Matter

Phases of Matter

Matter has many different phases (sometimes called states) which depend on the temperature and/or pressure.

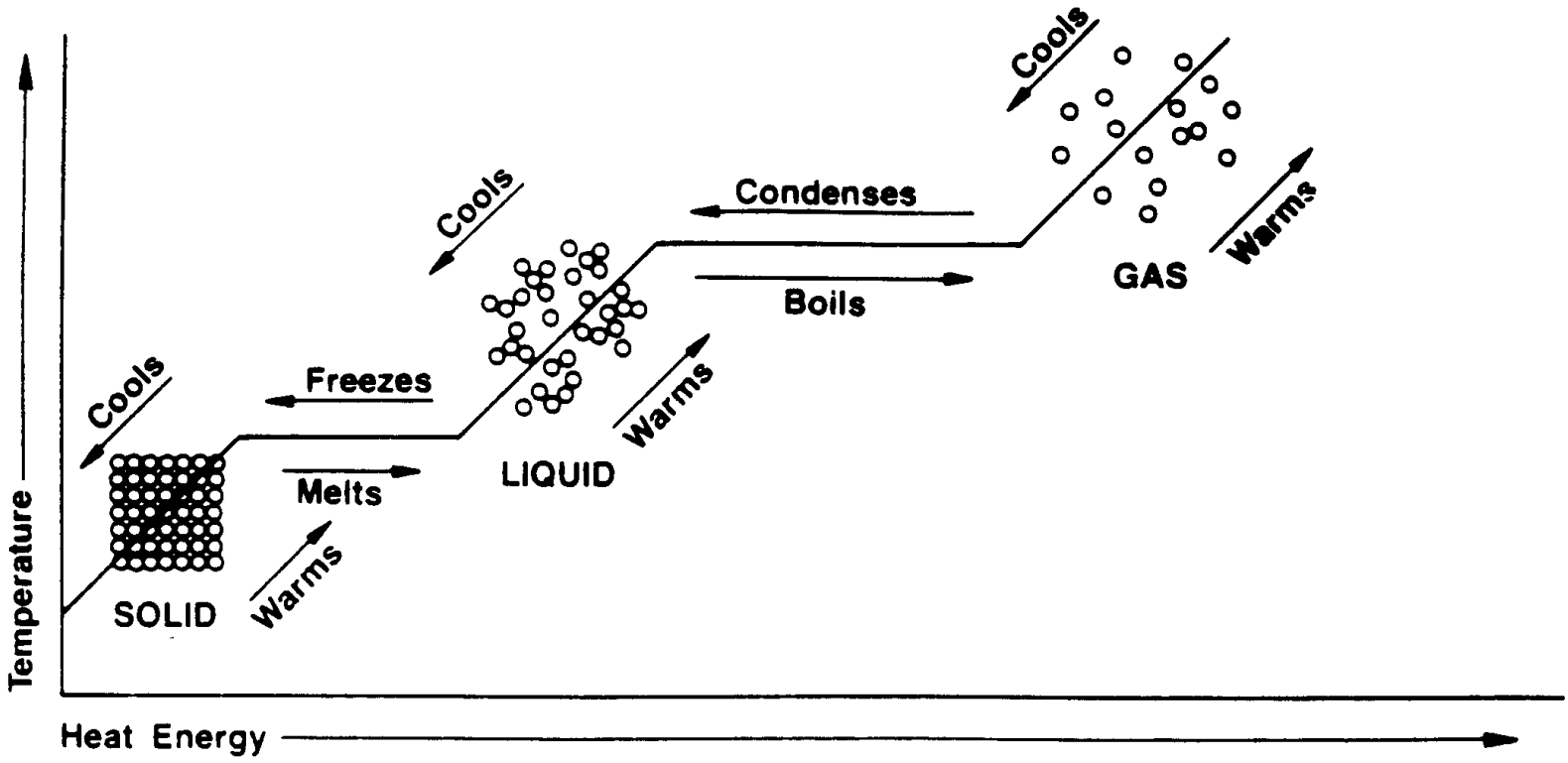
Some non common sates of matter include (but are not limited to):
- Plasma, glass, crystal, liquid crystal, magnetically ordered, superfluids like fermionic or Bose-Einstein condensates…

The 3 common phases of matter are: solid, liquid, and gas

	Solid	**Liquid**	**Gas**
Shape	Rigid, defined shape and volume	Takes shape of it's container but constant volume	Takes shape **and** volume of container
Effect of Temperature & Pressure	Negligible change in volume	Minimal change in volume	Drastic change in volume
Atomic/ Molecular scale	• Particles vibrating in fixed position • Relatively close together • Strong attractive forces between particles • Uncompressible • Vibration only	• Particles can move past each other • Relatively close together • Forces between particles vary in strength • Uncompressible • Vibration, translation, rotation available	• Particles can move past each other • Relatively far apart • Very small forces between particles • Compressible, almost all of a gas is space • Same degrees of freedom as liquid

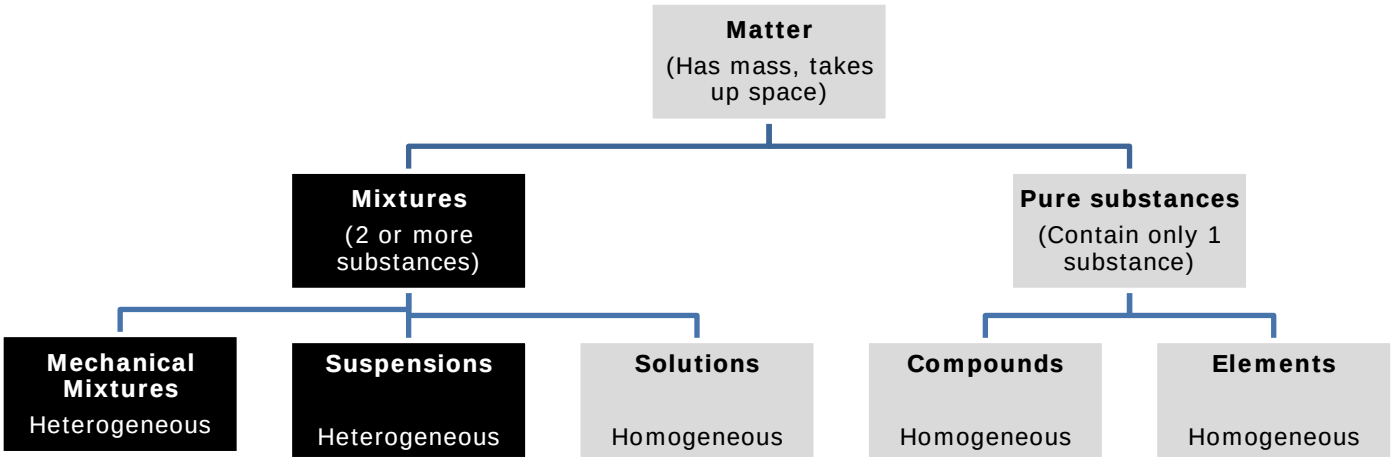
Phase changes between common states

Completely dependant on temperature and pressure. At 1 atmosphere pressure the melting point (mp) and boiling point (bp) are constant for pure substances. For mixtures melting and boiling happen over a temperature range.



At the phase change points (mp/fp or bp/cp) the energy going into the particles is **not** used to increase the average kinetic energy (aka temperature) of the system, but instead is used solely to change from one phase to another; notice the plateaus (horizontal parts) in the phase change diagram above, where energy is **not** increasing temp.

Classification of Matter



- Heterogeneous means that you can actually see different parts in the mixture (sand, muddy water, nuts and bolts) – scatters light

- Homogeneous means you can not see differences in parts in the substance (water, salt, steel) – uniform throughout

Solutions have two parts: a solvent (substance in greater amount) and a solute (substance in lesser amount)

Elements are pure substances that cannot be chemically decomposed (divided). They are made up of atoms (have different # of protons). See Periodic Table. Some exist as molecules: Ex. – H_2, O_2, P_4

Compounds are pure substances that can be decomposed into constituent elements. Contains 2 or more elements. Made up of molecules (non charged) or ions (charged). They have a constant, definite composition or ratio, can use formulae: Ex – H_2O or CO_2

Law of Definite Composition: compounds are made up of a definite ratio of elements Ex – H_2O: 2 parts hydrogen to 1 part oxygen (ratio!)

Law of Multiple Proportions: compounds can have different ratios with the same elements, thus forming completely different compounds: Ex – H_2O vs H_2O_2 or FeO vs Fe_2O_3

Separation of Matter

Physical Means of Separation

Mixtures (mechanical, Suspensions, Solutions) can be separated through many different processes, pure substances (compounds and elements) however must be broken down using chemical means (reactions)

1) Filtration
- Useful for large volumes
- Use a porous filter to separate particles on the basis of size
- Used for solid/solid and solid/liquid mixtures

2) Centrifugation
- Useful for smaller volumes
- Uses a spinning platform to separate on the basis of density
- Used for solid/liquid mixtures

3) Chromatography
- Moving substances along a stationary phase (ex. paper, sand) using a mobile phase (ex. water)
- Separates based on size and attraction to the stationary/mobile phases
- Usually used for liquid/liquid mixtures
- Uses Ratio of fronts (R_f) – Distance of solvent/solute

4) Distillation
- Separation of substances based on boiling point differences
- Involves evaporation and subsequent condensation
- Used for liquid/liquid mixtures

5) Separatory funnel
- Separation of immiscible liquids (not mixable, ex. oil & water)
- Separates based on solubility

Chemical Means of Separation

Mainly decomposition of compounds into constituent elements

1) Electrolysis
- Uses electrical energy to break apart compounds

2) Heating (decomposition)
- Uses heat energy to break apart compounds

Chemical and Physical changes

KMT (A review)

All particles (atoms, molecules and ions) are in constant motion above absolute zero (-273.15 Celsius or 0 Kelvin)

Solids have particles in an ordered arrangement (not moving much) and are close together

Liquids have particles moving around but are still close together

Gases have particles moving very fast, and are far apart

Classification of Elements

Elements can be classified based on their properties, notice they make up specific regions of the periodic table:

Type	Properties
Metal	Shiny (lustrous) bendable, ductile (stretched into wires) malleable (hammered into thin sheets) good conductors of heat AND electricity. Mostly solid at room temperature. Make up most of the periodic table
Non-Metal	Not shiny, not bendable (brittle) not good conductors. Most are gases at room temp. Found in the upper right hand of the periodic table
Metalloid	Small group of elements dividing the metals and non-metals (B, Si, Ge, As, Sb, Te, Po, At) tend to be hard, high mp and can be semi-conductors

Chemical and Physical Change:

When matter is heated or cooled, mixed together or separated, different types of changes occur:

Physical Change

- No alteration of chemical composition, only changes state
- Often very easy to change back to original form

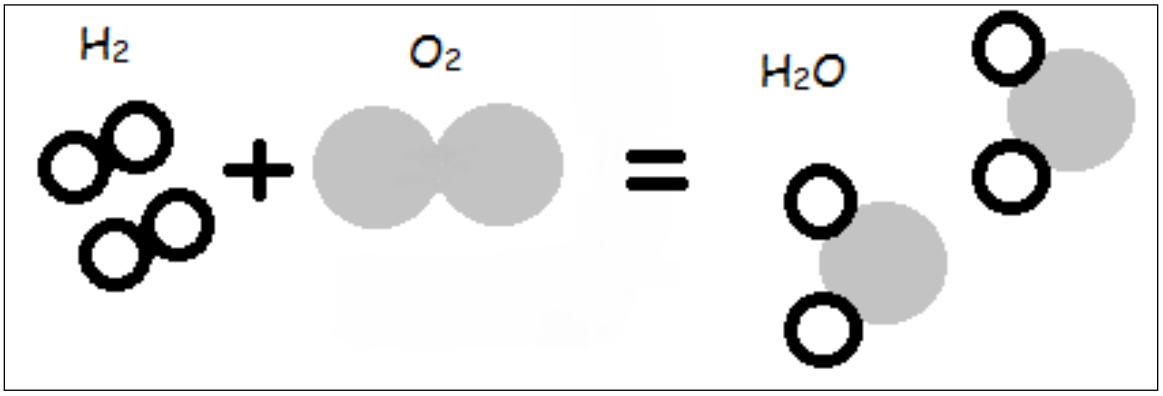
Ex. Ice melting to water and then boiling to steam; it's still water just changed phase

Chemical Change (Chemical Reaction)

- Changes which produce a new kind of matter, with new and different properties
- Products often have very different properties than reactants due to differences in energy (for example; when paper burns it turns into two gases (water and carbon dioxide) and solid carbon

Ex. Balanced Equation: _____

Diagram:



Hydrogen and oxygen gases combine at room temperature to make liquid water. In this case Hydrogen and oxygen are very reactive, high energy reactants, and water is a low energy product