1

What is Chemistry?

Chemistry- study of the structure, properties, and changes of *matter*.

Matter- Anything that has mass and occupies space.

Atom- composed of protons and neutrons (mass) and electrons (occupies space).

2

States of Matter

- Solid- has definite shape and volume
- Liquid- definite volume, no definite shape
- Gas- indefinite volume, no fixed shape
- (Plasma)

3

Matter from Simple to Complicated

Atom- The smallest particle of an element, composed of protons, neutrons and electrons.

Element- A pure substance composed of only one type of atom.

Compound (AKA *molecule*)- A pure substance composed of more than one element.

Mixture of molecules

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About 100 Elements

H

He

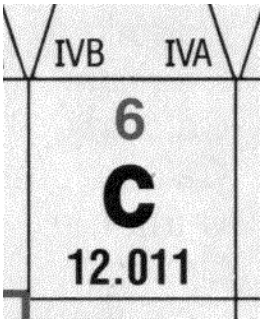
Unh

NaCl **NOT** NACL- this is so we can clearly indicate what a molecule is made up of.

EX: CONI

carbon oxygen nitrogen iodine (CONI)

cobalt nickel (CoNi)



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Elements

About 100

Where do they come from?

What are they used for?

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Sources of Elements

Earth's atmosphere- gases: N_2, O_2, H_2, others

seawater - Br_2, Cl_2, Na^+, K^+, Mg^{2+}, others

earth's crust - Li^+, Al^{2+}, Fe^{3+}, B, U, Mg^{2+}, others

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Element 1 - Hydrogen (H)

0.00005% of earth's atmosphere

most abundant element in known universe

colorless, odorless, tasteless gas

flammable when mixed with oxygen

uses: welding, flames, liquid H_2 used as coolant

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Five Main Branches of Chemistry

- Based on elements of interest
  - Inorganic chemistry- elements *other than* carbon
  - Organic chemistry- the chemistry of carbon molecules.
- Based other than on elements
  - Analytical chemistry- deals with measuring precise and usually small amounts of chemicals.
  - Physical chemistry- the physics of chemistry.
  - Biochemistry- deals with matter in living organisms.

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Chemical Formulas Are Used to Show How Elements Form Compounds

Molecular formulas do not show bonds

subscripts denote number of atoms, e.g. C_5H_{12}

superscripts denote charge, e.g. Ca^{2+}

Structural formulas show *chemical bonds* as (single) lines

EX: (very large structure)

Condensed formulas- for large molecules, helps to show atoms in relation to each other

EX: $CH_3CH_2CH_2CH_2CH_3$

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Practice Problems

1. Which elements are present in the compound CH_3CH_2SH?

Name	Symbol	Atomic Number	Atomic Weight
Actinium	Ac	89	227.0278
Aluminum	Al	13	26.98154
Americium	Am	95	(243)
Antimony (Stibium)	Sb	51	121.75†

2. Is O_2 an atom or a molecule?
3. How many atoms of hydrogen are in CH_3CH_2SH?

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Building Chemical Vocabulary

- CH_4 Methane Fuel
- H_2O water
- $C_6H_{12}O_6$ sugar
- $C_{12}H_{22}O_{11}$ sugar
- NaCl sodium chloride
- $CaCl_2$ calcium chloride

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Classifying Matter

Mixture- can be separated into two or more pure substances.

Heterogeneous- samples will not be equivalent (appearance, composition, and properties).

Homogenous- each sample will be equivalent.

Solution- uniform mixture of pure substances.

Pure substance- uniform and fixed composition.

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Pure Substances

- single type of element
- single type of compound

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Pure Substances

Only by studying a chemical in its pure form can we really understand what its properties are.

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Element 6 - Carbon (C)

0.027% of earth's crust

3 forms: diamond, graphite and amorphous

^{14}C (radioactive) continuously formed in earth's atmosphere by bombardment of cosmic N with solar neutrons

uses: many varied uses

$CH_3(CH_2)_{16}CO_2^-$ - stearic acid (soap)

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Changes

Chemical change- a rearrangement of matter which results in a change of physical properties.

Physical properties include solubility, color, melting point, odor, hardness, density, taste and state.

Physical change- A change in matter which does not alter the chemical properties of the matter.

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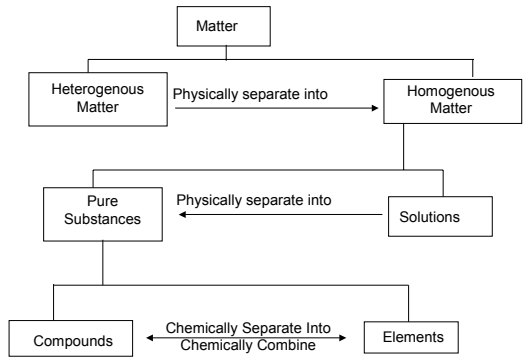
Summary of Matter



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Chemical Equations

Equations to chemists are like sentences to readers; they specify exactly what happens in a reaction, and specify everything that happens in a reaction.

Reactant(s) $\rightarrow$ Product(s)

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Chemical Equations: *Coefficients*

$2\ K + Cl_2 \rightarrow 2\ KCl$

2 K denotes how many react.

The 2 relates to everything which follows in the compound.

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Chemical Equations: Subscripts and Superscripts

$2\ K + Cl_2 \rightarrow 2\ KCl$

Cl_2 denotes 2 atoms of chlorine in a chlorine molecule

Subscripts refer only to the element immediately preceding

$MgO + H_2O \rightarrow Mg^{2+} + 2\ OH^-$

Superscripts will denote the charge on an ion

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Chemical Equations: State

$2\ K\ (s) + Cl_2\ (g) \rightarrow 2\ KCl\ (s)$

(s)(l)(g)(aq) denote the *state* of the molecules

aq = aqueous = dissolved in *water*

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Chemical Equations Must Be Balanced

There must be an equal number of atoms of each element on both sides of the equation.

$2\ K(s) + Cl_2(g) \rightarrow KCl(s)$ is not balanced

$2\ K(s) + Cl_2(g) \rightarrow 2\ KCl(s)$ is balanced

Balance only by placing a *coefficient* in front of molecule.

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Balancing Equations by Inspection

Don't change formulas of molecules or subscripts.

Don't forget that if you use a coefficient, all of the atoms in the molecule are increased.

Consider the substance with the most atoms first

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Chemical Reactions

$CH_4 + O_2 \rightarrow CO_2 + H_2O + \text{energy}$

$Fe + O_2 \rightarrow Fe_2O_3$

$C_4H_{10} + O_2 \rightarrow CO_2 + H_2O + \text{energy}$

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Energy and Chemicals

$C_6H_{12}O_6 + 6\ O_2 \rightarrow 6\ CO_2 + 6\ H_2O$ + Energy (glucose)

Potential Energy- energy stored in chemical bonds.

Kinetic Energy- Energy that results from a molecule being in motion.

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Observing Chemical Reactions

Changes in physical properties are indicative of a chemical reaction.

Physical Properties:
- Color
- Solubility
- Density
- Hardness
- mp/bp
- Odor
- Energy Changes

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Chemical Equations

You should be able for the exam to "read" a chemical equation.

$SO_4^{2-} + BaCl_2\ (aq) \rightarrow BaSO_4\ (ppt) + 2\ Cl^-$

$AgNO_3\ (aq) + NaCl \rightarrow AgCl\downarrow + NaNO_3\ (aq)$

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Sample Test Question

Balance the following reactions, or indicate that they are balanced as written.

$CH_4 + O_2 \rightarrow CO_2 + H_2O$

$C_8H_{18}\ (l) + O_2\ (g) \rightarrow CO_2 + H_2O$

$Fe_2O_3\ (s) + C\ (s) \rightarrow Fe\ (s) + CO_2\ (g)$

$SO_2 + O_2 \rightarrow SO_3$

$C_6H_{12}O_6(aq) \rightarrow CO_2(g) + CH_3CH_2OH(aq)$

$(NH_4)_2SO_4 + BaCl_2 \rightarrow BaSO_4\ (ppt) + NH_4Cl$

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Measurements

What are some of the things you have measured?

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Measurements

Length	inches, feet, yards, rods
Weight	lb, ton
Temperature	^oF
Time	sec, min, hr
Volume	cups, bushels
Energy	BTU

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Fundamental Scientific Measurements

	SI unit	abbreviation
Length	Meter	m
Mass (weight)	Kilogram	kg
Temperature	Kelvin	K
Time	Second	s
Amount	Mole	mol
Light intensity	Candela	cd
Electric current	Ampere	A

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Derived Scientific Measurements

	Formula	Unit abbreviation
Area	length x width	m^2
Volume	length x width x height	m^3
Density	mass/volume	g/mL

Many others that we will deal with later.

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Why the Metric System?

- Scientist use the metric system- easier to do conversions, communicate with others
- Case is very important- pay attention to detail
- prefixes commonly used
  - mega- M 10^6 million
  - kilo- k 10^3 thousand
  - centi- c 10^{-2} one-hundreth
  - milli- m 10^{-3} one-thousandth
  - micro- μ 10^{-6} one-millionth

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Measurement

An important point to reiterate is that all measurements in chemistry must include units.

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Sample Test Questions

1. Fill in the following table of measurements and units.

Measurement	SI Unit	Metric Unit
Length	m	_____
mass	____	_____
____	K	^oC

2. How many joules are in a megajoule (MJ)?

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Quality of Measurements Accuracy/Precision/Significant Figures

Accuracy- how close a measurement is to the "true value"

Precision- how reproducible is the measurement

Significant Figures- The number of significant figures is based on the measurements taken

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Example of Making Measurements and Significant Figures

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Rules That Govern Significant Figures

1. All non-zero digits are significant.
2. Zeros to the left of the first nonzero digit are not significant.
3. Zeros between nonzero digits are significant.
4. Zeros at the end of a number that includes a decimal point are significant.

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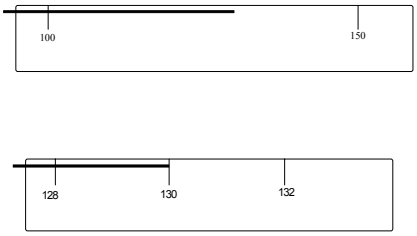
Why the End Zero Isn't Significant (without a decimal point)



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Calculations with Significant Figures

1. In addition and subtraction an answer should have no more decimal places than the number with the fewest decimal places.

   Rounding off.

   Exact numbers-numbers which are not measurements and therefore not estimated.
2. For multiplication and division the answer is limited to the number of digits in the number with the fewest significant figures.

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Sample Test Question

- How many significant figures should the following calculation have?

  $25.0 \times 3.0 \times 4.88$

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Scientific Notation

- Very large numbers (Avogadro's number)
  602,200,000,000,000,000,000,000 atoms/mol
- Very small numbers (mass of an electron)
  0.000,000,000,000,000,000,000,000,9110 g
- Number between 1 and 9.99
- $\times 10^{n}$ where n is the number of decimal places you had to move to get to the number
- 6.022×10^{23} atoms/mol
- and 9.110×10^{-28} g

44

Sample Test Question

Convert the following numbers into or out of scientific notation

0.000308

5.7×10^{4}

12,578

8.6×10^{-3}

57,867,908

65,000,000,000

45

Calculations in Scientific Notation (Appendix B)

- Addition and Subtraction
  - convert numbers to same power of 10
  - add or subtract coefficients
- Multiplication
  - multiply coefficients
  - add exponents
- Division
  - divide coefficients
  - subtract exponent of denominator

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Conversions (Appendix C)

1. Where are you?
2. Where do you want to go?
3. What conversion factors do you need to get there?

unit cancellation method
AKA Factor label method
AKA dimensional analysis

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Practice Conversion Problems

1. Over 40. billion kilograms of sulfuric acid are produced in the US each year. How many pounds per day is this?
2. What is the mass, in kilograms, of a 65-pound chimpanzee?