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Periodic Table: the elements are arranged in order of increasing proton number

- | | Group I | Group II | | | | | | | | | | | | | | | | | Group III | Group IV | Group V | Group VI | Group VII | Group VIII /
IX / X | | | |
|----------|----------------------|-----------------------|-----------------------|-----------------------|----------------------|------------------------|------------------------|-----------------------|---------------------|-----------------------|--------------------|---------------------|----------------------|-----------------------|----------------------|-----------------------|----------------------|---------------------|-----------------------|---------------------|-----------------------|-------------------|----------------------|------------------------|--|--|--|
| Period 1 | | | | | | | | | | | | | | | | | | | | | | | | He
Helium
2 | | | |
| Period 2 | Li
Lithium
3 | Be
Beryllium
4 | | | | | | | | | | | | | | | | | B
Boron
5 | C
Carbon
6 | N
Nitrogen
7 | O
Oxygen
8 | F
Fluorine
9 | Ne
Neon
10 | | | |
| Period 3 | Na
Sodium
11 | Mg
Magnesium
12 | | | | | | | | | | | | | | | | | Al
Aluminium
13 | Si
Silicon
14 | P
Phosphorus
15 | S
Sulfur
16 | Cl
Chlorine
17 | Ar
Argon
18 | | | |
| Period 4 | K
Potassium
19 | Ca
Calcium
20 | Sc
Scandium
21 | Ti
Titanium
22 | V
Vanadium
23 | Cr
Chromium
24 | Mn
Manganese
25 | Fe
Iron
26 | Co
Cobalt
27 | Ni
Nickel
28 | Cu
Copper
29 | Zn
Zinc
30 | Ga
Gallium
31 | Ge
Germanium
32 | As
Arsenic
33 | Se
Selenium
34 | Br
Bromine
35 | Kr
Krypton
36 | | | | | | | | | |
| Period 5 | Rb
Rubidium
37 | Sr
Strontium
38 | Y
Yttrium
39 | Zr
Zirconium
40 | Nb
Niobium
41 | Mo
Molybdenum
42 | Tc
Technetium
43 | Ru
Ruthenium
44 | Rh
Rhodium
45 | Pd
Palladium
46 | Ag
Silver
47 | Cd
Cadmium
48 | In
Indium
49 | Sn
Tin
50 | Sb
Antimony
51 | Te
Tellurium
52 | I
Iodine
53 | Xe
Xenon
54 | | | | | | | | | |
| Period 6 | Cs
Cesium
55 | Ba
Barium
56 | La
Lanthanum
57 | Hf
Hafnium
72 | Ta
Tantalum
73 | W
Tungsten
74 | Re
Rhenium
75 | Os
Osmium
76 | Ir
Iridium
77 | Pt
Platinum
78 | Au
Gold
79 | Hg
Mercury
80 | Tl
Thallium
81 | Pb
Lead
82 | Bi
Bismuth
83 | Po
Polonium
84 | At
Astatine
85 | Rn
Radon
86 | | | | | | | | | |
| Period 7 | Fr
Francium
87 | Ra
Radium
88 | Ac
Actinium
89 | | | | | | | | | | | | | | | | | | | | | | | | |

57 La Lanthanum 139	58 Ce Cerium 140	59 Pr Praseodymium 141	60 Nd Neodymium 144	61 Pm Promethium —	62 Sm Samarium 150	63 Eu Europium 152	64 Gd Gadolinium 157	65 Tb Terbium 159	66 Dy Dysprosium 163	67 Ho Holmium 165	68 Er Erbium 167	69 Tm Thulium 169	70 Yb Ytterbium 173	71 Lu Lutetium 175
89 Ac Actinium —	90 Th Thorium —	91 Pa Protactinium —	92 U Uranium —	93 Np Neptunium —	94 Pu Plutonium —	95 Am Americium —	96 Cm Curium —	97 Bk Berkelium —	98 Cf Californium —	99 Es Einsteinium —	100 Fm Fermium —	101 Md Mendelevium —	102 No Nobelium —	103 Lr Lawrencium —

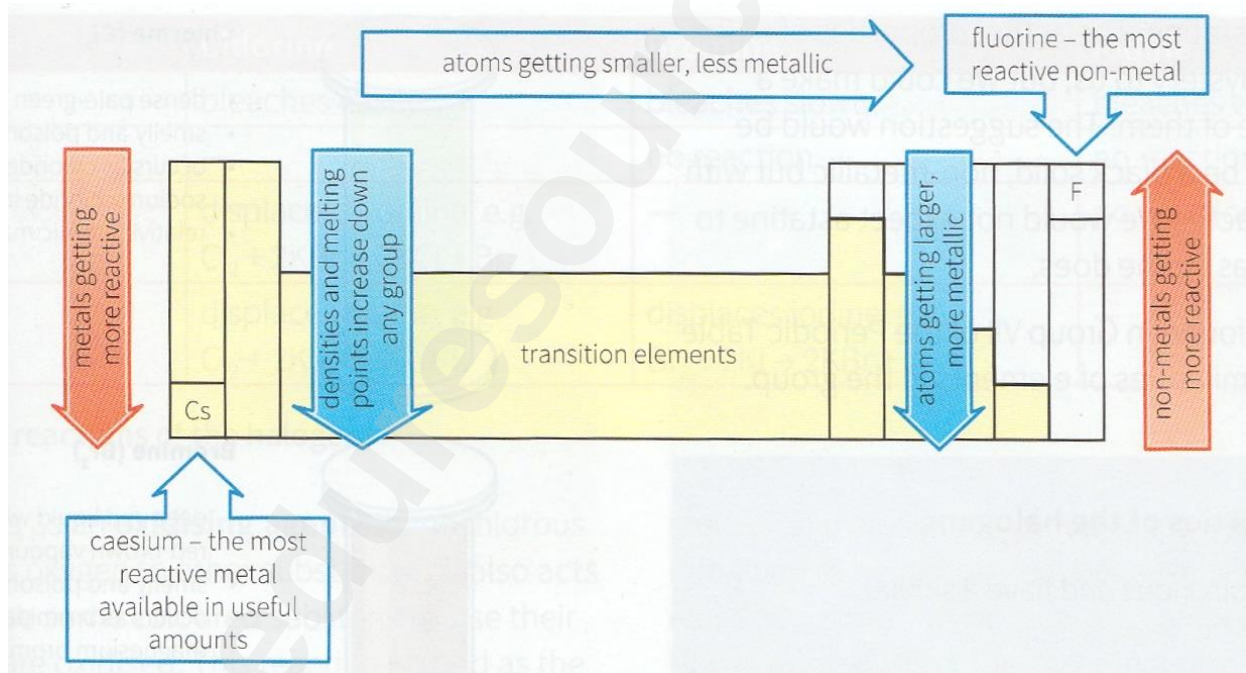
Elements in Groups I to 0 are sometimes known as the **main-group elements**.

 - The **reactive metals**: Group I – the alkali metals; Group II – the alkaline earth metals
 - The **'poor' metals**
 - The **non-metals**: includes Group VII – the halogens
 - The **transition elements**: hard, strong and dense metals
 - The **metalloids**: includes semiconductors, e.g. silicon and germanium
 - The **noble gases**: very unreactive

Metals	Non metals
Solids at room temperature, m.p b.p high	Solids or gases, m.p b.p low
Hard and dense	Softer, less dense
Good conductors of electricity	Insulators
Good conductors of heat	Poor thermal conductors
Malleable Ductile	Brittle in solid
Grey in colour, can be polished	Vary in colour
When struck, sonorous	Not sonorous

* **Metalloids(semi-metals)** - metal property non-metal property are mixed

- Look like metals, brittle like non-metals
- Uses - Semiconductors
- ex) silicon



1. Groups and periods in the periodic table

- **Main group elements** - elements present in Group 1 to group 8
- **Noble gases** - group 8 - the least reactive elements
- **Halogen** - group 7 - the most reactive elements
- **Alkali metals** - group 1 - the most reactive elements

2. Electron arrangement and the periodic table

- Elements in the same group = same number of outer electrons
- Metals - Group 1~3 - lose outer electrons relatively easily
 - Contribute them to the sea of electrons

C3.02 Trends in Groups

1. Group 1 - the alkali metals

Alkali metals - the most reactive metals - react with water to produce H_2 + alkaline solution

- Soft solids - low m.p b.p
- Low densities
- Can cut down by the knife
- Light grey, silvery surface
- Highly reactive - stored in oil
- Go down the group - reactivity $\uparrow$ m.p b.p $\downarrow$ density $\uparrow$

2. Group VII - the halogens

- Go down the group - reactivity $\downarrow$ B.p m.p $\uparrow$ gas to solid
- B.p m.p $\uparrow$ as down the group
- Gases to solid as atomic number $\uparrow$, pale to dark
- All poisonous and strong smell
- All diatomic molecules- Cl_2 Br_2
- + H_2 makes strong acids in dissolved water
- Examples
 - Chlorine - pale-green gas
 - Bromine - deep-red liquid
 - Iodine - grey solid with purple vapour

3. The chemical reactivity of the halogens

- Chlorine - dissolves in water to give an acidic solution(chlorine water)
 - $Cl_2 + H_2O \Rightarrow HCl + HClO$
 - Act as oxidising agent - 이 과정에서 bleach
 - Universal indicator damped is close to it, then it is BLEACHED
- **Displacement reaction**
 - Depending on the order of reactivity
 - $Cl_2 + 2KBr(\text{colourless}) \Rightarrow 2KCl + Br(\text{orange})$

4. Group VIII - the noble gases

- Not reactive at all
- M.p b.p low
- Uses
 - Helium - airship, balloon - light and unreactive
 - Neon light
 - Argon to fill the bulb

C3.03 Trends across a period

			C					
Na	Mg	Al	Si	P	S	Cl	Ar	
			Ge					
			Sn					
			Pb					

1. The transition elements

- Most useful metallic elements
- Less reactive, corrosion resistance, high m.p, b.p
- Hard, strong, high density
- Compounds are coloured
- More than one valency -Fe²⁺ & Fe³⁺

C3.04 Chemical bonding in elements & compounds

Chemical bonding: the outer electrons of each atom

1. Bonding in the elements

Diatomic molecules ex) O₂ H₂

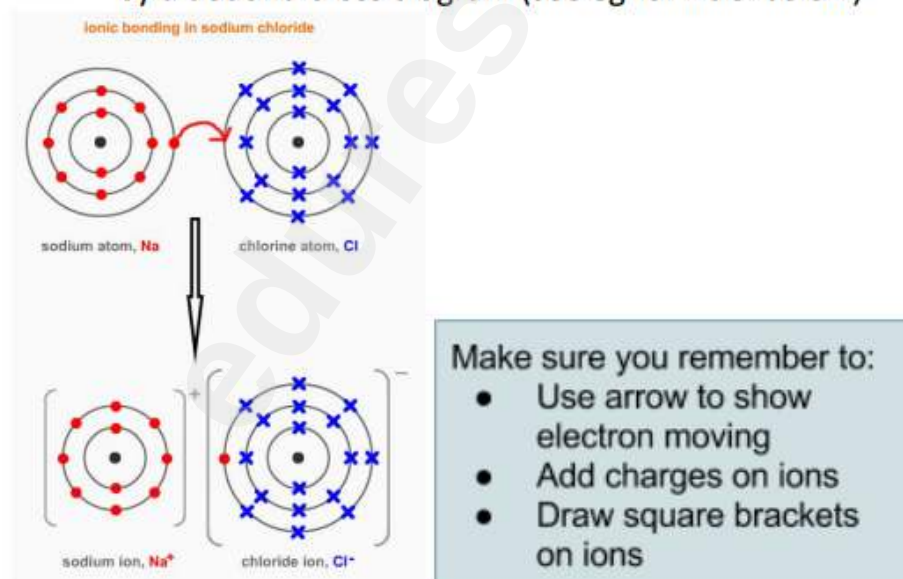
- Non metal + non metal = **covalent bonding**
- Metal + non metal = **ionic bonding**
- Metal + metal = **metallic bonding**

Chemical bonds

- Compounds- substances in which 2 or more elements are chemically combined.
- There are 3 types of strong chemical bonds: ionic, covalent and metallic.
- Ionic
 - o Particles are oppositely charged ions, which are electrostatically attracted
 - o Occurs in compounds formed from metals combined with non-metals
- Covalent
 - o Particles are atoms which share pairs of electrons. there is electrostatic attraction between nucleus of atoms and the shared pair of electrons
 - o Occurs in most non-metallic elements and in compounds of non-metals
- Metallic
 - o Particles are atoms which share delocalised electrons.
 - o metallic bonds are strong electrostatic attraction between positive metal ions and delocalised electrons
 - o Occurs in metallic elements and alloys

Ionic bonding

- Metal + Non-metal: electrons in the outer shell of the metal atom are transferred
 - o Metal atoms lose electrons to become positively charged ions
 - o Non-metal atoms gain electrons to become negatively charged ions
 - o NB: Ions – Atoms that have lost or gained electron/electrons.
- Ions produced by metals in Groups 1 and 2 and by non-metals in Groups 6 and 7 have the electronic structure of a noble gas (Group 0), meaning they have a full outer shell of 8 electrons
- Electron transfer during the formation of an ionic compound can be represented by a dot and cross diagram (see eg for NaCl below)



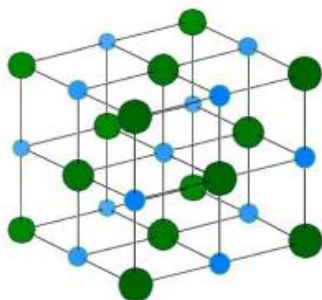
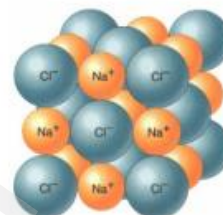
Ionic compounds

- A giant lattice structure of ions.
- Held together by strong electrostatic forces of attraction between oppositely charged ions
- The forces act in all directions in the lattice, and this is called ionic bonding.

An example is sodium chloride (salt):

can be drawn either as diagram below or to the right

diagram below: Na^+ (small blue particles) and Cl^- (larger green ones)

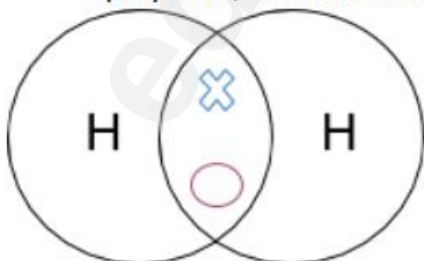


Different ways of showing ionic or covalent bonding/structure:

- Dot and cross diagrams: fine for showing the electronic structure of the ions in a crystal lattice of an ionic compound, but cannot show how the ions are arranged
- 2D diagram: gives a limited view of how the ions are arranged in the crystal and doesn't show any detail of how the ions were formed in making the ionic bond
- 3D diagram: doesn't show any detail of how the ions were formed in making the ionic bond but does show how the ions are arranged

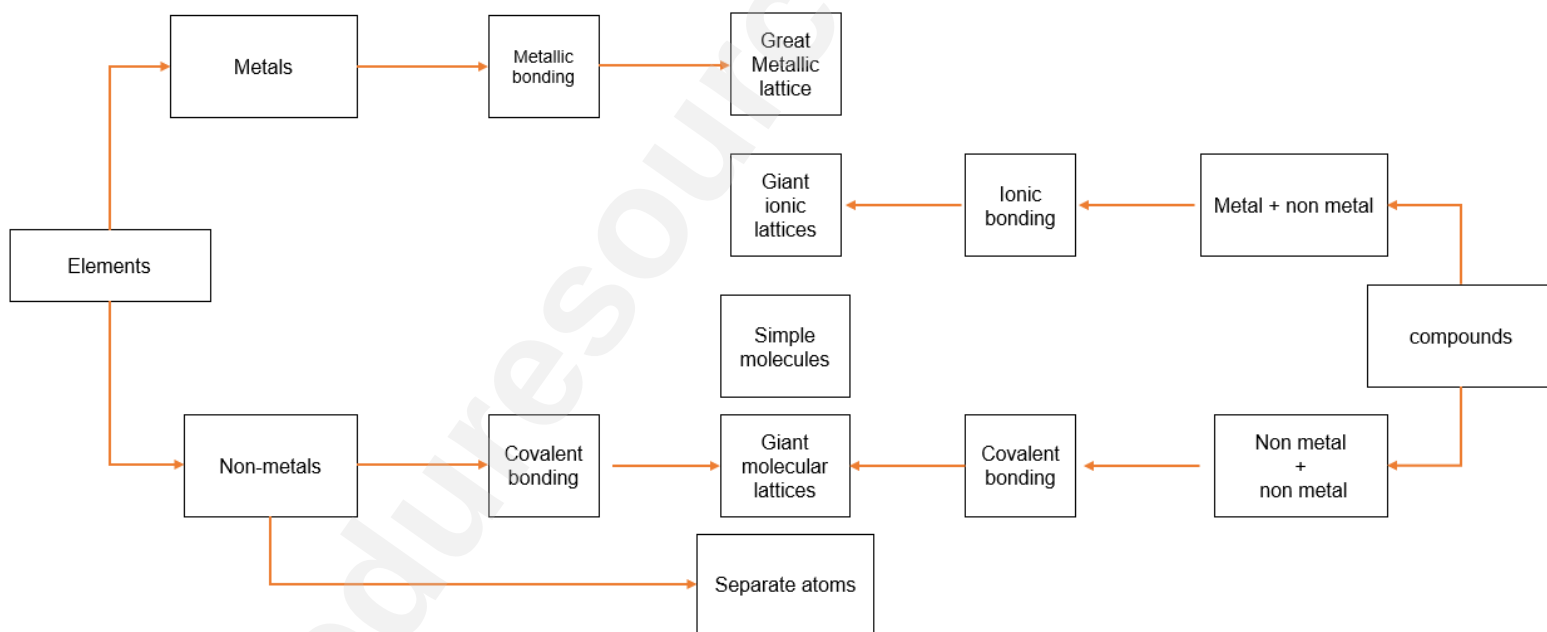
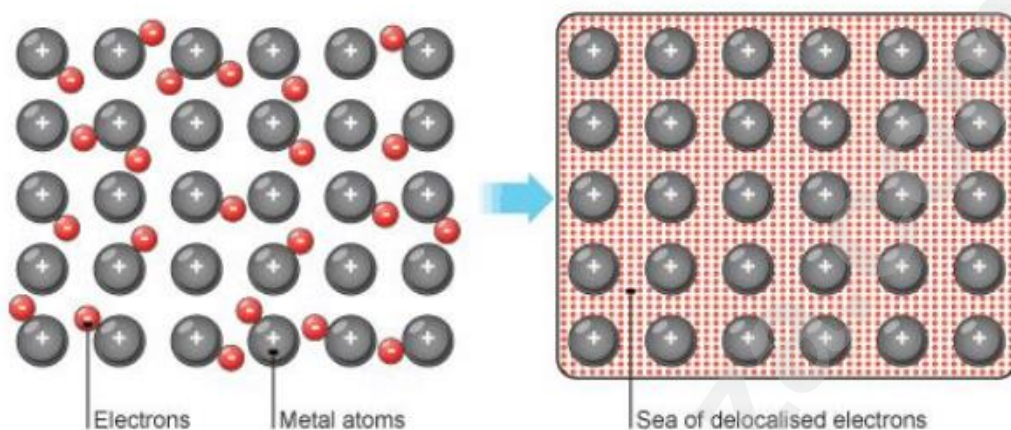
Covalent bonding

- When atoms share pairs of electrons, they form covalent bonds. These bonds between atoms are strong.
- Some covalently bonded compounds consist of small molecules e.g. HCl , H_2 , O_2 , Cl_2 , NH_3 , CH_4
- Some have very large molecules, such as polymers.
- Some have giant covalent structures (macromolecules) e.g. diamond, silicon dioxide.
- to show covalent bonding you can draw: dot and cross diagrams, repeat units for polymers, ball and stick and two- and three-dimensional diagrams e.g:



Metallic bonding

- Metals consist of giant structures of atoms arranged in a regular pattern.
- The electrons in the outer shell of metal atoms are delocalised and so are free to move through the whole structure.
- The sharing of delocalised electrons gives rise to strong metallic bonds.



2. Ionic group

- ex) SO_4^{2-} , NO_3^{-1} , NH_4^{+1}
- Made up of atoms covalently bonded together
- Have negative charge because they have gained electrons to make a stable structure
- One positive - NH_4

3. The physical properties of ionic and covalent compounds

- Ionic, simple covalent compounds - intermolecular forces between the particles
- Ionic compound - electrostatic attraction of the full chemical bonding
- Covalent > ionic to separate - low m.p b.p

Crystalline solids at room temperature	Regular arrangement of ions in a lattice - opposite charge are next to each other
Have high melting and boiling points	Ions are attracted to each other - strong electrostatic forces - large amount E for separating them
not soluble in organic solvents such as ethanol Soluble in water	Water is attracted to charged ions - many ionic solids dissolve
Conduct electricity when molten or dissolved in water(not when solid)	Liquid, solution - ions free to move about - can move towards the electrodes when a voltage is applied
Properties of simple covalent compounds	Reason for these properties
Often liquids or gases at room temperature	Made up of simple molecules - joined together by covalent bonds
Low m.p b.p	Forces between molecules(inter molecular forces) very weak - not much E for separating them
Soluble in organic solvents such as ethanol But few are soluble in water	Covalent compounds are Dissolved in covalent solvents
Do not conduct electricity	No ions present to carry the current

4. Naming of writing formulae

- If there is metal, it's named first
- Compounds containing only two elements - have ending -ide
 - Calcium bromide, sodium hydroxide
- Compounds containing an ionic group - have name with ate
 - Calcium carbonate, potassium nitrate, magnesium sulfate
- Prefixes - tell the number of that particular atom in the molecule
 - Carbon *monoxide dioxide trioxide tetroxide*

C3.06 Metals, alloys and crystals

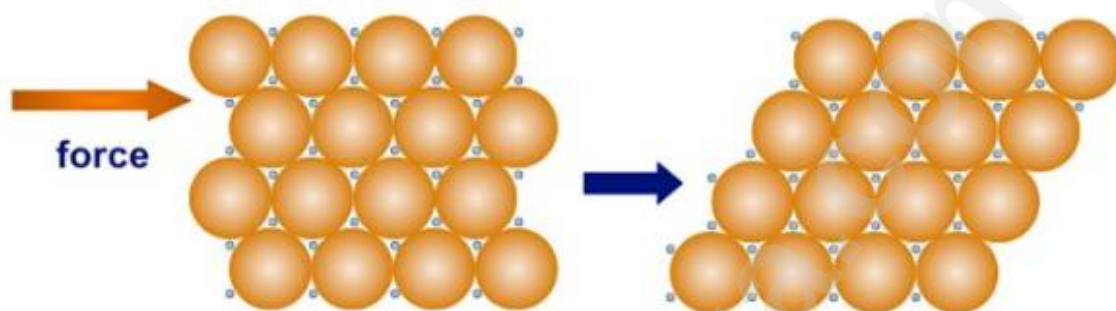
- 4 different types of solid physical structure
 - **Giant metallic lattice** - lattice of positive ions in a sea of electrons

- Giant ionic lattice - lattice of alternative positive and negative ions
- Giant covalent lattice - giant molecule
- Simple molecular substances - simple molecules held together by weak forces

1. Metal crystals

Regular packing of metal ions into a lattice surrounded by a sea of electrons

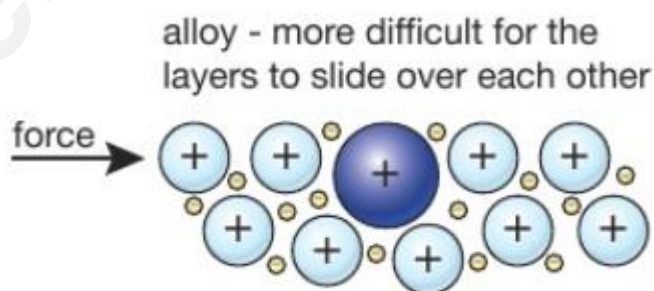
- High density - the packing is as close as possible
 - Alkali metals - less closely packed- lowest densities
- **Malleable**: metals can be rolled into sheets - work better when hot
- **Ductile**: stretched into wires - does not break under forces
- Conduct electricity - freely moving electrons



2. Alloys

Formed by mixing the molten metals together and cool and form a solid

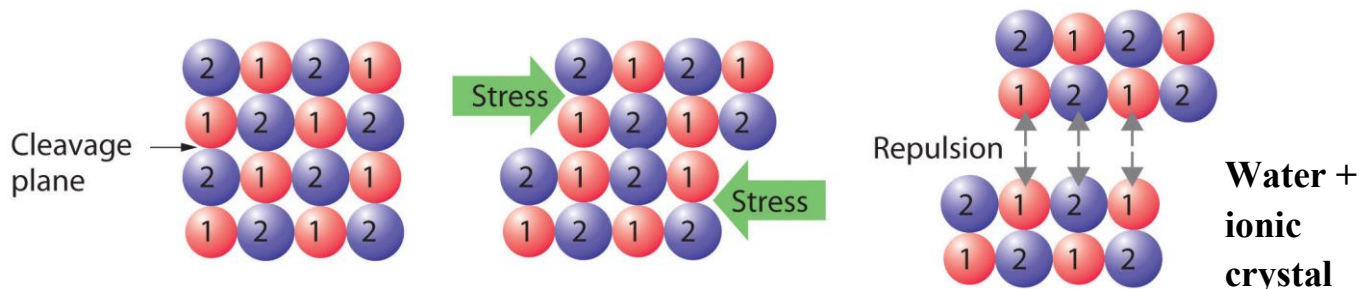
- Stronger than original
- Can be combined for many purposes
- Slid over - hard
- More stronger but more brittle

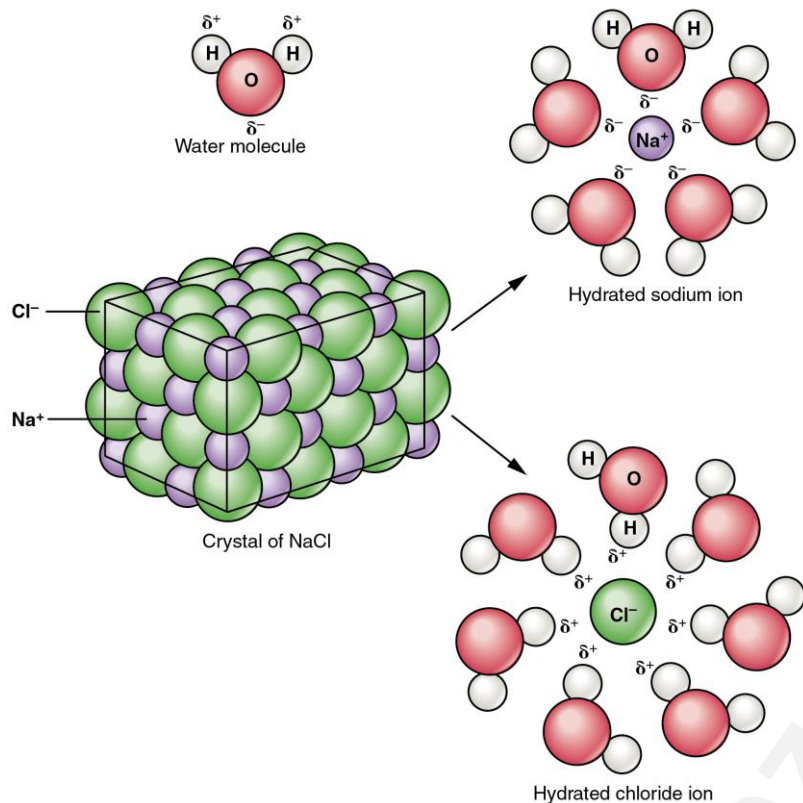


3. Ionic crystals

Nearest neighbours of an ion- opposite charge

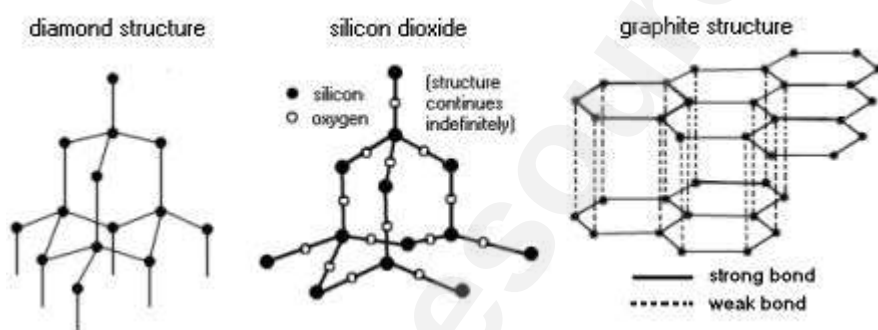
- Hard but brittle more brittle than metallic crystal
 - In metallic crystal, ions are identical, held together by the mobile electrons
- neutral
- When we push it - same charge - repulsion - force the layers apart
- High m.p, b.p
- Many dissolves in water
- When dissolves
 - Ions surrounded by water
 - Break up lattice keep ions apart
 - Can carry electric current





4. Giant covalent crystals

(macromolecules)



- Held together by strong covalent

bonds

- Diamond
 - Strong covalent bonds extend in all directions
 - High melting point and hard- bonding extends throughout the whole structure
 - No electrons at all
 - Bond - rigid , but very brittle
 - All outer electrons used to form covalent bonds
 - Denser than graphite
- Graphite
 - Conduct electricity
 - Slide over very easily
 - Electrons can move between the layers
- Silicon oxide - very similar property

5. Molecular crystals

Non-metal, covalently bonded compounds with low melting point

- By weak intermolecular forces, but break down by heat
- Liquid, solid all don't conduct electricity
- Low melting points

