Acids and Bases **Name**_____

Introduction to Acids and Bases

Read from **Lesson 1: What are Acids and Bases?** in the **Chemistry Tutorial Section, Chapter 15** of **The Physics Classroom**:

Part a: Properties of Acids and Bases Part b: Models of Acids and Bases

Summary of Properties and Models of Acids and Bases

Acids and **bases** are core chemical compounds that display characteristic behaviors and are central to many chemical reactions and biological processes.

Properties

Acids	Bases
Sour taste	Bitter taste
Very corrosive	Very corrosive
React with metals → H_2 gas	Slippery feel
React with carbonates → CO_2	Neutralize acids
pH < 7	pH > 7
Turn blue litmus paper red	Turn red litmus paper blue
Examples: HCl, H_2SO_4, HNO_3, $HC_2H_3O_2$	Examples: NaOH, KOH, NH_3, $Mg(OH)_2$

Chemical Reactions

- **Acid + Metal → H_2 + Salt** Example: $Zn + HCl \rightarrow H_2 + ZnCl_2$
- **Acid + Carbonate → CO_2 + H_2O + Salt** Example: $CaCO_3 + H_2SO_4 \rightarrow CO_2 + H_2O + CaSO_4$
- **Acid + Base → Salt + Water (Neutralization)** Example: $HBr + NaOH \rightarrow NaBr + H_2O$

Indicators

- **Litmus Paper:** Red in acid, blue in base.
- **Phenolphthalein:** Colorless in acid, pink/magenta in base.

Arrhenius Model of Acids and Bases

- **Acids**: Produce H^+ ions in water (e.g., HCl, HNO_3). Example: $HCl\ (aq) \rightarrow H^+(aq) + Cl^-\ (aq)$
- **Bases**: Produce OH^- ions in water (e.g., NaOH, $Ca(OH)_2$). Example: $NaOH\ (aq) \rightarrow Na^+\ (aq) + OH^-\ (aq)$
- Defines acids as **HA** and bases as **MOH**.

Brønsted-Lowry Model of Acids and Bases

- **Acids**: Proton (H^+) donors.
- **Bases**: Proton (H^+) acceptors.
- Focuses on **proton transfer** reactions: Example: $HF\ (aq) + H_2O\ (l) \rightarrow F^-(aq) + H_2O^+\ (aq)$

Conjugate Acid-Base Pairs

- Each reaction involves two pairs: Acid → Conjugate Base Base → Conjugate Acid
- Example: $HA + B \rightarrow A^- + HB^+$

Amphiprotic Substances

- Acts as either acid or base. Examples: H_2O, HCO_3^-, HSO_4^-

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Questions

1. Classify the following as an acid, base, or salt. Then, either name the compound or write the formula from the name.

Example: H_2CO_3	**acid**, base, or salt	carbonic acid
a. calcium hydroxide	acid, base, or salt	
b. $HC_2H_3O_2$	acid, base, or salt	
c. aluminum sulfate	acid, base, or salt	
d. hydrobromic acid	acid, base, or salt	
e. $Fe(OH)_3$	acid, base, or salt	
f. sulfuric acid	acid, base, or salt	
g. lithium hydroxide	acid, base, or salt	
h. nitrous acid	acid, base, or salt	
i. H_3PO_4	acid, base, or salt	
j. cobalt (II) chloride	acid, base, or salt	

2. **Read each statement carefully.** In the space before each statement, write the appropriate letter to classify the solution:
   - Write **N** if the statement describes a **neutral** solution.
   - Write **A** if it describes an **acidic** solution.
   - Write **B** if it describes a **basic** solution.
   - Write **AB** if it describes **both** an acid and a base.

_____ a. The pH of the solution is 7.0.
_____ b. The solution could feel slippery or taste bitter.
_____ c. The solution contains a compound that is a proton donor.
_____ d. The solution will turn a magenta color when phenolphthalein is added to it.
_____ e. The solution could taste sour and be found in citrus fruit.
_____ f. This solution reacts with an acid.
_____ g. The pH of the solution is less than 7.0.
_____ h. The solution is a reactant in a neutralization reaction.
_____ i. The solution contains a compound that is a proton acceptor.
_____ j. This aqueous solution contains a compound that produces H^+.
_____ k. This solution reacts with metals to form hydrogen gas.
_____ l. The solution is very corrosive.
_____ m. The pH of the solution is greater than 7.0.
_____ n. This aqueous solution contains a compound that produces OH^-.

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3. Molly Cule and Aaron Agin are working in the chemistry lab and need to adjust the pH of a solution by adding a base. Molly reaches for an aqueous solution of ammonia, but Aaron stops her. He claims that ammonia is not a base because it doesn't have "hydroxide" in its name.

   a. Is Aaron correct? If not, how could Molly explain why ammonia is considered a base?

   b. Write a balanced equation for the reaction of ammonia with water. Identify the Brønsted-Lowry acid, the Brønsted-Lowry base, the conjugate acid, and the conjugate base. Explain how proton transfer supports these identifications.

4. For the following Brønsted-Lowry acid-base equations, identify the acid, the base, the conjugate acid, and the conjugate base.

   a. $H_3PO_4\,(aq) + H_2O\,(l) \rightleftarrows H_2PO_4^-\,(aq) + H_3O^+\,(aq)$
   Acid:
   Base:
   Conjugate acid:
   Conjugate base:

   b. $PO_4^{3-}\,(aq) + HSO_4^-\,(aq) \rightleftarrows HPO_4^{2-}\,(aq) + SO_4^{2-}\,(aq)$
   Acid:
   Base:
   Conjugate acid:
   Conjugate base:

   c. $HSO_4^-\,(aq) + H_2O\,(l) \rightleftarrows SO_4^{2-}\,(aq) + H_3O^+\,(aq)$
   Acid:
   Base:
   Conjugate acid:
   Conjugate base:

   d. $H_2O\,(l) + H_2O\,(l) \rightleftarrows OH^-\,(aq) + H_3O^+\,(aq)$
   Acid:
   Base:
   Conjugate acid:
   Conjugate base:

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5. Oxalic acid, $H_2C_2O_4$, is a weak acid that is naturally found in many plants, such as spinach and rhubarb.

   a. What is the conjugate base of oxalic acid?

   b. Write the dissociation reaction for oxalic acid.

   c. Write the Brønsted-Lowry acid-base equation for the conjugate base of oxalic acid reacting with water.

6. Hydrogen sulfite (HSO_3^-) is used as a food additive to prevent spoilage and oxidation in food and drinks.

   a. What is the conjugate acid of hydrogen sulfite?

   b. Write the dissociation reaction for the conjugate acid of hydrogen sulfite.

   c. What is the conjugate base of hydrogen sulfite?

   d. Write the Brønsted-Lowry acid-base equation for the conjugate base of hydrogen sulfite reacting with water.

7. Chromic acid (H_2CrO_4) is a powerful oxidizing agent commonly used to convert alcohols into ketones or carboxylic acids.

   a. What is the conjugate base of chromic acid?

   b. Write the dissociation reaction for chromic acid.

   c. Write the Brønsted-Lowry acid-base equation for the conjugate base of chromic acid reacting with hydrofluoric acid.