# General Chemistry

***8 LECTURE COURSE***

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**Recommended Book:** **Chemistry and Chemical Reactivity - J.C. Kotz, P.M. Treichel, G.C. Weaver 6th edition, Thomson Books/Cole**

***further text books:***

***Chemistry- the molecular nature of matter and change – Silberberg 3rd edition***

***Chemistry-molecules, matter and change - Atkins and Jones, 5th edition***

***WebSites:*** ***http://www.tcd.ie/Chemistry/teaching/chemistry/jf/intro/intro.php***

***http://now.brookscole.com/kotz6e***

# Lecture 1

## Outline



Experimental setup: A flowerpot with a single drainage hole is filled with a mixture of iron oxide ($Fe_2O_3$) and coarsely ground aluminum (reaction mixture: Thermit® mixture). This is covered with a mixture of magnesium and barium peroxide ($BaO_2$) (ignition mixture). A strip of magnesium serves as a wick. A porcelain dish filled with sand is placed underneath.

## The Thermite Reaction

**Exothermic : Heat is released during this reaction (↔ endothermic)**

The magnesium-barium peroxide mixture is ignited by the burning magnesium ribbon. Magnesium oxide and barium oxide are produced in a strongly exothermic reaction according to:

$$BaO_2 + Mg \longrightarrow BaO + MgO$$

The heat emitted by this reaction ignites the Thermite® mixture.

Indices

Coefficients

Due to very high temperatures (up to 2400 °C, reaction enthalpy: 852 kJ/mol) the reaction of iron oxide with aluminium forms elemental iron, which seeps in liquid form out of the flower pot drainage hole:

$$Fe_2O_3 + 2\,Al \longrightarrow 2\,Fe + Al_2O_3$$

The molten iron is collected in the porcelain dish where it immediately hardens. An afterglow can be clearly seen. The Thermite® process is used to weld and join iron parts (such as iron tracks and street car tracks). A number of other metals can be obtained from their oxides by reduction with aluminium.

# CHEMISTRY

Is the study of matter,
its properties,
the changes that matter undergoes,
and
the energy associated with these changes.

## Chemical Systems

…… the substance viewed as a “chemical system”

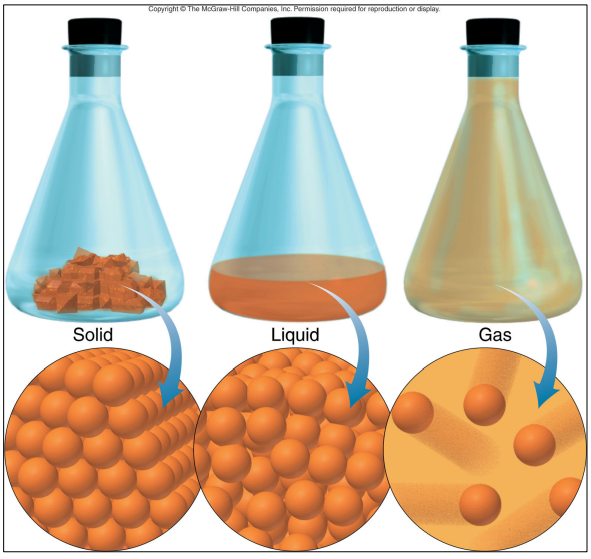
Sub-division; Analysis

chemical system ⇄ entities of the system

Construction; Synthesis

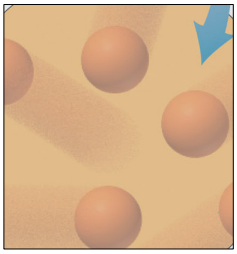
- Nature of the building units: Atoms, Molecules, Ions → qualitative aspects
- Number of building units → quantitative aspects
- Arrangement of the building units → structure

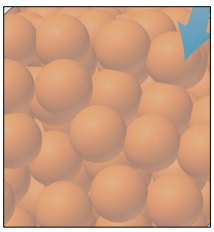
## The Physical States of Matter



A **Gas** has neither a definite shape nor definite volume:

*it adopts the volume and shape of the vessel containing it.*





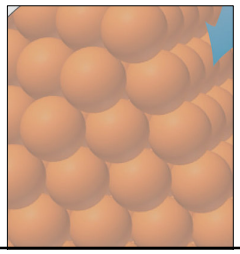
**Short range order**

A **Liquid** has definite volume but not shape:

*it adopts the shape of the vessel containing it.*

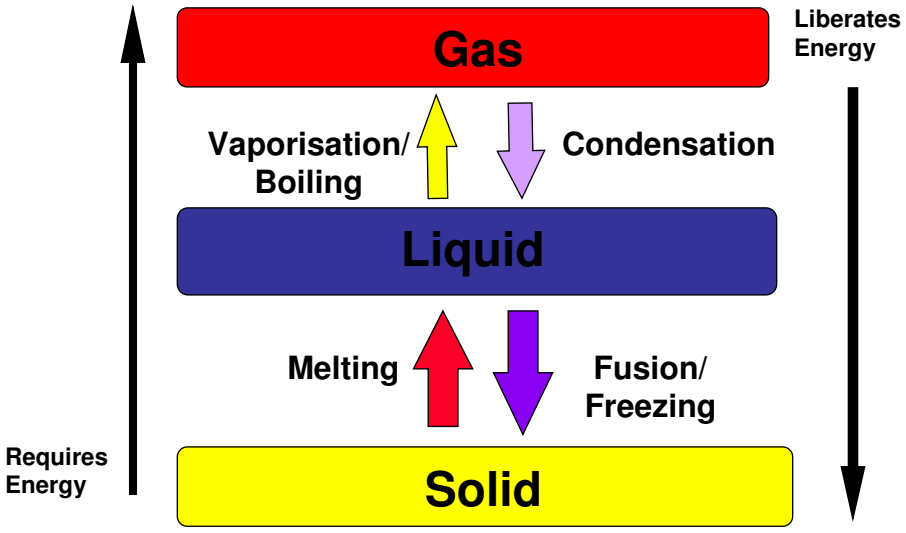
A **Solid** has definite volume and shape:

*which is independent of the vessel containing it.*



**Short- and long-range order**

## Changes of State

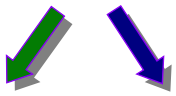


## Definitions

**Matter** anything that has mass and volume -the "stuff" of the universe

**Composition** the types and amounts of simpler substances that make up a sample of matter

**Properties** the characteristics that give each substance a unique identity



***Physical Properties***
those which the substance shows by itself without interacting with another substance, such as: colour, melting point, boiling point, density

***Chemical Properties***
those which the substance shows as it interacts with, or transforms into, other substances, such as: flammability, corrosiveness

**Sample Problem** **Distinguishing Between Physical and Chemical Change**

**PROBLEM:** **Decide whether each of the following process is primarily a physical or a chemical change, and explain briefly.**

(a) Frost forms as the temperature drops on a humid winter night.
(b) A cornstalk grows from a seed that is watered and fertilized.
(c) Dynamite explodes to form a mixture of gases.
(d) Perspiration evaporates when you relax after jogging.
(e) A silver fork tarnishes in air.

**Criteria:** **"Does the substance change composition or just change form?"**

**SOLUTION:**

(a) physical change (b) chemical change (c) chemical change

(d) physical change (e) chemical change

## Distinguishing between Intensive and Extensive Properties

An Intensive property is independent of the extent of the sample

- Intensive properties help identify a particular kind of matter
- Temperature, Melting point, Density

An **Extensive** property is dependent on the extent of the sample

- Extensive properties relate to the amount of matter present
- Mass, Volume, Length

## Pure Substances and Mixtures

**A Substance is a form of matter that has a definite composition and distinct properties.**

**Examples: water, ammonia, sucrose, gold, oxygen**

**It is important to distinguish between two different kinds of matter – i.e. Pure Substance and Mixtures:**

**Pure substances have:**

- **Fixed and definite composition**
- **Fixed and definite properties**
- **Their components cannot be separated by simple physical means**

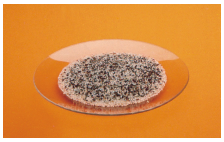
# Mixtures

A ***mixture*** is a combination of two or more substances in which the substances retain their distinct identities.

1. ***Homogenous mixture*** – composition of the mixture is the same throughout.

soft drink, solder

2. ***Heterogeneous mixture*** – composition is not uniform throughout.



**Can easily be separated by physical means**

*cement, iron filings in sand* *with a magnet*

**Solutions :** A homogeneous mixture is also called a solution.

Solutions in water are called ***aqueous solutions***, and are very important in chemistry. Although we normally think of solutions as liquids, they can exist in all three physical states.

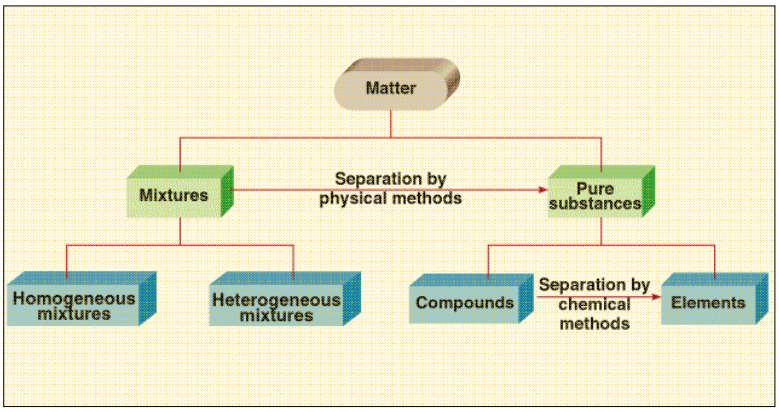
# Chemical Analysis

*…… often uses physical techniques*

Methods for separating the components of mixtures:

- **Filtration:**
  Separates components of a mixture based upon *differences in particle size*.
- **Distillation:**
  Separation is based upon *differences in volatility*.
- **Chromatography:**
  Separation is based upon *differences in solubility* in a solvent versus a chemical affinity to a stationary phase.
- **Crystallisation:**
  Separation is based upon *differences in solubility* of components in a mixture.

# Classification of Matter



# Measurement – SI Units

## SI - Base Units

| *Physical Quantity* | *Unit Name* | *Abbreviation* |
|---|---|---|
| mass | kilogram | kg |
| length | metre | m |
| time | second | s |
| temperature | kelvin | K |
| electric current | ampere | A |
| amount of substance | mole | mol |
| luminous intensity | candela | cd |

## Common Decimal Prefixes Used with SI Units

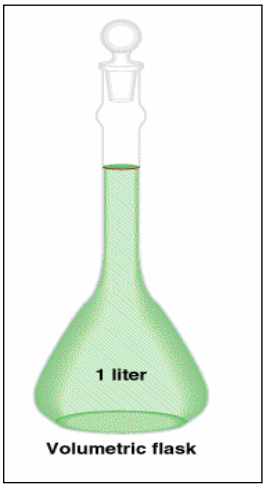
| *Prefix* | *Prefix Symbol* | *Number* | *Word* | *Exponential Notation* |
|---|---|---|---|---|
| tera | T | 1,000,000,000,000 | trillion | $10^{12}$ |
| giga | G | 1,000,000,000 | billion | $10^{9}$ |
| mega | M | 1,000,000 | million | $10^{6}$ |
| kilo | k | 1,000 | thousand | $10^{3}$ |
| hecto | h | 100 | hundred | $10^{2}$ |
| deka | da | 10 | ten | $10^{1}$ |
| ----- | ---- | 1 | one | $10^{0}$ |
| deci | d | 0.1 | tenth | $10^{-1}$ |
| centi | c | 0.01 | hundredth | $10^{-2}$ |
| milli | m | 0.001 | thousandth | $10^{-3}$ |
| micro | μ | 0.000001 | millionth | $10^{-6}$ |
| nano | n | 0.000000001 | billionth | $10^{-9}$ |
| pico | p | 0.000000000001 | trillionth | $10^{-12}$ |
| femto | f | 0.000000000000001 | quadrillionth | $10^{-15}$ |

## Derived SI Units

| Quantity | Definition of Quantity | SI unit |
|---|---|---|
| **Area** | **Length squared** | **$m^2$** |
| **Volume** | **Length cubed** | **$m^3$** |
| **Density** | **Mass per unit volume** | **$kg/m^3$** |
| **Speed** | **Distance traveled per unit time** | **m/s** |
| **Acceleration** | **Speed changed per unit time** | **$m/s^2$** |
| **Force** | **Mass times acceleration of object** | **$kg * m/s^2$ ( = newton, N)** |
| **Pressure** | **Force per unit area** | **$kg/(ms^2)$ ( = pascal, Pa)** |
| **Energy** | **Force times distance traveled** | **$kg * m^2/s^2$ ( = joule, J)** |

## Volume

*… SI derived unit for volume is cubic metre ($m^3$)*



Volumetric flask

$1\ mL = 1\ cm^3$

$1\ L = 1000\ mL = 1000\ cm^3 = 1\ dm^3$

$1\ dm = 10\ cm$

$1\ dm^3 = 10cm \times 10cm \times 10cm = 1000\ cm^3$

$1\ cm^3 = (1 \times 10^{-2}\ m)^3 = 1 \times 10^{-6}\ m^3$

## Density

*…… SI derived unit for density is $kg/m^3$*

$1\ g/cm^3 = 1\ g/mL = 1000\ kg/m^3$

$$\text{density} = \frac{\text{mass}}{\text{volume}} \qquad d = \frac{m}{V}$$

A piece of platinum metal with a density of 21.5 $g/cm^3$ has a volume of 4.49 $cm^3$. What is its mass?

$$d = \frac{m}{V} \Rightarrow m = d \times V$$

$$= 21.5\ g/\cancel{cm^3} \times 4.49\ \cancel{cm^3} = 96.5\ g$$

## *Temperature*

### …… Scales and Interconversions

**Celsius (°C) -** The centigrade temperature scale is the most commonly used scale around the world, water freezes at 0°C, and boils at 100°C.

### ….. *In science*

**Kelvin (K) -** The "absolute temperature scale" begins at absolute zero and only has positive values.

absolute zero = – 273.15°C

0°C = 273.15K

$$T\,(K) = T\,(^{o}C) + 273.15$$
$$T\,(^{o}C) = T\,(K) - 273.15$$