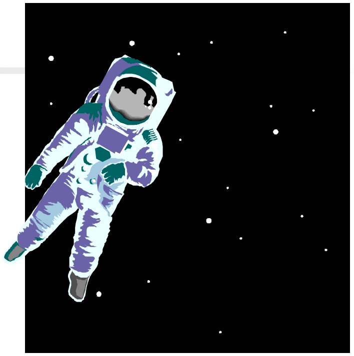
Chapter 4 Physics of Matter

Vacuum

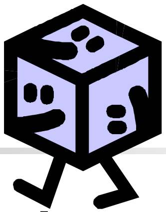


- A vacuum exists in outer space.
- It is the absence of all matter.
- Vacuums are relative
- Even in outer space some matter exists
- But the amount is so small that a person would die if exposed to vacuum without a space suite

States of Matter

- Solid
- Liquid
- Gas
- Plasma

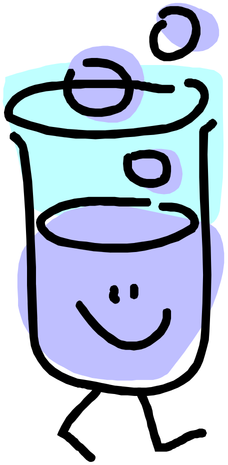
Solid



- **Solid** A rigid body, retains its shape unless distorted by a strong force.. Examples: rock, wood, plastic, iron

Liquid

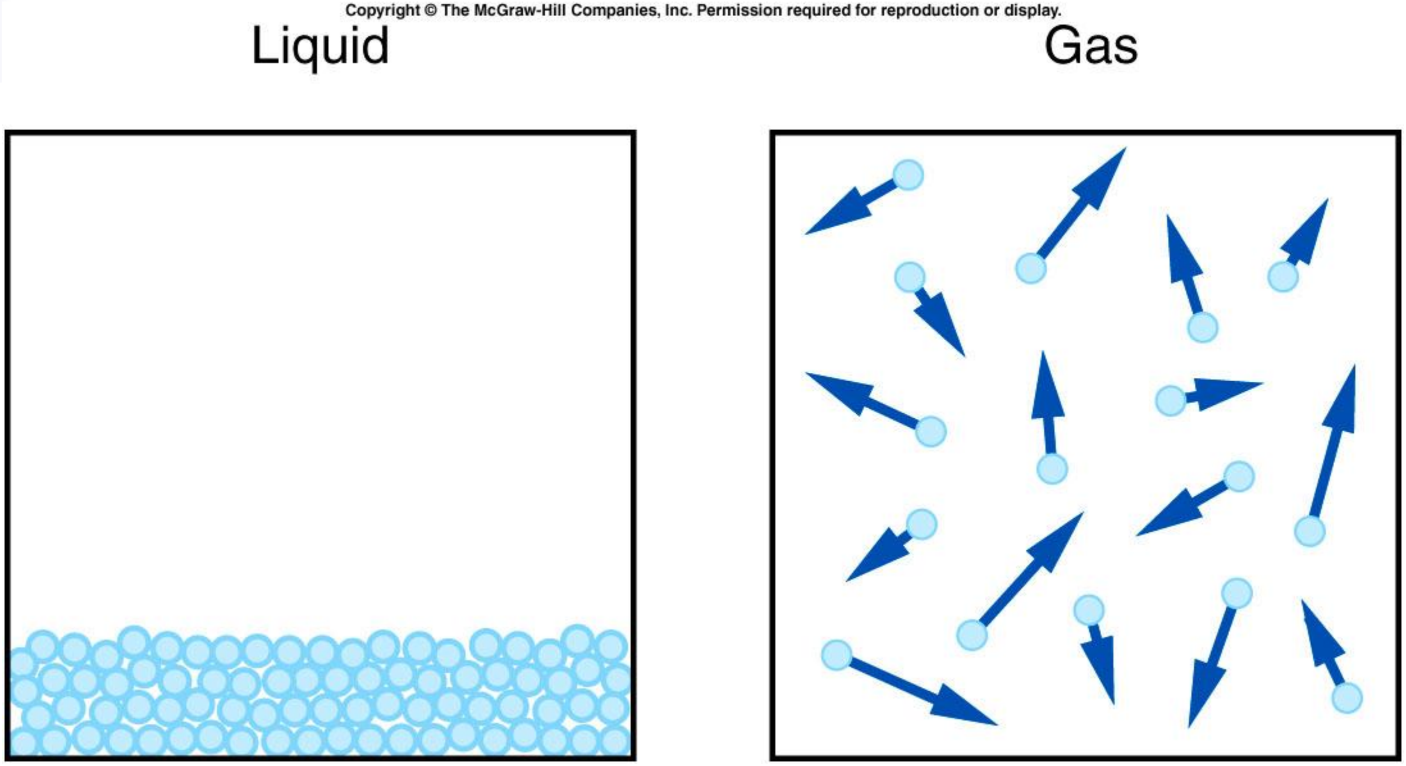
- Flow readily,
- conform to the shape of their container.
- Have a well defined boundary (surface).
- More dense than gases.
- Examples water, beverages, blood, oil,…



Gas

- Flow readily,
- conform to the shape and size of their container,
- do not have a well defined surface,
- can be compressed or expanded readily.
- Examples: air, carbon dioxide, helium, steam.

Inside Liguid vs Gas

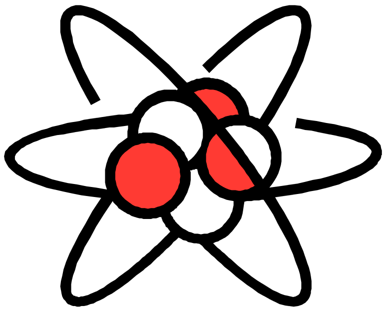


Plasma

- An ionized gas, often referred to as the fourth state of matter.
- It consists of positive ions and electrons
- interacts strongly with magnetic fields
- conducts electricity.
- Commonly exists only at higher temperatures or in strong electromagnetic fields
- Examples: Sun, candle flame, gases in operating fluorescent, neon, and vapor lights.

Structure or Particles of Matter

- **Greeks described smallest particles of matter as atoms.**
- **Now we know there are even smaller particles.**
- **Atoms are composed of**
  - **Electrons, protons and neutrons.**
  - **Protons and neutrons are in the center or nucleus of the atom**
  - **Electrons orbit around the nucleus**



Neutrons, Protons, Electrons

- **Neutron** Electrically neutral particle residing in the nucleus of an atom.
- **Proton** Positively charged particle residing in the nucleus of an atom.
- **Electron** Negatively charged particle, usually found orbiting the nucleus of an atom.

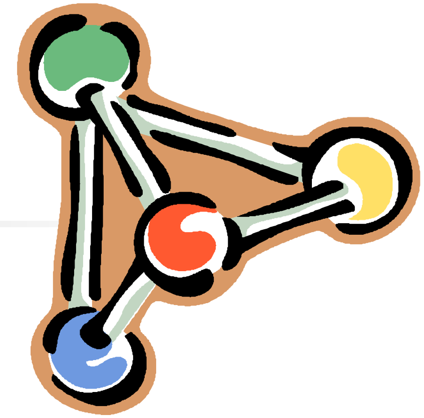
Elements

- One of over 115 different fundamental substances
- The simplest and purest forms of matter.
- All have the same type of Atom, specifically the same number of protons in the nucleus.
- Scientists are still discovering new elements so the number is always increasing.

Examples of Elements

- Gold, Silver, Oxygen, Silicon, Nitrogen,….
- Nitrogen is the most abundant element. It makes up about 80% of our air.
- Silicon is also very abundant, since it occurs in sand, a compound of Silicon and Oxygen.

Molecule/Compound



- Two or more atoms combine to form a molecule. If the atoms are different types it is a compound.
- A Compound is something composed of identical molecules of more than one type of atom or element. 2 or more elements combine chemically.
- E.G. SiO_2 Is a compound composed of molecules with Silicon and Oxygen atoms.

Mixture

- No chemical reaction, thus not a compound
- Parts do not combine uniformly, they just intermix.
- Parts can be recovered individually.
- Example, Instant Cocoa: chocolate, sugar, and milk powder.

Solutions

- **A homogeneous mixture of two or more substances, which may be solids, liquids, gases, or a combination of these**
- **The parts break down into individual molecules, and intersperse, but do not combine.**
- **E.G. salt in water-salt water**

Suspensions

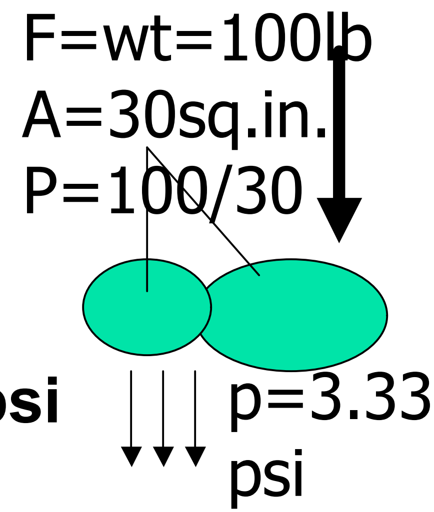
- A suspension has tiny particles, but many molecules in one particle.
- Not a chemical reaction, thus not a compound
- Their particles are larger than molecules thus not a solution.

Suspensions Examples

- Mayonaise, Gelatin, Butter, Ice Cream Orange Juice
- see http://encyclopedia.thefreedictionary.com/Suspension+(chemistry)

Pressure *(p)*

- The force per unit area for a force acting perpendicular to a surface. The force acting on a surface divided by its area.
- **P = Force/Area = F/A**
- **Force on the floor= Weight = 100 lbs**
- **Area of shoes surface 30 sq.in.**
- **Pressure on the floor =100/30= 3.33psi**



Pressure from spike heels

- **Heel area = .2x.2in=.04sq.in**
- **Sole area =2 x 4 in = 8 sq.in.**
- **Weight=100 lbs.**
- **On Heel P=100/.04 =2500 psi**
- **On Sole P=100/8 = 12.5psi.**

Equal Forces Unequal P

- **Note force is the same in both cases but the ratio of pressures is 2500/12.5 = 200 to 1!**

Mass density (D)

m=20kg

V=2 cu.m

- The mass per unit volume of a substance. The mass of a quantity of a substance divided by the volume it occupies.
- Mass density = mass/volume
- $D=m/V = 20kg/2m^3 = 10kg/m^3$

D of 2 x 2 x 4 m, 40KG Cube

- **D=?**
- **M= 40 kg,**
- **Cube of dimensions 2 x 2 x 4 m. V=lwh = 2 x 2 x 4 = 16 cubic meters**
- **D = m/V = 40Kg/ 16 m^3 = 2.5 kg/ m^3**

Weight density (D_w)

W=196 N

V=2 cu.m

- **The weight per unit volume of a substance. The weight of a quantity of a substance divided by the volume it occupies.**
- **D_w = W/V = Weight/Volume**
- **= 196 N/2 cu.m =98 N/m^3**

D_w of 2 x 2 x 4 m, 40KG Cube

- D_w **=?**
- **M= 40 kg, W = 40 x 9.8 = 392 N**
- **Cube of dimensions 2 x 2 x 4 m. V=lwh = 2 x 2 x 4 = 16 cubic meters**
- D_w **= W/V = 392N/ 16 m^3 = 24 N/ m^3**

Specific Gravity

- Relation between density of a material and density of water.
- Ratio Dx/Dw (Density of x divided by density of water).

What is the Specific Gravity of Concrete?

- Density of concrete =2500 kg/m^3,
- Density of water = 1000 kg/m^3.
- Specific Gravity of concrete =
- Dx/Dw = 2500/1000
- = 2.5. ***Note, no units on sp.gr*!**

Pressure in Fluids

- **Pressure increases with depth!**
- Law of fluid pressure The (gauge) pressure at any depth in a fluid at rest equals the weight of the fluid in a column extending from that depth to the top of the fluid divided by the cross-sectional area of the column.

Law of fluid pressure

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Pressure in Water

- **Water weighs 62.5 lbs/cu.ft**
- **A cube 1 x 1 x 1 ft has a surface of 1 sq.ft.**
- **At a depth of 1 ft you have 62.5 lbs/sqft pressure**
- **Multiply depth in ft by 62.5 to find P**
- **20 ft, P = 20 x 62.5 = 1250 lbs/sq.ft.**

Converting to lbs/sq.in

- **Gauges usually use lbs/sq.in**
- **1 sq.ft = 12in x 12 in = 144 sq.in.**
- **62.4 lbs/sq.ft = 62.4/144**
- **= .433 lbs/sq.in.**
- **Thus using psi:p=0.433 psi/ft x h(ft)**
- **At 20 ft. P = .433 x 20 = 8.66 psi.**

Gauge pressure vs total p

- measures difference between inside and outside pressure?
- see p. 141 and 142

Buoyant force

- The upward force exerted by a fluid on a substance partly or completely immersed in it.

Archimedes' Principle

- The buoyant force acting on a substance in a fluid at rest is equal to the weight of the fluid displaced by the substance.

Floating, Sinking, or Rising

- **Buoyant force greater than weight of object, object floats.**
- **Buoyant force less than weight, object sinks.**
- **Light object released from a submarine rises, if density less than water, otherwise sinks.**

Pascal's Principle

- Pressure applied to an enclosed fluid is transmitted undiminished to all parts of the fluid and to the walls of the container.

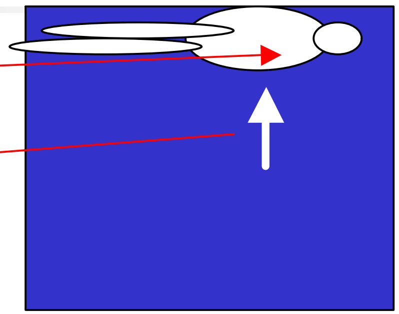
Problem Force from Pressure and Area

- Pressure = F/A then F = P x A
- Side of can 8 x 10 inches?
- Area 8 x 10 = 80 sq in., P=14.7psi
- F = 14.7 psi x 80 sq.in. = 1176 lbs

Mass from Density Problem

- Dm = M/Vol
- M = Dm x Vol
- Vol = 2m x 3m x 4m = 24 cu.m
- Dm = 11,340kg/cu.m
- M = 11,340 x 24 = 272,160 kg.

Buoyant Force Problem



- Swimmer's volume = 2 ft^3
- Buoyant Force,BF = ?
- BF= Wt of water he displaces
- = His Vol x density of water (62.4 lbs/ft^3)
- 2 ft^3 x 62.4 lbs/ft^3 = 124.8 lbs

Formulas Chapter 4

$p = F/A$ Pressure is Force divided by area perpendicular to the force

$D_m = m/V$

Mass density, D_m = mass, m/volume, V

$D_w = w/V$

Weight Density, D_w = weight, w/volume, V

$F_b = W_{FD}$

Archimedes' Principle: Buoyant Force = Weight of the fluid displaced

Special Case Equations

- $p = D_w h = D_m \times g \times h$ Gauge Pressure, p at a depth h in a liquid of wt density D_w or mass density D_m
- $p = 0.433$ (psi/ft) x h(ft) Gauge Pressure in psi underwater at a depth h in feet

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