Chapter 2 Atoms, elements and compounds

Thursday, August 17, 2023 12:03 PM

Matter

atom cell

PEN

(A combine with O ×)

Proton — Positive
Electron — Negative
Neutron — Neutral

When same atoms combine, they will make element

an atom of Hydrogen will combine with another atom of hydrogen, they will form element

Compound → when different atoms combine they will make compound e.g H_2O
↓ chemically

H_2O
2Hydrogen + oxygen

Molecule
- Elements — atom+atom: H+H → H_2, O+O → O_2, N_2, Cl_2, Br_2
  - element: Fe is not molecule
- Compound — H_2O Molecule: 2 atoms of H + 1 atom of O

Cl-Cl → Cl_2; H-H → H_2

CO_2 — Carbon + oxygen

Matter is made up of substance

Pure substance
① Element

impure substance
① Mixture

(2) Compound

Element is a pure substance formed from the single type of atoms

- 1 → Monoatomic He, Li, Ne, S, K, Na, Fe,
- 2 → Diatomic Cl_2, H_2, O_2, Br_2, I_2, N_2 (Molecule)

4 molecules of H_2

Compound

It is a pure substance which is made up of two or more different elements chemically combined. e.g H_2O, CO_2, NH_3, H_2SO_4, HNO_3

H_3O ✗ CO_3 ✗

Mixture

It is impure substance. It is formed when 2 or more substance are physically combined

(1) Sugar sucrose $C_{12}H_{22}O_{11}$ in water

(2) Air is a mixture of gases.

(3) Petroleum is also a mixture of hydrocarbons

(4) Sand + Fe — Mixture

Difference b/w element Compound and Mixture

Element	Compound	Mixture
(1) Definitions	Definition	Definition
(2) They cannot be broken down	They can be broken down and you get new things. $H_2O \xrightarrow[\text{current}]{\text{elec}} H_2 + O_2$	They can be separated Sand + Fe
(3) physical + chemical properties are same	Physical and chemical are not same because they are made of different elements	The chemical properties of a mixture are same as those of its components

10 Which two processes are involved in the preparation of magnesium sulfate from dilute sulfuric acid and an excess of magnesium oxide?

A neutralisation and filtration

B neutralisation and oxidation

C thermal decomposition and filtration

D thermal decomposition and oxidation

11 How many different salts could be made from a supply of dilute sulfuric acid, dilute hydrochloric acid, copper, magnesium oxide and zinc carbonate?

A 3 **B** 4 **C** 5 **D** 6

12 Which salt preparation uses a burette and a pipette?

A calcium nitrate from calcium carbonate and nitric acid

B copper(II) sulfate from copper(II) hydroxide and sulfuric acid

C potassium chloride from potassium hydroxide and hydrochloric acid

D zinc chloride from zinc and hydrochloric acid

13 Which acid reacts with ammonia to produce the salt ammonium sulfate?

A hydrochloric

B nitric

C phosphoric

D sulfuric

14 Copper carbonate reacts with dilute sulfuric acid to make copper sulfate.

$$CuCO_3(s) + H_2SO_4(aq) \rightarrow CuSO_4(aq) + CO_2(g) + H_2O(l)$$

Which row gives the correct order of steps for making copper sulfate crystals?

	step 1	step 2	step 3	step 4
A	add excess acid to the copper carbonate	filter	evaporate filtrate to point of crystallisation	leave to cool
B	add excess acid to the copper carbonate	filter	evaporate to dryness	leave to cool
C	add excess copper carbonate to the acid	evaporate to point of crystallisation	leave to cool	filter
D	add excess copper carbonate to the acid	filter	evaporate filtrate to point of crystallisation	leave to cool

15 Which acid reacts with ammonia to produce the salt ammonium sulfate?

A hydrochloric

B nitric

C phosphoric

D sulfuric

16 Anhydrous copper(II) sulfate can be made by heating hydrated copper(II) sulfate.

$$CuSO_4.5H_2O \rightarrow CuSO_4 + 5H_2O$$

What can be added to anhydrous copper(II) sulfate to turn it into hydrated copper(II) sulfate?

A concentrated sulfuric acid

B sodium hydroxide powder

C sulfur dioxide

D water

17 A compound is a salt if it

A can neutralise an acid.

B contains more than one element.

C dissolves in water.

D is formed when an acid reacts with a base.

18 Salts X and Y are separately dissolved in water.

Samples of the solutions obtained are separately tested with dilute hydrochloric acid and with aqueous sodium hydroxide.

In two of the tests, a gaseous product is formed. No precipitate is formed in any of the tests.

What are salts X and Y?

	X	Y
A	$AgNO_3$	$BaSO_4$
B	$BaSO_4$	Na_2CO_3
C	Na_2CO_3	NH_4Cl
D	NH_4Cl	$AgNO_3$

19 A liquid turns white anhydrous copper sulfate blue and has a boiling point of 103°C.

Which could be the identity of the liquid?

A alcohol

B petrol

C salt solution

D pure water

20 A salt is made by adding an excess of an insoluble metal oxide to an acid.

How can the excess metal oxide be removed?

A chromatography

B crystallisation

C distillation

D filtration

21 An excess of copper(II) oxide is added to dilute sulfuric acid to make crystals of hydrated copper(II) sulfate.

The processes listed may be used to obtain crystals of hydrated copper(II) sulfate.

1 concentrate the resulting solution

2 filter

3 heat the crystals

4 wash the crystals

Which processes are needed and in which order?

A 1, 2

B 1, 2

C 2, 1

D 2, 1

22 Salts can be prepared by reacting a dilute acid

1 with a metal;

2 with a base;

3 with a carbonate.

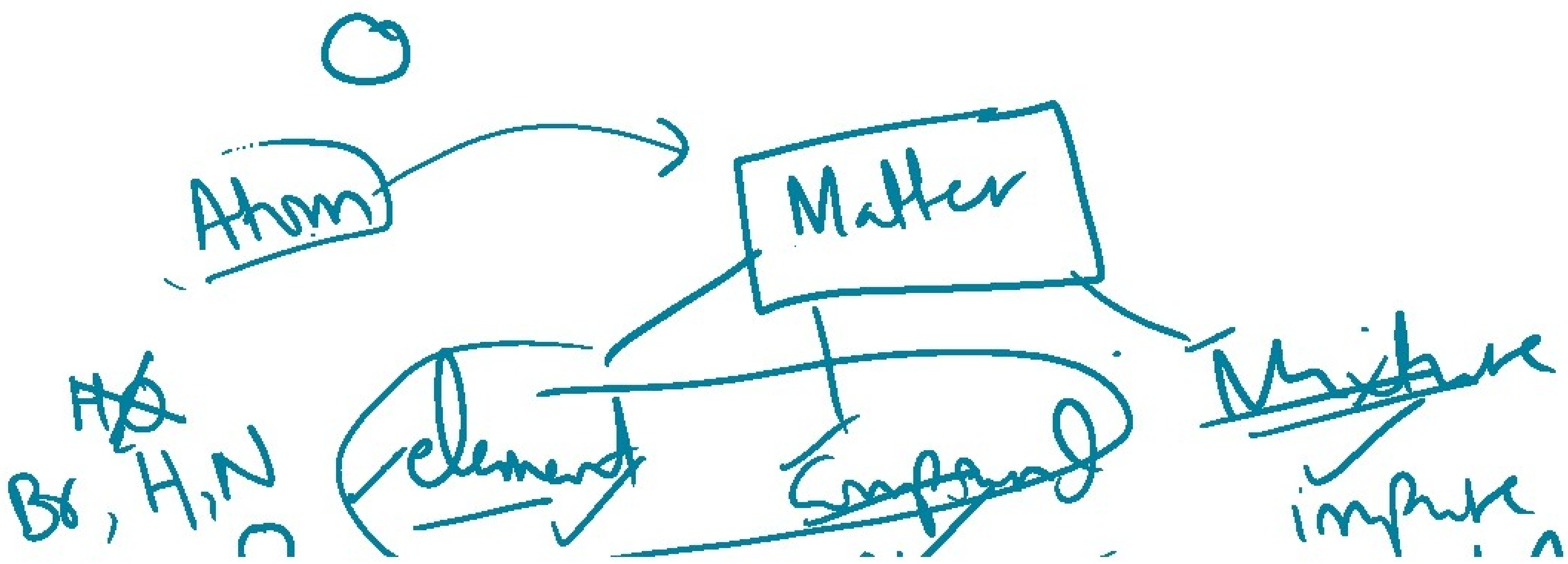
Which methods could be used to prepare copper(II) chloride?

A 1 and 2 only

B 1 and 3 only

C 2 and 3 only

D 1, 2



I, He, Li, Na, Al — Pure substance — substance

Molecule → Element: when same atoms join together
2H atoms → H_2 gas

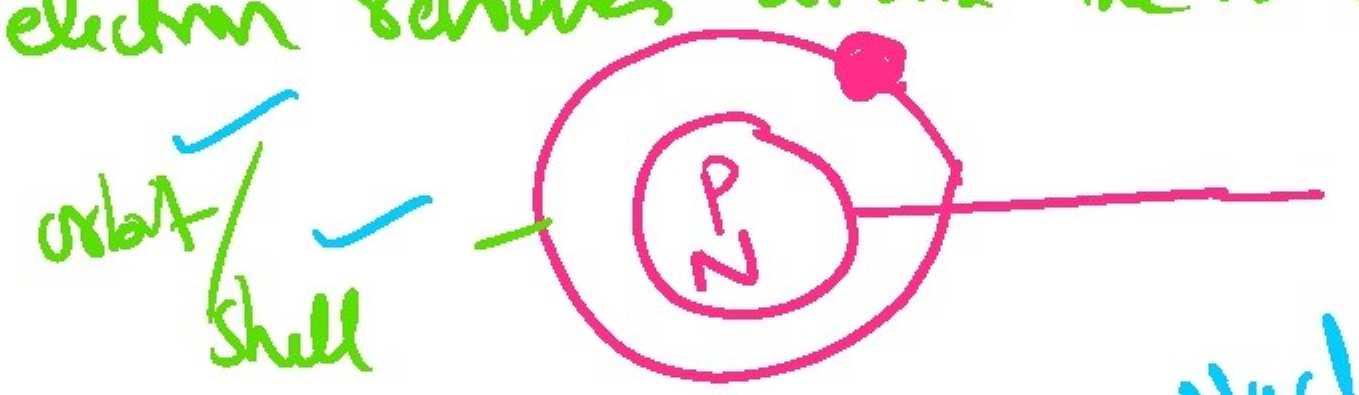
Molecule → Compound: When different atoms combine together
e.g. H_2O, NH_3,

metalloid: Ladder Shape

Structure of Atom

PEN
- Proton: +
- electron: −
- neutron: 0

electron revolves around the nucleus



Nucleons: P + N → Nucleons

Proton Number (Z)

118 elements → each element have unique number and you know the element by this number

It is also called Atomic number Z

Nucleon Number

P + N = Nucleon number

→ Also called Atomic Mass represented by A

Nucleon number — 23, Proton number — 11: $^{23}_{11}Na$ $\quad$ $^{A}_{Z}X$

In Periodic table all the elements are neutral

P = E

Electronic Configuration (You have to consider proton number)

Distribution of electron in various orbits or shells

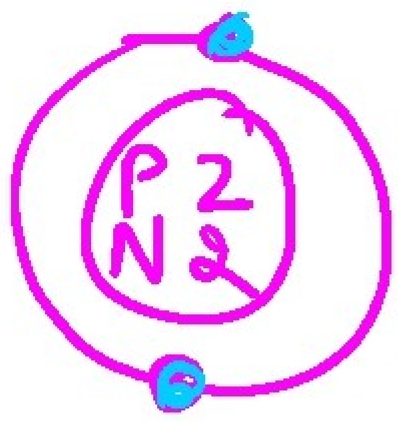
$^{23}_{11}Na$

1st shell 2nd shell 3rd shell

2 electrons 8 electrons 8 electrons.

$_1H$ = 1

^4_2He = 2



$_{11}Na$

2, 8, 1

$_{17}Cl$

2, 8, 7

18 Proton number → 2, 8, 8

14 Proton number → 2, 8, 4

H.W electronic configuration of first 20 elements

Ions

A neutral atom becomes an ion when it loses or gain an electron.

Na → Na^+

Metal ↓ always lose electrons and they become Positive Ions Cations

Non metals ↓ Gain electron and they become Negative Ions Anion

O ↓ O^{-2}

When atom is neutral → Stable

" " " Ion → Unstable

Valence shell and Valence electrons

Valence shell → Outer most shell which is half filled in most cases

Valence electrons → electron located in the outermost shell is called valence electrons.

Isotopes

Isotopes are the atoms of the same element having same proton number but different number of neutrons (different nucleon number)

nucleon number → P + N

For example

$^{1}_{1}H$ — P = 1, E = 1 — N = 0

$^{2}_{1}H$ — P = 1, E = — N = 1

$^{3}_{1}H$ — P = 1, E = 1 — N = 2

(P = E) Neutral atom

Ion

(1) Ion^{+} — P ≠ E

More P than E (Metal) → P > E

(2) Ion^{-} — P ≠ E

E > P (Non metal)

Chemical Bonding

Ionic | Covalent | Metallic bonding

(1) Ionic Bonding

⇒ Bonding b/w Metals (+) and Non metals (−)

⇒ electrostatic force of attraction (+ −)

Metal & Non metal

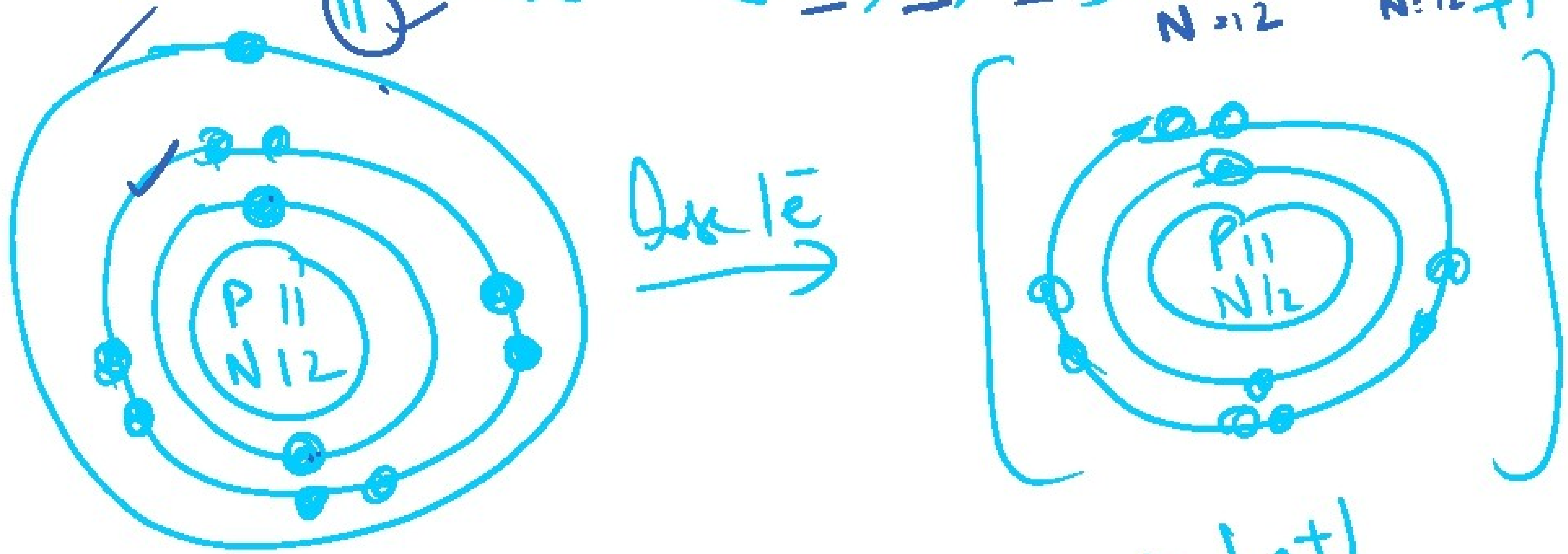
will lose electron → gain by non metal

For example $^{23}_{11}Na$ (2, 8, 1)

$^{23}_{11}Na$: P = 11, E = 11, N = 12

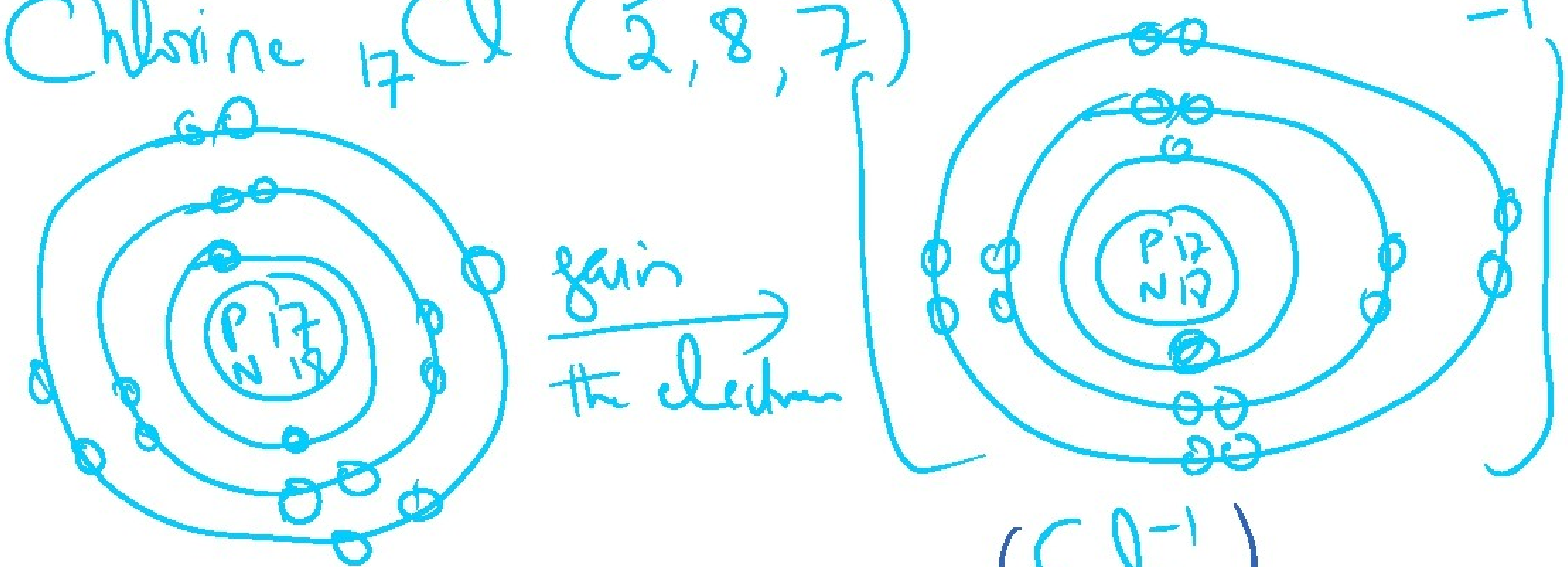
$^{23}_{11}Na^{+}$: P = 11, E = 10, N = 12, +1

Na^{+}



Na^{+1}

Chlorine $^{35}_{17}Cl$ (2, 8, 7)



(Cl^{-1})

Why atom loses or gain electron?

In order to attain the electronic configuration of noble gases (noble gas have complete outermost shell)

Duplet (2) Octate (8)

1st one shell → (2)

He 2 ✓

H 1

$_3Li$ = 2, 1

Li = 2, 1 (not duplet)

H, He we will say like this their duplet is completed, never say octate for H and He.

$Na \rightarrow Na^{+1} + 1\bar{e}$ (lost) (attain the electronic configuration of Neon)

2,8,1 → (2,8)   +P = 11, −E = 10

$Cl + 1\bar{e}$ (gain) $\rightarrow Cl^{-1}$ (attain the electronic configuration Argon)

2,8,7 → 2,8,8   +P = 17, −E = 18 ✓

$Na^{+} + Cl^{-} \rightarrow NaCl$

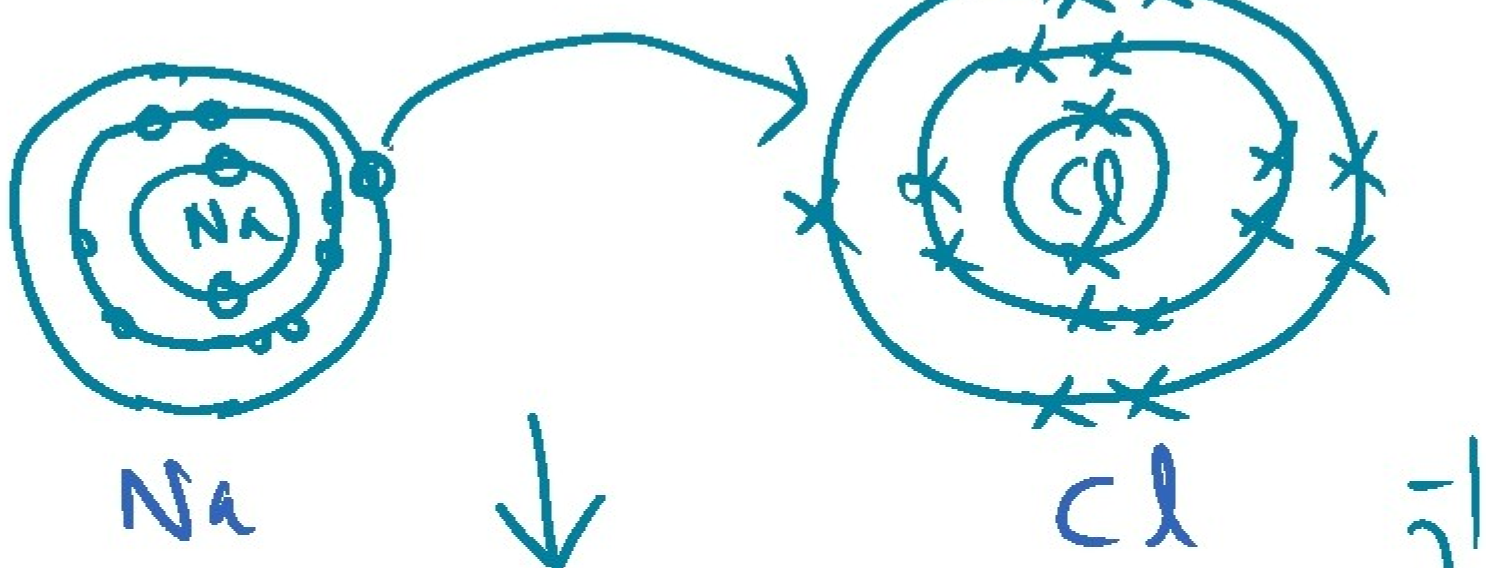
~~Dot~~

Dot and Cross Diagram

∘ Dot

× Cross

In representing the dot and cross diagram you have to consider the valence electrons.



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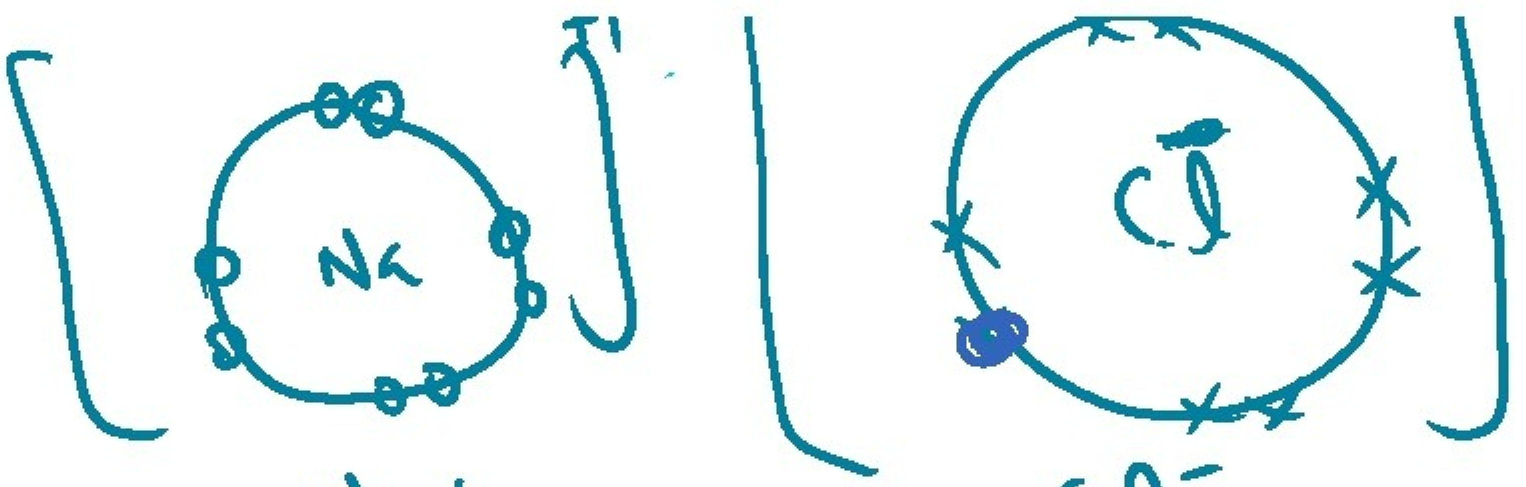
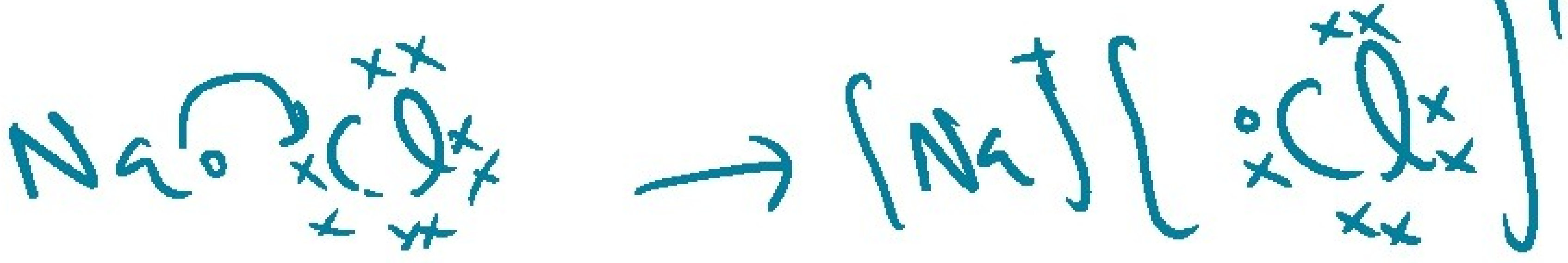
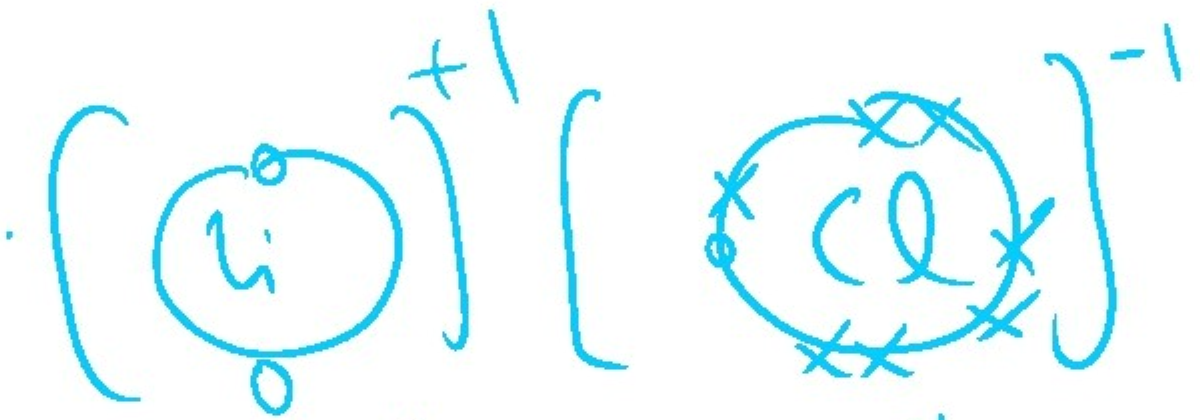


Na^+ (2,8) Cl^- (2,8,8)

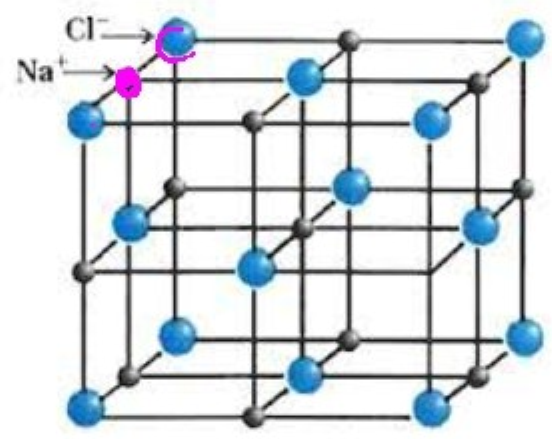


LiCl, MgO, $MgCl_2$



Li^{+1} Cl^{-1}

Giant Ionic Structure



Na^+ and Cl^- are arranged in giant lattice. Millions of Na^+ and Cl^- ions are arranged in this form

Na^+ Cl^- ratio is same 1 : 1

Each Na^+ is bonded to six Cl^- ion, similarly each Cl^- is bonded to six Na^+ ion.

The structure is so strong, there is attraction from every side which makes it difficult for the ions to break apart

Electrovalent bond is the another name

of Ionic bonding

// Why Positive ion is smaller as compared to negative Ion
Positive Ion loses electron and get shrink.
Negative Ion it gain the electron and get bigger in size //

Properties of Ionic Compound

(1) Melting and Boiling Point

Ionic compound are in the giant Ionic Lattice and there is strong electrostatic force of attraction which are hard to break. Therefore Ionic compounds have high melting and boiling point

(2) Strength
- (1) charge of Ion
- (2) Ionic radius

✓ Ionic Bonding $\propto$ charge of Ion

More charge of Ion, smaller will be the radius

Mg^{+2} (2) Al^{+3} (1) Na^{+1} (3)

$$\text{Ionic bonding} \propto \frac{1}{\text{Ionic radius}}$$

For example

NaCl and $MgCl_2$ ✓

Mg has greater charge Mg^{+2} and smaller Ionic radius.

(3) Conductivity

Metallic compound have free electrons in solid state

Ionic Compounds

$NaCl + H_2O \rightarrow Na^+ + Cl^-$

$NaCl \rightarrow Na^+ + Cl^-$

- Conduct electricity in aqueous solution and molten state – have free ~~electrons~~ Ions
- do not conduct electricity in solid state ($NaCl$) – have no free Ions

Molecules (Covalent Bonding)

$O + O \rightarrow O_2$ (atom + atom → element molecule)

$2H + 1O \rightarrow$ compound molecule

Simple

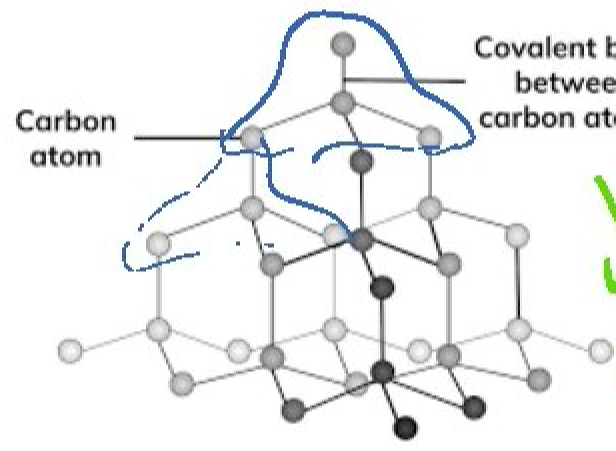
CO_2, HCl, CH_3OH, CH_4, N_2, Cl_2, O_2 ✓

Giant or Macromolecule (Big)

- Diamond (C)
- Graphite (C)
- SiO_2 (Sand)

Allotropes of Carbon are the different structural ~~formula~~ of the same elements. e.g

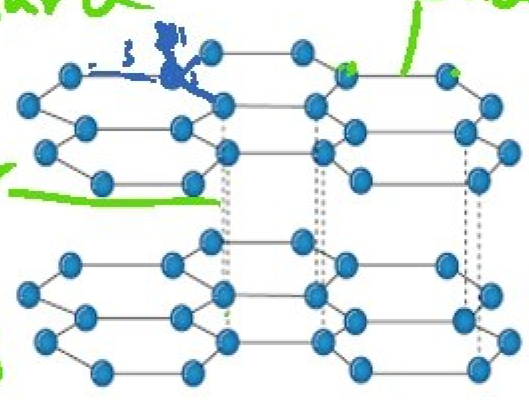
Diamond – Hard

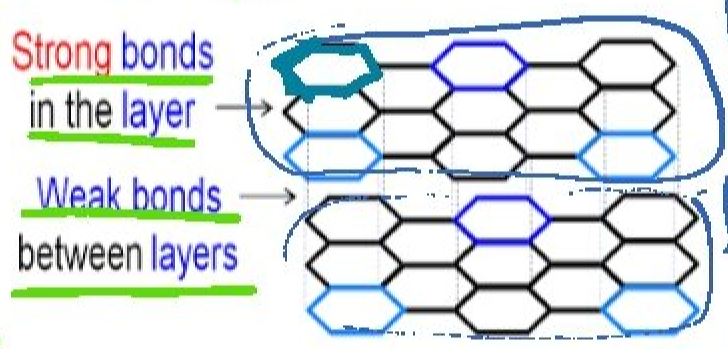


Graphite – Soft

Covalent bonding

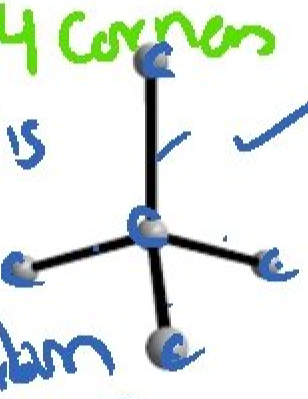
Vander Waal's forces





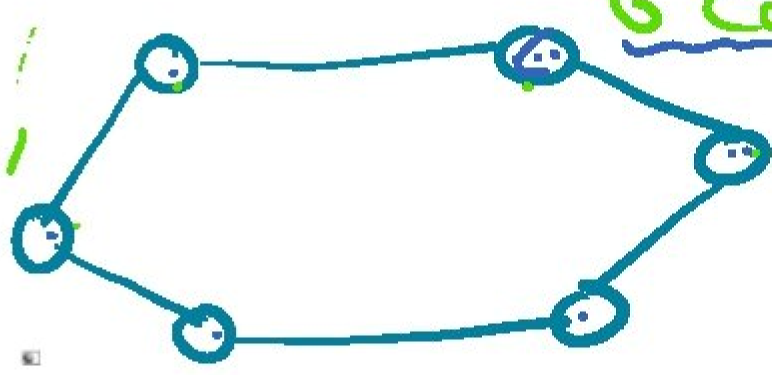
Tetrahedral Structure – 4 corners

Each C is connected with 4 Carbon making 4 bonds



Hexagonal structure – 6 corners

Each Carbon is connected with 3 Carbon making 3 bond leaving one electron free



Which one is the good conductor?

Diamond have no free electrons so it

is a bad conductor (Its Carbon is making all 4 Bonds)

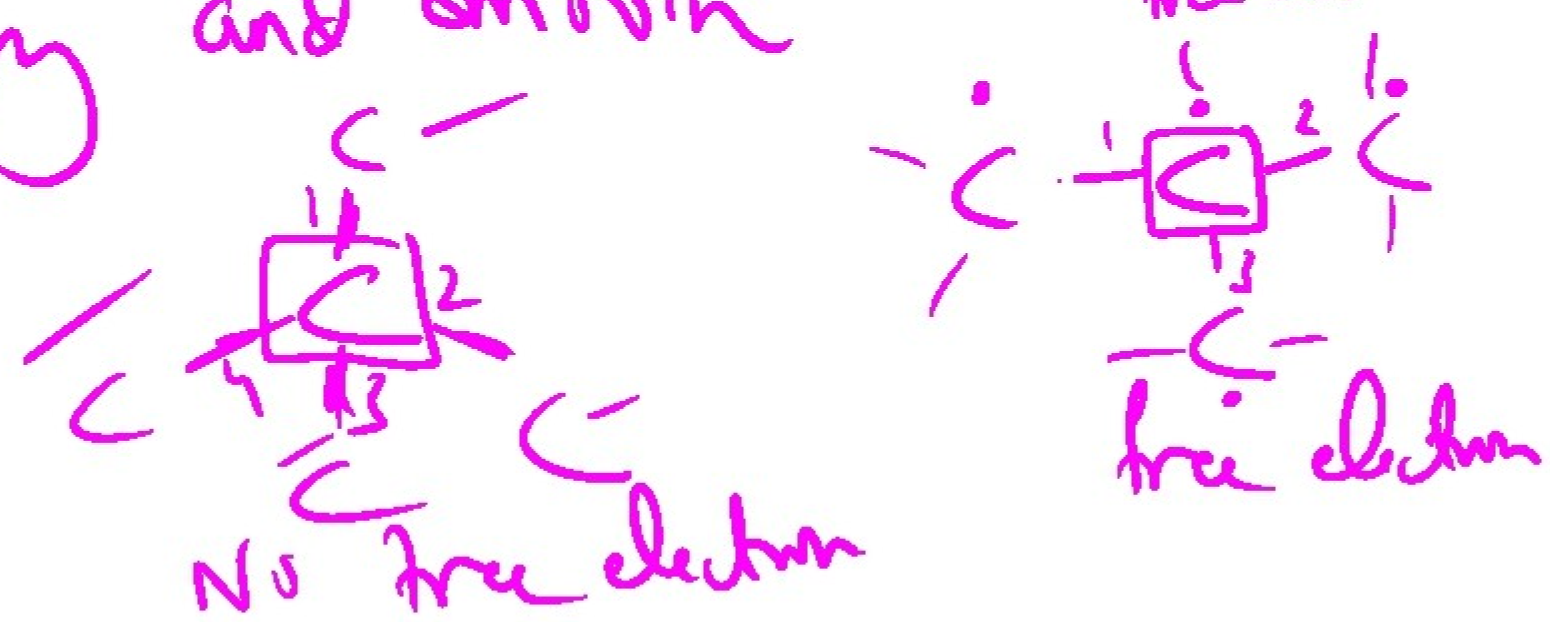
Graphite have one free electron because its Carbon can make just 3 bond leaving one electron free. This free electron is responsible for conduction.

(2) Melting and boiling Point.

Diamond have higher melting and boiling point, It is extremely hard and it is used for cutting tools

~~Wh~~ Why Graphite is soft?

The covalent bond within layers are very strong but the layers are connected to each other by weak forces only and hence the layers can slide over each other making graphite slippery and smooth

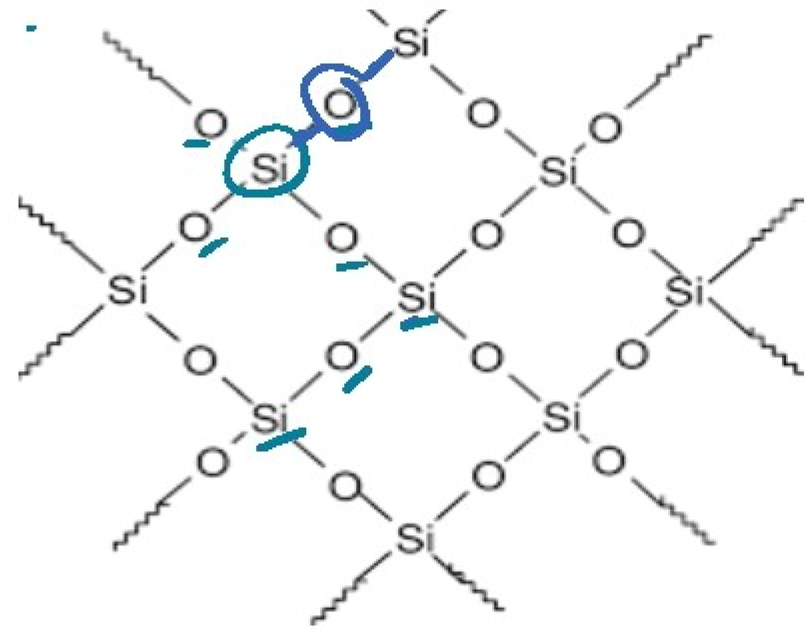


Silica

Silicon (IV) oxide, SiO_2, Sand, Quartz

⇒ Giant Covalent molecule

⇒ Each Si is bonded to 4 oxygen atom in a tetrahedral structure and each oxygen is bonded to 2 silicon



Diamond & silica have similarities
① Tetrahedral ③ Hard
② Bad conduction
④ Giant covalent structure

Covalent bonding

CO_2 ⇒ Non metal with Non metal
HCl ⇒ Sharing the electron pair
NH_3

Covalent bonding have
(1) One Pair (2 electron) → Single Covalent bond (–)

X:Y X=Y

(2) 2 Pairs (4 electrons) → Double Covalent bond (=)

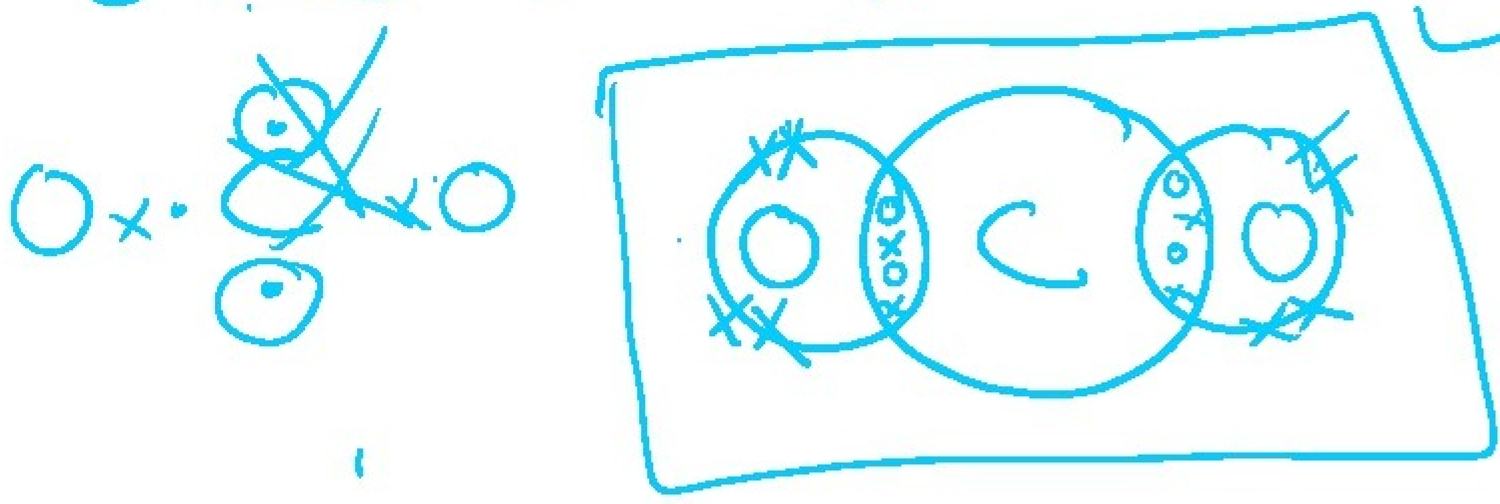
X⁝Y X≡Y

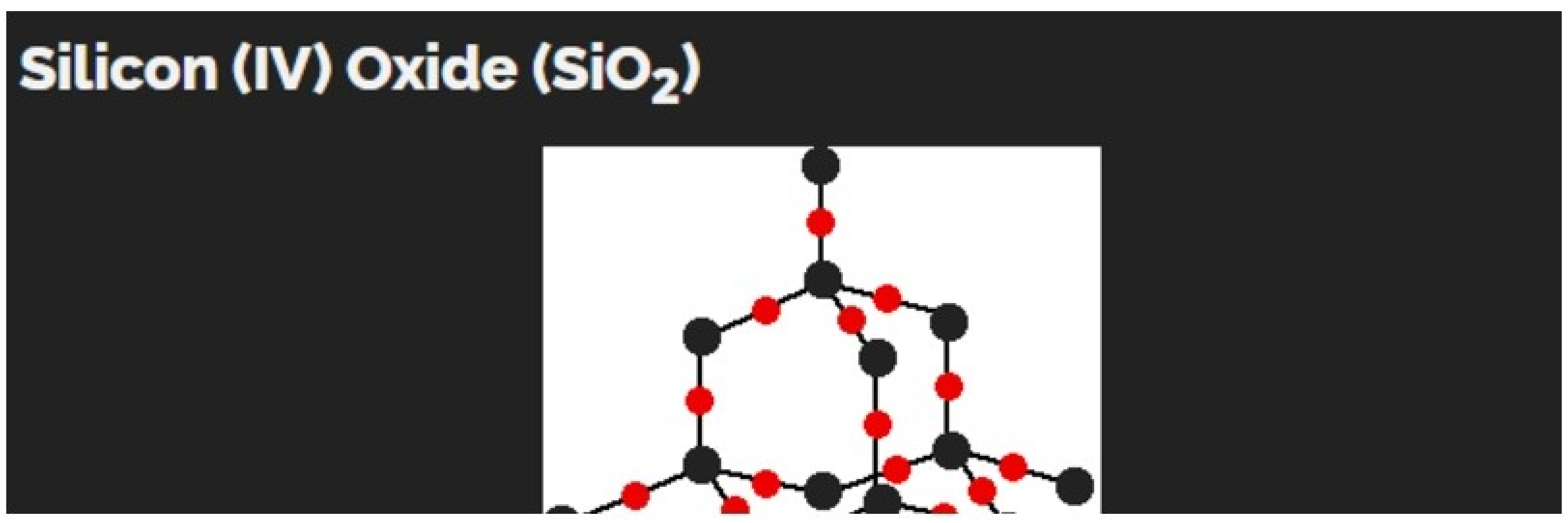
(3) 3 Pairs (6 electrons) → Triple covalent bond

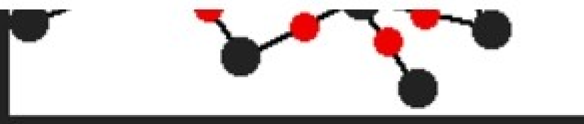
Dot and cross Diagrams

CO_2 (2) Take valence electrons only in dot and cross

O=C=O







Properties of Silicon (IV) Oxide

1. The structure of Silicon (IV) Oxide is **similar/resemblance to that of a diamond.**
2. **Hard Structure**
3. **High melting and boiling point** - More energy to overcome
4. **Rigid Tetrahedral Structure**
5. Does **not conduct electricity**

- **Each Silicon atom** is covalently bonded with **4 Oxygen Atoms**
- **Each Oxygen atom** is covalently bonded with **2 Silicon Atoms**

SiO_2 and diamond are similar in structure
⇒ Tetrahedral ⇒ giant molecule
⇒ High m.p and B.P ⇒ Non conductor

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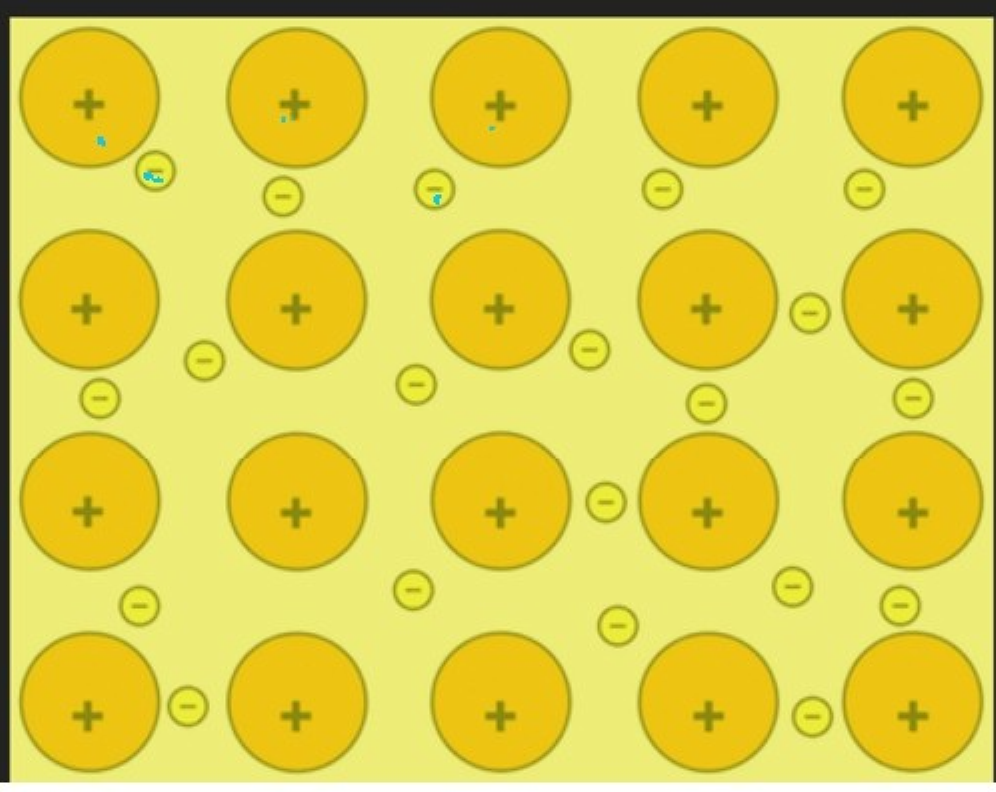
Metallic Bonding

Metallic Bonding: the electrostatic attraction between the positive ions in a giant metallic lattice and a "sea" of delocalised electrons.



⇒ In metal lattice, atoms lose their valence electrons and become positively charged
⇒ The valence electrons no longer belong to any metal atom and are said to be delocalized → which move freely from one point to another.
⇒ They move freely b/w metal ion

Structure and Bonding

Mobile electrons

1. Metallic Bonds have good electrical conductivity - **Delocalised electrons can move through the structures and carry current.**

2. High Melting and Boiling Point - **More energy to overcome strong forces of attraction between positive metal ions and the sea of delocalised electrons & Vibrate/Transfer Heat**
3. Malleability - Can be **hammered into shapes** as **layers can slide over each other.**
4. Ductility - Can be **drawn into thin wires**

Exam Tip

Metal conduct electricity in molten and solid state e.g. Cu wires

Ionic Compound Conduct electricity in molten + aqueous state

Ionic Compound do not conduct electricity in solid state

Why metals show Ductility and Malleability?

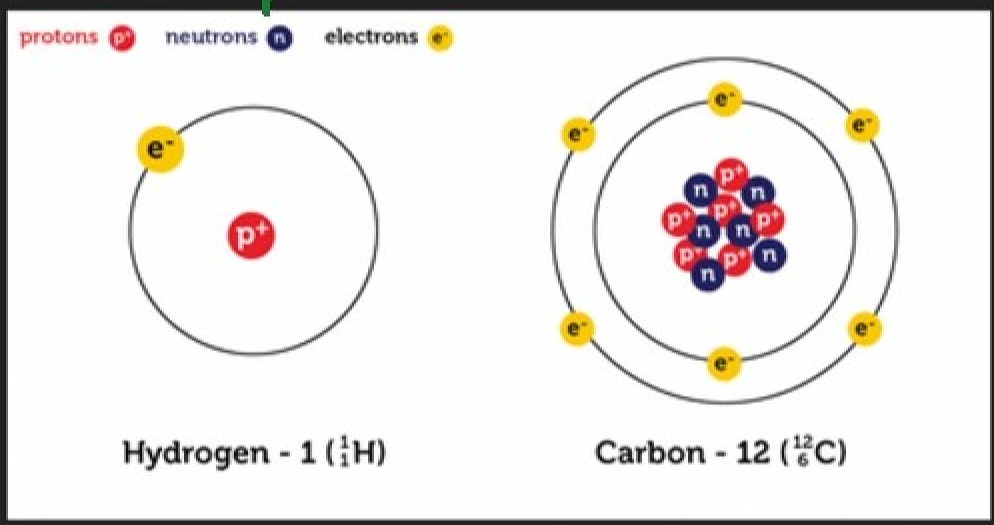
In metallic bonding if force is applied to the metal, one layer of atoms can slide over another layer without disrupting the metallic bonding as a result metallic bond is strong but flexible so metals can be hammered into different shapes (malleability) or drawn into wires (ductility) without breaking

Atomic Structure

- An atom comprises three subatomic particles: protons, neutrons and electrons.
- The atom is mostly space with a positively charged nucleus consisting of protons and neutrons in the centre and electrons in the space around the nucleus (held together by the electrostatic force of attraction between them and the positively charged nucleus)
- The characteristics of neutrons, protons and electrons are as follows:

Subatomic particle	Relative Mass	Relative Charge
Proton	1	+1
Neutron	1	0
Electron	1/1840	-1

- Since electrons and protons have opposing and equal charges, **the atom's overall charge is neutral.**
- Neutrons have the purpose of holding the nucleus together. The larger the nucleus gets, the more are the neutrons required to hold the nucleus together



In Neutral atom

P = E

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Relative Atomic Masses

- Most elements exist naturally as a mixture of their isotopes. Using the data on the abundance of these naturally occurring isotopes, we can calculate the mass relative atomic mass of the element.
- NOTE: for all purposes, the mass numbers of elements have been rounded off to the nearest whole number; however, only Chlorine is used with its actual mass number of 35.5. This is for the sake of simplicity of calculation
- An example for calculating the relative mass and abundance:

- An example for calculating the relative mass and abundance:

Q. Iridium has two isotopes. These isotopes are Iridium - 191 and Iridium - 193. A natural sample consists of of 37.3% of Iridium - 191. Calculate the relative atomic mass (A_r) of the natural sample of Iridium

A. →
Step 1. Identify the percentage of Iridium - 193
→ if the sample consists of 37.3% of Iridium - 191, it must consist of 100% - 37.3% of Iridium - 191
→ 100 - 37.3 = 62.7%
→ the sample consists of 62.7% of Iridium - 193
Step 2. Consider a sample of 100 atoms of Iridium. In that sample, 37.3 of atoms should have a mass of 191 and 62.7 atoms should have the mass of 193
THEN

average mass = $\frac{(37.3 \times 191) + (62.7 \times 193)}{100}$ = 192.2 (4 significant figures)

Answer: 192.4 ✓

$$\frac{(191 \times 37.3) + (193 \times 62.7\%)}{100}$$

100
37.3 %

$$\text{Average Mass} = \frac{(\text{Isotope 1 atomic mass} \times \text{\%age abundance}) + (\text{Isotope 2 atomic mass} \times \text{\%age abundance})}{100}$$

$$= \frac{(1 \times 99.988) + (2 \times 0.0115)}{100}$$

$$= 1.000115$$ ✓