Science Focus 8 - Unit 1

Teaching Notes

Edquest Resources 2001

Topic 1 – Matter on the Move (pgs. 6 – 12)

Fluid Properties …

The particle model helps to explain why gases and liquids flow, while solids do not.

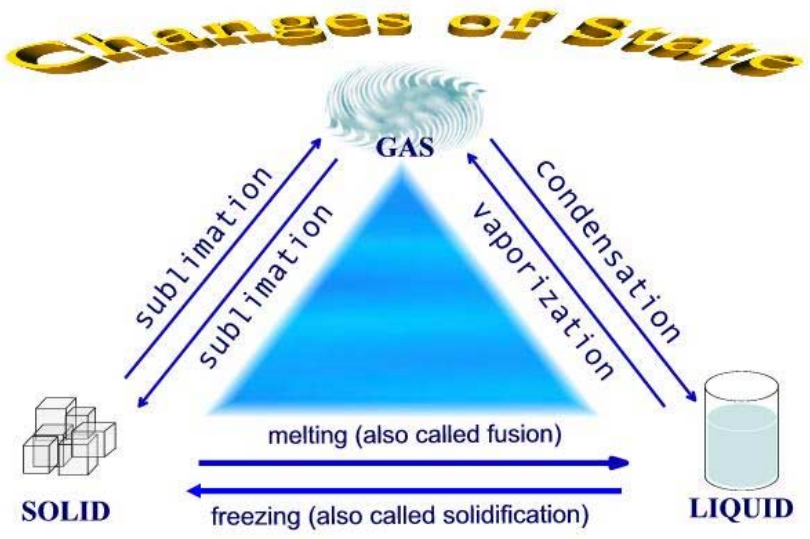
		
Solid …	**Liquid** …	**Gas** …
- have definite shape and volume	- have a definite volume, but no definite shape	- have neither a definite shape nor a definite volume
- particles are tightly packed together (vibrating)	- have enough energy to pull away from each other	- have lots of energy and huge spaces between each particle
- form a pile when they are poured (the particles do not continue to flow apart from each other)	- can be poured (always flowing to the lowest possible level) and form a level (flat) surface at rest	- flow easily past each other, move in all directions, do not flow to the lowest possible level

The Particle Model (Theory)

- All substances are made of tiny particles
- All particles in a pure substance are the same (Different pure substances are made of different particles)
- All the particles have spaces between them
- All the particles are always in motion (the speed of the particles increases/decreases when the temperature increases/decreases)
- The particles in a substance are attracted to one another (the strength of the attraction depends on the type of particle)

Changes of State

A change of state occurs when the particles of a substance gain or lose energy. The diagram below indicated the terminology used.



Applications

- The most common form of matter in our universe exists in a fluid state called **plasma**, which is a gaslike mixture of positively and negatively charged particles. (It is often considered to be the fourth state of matter) – Plasma, if controlled could be used as rocket fuel.

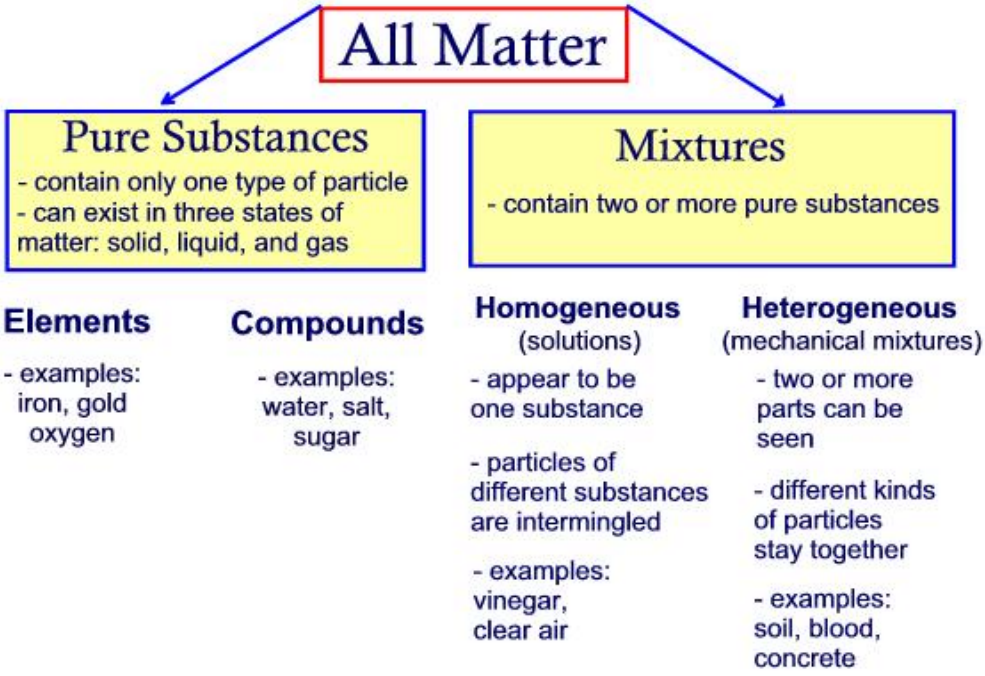
- Morphing is a special film effect that mimics the changes we see in the states of matter (*like terminator – when the policeman morphs into liquid*)

- Every substance has its own freezing and melting point which presents important applications for the manufacturing industry – like candle making

- Recycling industries apply the knowledge of changes of state to breakdown and reconstruct material for reuse.

Topic 2 – Mixing and Dissolving (pgs. 13 – 26)

Classification of Matter



- All pure substances have their own unique set of properties, or characteristics
- All mixtures contain two or more pure substances, which have their own distinct properties (some of which may be hidden)

Homogenous Mixtures

- are mixtures which look as though they have only one set of properties.
- the blended mixture has equal amounts of both substances (all parts of the mixture are the same)
- if the homogenous mixture does not have any settling of any of the substances it is made of, then it is called a **solution**
- solutions occur because each particle slips between each other particle and is evenly distributed throughout the entire mixture

Homogenous Mixtures

- the properties of the pure substances, in a heterogeneous mixture, are not hidden
- if there are two or more materials that are visible within a mixture, then it is called a heterogeneous mixture

In-Between Mixtures

- a heterogeneous mixture, in which the particles settle slowly after mixing, is called a **suspension** (eg. orange juice)
- a heterogeneous mixture, in which the particles do not settle at all, is called a **colloid** (eg. fog)
- to disperse the particles for a longer period of time, an emulsifying agent (like a protein) is used to form an **emulsion** (eg. mayonnaise)
- mixtures that are obviously two or more substances are called **mechanical mixtures**

the separate parts of the mechanical mixture are called **phases**

What Makes Materials Dissolve?

- forming a solution by mixing two or more materials together is called dissolving
- dissolving occurs because of the attracting between the particles (there may be a stronger attraction to the particles of another substance, than to the particles of the same substance)

Solutes and Solvents

The **solute** is the substance that dissolves in a **solvent**. The **solvent** is the substance that dissolves the **solute** to form a **solution**.
Soluble means to be able to be dissolved in a particular solvent. Solutes and solvents can be gases or liquids.

Water – the Universal Solvent

- it is called the 'universal solvent' because it can dissolve so many materials
- 97% of the water on Earth is Ocean water, 2% is frozen and only about 0.5% is 'usable' (and even this has materials already dissolved in it that can be harmful

The Rate of Dissolving

- the speed at which the solute dissolves in a solvent is called the rate of dissolving and can be affected by:
  - **agitation** (stirring or shaking)
  - **temperature**
  - **pressure**

How Much Can Be Dissolved?

- the limit to concentration is called **solubility**
- a **saturated solution** is one in which no more solute will dissolve in a specific amount of solvent at a specific temperature
- an **unsaturated solution** is one in which more solute can be dissolved in a specific solvent at the same specific temperature
- solubility chart (p. 20)
- **using the particle theory**, the attractive forces between the particles becomes balanced and no more particles of the solute can be attracted by the particles of the solvent

Beyond the Limit: Supersaturated Solutions

- a solution that contains more solute than would normally dissolve at a certain temperature is called a **super-saturated solution**.

Cleaning Up with Solvents

- Not all solute will dissolve in solvents. **Insoluble** means not able to be dissolved in a particular solvent.
- certain solvents are used for special circumstances because they will dissolve some solutes that water and other solvents cannot (rubbing alcohol is use to dissolve chlorophyll – grass stains, because the particles have strong attractions)

WHMIS Safety Symbols (refer to Safety Notes)

Applications

- Swedish dentists have developed a mixture that may replace the drill used for filling cavities. The mixture dissolves decayed dentine in teeth. It is a red mixture called **Carisolv**.

- **Perchloroethethylene** is the solvent used in ‘dry’ cleaning, even though it is a liquid

Topic 3 – Separating Earth's Mixtures (pgs. 27 – 38)

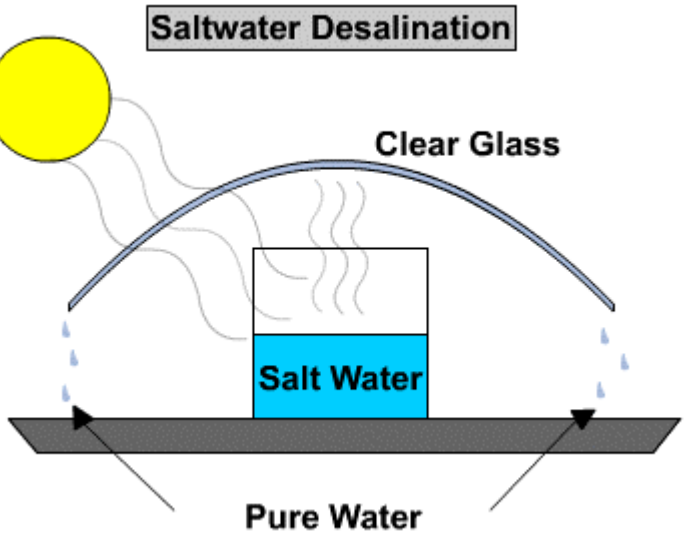
The Earth is rich in natural mixtures

Separating Mixtures

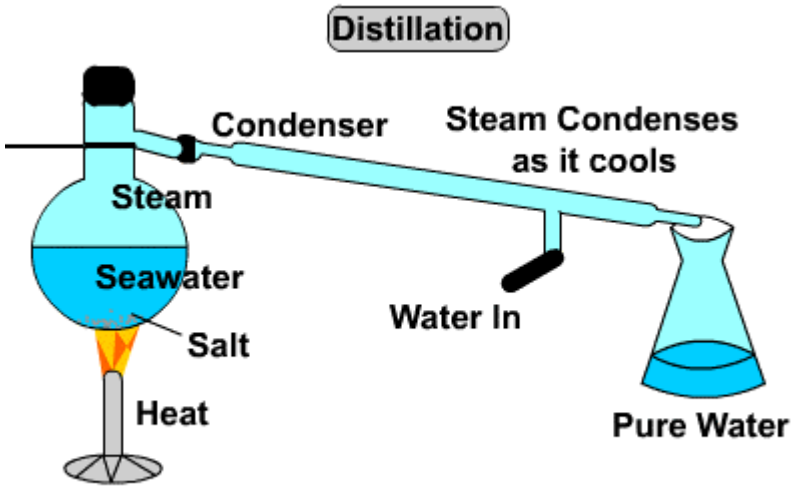
- when fluids are used to make solids flow, the solids must later be recovered
- separation methods are designed to take advantage of the unique properties of the substances that have been mixed

Desalinating Water

- the '**desert tent**' method (much like distillation) is inexpensive, but slow, and only practical in areas which receive a lot of bright sunlight



- **desalination plants**, along the Red Sea, use lots of energy and are very expensive to operate
- the process of removing water from a solution is called **dehydration**
- the **solvent** (which is the water, in most cases) is separated from the solution by means of evaporation
- **distillation** is a separation method that allows all the **liquid fractions** of a mixture to be separated from each other and collected independently
http://lorien.ncl.ac.uk/ming/distil/distil0.htm
- all seawater contains salt, but in varying amounts - from place to place, with the **dead sea** having the highest concentration



Processing Petroleum

- petroleum is a natural mixture of hydrocarbons and must be processed to recover useful petroleum products
- the process that does this is called **fractional distillation**
- when the petroleum is heated, it changes into a gas (**vaporize**), which is collected and cooled, enabling it to change back into a liquid (**recondense**)
- the recondensed liquid is further separated (the parts redondense at different temperatures) into each of the fractional parts, that are soluble in each other, but not in water
- fractional distillation is done in a two-tower structure and the fractional products can then be converted (further processed) into over 500,000 types of petrochemicals

Solid Mixtures From Underground

- an ore is a mineral (or group of minerals) that contains a valuable substance (like gold)
- to extract the substance (gold) that needs to be recovered it must be mined and crushed, then mixed with water to create a fine suspension
- chemicals are then added to dissolve only the substance (gold) you want
- the substance (gold) is then released from the solution when another substance (zinc) is added, allowing the residue (gold) to sink and be collected

Applications

- Convenience foods are often dehydrated, so they can be stored for long periods of time without spoiling (you just add water when you want to use it)
- petrochemical products include aspirin, sports equipment, eyeglasses, chewing gum, duct tape and fertilizer - check out this link
- there are many different types of salt, the most common one is sodium **chloride** (table salt) – potassium chloride is **potash**
- sugar beets and sugar cane are refined to give us sugar crystals, maple sap is boiled to make '**sweetwater**' or **maple syrup**

WRAP-UP p. 39

>>>> A good review of Topics 1 – 3 in this Unit <<<<

Topic 4 – Flow Rate and Viscosity (pgs. 40 – 49)

- a liquid's resistance to flow (its thickness or thinness) is called **viscosity**
- a thicker a liquid is, the more **viscous** it is and the higher viscosity it has
- viscosity is a property in liquids and gases (in which it increases and decreases differently than in liquids)
- the time it takes for a fluid to flow over a set distance is called **flow rate**

Product Performance and Viscosity

- viscosity is measured precisely in many industries (paint, cosmetics)
- nail polish goes on smooth and dries to a solid, while mascara is thick and dries quickly … the viscosity of these liquids is controlled by a solvent
- a **solvent** keeps the ingredients of the mixtures dissolved, then it evaporates

Product Appeal and Viscosity

- heat affects viscosity because it thins out the fluid, making it less viscous
-food manufacturers consider viscosity in order to make their product marketable (a candy that is too hard will not sell – if it is too hard)

Applications - a liquid for stripping paint off furniture would drip off before it had a chance to remove the paint, so the viscosity (making it a gel) was increased to improve its performance - a chef will thicken or thin gravy, or sauce, by adding, or taking away more solvent (water) - mechanics must adjust the viscosity of oil depending on the season of the year - artists change the viscocity of the paints they are using - technicians control the viscosity of chemicals in chemical processing plants

How Does the Viscosity of Liquids Vary?

- liquids flow at different rates because they have different viscosities
- as temperature increases, the attractive forces between the particles is less, so

the viscosity of a liquid **DECREASES** *as it is* **HEATED** *and* **INCREASES** *when it is* **COOLED**.

How Does the Viscosity of Gases Vary?

- gas particles flow differently than liquid particles, because they are so far apart and the attractive forces between the particles are very low
- instead of sliding past each other (as they do in a liquid), the particles of a gas are more likely to collide (increasing the resistance to flow and therefore increasing the viscosity)
- temperature has a direct effect on viscosity of a gas - as temperature increases, the attractive forces between the particles is less, so

the viscosity of a gas **INCREASES** *as it is* **HEATED** *and* **DECREASES** *when it is* **COOLED**

Topic 5 – Density (**pgs. 50 – 58**)

Density is mass per unit volume of a substance

- according to the particle theory, the size of the particles of a substance determines how many particles of that substance can 'fit into' a given space (each substance has its' own unique density)

Density of Solids, Liquids and Gases

Water is a special substance, because when it freezes, it expands and becomes less dense – thus ice is less dense than liquid water

- because water vapor particles have more space between them, there are fewer particles in the same space and the water vapor has a lower density than liquid water
- ***gases are less dense than liquids***
- when an object (solid) moves through a fluid (liquid or gas) it pushes the particles apart and moves between them
- liquid and gaseous particles tend to move 'out of the way' for solid particles as well, because they have less attractive force between the particles
- when heat is applied to a substance, the particles gain energy and the space between the particles increases – with more space between the particles, the density of the substance decreases

Density: How are Mass and Volume Related?

- **mass** is the amount of matter in a substance (number of particles)
- **volume** is a measurement of the amount of space occupied by the substance (space that allows the particles to be present)
- **capacity** is the greatest amount of matter in a substance
- **weight** is the force of gravity exerted on an object
- **force** is a push or pull, or anything that causes a change in the motion of an object
- **gravity** is the natural force that causes an object to move toward the centre of the Earth

A Formula for Density

- the mass-to-volume ratio is the relationship between mass and volume (expressed as a quantity of the mass divided by its volume)

Density = Mass / Volume (**D = m / V**)

- as long as the temperature and pressure stay the same, the mass-to-volume ratio, or density, of any pure substance is a **constant** (does not change)

Topic 6 – Buoyancy (pgs. 59 – 69)

Buoyancy is the tendency for materials to rise or float in a fluid

- the **buoyant force** is the upward force exerted on objects that are place in a fluid

The " Anti-Gravity " Force

- buoyancy refers to the ability of a fluid to support an object floating in or ion the surface of the fluid
- **floating** occurs when an object is suspended in the fluid
- the particles of a fluid exert a force in a direction opposite to the force of gravity, which ***pulls down*** – toward the centre of the Earth
- the upward force on objects, submerged in, or floated on fluids – ***pushes up***, away from the centre of the Earth
- buoyant force is measured in **Newtons** (N)

Sinkers and Floaters

- design has a lot to do with whether an object will sink or float – if the weight of the object is spread over a large enough area, water can support objects that have densities greater than water

Average Density

- the **average density** of an object is the total mass of all substances that are enclosed in the object, divided by the total volume

Benefits of Average Density

- average density is useful because it enables objects that would otherwise sink – such as large ships (TITANIC) – to float
- average density also helps floating objects sink – a **fish bladder** enables fish to increase or decrease their density, by adding or removing air
- depth-control has been adapted to enable the **submarine** (in water) and the **blimp** (in the air) to rise and dive, much like a fish – using the same principles of average density

http://www.howstuffworks.com/submarine.htm (flash demo)

http://www.howstuffworks.com/cargolifter.htm (dirigibles, blimps, etc.)

Story of Archimedes of Syracuse (Eureka!)
http://www.shu.edu/html/teaching/math/reals/history/

Archimedes' Principle

- states that: **the buoyant force acting on an object equals the weight (**force of gravity**) of the fluid displaced by the object.**
- used his own body (which displaced water in the bathtub) to prove the king's goldsmith was cheating the king
- the buoyant force does not depend on the weight of the submerged object, but rather on the weight of the displaced fluid

How Buoyancy and Density are Related

- The buoyant force of a liquid does not depend on physical state, but rather on density (This is also true for buoyancy in gases)
- the relationship between buoyancy and density is the basis for the **hydrometer**, which is an instrument designed to measure density directly
- the higher the hydrometer floats in the liquid being tested, the higher the density is (of the liquid)
- hydrometers are used widely in the food and beverage industries
- besides density, hydrometers can also (indirectly) measure sugar content of canned fruit syrup or alcohol content of wine

WRAP-UP p. 70

>>>> A good review of Topics 4 – 6 in this Unit <<<<

Topic 7 – Fluid Pressure (pgs. 71 – 77)

A Formula for Pressure

Pressure can be calculated by using the following formula:

Pressure (P) **= Force** (F) **/ Area** (A)

or, **P = F / A**

Force is measured in **newtons** (N)
Area is often measured in **square metres** (m^2)
Pressure is **newtons per metre square** (N/ m^2) - also called a **pascal** (Pa), after **Blaise Pascal** (a french scientist in honour of his pioneering work in pressure)
1000 pascals is called a **kilopascal** (kPa)

Compression of a Gas

- Compression of a gas is made possible because of these conditions:
  (1) the gas must be in an enclosed, sturdy, sealed container
  (2) the space between the particles still exists, enabling the substance to continue to be a gas
  (3) an external (outside) force is applied to push the particles closer together
- gases are compressible because their particles can be squeezed closer together into a smaller volume
  - because the space between the particles is already so small, liquids and solids are almost **incompressible**.
- instead of compressing when the force is applied to a solid or liquid, the force is transmitted (from particle to particle) throughout the substance

Some Advantages of Compression

- gases can exert a force back (a counterforce) when they are compressed – useful in cushioning shocks
- automobile shocks, airbags, running shoes
http://www.howstuffworks.com/airbag.htm
http://www.howstuffworks.com/category-automotive.htm

Atmospheric Pressure

- Earth's atmosphere is about 160 km thick and is held to the Earth by the force of gravity
- the force exerted by the weight of the air is called air pressure and changes with altitude
- the higher the altitude, the lower the pressure (because fewer particles are present, exerting pressure – the air is thinner)
- the pressure inside your body does not change as quickly, with changes in altitude, so the number of particles pressing from the **inside out** is still the same at the top of a mountain and at the base
- if the difference in pressure on either side of the eardrum becomes great, you experience a **'pop'** inside your ear (this is the pressure equalizing)

Measuring Air Pressure

- the most common device for measuring air pressure is the **barometer**
- in a mercury barometer, increased air pressure forces the column of mercury up the glass tube and allows it to fall when the air pressure decreases

Balanced and Unbalanced Forces

- if the inside of a closed container experiences a lower air pressure than the air pressure pushing on the outside, the walls of the container will buckle (cave in) because there is an **unbalanced force** - the force of the atmosphere is greater than the force within the container

Applications

- Blaise Pascal was only 16, when he published a geometry book, and invented his first mechanical calculator when he was 19
- Pascal's ideas formed the basis of 'hydraulics'
- cushioning materials (gymnastic mats, Styrofoam packaging and bubble wrap) are used to absorb the force of impact to reduce the pressure felt
- all-terrain vehicles have a wide tire to spread out the pressure over a larger area
- carbonated soda products are packaged in plastic bottles and are crushed when the air or soda is sucked out because of unbalanced forces unlike glass bottles which can withstand the external force acting on it
- the **carbonation** is provided by the carbon dioxide gas added to the syrup and then trapped in the bottle (if you open it quickly the carbon dioxide will escape quickly causing fizz)

Topic 8 – Fluid Systems (pgs. 78 – 84)

Applications

- Aerosols work because particles flow from areas of high pressure to low pressure (Aerosol spray counter http://www.invention.com/klein.htm)
- Aerosols use to have CFC's (**chlorofluorohydrocarbons**) but were banned because of their effect on the ozone layer (they break down ozone by reacting with ultraviolet light)
- Fire extinguishers work differently than aerosols (liquid carbon dioxide, under pressure, changes to a gas when released, because the particles gain energy and need more space)
- any gas or liquid under pressure must be in a very sturdy container (if the container is ruptured or exposed to high temperature, it can explode because the particles gain energy and need more space)
- (pneumatic tools) tampers are used to pack down dirt or gravel in road construction and dentist's use pneumatic drills

Hydraulic Systems

Hydraulics is the study of pressure in liquids
- devices that transmit applied forces through a liquid to move something else, because of pressure, are called **hydraulic systems**
- in a hydraulic system, a force is exerted on a continuous, enclosed liquid
- this force creates pressure which is transferred equally throughout the liquid

Hydraulics to Transport Fluids

- liquids flow away from the applied force in all directions (**pumps** provide the applied force, and **valves**, which can direct the fluid or allow it to escape from the system, control the flow of the liquid)

Pneumatic systems are similar to hydraulic systems, except that gases are used, instead of liquids - they operate on the principle that gases can be compressed

- compressors (devices used to compress air) are used to build up air pressure and then release it, allowing the compressed air to **decompress** (the particles move apart suddenly creating a strong, steady force that can be used to perform powerful tasks)

WRAP-UP p. 85

>>>> A good review of Topics 7 – 8 in this Unit <<<<