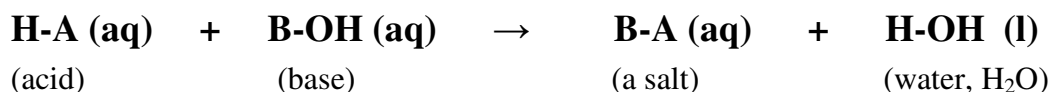


## Review #7: Solutions, Acids and Bases

### 1. Definitions:

- a) **Solution:** a homogeneous mixture. An impure substance that contains two or more different types of particles (atoms or molecules) that are uniformly mixed. Solutions have only one phase; that is, they have only one visible region of matter.
- b) **Solute:** the substance that is dissolved in the solvent, it is usually present in the smaller amount
- c) **Solvent:** the substance that dissolves the solute, it is usually present in the larger amount
- d) **Solubility:** the *maximum* amount of a certain solute that can be dissolved in a certain volume of a certain solvent at a certain temperature. The solubility of a substance is a physical property of that substance.
- e) **Mixture:** an impure substance that is made up of two or more different types of particles mixed together (but not bonded together). Mixtures can be either homogeneous (solutions) or heterogeneous (mechanical mixtures).
- f) **Homogeneous:** means that a substance is the same throughout; that there is only one visible phase of matter (the substance looks the completely uniform, regardless of what part you look at)
- g) **Heterogeneous:** means that a substance is not the same throughout; there are two or more visible phases of matter. You can see different regions in the substance, it is not uniform.
- h) **Alloy:** a solid in solid solution. Alloys are made by melting elements (usually metals) and mixing them while they are molten, then letting them harden. They are solutions because they are homogeneous.
- i) **% W / V:** a description of the concentration of a solution. Tells the **mass** of solute per **100 mL** of solution. For example, a 5% W/V solution of sugar would contain 5 g of sugar in 100 mL of solution.
- j) **% W / W:** a description of the concentration of a solution. Tells the **mass** of solute per **100 g** of solution. For example, one type of brass is 35% W/W zinc and 65% W/W copper. That is, this type of brass contains 35 g of zinc and 65 g of copper per 100 g of brass.
- k) **% V / V:** a description of the concentration of a solution. Tells the **volume** of solute per **100 mL** of solution. For example, vinegar is 5% V/V acetic acid in water.
- l) **Molar concentration:** the concentration of a solution given as the number of moles of solute in 1.00 L of solution. The units for molar concentration are mol/L, which can be abbreviated "M".
- m) **Precipitate:** a solid that forms when two solutions are mixed. A precipitate forms during a chemical reaction when a product of the chemical reaction is insoluble (does not dissolve) in water.
- n) **Unsaturated:** a solution that contains less than the maximum amount of solute that can dissolve in that volume at that temperature. If a seed crystal is added to an unsaturated solution, it will dissolve.
- o) **Saturated:** a solution that contains the maximum amount of solute that can dissolve in that volume at that temperature. If a seed crystal is added to a saturated solution, it will just sink to the bottom. It will not dissolve or cause other crystals to precipitate out.
- p) **Super-saturated:** a solution that contains more than the maximum amount of solute than can usually be dissolved in that volume at that temperature. If a seed crystal is added to a super-saturated solution, it will cause the surplus solute to precipitate out of the solution, leaving a saturated solution behind.
- q) **Acid:** a covalent compound which ionizes in water to produce H<sup>+</sup> ions.
- r) **Base:** a compound (usually an ionic compound) which dissociates in water to produce OH<sup>-</sup> ions.
- s) **Neutral solution:** a solution which contains neither H<sup>+</sup> nor OH<sup>-</sup> ions (for example, a solution of sodium chloride), or a solution that contains these ions in equal concentrations (for example, water). Its pH is 7.0.

- t) **Neutralization reaction:** a chemical reaction in which an acid is combined with a base. A double displacement reaction occurs and the products of the reaction are water and a salt. In general, a neutralization reaction looks like this:



- u) **Salt:** an ionic compound that is formed when a positive ion (either  $\text{NH}_4^{+1}$  or a metal ion) is bonded to a negative ion from an acid.
- v) **pH:** a measure of the strength of an acid or base. The pH scale goes from 0 to 14, where 0 is very acidic and 14 is very basic. The stronger the acid, the lower the pH. The stronger the base, the higher the pH.
- w) **Acid-base indicator:** A substance that changes colour depending on the pH of a solution. For example, bromothymol blue turns yellow in an acid, green in a neutral and blue in a basic solution. Phenolphthalein is colourless in an acidic or neutral solution, but pink in a base. Litmus is red in an acid and blue in a base.

2. Compare the chemical and physical properties of acids and bases:

Property	Acids	Bases
<b>How they are formed</b>	Acids form when a non-metal reacts with water	Bases form when a metal reacts with water
<b>Does the solution conduct electricity?</b>	The solution will conduct electricity (the better it conducts, the stronger the acid)	The solution will conduct electricity (the better it conducts, the stronger the base)
<b>Which ions are responsible for their properties?</b>	$\text{H}^+$	$\text{OH}^-$
<b>Taste</b>	Acids taste sour.	Bases taste bitter.
<b>Skin feel</b>	Acids feel the same as water on the skin.	Bases feel slippery (soapy) on the skin.
<b>Colour with phenolphthalein</b>	Phenolphthalein is colourless in an acid.	Phenolphthalein is pink in a base.
<b>Colour with red or blue litmus paper</b>	Both red and blue litmus turn red in an acid.	Both red and blue litmus turn blue in a base.
<b>Colour with Bromothymol blue</b>	Bromothymol blue turns yellow (orange) in an acid.	Bromothymol blue turns blue in a base.
<b>Reaction with metals</b>	When metals react with acids, they produce hydrogen gas and a salt.	Bases do not usually react with metals.
<b>Reaction with carbonates</b>	When carbonates react with acids, they produce carbon dioxide gas, liquid water and a salt.	Bases do not react with carbonates.
<b>pH</b>	pH is less than 7.0	pH is greater than 7.0

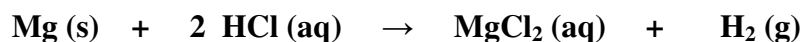
3. Complete the following by writing a word, phrase or number in the space provided:
- An example of a solid in liquid solution is: **salt dissolved in water, sugar dissolved in alcohol.**
  - An example of a gas in liquid solution is: **oxygen dissolved in water, a sealed soda pop** (CO<sub>2</sub> in water)
  - An example of a gas in gas solution is: **clean air** (the solvent is N<sub>2</sub>), the gas mixture in a scuba tank
  - An example of a liquid in liquid solution is: **acetic acid in water** (vinegar), **alcohol in gasoline**
  - An example of a solid in solid solution is: **brass** (zinc in copper), **stainless steel** (chromium in iron)
  - Two examples of alloys are: **brass, stainless steel, bronze, sterling silver, white gold** etc
  - An acid solution tastes **sour**.
  - An acid will cause bromothymol blue indicator to turn **yellow**.
  - All acids contain the element **hydrogen**.
  - The ion that gives bases their basic properties is the **OH<sup>1-</sup> (hydroxide)** ion.
  - Acids react with metals such as magnesium and calcium to produce **hydrogen gas**.
  - Acids react with compounds containing carbonate ions (CO<sub>3</sub><sup>2-</sup>) to produce **carbon dioxide** gas.
  - Bases taste **bitter** and feel **slippery**.
  - A base will cause the colour of phenolphthalein to turn from **colourless** to **pink**.
  - Acids react with bases to produce **water** and a **salt**. This is called a **neutralization reaction**.
  - What pH value indicates a neutral solution? **7.0**
  - Sea water has a pH of 8. Is sea water is acidic, basic, neutral? **basic**
  - Lemon juice is **very** acidic. The pH might be (2, 5, 7, 9, 13): **pH is about 2**
  - Are solutions of strong bases good or poor conductors of electricity? **good conductors in solution**

4. Name these acids and bases:

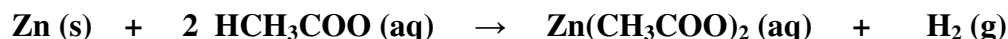
HCl	hydrochloric acid	HClO <sub>4</sub>	perchloric acid
KOH	potassium hydroxide	NaOH	sodium hydroxide
NH <sub>4</sub> OH	ammonium hydroxide	HIO <sub>2</sub>	iodous acid
HNO <sub>3</sub>	nitric acid	H <sub>2</sub> S	hydrosulfuric acid
HCH <sub>3</sub> COO	acetic acid	HBrO <sub>3</sub>	bromic acid
H <sub>2</sub> SO <sub>3</sub>	sulfurous acid	HI	hydroiodic acid
H <sub>3</sub> PO <sub>4</sub>	phosphoric acid	HNO <sub>2</sub>	nitrous acid

5. Write a balanced chemical equation showing the reaction between:

- a) **magnesium metal and hydrochloric acid**



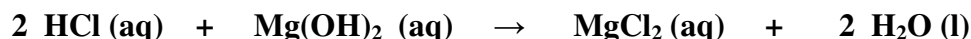
- b) **zinc metal and acetic acid**



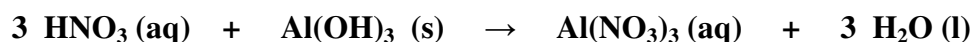
- c) **sulfuric acid and pure calcium carbonate**



- d) **hydrochloric acid and a solution of magnesium hydroxide**



e) nitric acid and pure aluminum hydroxide



f) hydrosulfuric acid and a solution of sodium carbonate



6. Why are hydrogen compounds such as HCl (g) and H<sub>2</sub>S (g) not really acids until they are dissolved in water?

Hydrogen compounds such as HCl (g) and H<sub>2</sub>S (g) are covalent compounds. Covalent compounds do not contain ions because their electrons are shared (not transferred). So these compounds in their pure state do not have H<sup>+</sup> ions. Because there are no H<sup>+</sup> ions, these substances are not acids. However, when these substances are dissolved in water, the water allows the substances to ionize and form H<sup>+</sup> ions. After these substances have dissolved in water and ionized to form H<sup>+</sup> ions, they are then considered to be acids.

7. Explain what is meant by ionization and dissociation.

**Ionization** refers to a reaction in which ions are formed. For example, when a covalent compound such as HCl (g) dissolves in water, the water allows electrons to be transferred from the H atom to the Cl atom and this forms H<sup>+</sup> and Cl<sup>1-</sup> ions. That is, the HCl **ionizes** or forms ions.

**Dissociation** just means “to separate”. When ionic substances dissolve in water, their ions dissociate (separate) and spread out through the solution. The ions are already present in the ionic compound, they just dissociate from each other when they are dissolved in water.

8.a) What is the difference between a strong acid and a weak acid. Give an example of each.

A **strong acid** is an acid that completely ionizes in water; that is, all of the acid molecules form ions so the concentration of H<sup>+</sup> ions in the solution is very high. Because there are so many ions present, strong acids are very good conductors of electricity and have very low pH (<4.5). The six common strong acids are: HCl (aq), HBr (aq), HI (aq), HClO<sub>3</sub> (aq), HNO<sub>3</sub> (aq), and H<sub>2</sub>SO<sub>4</sub> (aq).

A **weak acid** is an acid that does not ionize very much when it is dissolved in water, so most of the acid molecules stay intact as covalent molecules with their hydrogen atoms still attached. Because very few H<sup>+</sup> ions are formed, weak acids are poor conductors of electricity in solution and the pH of weak acids is closer to neutral (4.5 to 6.5). Some weak acids include H<sub>2</sub>CO<sub>3</sub> (aq), HCH<sub>3</sub>COO (aq), H<sub>2</sub>S (aq), HF (aq), H<sub>3</sub>PO<sub>4</sub> (aq) and organic acids such as citric acid, amino acids, nucleic acids (DNA) etc.

8b) How is a concentrated solution different than a dilute solution?

A **concentrated solution** is a solution in which there is a relatively large amount of solute in a relatively small amount of solvent.

A **dilute solution** is a solution in which there is a relatively small amount of solute in a relatively large amount of solvent.

8c) How is a "strong" acid different than a "concentrated" acid?

A **strong acid** is an acid that completely ionizes when it is dissolved in water. The strength of an acid tells us only about how much an acid ionizes.

A **concentrated acid** is when there are a lot of acid molecules in a relatively small amount of solvent.

So, we can have a concentrated, strong acid, for example a 12.0M solution of HCl. HCl is a strong acid because it completely ionizes in water and it is concentrated because there is a lot of acid and very little water in the solution.

And, we can have a dilute, strong acid, for example, 0.100 M HNO<sub>3</sub>. HNO<sub>3</sub> is a strong acid because it completely ionizes in water (so all of the acid in the solution will be present as H<sup>+</sup> ions and NO<sub>3</sub><sup>1-</sup> ions). However, the solution is also dilute, because there is not very much acid in the solution.

9. A chemist mixes 50.0 mL of 18.0 M H<sub>2</sub>SO<sub>4</sub> with water to make a final volume of 250 mL. What is the molar concentration of the final solution? (3.6 mol/L)
10. 80.0 g of lithium hydroxide is dissolved in enough water to make 500.0 mL of solution. What is the molar concentration of the solution? (6.68 mol/L)
11. What mass of sodium acetate is present in 600.0 mL of a 4.00 M solution? (197 g)
12. What is the difference between a strong base and a weak base? Give an example of each.

A **strong base** is a base that completely dissociates in water; that is, all of the base molecules dissolve and dissociate to form ions so the concentration of OH<sup>-</sup> ions in the solution is very high. Because there are so many ions present, strong bases are very good conductors of electricity and have very high pH (>9.5). Some strong bases include: NaOH (aq), KOH (aq), LiOH (aq) and Ca(OH)<sub>2</sub> (aq).

A **weak base** is a base that does not dissociate very much in water, usually this is because the base is not very soluble (many hydroxides are not soluble- remember our solubility rules?). Ammonia is also a weak base because it does not ionize very much in water. Because there are very few OH<sup>-</sup> ions in the solution, weak bases are poor conductors of electricity in solution and the pH of weak bases is closer to neutral (7.5 to 9.5). Some weak bases include NH<sub>4</sub>OH (aq), Cd(OH)<sub>2</sub> (aq), Al(OH)<sub>3</sub> (aq), Zn(OH)<sub>2</sub> and any other insoluble bases.

13. Classify each of the following as acidic, basic or neutral:  
a) pH 0 to 6.5: **acidic** b) pH 7: **neutral** c) pH 7.5 to 14: **basic**
14. Which of the following are strong acids? (Circle the strong acids)  
**HCl**, **H<sub>2</sub>SO<sub>4</sub>**, HC<sub>2</sub>H<sub>3</sub>O<sub>2</sub>, **HBr**, H<sub>2</sub>CO<sub>3</sub>, H<sub>3</sub>PO<sub>4</sub>, NaOH, NH<sub>3</sub>
15. Write balanced chemical equations for the reactions between the following solutions. Indicate any precipitates that will form.
  - a) potassium sulfate and copper (II) nitrate  
$$\mathbf{K_2SO_4 (aq) + Cu(NO_3)_2 (aq) \rightarrow CuSO_4 (aq) + 2 KNO_3 (aq)}$$
  - b) lithium sulfide and barium acetate  
$$\mathbf{Li_2S (aq) + Ba(CH_3COO)_2 (aq) \rightarrow 2 LiCH_3COO (aq) + BaS (s)}$$
  - c) ammonium bromide and lead (II) chlorate  
$$\mathbf{2 NH_4Br (aq) + Pb(ClO_3)_2 (aq) \rightarrow 2 NH_4ClO_3 (aq) + PbBr_2 (s)}$$
  - d) sodium chloride and magnesium nitrate  
$$\mathbf{2 NaCl (aq) + Mg(NO_3)_2 (aq) \rightarrow 2 NaNO_3 (aq) + MgCl_2 (aq)}$$