Chapter: Solutions, Acids, and Bases

Section 1: How Solutions Form

Section 2: Solubility and Concentration

Section 3: Acids, Bases, and Salts

Section 4: Strength of Acids and Bases
What is a solution?

- A **solution** is a mixture that has the same composition, color, density, and even taste throughout.
Solutes and Solvents

• The substance being dissolved, is the **solute**.

• The substance doing the dissolving, is the **solvent**.

• A solution in which water is the solvent is called an **aqueous** (A kwee us) **solution**.
Nonliquid Solutions

- Solutions also can be gaseous or even solid.
- The air you breathe is a solution.
- Solid solutions are known as alloys.
How Substances Dissolve

- Water molecules cluster around sugar molecules with their negative ends attracted to the positive ends of sugar.
How Substances Dissolve

- The water molecules pull the sugar molecules into solution.
How Substances Dissolve

- The water molecules and the sugar molecules mix evenly, forming a solution.
Dissolving Liquids and Gases

- When gases dissolve in gases or when liquids dissolve in liquids, this movement spreads solutes evenly throughout the solvent.

Dissolving Solids in Solids

- The solid metals are first melted and then mixed together.
Rate of Dissolving

- There are several things you can do to speed up the rate of dissolving—stirring, reducing crystal size, and increasing temperature.

Stirring

- Stirring a solution speeds up the dissolving process because it brings more fresh solvent into contact with more solute.
Crystal Size

- Grind large crystals into smaller ones.
- Breaking the solid into many smaller pieces greatly increases its surface area.
Increasing the temperature of a solvent speeds up the movement of its particles.

This increase causes more solvent particles to bump into the solute.

As a result, solute particles break loose and dissolve faster.
A _______ is a mixture that has the same composition, color, and density throughout.

A. solvent  
B. solute  
C. solution  
D. substance
The answer is C. A mixture that has the same composition, color, and density throughout is a solution.
Question 2

The substance being dissolved in a solution is the __________.

A. aqueous phase
B. media
C. solute
D. solvent
The answer is C. The substance doing the dissolving is the solvent; the substance being dissolved is the solute.
Question 3

Which of these factors does not affect solubility?

A. container size
B. crystal size
C. surface area
D. temperature
The answer is A. Speeding up movement of the particles by stirring and increasing the temperature, and decreasing the crystal size all increase the dissolving rate of a solute.
How much can dissolve?

- **Solubility** (sol yuh BIH luh tee) is the maximum amount of a solute that can be dissolved in a given amount of solvent at a given temperature.
Comparing Solubilities

- The amount of a solute that can dissolve in a solvent depends on the nature of these substances.
Concentration

• The concentration describes how much solute is present in a solution compared to the amount of solvent.

Precise Concentrations

• Concentrations of solutions can be described precisely, such as the percentage by volume of the solute.
Types of Solutions

Saturated Solutions

- A saturated solution is a solution that contains all the solute it can hold at a given temperature.
Saturated Solutions

- The table shows the amounts of a few solutes that can dissolve in 100 g of water at different temperatures to form saturated solutions.

<table>
<thead>
<tr>
<th>Compound</th>
<th>0°C</th>
<th>20°C</th>
<th>100°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copper(II) sulfate</td>
<td>23.1</td>
<td>32.0</td>
<td>114</td>
</tr>
<tr>
<td>Potassium bromide</td>
<td>53.6</td>
<td>65.3</td>
<td>104</td>
</tr>
<tr>
<td>Potassium chloride</td>
<td>28.0</td>
<td>34.0</td>
<td>56.3</td>
</tr>
<tr>
<td>Potassium nitrate</td>
<td>13.9</td>
<td>31.6</td>
<td>245</td>
</tr>
<tr>
<td>Sodium chlorate</td>
<td>79.6</td>
<td>95.9</td>
<td>204</td>
</tr>
<tr>
<td>Sodium chloride</td>
<td>35.7</td>
<td>36.0</td>
<td>39.2</td>
</tr>
<tr>
<td>Sucrose (sugar)</td>
<td>179.2</td>
<td>203.9</td>
<td>487.2</td>
</tr>
</tbody>
</table>
You can use a solubility curve to determine how much solute will dissolve at any temperature given on the graph.
An unsaturated solution is any solution that can dissolve more solute at a given temperature.
A supersaturated solution is one that contains more solute than a saturated solution at the same temperature.
Supersaturated solutions are unstable.
Question 1

What is solubility?

Answer

Solubility is the maximum amount of a solute that can be dissolved in a given amount of solvent at a given temperature.
A(n) ____________ solution is any solution that can dissolve more solute at a given temperature.

A. electrolyte  
B. saturated  
C. supersaturated  
D. unsaturated
The answer is D. A saturated solution contains all the solute it can hold at that temperature, but an unsaturated solution can hold additional solute.
Question 3

Which is true of a supersaturated solution?

A. conducts electricity in water
B. can dissolve more solute at a given temperature
C. cannot form crystals when additional solute is added
D. unstable
The answer is D. Supersaturated solutions are unstable; solute readily crystallizes from solution when seed crystals are added.
Acids

- An **acid** is a substance that produces hydrogen ions in a water solution.
- When an acid dissolves in water, $H^+$ ions interact with water molecules to form $H_3O^+$ ions.
- Acids taste sour.
- Acids are corrosive.
- An **indicator** is an organic compound that changes color in acids and bases.
Many foods contain acids.

<table>
<thead>
<tr>
<th>Name, Formula</th>
<th>Use</th>
<th>Other Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acetic acid, CH₃COOH</td>
<td>Food preservation and preparation</td>
<td>When in solution with water, it is known as vinegar.</td>
</tr>
<tr>
<td>Acetylsalicylic acid, HOOC-C₆H₄-OOCCH₃</td>
<td>Pain relief, fever relief, to reduce inflammation</td>
<td>Known as aspirin.</td>
</tr>
<tr>
<td>Ascorbic acid, H₂C₆H₄O₆</td>
<td>Antioxidant, vitamin</td>
<td>Called vitamin C.</td>
</tr>
<tr>
<td>Carbonic acid, H₂CO₃</td>
<td>Carbonated drinks</td>
<td>Involved in cave, stalactite, and stalagmite formation</td>
</tr>
<tr>
<td>Hydrochloric acid, HCl</td>
<td>Digestion as gastric juice in stomach, to clean steel in a process called pickling</td>
<td>Commonly called muriatic acid</td>
</tr>
<tr>
<td>Nitric acid, HNO₃</td>
<td>To make fertilizers</td>
<td>Used to produce nitrogen fertilizers</td>
</tr>
<tr>
<td>Phosphoric acid, H₃PO₄</td>
<td>To make detergents, fertilizers, and soft drinks</td>
<td>Slightly sour but pleasant taste, detergents containing phosphates cause water pollution</td>
</tr>
<tr>
<td>Sulfuric acid, H₂SO₄</td>
<td>Car batteries, to manufacture fertilizers and other chemicals</td>
<td>Dehydrating agent, causes burns by removing water from cells</td>
</tr>
</tbody>
</table>
Bases

• Bases can be defined in two ways.

• Any substance that forms hydroxide ions, \( \text{OH}^- \) in a water solution is a base.

• A base is any substance that accepts \( \text{H}^+ \) from acids.
Properties of Bases

- In solution, bases feel slippery and have a bitter taste.
- Bases react with indicators to produce changes in color.
Common Bases

- You probably are familiar with many common bases because they are found in cleaning products used in the home.

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<tr>
<th>Name, Formula</th>
<th>Use</th>
<th>Other Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminum hydroxide, Al(OH)_3</td>
<td>Color-fast fabrics, antacid, water purification as shown in Figure 13</td>
<td>Sticky gel that collects suspended clay and dirt particles on its surface</td>
</tr>
<tr>
<td>Calcium hydroxide, Ca(OH)_2</td>
<td>Leather-making, mortar and plaster, to lessen acidity of soil</td>
<td>Called caustic lime</td>
</tr>
<tr>
<td>Magnesium hydroxide, Mg(OH)_2</td>
<td>Laxative, antacid</td>
<td>Called milk of magnesia when in water</td>
</tr>
<tr>
<td>Sodium hydroxide, NaOH</td>
<td>To make soap, oven cleaner, drain cleaner, textiles, and paper</td>
<td>Called lye and caustic soda; generates heat (exothermic) when combined with water, reacts with metals to form hydrogen</td>
</tr>
<tr>
<td>Ammonia, NH_3</td>
<td>Cleaners, fertilizer, to make rayon and nylon</td>
<td>Irritating odor that is damaging to nasal passages and lungs</td>
</tr>
</tbody>
</table>
When an acid dissolves in water, the negative areas of nearby water molecules attract the positive hydrogen in the acid. The acid dissociates into ions and the hydrogen atom combines with a water molecule to form hydronium ions.
Dissociation of Bases

• The positive areas of nearby water molecules attract the $-\text{OH}$ of the base.
• The base dissociates into a positive ion and a negative ion.
• Unlike in acid dissociation, water molecules do not combine with the ions formed from the base.
Neutralization is a chemical reaction between an acid and a base that takes place in a water solution.
Acid-Base Reactions

acid + base → salt + water

- A salt is a compound formed when the negative ions from an acid combine with the positive ions from a base.

<table>
<thead>
<tr>
<th>Name, Formula</th>
<th>Common Name</th>
<th>Uses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sodium chloride, ( \text{NaCl} )</td>
<td>Salt</td>
<td>Food, manufacture of chemicals</td>
</tr>
<tr>
<td>Sodium hydrogen carbonate, ( \text{NaHCO}_3 )</td>
<td>Sodium bicarbonate, baking soda</td>
<td>Food, antacids</td>
</tr>
<tr>
<td>Calcium carbonate, ( \text{CaCO}_3 )</td>
<td>Calcite, chalk</td>
<td>Manufacture of paint and rubber tires</td>
</tr>
</tbody>
</table>
Question 1
What does an acid produce in solution?

Answer
An acid produces hydrogen ions in solution, which interact with water molecules to form hydronium ions.
Question 2

Which changes color in acids and bases?

A. ammonia
B. antacid
C. detergent
D. litmus
The answer is D. Litmus is an indicator that turns blue in bases and red in acids.
Question 3

Any substance that forms ____________ in a water solution is a base.

A. \( \text{H}_3\text{O}^+ \)
B. \( \text{OH}^- \)
C. \( \text{H}^{++} \)
D. \( \text{H}_2\text{O} \)
Answer

The answer is B. A base is any substance that forms hydroxide ions in water.
The strength of an acid or base depends on how many acid or base particles dissociate into ions.

When a strong acid dissolves in water, almost 100 percent of the acid molecules dissociate into ions.
When a weak acid dissolves in water, only a small fraction of the acid molecules dissociates into ions.
Strong and Weak Bases

• A **strong base** dissociates completely in solution.

• A **weak base** is one that does not dissociate completely.
Strength and Concentration

- The terms *strong* and *weak* refer to the ease with which an acid or base dissociates in solution.
- *Dilute* and *concentrated* are used to indicate the concentration of a solution, which is the amount of acid or base dissolved in the solution.
pH of a Solution

- The pH of a solution is a measure of the concentration of H\(^+\) ions in it.
- The pH measures how acidic or basic a solution is.
One way to determine pH is by using indicator paper.

The final color of the pH paper is matched with colors in a chart to find the pH.

An instrument called a pH meter is another tool to determine the pH of a solution.
Blood pH

• The pH of blood must remain between 7.0 and 7.8.

• Some enzymes cannot work outside this pH range.

• Buffers are solutions containing ions that react with additional acids or bases to minimize their effects on pH.
Question 1
What is the difference between a strong acid and a weak acid?

Answer
In strong acids, nearly all the acid molecules dissociate into ions. In weak acids, a small fraction of the molecules dissolve in water.
Question 2

What is the difference between the terms “strength” and “concentration?”

Answer

Strength refers to the ease with which an acid or base dissociates in solution. Concentration is the amount of an acid or base dissolved in the solution.
Question 3

The pH of a solution is a measure of the concentration of _________ in the solution.

A. $\text{H}^+$
B. $\text{H}_3\text{O}^+$
C. $\text{COOH}$
D. $\text{HCl}$
The answer is A, the greater the $H^+$ concentration, the lower the pH and the more acidic the solution.
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