Factors that Affect the Rate of Dissolving and Solubility

Dissolving

One very important property of a solution is the rate of __________, or how quickly a solute dissolves in a solvent. When dissolving occurs, there in ____________ ____________ involved. Therefore, the solute and solvent can be separated using ____________ properties such as ____________ or ____________.

The rate at which a solute dissolves depends on a number of factors:

i) Temperature

Increasing temperature increases the ____________ (energy of motion) of the molecules, which increases the frequencies of ____________ and the rate of dissolving.

ii) Agitation

Stirring/shaking brings ____________ into contact with ____________, increasing ____________ and the rate of dissolving.

iii) Particle Size

__________ into smaller pieces increases the ____________ that is in contact with ____________, thus increasing the rate of dissolving.

The Dissolving Process

Whether or not a solute dissolves and to what extent depends on the forces of attraction between:

- Ionic compounds -
- Covalent molecules -

2. The ____________ forces (between particles) holding the ______ together must be broken (__________).

3. Solute and solvent ____________ (__________) and the molecules of solute fill in the spaces between solvent molecules.

Note: Dissolving is more likely to occur if the energy required (steps 1 and 2) is less than the energy released (step 3).

Polar and Non-Polar Substances

In general, we can follow the rule of "________________" when trying to predict the solubility of different particles. ______ solutes and ______ solutes dissolve in ______ and ______ dissolve in ______.

Remember, you can use the difference in electronegativities (______) to predict if a compound is ionic, polar or non-polar.

There are a few possible forces that act between particles, which helps to explain the "like dissolves like" trend:

Dipole-Dipole Attractions - the attraction between the _______________________ on two different _______ molecules.

Ion-Dipole Attractions - the attractive forces between an ____ and a ______ molecule.

Ions posses a ____________, and are therefore attracted to the ____________ on the polar molecules.

When ions are present in an ________ solution, each ion is ____________. This means that water molecules surround the ion. Hydrated ions can conduct electricity and are referred to as ____________.
Solubility

Solubility describes the ________ of _________ that can be dissolved in a given _______ of ______________ under given conditions.

A solute is described as ________ in a particular solvent if its solubility is _______ than ____________________.

A solute is described as ________ in a particular solvent if its solubility is _______ than ____________________.

Substances with solubility between these limits are called ____________________.

Factors affecting solubility include:

i) Molecular Size
   ________ molecules tend to be more soluble than _________ ones.

ii) Temperature
   Affects the solubility of gases and solids in liquids.
   For gases in liquids: as temp __ solubility __
   For solids in liquids: as temp __ solubility __

A ____________________ (graph) describes how much solute can be dissolved in a given solvent at a certain temperature.

iii) Pressure
   Affects the solubility of gases in liquids.
   As pressure __ solubility __

Concentration of Solutions

Concentration is defined as the amount of _____ per quantity of ________.

The concentration of a solution can be calculated. The approach for each calculation varies, depending on the ________ of solution.

1. Calculation as Mass/Volume (m/v) Percent

Gives the mass of solute dissolved in a volume of solution, expressed as a percent.

Mass/Volume % =

Examples:

2.00 mL of distilled water is added to 4.00 g of a powdered drug. The final volume of the solution is 3.00 mL. Calculate the percent m/v and then express the drug concentration in g/100 mL.

What mass of a drug is required to make a 2.0 L solution if the recommended concentration is 1.7%?
2. Calculation as Mass/Mass (m/m) Percent

Gives the mass of solute divided by the mass of solution, expressed as a percent.

\[ \text{Mass/Mass } \% = \]

Example:

An aqueous solution of calcium chloride has a mass of 23.47 g. The solvent was evaporated and the residue has a mass of 4.58 g. Calculate the m/m % of calcium chloride in the solution. How many grams of calcium chloride would be present in a 100 g sample?

3. Concentration as Volume/Volume (v/v) Percent

Gives the volume of solute divided by the volume of solution, expressed as a percent.

\[ \text{Volume/Volume } \% = \]

Example:

Rubbing alcohol is sold as a 70% (v/v) solution. What volume of alcohol is used to make 500 mL of rubbing alcohol?

4. Parts per Million (ppm) and Parts per Billion (ppb)

Describes the concentration of very small quantities. Usually expressed in terms of mass/mass relationships.

\[ \text{ppm} = \]

\[ \text{ppb} = \]

Note: Your final answer does not refer to the number of particles per million or billion, but rather the mass of solute compared to the mass of solution.

Example:

A shipment of oranges is returned if it contains more than 25 ppb of mould. A company received 20 000 kg of oranges. What is the maximum mass of mould allowed before the shipment should be sent back?
Molar Concentration

Molarity (C) is the number of _______ of ________ dissolved per _______ of _________.

The equation we use to calculate molar concentration is:

Where,   \( C = \)
\( n = \)
\( V = \)

Examples:

What is the molar concentration of 1.20 g of NaNO\(_3\) in 80.0 mL of solution?

Preparing Solutions and Dilutions

A __________________ solution is a solution with ____________________.

There are 2 ways to prepare a solution:

i. 
ii. 

A useful tool in preparing solutions is a __________________ → a pear-shaped glass with a flat bottom and a long neck. Volumetric flasks provide very accurate tools for measuring volumes.

To prepare a solution you should perform the following steps:

1. Determine the ____________ required to make the desired ________ and ____________________ of solution.

2. Measure out and dissolve the ______ in approximately __________________ of ________________.

3. Raise the ____________________ to the desired total volume by adding more _______________.

How many grams of potassium hydroxide will be required to prepare 650 mL of 0.430 M solution?

Diluting is a process that makes a solution that is less concentrated. This can be done by:

i. 
ii.
Dilution Calculations:

Step 1: Find the number of ______ you need.
Step 2: Find the _______________________ you need.
Step 3: Top up with ________________

Example #1
How do you make a 1.50 L solution of NaCl with a concentration of 6.00 M from a stock solution with a concentration of 15.0 M?

Alternatively we can perform dilution calculations using the following equation:

Where,
\[ C_1 = \frac{V_1 \times C_2}{V_2} \]

Let's try this equation to solve the previous example!!!

Example #2
If 85.0 mL of 0.950 M sodium sulfate solution was used to prepare 200 mL of a dilute sodium sulfate solution, what is the new concentration made?
Reactions in an Aqueous Solution—Ionic Equations

When an ionic compound is placed in water, most will ______, which means they are ______ in water. Some ionic compounds will remain as a ______ and are ______.

If an ionic compound dissolves in water, it means that the compound is temporarily splitting apart into its ______. This process is referred to as an ionic compound ______. This is NOT a ______ and the ionic compound will readily ______ when removed from the water source.

Double displacement reactions occur in water, and are a direct result of ionic compounds dissociating into their ions. Recall that a double displacement reaction will only occur if ______, ______ or a ______ forms.

We can show the step-by-step process of a double displacement reaction by writing out an ionic equation. There are several different components to an ionic equation.

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Ionic Equation</td>
<td></td>
</tr>
<tr>
<td>Net Ionic Equation</td>
<td></td>
</tr>
<tr>
<td>Spectator Ion</td>
<td></td>
</tr>
</tbody>
</table>

Example #1

Word Equation: Silver nitrate reacts with sodium chloride
Balanced Equation
Total Ionic Equation
Net Ionic Equation
Spectator Ions

Example #2

Word Equation: Calcium bromide reacts with lithium chlorate
Balanced Equation
Total Ionic Equation
Net Ionic Equation
Spectator Ions

Precipitate reactions can be used to generate a precipitation profile for known ions, which can be used to identify ions in solution.

Calcium bromide reacts with lithium chlorate

<table>
<thead>
<tr>
<th>Ion</th>
<th>CO$_3^{2-}$</th>
<th>OH$^-$</th>
<th>SO$_4^{2-}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ca$^{2+}$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ba$^{2+}$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unknown</td>
<td>ppt</td>
<td>ppt</td>
<td>ppt</td>
</tr>
</tbody>
</table>

The unknown precipitation profile matches that of __________.

Flow charts can also be used to illustrate what ions may be added to a solution containing many ions to allow for individual separation of ions by precipitation.

When attempting to separate ions from a solution a piece of lab equipment called a ______ can be used. A centrifuge ______ at very high speeds to separate different particles from each other based on their ______.

The part of the solution that does not settle to the bottom of the centrifuge is called the ______.
Solution Stoichiometry

Recall that stoichiometry involves calculating the amounts of reactants and products in chemical reactions using a balanced chemical equation. Previously you learned how to calculate the amount of atoms, particles or mass of a compound using the stoichiometry strategies. You can apply these same skills when approaching calculations involving solutions, with the addition of a few additional steps.

Example #1

Calculate the concentration of calcium chloride in a solution made by mixing 150 mL of a 0.200 M calcium hydroxide solution with 100 mL of a 0.500 M hydrochloric acid solution.

Example #2

Suppose you want to remove the barium ions from 120 mL of 0.050 00 M aqueous barium nitrate solution. What is the minimum mass of sodium carbonate that you should add?
**Strong and Weak Acids and Bases**

**Strong acid**

*Example:*

When hydrogen chloride molecules enter an aqueous solution, ______ of the hydrogen chloride molecules dissociate. As a result, the solution contains the same percent of H+ ions (in the form of H_3O^+) and Cl ions: 100%

**Weak acid**

*Example:*

On average, only about _____ of the acetic acid molecules dissociate at any given moment.

Notice that the arrow used in the dissociation of a weak acid points in both directions. This indicates that the reaction is ___________. The products of the reaction will also react to produce the original reactants.

**Some useful terms:**

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monoprotic acid</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diprotic acid</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Triprotic acid</td>
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</tbody>
</table>

In both diprotic and triprotic acids, the dissociation of the first hydrogen ion will result in a stronger acid than the acid formed by the second and third dissociation.

**Strong base**

*Examples:*

**Weak base**

*Example:*

**Concentration of an Acid or Base**

Recall that when in solution, acids and bases dissociate into ions. When you determine the concentration of hydrogen ions in solution (amount of H+ ions/ total solution volume) you are determining the pH of that particular solution. pH stands for, "the power of hydrogen". The pH of a substance can be determined a number of different ways, such as with the use of pH paper, an electronic pH meter or mathematically using the following formulas:

Square brackets [ ] around a chemical formula represents, "the concentration of"

*Examples:*

What is the pH of a solution with a [H_3O^+] of 1.0 x 10^-5?

Gastric juice has a pH of 1.5, what is the [H_3O^+]?

The relative concentration of [H_3O^+] and [OH^-] ions are as follows:

Acidic
Neutral
Basic

A pH scale is a convenient way to relate the pH of a solution to its degree of acidity/alkalinity.

The pH scale ranges from 1 to 14 and each pH unit represents a factor of 10.

*Examples:*

A change in pH from 3 to 8 is a(n) __________ increase/decrease in [H_3O^+]

A change in pH from 11 to 2 is a(n) __________ increase/decrease in [H_3O^+]
Neutralization Reactions

Neutralization occurs when ___________ (Arrhenius base) and ___________ (acid) are mixed to make ___________ and a ___________. The general word equation is:

Example:

Aqueous solutions of hydrobromic acid and beryllium hydroxide undergo a neutralization reaction to produce water and beryllium bromide.

Complete the following equations:

___ H₂SO₄ (aq) + ___ LiOH (aq) →

___ Ca(OH)₂ (aq) + ___ H₃PO₄ (aq) →

Which acid and base would you react together to produce the following salts:

i) KNO₃

ii) Ca(CH₃COOH)₂

Acid-Base Titrations

A "titration" refers to a technique that involves the careful measuring of the ___________ of one solution required to completely react with a ___________ of another.

In an acid-base titration, measuring the volume of a _______ (of ___________) allows us to determine the ___________ of the _______. In this case an ___________ is used to indicate when the neutralization reaction is complete. ___________ is the most common indicator used. It will be ______ when added to the ______; neutralization occurs at the first signs of the solution ___________ and _______ a ___________.

Example #1

In an acid-base titration, 25.00 mL of HNO₃ is required to neutralize 33.00 mL of 0.25 M NaOH. Calculate the molarity of the acid?
Example #2

In an acid-base titration, 43.00 mL of 0.30 M KOH is required to neutralize 10.00 mL of H₂SO₄. Calculate the molarity of the acid?