

Topic 2 – Molecules of Elements

2.1 Stability of An Atom (4.1, 6.1)

Element: pure substance that × broken down into simpler substances by chemical processes

Substance	Classification	Atoms
Sugar	Compound	Carbon, hydrogen, oxygen
Water vapour		Hydrogen, oxygen
Carbon	Element	Carbon
Hydrogen		Hydrogen
Oxygen		Oxygen

Chemical symbols of elements

Names and symbols of common elements

Proton number	Symbol	Element
1	H	Hydrogen
2	He	Helium
3	Li	Lithium
4	Be	Beryllium
5	B	Boron
6	C	Carbon
7	N	Nitrogen
8	O	Oxygen
9	F	Fluorine
10	Ne	Neon
11	Na	Sodium
12	Mg	Magnesium
13	Al	Aluminium
14	Si	Silicon
15	P	Phosphorus
16	S	Sulphur
17	Cl	Chlorine
18	Ar	Argon
19	K	Potassium
20	Ca	Calcium
	Fe	Iron
	Co	Cobalt
	Ni	Nickel
	Cu	Copper

	Zn	Zinc
	Br	Bromine
	Ag	Silver
	Sn	Tin
	I	Iodine
	Au	Gold
	Hg	Mercury
	Pb	Lead

- *Shiny*: lustrous
- *Dull*: non-lustrous
- *Ductile*: can be drawn into wires
- *Malleable*: can be hammered into different shapes without breaking
- *Brittle*: easily broken when hammered

Classifying elements

Classified based on:

Ways	Classification
1. Metallic & non-metallic properties	1) Metals 2) Non-metals 3) Metalloids (both)
2. Physical states (r.t.p.)	1) Gases 2) Liquids 3) Solids

Properties

Properties	Metals	Metalloids	Non-metals
Appearance	Shiny	Shiny	Dull
Physical state at r.t.p.	Mostly solids (except Hg)	Solids	1) Gases 2) Volatile liquids 3) Solids
Melting & boiling points	High (except Na, K, Hg)	High	Low (except C, Si)
Ductility	Ductile	Brittle	Brittle if solid
Malleability	Malleable		
Heat conductivity	Good	Moderate	Poor (except graphite, diamond)
Electrical conductivity	Good	Moderate	Poor (except graphite)

Physical states

Physical state	Metals	Metalloids	Non-metals
Gases			Helium (He), oxygen (O ₂), ...
Liquids	Mercury (Hg)		Bromine (Br ₂)
Solids	Gold (Au), aluminium (Al), ...	Silicon (Si), ...	Carbon (C), sulfur (S), ...

Atoms and molecules

Atoms: smallest particles of an element having chemical properties of the element

Element: only 1 type of atom

Molecule: group of 2 or more atoms chemically combined

Molecular formula:

[Element]_[number of atoms]

*number of atoms is negligible if 1

H₂: 1 molecule of hydrogen
2H: two atoms of hydrogen

Type	Atoms	Explanation	Examples
1. Monatomic element	1	Noble gases	<ul style="list-style-type: none">Helium (He)Neon (Ne)Argon (Ar)
2. Diatomic molecule	2	Diatomic: 2 atoms chemically bonded	<ul style="list-style-type: none">Hydrogen (H₂)Chlorine (Cl₂)Iodine (I₂)
3. Polyatomic molecule	≥ 3	Triatomic: 3 atoms chemically bonded	<ul style="list-style-type: none">Ozone (O₃)Phosphorus (P₄)Sulfur (S₈)

Noble gases behave differently

Noble gases

- Elements
 - Helium (He)
 - Neon (Ne)
 - Argon (Ar)
 - Krypton (Kr)
 - Xenon (Xe)
 - Radon (Rn)
- Monatomic (exist as individual atoms)
- Stable, unreactive
- × react to form compounds / molecules

Electronic configuration of noble gas

Electronic configuration of noble gas atoms

Electronic configuration	Outer electrons	Elements
Duplet	2	He
Octet	8	Ne, Ar, Kr, Xe, Rn

Noble gas: unreactive → **fully filled outer shells**

- Duplet electronic configuration
- Octet electronic configuration

Atoms achieve electronic configuration of noble gas

Fully filled outer shells

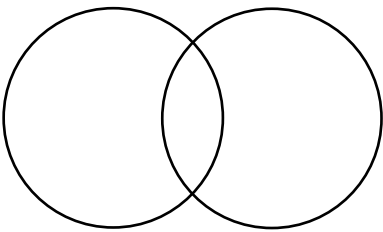
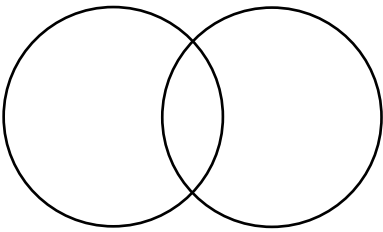
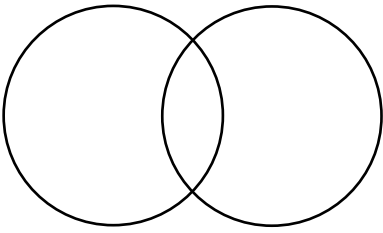
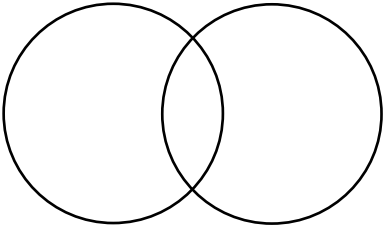
- Lose** outer electrons → positive ion
- Gain** outer electrons → negative ion
- Share** outer electrons → covalent bond

2.2 Covalent Bonding (7.1)

Covalent bond: bond formed by sharing of electrons between atoms

- Atoms share electrons → molecule
- Strong force of attraction between atoms
- '–': 1 single covalent bond (1 pair of shared electrons)
'=': 1 double covalent bond (2 pair of shared electrons)
- Formation of covalent bond
 1. Atoms of same element
 2. Atoms of different elements

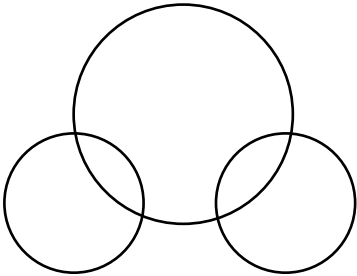
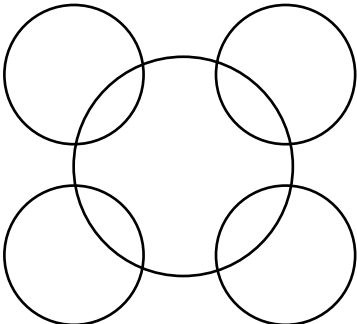
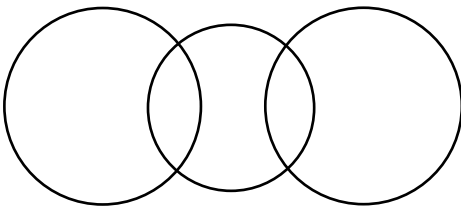
Molecules of elements

Molecule	Dot and cross diagram (remember to write the key)	Covalent bond	Structural formula	Molecular formula
Hydrogen		1	H – H	H ₂
Chlorine		1	Cl – Cl	Cl ₂
Oxygen		2	O = O	O ₂
Nitrogen		3	N ≡ N	N ₂

Molecules of compounds

Atoms of different elements → covalent bond

1. Covalent compound
2. Molecular compound

Compound	Bonds	Dot and cross diagram	Structural formula	Molecular formula
Water	2 single O–H bonds		$\begin{array}{c} \text{O} \\ / \quad \backslash \\ \text{H} \quad \text{H} \end{array}$	H ₂ O
Methane	4 single C–H bonds		$\begin{array}{c} \text{H} \\ \\ \text{H} - \text{C} - \text{H} \\ \\ \text{H} \end{array}$	CH ₄
Carbon dioxide	2 double C=O bonds		O = C = O	CO ₂

Chemical formulae of covalent substances

Molecules of elements

1. Diatomic molecule: subscript 2 after chemical symbol
2. Triatomic molecule: subscript 3 after chemical symbol
3. Molecule: large number of atoms
 - Chemical formula = chemical symbol of element
 - Sulfur: S₈ → S

Covalent compounds

- name indicates:
 1. elements present
 2. prefix

Prefix	Atoms
mono	1
di	2
tri	3
tetra	4

- Common substances
 - 1) ammonia (NH₃)
 - 2) hydrogen peroxide (H₂O₂)
 - 3) methane (CH₄)
 - 4) ozone (O₃)
 - 5) water (H₂O)