

**EVALUATING  
ACADEMIC READINESS  
FOR APPRENTICESHIP TRAINING**  
Revised for  
**ACCESS TO APPRENTICESHIP**

**SCIENCE SKILLS  
CHEMICAL PROPERTIES OF MATTER**

**AN ACADEMIC SKILLS MANUAL  
for  
The Hairstylist Trade**

*Workplace Support Services Branch  
Ontario Ministry of Training, Colleges and Universities*

*Revised 2011*

In preparing these Academic Skills Manuals we have used passages, diagrams and questions similar to those an apprentice might find in a text, guide or trade manual.

**This trade related material is not intended to instruct you in your trade. It is used only to demonstrate how understanding an academic skill will help you find and use the information you need.**

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## SCIENCE SKILLS

### CHEMICAL PROPERTIES OF MATTER

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*An academic skill required for the study of the  
Hairstylist Trade*

As a hairstylist, you will work with many different kinds of materials, from steel scissors and plastic curlers to hair colouring solutions. All of the materials you use are recognized by their characteristics or properties. There are two main types of properties – chemical properties and physical properties.

Chemical properties depend on the compositions and arrangement of the molecules that make up a substance. Because the chemical properties of a material result from its atomic characteristic, we can't directly observe them. However, the chemical properties of a substance determine all its other features – its physical characteristics and how it reacts in the environment.

Physical properties are the features of a substance that we can see or measure, such as its colour, physical state or electrical conductivity. Because the physical properties of a material depend on its chemical composition, they are closely linked. We use physical properties to assess the chemical make-up of a substance.

You won't have to know the chemical composition of the materials you use, but you should know the effects of their chemical and physical properties. For example, you don't want to choose a metal implement that will chemically react with water or with a disinfectant and corrode.

Some materials must be handled carefully because they can pose a health risk. For example, a nail polish remover might say, "Volatile solvent. Use only in well-ventilated area." This health warning is better understood if you know that a volatile substance is one that changes rapidly from a liquid to a gas at room temperature.

This skill manual looks at the chemical characteristics of substances and how they influence its physical properties, including changes of state. The following topics are covered:

- ◆ Review of atomic structure
- ◆ Chemical properties
- ◆ Chemical change
- ◆ Physical states of matter
- ◆ Kinetic energy
- ◆ Changes of state
- ◆ Direction of changes of state
- ◆ General properties of matter

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## **REVIEW OF ATOMIC THEORY**

An **atom** is the smallest building block of matter.

- Atoms are composed of subatomic particles called **protons**, **neutrons** and **electrons**.
- The number of protons in an atom determines what element that atom forms.

An **element** is a substance made up of only one type of atom. An element cannot be broken down by a chemical reaction into other, more basic substances.

- Oxygen is an element because pure oxygen can't be broken down into smaller particles.
- Other examples of elements include: hydrogen, carbon, iron, lead and silicon.
- Water is not an element because it can be broken down into atoms of the elements oxygen and hydrogen.

A **molecule** is formed when individual atoms are joined together by a **covalent**, **ionic** or **metallic bond**.

- An oxygen molecule is formed when two oxygen atoms bond.
- A carbon monoxide is formed when one oxygen atom and one carbon atom bond.
- A molecule of water consists of one oxygen atom and two hydrogen atoms.
- A molecule of silica consists of two oxygen atoms and one silicon atom.

The molecules of a **compound** consist of atoms of two or more different elements bonded together in an unchanging ratio. A compound is a substance formed by chemical reaction. The molecular makeup of a substance remains unchanged unless there is a chemical change.

- Pure water is a compound. Every molecule of water formed by the bonding of two hydrogen atoms with one oxygen atom.
- Molecules of rust all contain both iron and oxygen.
- Silica molecules join together in a crystal structure to form glass. Silica is used as a gel forming agent in fluids and fine silica particles are used as in scrub cleansers.

## **CHEMICAL PROPERTIES OF MATTER**

**The chemical properties of matter** are those that relate to its atomic and molecular structure and how it changes in composition or how it interacts with other matter.

The chemical properties of any substance are controlled by the stability of the outer electron shells of its atoms and by the stability of the molecular bonds that form the substance. We examine the chemical properties of a substance by looking at how it reacts when it comes in contact with other substances.

Some examples of chemical properties are:

- paper burns
- nitrogen does not burn
- iron rusts
- gold does not rust
- wood rots

- silver does not react with water
- sodium reacts with water

In each of these, the substance's chemical property is its tendency to:

- react
- tarnish
- corrode
- explode

## **CHEMICAL CHANGE**

The chemical properties of a substance determine all of its characteristics, including its physical features. Most chemical properties of a material are described in terms of how it reacts with other substances to undergo chemical changes. For example, some materials react chemically with oxygen – they rust, burn or explode.

*A **chemical change** takes place when the atoms making up a substance are rearranged to form a new substance with a different molecular structure and with completely new properties.*

Chemical properties change when a substance undergoes a chemical change.

### **Rusting**

A chemical change takes place when iron, a solid metal, changes to a crumbly, reddish brown material called iron oxide or rust.

- Rusting is a chemical change in which molecules of iron, a solid metal, slowly bond with molecules of oxygen to form iron oxide molecules (rust).
- Iron oxide (rust) results from the chemical reaction between the element iron and the element oxygen, which is found as a common gas in air and also as one of the elements, along with hydrogen, that makes up water.
- As a result of the chemical reaction, the molecule of a new substance, iron oxide, is formed.
- The iron oxide molecule is made of two atoms of iron joined with three atoms of oxygen.
- The individual components iron and oxygen are quite different from the substance that results when they combine to form a flaky, porous material called rusted iron.

What is important here is that *a **chemical reaction is a process which rearranges atoms and the bonds that hold them together to produce a new substance with characteristics unlike any of the individual elements which form it.***

Let's look at how the reaction occurs.

- Oxygen is a very reactive element and will combine with many other elements.
- When oxygen does combine with another element, the process is called oxidation and the resulting substance is called an oxide.
- When rusting occurs, the oxygen (O<sub>2</sub>) in moist air comes in contact with iron (Fe). The oxygen in air slowly combines with the iron molecules.

- Four single atoms of iron ( $4\text{Fe}$ ) combine with the three oxygen molecules ( $3\text{O}_2$ ), resulting in two molecules of iron oxide. Iron oxide is written in its chemical format as  $2\text{Fe}_2\text{O}_3$ .
- The chemical formula for rusting of iron is:
  - $4\text{Fe} + 3\text{O}_2 \rightarrow 2\text{Fe}_2\text{O}_3$
  - We say four iron atoms combine with 3 oxygen molecules to produce 2 iron oxide molecules.

### Corrosion and combustion

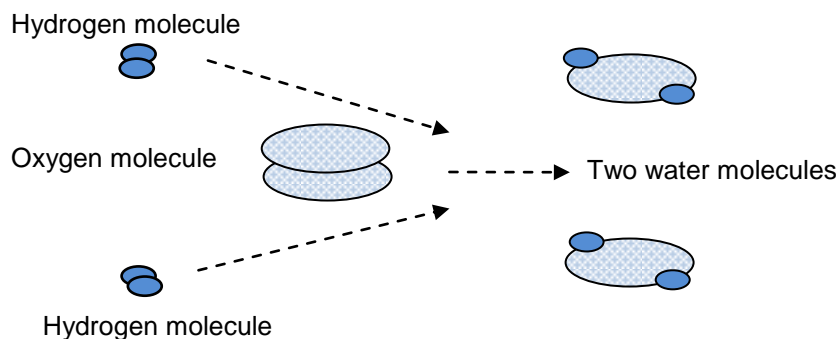
This rusting reaction is also called corrosion. Corrosion is a slow oxidation process. When oxygen combines rapidly with other elements, the reaction gives off heat and light and is called combustion.

- Burning in a wood fire is a rapid chemical change in which the carbon molecules in wood bond with oxygen in the air, forming two new molecules. These molecules, carbon dioxide and carbon monoxide, are both combinations of carbon and oxygen.

### Creation of a water molecule

Let's look more closely at another chemical reaction, the formation of water. As we said, water is very different from the oxygen and hydrogen gas molecules it is made from.

**Example;** Water is formed when two hydrogen molecules ( $2\text{H}_2$ ) combine with one oxygen molecule ( $\text{O}_2$ ) to form two molecules of  $\text{H}_2\text{O}$ . The chemical formula for the formation of water is:  $2\text{H}_2 + \text{O}_2 \rightarrow 2\text{H}_2\text{O}$



#### **A Chemical Change: Formation of water molecules.**

Two hydrogen molecules and one oxygen molecule react to form two water molecules.

### Catalysts

Many chemical changes involve other substances called *catalysts*. They speed up the rate of a chemical reaction and help organize the molecules involved.

- A catalytic converter on a car contains catalysts which increase the rate at which the polluting molecules that result from the combustion of gasoline are broken down to less harmful molecules.

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All the complex substances used in your trades are made of molecules that have chemically combined in different arrangements.

### **Relation of physical change to chemical change**

Chemical and physical properties are closely related because a substance's physical properties are a result of its chemical structure. When a chemical change takes place, a new substance is produced. When a physical change takes place, the substance might look and behave differently but it is still the same substance.

*In a **chemical change** a substance will change both physically and chemically.*

- When water undergoes a process called electrolysis, an electric current is passed through liquid water causing a chemical change to occur.
- The water molecules break apart and separate into independent molecules of hydrogen and oxygen gases.
- Gases still bubble up from the water but now they have chemically split into hydrogen and oxygen gas, not water vapour.

*A **physical change** can take place in a substance without changing its underlying chemical structure.*

- Water changes only its physical structure when it changes from a liquid to a gas.
  - We can see bubbles of water vapour evaporating into the air as water boils.
  - Each water vapour molecule is still made of two hydrogen atoms and one oxygen atom.
  - Each water vapour molecule is still made of two hydrogen atoms and one oxygen atom.
  - The water only changes physically, not chemically. The molecules of water vapour remain unchanged.

A **mixture** occurs when two or more substances are physically blended but do not combine chemically. There is no change in the molecular structure of any of the substances in a mixture. Each substance in the mixture keeps its original structure and properties when it is separated out of the mixture. For example:

- Salt can dissolve in water but it does not form molecular bonds with water molecules.
- Drinking water is a mixture of pure water (H<sub>2</sub>O) and salts and minerals that are dissolved in it.
- Latex paint is a mixture of water, particles of a polymer, or plastic, (which eventually forms the hard paint coat when the paint dries) and pigments to give the paint color.
- Steel is a solid mixture of iron, carbon and other metals. These substances are mixed in a liquid state. They don't combine chemically in either the liquid state or when they cool to the solid state. Each component remains physically distinct.

## **PHYSICAL STATES OF MATTER**

All substances exist in one of three different **physical states**. These states are called **solid, liquid and gas**. A wire is a solid made from copper. Mercury, found in a control switch, is a liquid. The air used in pneumatic controls is a gas.

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The state of a substance depends on its temperature (and pressure, if the substance is a gas). If the temperature changes enough, a substance can change to a different state. The physical state of a substance depends on the amount of heat or kinetic energy in the molecules making up the substance.

Heat determines the physical state of a substance. Since the range of temperatures on the earth is quite limited, most of the objects that we are familiar with exist in one state. Metals are solid while ethanol is a liquid and carbon dioxide is a gas.

- Water is an important exception. It can exist in any of the three physical states, that is, as a solid, a liquid or a gas, depending on the temperature. Water is a liquid at temperatures from 0 to 100 degrees Celsius. Above 100° C, it changes into a gas. Below 0° C, it changes into a solid.
- Gasoline is another substance that can easily change state. It consists of long molecules of hydrogen and carbon with other additives. It is liquid at room temperature but it will change to a vapour or gas if the temperature is raised a small amount. Note that although we use the short form “gas” when speaking of gasoline, it is found as a liquid at room temperature.

### **Solids**

Many of the objects you work with, such as hair, chairs and tables, are solids. A **solid** has a definite shape and volume. Molecules in a solid vibrate in place. They are tightly packed in a regular crystal pattern or in irregular arrangements of long chain molecules. Solids can be held together by ionic, covalent or metallic bonds.

- Iron is an example of a regularly arranged solid. It becomes liquid only if a large amount of heat is added to cause it to melt. Once molten iron cools, it becomes solid again.
- Thermoplastics are irregularly arranged solids that have many uses in the mechanical construction field.

### **Liquids**

A **liquid** has a definite size or volume but not a definite shape. The molecules in a liquid vibrate, move about, and slide past each other. They are close together with no regular arrangement. A liquid takes the shape of the container in which it is held and presses on the container in the same amount in all directions.

- Many liquids you work with, such as disinfectants, are solutions that are based on water.

### **Gases**

A **gas** has no definite volume or shape. The molecules in a gas vibrate and move freely at high speeds. They are well separated with no regular arrangement.

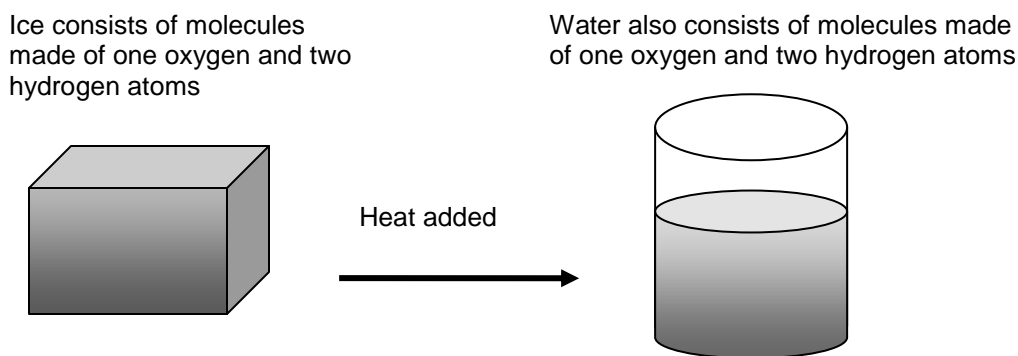
- Air, the most common gas found in a building, is actually a mixture of different gases such as oxygen gas and carbon dioxide gas.

## Changes of state

The chemical composition of a substance determines what state it occurs in at a given temperature. But when a substance changes from one state to another, only the physical state changes, not the chemical properties.

- Liquid oxygen has the same molecular structure as oxygen gas; each molecule of it is formed by the bonding of two oxygen atoms. They look different but structurally they are the same.
- When water melts from its solid form (ice) into its liquid state, it changes its physical state but not its chemical makeup. Its molecules still all have the same structure: two hydrogen atoms combined with one oxygen atom.

When solid ice melts to liquid water, only the physical state changes. Ice, liquid water and water vapour have quite different appearances and behave differently, but each water molecule has the same chemical structure regardless of the physical state. See Figure 1.



**FIGURE 1: Chemical Make-Up Stays The Same When Physical State Changes**

## ***KINETIC ENERGY***

The amount of heat in a substance determines its physical state. *At the molecular level, the amount of **heat** is similar to the amount of **motion** in the molecules making up a substance.*

At the molecular level, all molecules of any substance have a certain amount of heat. This causes them to be in constant motion. The motion can vary from vibration in place to rapid, random motion in space. The amount of motion depends on the amount of heat or kinetic energy present in the molecules.

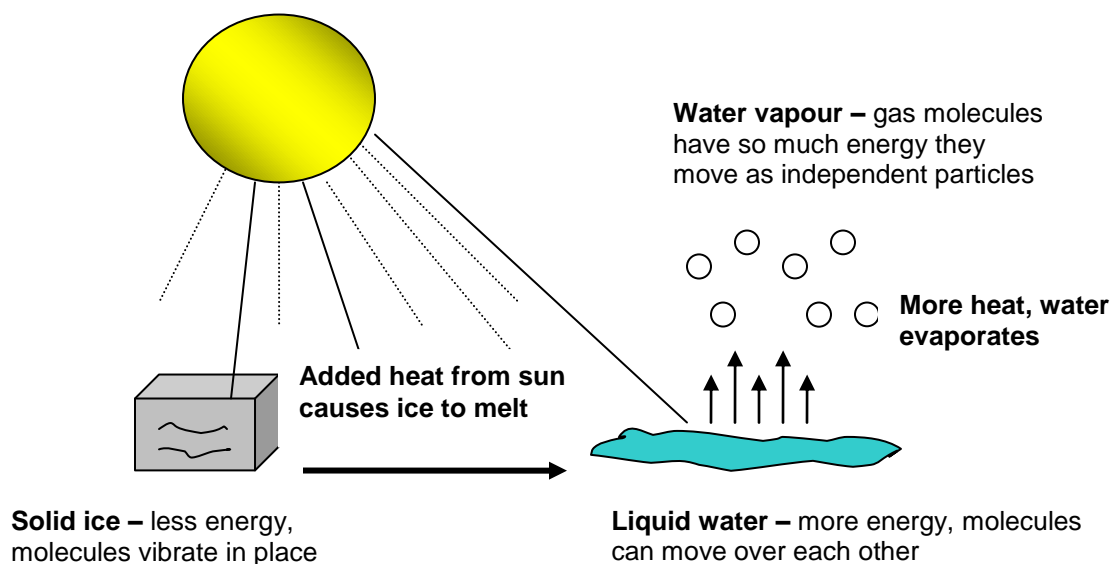
***Kinetic energy*** is another name for the molecular motion of an object. Every substance has a different amount of kinetic energy for a given temperature. This energy depends on the chemical makeup of the substance.

Kinetic energy tends to move molecules apart. There are also natural forces of attraction between molecules that tend to hold them close together.

- ◆ Gas molecules have too much kinetic energy to be held together by these forces. They exist as independent molecules that move around rapidly.
- ◆ The molecules of solid and liquid substances have less kinetic energy or motion in their molecules. The amount of kinetic energy in solids and liquids is too weak to allow them to escape the force of attraction between their individual molecules. They are held together by these forces of attraction.

In other words, there are two different forces working within a substance and these forces are in opposition. The force of attraction causes molecules to stay close together; the force of motion, caused by the amount of heat a substance has, causes molecules to move apart. ***A substance's physical state depends on the relative strength of these two forces.***

If the molecules of a substance have a low amount of heat or kinetic energy, the forces that work to hold it together are strong enough to keep its molecules in a fixed position. It exists as a solid (See Figure 2).



**FIGURE 2: The Effect Of Heat On Water's Physical State**

If a substance gains kinetic energy, its molecules partially escape the bonding forces and begin to move more rapidly. The substance exists as a liquid. Liquid molecules have more energy, enabling them to flow over each other.

If the molecules of a substance have enough kinetic energy to overcome the forces that hold it together as a solid or liquid, it will exist as a gas. The molecules forming the gas exist as independent particles that move rapidly in random directions. Gas molecules expand to completely fill the area they are contained in.

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Kinetic energy causes materials to expand when the temperature rises and contract when it falls.

- Metal expands when it is heated and contracts when it cools.
- If you leave a can containing a volatile solution such as acetone open in a room, the smell of acetone quickly fills the room. (A volatile solution is a one that will start to change to a gas at room temperature if it is free to escape.) The acetone molecules evaporate rapidly to become evenly mixed with the other air molecules in the room.
  - This is why you should have plenty of ventilation when you use materials such as rapidly drying nail polish.
  - The solvents used in the polish, which can be toxic if breathed in large amounts, evaporate quickly into the air where you are working as the material dries.
  - When you have finished using these types of solvents, they should be tightly closed so they don't dry out in their containers and so they can't escape into the room.

### **In Brief**

- ◆ The molecules of a substance have a certain attraction to each other.
- ◆ All molecules also have a certain amount of kinetic or heat energy that causes them to tend to move apart.
- ◆ Since the amount of heat is measured as temperature, we say that the temperature of a substance determines its state as a solid, liquid or gas.

### **Pressure and molecular activity**

The amount of pressure can also influence the motion of molecules. Pressure doesn't have much effect on the motion of solids, since they mostly vibrate in one place. The pressure exerted on the surface of a liquid, however, can influence how easily the liquid molecules can escape into the atmosphere.

If the air pressure above a liquid surface is increased, more pressure bears down on the liquid molecules. As a result of this pressure, they will need more energy or more heat before they can change to gas molecules. If the pressure is decreased, the liquid molecules change into a gas more quickly.

If the outside pressure exerted on a gas is increased, the gas is compressed. The gas molecules move with less kinetic energy. This increases the number of molecules changing to a liquid.

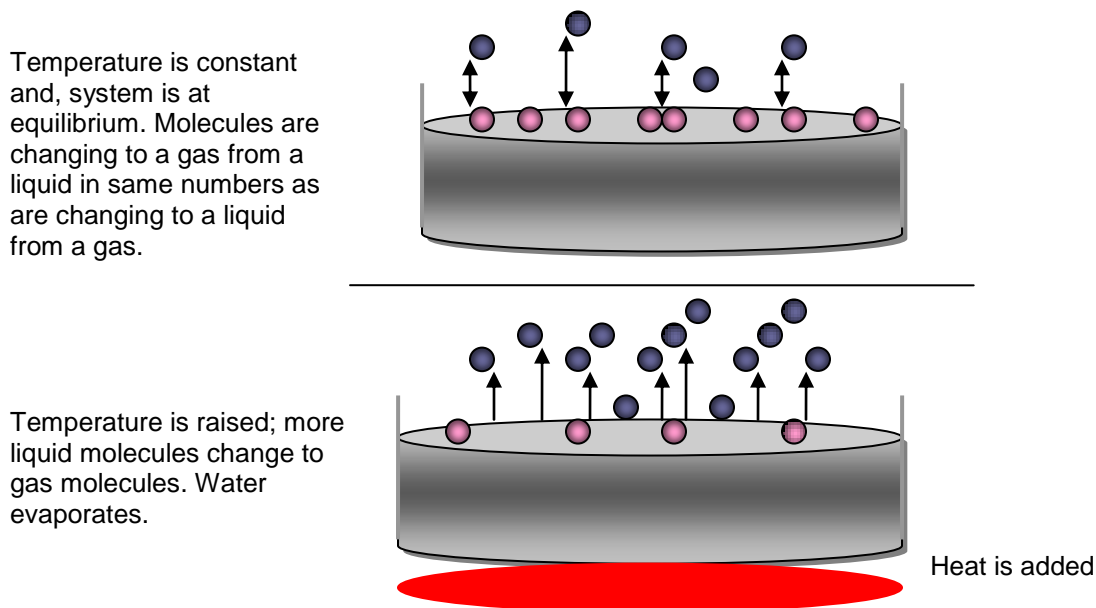
- Hairspray is held as a mixture of solid and liquid material under pressure in a metal container, although most of the liquid would be normally a gas at room temperature.
- If the spray nozzle of a pressurized container is pressed, the pressurized contents escape rapidly. As they escape, the pressure is suddenly removed from the liquid contents of the container and they change to a gas.
- When the hair spray gas molecules land on strands of hair, the solids in the mixture stick to the hair and act as a holding agent.

## CHANGES OF STATE

The molecules which make up a substance, whether it is a solid, liquid or gas, have an average kinetic energy that depends on the temperature of the substance. Some individual molecules, however, possess a higher or lower amount of energy. For this reason, individual molecules, especially of substances like perfume or water, can and do change state at any time.

- When an individual molecule of liquid perfume gains enough energy, it overcomes the bonding forces that hold it as a liquid and it vaporizes into a gas molecule. The bottle only has to be opened for us to smell the gas molecules as perfume in the air.
- Consider a half full, closed container of water. When an individual molecule of water gains enough energy, it overcomes the bonding forces that hold it as a liquid and it vaporizes into a gas molecule.

At the same time, any of the escaped vapour molecules floating above the liquid might lose energy so that they condense back into the liquid. If the temperature remains constant, there are usually the same number of molecules changing into a higher state as there are changing into a lower state. The substance remains in *equilibrium* until the temperature changes. See Figure 3.



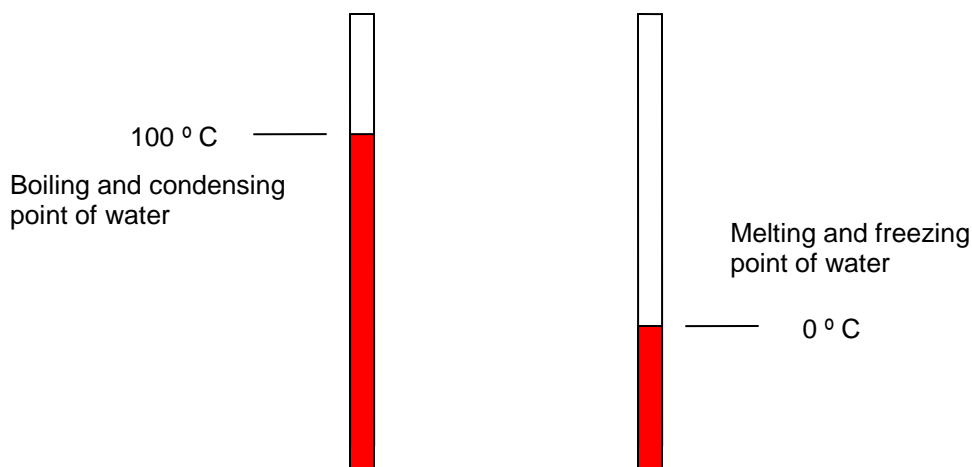
**FIGURE 3: Effects Of Heat On A System At Equilibrium**

When the temperature of a liquid is raised because heat is applied to it, the equilibrium is broken. Many liquid molecules now start changing to vapour molecules. At a certain temperature, all the liquid molecules change quickly into gas molecules. This is called the **boiling or vapourization point**. Each different substance has its own vapourization point.

Gas molecules that are cooled rapidly change back into liquid molecules at a certain temperature called the **condensation point**. For an individual substance, this is the same temperature as its boiling point.

When a solid changes to a liquid, we say it melts. The temperature at which a solid melts rapidly into a liquid is called the **melting point**. Similarly, when a liquid changes to a solid, we say it freezes. The temperature at which this occurs rapidly is called the **freezing point**. Each substance has an individual freezing point that is the same temperature as its melting point.

Chemicals can be added to a substance so that the new mixture will have a different freezing point than the original substance. For example, water freezes at  $0^{\circ}\text{C}$  but if antifreeze is added to it, the freezing point of the new mixture becomes much lower. That is why adding antifreeze to the radiator of a vehicle in winter keeps the liquid coolants from freezing.



**FIGURE 4: Water Boils And Condenses At 100 °C. It Melts And Freezes At 0 °C**

**In Brief:**

- ◆ Solids change to liquids at the **melting point**.
- ◆ Liquids change to solids at the **freezing point**.
- ◆ Liquids change to gases at the **boiling point**. This is also called the **vapourization point**.
- ◆ Gases change to liquids at the **condensation point**.
- ◆ In most substances, the melting point and the freezing point occur at the same temperature.
- ◆ In most substances, the boiling or vapourization point and the condensation point occur at the same temperature.

Molecules in solid substances can change directly into a gas without changing into a liquid first. For example, ice on a window can change directly into water vapour. When molecules change from a solid directly to a gas, the change is called **sublimation**.

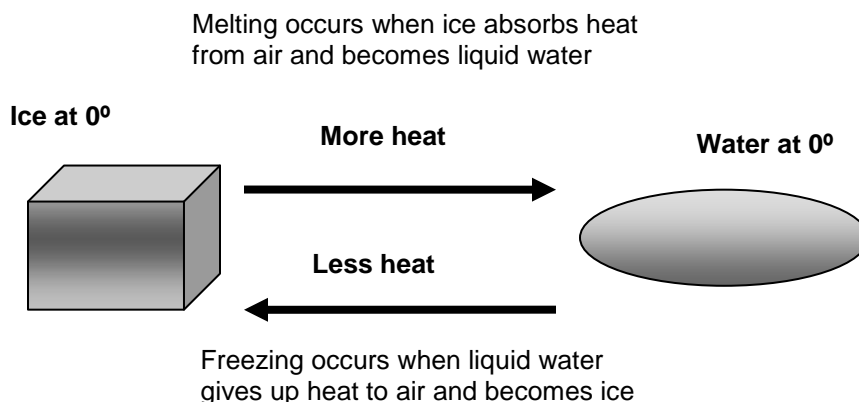
## **DIRECTION OF CHANGE OF STATE**

Heat always flows “downhill” from hotter molecules to cooler molecules. In a closed area, equilibrium is established - all nearby objects have the same amount of heat. If no heat is added to a closed system, all objects within the system will eventually reach the same temperature. This helps explain why changes of state occur in a specific direction.

- If wax is heated until it melts and then the source of heat is removed, the hot liquid wax gives up heat to the atmosphere until it reaches the same temperature as its surroundings. As the wax cools, it reaches a point at which it solidifies into a solid object once again. The now solid wax eventually reaches the same temperature as its environment. It no longer gives up heat to the air and objects around it because they are all at the same temperature.

When an object is hotter than its surroundings, it gives up heat until it reaches an equilibrium with its surroundings. As it gives up heat, it might reach the temperature at which a downward change of state (from gas to liquid, or liquid to solid) occurs.

An object will only reach the temperature at which an upward change of state (from solid to liquid, or liquid to gas) occurs if heat from an outside source, such as the sun or a fire, is applied to the object.



**FIGURE 5: Influence Of Heat On Direction Of Changes Of State**

*Freezing and melting occur at the same temperature but the direction of the change of state depends on whether heat is given up or if it is absorbed.*

- Ice melts into water at 0°C and water freezes into ice at the same temperature.
- If the surrounding air is colder than the water at 0°C, the water will give up heat to the colder air and freeze into ice.
- If the surrounding air is warmer than the water at 0°C, the water will absorb heat from the air and melt to a liquid.

This happens because heat always flows from hotter objects to cooler objects until an equilibrium is reached in which all nearby objects are at the same temperature.

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*The condensation point is the same as the boiling point, but the changes are in opposite directions.* The direction of the change depends on whether heat is given up or absorbed.

- Water boils at 100 °C and water vapour condenses at the same temperature.
- If the surrounding air is colder than water vapour at 100 °C, the water vapour loses heat to the air and condenses into a liquid.
- If the surrounding air is warmer than liquid water at 100 °C, the water will absorb heat from the air and change to water vapour.

When water is heated to 100°C, the liquid molecules on the surface have enough energy to vaporize rapidly into water vapour molecules.

A liquid that is boiling does not increase in temperature if more heat is added.

- Instead the liquid molecules vaporize more quickly. They use the added heat to gain enough kinetic energy to overcome the attractive forces that keep them in liquid form and they move off as independent gas molecules.
- Only when all of the water has been vaporized does the temperature of any substances mixed in the water begin to rise. That is why potatoes don't burn until the water they are cooking in is all gone.

As water vapour molecules rise into the cooler atmosphere, they condense into clouds of liquid water droplets. When the droplets become too heavy, they fall to earth as rain.

As water vapour molecules rise into the cooler atmosphere, they condense into clouds of liquid water droplets. When the droplets become too heavy, they fall to earth as rain.

- If warm air, which contains water vapour, comes in contact with a colder substance such as glass, the water vapour gives up heat to the glass. If the vapour gives up enough heat, the vapour condenses into liquid water on the glass.
- This is why we see condensation on windows on a cold morning. The air in the room is warmer than the glass. The water vapour in the air gives up heat to the glass and cools enough that it condenses or changes from a gas to a liquid.

This process is used to cool a refrigerator.

- A liquid coolant inside the coils is forced into a small space.
- The increase in pressure causes it to change to a gas.
- This change of state requires heat, which is taken from the inside of the fridge, causing it to become cooler.
- The gas then goes to an area at the back of the fridge where it changes back to a liquid.
- This change gives off heat, which is released into the outside air.
- The heat absorbed and released during changes of state is used to cool our food.

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## **GENERAL PROPERTIES OF MATTER**

Properties such as volume, weight, mass, center of gravity, inertia, pressure and density are interconnected. They depend on the types of molecules that make up an object and whether an object is a solid, liquid or gas.

For example, an object made of heavy, closely packed atoms such as iron will weigh more and exert more pressure than a similar size object made mostly of carbon atoms. We will look at some of these properties.

### **Volume**

*Volume is the amount of space an object occupies.*

A *solid* has **definite shape and volume**. The bonding forces that occur between the molecules of a solid hold them in a fixed position so that the space a solid occupies remains relatively constant, as does its external boundaries.

- The volume of a rectangular solid can be calculated by multiplying its length times its width times its height. The volume of an irregular solid can be calculated by measuring the volume of water it displaces.

A *liquid* has a **definite volume but no definite shape**. The space it occupies (its volume) stays the same no matter what kind of container it is held in but it will flow to take the shape of the container.

- The volume of a liquid is found by pouring it into a graduated measuring cup. We read the amount of volume occupied by the liquid from the measurements on the side.

*Gases* have **no definite volume or shape**. Gas molecules usually exist as independent particles. Each particle has its own molecular volume. If a gas is confined in an enclosed area, the gas molecules will expand to completely fill the area they are contained in.

- The volume of a gas held in a container depends on the size of the container.
- The volume of a gas in a flexible container is not constant but varies with the temperature and the outside pressure exerted on the container.
  - If a flexible container holding a gas has outside pressure exerted on it, the volume of the gas (and the container) will get smaller as the pressure increases.
  - If the temperature of the gas rises, the gas molecules become more active, increasing the pressure on the container and expanding its walls, thereby increasing the volume of both the gas and the container.

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## Weight and mass

In scientific terms, weight and mass are different properties. *The **weight** of an object is a measure of the force of the earth's gravity pulling on its mass.* The weight of an object can be found using a spring or digital scale.

- A solid can be placed directly on the scale and measured.
- A liquid or a gas must be placed in a container of a known weight before they are measured. The weight of the container is then subtracted from the total weight to get the weight of the liquid or gas.

*Mass is a measure of the amount of matter in an object.* In the metric system, the basic units of mass are the **gram** and the **kilogram**. In the imperial system the basic units of mass are the **ounce** and the **pound**.

- Mass is measured with a balance scale against a standard mass.
- The mass of an object remains constant while its weight can vary, depending on how close the object is to the surface of the earth.
  - The closer to the earth an object is, the stronger the pull of gravity and the greater the weight.

In everyday use, we tend to refer to weight and mass as being the same thing. The term kilogram tends to be used for both mass and weight in the metric system, just as the term pound is used for both mass and weight in the imperial system.

## Pressure

*A solid exerts a force in a downward direction over the area it is resting on because of its weight (the pull of the earth's gravity on the object's mass). This force is called **pressure**.*

- The pressure exerted on parts of a building such as the weight of the walls on the foundation or the snow load on the roof must be considered when calculating how strong those parts should be.
- Regulations in the automotive industry are concerned with making sure structures are strong enough to withstand the pressures exerted on them in an accident.

Pressure is calculated by finding its weight per unit area or by dividing its weight by the area it sits on. The formula for pressure is:

Pressure = force divided by area

or

$$P = F/a$$

The common unit of pressure in the metric system is the **kilopascal (kPa)**. In the imperial system, the unit of pressure is **pounds per square inch (psi)**.

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*Like solids, liquids exert a downward force or pressure because of their weight. Liquids also exert pressure in a sideways direction because their molecules flow over each other and move in all directions. If a liquid is completely enclosed, such as in a pipe, it will exert pressure evenly in all directions.*

*Gases confined in a container also exert pressure evenly in all directions. Gas molecules are continually in motion, bouncing off any surface they collide with and then continuing in a new direction. These collisions create a pressure known as gas pressure.*

*The pressure exerted by a gas depends on its volume and its temperature.*

### **Density**

**Density** is defined as the mass or weight per unit volume. Density is the quality of lightness or heaviness of an object. When we pick up an object, we have a feel for whether it is light or heavy. But sometimes we need a more precise definition of heaviness and lightness. In that case, we use the term density.

- When there are two cartons the same size, one containing shampoo and the other containing cleaning cloths, the carton containing the cloths is less dense. Although the volumes of the two cartons are the same, the weights of the objects inside are different, resulting in different densities.

### **Odour and Colour**

Other physical properties include odour and colour. These properties can help you identify certain substances. For example, ammonia has a distinctive, pungent odour. Colour helps you identify the right hair tint when choosing hair colouring products.

### **CONCLUSION**

The chemical properties of a substance depend on the types and arrangement of atoms that make up the substance. When a substance changes physically, it still maintains the same chemical properties. When a metal rod is cut in two, the new pieces weigh less than the original piece but the types and arrangement of atoms in the smaller pieces are the same as when they were in one, larger piece.

Only when a substance undergoes a chemical change does it then change into a new substance. When oxygen gas combines with iron, a chemical change takes place and a new substance, iron oxide or rust, is formed.

When a substance undergoes a physical change, it can behave in a different way. For example, molten iron flows while solid bar is rigid. The unique characteristics of a substance depend on both its chemical and its physical properties.

Molecules possess differing amounts of heat, which gives them kinetic energy - the ability to vibrate or move. Whether a substance exists as a solid, liquid or gas depends on the kinetic energy of its molecules. The amount of kinetic energy molecules have depends on the amount of

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heat present. The strength of this active force relative to the bonding force determines the state of a substance.

Any substance can exist as a solid, a liquid or a gas if its temperature is raised or lowered enough, but we are mostly concerned with the state of substances at the earth's temperature. Most objects you work with occur as solids, keeping a definite shape and volume. Liquids have a definite volume but take the shape of their container. Water is the most common liquid on earth. The atmosphere is filled with invisible gases that have no definite shape or volume.

Substances change state from solid to liquid and a liquid to a gas at specific temperatures. These temperatures are called the melting and boiling point of that substance. If the change is in the opposite direction, the changes are called the condensation and the freezing point. Heat must be added to change a solid to a liquid or a liquid to a gas. Heat is released if a gas condenses to a liquid or if a liquid freezes to a solid.

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**Answer the following questions. Answers are at the end of this skills manual.**

1. The three physical states that matter can exist in are \_\_\_\_\_ , \_\_\_\_\_ and \_\_\_\_\_.
2. The chemical properties of a substance depend on the type of \_\_\_\_\_ it is made up from and their arrangement.
3. Whether a substance exists as a solid, liquid or gas depends on its \_\_\_\_\_ .
4. When a solid changes directly into a gas, the process is called \_\_\_\_\_ .
5. When gas molecules lose enough heat, they \_\_\_\_\_ and change to the liquid state.
6. The melting point of a substance is at the same temperature as the \_\_\_\_\_ point.
7. Water freezes at \_\_\_\_\_ C. This is also the temperature at which ice \_\_\_\_\_ .
8. Water boils at \_\_\_\_\_ C. This is also the temperature at which water vapour \_\_\_\_\_.
9. When ice melts to water, it \_\_\_\_\_ heat from the atmosphere.
10. When water freezes to ice, it \_\_\_\_\_ heat to the air.
11. The molecules of a liquid \_\_\_\_\_ over each other.
12. Solids have a \_\_\_\_\_ shape and volume.
13. Liquids have a definite \_\_\_\_\_ but take the shape of their \_\_\_\_\_.
14. Gas molecules \_\_\_\_\_ to completely fill their container.
15. Solid objects exert pressure only in a \_\_\_\_\_ direction.
16. Gases and liquids in an enclosed container exert pressure evenly in \_\_\_\_\_ directions.

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**ANSWER PAGE**

1. solid  
liquid  
gas
2. atoms (or elements)
3. temperature
4. sublimation
5. condense
6. freezing
7. 0°, melts
8. 100°, condenses
9. absorbs
10. gives up
11. flow (or glide, move)
12. definite
13. volume, container
14. expand
15. downward
16. all