Matter and material: Revision of matter and classification

Objectives

- Revise properties of materials.
- Describe matter as being made up of particles.
- Differentiate between atoms, elements, molecules and compounds.
- Define pure substances, homogenous mixtures and heterogenous mixtures.
- Illustrate the microscopic representation of materials at a particle level.
- Classify substances as metals, nonmetals and metalloids and identify their positions on the periodic table.
- Write names and formulas of elements and compounds.

Materials and their properties

Different materials have different properties. Properties of materials are the characteristics that make materials unique from one another. Here are some common properties of materials that are important for us to be aware of:

- **Strong and weak:** A strong material can withstand a lot of force or pressure, whereas a weak material cannot withstand a lot of force or pressure.
- **Flexible and rigid:** The more bendable a material, the more flexible it is. A material that cannot bend is considered rigid.
- **Absorbent and waterproof:** Water cannot pass through a material that is waterproof. An absorbent material soaks up water easily.
- **Brittle, malleable and ductile:** A brittle material breaks or cracks easily. This is a characteristic of nonmetals. Metals are described as malleable and ductile. A malleable material can be hammered into shape without cracking. A ductile material can be drawn out into a thin wire without breaking.
- **Electrical conductor and electrical insulator:** An electrical conductor allows electric current to flow through it. An electrical insulator does not allow electric current to flow through it. Materials such as copper and aluminium are good electrical conductors so we use them in electrical wiring. However, we cover our electrical wiring in an electrical insulator such as plastic to protect us from the electric current.
- **Thermal (or heat) conductor and thermal (or heat) insulator:** A thermal conductor allows heat energy to flow through it easily, meaning that heat flows in and out of the material easily. A thermal insulator is a poor conductor of heat energy. Materials such as stainless steel and aluminium are good heat conductors so we use them to make pots to heat our food. However, the pot handle is made of plastic to prevent us from burning our hands.
- **Magnetic and nonmagnetic:** Materials that have a magnetic field surrounding them are known as magnetic materials. Only a few metals can be permanently magnetised, and these include iron, cobalt and nickel. Other metals can be weakly and temporarily magnetised in two ways:
  - Being in the presence of a permanent magnet; and
  - Passing an electric current through the metal. Any metal that has an electric current flowing through it produces an electromagnet, meaning that the metal is magnetic only while the current is flowing through it.
- **Melting and boiling points:** Many materials have their own unique melting and boiling points. When a material melts and boils, the chemical composition of the material remains the same, only the state of the material changes. Some materials don't melt/boil but rather burn in the presence of heat. Burning is a type of decomposition chemical reaction.
- **Phase (or state) of the material at room temperature:** Is the material a solid, a liquid or a gas at room temperature? Room temperature is 20-23°C.
- **Density:** Different materials have different densities. Density is defined as mass per unit volume. You may think of density as how closely together the particles are arranged. If the particles that make up the material are arranged very closely, then the material is dense.

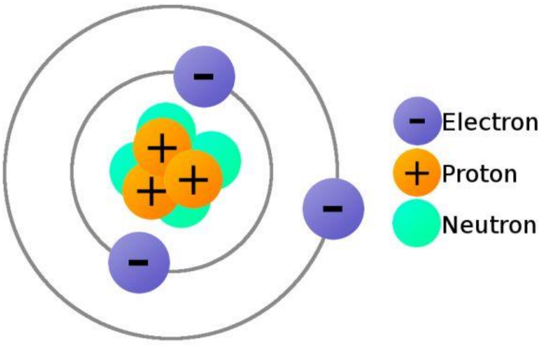
There are other properties of materials, such as being durable, rust-proof, shiny or matt, elastic or inelastic, fibrous, easy to clean and cost-effective.

The particle nature of matter

All matter consists of particles. When we refer to a particle we may refer to:

- An atom;
- An element;
- A molecule; or
- A compound.

Atom: ^{D} An atom is the most basic single particle that makes up matter. For example, this is a lithium atom:



Most substances do not exist as unattached atoms, but rather as atoms that are bonded together to form a molecule or a compound. Generally, it is only noble gases that are made up of unattached atoms. Noble gases are group 18 elements that are unreactive. Noble gases are also known as inert gases.

Element: *^{D} An element is a pure substance that consists of only one type of atom. The periodic table of elements represents all the known elements. A single lithium atom is made up of the element lithium. The chunks of lithium metal below are also made up of the element lithium, and each chunk consists of millions of lithium atoms.

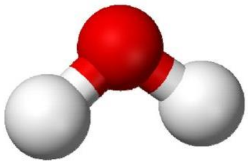
Molecule: ^{D} A molecule is a substance made of more than one atom chemically bonded together.

Compound: ^{D} A compound is a substance made up of more than one type of atom chemically bonded together.

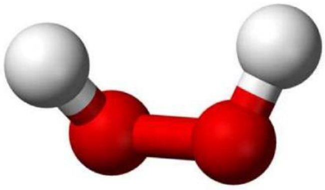
This means that not all molecules are compounds, but all compounds are molecules.

Video on atoms, molecules and compounds: **https://www.youtube.com/watch?v=DkAXO--BYEw**

The atoms that make up molecules are always combined in a fixed ratio. For example, a water molecule is H_2O. Water is always made up of **2** hydrogen atoms and **1** oxygen atom. The ratio of hydrogen to oxygen in water is therefore **2:1**. If water and oxygen combine in a 2:2 ratio, they would form the molecule **H_2O_2** which is hydrogen peroxide. This is a bleaching agent which has a completely different set of properties to H_2O.



H_2O



H_2O_2

*^{D} represents a definition. Definitions need to memorised word for word.

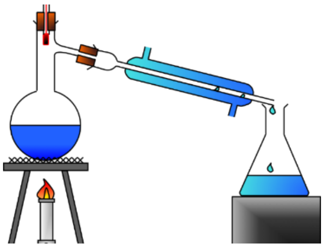
Pure substances and mixtures

Materials may be a pure substance or a mixture of pure substances. What is a pure substance? [D] A substance that cannot be separated into simpler components by physical means.

In real life very few materials occur in pure form. Most materials are mixtures of pure substances. What is a mixture? [D] Two or more pure substances existing together, meaning that they can be separated into simpler components by physical means.

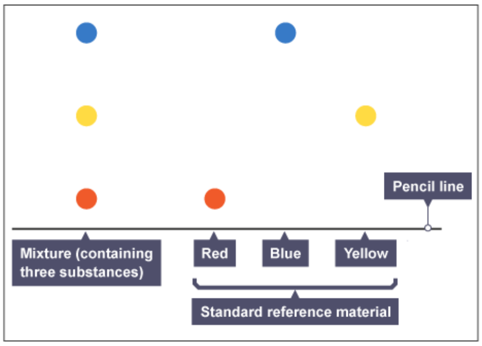
Let's recap the physical means of separation:

- **Hand sorting:** used for the separation of solids that are distinct from each other, e.g. separating different coloured beads from each other.
- **Sieving:** used to separate solids that have different sizes, e.g. separating gravel from sand.
- **Filtration:** used to separate a non-soluble solid from a liquid e.g. separating water from sand. Filter paper lines a filter funnel. The sand is the residue that remains on the filter paper. The water is the filtrate that passes through the filter paper.
- **Magnetism:** used to separate a magnetic material from a nonmagnetic material e.g. separating iron from sulfur.
- **Evaporation:** used to separate a soluble solid (solute) from a solution e.g. salt water. The water (solvent) boils away while the salt (solute) stays behind.
- **Distillation:** also used to separate a soluble solid from a solution e.g. salt water. On the left is a flask containing a solution of salt water. The water (solvent) is heated to boiling point and moves down the condenser and into a beaker on the right. At the end of the process, the flask on the left will be left with the salt, while the beaker on the right will contain the pure water, also known as the distillate.



Simple distillation process

- **Chromatography:** used to test the purity of dyes, foods and beverages. It is also widely used in the sports industry to identify potential drugs in the bloodstream of athletes. Chromatography is the process of separating substances into their individual components. If a substance is pure then chromatography will only produce one component at the end of the process. If a substance is made up of a mixture, then several components will be seen at the end of the process.



Chromatography process

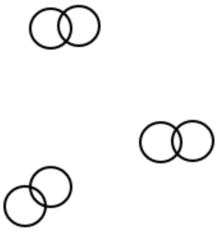
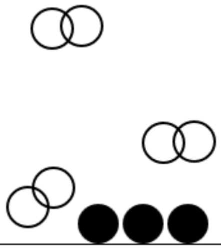
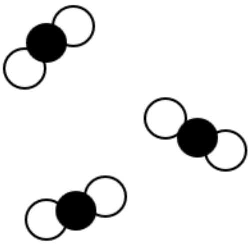
Consider the paper chromatography process for ink C, D and E. Ink E is a pure substance since it is made up of only one type of pigment. Inks C and D are mixtures of pigments since they separated into more than one colour.

Video on paper chromatography: **https://www.youtube.com/watch?v=PvHvx7k7UPU**

A pure substance will be made up of one type of atom, element, molecule or compound. For example, a copper bracelet that is made up only of the element copper is a pure substance. A glass of distilled (pure) water, made up of only H_2O molecules, is a pure substance. Remember that once a chemical bond has formed between atoms, a new pure substance forms with its own unique set of properties.

Consider the following:

- Carbon is a black solid that is made of the element carbon. It is a pure substance.
- Oxygen is a type of gas that is made of oxygen molecules. It is a pure substance.
- A mixture of carbon and oxygen involved carbon and oxygen existing in the same space, but not chemically reacting. The carbon and oxygen each maintain their own unique set of properties.
- Once a chemical reaction has taken place between carbon and oxygen, carbon dioxide forms, which is a type of gas. This substance has its own unique set of properties that are different to the properties of carbon on its own and oxygen on its own. It is a pure substance.

Carbon – pure substance	Oxygen – pure substance	Carbon and oxygen – mixture	Carbon dioxide – pure substance
			

Can carbon, oxygen and carbon dioxide be separated by physical means? **No.** We cannot break down an atom and chemical bonds cannot be separated by physical means.

Can the mixture of carbon and oxygen be separated by physical means? **Yes.** Mixtures can be separated by physical means since they are not chemically bonded.

Because each pure substance has its own unique set of properties, we may use these known properties to test for the purity of a substance. For example, we know that pure water boils at 100°C and solidifies at 0°C. Given a glass of tap water, would we expect it to boil at exactly 100°C and solidify at exactly 0°C? **No.** Tap water is a mixture of water and several salts such as calcium and magnesium. It will not display the properties of pure water.

As mentioned above, in nature, most materials are found as mixtures. Here are some examples of mixtures:

- The air around us is a mixture of gases such as nitrogen, oxygen and carbon dioxide.
- A fruit is a mixture of sugar, water, fibre and vitamins.
- Soil is a mixture of sand, pebbles, plant matter and animal matter.
- An alloy is a mixture of metals or a mixture of metals with nonmetals, but the resulting material has metallic properties. For example, steel is a mixture of iron, carbon (a nonmetal) and other metals. Steel is an alloy.

In a mixture, the substances that make up the mixture:

- Keep their physical properties. For example, if we mix sand and water, the sand still has all the properties of sand and the water still has all the properties of water.
- Are not in a fixed ratio. You may make sugar water with 1 cup or water and 1 spoon of sugar, or with ½ a cup of water and 3 spoons of sugar – either way it is a mixture of sugar and water.

Heterogeneous and homogenous mixtures

Mixtures may be further divided into homogenous and heterogenous mixtures. A homogenous mixture is a uniform mixture [D]. It looks the same throughout. We cannot see the different components of the mixture. Examples include tap water, the air around us, a cup of coffee and steel. A heterogeneous mixture is a non-uniform mixture [D]. It does not look the same throughout. We can see the separate components of the mixture. Examples include a bowl of cereal with milk, chocolate chip cookies, a soil sample and a carbonated drink.

Homogenous mixture

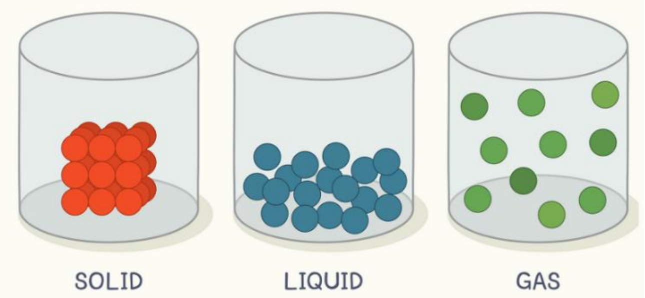
Heterogenous mixture

Video on pure substances and mixtures: **https://www.youtube.com/watch?v=-s7XSyl3jhI**

Microscopic representation of pure substances and mixtures

Usually, it is impossible just by looking at a substance to know if it is a pure substance or a homogenous mixture. Both look the same throughout. It is also not possible to know just by looking at a substance if it is made up of elements or compounds. We need to know what the substance is made of microscopically. The microscopic structure does not mean that we can see an atom through a microscope, but rather, it is the mental picture that we create.

Here is the microscopic structure of a solid, liquid and a gas:



At a macroscopic level, we discuss properties such as the state of matter, its melting point and its boiling point. The macroscopic level refers to "big" properties that we can see and measure. At a microscopic level, we discuss atoms and molecules. Microscopic level refers to "small" properties, sometimes too small to be seen even with the aid of a microscope.

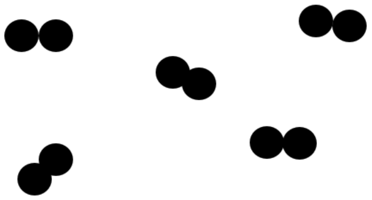
Microscopically:

- The particles of solids are very close together, have very small spaces between them, arranged in a regular pattern, vibrate in their position and have very strong forces of attraction between them.
- The particles of liquids are close together (10 times further apart relative to the solid phase), have small spaces between them, slip and slide past each other, and have strong forces of attraction between them.
- The particles of gases are spread far apart (1000 times further apart relative to the solid phase), move freely and randomly, and have very weak forces of attraction between them.

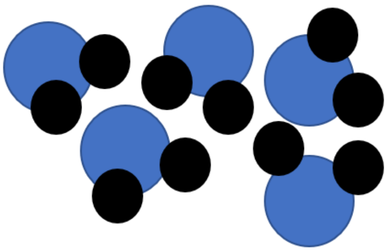
Diatomic molecules are two of the same element bonded together. This is how they exist in nature when they are 'alone', unless bonded to a compound. Diatomic molecules include hydrogen (H_2), oxygen (O_2), nitrogen (N_2) and group 17 elements fluorine (F_2), chlorine (Cl_2), bromine (Br_2) and iodine (I_2). Diatomic molecules are gases at room temperature, except for:

- Bromine, which is a brown liquid and
- Iodine, which is a purple solid.

The microscopic representation of diatomic molecules in the gas phase looks like this:



The microscopic representation of water (H_2O) in the liquid phase looks like this:



Metals, nonmetals and metalloids in the periodic table

The elements in the periodic table are arranged in columns and rows. The columns of the periodic table are called **groups**. Each group has a number, from left to right. There are **18 groups**. The rows of the periodic table are called **periods**. Each period has a number, from top to bottom. There are **7 periods**. We may use the group and period numbers to describe where an element is found in the periodic table. For example, Calcium is in **group 2 period 4**. The elements in the periodic table can be classified into three groups: metals, nonmetals and metalloids/semimetals.

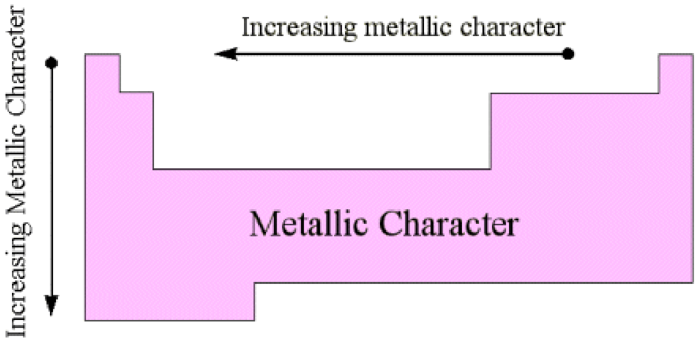
Metals

Most elements are metals. Metals are silver-grey in colour, except for copper and gold. All metals are solid at room temperature, except for mercury, which is a liquid at room temperature.

Characteristics of metals:

- Reflect light when they are polished.
- Can be hammered without breaking (malleable).
- Can be stretched into thin wires without breaking (ductile).
- Have high melting points.
- Good conductors of heat.
- Good conductors of electricity.
- Have high densities.

However, some metals reflect light better than others; some metals are better conductors of electricity than others; some metals can be flattened more easily than others. We may say that some metals have stronger metallic properties than others. As a generalisation, metals at the bottom of a column in the periodic table are more metallic than those at the top. Metals on the left of the periodic table are also generally more metallic.



Nonmetals

At room temperature, nonmetals may exist as solids (e.g. carbon and iodine) or as gasses (e.g. nitrogen and oxygen). Bromine is the only nonmetal that exists as a liquid at room temperature.

Characteristics of nonmetals:
- Do not reflect light.
- Poor conductors of heat.
- Poor conductors of electricity.
- Have low melting points.
- Brittle.

Noble gases are nonmetals in group 18 of the periodic table. Noble gases get their name from their unique property of not combining with other elements. They do not form compounds because they have a full outer energy level. We will learn about this later.

Metalloids/semimetals

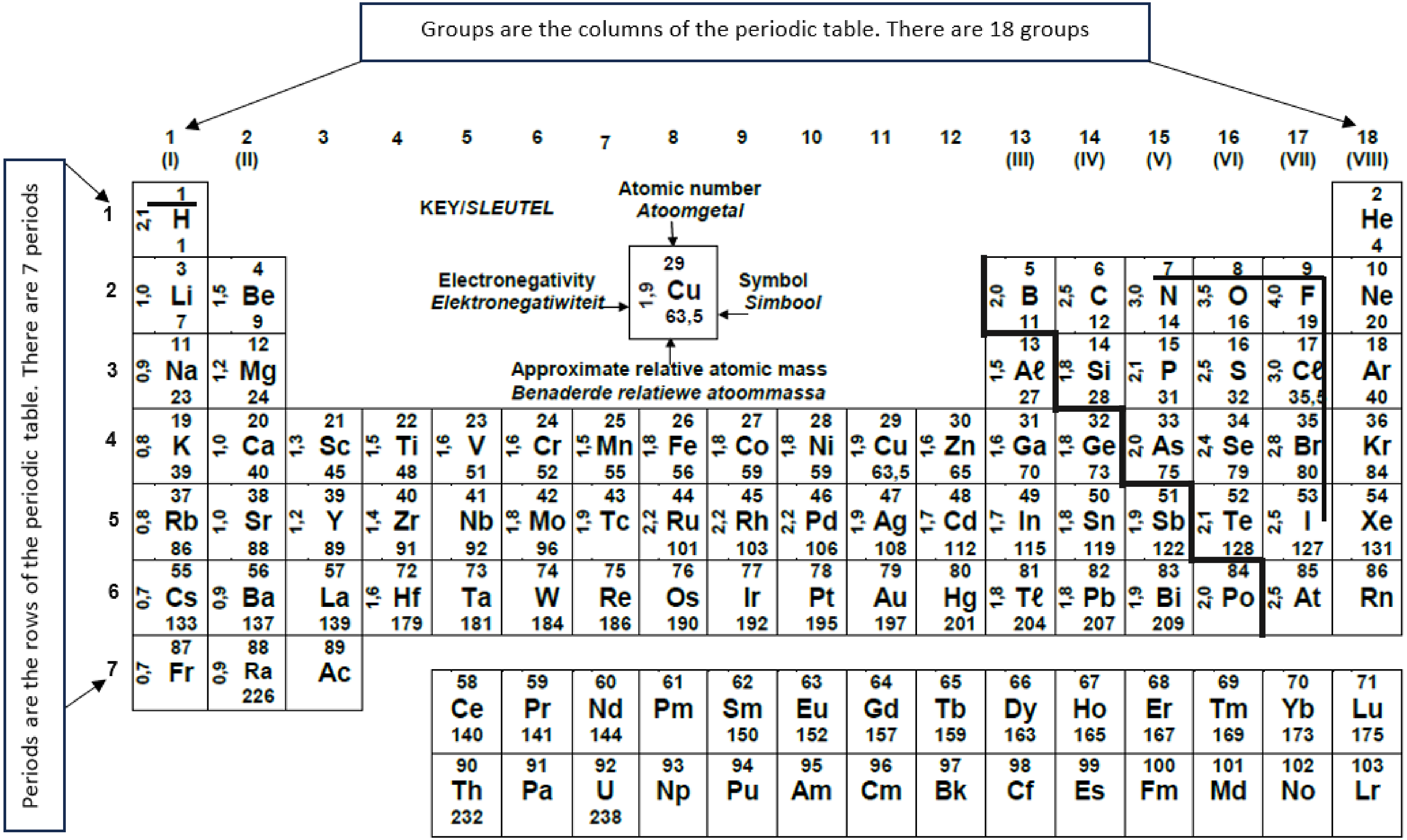
In the periodic table, metals and nonmetals are separated by a zigzag (see the darkened lines in the periodic table below starting to the left of bromine, B). Elements found along the zigzag are known as metalloids or semimetals. Aluminium is an exception – it is a metal even though it is found along the zigzag line. Metalloids have properties of both metals and nonmetals. Some are dull and some are shiny, some are brittle, while others are malleable and ductile.

Characteristics of metalloids:
- Solid at room temperature.
- Good conductors of heat (but not as good as metals).
- Poor conductors of electricity at room temperature.
- Good conductors of electricity at higher temperatures.

Metalloids are **semiconductors**. This is because they are poor conductors of electricity at room temperature but good conductors of electricity at higher temperatures.

Video on silicon as a semiconductor: **https://www.youtube.com/watch?v=gUmDVe6C-BU&t=64s** up to 1:05

The periodic table below is the same periodic table that you will receive on every test and exam from now until the end of Grade 12. It is a good idea to label the group and period numbers, make the zig zag lines to identify the metalloids, and mark off the elements that exist as diatomic molecules. I mark them off with a "7", but don't forget that hydrogen is also a diatomic molecule.



Groups are the columns of the periodic table. There are 18 groups

Periods are the rows of the periodic table. There are 7 periods

KEY/*SLEUTEL*

Atomic number / *Atoomgetal*: 29

Electronegativity / *Elektronegatiwiteit*: 1,9

Symbol / *Simbool*: Cu

Approximate relative atomic mass / *Benaderde relatiewe atoommassa*: 63,5

	1 (I)	2 (II)	3	4	5	6	7	8	9	10	11	12	13 (III)	14 (IV)	15 (V)	16 (VI)	17 (VII)	18 (VIII)
1	1 2,1 H 1																	2 He 4
2	3 1,0 Li 7	4 1,5 Be 9											5 2,0 B 11	6 2,5 C 12	7 3,0 N 14	8 3,5 O 16	9 4,0 F 19	10 Ne 20
3	11 0,9 Na 23	12 1,2 Mg 24											13 1,5 Aℓ 27	14 1,8 Si 28	15 2,1 P 31	16 2,5 S 32	17 3,0 Cℓ 35,5	18 Ar 40
4	19 0,8 K 39	20 1,0 Ca 40	21 1,3 Sc 45	22 1,5 Ti 48	23 1,6 V 51	24 1,6 Cr 52	25 1,5 Mn 55	26 1,8 Fe 56	27 1,8 Co 59	28 1,8 Ni 59	29 1,9 Cu 63,5	30 1,6 Zn 65	31 1,6 Ga 70	32 1,8 Ge 73	33 2,0 As 75	34 2,4 Se 79	35 2,8 Br 80	36 Kr 84
5	37 0,8 Rb 86	38 1,0 Sr 88	39 1,2 Y 89	40 1,4 Zr 91	41 Nb 92	42 1,8 Mo 96	43 1,9 Tc	44 2,2 Ru 101	45 2,2 Rh 103	46 2,2 Pd 106	47 1,9 Ag 108	48 1,7 Cd 112	49 1,7 In 115	50 1,8 Sn 119	51 1,9 Sb 122	52 2,1 Te 128	53 2,5 I 127	54 Xe 131
6	55 0,7 Cs 133	56 0,9 Ba 137	57 La 139	72 1,6 Hf 179	73 Ta 181	74 W 184	75 Re 186	76 Os 190	77 Ir 192	78 Pt 195	79 Au 197	80 Hg 201	81 1,8 Tℓ 204	82 1,8 Pb 207	83 1,9 Bi 209	84 2,0 Po	85 2,5 At	86 Rn
7	87 0,7 Fr	88 0,9 Ra 226	89 Ac															

58 Ce 140	59 Pr 141	60 Nd 144	61 Pm	62 Sm 150	63 Eu 152	64 Gd 157	65 Tb 159	66 Dy 163	67 Ho 165	68 Er 167	69 Tm 169	70 Yb 173	71 Lu 175
90 Th 232	91 Pa	92 U 238	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr

Names and formulas of chemical substances

Elements have chemical symbols and names as per the periodic table. For example, Mg is magnesium; O is oxygen. Chemical formulas of compounds use the chemical symbols of the elements that make them up and the ratio in which these elements bond. For example, MgO is the chemical formula of a compound that is made up of one magnesium atom and one oxygen atom. Chemical names of compounds identify the names of the elements that make up the compound. For example, based on the name magnesium oxide, we may identify that this compound is made up of magnesium and oxygen atoms. Some compounds also have common names. For example, magnesium oxide is commonly known as magnesia which is the active ingredient in antacids (such as Eno and Rennies) that help to relieve the symptoms of heartburn. Here are a few more examples of chemical formulas, chemical names and common names:

Chemical formula	Chemical name	Common name
H_2O	Dihydrogen monoxide	Water
NaCl	Sodium chloride	Table salt
NH_3	Nitrogen trihydride	Ammonia
CH_4	Carbon tetrahydride	Methane

When it comes to chemical names, because there are millions of different types of compounds or molecules there are also millions of names. Unfortunately, many compounds were named before it became obvious that a systematic method would be needed. To add to the confusion, the system for naming compounds has changed over the years.

Writing the chemical formula of a molecular compound given the chemical name

A molecular compound is made up of only nonmetals or semimetals and nonmetals.

Step 1: Represent each kind of element in a compound with the correct symbol for that element. Dihydrogen monoxide is made up of hydrogen, H, and oxygen, O.

Step 2: Use the subscripts (small and lowered numbers) to indicate the number of atoms of each element in the compound.

1: mono-
2: di-
3: tri-
4: tetra-
5: penta-
6: hexa-
7: hepta-
8: octa-

Dihydrogen indicates two hydrogen atoms, while monoxide indicates one oxygen atom, hence H_2O (we do not write H_2O_1).

The order in which the elements in a molecular compound are displayed follows some rules with many exceptions.

- Hydrogen usually comes first in a molecular compound e.g. H_2O.
- When carbon and hydrogen react to form a compound, carbon always comes before hydrogen in the formula e.g. CH_4.
- Generally, the element that is in a more metallic position (further towards the left or further down the periodic table) comes first in a molecular compound e.g. NO_2 and SO_2.

For example:

- Dihydrogen monoxide is H_2O
- Dihydrogen dioxide is H_2O_2
- Carbon disulfide is CS_2
- Diphosphorus tetraiodide is P_2I_4

Naming molecular compounds made of two nonmetals or a semimetal and a nonmetal

You may use this method for a molecular compound that contains two nonmetals or a molecular compound that contains a semimetal and a nonmetal.
Step 1: Name the elements in the same order as they appear in the formula.
Step 2: Drop the last syllable (sometimes two syllables) in the name of the final element and add –ide.
Step 3: Add prefixes to the name of each element to indicate the number of atoms of that element in the molecule. The mono- prefix is omitted from the first element in the name.

For example:
- CO is carbon monoxide
- CO_2 is carbon dioxide
- C_2H_4 is dicarbon tetrahydride
- PH_3 is phosphorus trihydride
- Si_2Cl_6 is disilicon hexachloride

Naming ionic compounds made of one metal and one nonmetal

An ionic compound is made up of a metal and nonmetal. You may use this method for an ionic compound that contains one metal and one nonmetal.

Step 1: Name the elements in the same order as they appear in the formula. Note that the metal always comes first.
Step 2: Drop the last syllable (sometimes two syllables) in the name of the final element and add –ide. Because a metal is involved, no prefixes are used.

For example:
- CaS is calcium sulfide
- Na_2S is sodium sulfide
- Li_3N is lithium nitride
- Fe_2O_3 is iron oxide

Naming ionic compounds made of one metal and two nonmetals, one of which is O

Step 1: Name the elements in the same order as they appear in the formula. Note that the metal always comes first.
Step 2: Name the first element, then name the element that is not oxygen and add –ate to the end of its name. The oxygen is dropped from the name. Because a metal is involved, no prefixes are used.

For example:
- $CaCO_3$ is calcium carbonate
- K_2SO_4 is potassium sulfate
- $Al_2(CO_3)_3$ is aluminium carbonate
- $Ba_3(PO_4)_2$ is barium phosphate

This rule has two exceptions to it:
- –OH is called hydroxide. When a metal is bonded to –OH, the name of the compound will end in –ide.
- $–NO_2$ and $–NO_3$ are similar but the number of oxygen atoms different. $–SO_3$ and $–SO_4$ are also similar with a differing number of atoms. The compound with more oxygen atoms will end in –ate. The compound with fewer oxygen atoms will end in –ite.

For example:
- NaOH is sodium hydroxide
- $Al(OH)_3$ is aluminium hydroxide
- KNO_3 is potassium nitrate, while KNO_2 is potassium nitrite
- $Al_2(SO_4)_3$ is aluminium sulfate, while $Al_2(SO_3)_3$ is aluminium sulfite

Practice questions and answers

Practice questions

1. Consider the following substances and classify each one as only a molecule OR a molecule and a compound by filling in the table below:
    - S_8: octasulfur (used in industrial processes).
    - O_3: ozone (makes up the ozone layer).
    - CO_2: carbon dioxide (used by plants in the process of photosynthesis).
    - O_2: oxygen (used by all living organisms in the process of respiration).
    - NaCl: sodium chloride (table salt).
    - I_2: iodine (used by the body to make the thyroid hormone).
    - $CaSO_4$: calcium sulfate (used in building material).
    - P_4: tetraphosphorus (used in industrial processes).
    - NH_3: ammonia (used as agricultural fertiliser and in cleaning detergents).
    - CH_4: methane (a natural gas that may be used to produce electricity).
    - Fe_2O_3: iron oxide (rust).

Only a molecule	A molecule and a compound

2. Provide the microscopic representation of the following:
    2.1 A mixture of two types of compounds in the liquid phase.
    2.2 A mixture of an element, a diatomic molecule and a compound in the gas phase.
    2.3 Pure iodine.
    2.4 Mixture of helium and hydrogen.

3. Provide the chemical formulas of the following compounds:
    3.1 Sulfur triiodide
    3.2 Sulfur trioxide
    3.3 Nitrogen monoxide
    3.4 Carbon disulfide
    3.5 Carbon monoxide
    3.6 Nitrogen trihydride
    3.7 Silicon dioxide
    3.8 Boron trifluoride

4. Provide the chemical names of the following compounds:
    4.1 CO_2
    4.2 SO_2
    4.3 NO_3
    4.4 CCl_4
    4.5 NaCl
    4.6 CuO
    4.7 MgS
    4.8 MgF_2
    4.9 Fe_2O_3
    4.10 $CaCl_2$
    4.11 $CuCO_3$
    4.12 $NaNO_3$
    4.13 $CuSO_4$
    4.14 $KClO_3$
    4.15 NaOH
    4.16 $Al(OH)_3$

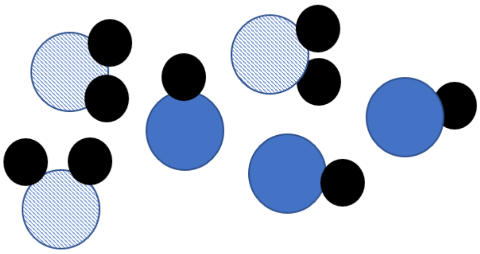
Practice question answers

1.

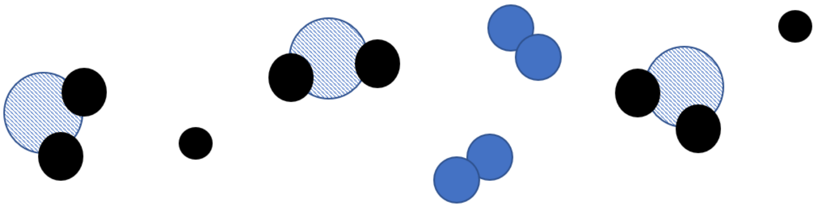
Only a molecule	A molecule and a compound
S_8	CO_2
O_3	NaCl
O_2	$CaSO_4$
I_2	NH_3
P_4	CH_4
	Fe_2O_3

2.

2.1 Note that both types of particles are compounds. Note small spaces between the particles, no organised pattern, due to the liquid phase.

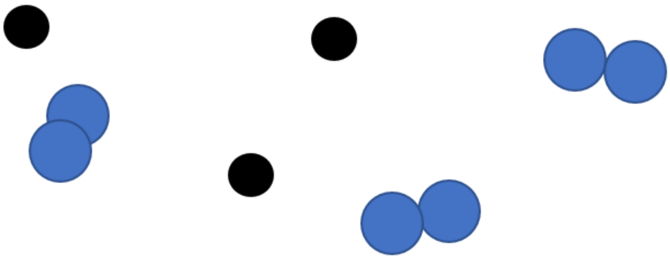


2.2 Note large spaces between the particles due to the gas phase.



2.3 Note that iodine is a solid at room temperature, therefore the particles are very close to each other and in an organised pattern. Recall that according to the particle model of matter, there are always spaces between the particles, so the particles should never touch.

2.4 Note large spaces between the particles due to the gas phase.



3.

- 3.1 SI_3
- 3.2 SO_3
- 3.3 NO
- 3.4 CS_2
- 3.5 CO
- 3.6 NH_3
- 3.7 SiO_2
- 3.8 BF_3

4.

- 4.1 Carbon dioxide
- 4.2 Sulfur dioxide
- 4.3 Nitrogen trioxide
- 4.4 Carbon tetrachloride
- 4.5 Sodium chloride
- 4.6 Copper oxide
- 4.7 Magnesium sulfide
- 4.8 Magnesium fluoride
- 4.9 Iron oxide
- 4.10 Calcium chloride
- 4.11 Copper carbonate
- 4.12 Sodium nitrate
- 4.13 Copper sulfate
- 4.14 Potassium chlorate
- 4.15 Sodium hydroxide
- 4.16 Aluminium hydroxide