Chemistry 11 Review

Chemistry is the branch of science that deals with the properties, composition and behavior of **matter.**

Chemistry is found all around us in our daily lives:

Ex. Plastics, computer chips, climate change, lenses, GE foods, ceramics, pesticides…

Elements have incredible flexibility, and can be changed into a multitude of different components:

Ex. Silicon (Si) – found in computer chips, glasses, ceramics, optical fibres, rocks and minerals…

Chemists seek to understand matter through **experimentation**, which involves making careful unbiased observations

Observations: done by using your senses to experience and can be –

Qualitative: (descriptive) – colors, odors, textures, flavors…
Quantitative: (numbers) – measurements; mass, temperature, length, amount…

Interpretations: (aka inferences) are conclusions based on your observations and experiences

Observations must be repeated several times by different people in order to be accepted as true; reproducibility

When a regularity is observed in the behavior of mater, a **hypothesis** (or temporary explanation) is formed about the observation

When the hypothesis has been tested by; accounting for observed events AND predicting future events, we call it a **theory**

To explain a theory we use **models**: these can be physical objects, symbols, equations and/or images. The models must change as the theory is disproved by future experimentation.

Introduction to Matter

Matter is anything that has mass (also defined as inertia, or resistance to change in motion) and occupies space (examples?)

Not matter: Energy (light, sound…), feelings, emotions

Properties of matter include melting point (mp) boiling point (bp) density, colour, odour, chemical reactivity, electrical conductivity (***intensive property***). But does **NOT** include things like; mass, volume which are dependant on the size of the sample and/or the temperature (***extensive property***)

Measurement and units

Scientific Measurement

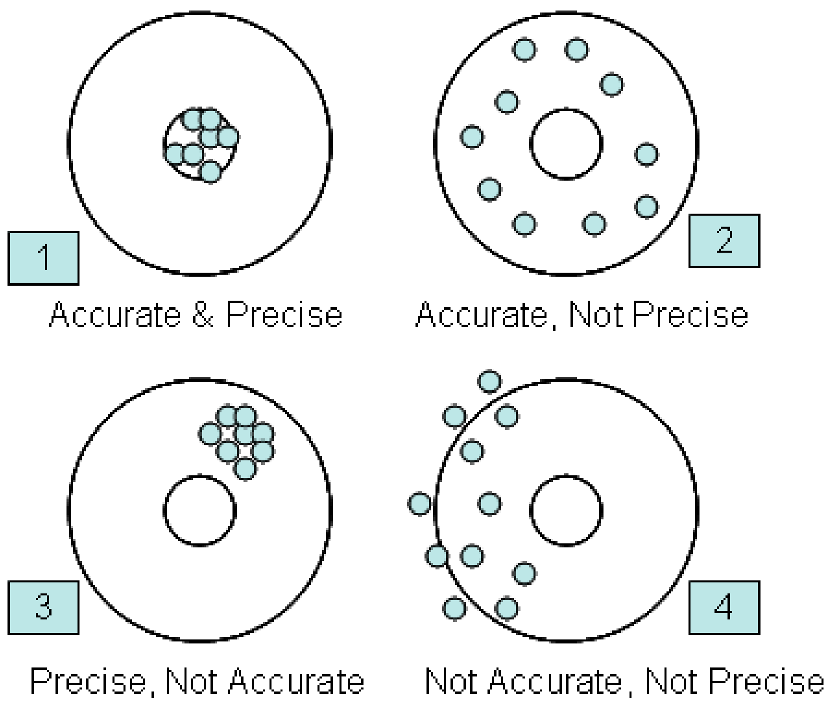
Measurement in scientific studies is meant to be as accurate and precise as possible so we can get good reliable results.

Scientific Notation

Numbers used in science are often very big or very small, such as the speed of light (300,000,000 m/s) of the size of an atom (~0.00000000010 m). In science we write these numbers in a condensed format like: 3.0×10^8 or 1.0×10^{-10}. It is always written as a number from 1 – 10 multiplied by some power of ten.

Accuracy vs Precision

Accuracy can be defined as the closeness to the accepted value
Precision can be defined as the **repeatability** of a test, or the amount of uncertainty given to a measurement

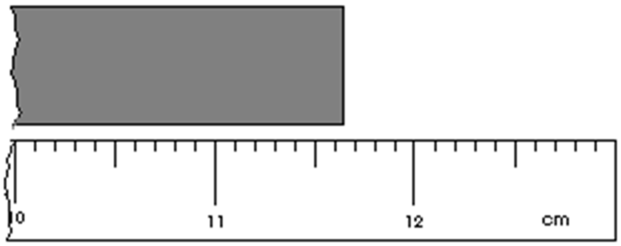


SI Units – *Système international d'unités*

- meters, seconds, kilograms, amps, kelvin, candela, and moles

ALWAYS INCLUDE UNITS WHEN MAKING MEASUREMENTS!

Significant Figures and Uncertainty



When we make a measurement, whether it's with a ruler, a graduated cylinder, or a mass spectrometer, there is always an amount of uncertainty associated with that measurement.

For example, with this ruler (above) you could say that the object (in grey) is larger than 11cm, but smaller than 12 cm. More precisely you could say it's between 11.6 and 11.7cm. But a scientist would record it as 11.66cm or 11.64 cm but that last digit is an approximation.

So we always record one more figure (or digit) beyond the smallest division mark on our measuring device. And that last digit is the uncertain (or approximate) digit.

A reading of 11cm has 2 significant figures (or Sig Fig's) 11.6cm has 3, and 11.64cm has 4 sig figs (notice all these measurements have units)

We want to have measurements with the most sig figs possible; this gives us better precision in our data.

Uncertainty

When you make measurements uncertainty is given as the range that a value could fall under, so for the previous question a range for the ruler would be between 11.64cm and 11.66cm, we could record this as 11.65 ± 0.01 cm. The "plus/minus" 0.01cm is the uncertainty.

If you are measuring on a digital scale or a device that you can not see the increments then the uncertainty should be labeled on the device you're using.

If you can see the increments (as with a ruler or graduated cylinder) then take generally we take it to be the first uncertain digit

When adding or subtracting uncertainties the resultant uncertainty is the sum of the individual uncertainties

When multiplying or dividing the resultant uncertainty is the sum of the percentage of uncertainty in the measurements.

Rules with Sig Figs

When you read a measurement, or more importantly when you do a calculation with a measurement, you need to know how many sig figs.

Generally we omit zeros unless they are between two non zeros. Zeros that are before (leading) a small number or after (trailing) a large number are NOT SIGNIFICANT

Numbers in scientific notation are all significant (not the x 10^x part)

Ex.

1,125,600	5 sig figs
0.00021	2 sig figs
3.95×10^3	3 sig figs
50,505,000	5 sig figs
0.00000000000009	1 sig fig

Calculations with Sig Figs

When multiplying or dividing your answer should have the same number of sig figs as the measurement with the LOWEST sig figs

Ex.

1210 ÷ 43	28
45 x 751	34000
$5 \times 10^{-4} \times 2.534 \times 10^{3}$	1

When adding or subtracting your answer should have the same number of digits (place values) as the measurement with the lowest number of digits (place values)

Ex.

1+10	10
0.0005 + 15.02	15.02
65.0 - 15	5.0×10^1
$5 \times 10^{-4} + 2.534 \times 10^{-3}$	3.0×10^{-3}

Matter

Phases of Matter

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

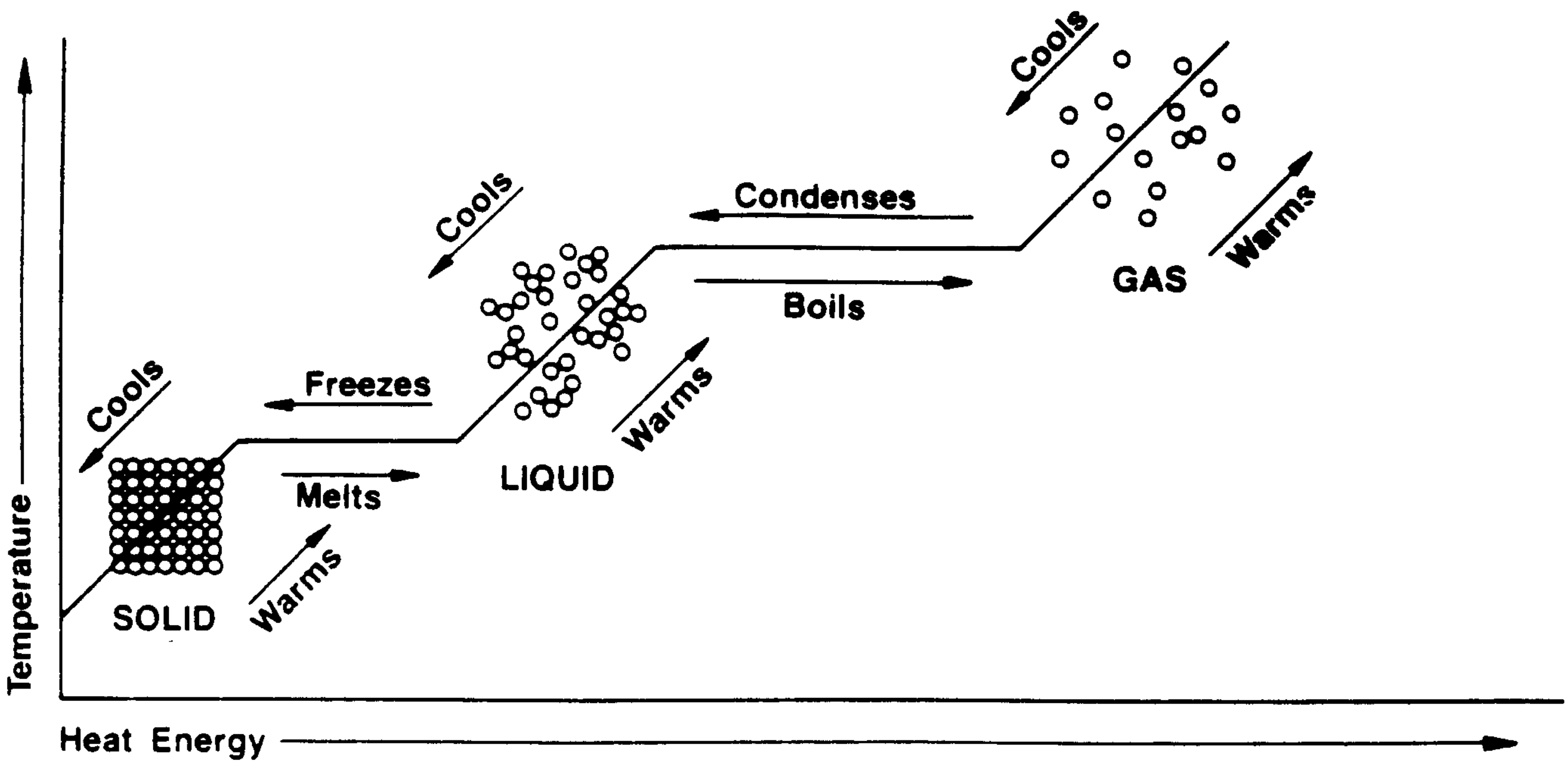
Some non common sates of matter include (but are not limited to):
- Plasma, glass, crystal, liquid crystal, magnetically ordered, superfluids like fermionic or Bose-Einstein condensates…

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

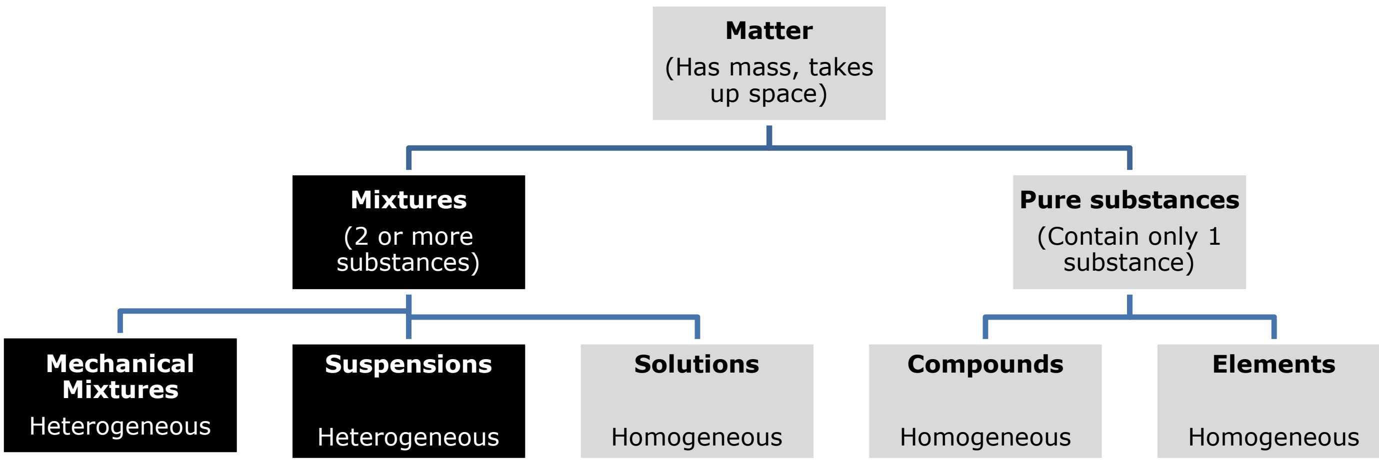
Phase changes between common states

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

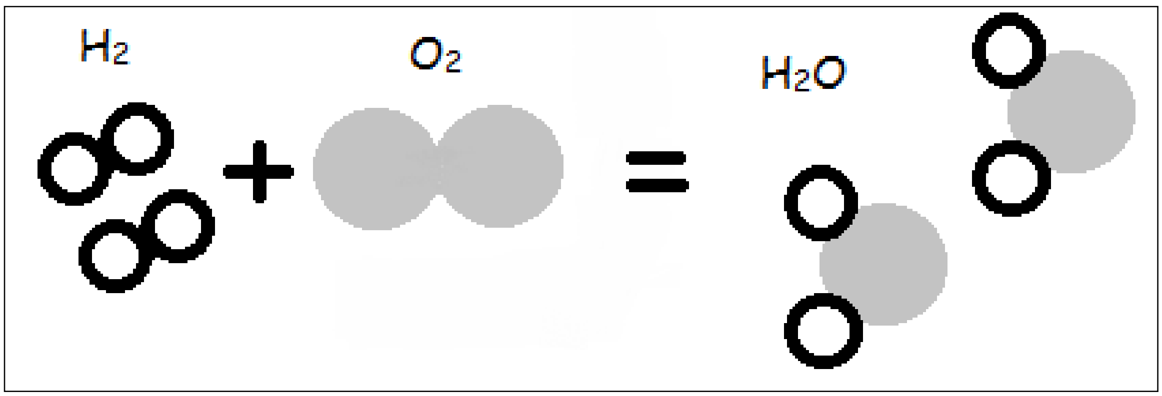
Ex. Ice melting to water and then boiling to steam; it's still water just changed phase

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. $2\ H_{2\ (g)} + O_{2\ (g)} \rightarrow 2\ H_2O_{\ (l)}$

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