Matter and Changes

SNC2D 06-07

Text Reference: 5.1 – 5.2, Pages 170 - 179

Chemistry: explains matter and the changes it undergoes.

Technology: is the application of science to solve practical problems.

Have you ever heard the question, "what is the matter now?"

Well, let me rephrase the question, "Now, what is matter?" Matter is simply something which occupies space and has mass. Any substance which you can observe with your senses is matter, example: smoke, rocks, water, gasoline, grass, etc.

Matter: is defined as anything which occupies space and has mass. All types of matter can be classified under the three headings: **solids, liquids and gases.** These three headings are known as the **three states** of matter:

solid$_{(s)}$ **liquid$_{(l)}$** **gas$_{(g)}$**

We may consider the properties of a material to help us to decide in which state the material is:

	solid$_{(s)}$	**liquid$_{(l)}$**	**gas$_{(g)}$**
• molecular model			
• structure			
• shape			
• strength of attractive forces			

The state that a substance takes depends on the temperature and pressure. In general, substances tend to be solids at lower temperatures and liquids at higher temperatures. To know the actual state of a substance, you need to know its temperature and pressure.

The Scientific Method

Science uses a unique method to investigate nature. The method is called the scientific method and can be summarized in **five steps**:

1. **Observation**: The first step in the scientific method consists of observation.
   a. Qualitative: Consists of observation without any measurement, only appearance, odour, colour, etc. is involved.
   b. Quantitative: Consists of measurement with numbers that indicate how much, how fast, how small, etc.

2. **Experimentation**: Makes it possible to "observe" the facts.

3. **Hypothesis**: Form an opinion (or a supposition) based on the observed facts, as to why things work the way they do. Often, the hypothesis is "an educated guess", a tentative explanation of the observed facts. Hypothesis may also be defined as one of many possible and reasonable explanations for an observation or a pattern..

4. **Theorization**: Make a theory out of the hypothesis. The theory explains a set of observed results which are always the same regardless of how many times an experiment is performed. After a sufficient time (many years), the theory becomes a "law" of science. A law is a statement of a regularity that has been observed, usually in a number of experiments.

5. **Communication**: Dissemination of the knowledge gained is important so that other scientists can test out the new theory thereby proving or disproving it. This communication is usually done through lab reports, journals, and periodicals.

Classification of Matter

As there are many different kinds of matter, it seems sensible to divide them up into groups on the basis of their properties.

System: the particular collection of materials which is isolated for experimental study.

Phase: is a physically separate part of a material having a uniform set of properties.

Composition: refers to the parts or components of a sample of matter and their relative proportions.

Properties: are those qualities or attributes that we can use to distinguish one sample of matter from another.

Pure Substance: is a homogeneous (uniform) material consisting of one particular kind of matter (one phase). Elements and compounds are pure substances.

Atoms: matter is built up from very tiny units called atoms, presently there are there are 114 different types of atoms and all matter is made up of just these 114 types!

Elements: are pure substances that cannot be decomposed into anything simpler by chemical means - they contain just one type of particle (atoms).
An element is represented by a symbol and can be in any phase.
There are 114 elements known so far, (96 are solids, 2 are liquids, and 11 are gases).
When elements exist alone, or uncombined with other elements, they are said to be in a "free" or "elemental state".
The elements are classified as metals and non-metals.
Elements are abbreviated by using a single letter, (always capital), or the first two letters of the name, (the first letter of a double lettered symbol is always capitalized).

Compounds: are substances in which atoms of different elements are combined with one another.

Elements and compounds are often called pure substances.
A substance is classified as pure if it meets the following criteria:
(1) it has the same composition throughout the sample,
(2) its components cannot be separated by physical methods,
(3) changes of state occur at a constant temperature, (the closer the boiling or freezing points are to the fixed points for the pure substance, the higher the level of purity).

Molecule: is the smallest entity having the same proportions of he constituent atoms as does the compound as a whole.

Mixtures: are composed of two or more substances each of which retains its own characteristic properties- i.e. they contain different types of particles which are physically mixed (each of the components of a mixture retain their properties), rather than chemically joined.
A mixture is a heterogenous blending of two or more substances, e.g.: sand and salt.
A mixture can be separated by simple physical changes.
The constituents of a mixture join in variable proportions.
Mixtures can exist in one or more phases (heterogeneous).

Homogeneous Mixtures: substances are composed of a single phase, and are uniform in composition and properties throughout a given sample.

Heterogeneous: substances are composed of more than one phase - the components separate into distinct regions. Thus, the composition and physical properties vary from one part of the mixture to another.

The Classification of Matter: Copy Figure 2 Page 172:

Properties of Matter: Physical and Chemical Properties

Imagine that you have a glass of water in front of you:
now, using your skill as an observer write down as many observations as you can about the water.

You should be able to separate your observations into qualitative and quantitative ones.

You can also describe water by identifying its Physical and Chemical properties.

Physical Property: is a property that may be determined by examination or measurement without causing a change in the composition of a substance, e.g. state (gas, solid, liquid), density, bp, colour, etc.
Example: Water is a clear, colourless, odourless, and tasteless liquid. Baking soda is a white, crystalline solid at room temperature that dissolves in water to form a clear, colourless solution.

A **qualitative physical property** is a property based on the use of descriptive terms.

Examples of Qualitative Physical Properties:

colour:	red, green, blue, etc.
odour:	pleasant, sharp, choking, putrid, spicy
taste:	sweet, sour, bitter, salty
state:	solid, liquid, gas
luster:	shiny, dull
texture:	smooth, silky, rough, slippery
hardness:	soft, hard, the harder the material, the more difficult it is to scratch.
flexibility:	rigid, brittle, flexible
transparency:	clear, opaque, translucent
magnetism:	magnetic, non-magnetic
conductivity:	conductor, (or heat or/and electricity), non-conductor
malleability:	malleable (how materials behave when it is squeezed, by hammering or pressure), non-malleable. (All substances that are malleable are also ductile.)
ductility:	ductile, (i.e. how much a material stretches when pulled, before breaking), non-ductile
viscosity:	viscous, (i.e. thick, not easily flowing), non-viscous, (i.e. runny)
volatility:	highly volatile (i.e. evaporates easily into the gas phase), low volatility
Crystallinity:	cleavage planes are the smooth flat surfaces that form given angles, and along which a crystalline substance will break. For example, the new surfaces that are produced when a salt or sugar crystal are crushed, or a diamond is cut are cleavage planes. Glass is not crystalline. A crystal is a substance that has cleavage planes, is non-malleable, and has a definite melting point.

In other words, if some material has a quality that distinguishes it from another, then this is a **characteristic property**.

Some properties that can be measured are not characteristic properties.
This is *because there are properties that are common to all matter*; these include mass, volume, and temperature.

A **quantitative physical property** is a property containing a measured numerical value, and is stated in units. Example, water freezes at $0^{O}C$ and boils at $100\ ^{O}C$ and has a density of $1 g/cm^3$.

Examples of quantitative physical property :

Property	Units
density:	g/mL, g/cm^3, kg/m^3
melting point:	^{O}C
boiling point**:**	^{O}C
solubility:	mol/L
heat of fusion:	J/g
heat of vaporization	J/g
vapour pressure:	kPa

Physical and Chemical Changes in Matter

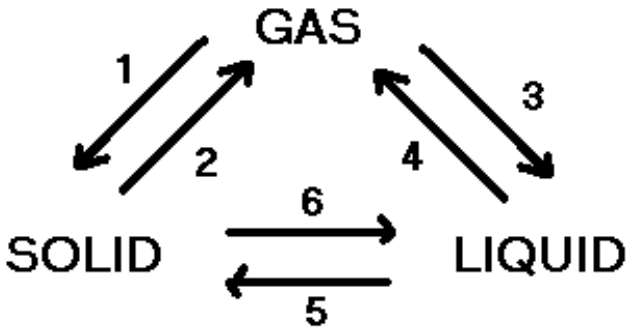
Have you ever heard the expression, "Nothing stays the same"?

Such is the case with the state in which matter can exist.
Three states of matter are gas, liquid and solid.
It is possible to change matter from one state into another with either an input of energy or output of heat, (i.e. endothermic or exothermic reactions).

Physical Changes:

1. Change of state, (solid, liquid, gas) or change of appearance without a change in chemical composition.
2. Original materials retained.
3. No heat liberated (*exothermic*) or absorbed (*endothermic*), but heat can be added or removed to change state, e.g. evaporation, freezing, etc.
4. Physical means of separation, e.g. magnetism, sedimentation, flotation, solution, etc.
5. Use terms such as: melting, freezing, condensation, dissolving, boiling, mixing, cutting, grinding, tearing, chopping, etc.
6. Change is reversible, the change is temporary, e.g.: ice ⟶ water ⟶ ice

Changes of State



1. **Gas Sublimation**: is the change of state in which a gas turns directly into a solid without going through a liquid phase

2. **Solid Sublimation**:

3. **Condensation:**

4. **Vaporization**:

(Note: Evaporation: is the change of state in which a liquid turns into a gas at any temperature below its boiling point.)

5. **Freezing (Solidification)**:

6. **Melting (Fusion):**

Chemical Property: the behaviour of a substance during a chemical reaction, (i.e. those changes which involve changing various kinds of matter into other substances with different compositions, different structures and different properties).
Example: when baking soda is added to vinegar, (acetic acid), a vigorous reaction occurs, producing a new substance, a colourless gas called carbon dioxide.

Chemical properties also include the behaviour of a substance when it is exposed to light, heat or an electric current.
For example, silver compounds darken on exposure to light, gasoline will burn when ignited, and water will separate into hydrogen gas and oxygen gas when an electric current is passed through it.

Changes of State: Chemical Changes:

One of the main ideas of science is that matter can not be created nor destroyed. But, matter can change.
Chemical change may be recognised by the following criteria:

1. Change in appearance **with** a change in chemical composition.
2. Formation of new materials, new molecules are produced.
3. Heat either absorbed or liberated in chemical reaction.
4. Chemical means of separation, e.g. synthesis, decomposition, etc.
5. Use terms and descriptions such as: *burning, cooking, digesting, rusting, corroding, growing, reacts with, tarnishing, etc.*
6. Change is irreversible, the change is permanent, e.g.: burning log $\longrightarrow$ ashes

When a chemical change occurs, there is usually *some evidence, (i.e. criteria* for a chemical change***) such as:***

- *a change in colour,*
- *change in temperature*
- *mass of the reacting substances,*
- *evolution of a gas,*
- *formation of a precipitate (insoluble solid produced after chemical reaction).*

Some examples of chemical changes include: combustion, electrolysis, fermentation, oxidation

Demo: Tests for Gases

1. Hydrogen:
Preparation: zinc metal and hydrochloric acid
Properties of hydrogen gas:

Test for Test: Result of Test:

(An explosion is a rapid expansion of gases caused by rapid heating, examples are the gases produced by dynamite, and the solution of gasoline vapour and oxygen burning in an automobile engine.)

2. Oxygen
Preparation: hydrogen dioxide and manganese dioxide (as a catalyst)
Properties of oxygen gas:

Test for oxygen gas: Result of Test:

Carbon Dioxide:
Preparation: calcium carbonate and hydrochloric acid
Properties of carbon dioxide:

Test for carbon dioxide: Result of Test:

(A precipitate is an insoluble substance, i.e. a substance that will not dissolve in a solvent, produced in a solution.)

Water vapour
Test for water vapour: Result of Test:

Homework:

1. Page 175, # 1 – 9
2. Worksheet: Matter Concepts
3. Lab: Chemical Change