Presented By :
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EXPERIMENT 4 – ACIDS, BASES AND SALTS

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, H+ or H3O+).

$$HCl\ (aq) \rightarrow H^+(aq) + Cl^-(aq)$$

► Base: Substance that, when dissolved in water, increases the concentration of hydroxide ions, OH-

$$NaOH\ (aq) \rightarrow Na^+(aq) + OH^-(aq)$$

Brønsted–Lowry: **must have both**

1. An Acid: proton donor

and

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

Brønsted-Lowry acids and bases are always paired.

$$HCl(aq) + H_2O \rightleftharpoons H_3O^+(aq) + Cl^-(aq)$$

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

$$HCl + H_2O \rightleftharpoons \left[Cl^- \cdots H^+ \cdots H_2O\right] \rightleftharpoons H_3O^+ + Cl^-$$

$$NH_3 + H_2O \rightleftharpoons \left[NH_3 \cdots H^+ \cdots OH^-\right] \rightleftharpoons NH_4^+ + OH^-$$

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 on the skin الإحساس بالوخز

3) Turn blue litmus (vegetable dye) red

4) React with several metals (e.g., Zn and Mg) releasing $H_2(g)$ ⇒ 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 → 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) **Nonoxidixing acids** such as **HCl** [26], **acetic acid** [35] and **H_3PO_4** [7]

Example: $HCl\ (aq) + Zn(s) \rightarrow H_2\ (g) + ZnCl_2\ (aq)$

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

generate hydronium ,(ranked no 1 in usage, oil of vitriol(زيت الزاج)) dilute HNO_3[13] and H_2SO_4[1] ions in water.

For conc

$HNO_3(aq), Cu(s) + 4HNO_3(aq) \rightarrow Cu(NO_3)_2$(aq, blue) + $2NO_2$(g, red-brown gas) + $2H_2O$

Concentrated HNO_3[13] and H_2SO_4[1] are of excellent oxidizing properties.

Acidic aqueous solutions result from the reaction of a

1- Nometallic hydride with water

$HCl\ (g) + H_2O \rightarrow H_3O+\ (aq) + Cl\text{-}(aq)$

2- Nometallic oxide with water

$SO_3(g) + 2H_2O \rightarrow H3O+(aq) + HSO_4\text{-}(aq)$

$CO_2(g) + 2H_2O \rightarrow H_3O+(aq) + HCO_3\text{-}\ (aq)$

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

$CH_3COOH(aq) + H_2O \rightarrow H_3O+(aq) + CH_3COO\text{-}(aq)$

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Acids you must know:

Common Strong Acids:

dissociation in water, good proton 100% donors

Hydrochloric acid, HCl

Nitric acid, HNO_3

Sulfuric acid, H_2SO_4

Perchloric acid, $HClO_4$

Common Weak Acids

dissociation in water, poor proton 5% > donors

Phosphoric acid, H_3PO_4

Acetic acid, $HC_2H_3O_2$

Citric acid, $C_6H_8O_7$

Uses of acids

- H_3PO_4 - soft drinks, fertilizer, detergents
- H_2SO_4 - fertilizer, car batteries
- HCl - gastric juice, Stomach acid
- $HC_2H_3O_2$ - vinegar

Some common acids. From cider vinegar to carbonated beverages, from fruits and fruit juices to rust removers, acids are in our food and household chemicals.

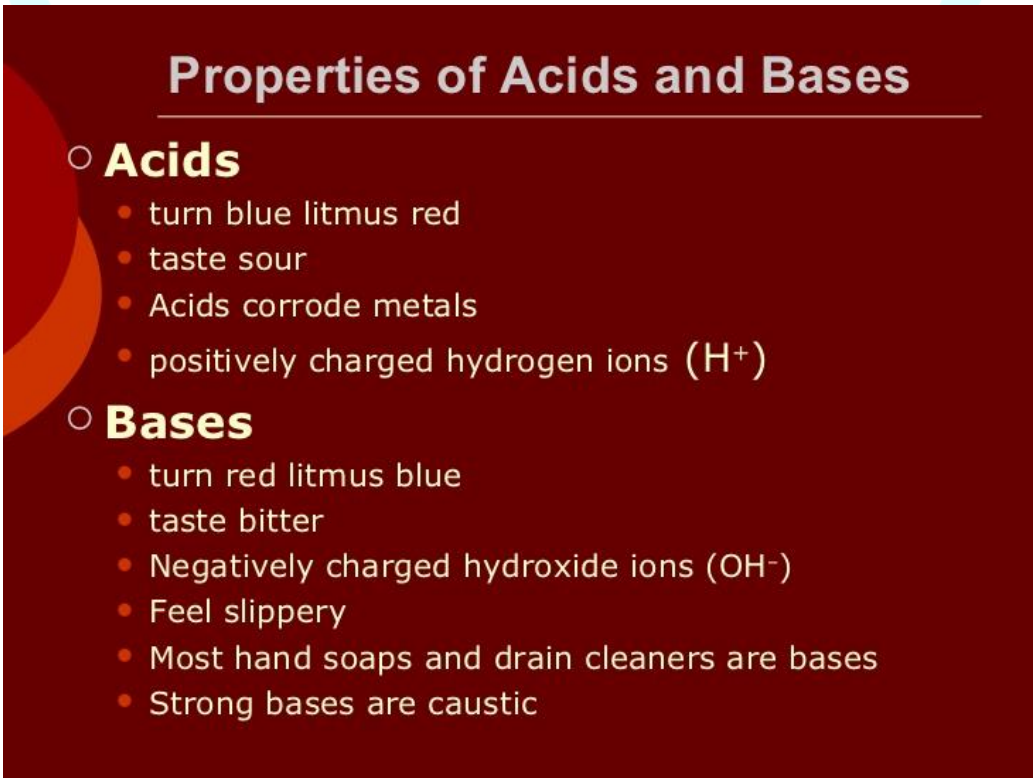
Some common bases. From the antacids we take internally to the chemicals we use to remove grease and wax, we depend on these chemicals we call alkalies or bases.

Properties of Bases

Produce or cause an increase in hydroxide ions (OH-) in H2O, pH > 7

- Taste bitter طعم مر
- Have a slippery touch 'soapy' feel ملمس انزلاقي
- 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 (H+)

Most of hand soaps, detegents and drain cleaners are bases



Basic aqueous solutions can result from

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

$$O^{2-}(aq, \text{from } CaO) + H_2O \rightarrow 2OH^-(aq)$$

2- Anion that reacts with water

$$CO_3^{2-}(aq, \text{from } Na_2CO_3) + H_2O \rightarrow HCO_3^-(aq) + OH^-(aq)$$

3- molecular species that reacts with water

$$NH_3(aq) + H_2O \text{ ! } OH^-(aq) + NH_4^+(aq)$$

Uses of bases

- preparation of soaps and detergents NaOH – lye , drain and oven cleaner.
- ,$Mg(OH)_2$ - laxative, antacid

clinical applications of Antacids: to neutralize excess stomach acid.

$$Mg(OH)_2 + 2HCl \rightarrow MgCl_2 + 2H_2O$$

- NH_3 -cleaners, fertilizer

Some common acids. From cider vinegar to carbonated beverages, from fruits and fruit juices to rust removers, acids are in our food and household chemicals.

Some common bases. From the antacids we take internally to the chemicals we use to remove grease and wax, we depend on these chemicals we call alkalies or bases.

pH Scale

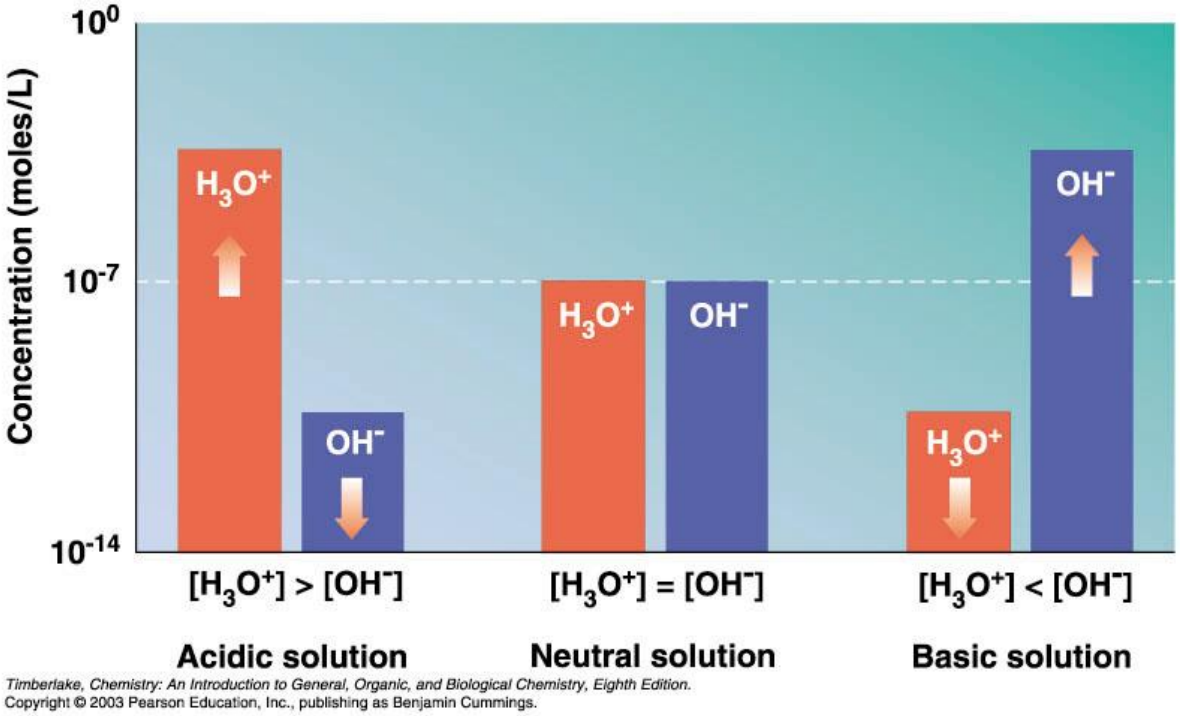
pH

a measure of the concentration of H3O+ ions in solution measured with a pH meter or an indicator with a wide color range

pH = -log [H+] = -log [H3O+]

Lower pH value indicates a stronger acid.

Higher pH value indicates a stronger base.



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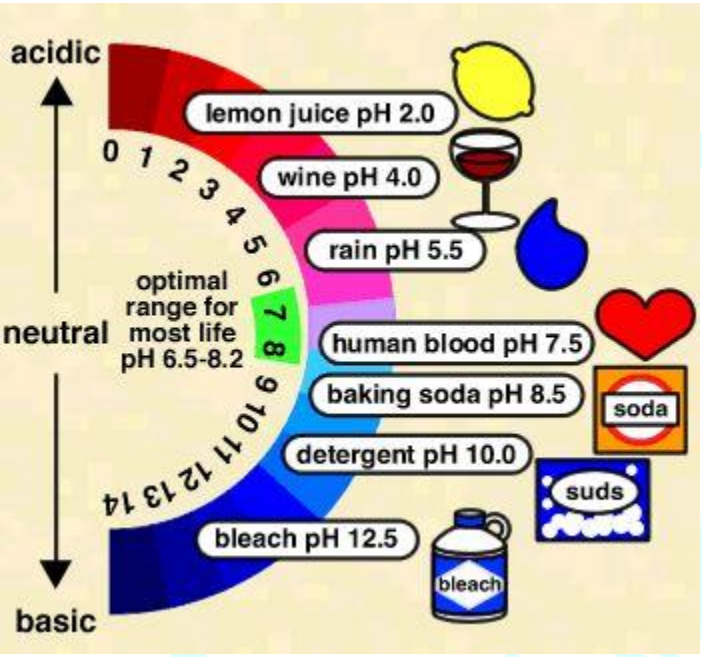
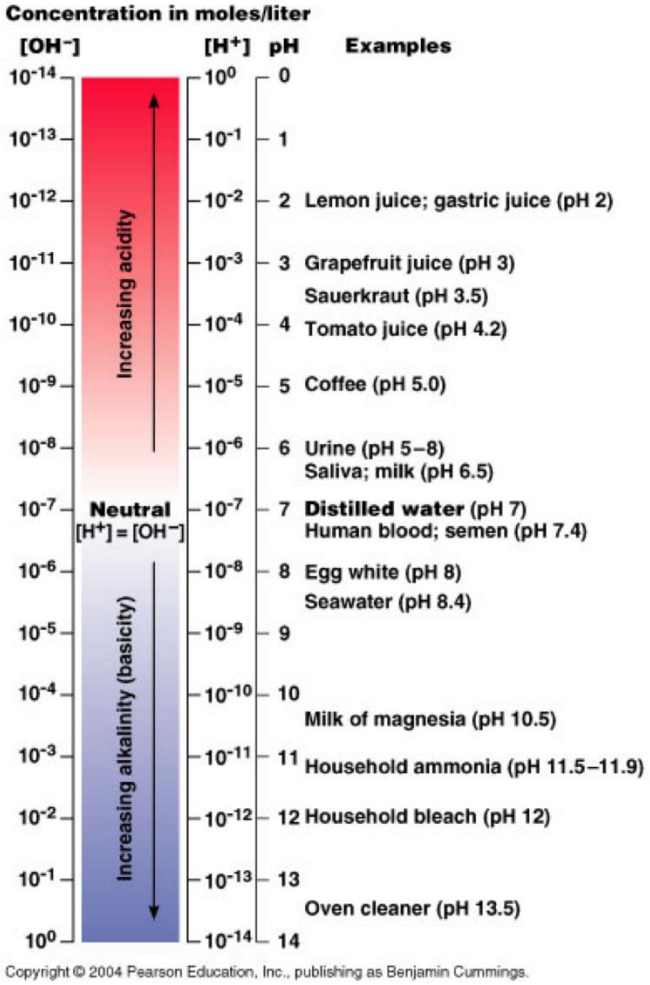
pH of Common Substances



Acids Have a pH less than 7

Bases have a pH greater than 7



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**: NaCl and $Na2SO_4$

► **Acidic salts**: **Fe**Cl3, **Al**Cl3 and **NH_4**Cl

► **Basic salts**: Ca**CO_3**, Na2**CO_3** and Na3**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:

Acid + metal → salt + hydrogen

For example:

$$2HCl(aq) + Mg(s) \rightarrow MgCl_2(aq) + H_2(g)$$

• 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

$$H_2SO_4(aq) + Fe(s) \rightarrow FeSO_4(aq) + H_2(g)$$

Reactivity of Metals with HCl and acetic acid

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 $CuCl_2$

❑ 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

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 ⇒ cause severe skin burns and irritation to mucous membranes (الأغشية المخاطية).

▪ Clean up acid and base spills directly with excess water, and baking soda, $NaHCO_3$.

▪ 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_3 and then again with 6 M CH_3COOH- .

❖ Relative reactivity of metals with acids.

	Mg	Zn	Cu
6 *M* HCl	Fast	Medium	NR
6 *M* HNO_3	Fast	Slow	Very slow
6 *M* CH_3COOH	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.

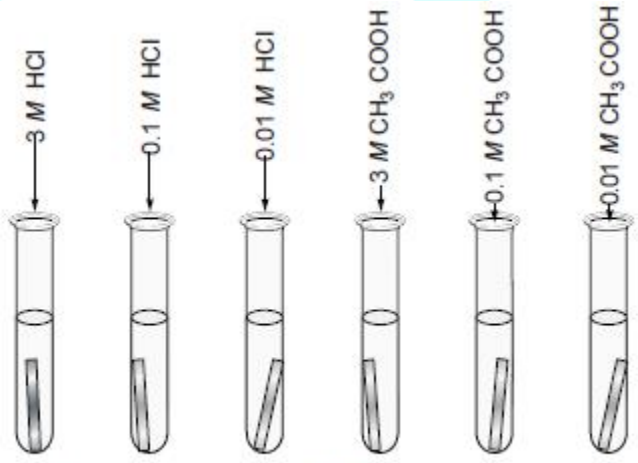


Figure 6.7 A setup for testing the effect of different acids and acid strengths on their reactivity with a metal.

► 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. conc $H_2SO_4 + I^- \rightarrow I2$ (**violet**)$+ H_2S(g) + H_2O$

► **???** Test tube 2. conc $H_3PO_4 + I^-$

$3NaI + \text{conc } H_3PO_4 \rightarrow 3HI + Na_3PO_4$

► Hold moistened blue litmus paper over each test tube to test for any escaping gases

► compare the relative oxidizing strength of these 2 acids

❖ Neutralizing NaOH solution with acid

NaCl + H2O → NaOH (strong base, aq) + HCl (strong acid, aq)

Red litmus paper **Blue litmus paper**

❖ Slaking Of Quicklime اطفاء الجير الحي

$Ca(OH)_2 \rightarrow H_2O + CaO(s)$

a base A basic oxide

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

AMMONIA GAS

❑ Production of ammonia

$2NH_3(g) + CaCl_2(aq) + 2H_2O \rightarrow 2NH_4Cl + Ca(OH)_2$ (thin paste)

NH_3 is a colorless gas with a very pungent (strong) odor

❑ Test for the flammability of ammonia

$NH_3(g) + O_2 \rightarrow N_2(g) + H_2O$

❑ Test for the solubility of ammonia

$NH_3(g) + H_2O \rightarrow OH^-(aq) + NH_4^+(aq)$, basic solution

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

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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.

- M and 0.000010 M HCl 0.10
- M NaCl (table salt) 0.10
- Vinegar
- Lemon juice
- Pepsi cola
- Household ammonia
- Detergent solution
- M NaOH 0.10
- M Na_2CO_3 0.10
- M Na_3PO_4 0.10