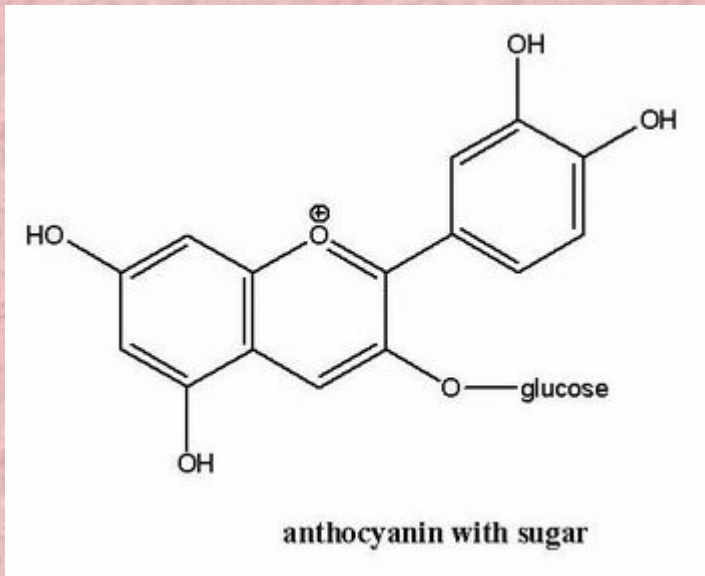
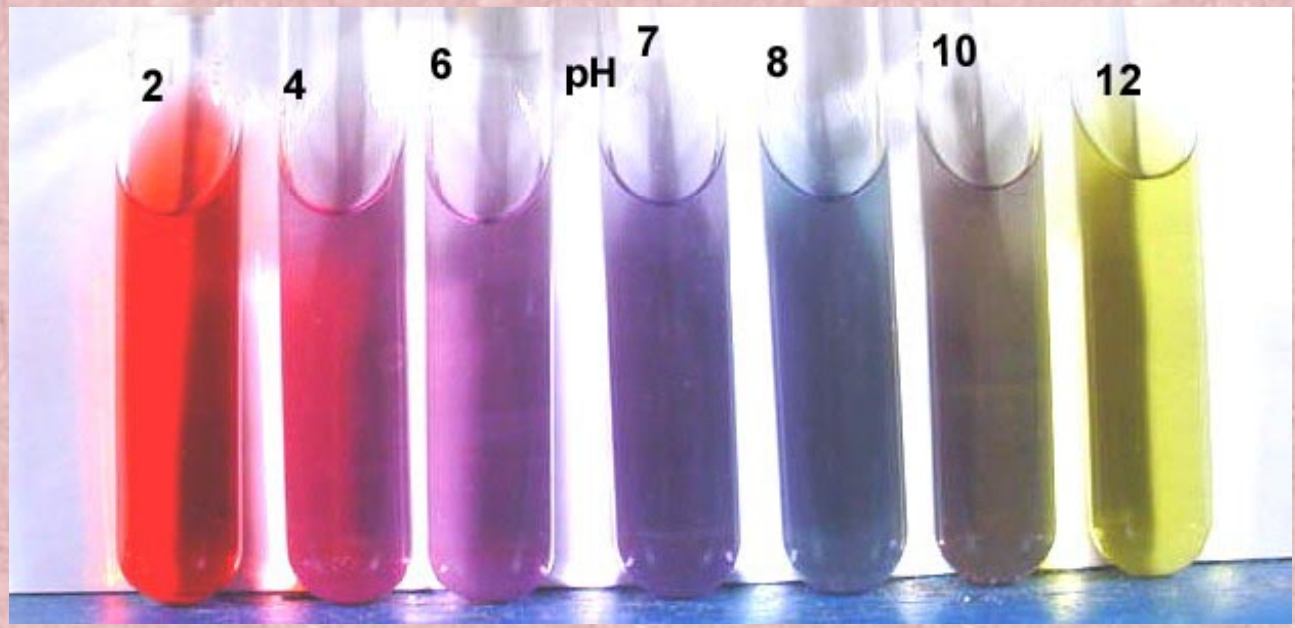
CHAPTER ONE

The Foundations of Chemistry



anthocyanin with sugar

Red pigment



CHAPTER 1
The Foundations of Chemistry

The rose on the right is in an atmosphere of sulfur dioxide, SO_2.

Gaseous SO_2 and aqueous solutions of HSO_3^- and SO_3^{2-} ions are used as bleaching agents.

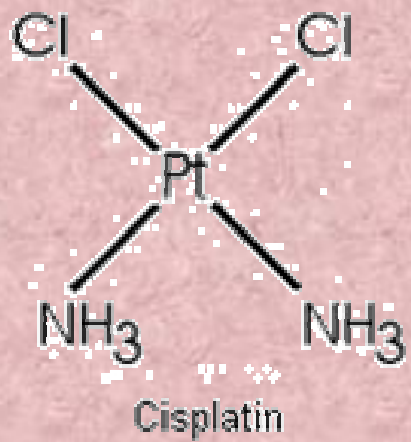
A similar process is used to bleach wood pulp before it is converted to paper.

Why is lemon often added to seafood?

The odor that we associate with fish is due to the presence of amines. That is one reason why lemon is often added to seafood. The citric acid (a weak acid) neutralizes the odor of the amines.

Treatment of cancer

Platinum



Cisplatin

Slows the growth Of cancer cells

Barnett Rosenberg

Matter and Energy - Vocabulary

- Chemistry
  - **Science that describes matter – its properties, the changes it undergoes, and the energy changes that accompany those processes**
- Matter
  - **Anything that has mass and occupies space.**
- Energy
  - **The capacity to do work or transfer heat.**

States of Matter

- Solids

Ice is solid H_2O

States of Matter

- Solids
- Liquids

Liquid

H_2O

States of Matter

- Solids
- Liquids
- Gases

Steam is gaseous H_2O

States of Matter

- Solids
- Liquids
- Gases
- Plasma (another form of the gaseous state)

Chemical and Physical Properties

- Chemical Properties - chemical changes
  - rusting or oxidation
  - chemical reactions
- Physical Properties - physical changes
  - changes of state
  - density, color, solubility
- Extensive Properties - depend on quantity (mass, volume)
- Intensive Properties - do not depend on quantity (color, temperature, density, melting point, etc.)

Chemical and Physical Properties

- Chemical Properties - chemical changes
  - rusting of iron

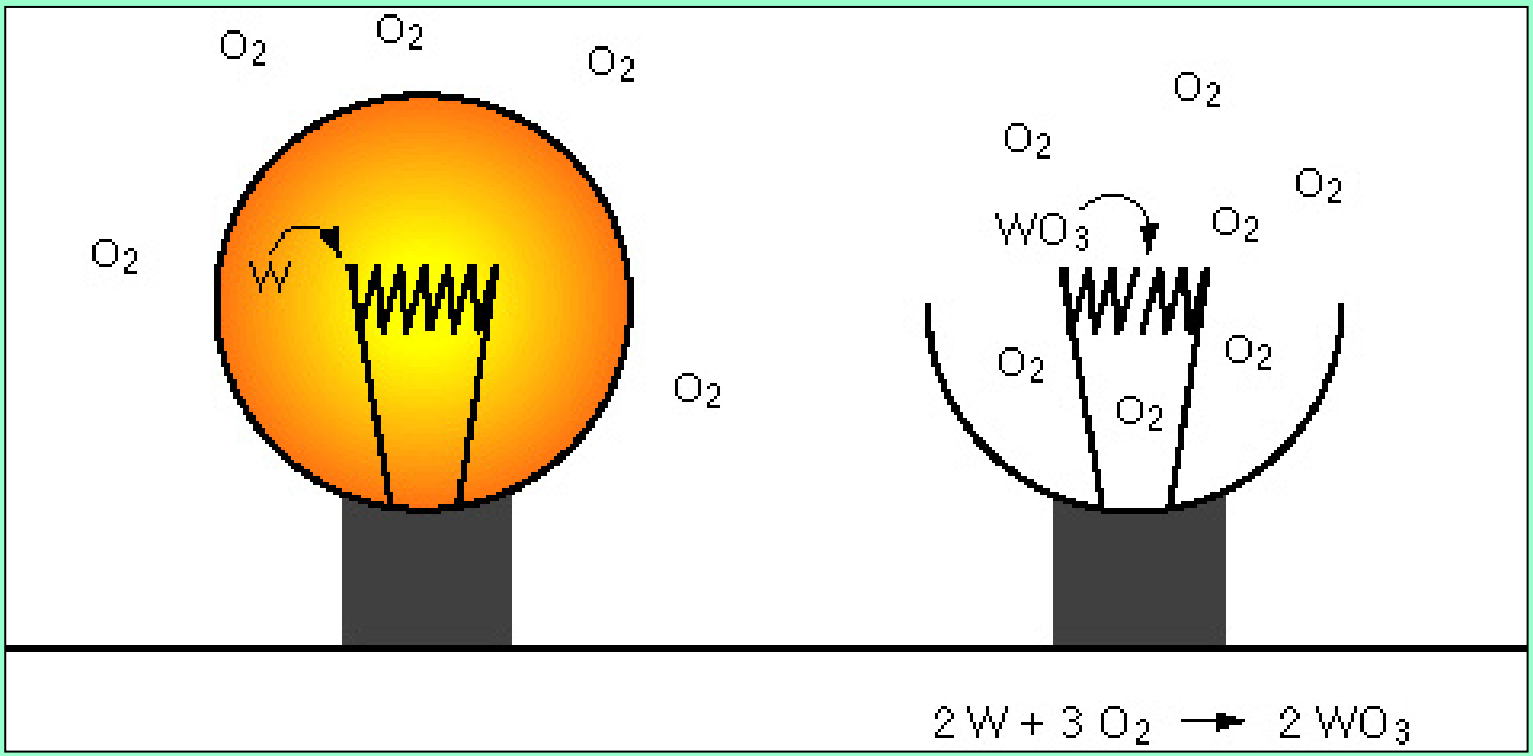
$$Fe + O_2 \xrightarrow{\text{unbalanced}} Fe_2O_3$$

  - Burning gasoline

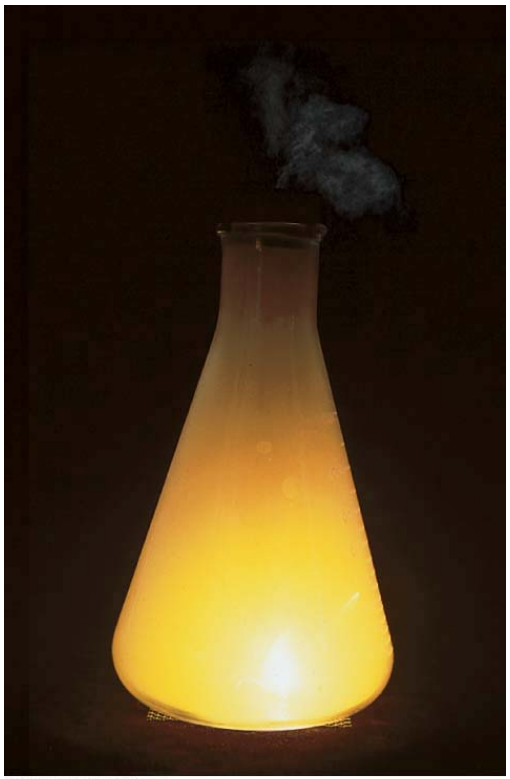
$$C_8H_{18} + O_2 \xrightarrow{\text{unbalanced}} CO_2 + H_2O$$

Chemical Changes

$$2W + 3O_2 \longrightarrow 2WO_3$$



Label each of the following as either a physical process or a chemical process?



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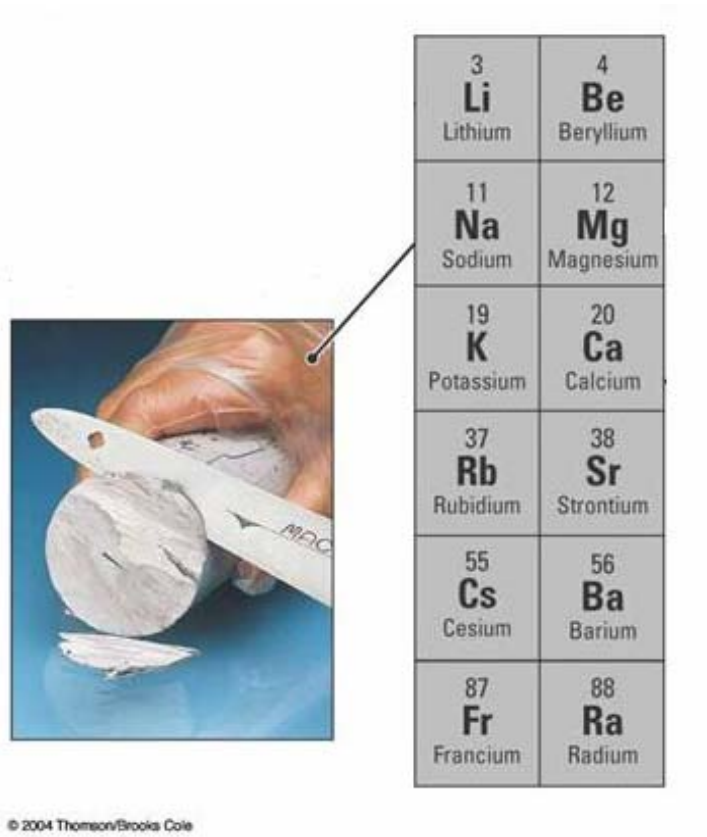


Exothermic…Endothermic

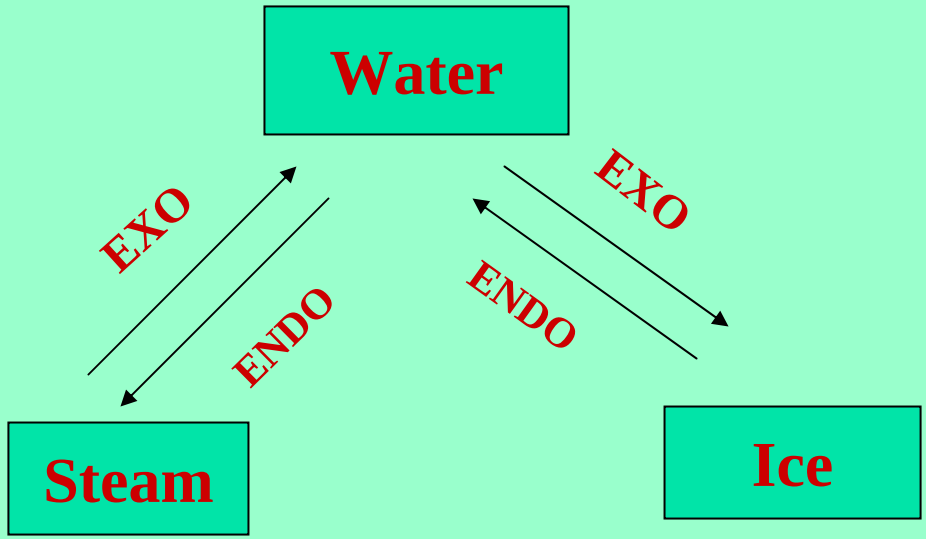
- **(a) Combustion is an *exothermic* process in which a chemical reaction *releases* heat.**
- **(b) The freezing of water is an *exothermic* process. Heat must be *removed* from the molecules in the liquid state to cause solidification.**
- **(c) The melting of ice is an *endothermic* process. The system *requires* heat to break the attractive forces that hold solid water together.**

Exothermic…Endothermic

- **(d) The boiling of water is an *endothermic* process. Molecules of liquid water must *absorb* energy to break away from the attractive forces that hold liquid water together in order to form gaseous molecules.**

- **(e) The condensing of steam is an *exothermic* process. The heat stored in water vapor must be *removed* for the vapor to liquefy. The condensation process is the opposite of boiling which requires heat.**

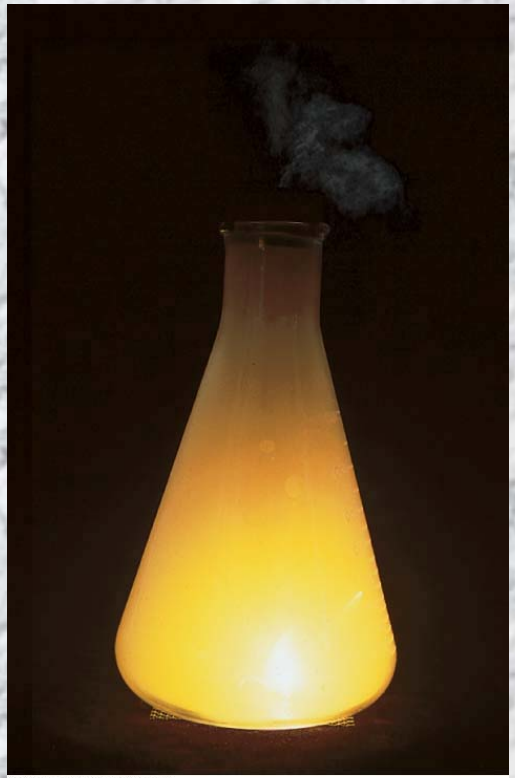
Exothermic…Endothermic



Take-Home Vocabulary

- **Endothermic: Describes processes that *absorb* heat energy.**
- **Exothermic: Describes processes that *release* heat energy.**
- **Energy: The *capacity to do work* or transfer heat.**

Exothermic...Endothermic



Exothermic...Endothermic

Mixtures, Substances, Compounds, and Elements

- Substance
  - matter in which all samples have identical composition and properties
- Elements
  - substances that cannot be decomposed into simpler substances via chemical reactions
- Elemental symbols
  - found on periodic chart (Table 1-2)

Mixtures, Substances, Compounds, and Elements

- What is the symbol for the element copper?

a. C

b. Co

c. Cm

d. Cu

e. Cr

Mixtures, Substances, Compounds, and Elements

Which name - symbol combination is **wrong**?

a. silver – Au
b. krypton – Kr
c. zinc – Zn
d. platinum – Pt
e. tungsten - W

Mixtures, Substances, Compounds, and Elements

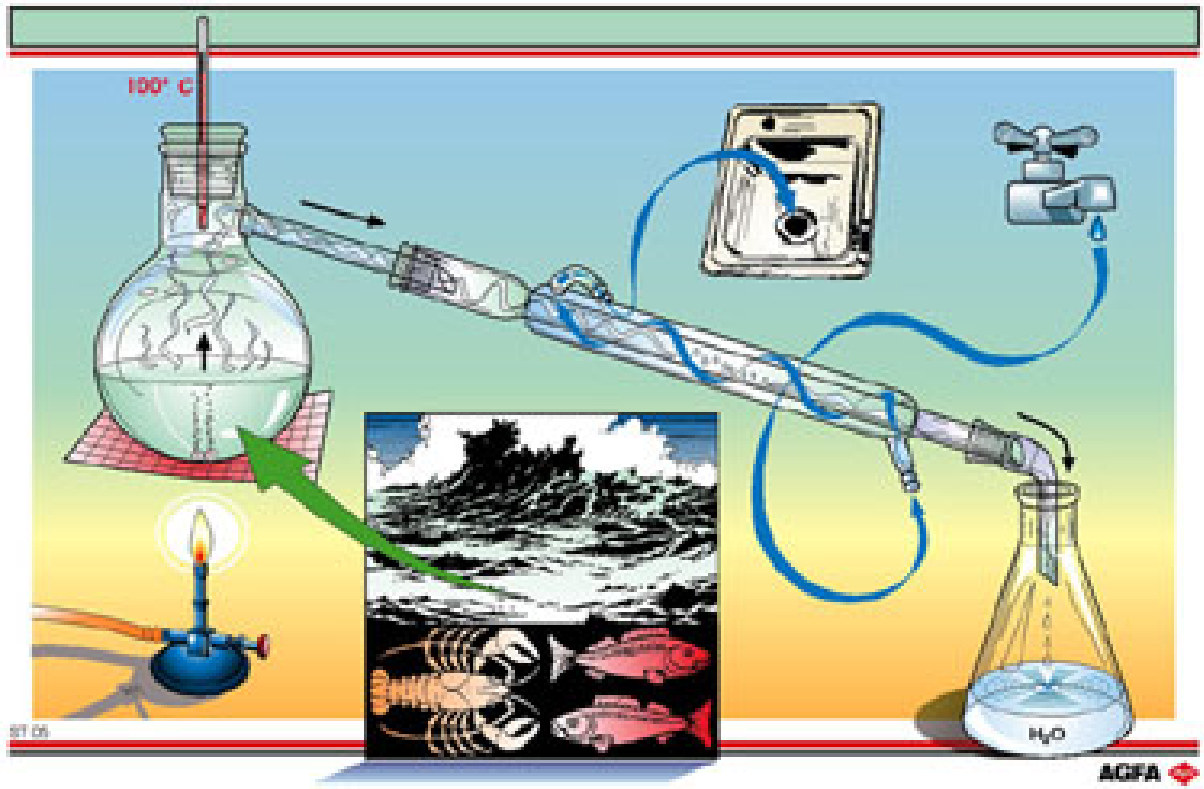
- Compounds
  - substances composed of two or more elements in a definite ratio by mass
  - can be decomposed into the constituent elements
    - Water is a compound that can be decomposed into simpler substances – hydrogen and oxygen

Mixtures, Substances, Compounds, and Elements

- Mixtures
  - composed of two or more substances
  - homogeneous mixtures: e.g. solution (dissolved salt + water, brass, etc.)
  - heterogeneous mixtures: e.g. soil (rocks, clay, organic matter, etc.)

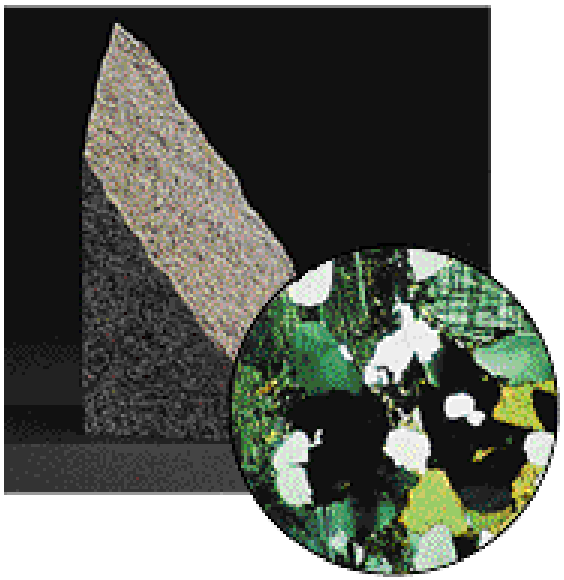
Mixtures, Substances, Compounds, and Elements

- Mixtures
  - composed of two more substances
  - homogeneous mixtures: NaCl

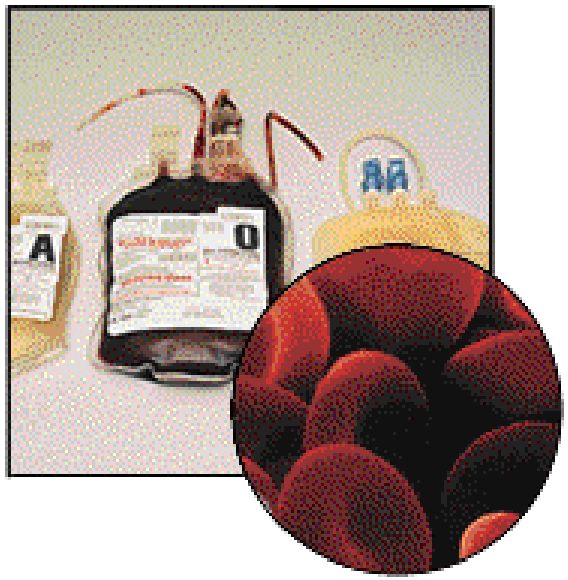


Distillation for separating homogeneous solid – liquid and liquid - liquid mixtures

Mixtures, Substances, Compounds, and Elements



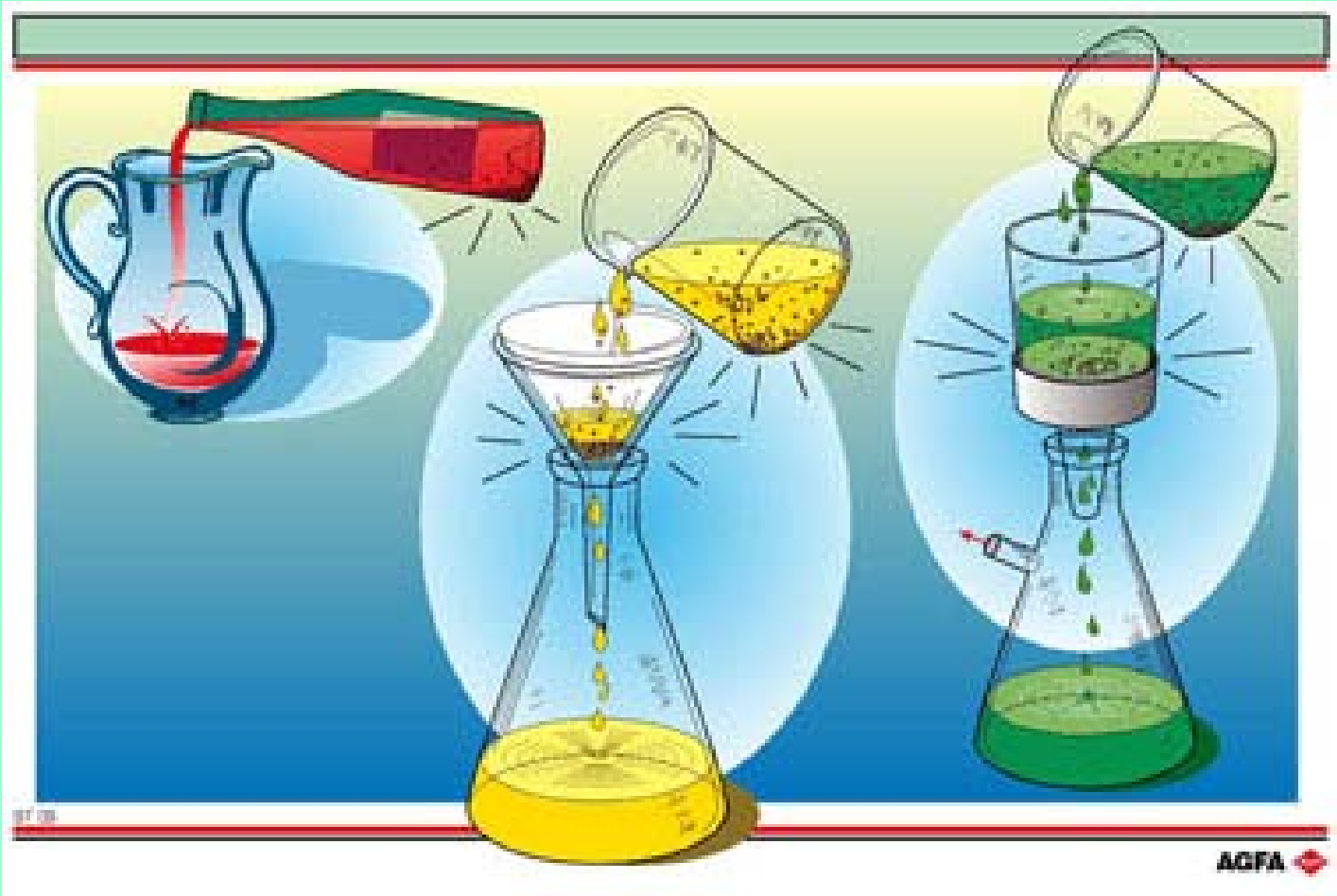
A Granite, a heterogeneous mixture



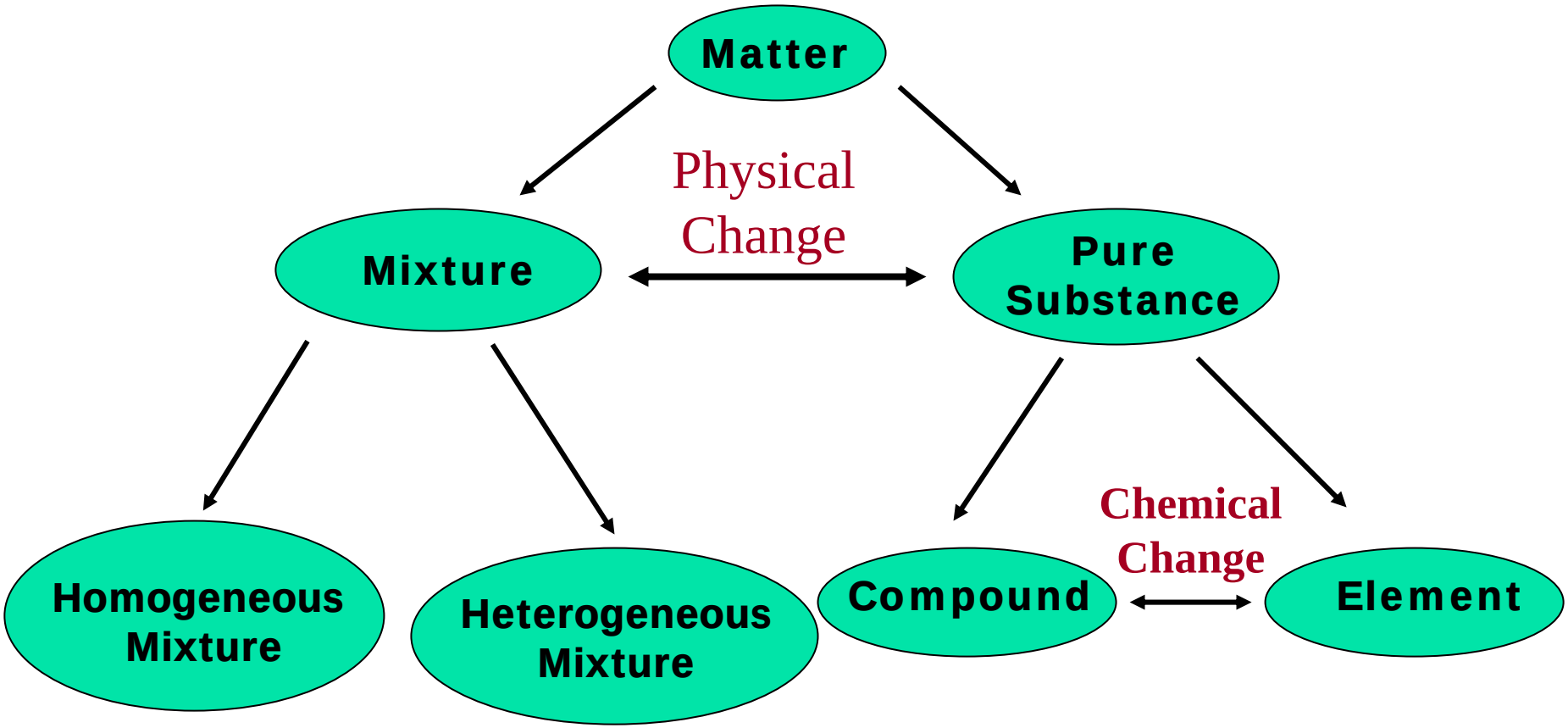
B Human blood, a heterogeneous mixture

C Copper(II) sulfate ($CuSO_4$) in water, a homogeneous mixture (solution)

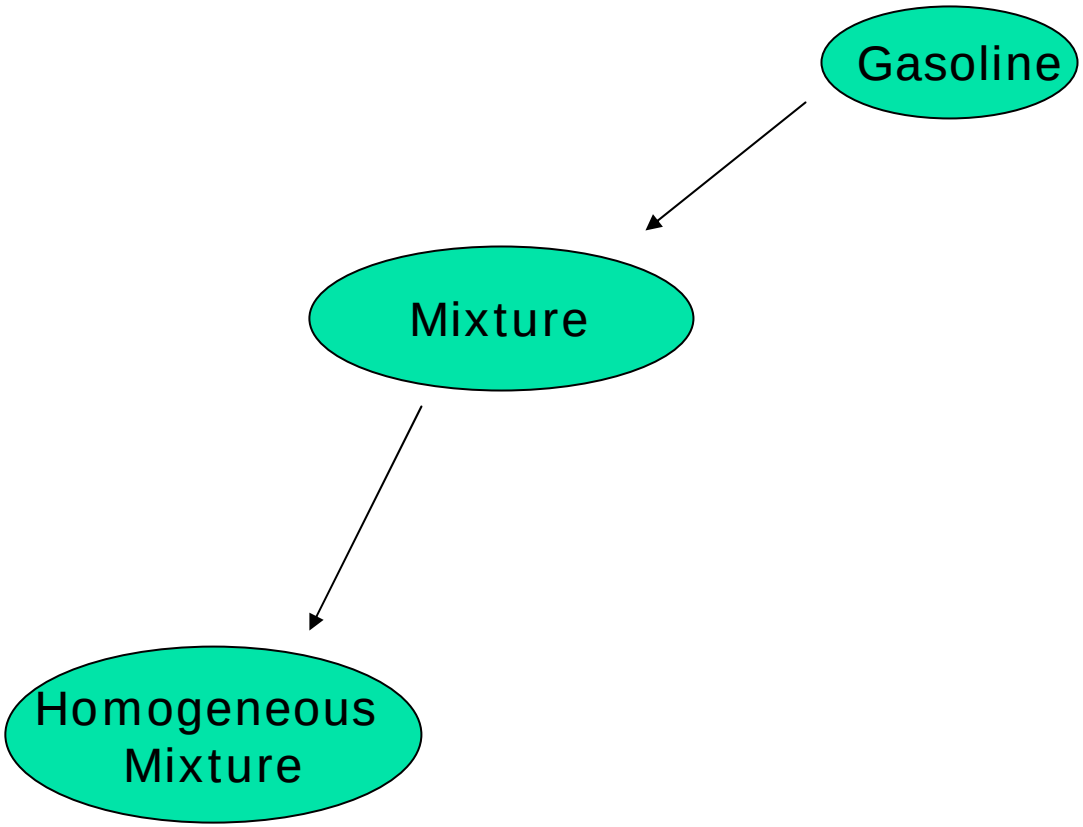
Mixtures, Substances, Compounds, and Elements



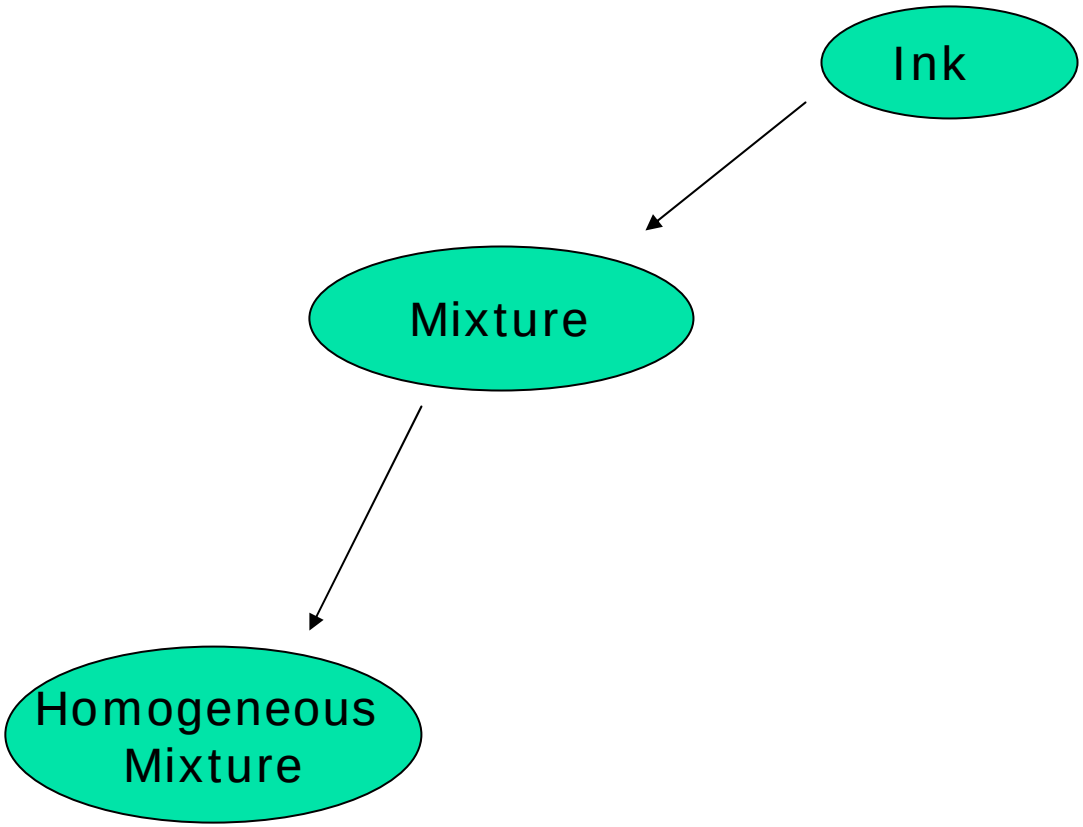
Mixtures, Substances, Compounds, and Elements



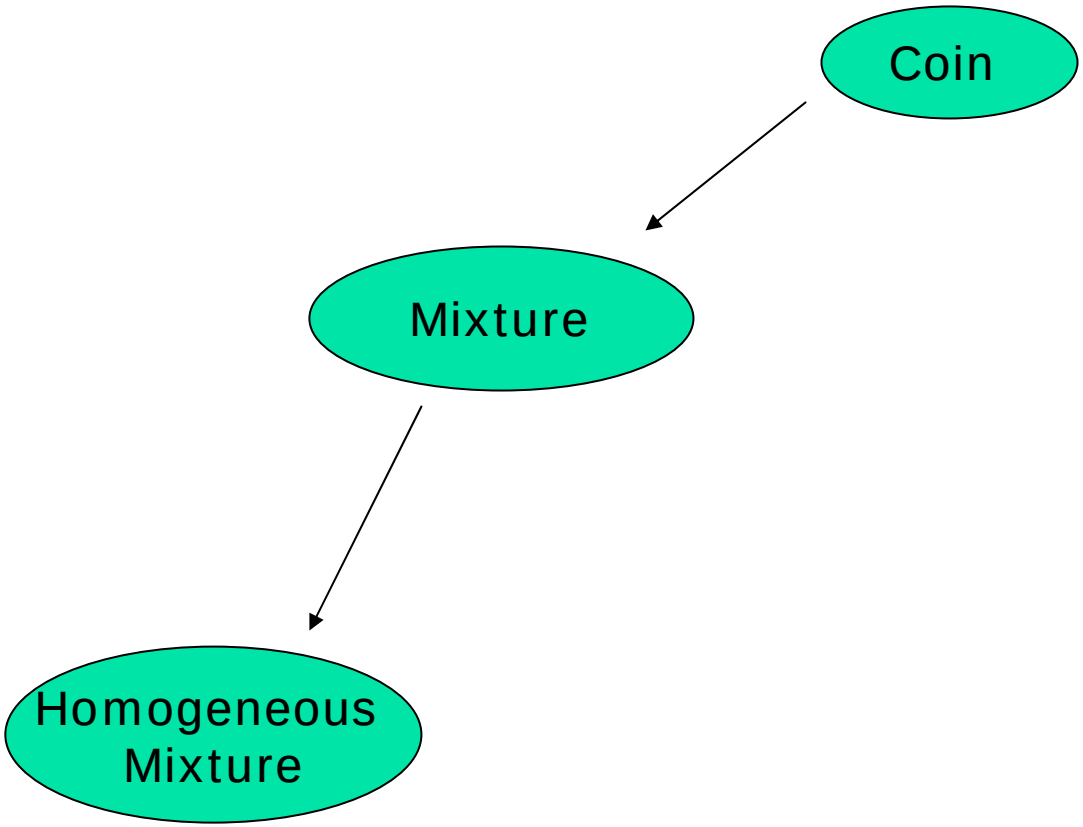
Flow-Chart for Gasoline



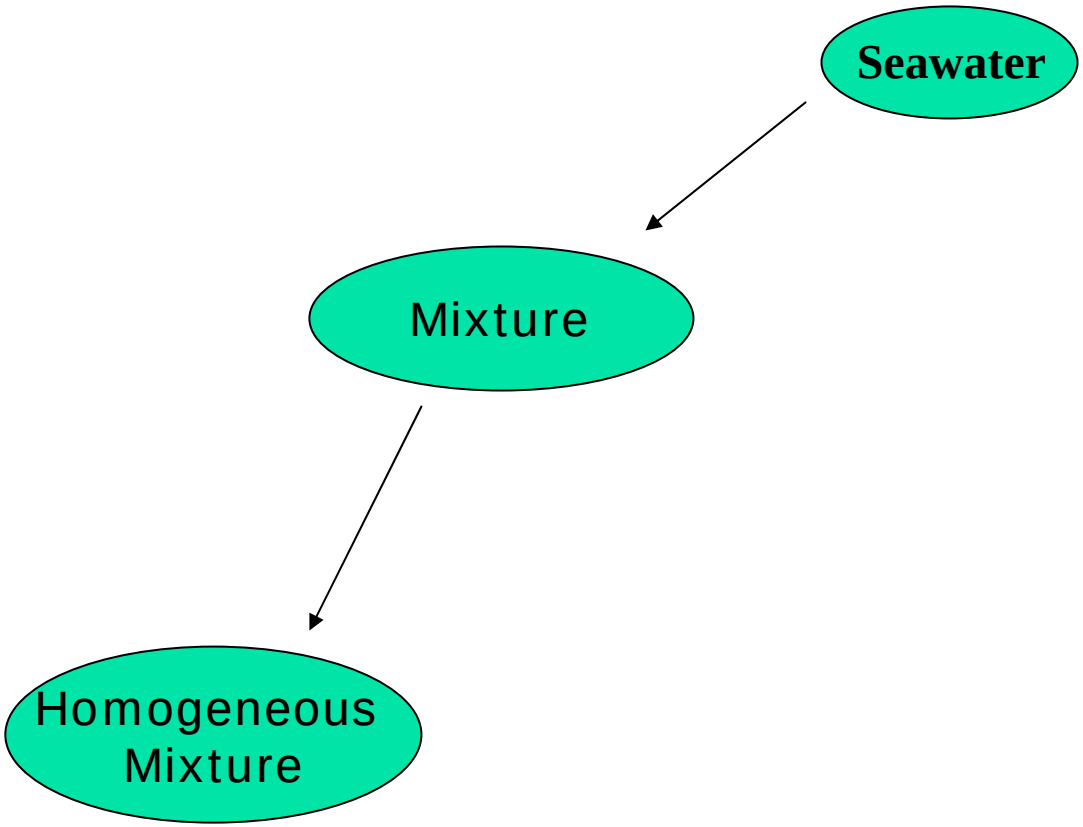
Flow-Chart for Ink



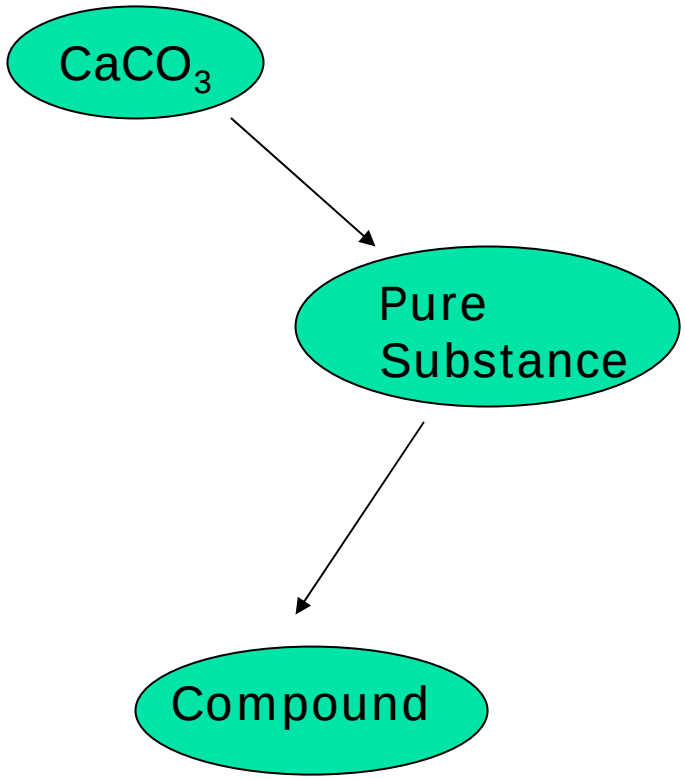
Flow-Chart for a Coin



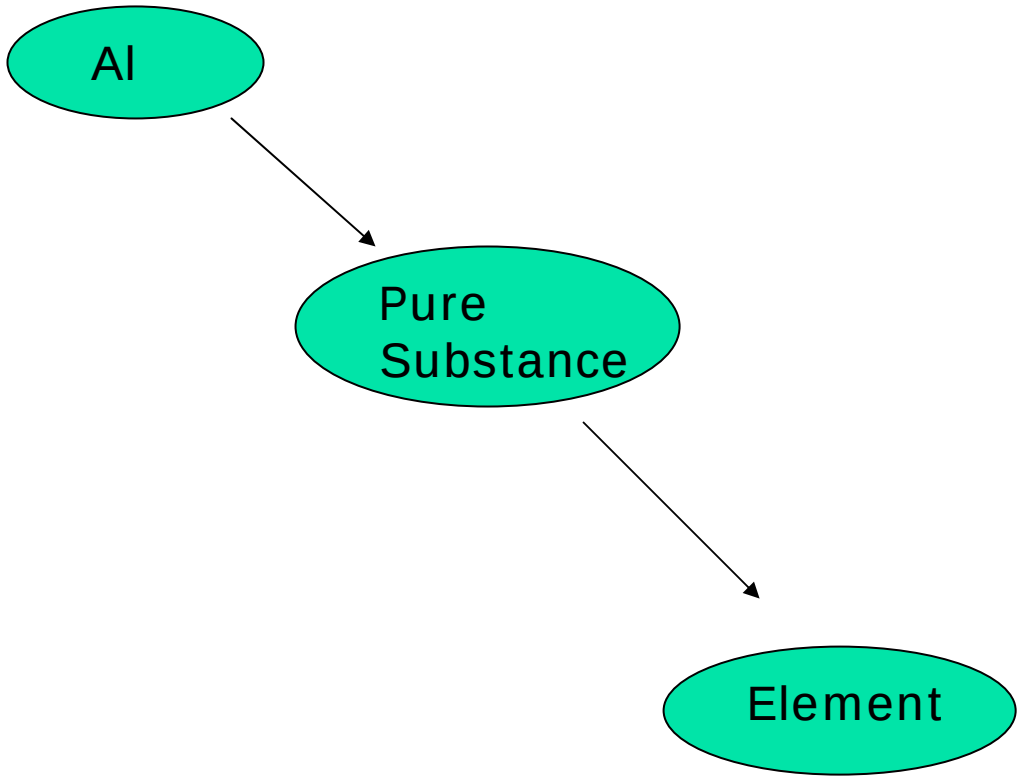
Flow-Chart for Seawater



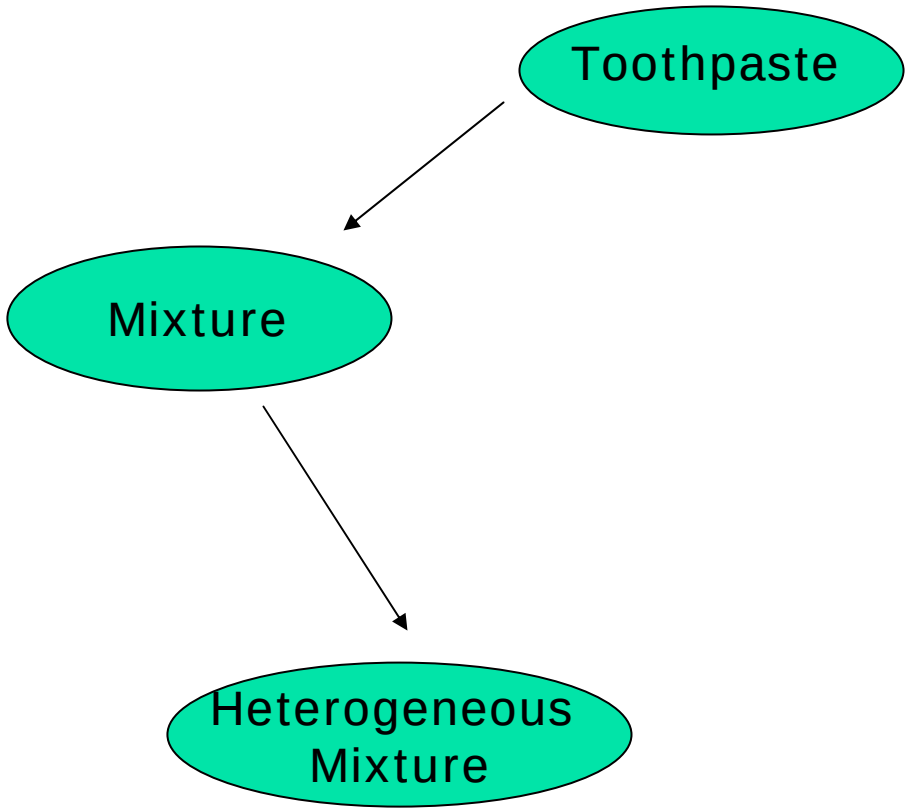
Flow-Chart for $CaCO_3$



Flow-Chart for Aluminum Foil



Flow-Chart for Toothpaste



Classify each of the following as a homogeneous or a heterogeneous mixture?

You do it !

- **Muddy river water**

- **Sugar dissolved in water**

Take-Home Vocabulary

- Chemical change: A change in which one or more *new substances* are formed.

- Physical change: A change in which a substance changes from one physical state to another, but *no substances with different compositions* are formed.

Take-Home Vocabulary

- **Mixture: A sample of matter composed of *variable amounts* of two or more substances, each of which retains its identity and properties.**
- **Heterogeneous mixture: A mixture that *does not have uniform composition* and properties throughout.**
- **Homogeneous mixture: A mixture that *has uniform composition* and properties throughout.**

Measurements in Chemistry

Quantity	Unit	Symbol
length	meter	m
mass	kilogram	kg
time	second	s
current	ampere	A
temperature	Kelvin	K
amt. substance	mole	mol

Measurements in Chemistry
Metric Prefixes

Name	Symbol	Multiplier
mega	M	10^{6}
kilo	k	10^{3}
deka	da	10
deci	d	10^{-1}
centi	c	10^{-2}

Measurements in Chemistry
Metric Prefixes

Name	Symbol	Multiplier
milli	m	10^{-3}
micro	μ	10^{-6}
nano	n	10^{-9}
pico	p	10^{-12}
femto	f	10^{-15}

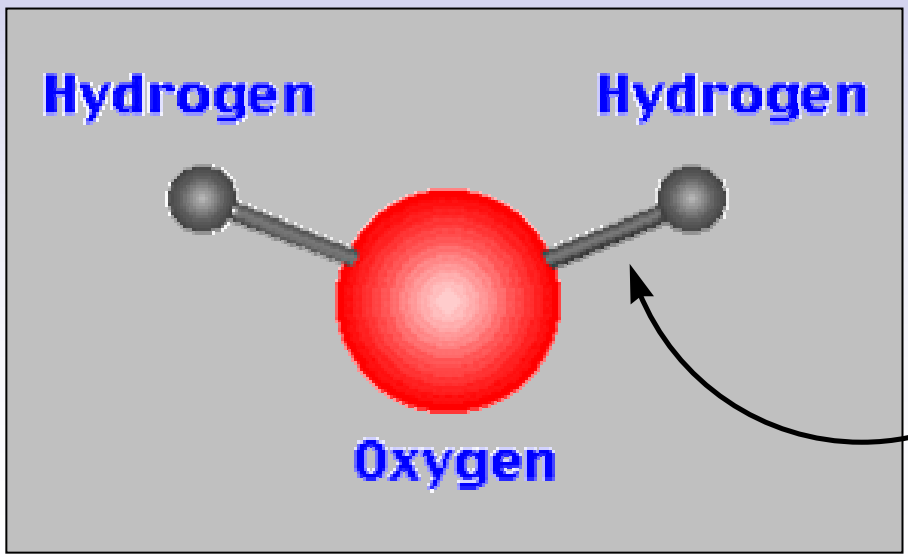
UNITS OF MEASUREMENT

Use SI units – based on the metric system

Length	**Meter, m**
Mass	**Kilogram, kg**
Time	**Seconds, s**
Temperature	**Celsius degrees, ^{o}C** **Kelvin, K**

Units of Length

- 1 kilometer (km) = ? meters (m)
- 1 meter (m) = ? centimeters (cm)
- 1 centimeter (cm) = ? millimeter (mm)
- 1 nanometer (nm) = 1.0×10^{-9} meter (m)



O-H distance =
9.4×10^{-11} m
9.4×10^{-9} cm
0.094 nm

Density

What is density?

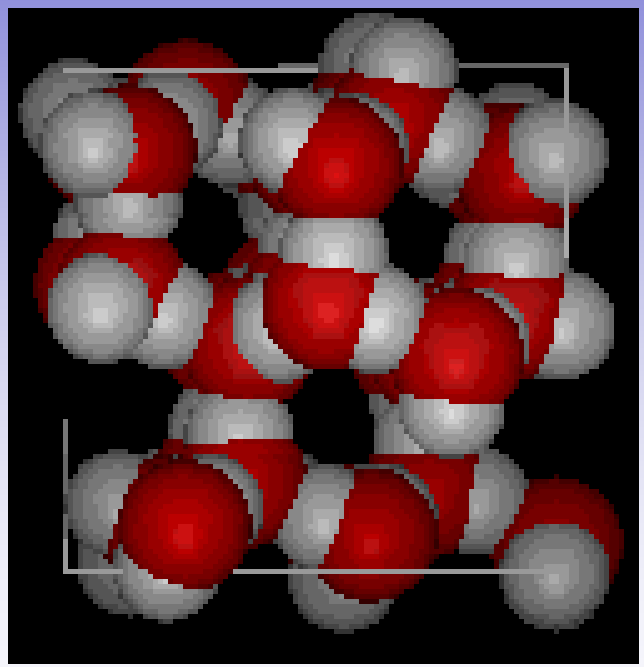
- how heavy something is for its size
- Density is a measure of mass per unit of volume. The higher an object's density, the higher its mass per volume

$$\text{density} = \text{mass}/\text{volume}$$

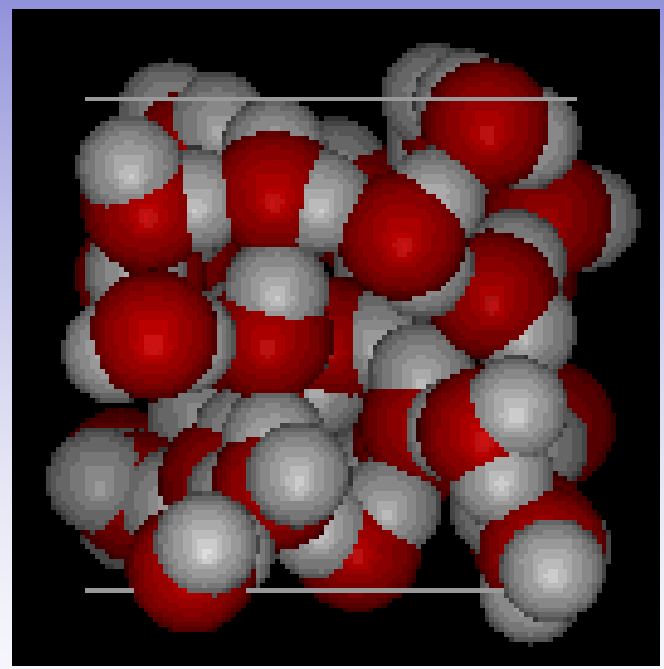
- units will be g/mL or g/cm^3
- Independent of how much of it you have
  - ↳ ***Intensive Physical Property***
- gold - high density
- air low density

Density

- ***Why does ice float in liquid water?***



Ice

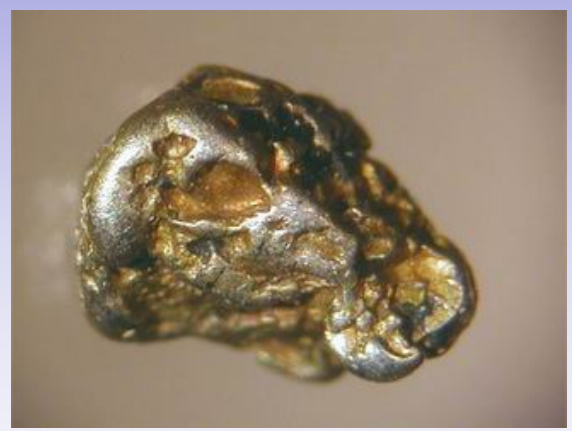


Water

DENSITY – an important and useful physical property

$$\text{Density} = \frac{\text{mass (g)}}{\text{volume (mL or cm}^3\text{)}}$$

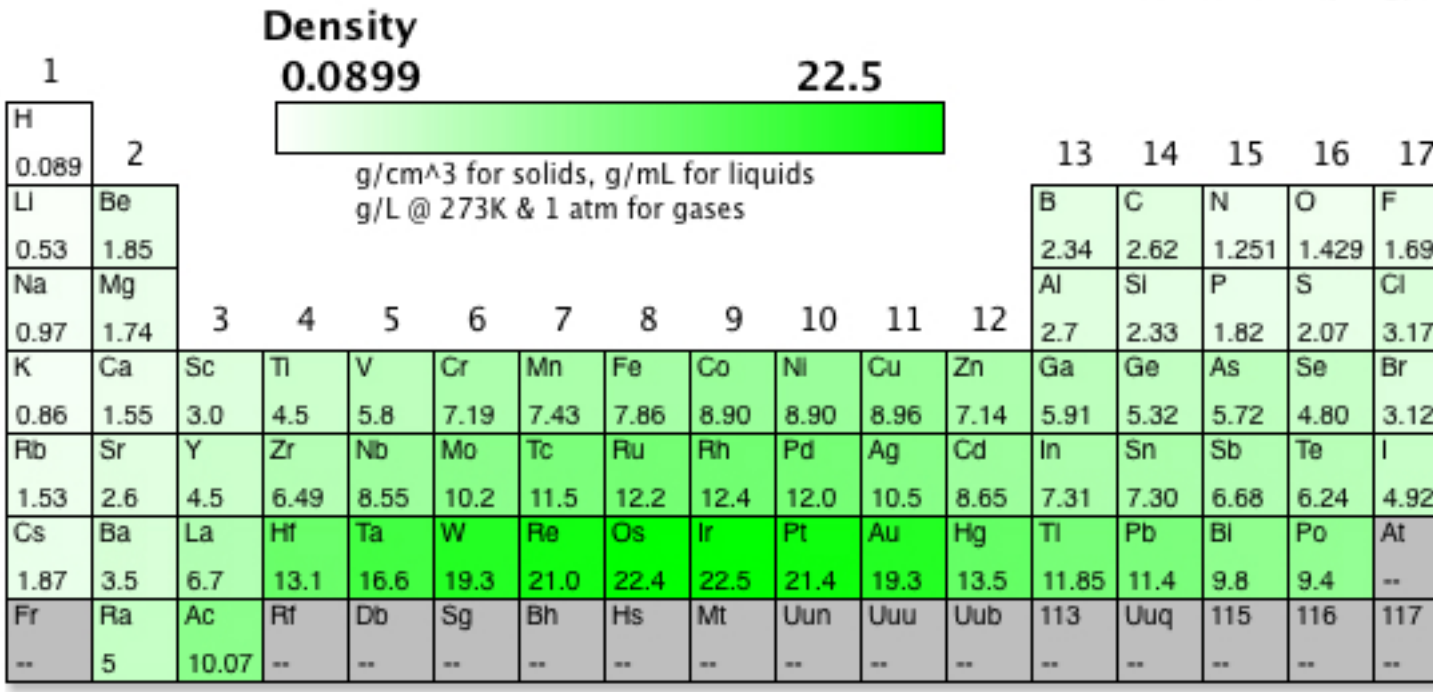
Mercury
13.6 g/cm³



Platinum
21.5 g/cm³

Aluminum
2.7 g/cm³

Relative Densities of the Elements



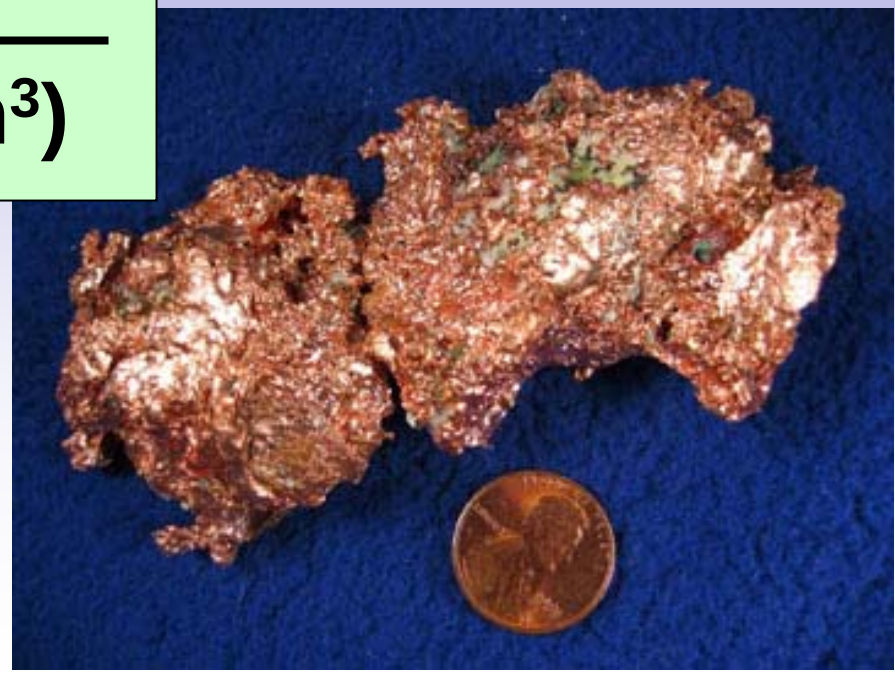
1												13	14	15	16	17	18
H 0.089	2																He 0.179
Li 0.53	Be 1.85											B 2.34	C 2.62	N 1.251	O 1.429	F 1.696	Ne 0.901
Na 0.97	Mg 1.74	3	4	5	6	7	8	9	10	11	12	Al 2.7	Si 2.33	P 1.82	S 2.07	Cl 3.17	Ar 1.784
K 0.86	Ca 1.55	Sc 3.0	Ti 4.5	V 5.8	Cr 7.19	Mn 7.43	Fe 7.86	Co 8.90	Ni 8.90	Cu 8.96	Zn 7.14	Ga 5.91	Ge 5.32	As 5.72	Se 4.80	Br 3.12	Kr 3.74
Rb 1.53	Sr 2.6	Y 4.5	Zr 6.49	Nb 8.55	Mo 10.2	Tc 11.5	Ru 12.2	Rh 12.4	Pd 12.0	Ag 10.5	Cd 8.65	In 7.31	Sn 7.30	Sb 6.68	Te 6.24	I 4.92	Xe 5.89
Cs 1.87	Ba 3.5	La 6.7	Hf 13.1	Ta 16.6	W 19.3	Re 21.0	Os 22.4	Ir 22.5	Pt 21.4	Au 19.3	Hg 13.5	Tl 11.85	Pb 11.4	Bi 9.8	Po 9.4	At --	Rn 9.91
Fr --	Ra 5	Ac 10.07	Rf --	Db --	Sg --	Bh --	Hs --	Mt --	Uun --	Uuu --	Uub --	113 --	Uuq --	115 --	116 --	117 --	118 --

Ce 6.78	Pr 6.77	Nd 7.00	Pm 6.48	Sm 7.54	Eu 5.26	Gd 7.89	Tb 8.27	Dy 8.54	Ho 8.80	Er 9.05	Tm 9.33	Yb 6.68	Lu 9.84
Th 11.7	Pa 15.4	U 18.90	Np 20.4	Pu 19.8	Am 13.6	Cm 13.51	Bk --	Cf --	Es --	Fm --	Md --	No --	Lr --

Problem

A piece of copper has a mass of 57.54 g. It is 9.36 cm long, 7.23 cm wide, and 0.95 mm thick. Calculate density (g/cm^3)

$$\text{Density} = \frac{\text{mass (g)}}{\text{volume } (cm^3)}$$



Strategy

1- Get dimensions in common units

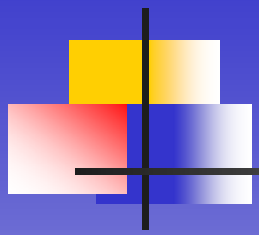
$$0.95 \text{ mm} \times \frac{1 \text{ cm}}{10 \text{ mm}} = 0.095 \text{ cm}$$

2- Calculate volume in cubic centimeters

$$V = (9.36 \text{ cm})(7.23 \text{ cm})(0.095 \text{ cm}) = 6.43 \text{ cm}^3$$

3- Calculate the density

$$\frac{57.54 \text{ g}}{6.43 \text{ cm}^3} = 8.95 \text{ g/cm}^3$$



Problem

Example: Calculate the density in g/mL of a substance if 742 grams of it occupies 97.3 cm^3.

Strategy

1- Convert dimensions to the desired units.

$$1\,\text{cm}^3 = 1\,\text{mL} \;\therefore\; 97.3\,\text{cm}^3 = 97.3\,\text{mL}$$

$$\text{density} = \frac{\text{m}}{\text{V}}$$

2- Calculate the density.

$$\frac{742\ \text{g}}{97.3\ \text{mL}} = 7.63\ \text{g/mL}$$

Problem

Example: Suppose you need 125 g of a corrosive liquid for a reaction. What volume do you need?

liquid's density = 1.32 g/mL

You do it!

Problem

Example: Suppose you need 125 g of a corrosive liquid for a reaction. What volume do you need?

liquid's density = 1.32 g/mL

$$\text{density} = \frac{m}{V} \therefore V = \frac{m}{\text{density}}$$

Problem

$$\text{density} = \frac{m}{V} \therefore V = \frac{m}{\text{density}}$$

$$V = \frac{125\ \text{g}}{1.32\ \text{g/mL}} = 94.7\ \text{mL}$$

Specific Gravity

$$\text{Specific Gravity} = \frac{\text{density(substance)}}{\text{density(water)}}$$

- **Water's density is essentially 1.00 at room Temperature.**
- **Thus the specific gravity of a substance is very nearly equal to its density.**
- **Specific gravity has no units.**

Problem

A 31.10 gram piece of chromium is dipped into a graduated cylinder that contains 5.00 mL of water. The water level rises to 9.32 mL. What is the specific gravity of chromium?

You do it

Strategy

1- Calculate volume of chromium.

Volume of Cr = 9.32 mL – 5.00 mL = 4.32 mL

2- Calculate the density.

$$\frac{31.10\ \text{g}}{4.32\ \text{mL}} = 7.20\ \text{g/mL}$$

3- Calculate the specific density.

$$\frac{7.20\ \text{g/mL}}{1.00\ \text{g/mL}} = 7.20$$

Problem

What is the mass of 35.0 mL of a liquid with a specific gravity of 2.64?

a. 35.0 g

b. 13.3 g

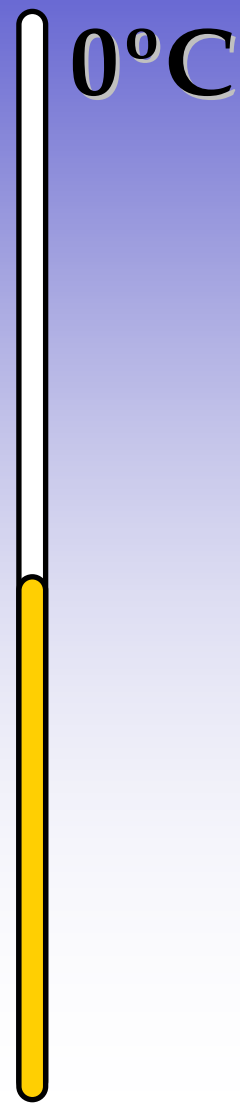
c. 26.2 g

d. 92.4 g

e. 0.0754 g

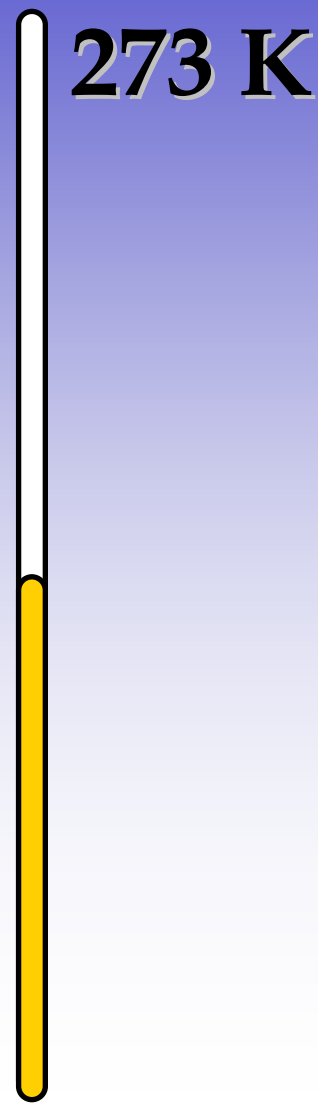
Measuring Temperature

- Celsius scale.
- water freezes at 0 °C
- water boils at 100 °C
- body temperature 37 °C
- room temperature 20 – 25 °C



Measuring Temperature

- Kelvin starts at absolute zero (-273 ° C)
- degrees are the same size
- C = K -273
- K = C + 273
- Kelvin is always bigger.
- Kelvin can never be negative.



Temperature is different

- than heat.
- Temperature is which way heat will flow (from hot to cold)
- Heat is energy, ability to do work.
- A drop of boiling water hurts,
- kilogram of boiling water kills

Problem

Example: Express 548 K in Celsius degrees.

$$K = {}^{o}C + 273$$

$${}^{o}C = K - 273$$

$${}^{o}C = 548 - 273$$

$${}^{o}C = 275$$

Reading….

Please read section 1-12

for more examples:

HEAT AND TEMPERATURE

Homework Assignment

Textbook Problems **(optional, Chapter 1):**

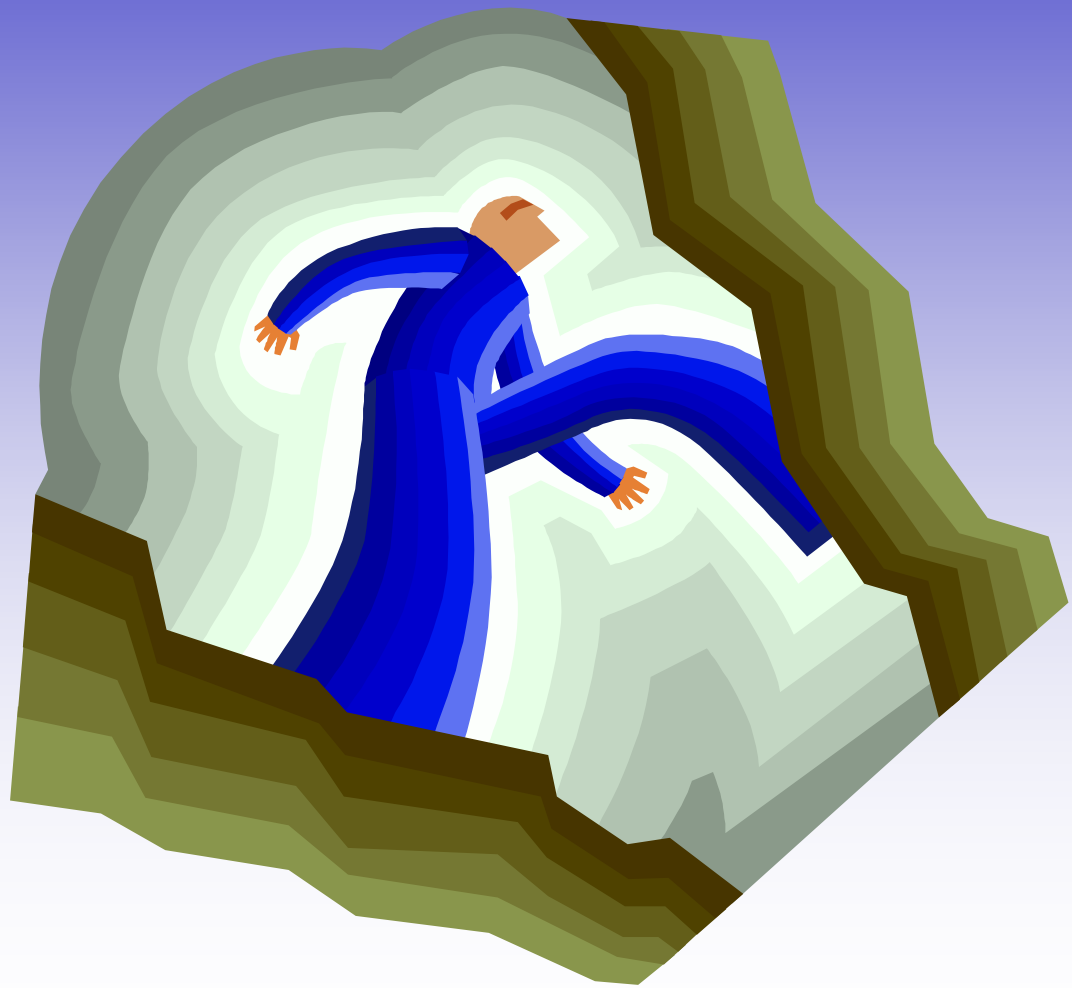
11, 13, 15, 18, 19, 23, 27, 35, 40, 41, 43, 46, 48, 49, 53, 73, 74

One-line Web Learning (OWL):

Chapter 1 Exercises and Tutors – Optional

Introductory math problems and Chapter 1 Homework problems – Optional

End of Chapter 1



Reading….

Chapter 2:

Chemical Formulas and Composition Stoichiometry

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