

# *EXPERIMENT 9*

## *ACIDS, BASES AND SALTS* *(الأحماض والقواعد والأملاح)*

**BY**

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## Purposes:



- 1) To become familiar with the chemical properties of acids, bases, and salts
- 2) To estimate the pH of household preparations and laboratory common acids, bases, and salts
- 3) To write equations that account for observations from chemical reactions

## Some Definitions

### ❖ Arrhenius acids and bases

➤ **Acid:** Substance that, when dissolved in water, increases the concentration of hydrogen/hydronium ions (protons,  $\text{H}^+$  or  $\text{H}_3\text{O}^+$ ).



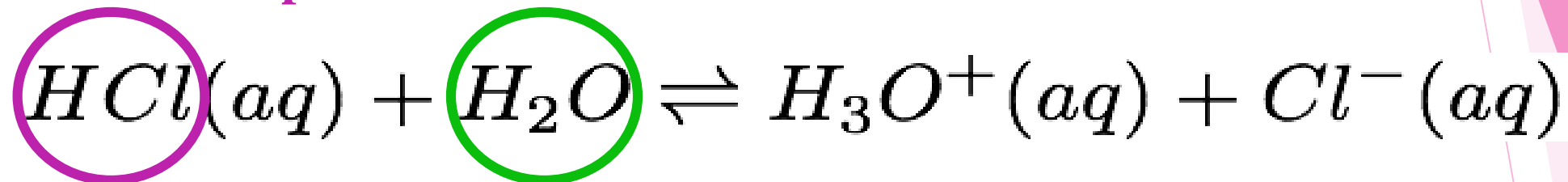
➤ **Base:** Substance that, when dissolved in water, increases the concentration of hydroxide ions,  $\text{OH}^-$ .



- **Brønsted–Lowry**: must have *both*

Brønsted-Lowry acids and bases are always paired.

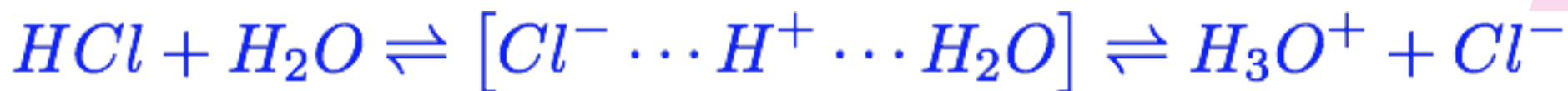
1. An Acid: proton donor



and

2. a Base: proton acceptor (...must have a pair of nonbonding electrons)

Which is the acid and which is the base in each of these rxns?



## Properties of Acidic solutions

An Acid is a substance that produces hydrogen ions ( $H^+$  or Hydronium ion,  $H_3O^+$ ) in  $H_2O$ ;  
 $pH < 7$

- 1) Taste sour or tart (طعم حامض أو لاذع)
- 2) Cause a pricking sensation (الإحساس بالوخز) on the skin
- 3) Turn blue litmus (vegetable dye) red
- 4) React with several metals (e.g., Zn and Mg) releasing  $H_{2(g)}$   $\Rightarrow$  acids corrode metals.
- 5) Corrosive: burn your skin (مادة أكالة: تحرق بشرتك)
- 6) react with base to form salt and water ( $HCl + NaOH \rightarrow NaCl + H_2O$ )
- 7) Act as electrolytes in solution  $\Rightarrow$  conduct electricity
- 8) React with carbonates releasing  $CO_{2(g)}$

□ Most of the foods and drinks are acidic,

Example: think of lemon juice as being quite acidic to taste but milk not quite so (slightly acidic)

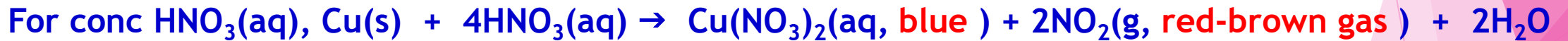
## Types of acids

1) **Nonoxidizing acids such as HCl<sup>26</sup>, acetic acid<sup>35</sup> and H<sub>3</sub>PO<sub>4</sub><sup>7</sup>**



2) **Oxidizing acids: these are concentrated and strong acids**

➤ **dilute HNO<sub>3</sub><sup>13</sup> and H<sub>2</sub>SO<sub>4</sub><sup>1</sup> (oil of vitriol, ranked no 1 in usage), generate hydronium ions in water.**



➤ **Concentrated HNO<sub>3</sub><sup>13</sup> and H<sub>2</sub>SO<sub>4</sub><sup>1</sup> are of excellent oxidizing properties**

# Acidic aqueous solutions result from the reaction of a

## 1-Nonmetallic hydride with water



## 2-Nonmetallic oxide with water



## 3- molecular species with water such as citric acid, ascorbic acid (vitamin C) and acetic acid found in vinegar,



## Acids you must know:

### Common Strong Acids:

100% dissociation in water, good proton donors

Sulfuric acid,  $\text{H}_2\text{SO}_4$

Hydrochloric acid,  $\text{HCl}$

Nitric acid,  $\text{HNO}_3$

Perchloric acid,  $\text{HClO}_4$

### Common Weak Acids:

< 5% dissociation in water, poor proton donors

Phosphoric acid,  $\text{H}_3\text{PO}_4$

Acetic acid,  $\text{HC}_2\text{H}_3\text{O}_2$

Citric acid,  $\text{C}_6\text{H}_8\text{O}_7$



## Uses of acids

- $\text{H}_3\text{PO}_4$  - soft drinks, fertilizer, detergents
- $\text{H}_2\text{SO}_4$  - fertilizer, car batteries
- $\text{HCl}$  - gastric juice, Stomach acid
- $\text{HC}_2\text{H}_3\text{O}_2$  - vinegar



# Properties of Bases

Produce or cause an increase in hydroxide ions ( $\text{OH}^-$ ) in  $\text{H}_2\text{O}$ ,  $\text{pH} > 7$

- ❖ Taste bitter (طعم مر)
  - ❖ Have a slippery touch (ملمس انزلاقي), 'soapy' feel
  - ❖ Turn red litmus blue
  - ❖ Destroy body tissue/ dissolve fatty (lipid) material
  - ❖ Strong bases are caustic (كاوية)
  - ❖ Act as electrolytes in solution
  - ❖ Neutralise solutions containing hydrogen ions ( $\text{H}^+$ )
- Most of hand soaps, detergents and drain cleaners are bases

# Properties of Acids and Bases

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## ○ **Acids**

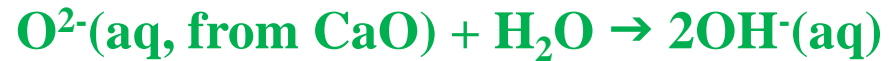
- turn blue litmus red
- taste sour
- Acids corrode metals
- positively charged hydrogen ions ( $H^+$ )

## ○ **Bases**

- turn red litmus blue
- taste bitter
- Negatively charged hydroxide ions ( $OH^-$ )
- Feel slippery
- Most hand soaps and drain cleaners are bases
- Strong bases are caustic

## Basic aqueous solutions can result from

**1- action of water on a soluble oxides (e.g., CaO ) or hydroxides (e.g., NaOH)**



**2-Anion that reacts with water**



**3- molecular species that reacts with water**



## Uses of bases

- $\text{NaOH}$  <sup>8</sup> – lye (غسول), drain and oven cleaner, preparation of soaps and detergents
- $\text{Mg}(\text{OH})_2$  - laxative, antacid,  
clinical applications of Antacids: to neutralize excess stomach acid



- $\text{NH}_3$  <sup>5</sup> - cleaners, fertilizer



# pH Scale

- **pH**

- a measure of the concentration of  $\text{H}_3\text{O}^+$  ions in solution
- measured with a pH meter or an indicator with a wide color range
- $\text{pH} = -\log [\text{H}^+] = -\log [\text{H}_3\text{O}^+]$



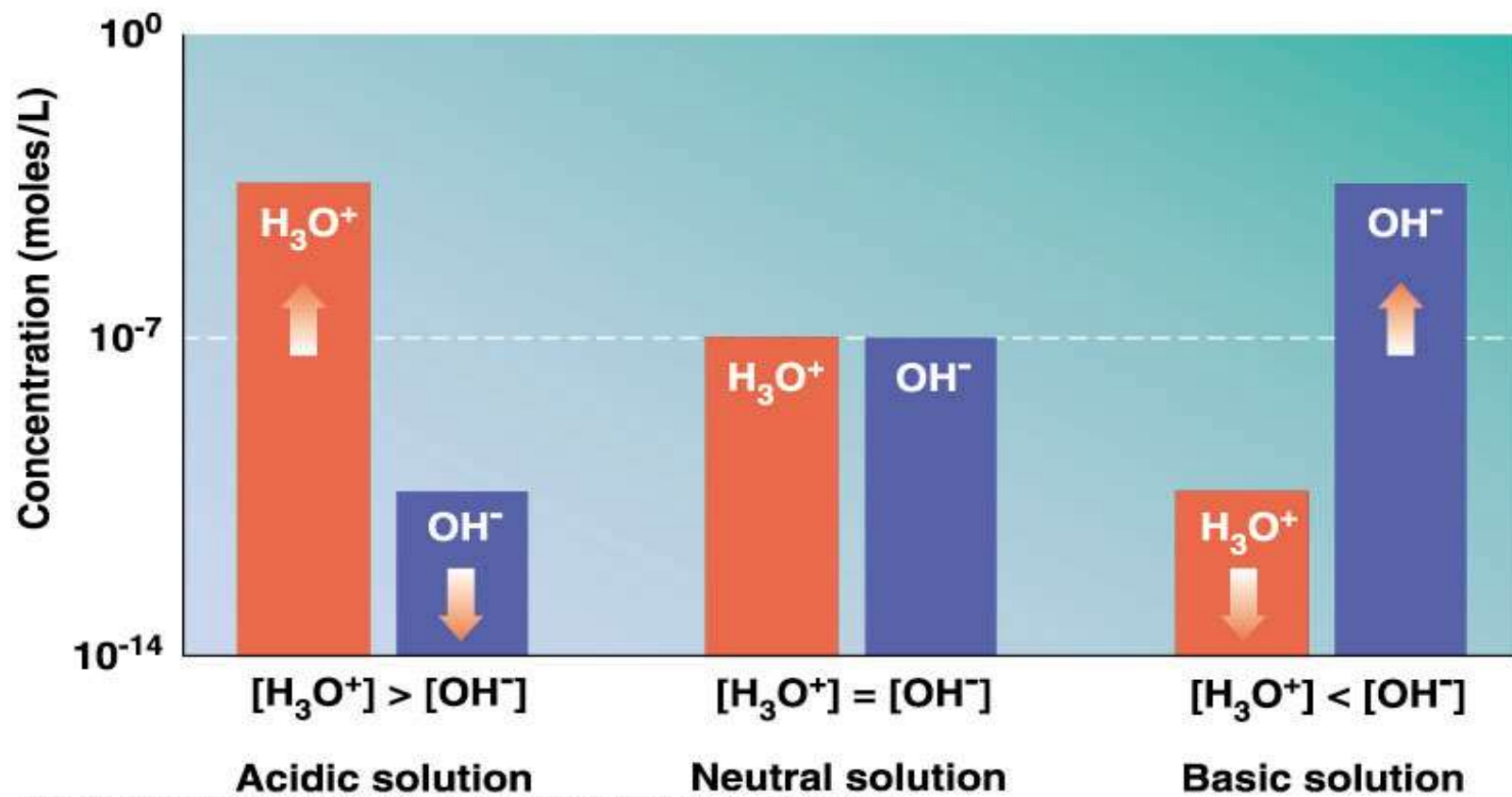
INCREASING  
ACIDITY

NEUTRAL

INCREASING  
BASICITY

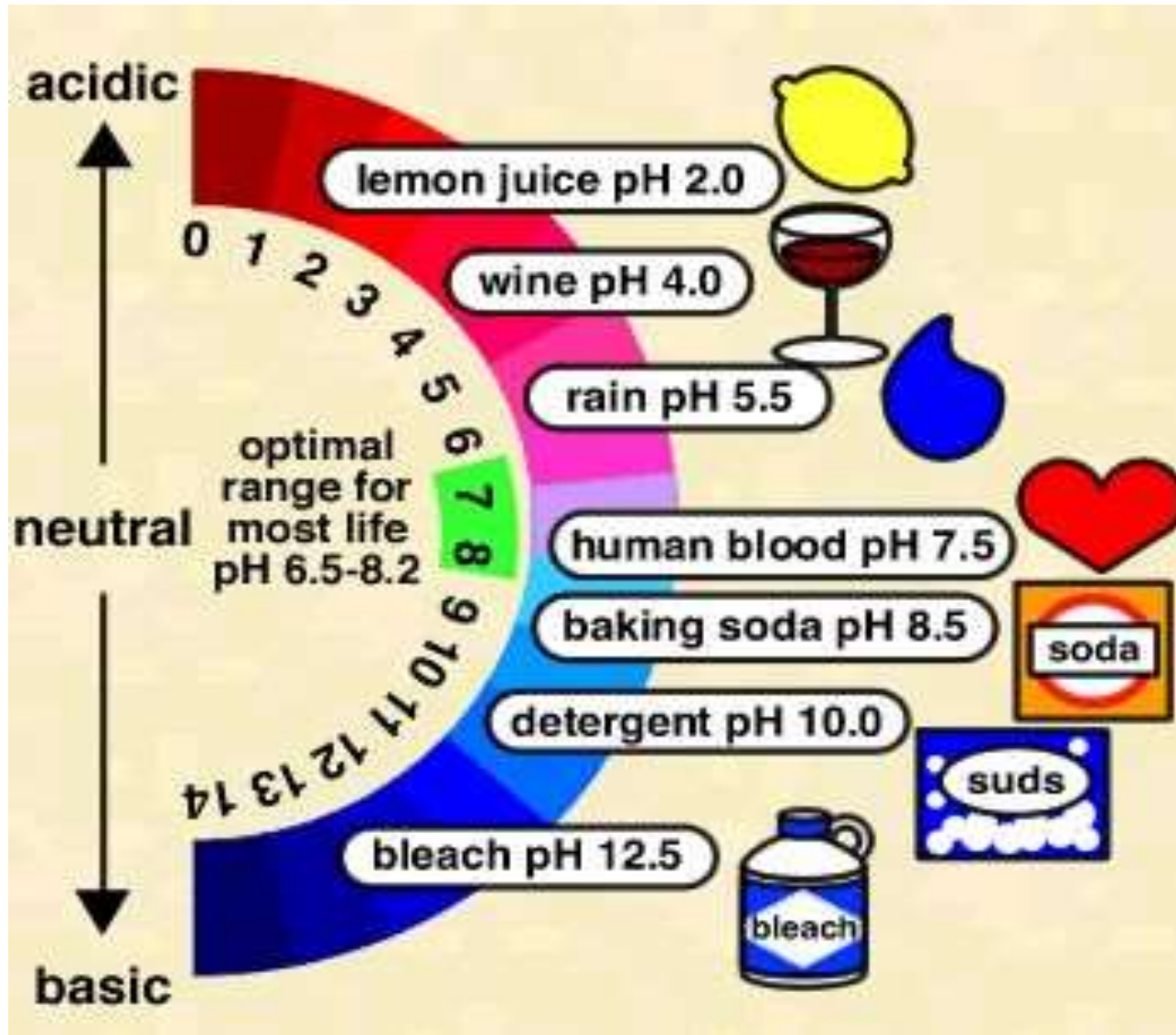
Lower pH value  
indicates a  
stronger acid.

Higher pH value  
indicates a  
stronger base.



Timberlake, *Chemistry: An Introduction to General, Organic, and Biological Chemistry, Eighth Edition*.  
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# pH of Common Substances

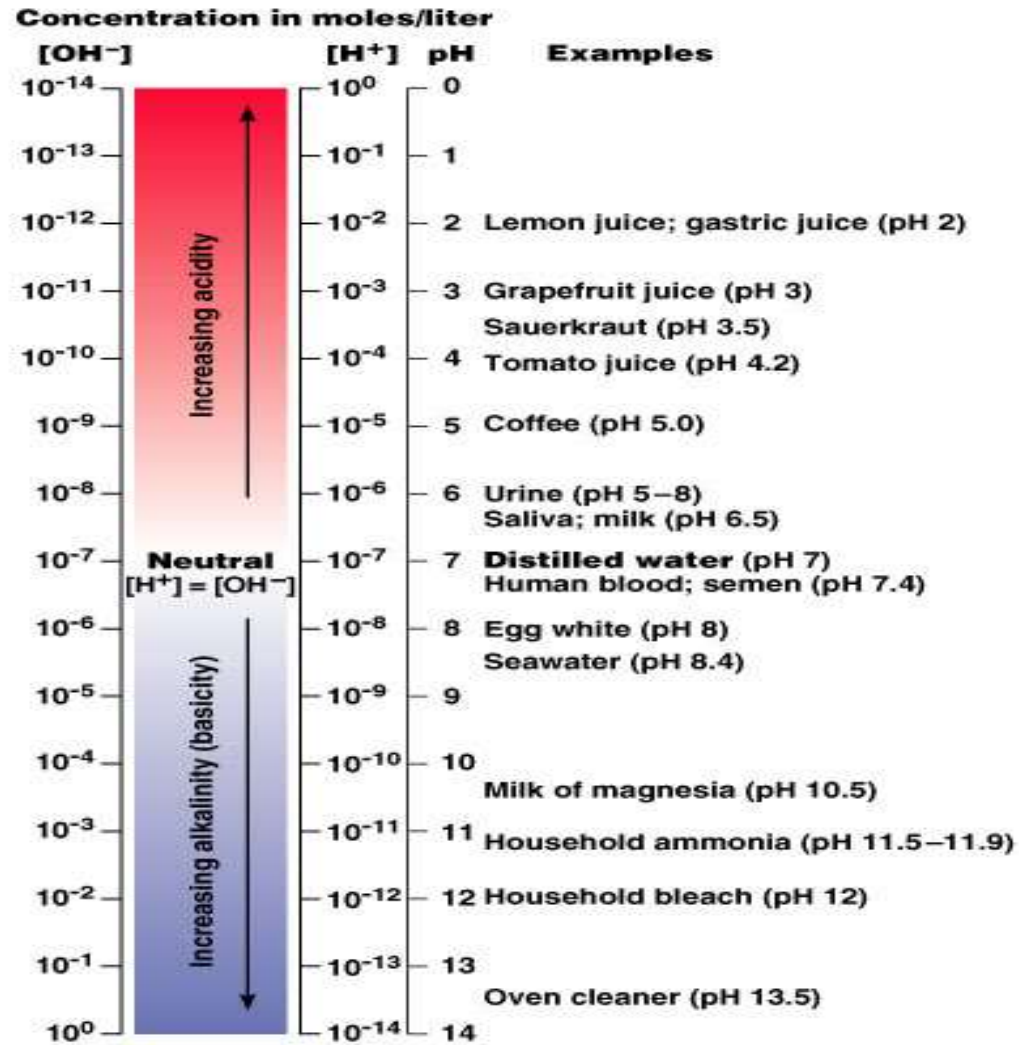


Acids Have  
a pH less  
than 7

Bases have  
a pH  
greater  
than 7



# pH of Common Substances



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## Estimation the pH of aqueous solutions

- ❑ **Acid-base indicators: organic compounds whose color depends on the pH of the solution**
  - Litmus paper: **RED** in an acidic solution and **BLUE** in a basic solution
  - Universal indicator or color plate (دليل عام أو شريحة الالوان): a mixture of acid-base indicators that can be used to approximate the pH of the solutions
  - Phenolphthalein (phph): colorless (in acidic solution) to **pink** (in basic soln)
- ❑ **pH meter: give a precise value of pH**

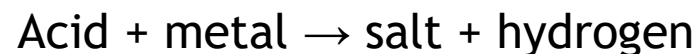
# Solutions of salts as acids or bases

- Neutral salts:  $\text{NaCl}$  and  $\text{Na}_2\text{SO}_4$
- Acidic salts:  $\text{FeCl}_3$ ,  $\underline{\text{Al}}\text{Cl}_3$  and  $\underline{\text{NH}}_4\text{Cl}$
- Basic salts:  $\text{Ca}\underline{\text{CO}}_3$ ,  $\text{Na}_2\underline{\text{CO}}_3$  and  $\text{Na}_3\underline{\text{PO}}_4$

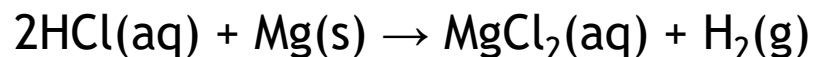
## ☐ Reactions of acids with metals

Acids take part in reactions in which salts are produced. In these reactions, the hydrogen ions in the acids are replaced by metal ions.

When acids react with metals, the products are a salt and hydrogen. In general:

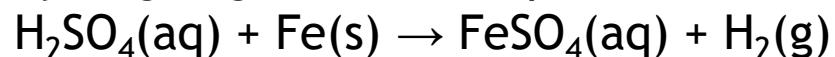


For example:



Zn and Fe also react with hydrochloric acid.

Mg, Zn and Fe also react with sulfuric acid. The products are a salt and hydrogen gas. For example:



K	Potassium	↑ most reactive               ↓ least reactive
Na	Sodium	
Ca	Calcium	
Mg	Magnesium	
Al	Aluminium	
C	<i>Carbon</i>	
Zn	Zinc	
Fe	Iron	
Sn	Tin	
Pb	Lead	
H	<i>Hydrogen</i>	
Cu	Copper	
Ag	Silver	
Au	Gold	
Pt	Platinum	

*(added for comparison)*



## Reactivity of Metals with HCl and acetic acid

[https://www.youtube.com/watch?v=Na\\_6j9y9ke8](https://www.youtube.com/watch?v=Na_6j9y9ke8)

<https://www.youtube.com/watch?v=OQDnJZGHWNw>

Copper is a very unreactive metal, and it **does not react with hydrochloric acid**. It is above copper in a metal reactivity series, so **copper** cannot replace the hydrogen in HCl to form  $\text{CuCl}_2$ .

### □ Categorizing the metals according to their reactivity:

- ✓ Very rapid reaction: K, Na
- ✓ Rapid reaction: Ca, Mg
- ✓ Slow reaction: Al, Zn, Fe, Sn
- ✓ No reaction: Pb, Cu, Ag, Au

K	Potassium	↑ most reactive
Na	Sodium	
Ca	Calcium	
Mg	Magnesium	
Al	Aluminium	
C	<i>Carbon</i>	
Zn	Zinc	
Fe	Iron	
Sn	Tin	
Pb	Lead	
H	<i>Hydrogen</i>	
Cu	Copper	
Ag	Silver	
Au	Gold	
Pt	Platinum	

*(added for comparison)*

↓ least reactive

## EXPERIMENTAL PROCEDURE

- *-The chemical properties of a range of acids, bases, and salts are observed.*
- *- Write ionic and net ionic Chemical equations to account for the observations.*
- *-The pH of selected acids, bases, and salts are estimated with pH test paper or universal indicator.*
- *-Perform the experiment and record your observation on the Report Sheet.*

### Caution:

- Be very careful in handling dilute and concentrated acids and bases  $\Rightarrow$  cause severe skin burns and irritation to mucous membranes (الأغشية المخاطية).
- Clean up acid and base spills directly with excess water, and baking soda,  $\text{NaHCO}_3$ .
- Refer to the Laboratory Safety section at the beginning of this manual.

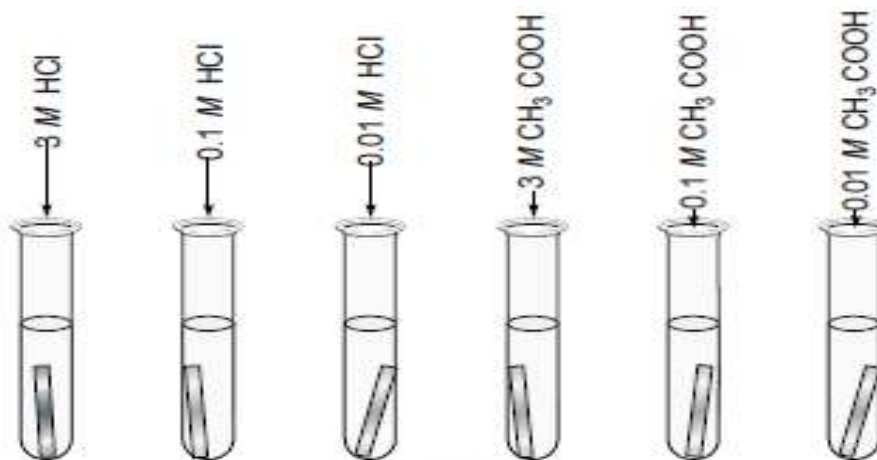
## Action of Acids on Metals

- ❖ -Place a small (1 cm) polished strip of Mg, Zn, and Cu into separate small clean test tubes. To each test tube, add just enough 6 M HCl to submerge the metal and observe for several minutes. Record your observations on the Report Sheet.
- ❖ -Repeat the test of the three metals with 6 M HNO<sub>3</sub> and then again with 6 M CH<sub>3</sub>COOH.
- ❖ Relative reactivity of metals with acids:

	Mg	Zn	Cu
6 M HCl	Fast	Medium	NR
6 M HNO <sub>3</sub>	Fast	Slow	Very slow
6 M CH <sub>3</sub> COOH	slow	slow	NR

## Effect of Acid Concentration on Reaction Rate

- Set up 6 small clean test tubes having about 1.5 mL of the acid solutions shown in the following Figure. Add a small (1 cm) polished strip of Mg to each solution and Explain your observations.



**Figure 6.7** A setup for testing the effect of different acids and acid strengths on their reactivity with a metal.

- The reaction rate is greatest with 3 M HCl and lowest with 0.10 M HCl.
- The reaction of the Mg in the HCl solutions (strong acid) is more rapid than in acetic acid (weak acid) solutions of like concentrations.

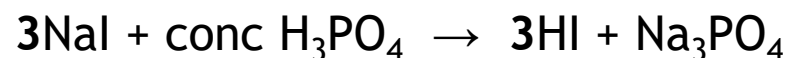


## Oxidizing strength of acids

Observe the color change, if any occur, for the reactions of the following acids with NaI.

➤ Test tube 1.  $\text{conc H}_2\text{SO}_4 + \text{I}^- \rightarrow \text{I}_2$  (violet) +  $\text{H}_2\text{S(g)} + \text{H}_2\text{O}$

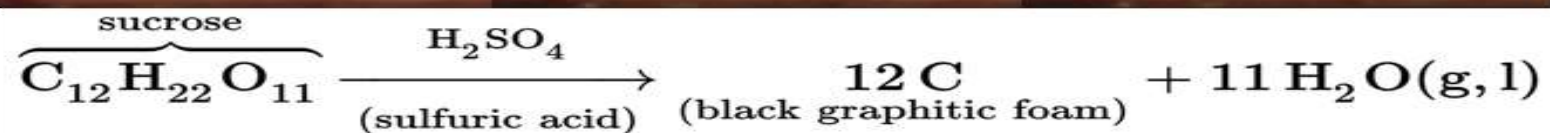
➤ Test tube 2.  $\text{conc H}_3\text{PO}_4 + \text{I}^- \rightarrow \text{???$



- -Hold moistened blue litmus paper over each test tube to test for any escaping gases.
- -compare the relative oxidizing strength of these 2 acids

## Dehydrating effect of concentrated (conc) acid

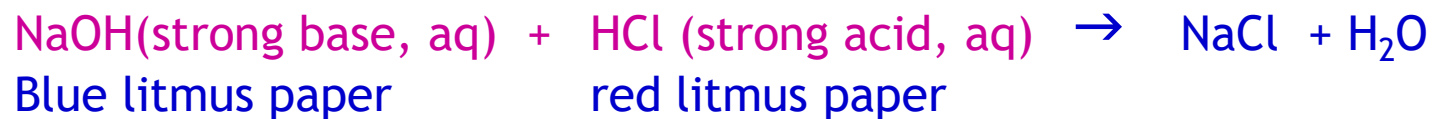
- Few drops of conc  $\text{H}_2\text{SO}_4$  + small amount of sugar
  - C (blackened charred, متفحم أسود) +  $\text{H}_2\text{O}$
  - ⇒ Conc  $\text{H}_2\text{SO}_4$  is a strong dehydrating and oxidizing agent



## Review questions

1. List the properties of acids & bases.
2. Discuss the pH scale:
  - ❖ Define the ion product of water and indicate how this is determines the pH scale.
  - ❖ Use the pH scale to determine if a given solution is acidic, neutral or basic.
3. Distinguish between strong acids & weak acids: List clinical uses of these acids & write equations for their dissociation in water
4. Distinguish between strong & weak bases; List clinical uses of these bases & write equations for their dissociation in water.
5. Complete simple equations for the neutralization reaction of an acid & a base; Discuss clinical applications of acid-base neutralization.

❖ Neutralizing NaOH solution with acid



❖ Slaking Of Quicklime (اطفاء الحير الحي)



A saturated solution of calcium hydroxide is called lime water, turn red litmus paper blue

# AMMONIA GAS

## □ Production of ammonia

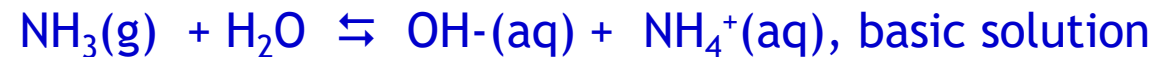


NH<sub>3</sub> is a colorless gas with a very pungent (strong) odor

## □ Test for the flammability of ammonia



## □ Test for the solubility of ammonia



Ammonia gas is a weak base, which is soluble in water, and turns phenolphthalein pink

**pH Measurements:** Measure the pH of the following solutions by using the universal indicator, record the approximate pH and write balance equation.

1) pH of water: tap water, boiled deionized water

2) Common solutions and salts

- 0.10 M and 0.000010 M HCl
- 0.10 M NaCl (table salt)
- Vinegar
- Lemon juice
- Pepsi cola
- Household ammonia
- Detergent solution
- 0.10 M NaOH
- 0.10 M Na<sub>2</sub>CO<sub>3</sub>
- 0.10 M Na<sub>3</sub>PO<sub>4</sub>

## Prelaboratory Assignment: Acids, Bases, and Salts

1. In an aqueous solution,
  - a. name and write the formula of the ion that makes a solution acidic.
  - b. name and write the formula of the ion that makes a solution basic.
2.
  - a. Muriatic acid is used to adjust the pH of swimming pools. What is the formula of muriatic acid? Does the pH of the swimming pool increase or decrease as a result of adding muriatic acid? Explain.
  - b. Battery acid is a rather concentrated solution of sulfuric acid. What is the formula of sulfuric acid?
3. Aqueous salt solutions often are *not* neutral with respect to pH. Explain.
4.
  - a. Milk of magnesia is used as a laxative and to treat upset stomachs. What is the formula of milk of magnesia?
  - b. Washing soda is often added to detergent formulations to make the wash water more basic. What is the formula of the anhydrous form of washing soda? Does it increase or decrease the pH of the wash water? Explain.

5. Three solutions have the following pH:

• Solution 1: pH 7.4,

Solution 2: pH 10.6,

Solution 3: pH 3.7

a. Which solution contains the highest  $\text{H}_3\text{O}^+$  ion concentration? \_\_\_\_\_

b. Which solution is the most acidic? \_\_\_\_\_

c. Which solution is the most basic? \_\_\_\_\_

6. Metallic ions with a higher positive charge are more strongly hydrated and tend to be more acidic in solution. Comparing a 0.12 M  $\text{FeCl}_3$  solution to a 0.12 M  $\text{FeCl}_2$  solution, which solution would have a lower pH? Explain.

e. What spectator ions remain in solution in the reaction mixture?

f. Write the **net ionic** reaction that accounts for the appearance of the precipitate.



## Postlaboratory Questions

1. Part A.1. The observation for the reaction of 6 M HCl was obviously different from that of 6 M CH<sub>3</sub>COOH. What were the contrasting observations? How do the two acids differ? Explain.
2. Part A.2. As the molar concentration of an acid decreases, the reaction rate with an active metal, such as magnesium, is expected to \_\_\_\_\_. Explain.
3. Part B.1. 6 M H<sub>2</sub>SO<sub>4</sub> is carelessly substituted for 6 M HCl. Will more or fewer drops of 6 M H<sub>2</sub>SO<sub>4</sub> be required for the litmus to change color? Explain.
4. Part B.1. Write a net ionic equation for the reaction of hydrochloric acid with sodium hydroxide.
5. Part B.3. Sodium carbonate dissolved in water produces a basic solution. Water-soluble potassium phosphate, K<sub>3</sub>PO<sub>4</sub>, also produces a basic solution. Write an equation that accounts for the basicity of K<sub>3</sub>PO<sub>4</sub>.
- \*6. Part B.3. The setting of mortar is a time-consuming process that involves a chemical reaction of quicklime, CaO, with the carbon dioxide and water of the atmosphere, forming CaCO<sub>3</sub> and Ca(OH)<sub>2</sub> respectively. Write the two balanced equations that represent the setting of mortar.
7. Part C.1. The unboiled, deionized water has a measured pH less than 7. Explain.