\) and Mg\(^{2+}\) ions in hard water.
Softening Hard Water

• Some homes contain water softening units.
Softening Hard Water

- Some homes contain water softening units.
Purifying the Water We Drink

• The first step to purifying water is removing particles and bacteria.
Purifying the Water We Drink

- The first step to purifying water is removing particles and bacteria.

1. Slaked lime and aluminum sulfate added to water react to form gelatinous aluminum hydroxide.
2. Impurities captured by aluminum hydroxide as it settles.
3. Gelatinous aluminum hydroxide and impurities collect at bottom of basin.
Purifying the Water We Drink

• Water is then aerated to improve the taste and smell.
Purifying the Water We Drink

• Water is then aerated to improve the taste and smell.
• Lastly, the water is disinfected with chlorine gas (or ozone).
Which of the following is not a method of disinfecting drinking water?

A. Chlorine gas
B. Boiling
C. Aeration
D. Iodine tablets
Which of the following is not a method of disinfecting drinking water?

A. Chlorine gas
B. Boiling
C. Aeration
D. Iodine tablets
Purifying the Water We Drink

- Sea water can be converted to drinking water through desalination.
Purifying the Water We Drink

• Sea water can be converted to drinking water through desalination.
  – Distillation
  – Reverse osmosis
Purifying the Water We Drink
Purifying the Water We Drink

Submicroscopic pore

Semipermeable membrane

Net flow of water molecules

Fresh water

Solution

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Purifying the Water We Drink

(a) Osmosis
- Fresh water
- Salt water
Net flow of water molecules

(b) Equilibrium
- Osmotic pressure

(c) Reverse osmosis
- External pressure
Net flow of water molecules
Wastewater Treatment

• Screening removes large insoluble items.
Wastewater Treatment

• Screening removes large insoluble items.
• Primary treatment allows smaller insolubles to settle to the bottom or rise to the top for removal.
Wastewater Treatment

• Screening removes large insoluble items.
• Primary treatment allows smaller insolubles to settle to the bottom or rise to the top for removal.
• Secondary treatment aerates the water and allows finer particles to settle for removal.
Wastewater Treatment

• Screening removes large insoluble items.
• Primary treatment allows smaller insolubles to settle to the bottom or rise to the top for removal.
• Secondary treatment aerates the water and allows finer particles to settle for removal.
• Tertiary treatment filters the water.
Wastewater Treatment

- Insoluble-waste screen
- Grit chamber
- Skimmer
- Settling basin
- Chlorine
- Sludge
- To secondary treatment or outfall
- Raw sewage
- Grit
- To solid-waste disposal site
- To solid-waste disposal site

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