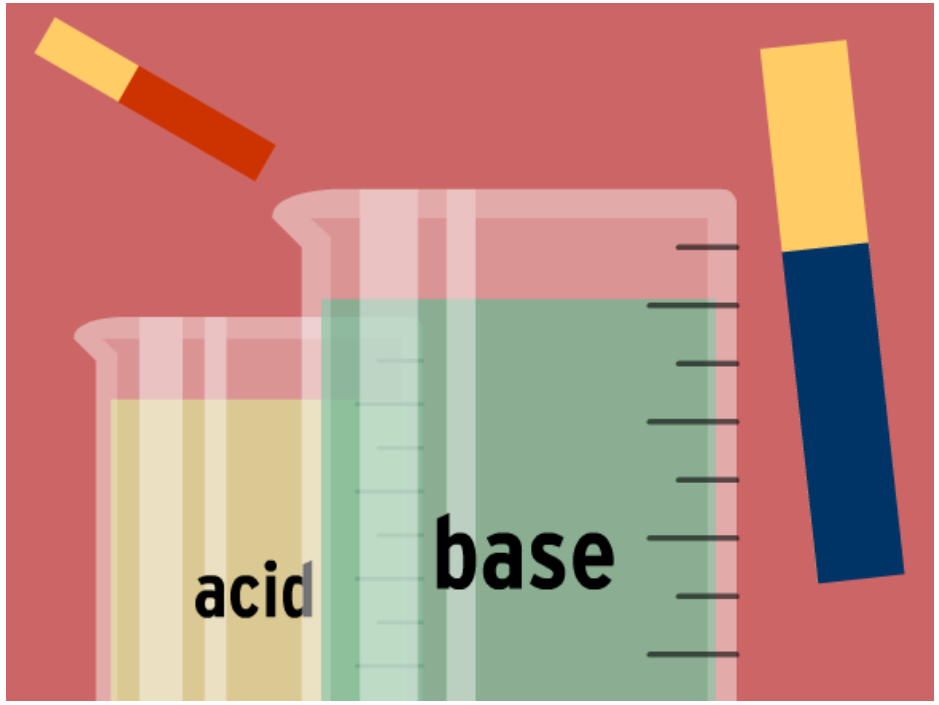
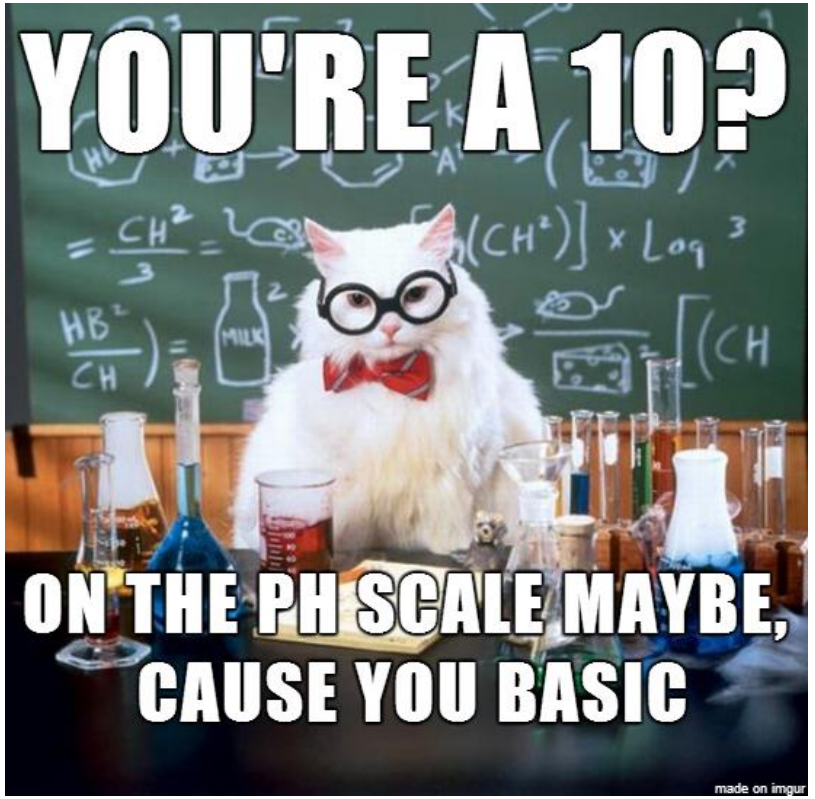
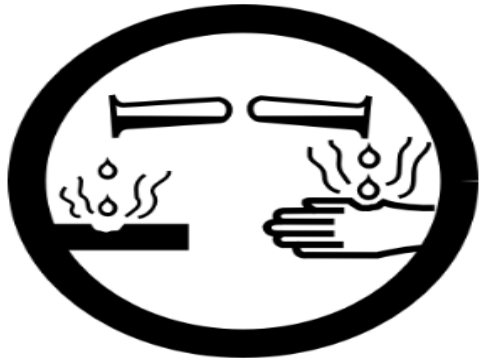
5.1 Acids and Bases





5.1 Acids and Bases

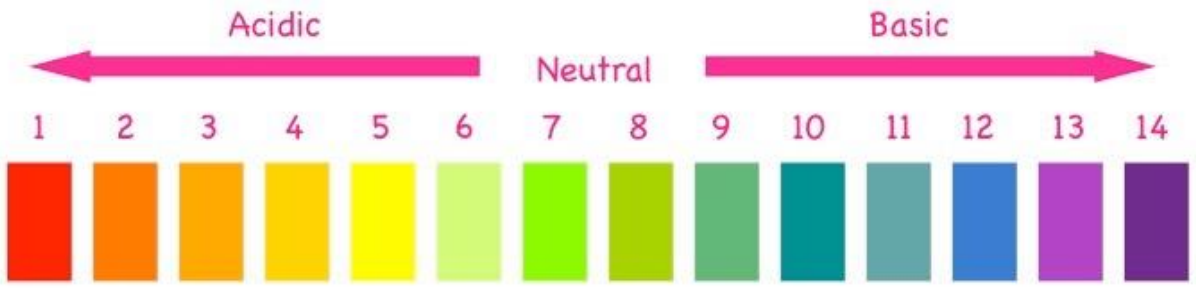
- Many familiar compounds are **acids** or **bases**.
  - Classification as acids or bases is based on chemical composition.
- Acids and bases can be very dangerous.
  - Both can be very corrosive. NEVER try to identify an acid or base by taste or touch!

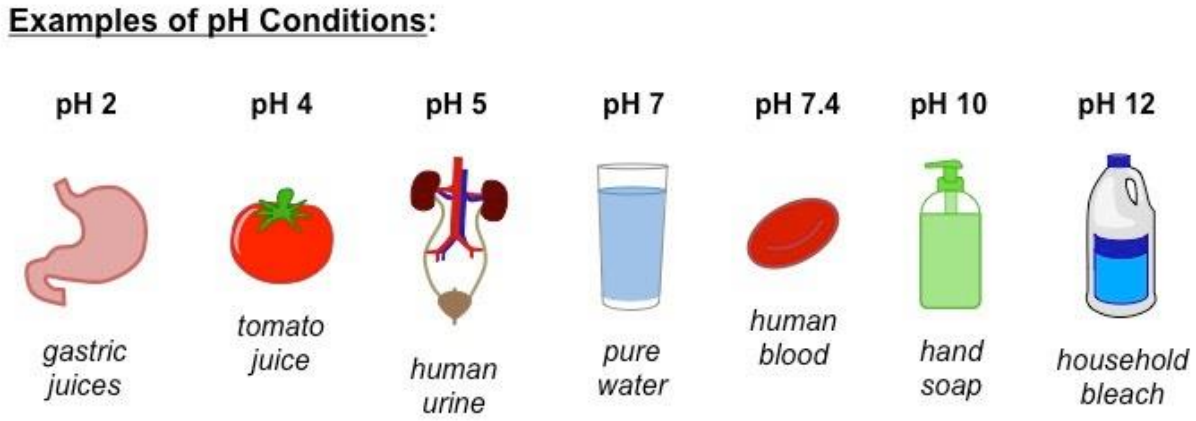


- The strength of acids and bases in measured on the **pH** scale.
  - pH below 7 = acidic, pH above 7 = basic, pH 7 = **neutral**
  - 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14

Acids *Neutral* *Bases*

  - Each decrease of 1 on the pH scale indicates **10×** more acidic
    - For example, pH 4 is **10** times more acidic than pH 5.
    - pH 3 is **1000** times more acidic than pH 6.

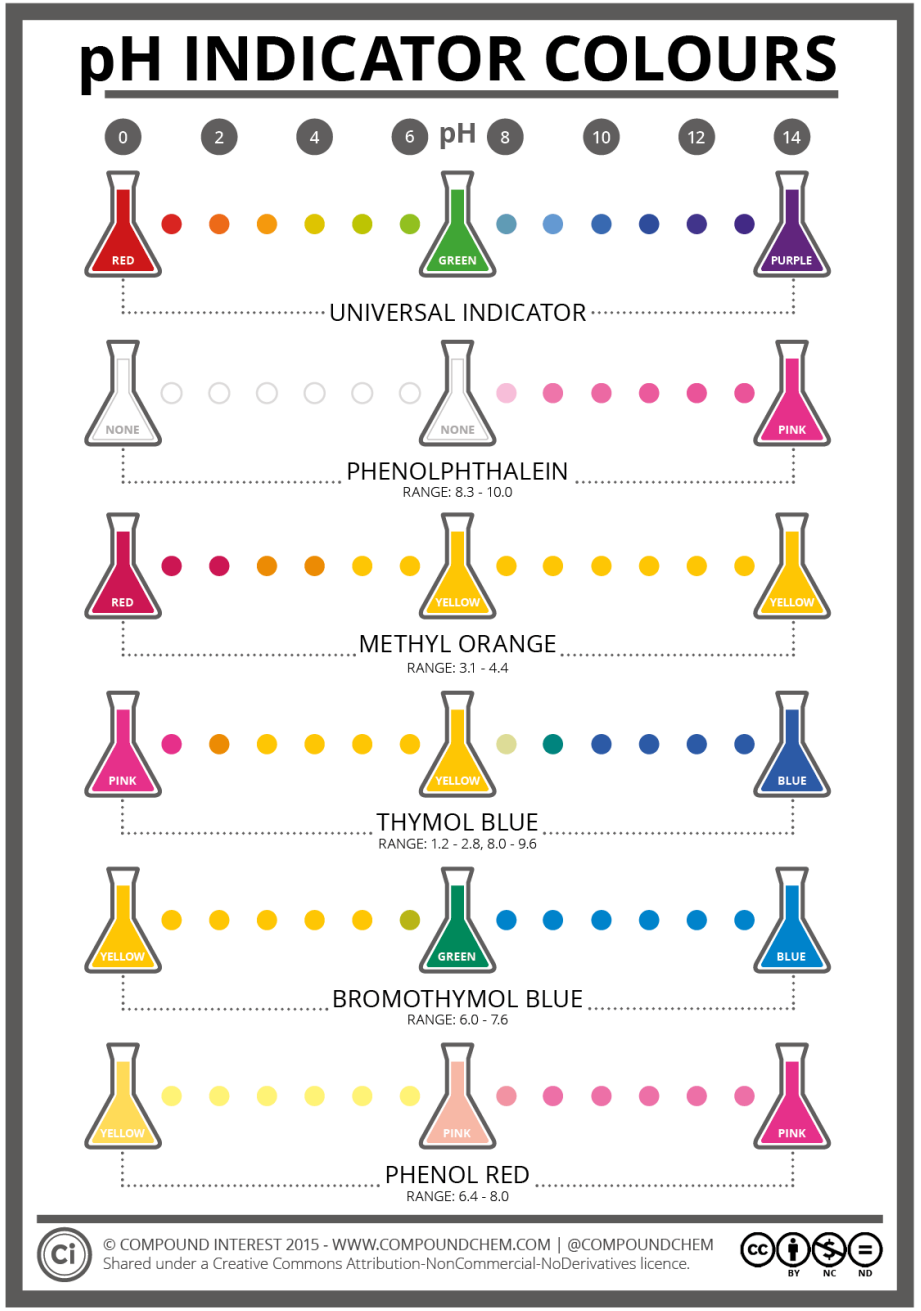




See pages 220 - 222

pH Indicators

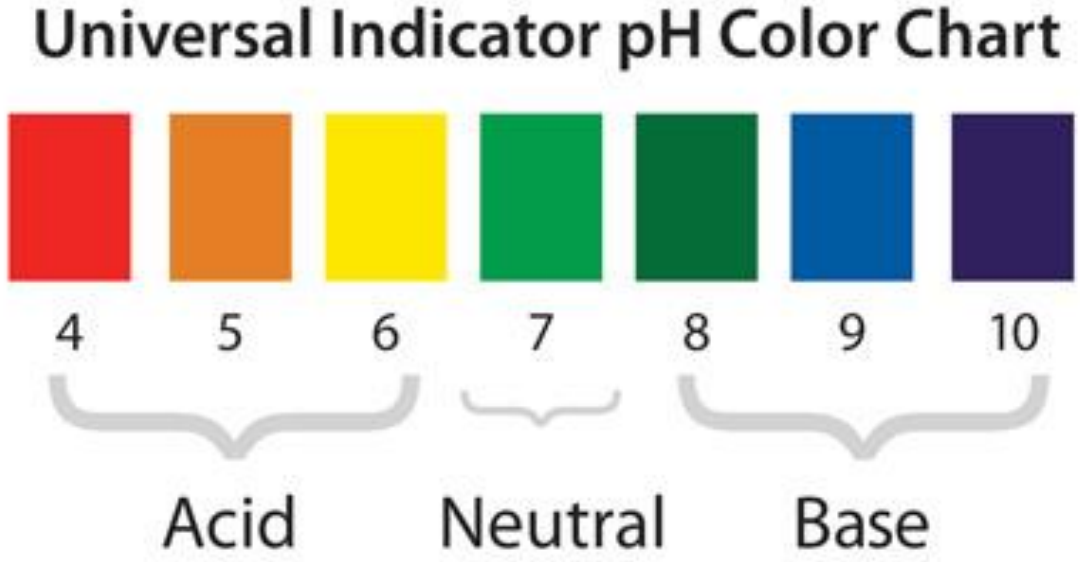
- The pH of acids and bases cannot be determined by sight.
  - Instead, pH is measured by other chemicals called **indicators** or by a pH meter that measures the electrical conductivity of the solution.

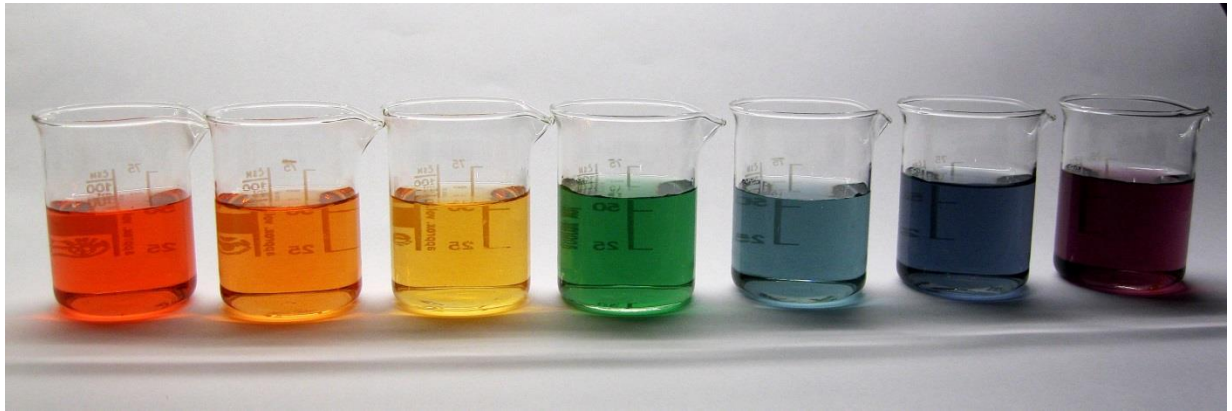


- pH indicators change colour based on the solution they are placed in.
  - **Litmus** is the most common indicator, and is used on litmus paper.
    - Two colours of litmus paper: Blue = **basic** and Red = **acidic**.
    - Blue = pH **above** 7, Red = pH **below** 7.

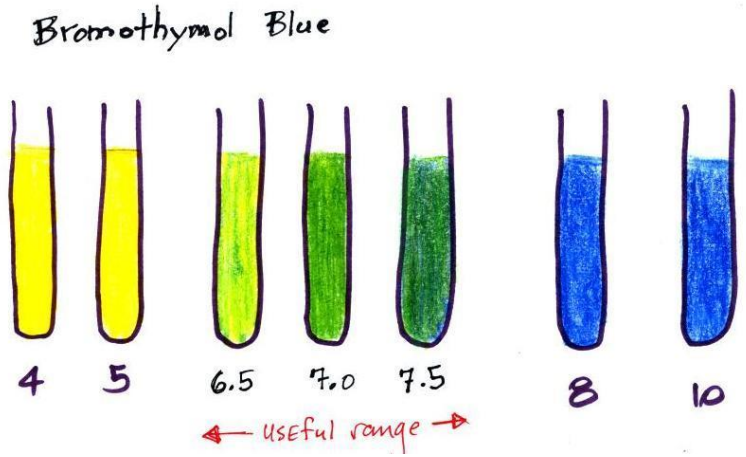
Litmus paper

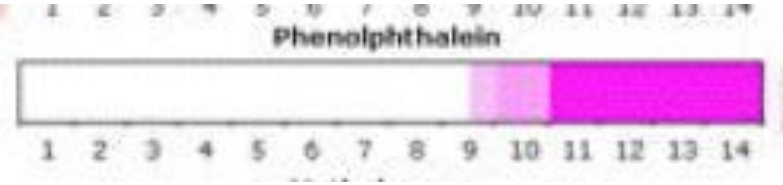
- Universal indicator contains many indicators that turn different colours at different pH values (can be in liquid form, or on paper strips like litmus).





- A **pH meter** uses electrical probes to measure how solutions conduct electricity.
- Indicators change colour at different pH values, so different indicators are used to identify different pH values.
  - Bromothymol blue for pH 6 – 7.6, phenolphthalein for pH 8.2 – 10.





- Many natural sources, such as beets and **red cabbage**, are also indicators.

Acid-base indicator	pH Range in Which Colour Change Occurs	Colour Change as pH Increases
Methyl orange	3.2–4.4	red to yellow
Methyl red	4.8–6.0	red to yellow
Bromothymol blue	6.0–7.6	yellow to blue
Litmus	7.0	red to blue
Phenolphthalein	8.2–10.0	colourless to pink
Indigo carmine	11.2–13.0	blue to yellow

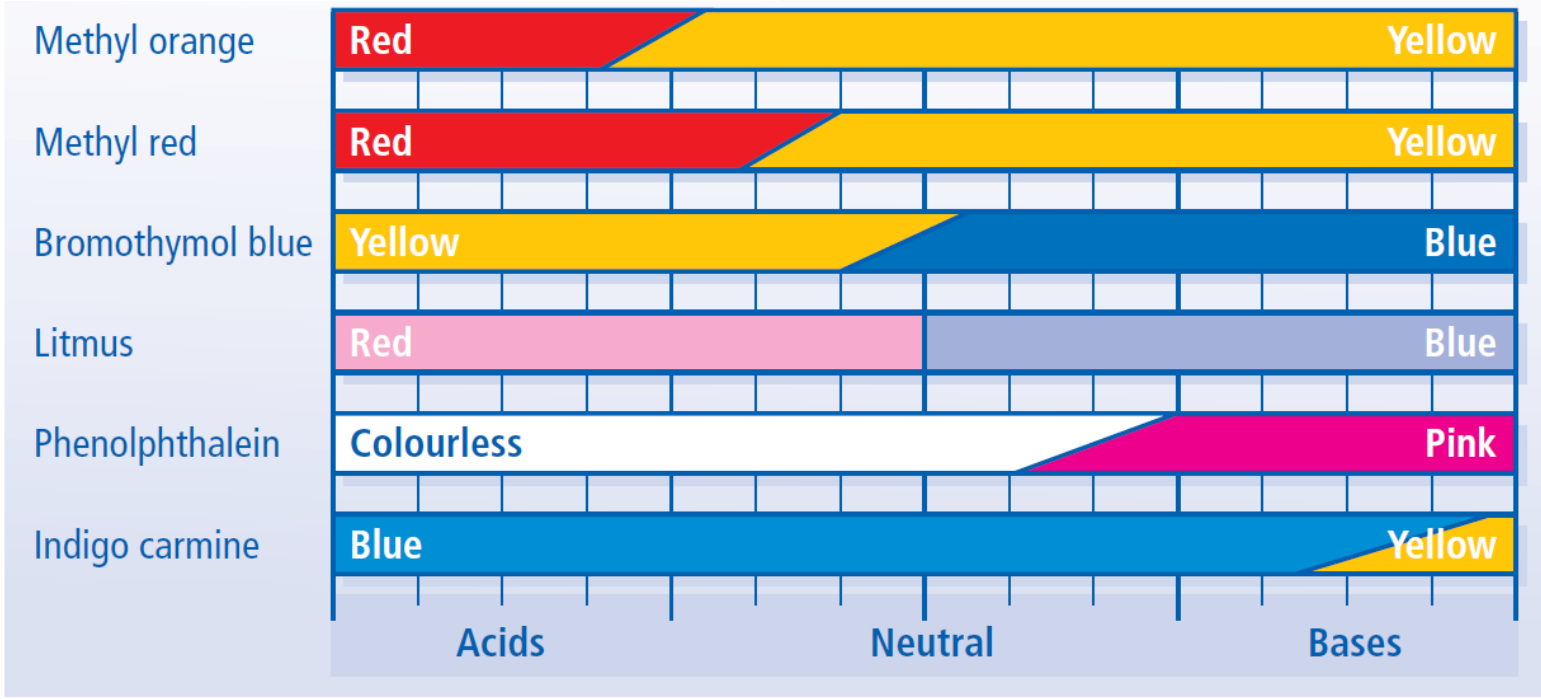


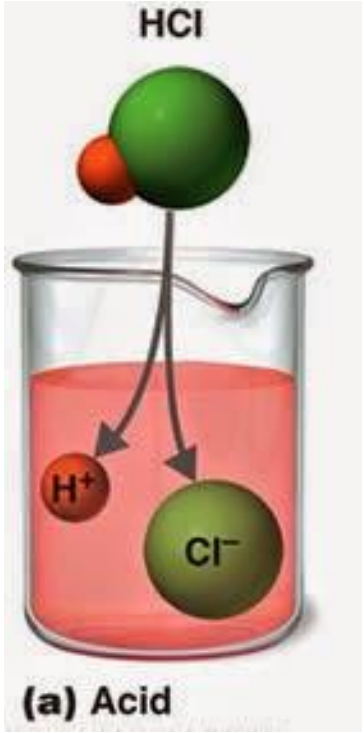
Figure 5.6 Common acid-base indicators and their pH colour change

Reading Check

1. What is the pH scale?
2. Above what pH level is a solution said to be basic or alkaline?
3. When the pH rises from 10 to 12, how many times more basic has the solution become?
4. What colour is litmus paper in an acidic solution?
5. What colour is bromothymol blue at the following pH levels?
   (a) pH 5
   (b) pH 7
   (c) pH 9

Acids

- If you know a compound's **chemical formula**, you may be able to identify whether it as an acid.
  - Acids often behave like acids only when dissolved in **water.**
  - Therefore, acids often are written with symbol (**aq**) = aqueous = water.



Sulfuric acid is used in batteries.

See pages 225 - 226

- The chemical formula of an acid usually starts with **hydrogen** (**H**).
  - Acids with a **carbon** usually have the C written **first**.
    - $HCl_{(aq)}$ = hydrochloric acid, $HNO_{3(aq)}$ = nitric acid, $CH_3COOH_{(aq)}$ = acetic acid

Table 5.2 Some Common Acids

Formula	Chemical Name	Common Name	Examples of Uses
HCl(aq)	hydrochloric acid	muriatic acid	• Produced in the stomach to help digest food
H_2SO_4(aq)	sulfuric acid	battery acid	• Used in automobile batteries • Used to clean metals
HNO_3(aq)	nitric acid	nitric acid	• Used to make fertilizers
CH_3COOH(aq)	ethanoic acid	acetic acid	• Present in vinegar

- Classifying acids:
  - **Binary** Acids usually contain only two elements
    - E.g. HF
  - Oxy Acids contain **oxygen** as part of a polyatomic ion
    - E.g. H_2SO_4

Naming Acids

- Naming Binary Acids
  - Hydrogen + …-*ide* = **hydro…*ic* acid**
    - $HF_{(aq)}$ = hydrogen fluoride = **hydrofluoric acid**

Table 5.3 Some Non-Oxygen Acids

Formula	Chemical Name	Formula in Solution	Formula Name Can Be Changed to	Examples of Uses
HF	hydrogen fluoride	HF(aq)	hydrofluoric acid	• Manufacturing aluminum and uranium
HCl	hydrogen chloride	HCl(aq)	hydrochloric acid	• Producing plastic
HBr	hydrogen bromide	HBr(aq)	hydrobromic acid	• Extracting metal ore
HI	hydrogen iodide	HI(aq)	hydriodic acid	• Taking part in chemical reactions to make other compounds

- Try: Write the name or the formula of the acids listed below:
  - HCl — Hydrogen chloride → Hydrochloric acid
  - HI — Hydrogen iodide → Hydroiodic acid
  - HCN — Hydrogen cyanide → Hydrocyanic acid
  - Hydrobromic Acid — HBr

- Naming Oxy Acids → **have polyatomic ions and end differently**
  - Hydrogen + …-*ate* = **(remove hydrogen)…*ic* acid**
    - $H_2CO_{3(aq)}$ = hydrogen carbonate = carbonic acid
  - Hydrogen + …-*ite* = **(remove hydrogen)…*ous* acid**
    - $H_2SO_{3(aq)}$ = hydrogen sulphite = sulphurous acid

Table 5.4 Some Acids Containing Oxygen

Formula	Chemical Name	Formula in Solution	Formula Name Can Be Changed to	Examples of Uses
$HClO_4$	hydrogen perchlorate	$HClO_4(aq)$	perchloric acid	• Manufacturing explosives and speeding up chemical reactions
$HClO_3$	hydrogen chlorate	$HClO_3(aq)$	chloric acid	• Air pollution control
$HClO_2$	hydrogen chlorite	$HClO_2(aq)$	chlorous acid	• Disinfectant
HClO	hydrogen hypochlorite	HClO(aq)	hypochlorous acid	• Treating water in swimming pools

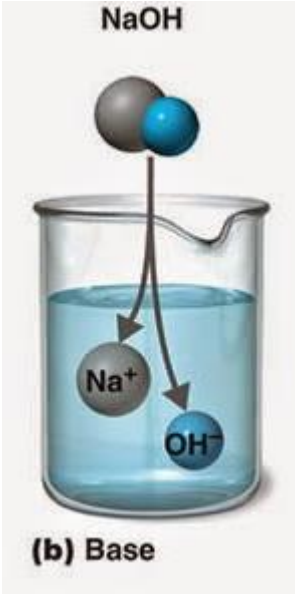
- Try: Write the name or the formula of the acids listed below:
  - H_2SO_4 Hydrogen sulfate → Sulfuric acid
  - HNO_3 Hydrogen nitrate → Nitric acid
  - HNO_2 Hydrogen nitrite → Nitrous acid
  - Phosphoric acid H_3PO_4
  - Chlorous acid $H^+ + ClO_2^- \rightarrow HClO_2$

Reading Check

1. How can you recognize an acid by its chemical formula?
2. State which acid is present in:
   (a) your stomach; (b) vinegar; (c) automobile batteries
3. State another name for aqueous hydrogen fluoride, HF(aq).
4. State another name for aqueous hydrogen perchlorate, $HClO_4$(aq).
5. What does corrosive mean?

Bases

- If you know a compound's chemical formula, you may be able to identify it as a base.
  - Bases often behave like bases only when **dissolved** in water.
  - Therefore, bases are often written with the symbol (aq) = aqueous = water.
- The chemical formula of a base usually ends with **hydroxide (OH).**



See page 227

- Bases can be gentle or very caustic.
- Examples of common bases:
  - $NaOH_{(aq)}$ **Sodium Hydroxide**
  - $Mg(OH)_{2(aq)}$ **Magnesium Hydroxide**
  - $Ca(OH)_{2(aq)}$ **Calcium Hydroxide**
  - $NH_4OH_{(aq)}$ **Ammonium Hydroxide**

Table 5.5 Some Common Bases

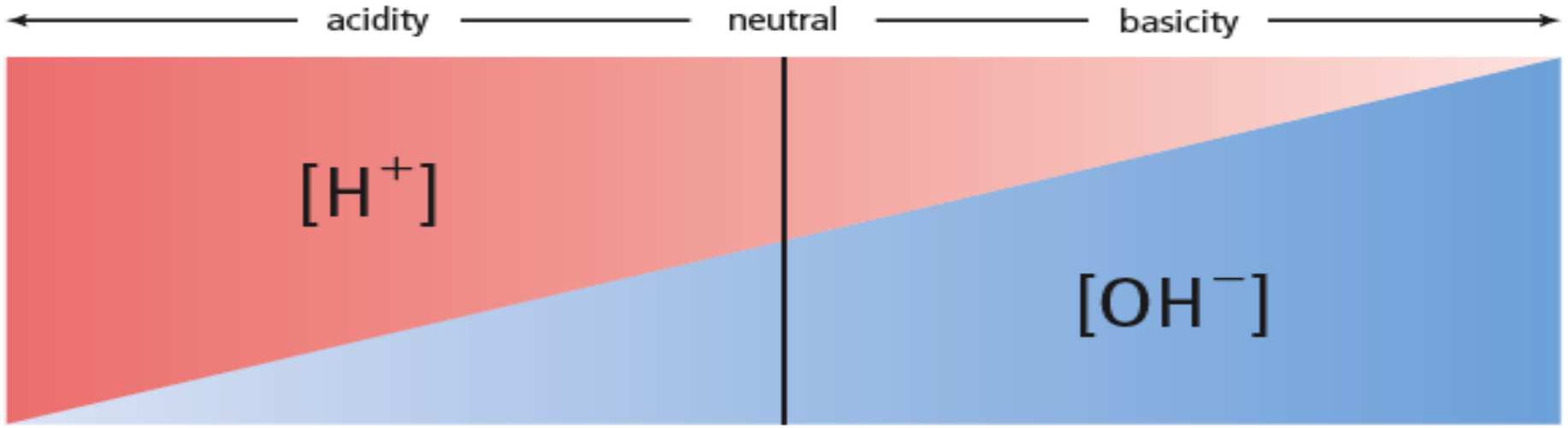
Formula	Chemical Name	Common Name	Examples of Uses
NaOH	sodium hydroxide	caustic soda, lye	• Drain and oven cleaner • Used to manufacture paper, glass, and soap
$Mg(OH)_2$	magnesium hydroxide	milk of magnesia	• Active ingredient in some antacids
$Ca(OH)_2$	calcium hydroxide	hydrated lime	• Soil and water treatment
NH_4OH	ammonium hydroxide	household ammonia	• Kitchen cleaner • Used to make fertilizer

Reading Check

1. How can you recognize a base by its formula?
2. State which base is present in:
   (a) milk of magnesia
   (b) drain cleaner
   (c) household ammonia
3. Give an example of a highly reactive base.
4. What is another term used to describe highly reactive bases?

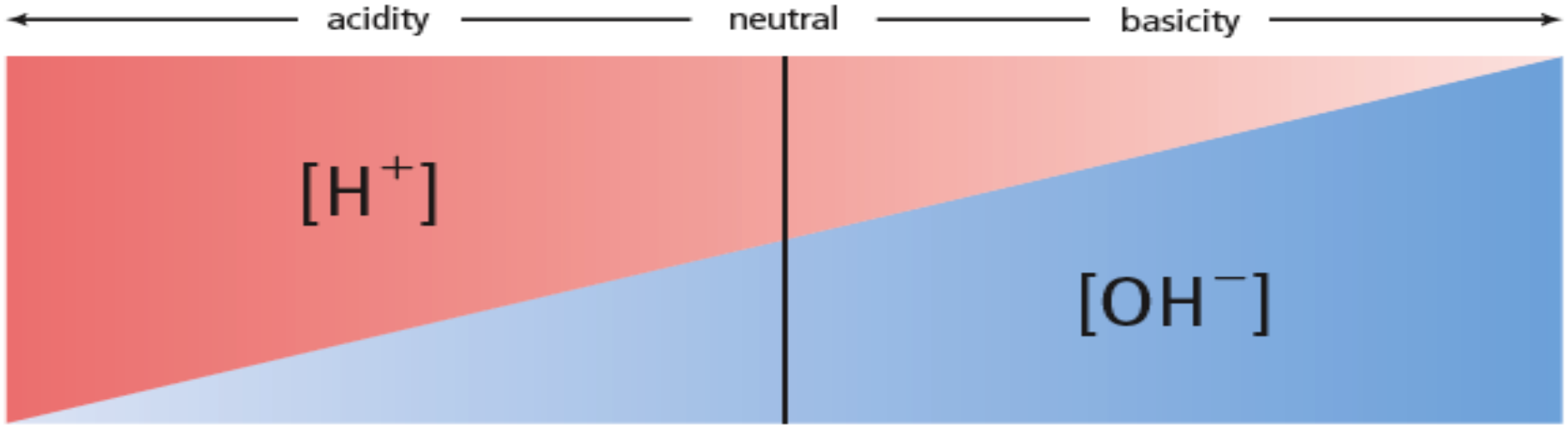
Production of Ions

- Acids and bases can conduct electricity because they release ions in solution.
  - Acids release **hydrogen ions**, H^+ .
  - Bases release **hydroxide ions** OH^-.



See page 228

- The pH of a solution refers to the **concentration** of ions it has.
  - Square brackets are used to signify concentration, $[H^+]$, $[OH^-]$
    - High $[H^+]$ = **low** pH, very acidic
    - High $[OH^-]$ = **high** pH, very basic



- A solution cannot have BOTH high [H^+] and [OH^-]; they cancel each other out and form water. This process is called **neutraliztion**.
- $H^+ + OH^- \rightarrow H_2O$

Properties of Acids and Bases

Table 5.6 Properties of Acids and Bases

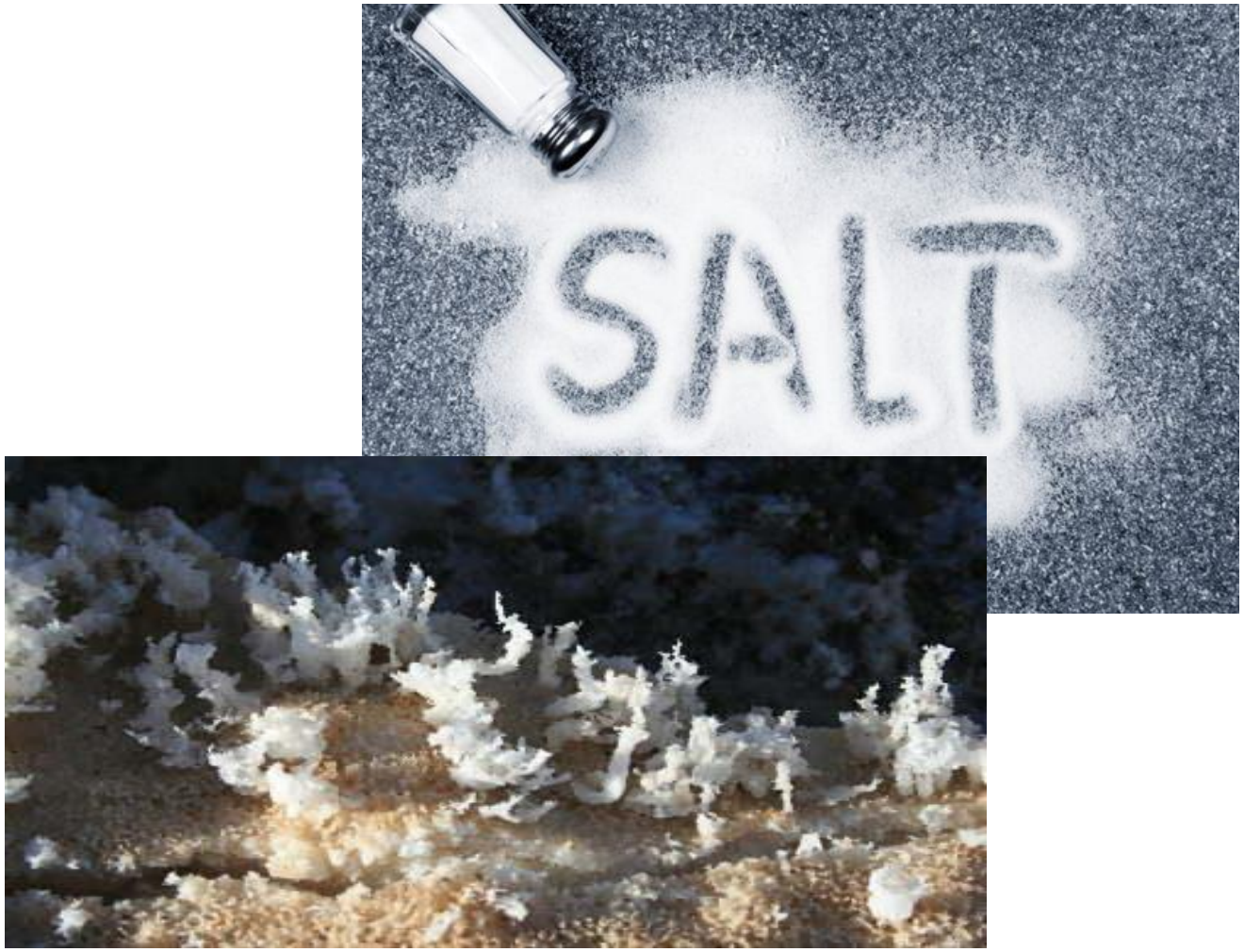
Property	Acid	Base
Taste CAUTION: Never taste chemicals in the laboratory.	• Acids taste sour. Lemons, limes, and vinegar are common examples.	• Bases taste bitter. The quinine in tonic water is one example.
Touch CAUTION: Never touch chemicals in the laboratory with your bare skin.	• Many acids will burn your skin. Sulfuric acid (battery acid) is one example.	• Bases feel slippery. • Many bases will burn your skin. Sodium hydroxide (lye) is one example.
Indicator tests	• Acids turn blue litmus paper red. • Phenolphthalein is colourless in an acidic solution.	• Bases turn red litmus blue. • Phenolphthalein is colourless in slightly basic solutions and pink in moderate to strongly basic solutions.
Reaction with some metals, such as magnesium or zinc	• Acids corrode metals.	• No reaction
Electrical conductivity	• Conductive	• Conductive
pH	• Less than 7	• More than 7
Production of ions	• Acids form hydrogen (H^+) ions when dissolved in solution.	• Bases form hydroxide (OH^-) ions when dissolved in solution.

See page 229

To Do:

1. Take out your chp 5.1 package and do:
   -BLM 2-25 (omit BLM 2-26) and WB pgs 86, 87, 88
   - Work on this for the rest of class

5.2 Salts



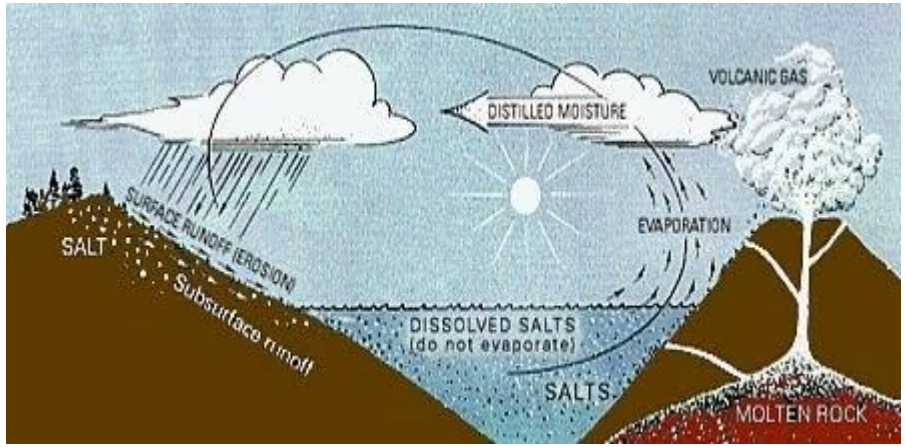
Salt crystals in Death Valley

Figure 5.12 Mahatma Gandhi and his followers gathering salt

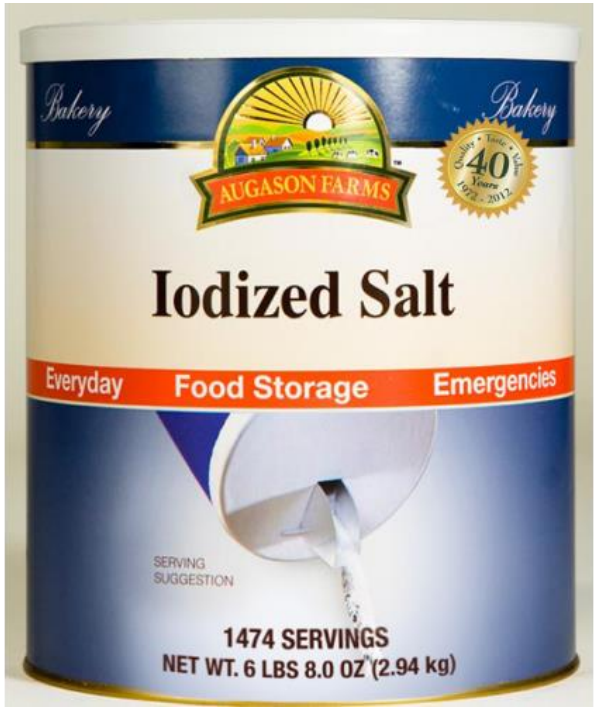
Figure 5.13 Western Canada has a huge deposit of rock salt that averages 122 m in thickness, covers approximately 390 000 km^2, and contains more than a million billion tonnes of salt. The salt is mined for use as road salt.

5.2 Salts

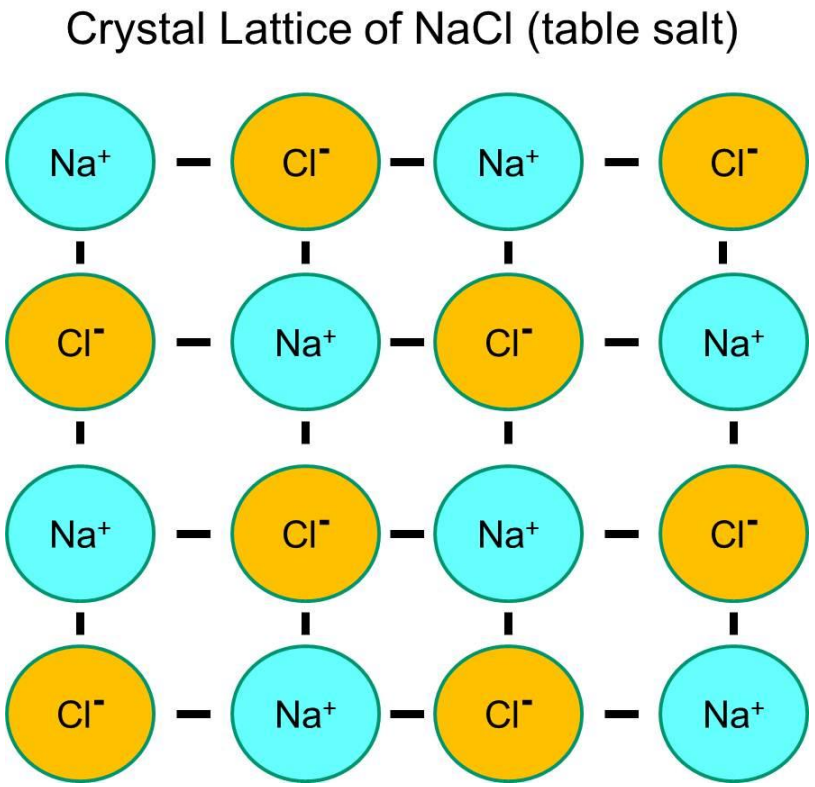
- Salts are **ionic** compounds formed when acids and bases react.
  - Salts are also produced when **oxides** or **carbonates** react with acids or when **metals** react with acids.
- **Table** salt, NaCl, is found in **sea** water, salt lakes or **rock** deposits.

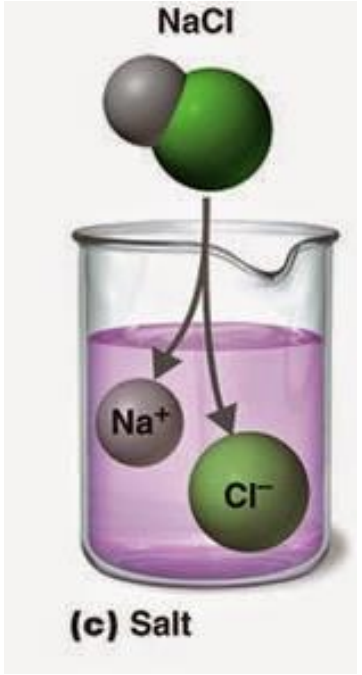


- Salt was once very valuable as a commodity.
- Iodine is now added to salt to minimize goiter (a disease of the thyroid).



- NaCl is only one kind of salt.
  - A salt is made up of a **positive** ion from a base and a **negative** ion from an acid.





- Salts are found in many things:
  - In **batteries**, explosives and **fertilizers**
  - In **multivitamins** and in many living cells

Acid-Base Neutralization, and Metal Oxides and Non-Metal Oxides

The effects of acid rain on a forest

- Neutralization reactions occur when an **acid** and a **base** react to produce a **salt** and **water.**
  - HX(aq) + MOH(aq) → MX(aq/s) + HOH(l)
  - $HCl(aq) + NaOH(aq) \rightarrow NaCl(s) + H_2O(l)$

    acid *base* *salt* *water*

  - **Another example:**

$$3H_2SO_4 + 2Al(OH)_3 \rightarrow Al_2(SO_4)_3 + 6H_2O$$

acid + base → salt + water

DEMO

- Acid- Base Neutralization

- HCl (acid) + NaOH (base)
- Red cabbage indicator

Practice Problems

Complete and balance the following neutralization reactions. Then, write the names of all the reactants and all the products in each chemical reaction. Consider the formulas of your products carefully before you begin to balance.

1. $HCl + KOH \rightarrow$
2. $H_2CO_3 + Mg(OH)_2 \rightarrow$
3. $CH_3COOH + CsOH \rightarrow$
4. $H_3PO_4 + NaOH \rightarrow$
5. $HNO_3 + Ca(OH)_2 \rightarrow$

Answers provided on page 592

- Metal oxides react with water to form **bases**.
  - MO(s) + H_2O(l) → MOH(aq)

  - Examples:
    - Na_2O(s) + H_2O(l) → 2NaOH(aq)

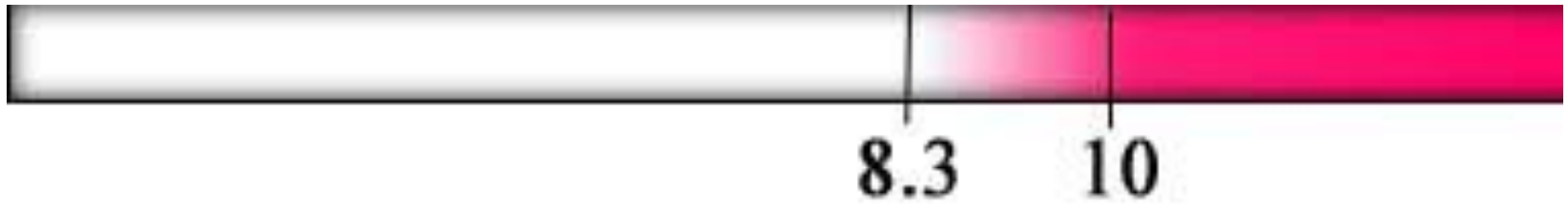
    - CaO(s) + H_2O(l) → Ca2+ and OH- → $Ca(OH)_2$ (aq)

    - MgO(s) + H_2O(l) → Mg2+ and OH- → $Mg(OH)_2$ (aq)

Peroxide	Chemical name
Na_2O	Sodium(I) oxide
K_2O	Potassium(I) oxide
FeO	Ferrous(II) oxide
MgO	Magnesium(II) oxide
MnO_2	Manganese(IV) oxide
CaO	Calcium(II) oxide
Cr_2O_3	Chromium(III) oxide
Cu_2O	Copper(I) oxide
ZnO	Zinc(II) oxide

Demo

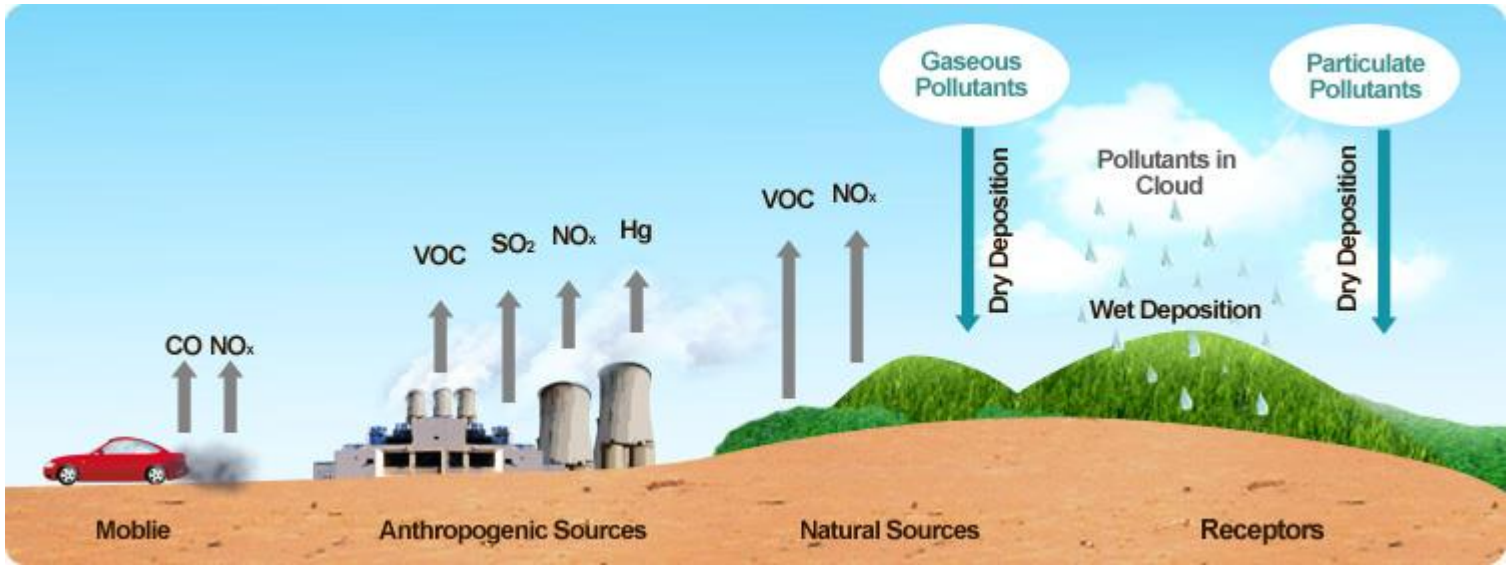
- Metal oxides make bases:
  - Magnesium strip of metal + flame→ magnesium oxide
  - Add indicator to water- Phenolthaleine- what is the pH?
  - Add magnesium oxide and watch colour change- what is the pH now?



- Non-metal oxides react with water to form **acids**
- $NO(s) + H_2O(l) \rightarrow HN(aq)$

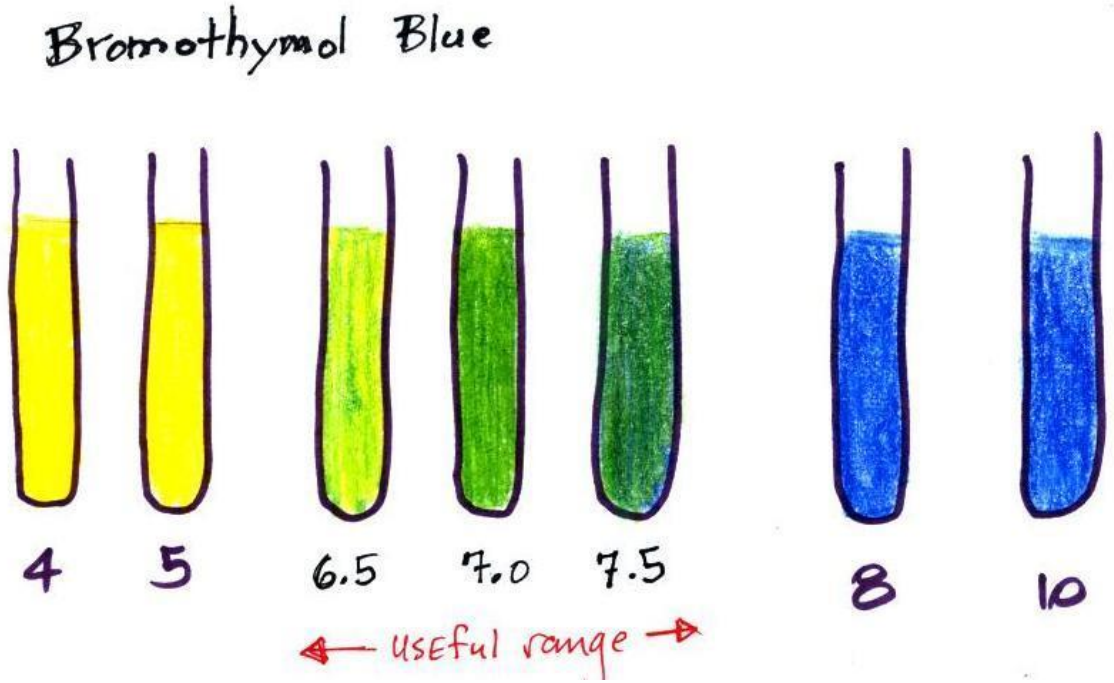
  - $CO_2(g) + H_2O(l) \rightarrow H_2CO_3(aq)$
  - $SO_3(g) + H_2O(l) \rightarrow H_2SO_4(aq)$
  - $NO_2(g) + H_2O(l) \rightarrow H_2NO_3(aq)$

- Non-metal oxides are formed from the burning of **fossil fuels**.
  - Acid added to water in the atmosphere = acid **precipitation**



Demo

- Non-metal oxides make acids:
  - Add indicator to water- bromthymol blue- what is the pH?
  - Add a straw and blow air into the liquid and watch colour change- what is the pH now?



Oxides

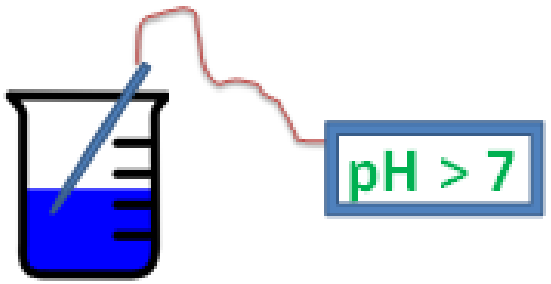
CO_2, SO_2, CaO, CO, ZnO, BaO, NO_2

Metal Oxides

CaO, ZnO, BaO,

Water

$Ca(OH)_2$, $Zn(OH)_2$, $Ba(OH)_2$



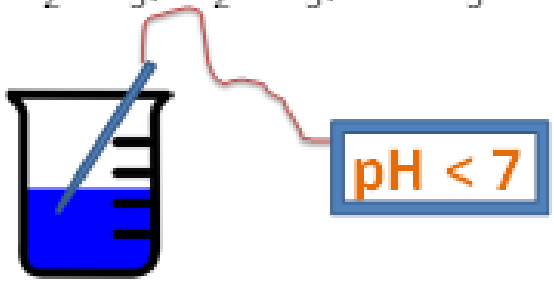
$MO(s) + H_2O(l) \rightarrow MOH(aq)$

Non-metal Oxides

CO_2, SO_2, NO_2

Water

H_2CO_3, H_2SO_3, HNO_3



$NO(s) + H_2O(l) \rightarrow HN(aq)$

Reading Check

1. What two types of pure substances are produced from the neutralization of an acid and a base?
2. What environmental problem is associated with the burning of coal and gasoline?
3. When a non-metal oxide is mixed with water, does the water become acidic or basic?
4. When a metal oxide is mixed with water, does the water become acidic or basic?

Acids and Metals, and Acids and Carbonates

- Acids and Metal
  - The most reactive metals, at the bottom of groups **1** and **2** on the periodic table, react **vigorously** with water and acids.
  - All other metals are **less** reactive than those in groups 1 and 2.

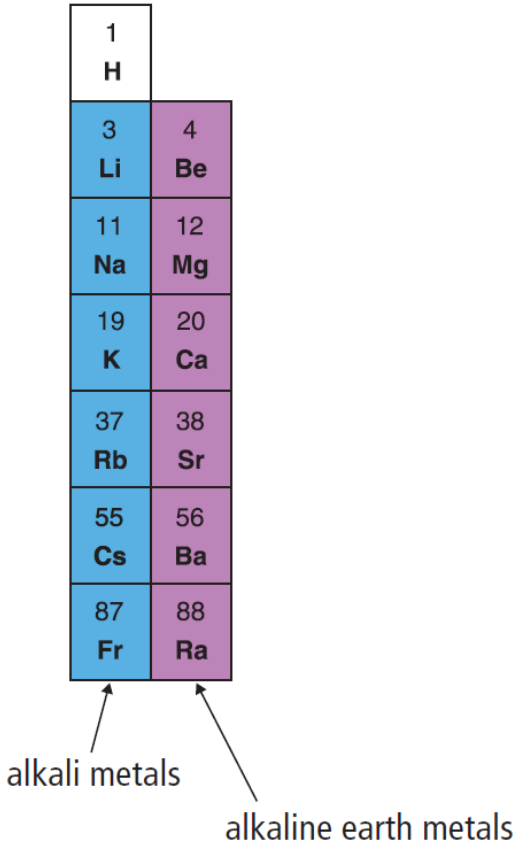


Figure 5.16 Metals increase in reactivity as you go down columns 1 and 2.

- When metals do react with acids, **H_2 gas** is usually released.
- $2HCl(aq) + Mg(s) \rightarrow MgCl_2(s) + H_2(g)$
- $HCl(aq) + Zn(s) \rightarrow$ $ZnCl + H_2(g)$
- $H_2SO_4(aq) + Mg(s) \rightarrow$ $MgSO4 + H_2(g)$

Practice Problems

Complete and balance the following chemical reactions between an acid and a metal. Remember that each reaction will produce a salt and hydrogen gas (H_2). Consider the formulas of your products carefully before you begin to balance.

1. $HCl + Zn \rightarrow$
2. $H_2SO_4 + Mg \rightarrow$
3. $HBr + Al \rightarrow$
4. $HCl + Ca \rightarrow$
5. $H_2SO_3 + Al \rightarrow$

Answers provided on page 592

Acids and Carbonates

- Carbonates **neutralize** acids, **protecting** locations with natural carbonate supplies from acid precipitation.

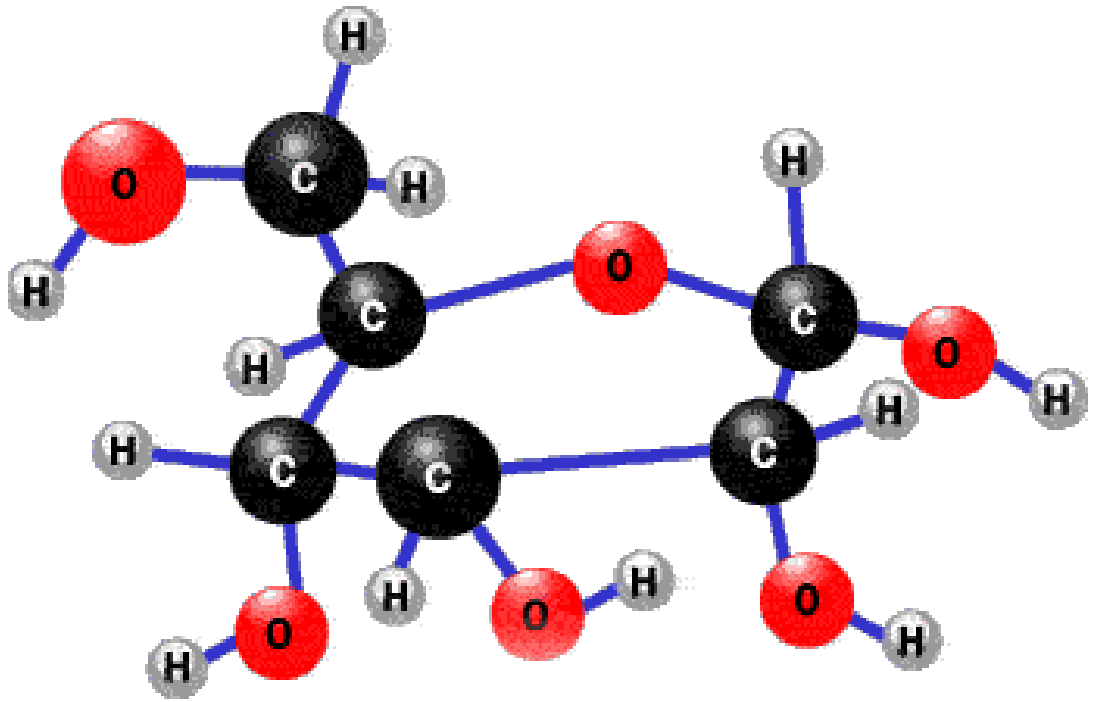
- $H_2SO_4(aq) + CaCO_3(s) \rightarrow CaSO_4(s) + H_2O(l) + CO_2(g)$

  sulphuric acid — *calcium carbonate* — *calcium sulphate* — *water* — *carbon dioxide*

To Do

- Chp 5.2 package pgs 93, 94, check understanding pg 1, 2

5.3 Organic Compounds



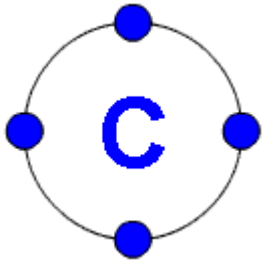
5.3 Organic Compounds

- Organic compounds contain **carbon** and usually hydrogen.
  - "Organic" sounds like the compounds come from **living** things, but some do, and some do not.
  - Inorganic compounds are compounds that do not have **carbon**.

Table 5.7 Comparing Formulas of Organic Compounds and Inorganic Compounds

Organic: Must Contain Carbon		Inorganic Containing Carbon
CH_4	methane (a hydrocarbon)	$CaCO_3$, Na_2CO_3 (carbonates)
CH_3CH_2OH	ethanol (an alcohol)	Al_4C_3, SiC (carbides)
C_6H_5COOH	benzoic acid (an organic acid)	CO, CO_2 (oxides)
$K_2HC_6H_5O_7$	potassium citrate (an organic salt)	**Inorganic Not Containing Carbon**
		$FeCl_2$
$C_8H_{10}N_4O_2$	caffeine (a stimulant)	$(NH_4)_2SO_3$
$CH_3\_(CH_2)_n\_CH_3$	polyethylene (a plastic) where $n = 5000$ and the CH_2 unit repeats about 5000 times	PBr_3

See pages 244 - 246



- Carbon has **four** electrons in its valence shell, which allows for more chemical bonding possibilities than any other element.
  - Long **chains** of carbons form petroleum and **plastics**.
- Organic molecules always have C **before** H in their formulas.
  - This differentiates organic compounds from **acids**, which almost always start with H.

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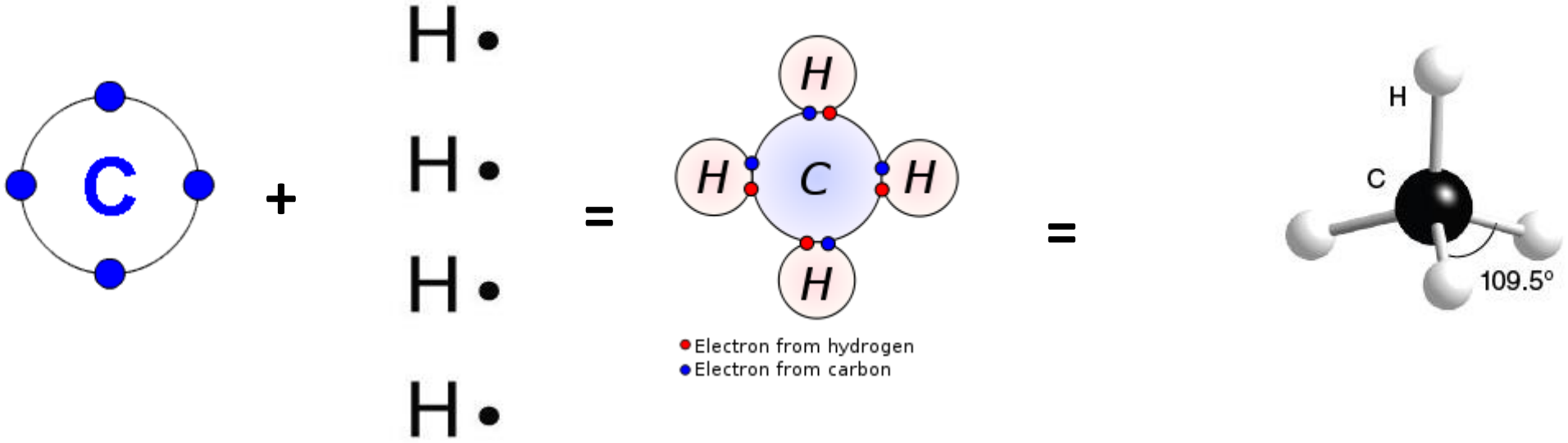
$C_8H_{10}N_4O_2$	caffeine (a stimulant)	$FeCl_2$
$CH_3\_(CH_2)_n\_CH_3$	polyethylene (a plastic) where $n = 5000$ and the CH_2 unit repeats about 5000 times	$(NH_4)_2SO_3$
		PBr_3

You can build organic compounds easily…

Example: What is the structure for CH_4?



Hydrocarbons

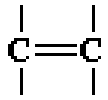
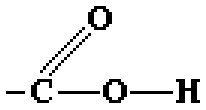
- A hydrocarbon is an organic compound that contains **only** carbon and hydrogen.
  - Hydrocarbons are based on a carbon chain, with **hydrogen** atoms added on the **sides**.
  - The simplest hydrocarbons are:
    - **methane** (CH_4)
    - **ethane** (C_2H_6)
    - **propane** (C_3H_8)
    - **butane** (C_4H_{10})
    - **pentane** (C_5H_{12})
  - All hydrocarbons are **flammable**, and most are liquids are room temperature.

Chain length	
C_1	meth-
C_2	eth-
C_3	prop-
C_4	but-
C_5	pent-
C_6	hex-
C_7	hept-

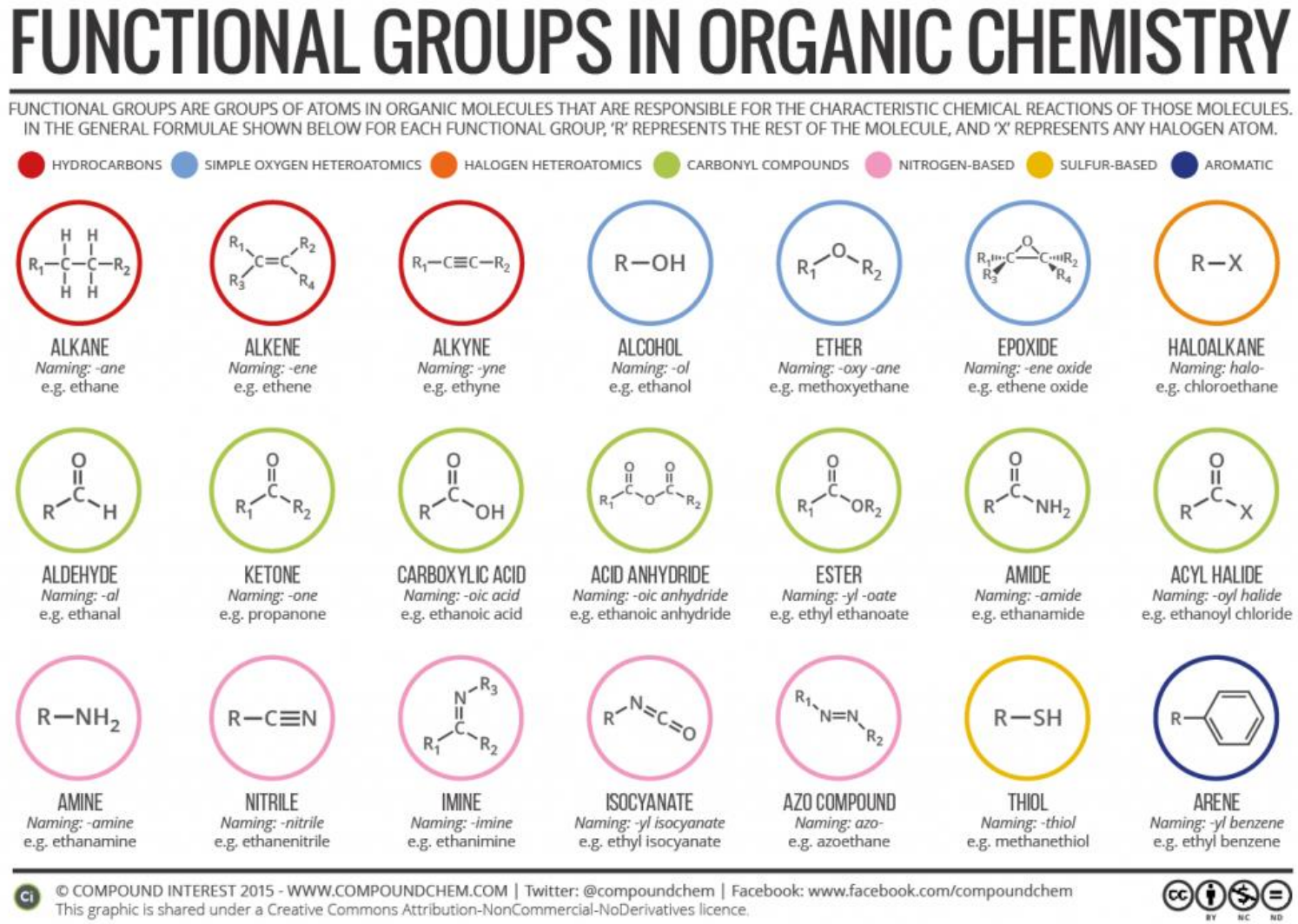
Alcohols

- Alcohols are organic compounds with C, H, and **O**.
  - The simplest alcohols are methanol (CH_4O), ethanol (C_2H_6O), and isopropyl alcohol (C_3H_8O).
  - Alcohols are very good **solvents** (they dissolve other substances).
  - Alcohols are generally very **flammable**.
  - Naming of alcohols is similar to Alkanes (the list on the last slide), except we add an "**-ol**" ending
    - Methanol (CH_3OH)
    - Ethanol (C_2H_5OH)
    - Propanol (C_3H_7OH)
    - Butanol (C_4H_9OH)
    - Pentanol ($C_5H_{11}OH$)

There are Other terms used for Other Functional Groups:

Functional group	
	-ene
-C≡C-	-yne
-O—H	-ol
-S—H	-thiol
	-oic acid

There are many functional groups in Organic Chemistry…



To Do:

- **Chapter 5.3 package**
- **Lab- Building Covalent Compounds using Molymods**

- **Tuesday- Chapter 5 Review Day**
- **Wednesday- CHAPTER 5 TEST**