GENERAL CHEMISTRY I -- Chem 205

By learning the fundamentals of chemistry, you'll learn to address real world questions…

- Why does ice float? & Is this *normal*?
- What is battery acid? & Why is it in there?
- How do neon signs work?
- What will help get a grease stain out?
- How do air bags work?

(1)

GENERAL CHEMISTRY I -- Chem 205

WHY STUDY CHEMISTRY ?

- learn how substances tend to behave, & why
- learn to figure out how everyday stuff works

BUILD SKILLS:

- learn to think on multiple levels
- learn to apply knowledge
- learn to attack problems

Section 03: Tues & Thurs 8:45-10:00 in SP-S110
Lecture 01: Thurs. Jan.03/08

Professor: Dr. Cerrie Rogers, SP-201.17, x5838
office hours Mon.-Fri., 4-5pm

Chemistry - think small to understand the big picture

macroscopic ⟷ microscopic ⟷ particulate

Graphite: slippery

WHY?

- layered structure of carbon atoms
- layers can slide!

How is behaviour related to composition?

- What are the substance's fundamental building blocks?
- How they are arranged?

Can we manipulate composition to get results we want?

- Pharmaceuticals, plastics, preservatives, paints, *etc…*

← TIMELINE OF TOPICS IN CHEM205

1ST: WHAT HAPPENS (practical)

2ND: UNDERSTANDING WHY (theoretical)

Classifying matter & making measurements

Atoms & elements

Molecules, ions & their compounds

Chemical equations & reaction outcomes

Typical reactions that occur in water

How to realistically think about atoms

Why different elements have different properties

Understanding how molecules are "put together" & how this affects the substance's properties

Understanding the behaviour of gases

CHAPTER 1: Matter & Measurement

1.1 Classifying matter
1.2 Elements & atoms
1.3 Compounds & molecules
1.4 Physical properties
1.5 Physical & chemical changes
1.6 Units of measurement
1.7 Precision, accuracy & experimental error
1.8 Mathematics of chemistry

Order:

Start with: qualitative aspects sections 1.1-1.5

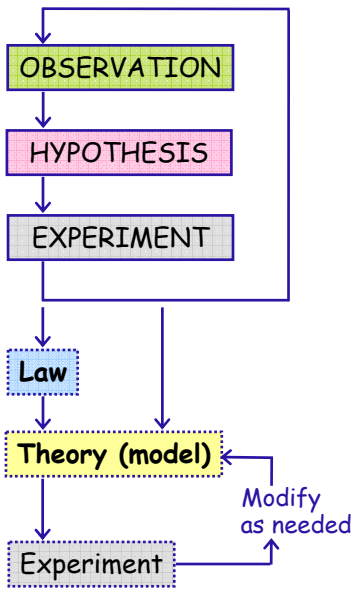
Next class: quantitative aspects sections 1.4, 1.6-1.8

Chapter Goals:

1. **Classify matter**
2. **Recognize elements, atoms, compounds, molecules**
3. **Identify physical & chemical properties & changes**
4. **Apply the kinetic-molecular theory to the properties of matter**
5. **Use metric units & significant figures correctly**
6. **Understand & use the mathematics of chemistry**

The Scientific Method (*cf* Kotz's preface to students)

- Qualitative / Quantitative
- Tentative explanation
- Systematic, controlled observations / measurements
- Verbal / mathematical description of **WHAT HAPPENS**
- Model proposed to explain **WHY** the behaviour occurs



From: *Chemistry – Principles, Patterns & Applications*, by B.Averill & P. Eldredge; Pearson; 2007.

Qualitative observation = describing things

1.4 Physical properties

see Table 1.1

How can we identify a substance (if it's pure)?
Can observe & describe…without changing its composition

- Colour, odour
- State of matter: ***Gas? Liquid? Solid?***
- Appearance: ***Shape? Powdered? Crystalline? Transparent?***
- Melting point, boiling point
- Solubility: ***How much will dissolve? In what will it dissolve?***
- Electrical conductivity: ***conductor vs. insulator?***
- Malleability: ***easily deformed?***
- Ductility: ***easily drawn into a wire?***
- Viscosity: ***for liquids: thick or thin? Does it flow easily?***
- Density: ***mass per unit volume***

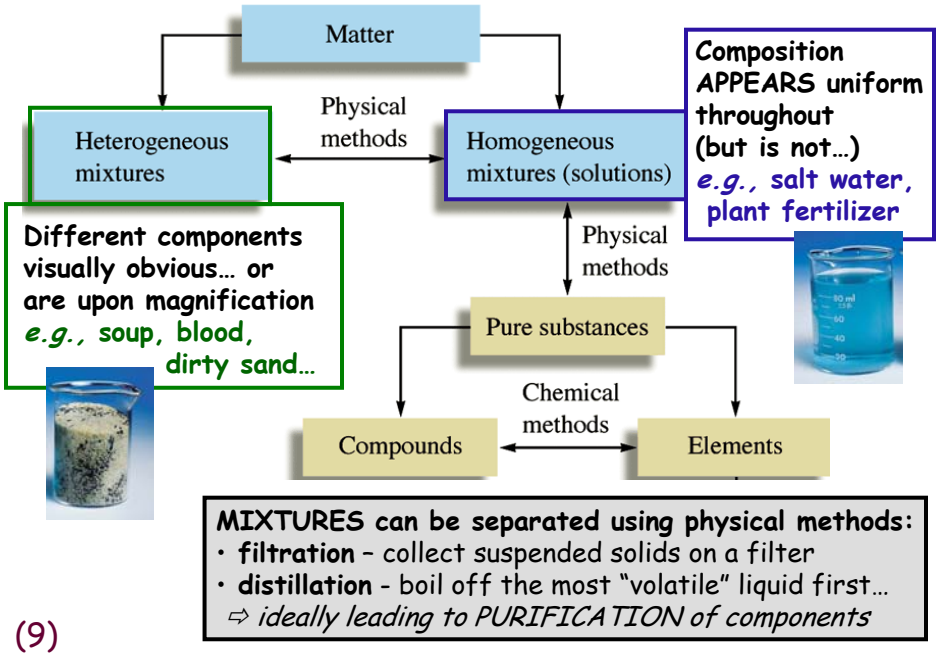
(7)

Remember your common knowledge:

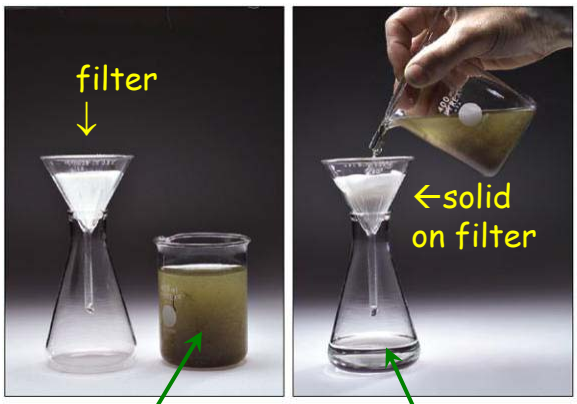
Property	Aluminum	Table salt
Colour		
Appearance		
Soluble?		
Malleable?		
Ductile?		

(8)

Classifying matter: mixtures *vs.* pure substances



Separating heterogeneous mixtures: Filtration



heterogeneous liquid - solid mixture

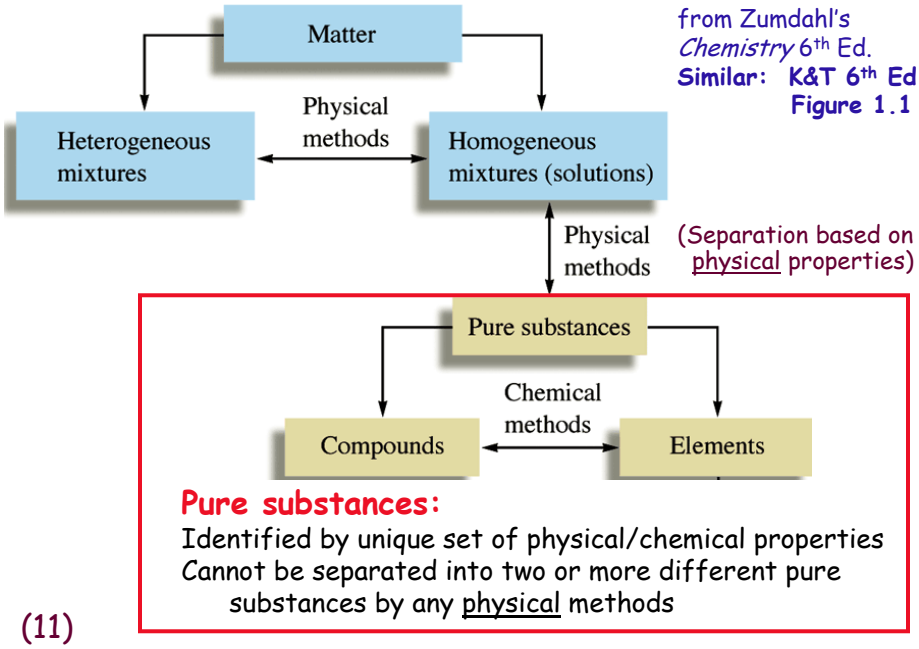
homogeneous liquid filtrate

Kotz 6th Figure 1.5

industrial scale

→ to further purify:
…evaporate solvent & collect residue

Classifying matter: mixtures *vs.* pure substances



from Zumdahl's *Chemistry* 6th Ed.
Similar: K&T 6th Ed. Figure 1.1

(Separation based on physical properties)

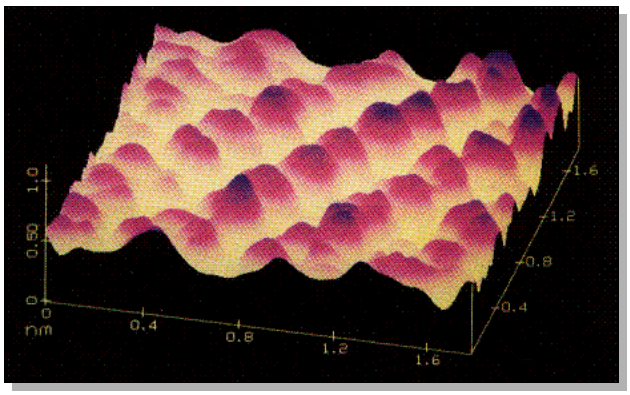
Pure substances:
Identified by unique set of physical/chemical properties
Cannot be separated into two or more different pure substances by any physical methods

1.2 Elements and atoms

(details? Ch. 2, 7, 8)

Building blocks: what are elements made of?

An **ATOM** = smallest particle of an element that has the chemical properties of that element



A layer of copper (Cu) atoms on a silica (SiO_2) surface.

(from Kotz 5th Ed.)

Distance across = 1.8 nanometers (1.8 x 10^{-9} m)

CHEMICAL ELEMENT: *building blocks made of ONE kind of atoms*
= pure substance that <u>cannot be decomposed</u> into other substances via physical means (*i.e.,* manipulating phys. properties).

Figure 1.6

1.3 Compounds & molecules

COMPOUND: *building blocks (all same) composed of 2 or more elements*
= pure substance requiring **chemical means** to revert back to elements

Properties: <u>different</u> from parent elements

Composition: <u>specific</u> proportions of elements

1) chemical formula
= atom-to-atom ratio

2) percentage composition
= % each element by mass

Water:
11.19% H & 88.81% O by mass
In 100g of water:
11.19 g due to H atoms, 88.81 g to O atoms (as part of molecules!)

- NOT just a physical mixture

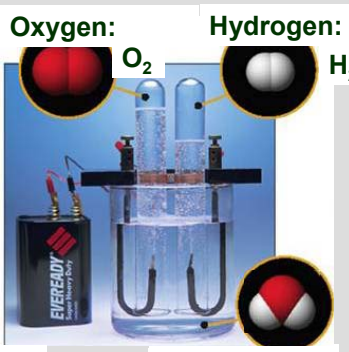


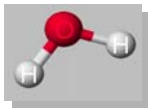
Fig. 1.6 Water: H_2O

Building blocks for compounds *(details? Ch. 3, 9)*

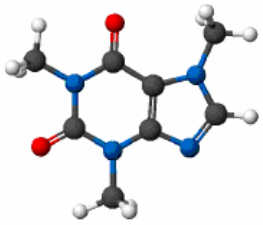
= smallest group of atoms / ions that retains BOTH the composition & characteristics of the compound

COVALENT COMPOUNDS

MOLECULE = atoms bonded together into discrete unit



Water
H_2O

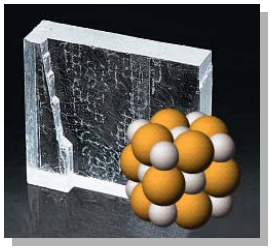


Caffeine
$C_8H_{10}N_4O_2$

IONIC COMPOUNDS

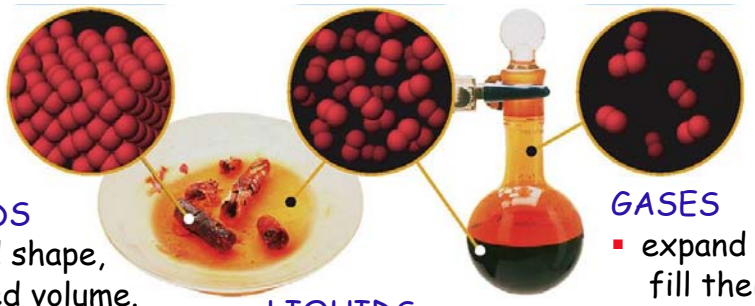
IONS = electrically-charged atoms or groups of atoms

Common salt NaCl



1.1 Classifying matter: States of matter (a particulate view)

Kotz 6th Active Fig. 1.2



SOLIDS

- rigid shape, fixed volume.
- external shape can reflect particles' arrangement.
- behaviour is reasonably well understood.

LIQUIDS

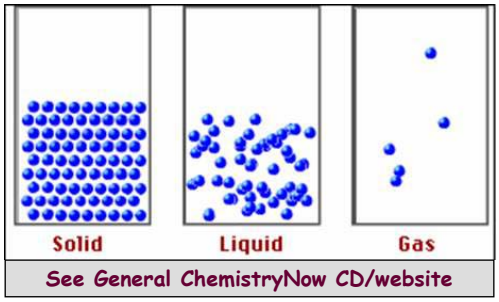
- fluid shape, but fixed volume.
- behaviour is not well understood (*i.e.*, complicated).

GASES

- expand to fill their container.
- behaviour very well understood (& simple).

See Ch. 12

Matter consists of particles in constant motion.
– Kinetic Molecular Theory



See General ChemistryNow CD/website

Kinetic energy ∝ Temp.
i.e., higher temperature
⇩
faster motion

- Between particles: **forces of attraction…**
- Low temperatures: matter usually solid
  - *WHY?* K.E. is low ∴ attractive forces seem large
- Higher temperatures: change to liquid…or gas…
  - *WHY?* Higher K.E. ∴ can overcome attractions

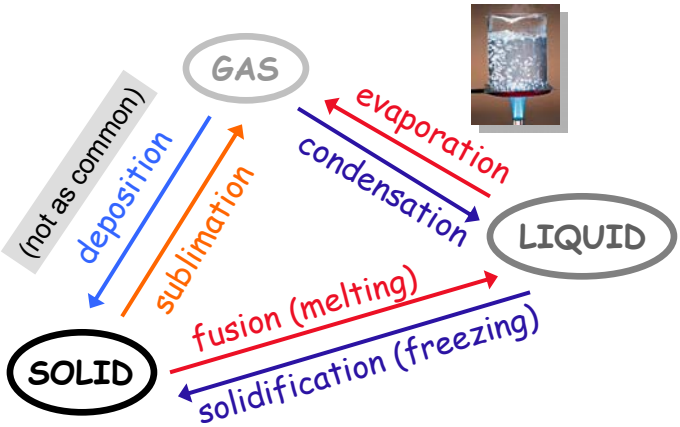
(17)

Physical change *e.g.,* phase changes (changes of state)

→ Change in organization of particles, but NOT composition
→ Temperatures at which these changes occur are characteristic intrinsic properties

When particles move closer together: energy released as heat

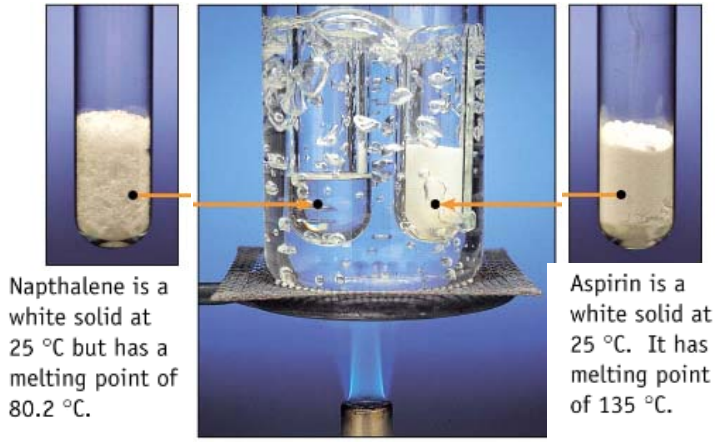
When particles are forced farther apart: energy input required



Making observations: always describe before AND after

PHYSICAL CHANGE:

Figure 1.12: using a physical property for identification



Napthalene is a white solid at 25 °C but has a melting point of 80.2 °C.

Aspirin is a white solid at 25 °C. It has a melting point of 135 °C.

PHASE CHANGE: $C_{10}H_8(s) \xrightarrow{\text{Physical change}} C_{10}H_8(l)$

Naphthalene solid → Naphthalene liquid

(19)

1.5 Physical change *vs.* chemical change

Change in organization of atoms/molecules/ions	Change in composition of atoms/molecules/ions
WHY: Change in interactions between molecules	*WHY:* Rearrangement of bonds between atoms/ions
Identity of substance(s) UNCHANGED	Identity of substance(s) CHANGED
melting butter dissolving sugar boiling water	**burning butter digesting sugar reacting water with Na(s)**
BOTH often involve transfers of energy: release (or absorption) of HEAT or LIGHT	

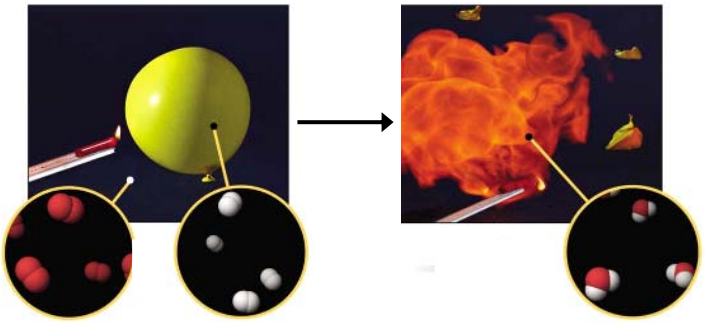
(20)

Chemical change: change in composition

- Chemical reactions involve REARRANGEMENT of bonds between atoms…but not net loss/gain of atoms

Macroscopic view:

Particulate view:



Symbolic view:

$2\ H_2(g) + O_2(g) \longrightarrow 2\ H_2O(g)$

Reactants — Chemical change — Products

Fig. 1.13

Chemical properties: rxns typical of a substance

- Rusting -- of iron
- Combustion -- of wood, gasoline "organic materials"
- Tarnishing -- of silver
- Hardening -- of cement
- Violent reaction with water
  - *E.g.,* potassium metal →

Fig. 1.13

Making observations: Always describe <u>before</u> AND <u>after</u>

ASSIGNED READINGS

- NEXT CLASS: covers rest of chapter 1
- BEFORE NEXT CLASS:

  READ all of Chapter 1 & work on exercises

- **LABS & TUTORIALS START NEXT WEEK.**
  ARRIVE PREPARED: lab coat, safety glasses
  lab manual
  completed Expt. #1 prelab.
  completed tutorial homework
- **CHEM 101 SEMINARS ARE NEXT WEEK.**
  SIGN UP AT CHEMISTY MAIN OFFICE: SP-201.01