Chemical Bonding

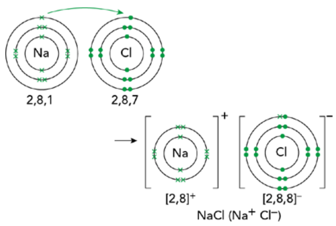
A. TYPE OF CHEMICAL BOND

Ionic Bond

Ionic bond is formed when positive and negative ion are combined together. Atom that loses electron will have positive ion while that gained electron will have negative ion. Usually, metal atoms gained electron and non-metal atoms loss electron

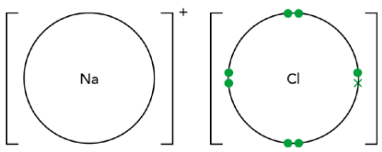
When combining, the electron from metal atom is transferred to non-metal atom to complete the outer shell and thus, they end up having an electron configuration that is similar to noble gas with strong force of attraction. We can also call ionic bond as electrovalent bond

The ions in ionic bond are arranged with repeating pattern and because of this, the attraction of both ions with different charge are very strong



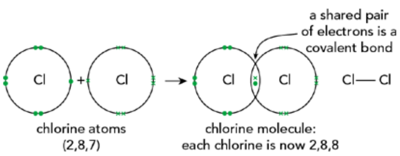
To see arrangement of outer shell electrons in ionic bond, we use dot-and-cross diagrams

A dot-and-cross diagrams shows only outer electron shells, charge of the ion by using square brackets and written at the top right-hand corner of square brackets

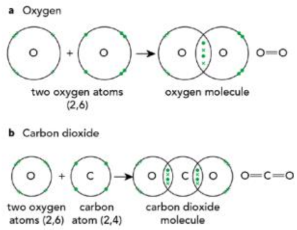


Covalent Bond

Unlike ionic bond, covalent bond formed when two non-metals atom is meet and combined together by sharing electron. The pair of outer shell electrons not used in bonding are called lone pairs

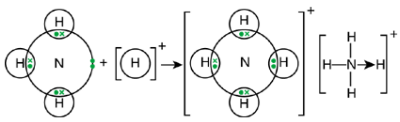


Some atoms are also bond together by sharing two pairs of electrons called double covalent bond. There are also some atoms sharing three pairs of electrons called triple covalent bond



Co-ordinate Bonding (Dative Covalent Bonding)

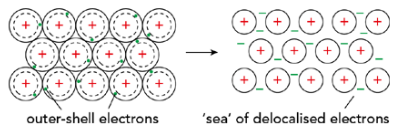
The difference from covalent bond, co-ordinate bond formed when one atom is sharing both electrons needed for a covalent bond to the other atom or in other words, one atom need to have a lone pair of electrons while the other have an unfilled orbital to accept the lone pair or electron deficient compound



Metallic Bond

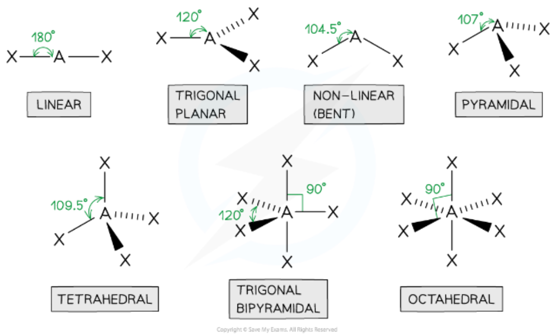
Metallic bond is known by its strong bond since the electron of the metal atom is delocalised

Delocalised electron is electron that is not associated with any one particular atom or bond



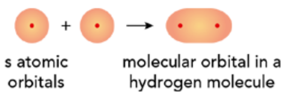
In metals, the delocalised electron moves throughout the metallic structure between the metal ions when a voltage is applied

B. SHAPE OF MOLECULES

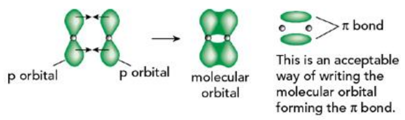


C. σ BONDS AND π BONDS

- **Sigma (σ) Bonds**
  They are formed from the end-on overlap of s orbitals



- **Phi (π) Bonds**
  They are formed from the sideways overlap of adjacent p orbitals



D. ELECTRONEGATIVITY

- Electronegativity is the ability of an atom to attract a pair of electrons towards itself in a covalent bond

- The greater the value of electronegativity, the greater power of an atom to attract the electron in a covalent bond

- Factors Affecting Electronegativity
  1. **Nuclear Charge**
     Positively charged protons in nucleus and electron could attracted each other. As the proton number increase, the nuclear attraction for the electrons in outer shells. As the result, this is also increased the electronegativity
  2. **Atomic Radius**
     Atomic radius is the distance between nucleus and electron in outermost shells. As the atomic radius is increased, the attraction between electrons and nucleus will be weaker and as the atomic radius is decreased, the attraction between electrons and nucleus will be stronger. As the result, this is also decreased the electronegativity and vice versa
  3. **Shielding Effect**
     Shielding effect is caused by increasing number of shell and subshells. This is also making the outer electron become less experienced the nucleus attractive force of the nucleus and thus, it decreases the electronegativity

- **Electronegativity Trends**

	Down a Group	Across a Period
Nuclear Charge	Increases	Increases
Shielding	Increases	Reasonably Constant
Atomic Radius	Increases	Decreases
Electronegativity	Decreases	Increase

E. POLARITY

- When two atoms with the same electronegativity values, it means that both atoms are equally shared each electron or in other word, we can say the covalent bond is non-polar

- If it has different electronegativity value, the more electronegativity atom attracts the pair electron towards it

- The degree polarity of a molecule is measured as a dipole moment and the direction is shown by the sign of arrow points from positive to negative partial charge

- We can also say both of them are partially charged and the covalent bond is polar or it has dipole

- The less electronegative atom will have partial charge δ^+ and the more electronegative atom have partial charge δ^-

- The greater the difference in electronegativity, the more polar the bond become

- But not all molecules with polar bonds are polar molecules. Sometimes the polar bonds cancel each other because the same types of bonds have dipole pulling in opposite direction

- **Polarity and Chemical Reactivity**
  Polarity influence chemical reactivity for example, chloroethane, C_2H_5Cl is more reactive than ethane C_2H_6 because reagents such as OH^- can attack the delta-positive carbon atom of polarised C–Cl bond

F. INTERMOLECULAR FORCES

- The forces between molecule are weaker than the forces within molecules

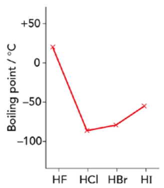
- We can call intermolecular forces as van der Waals forces

- There are two types of van der Waals forces
  1. **London Dispersion Force**
     A force between a molecule with temporary dipole and a molecule with induced dipole. This force is also called instantaneous dipole – induced dipole forces (id–id)
  2. **Permanent Dipole – Permanent Dipole Force (pd–pd)**
     A force between two molecules with permanent dipole. Hydrogen bond is the special type of pd–pd force

- Hydrogen bond is the strongest form of molecular bonding with permanent dipole-permanent dipole bonding

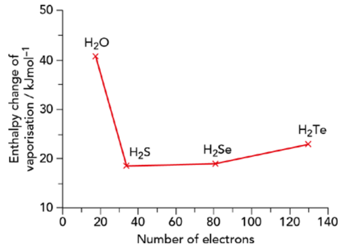
- It is occurred when a hydrogen atom is attached to F, O and N atom

- **The Effect of Hydrogen Bond to High Boiling Point**
  For example, let's comparing some hydrogen halides by showing the boiling point

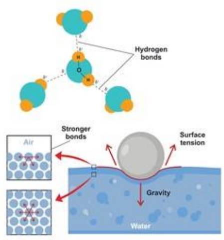


We can see here that from HCl to HI boiling point is rising due to increasing electron number but, HF is a different case. This is because the hydrogen bonding in HF needs higher temperature to break the bond

- Hydrogen Bond and Water Properties
  1. **Enthalpy Change of Vaporisation and Boiling Point**
     Water has unexpectedly high enthalpy change of vaporisation and boiling point



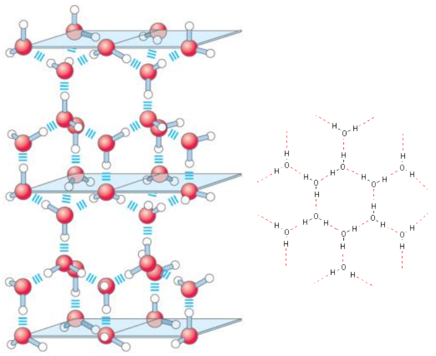
     If we compare it to other hydrides of group 16 element, the enthalpy change of vaporisation is increased from H_2S to H_2Te because of increasing electron number. But the increasing order is not applied with H_2O since it has hydrogen bond which affect the boiling point and enthalpy change of vaporisation
  2. **High Surface Tension and Viscosity**
     The water molecules at the surface of liquid creates hydrogen bonds with other water molecules. These molecules pull downwards on the surface molecules causing the surface them to become compressed and more tightly together at the surface and thus the surface tension of water is high



     Hydrogen bond is also reducing the ability of water molecules to slide over each other so the viscosity of water is high

3. Density of Water in Two States (Solid and Liquid)

Usually, solid states are denser than their liquid states since the particle is more closely packed together



But water has different case because in solid state as it is packed in a 3D hydrogen-bonded network in a rigid lattice. Because of this packing, the hydrogen bond relatively has longer bond length so each water molecule is a bit further than in liquid water and thus, the water in solid state is less dense than the water in liquid state

C. BONDING AND PHYSICAL PROPERTIES

Physical State at Room Temperature and Pressure

1. Ionic Compounds
   Ionic compounds are relatively in solid state at RTP since its strong ionic bond that holding the ion and it's arranged in a lattice with oppositely charged ion close to each other
2. Metals
   All metals aside mercury is in solid state. This is because it takes a lot of energy to break the strong attractive force between the positive ion and the sea of delocalised electron
3. Covalent Compounds
   Simpler molecular (e.g., water and ammonia) are usually liquid or gases because of the intermolecular forces are weak. But there are also in solid states because of the total of London forces are considerable though its melting point is still lower than some ionic compound and most metals

Solubility

1. Ionic Compounds
   Ionic compounds are soluble in water because the water molecule is polar and attracted to ions on the surface of the ionic solid
2. Metals
   Most metals are not soluble in water because the force attraction is difficult to break but there are some metals like sodium and calcium could react with water (rather than dissolve in water)
3. Covalent Compounds
   Covalent compounds are depending on the polarity of the compound. Some are soluble because polar and hydrogen bonding that makes easily dissolve in water
   but some are not because of non-polar

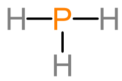
Electrical Conductivity

1. Ionic Compounds
   Ionic compounds do not conduct electricity because the ion could not move freely unless if it's molten
2. Metals
   Metals conduct electricity because the delocalised electrons move throughout the structure when voltage is applied
3. Covalent Compounds
   Covalent compounds with simple molecular do not conduct electricity because they have neither ions nor electrons that could move freely

H. EXERCISE

1. [9701_m15_qp 12_003]
Phosphorus forms a compound with hydrogen called phosphine, PH_3. This compound can react with a hydrogen ion, H^+. Which type of interaction occurs between PH_3 and H^+?
   (A) Dative covalent bond
   (B) Dipole – dipole forces
   (C) Hydrogen bond
   (D) Ionic bond

Solution
In this question, we should draw the structure of the compound first

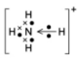


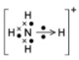
The compound has a lone pair of electrons from phosphorus, this pair then is donated to the electron-deficient atom, H^+ to make phosphonium ion and thus, the correct answer is (A)

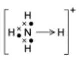
2. In acidic conditions, ammonia, NH_3, reacts with a proton, H^+, to form ammonium NH_4^+.

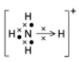
By using the following key:
- • N electron
- x H electron

Which of the following Dot & Cross diagrams correctly illustrate electron movement in this reaction?

(A) 

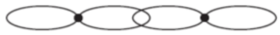
(B) 

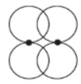
(C) 

(D) 

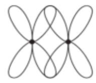
Solution
The NH_3 compound has a lone pair of electrons which then is donated to the H atom to form an ammonium. Therefore, the arrow should be draw from NH_3 to H with the lone pair electron of NH_3 drawn as •• on the arrow and the correct answer is B

3. Which diagram describes the formation of a π bond from the overlap of its orbital?

(A) 

(B) 

(C) 

(D) 

Solution
π bond is formed from the sideways overlap of adjacent p orbitals so, the correct answer is B