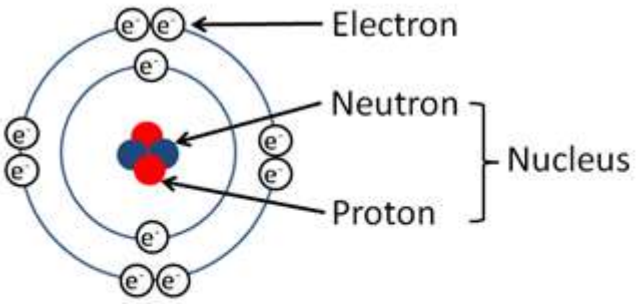
Tutopiya's GCE O Level Chemistry Mid-Year Examination Notes

Made by: Tutopiya

Atomic Structure



(Source)

Isoelectronic: Isoelectronicity happens when two or more molecules have the **same structure and the same electron configurations.** However, they differ by what specific elements are at certain locations in the structure.

Isotopes: Isotopes are two or more types of atoms that have the **same atomic number and position** in the periodic table. They differ in nucleon numbers due to **different numbers of neutrons in their nuclei.**

Finding the relative atomic mass of isotopes

- Add an abundance of the first isotope multiplied by its atomic mass to an abundance of the second isotope multiplied by its atomic mass and so on and so forth and then divide it by the number of isotopes.
- The formula is as follows:

$$\frac{\sum(\text{Isotope abundance x Isotope mass number})}{\sum \text{Isotope abundance}}$$

(Source)

Electronic structure

- s,p,d,f,g orbital notation

Aufbau Principle

- Electrons fill up orbitals of lowest energy first before proceeding to higher energy levels

Pauli exclusion principle

An orbital can only hold a max of 2 electrons of opposite spins

Hund's rule of multiplicity

Electrons occupy different orbitals each first before pairing up in each orbital

1s,2s,2p,3s,3p,3s,4s,3d……

Overlap in energies of certain layers: 4s and 3d, 3d is higher

In the case of ions drawing electrons will draw from 4s first before 3d even if it's a higher orbital

s = 2, p =6, d=10, f= 14

Can write using noble gas core

1s2,2s2,2p6,3s2 as [Ne] 3s2

Separation Techniques

Filtration

- A separate mixture of insoluble solid and liquid

- Mixture poured through filter paper

Sublimation

- Change of a state of a substance from solid to gaseous without going through the liquid state on heating

- Mixture is heated gently, sublimate condenses on cooler sides of the funnel

Distillation

Fractional distillation: separate a mixture of miscible liquids using a fractionating column

Separates liquids in order of boiling points

- Liquid with lowest boiling point distilled first

- Liquid with highest boiling point distilled last

Chromatography

Separate and identify both coloured and colourless mixtures

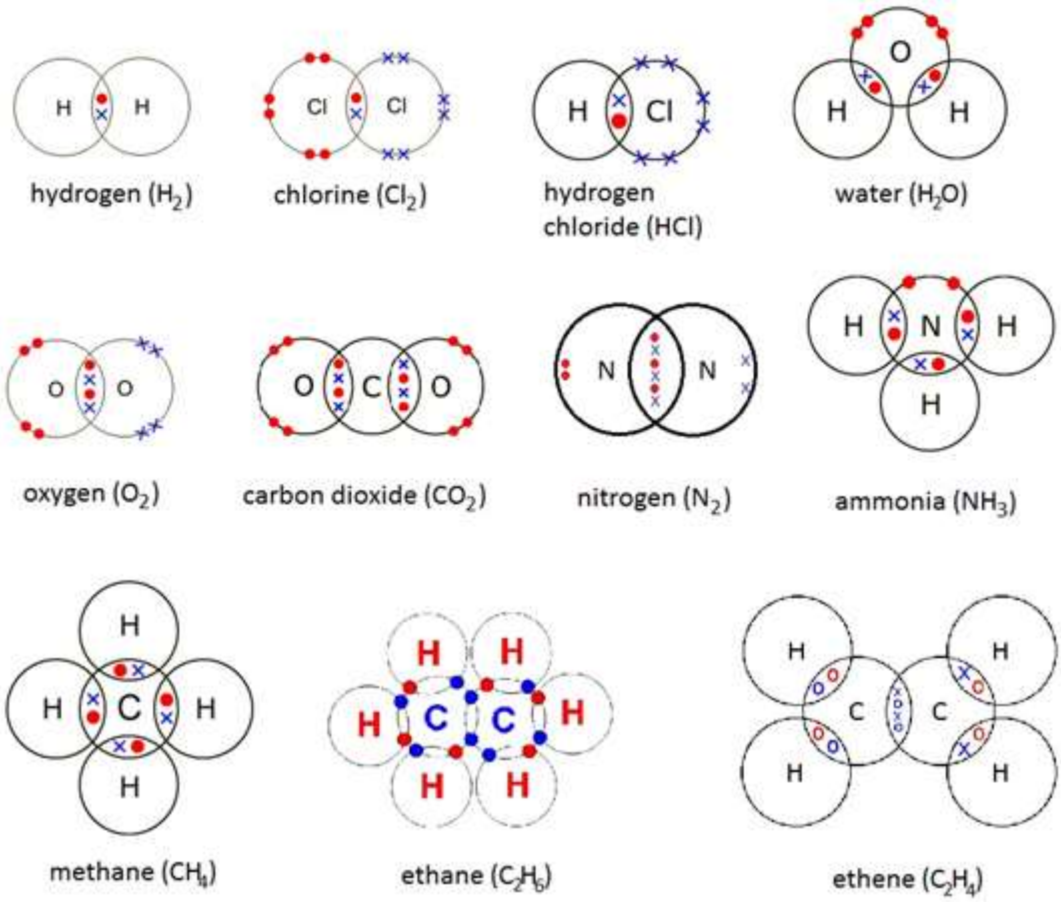
The mixture must be dissolved in the same solvent

Components travel at different rates over the paper, depends on solubility in the solvent. The more soluble it is, the faster it moves.

Rf value = Dist. Moved by substance/ Dist. Moved by solvent.

Chemical Bonding

Dot and cross diagrams



(Source)

Ionic Bonding

The electrostatic force of attraction between two oppositely charged ions.

They are usually formed between non-metals and metals.

They have high melting and boiling points.

- Due to the strong electrostatic forces of attraction between oppositely charged ions in the giant ionic crystalline lattice structure, a large amount of heat energy is needed to break these bonds

Ionic substances conduct electricity in an aqueous and molten state but not in solid

- In a solid-state, ions are held together by a strong force of electrostatic attraction between oppositely charged ions. They can only vibrate around their own position.

- In the liquid state, the strong forces of electrostatic attraction between oppositely charged ions are broken. Ions are free to move around and Electricity can be conducted by these mobile ions. They are also soluble in water.

- Water molecules can bond with both positive and negative ions, breaking up the lattice structure

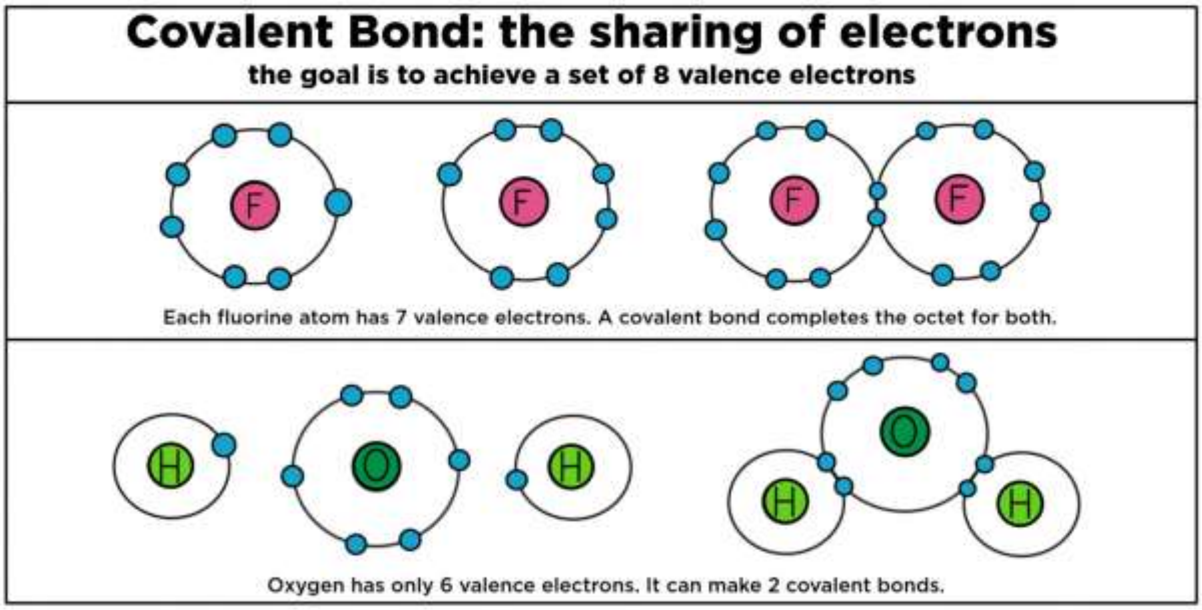
Metallic Structures

- Metallic structures consist of positive ions in a sea of delocalized valence electrons

- Metallic ions and a sea of delocalized valence electrons have a strong force of electrostatic attraction between them

- Can conduct electricity: Sea of delocalized valence electrons can move around freely and help to conduct electricity

Covalent Bonding

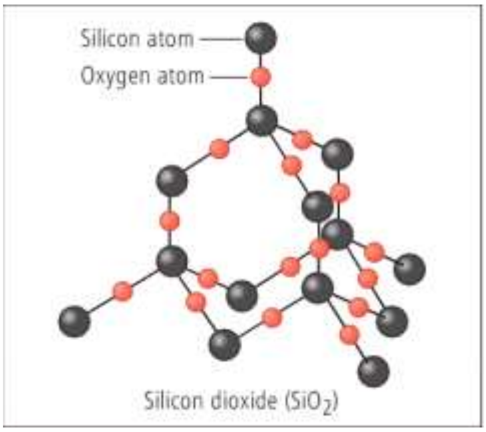


(Source)

Two main types of Structure: Giant and Simple Molecular structures

Between two non-metals

Giant Molecular Structure



(Source)

- Covalently bonded: Millions of atoms joined by strong covalent bonds through the structure

Classic examples: Diamond, SiO_2

- High melting and boiling points\Hardness

The whole structure is held together by a network of strong covalent bonds between atoms.

A large amount of energy is needed to break these bonds.

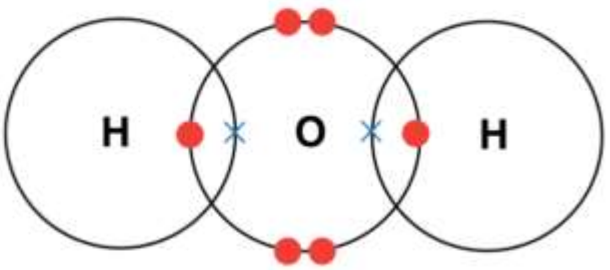
Exceptions to normal GMS: Graphite

Layered structure, between layers of strong covalent bonds, there is weak Van Der Waal's force. Van Der Waal's force can be overcome easily and thus graphite is soft and easily broken.

Can conduct electricity

There is a non-bonded valence electron on each carbon atom as only three covalent bonds are formed, thus these electrons can help to conduct electricity

Simple Molecular Structure



(Source)

Strong covalent bonds between atoms within a molecule but weak intermolecular forces(Van Der Waal's force or H-bonding) between molecules.

Low Melting and Boiling point

Due to weak intermolecular forces of attraction between molecules

Little heat energy is needed to overcome these intermolecular forces of attraction.

Non-conductor of electricity

Neutral molecules that do not contain mobile ions or delocalized electrons.

Exceptions of cases: Hydrogen Bonding

- N, O, F

Hydrogen with N, O, or F usually results in a covalently bonded atom with hydrogen bonding between molecules as well.

While they have Van Der Waal's forces similar to normal Simple Molecular structure, they are also held together by hydrogen bonding and thus need more energy to overcome these forces.

Ionic Equations

Ionic equations are chemical equations that have the non-participating ions removed.

Key points

- Do not remove solid/liquid/gas reactants/products

- Remove aqueous reactants/products or parts of them that do not end up as a solid, liquid, or gas in the final equation.

- Add charges to aqueous reactants/products that have had their counterparts removed.

HCl (aq) +NaOH (aq) -> NaCl (aq) + H_2O (l)

- HCl and NaOH are aqueous. However, H and O become H20, a product that is a liquid, thus they are not removed but Cl and Na are.

Ionic Equation : H^+(aq) + OH^- (aq) -> H_20 (l)

Acids, Bases, and Salts

Acids

- A substance that produces H+ ions as the sole positive ion in water.

- Weak acids do not disassociate fully, strong acids disassociate fully

- Turns blue litmus paper red

- <7 on the pH scale

Reactions with other substances

- React with metals

Products are hydrogen gas and salt

- React with carbonates

Products are carbon dioxide, salt, and water

- React with metal hydroxides/oxides (Neutralisation)

Products are salt and water

Bases

A substance that produces OH- ions as a sole negative ion in water

Alkali = soluble base

Turns red litmus paper blue

>7 on the pH scale

Reactions with other substances

React with acids (Neutralisation)

Products are salt and water

React with ammonium salts

Products are salt, water, and ammonia gas

Alkali reacts with a metal salt

Products are metal hydroxide and salt

Oxides

Metallic oxides

Basic Oxides

Reacts with acid to produce salt and water

CaO, MgO

Amphoteric Oxides

Reacts with both acids and bases

ZnO, Al_2O_3, PbO

Non-metallic oxides

Acidic Oxides

Reacts with alkalis to produce salt and water

NO_2, CO_2, SO_2

Neutral Oxides

Does not react with either alkali or water

CO, NO

Solubility Rules

Nitrates	All are soluble
Sulfates	All soluble except Ba, Ca, Pb
Chlorides	All soluble except Ag, Pb
Carbonates	All insoluble except Group 1 Metal and ammonium carbonates
Hydroxides and Oxides	All insoluble except Group 1 Metal and some Group 2 Metals
Reactivity of metals	Most reactive: K, Na, Ca, Mg ,Al
Most non-reactive: Gold, Platinum, Silver, Copper	Preparation of Salts

Qualitative Analysis

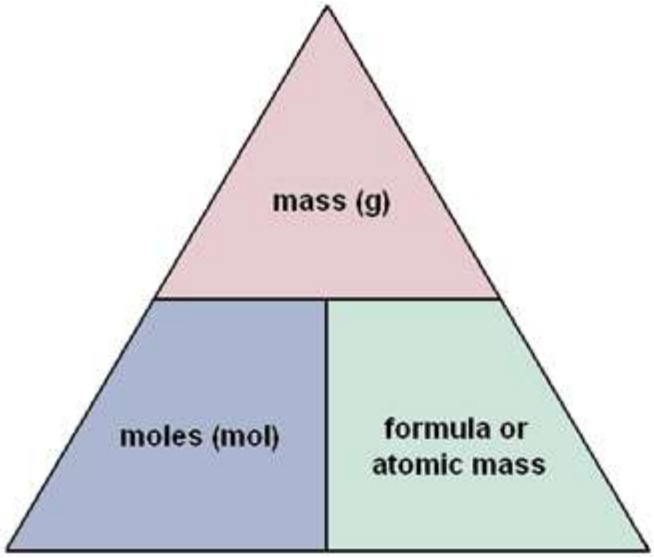
Test for cations	
NaOH	**White precipitate produced** Insoluble in excess Ca Soluble in excess Al, Pb, Zn **Green precipitate produced** Fe^{2+} (insoluble in excess) **Reddish-brown precipitate produced** Fe^{3+} (insoluble in excess)

	Blue precipitate produced Cu^{2+} (insoluble in excess)
NH3	No precipitate Ca White precipitate produced Soluble in excess Zn Insoluble in excess Al, Pb Fe^{2+}, Fe^{3+} and Cu^{2+} are similar to reactions in NaOH
Note: To identify between Al and Pb, react both with chloride ions. Al with chloride ion produces white ppt while Pb with chloride ion produces a colorless solution.	
Test for anions	
Carbonate	Add dilute acid: Carbon dioxide, water, and salt is produced
Sulfate	Acidify with dilute nitric acid, add aqueous barium nitrate White ppt formed
Chloride and Iodine	Acidify with dilute nitric acid, add aqueous silver nitrate/lead (II) nitrate) Chloride: White ppt, Iodine: Yellow ppt
Nitrate	Add aqueous NaOH and aluminum foil/Devarda's alloy and then warm gently The effervescence of colourless and pungent gas turns moist red litmus paper blue.

Test for gases

Test for gases	
Hydrogen	A lighted splint (extinguished with pop sound)
Oxgen	A glowing split (rekindles the splint)
Carbon dioxide	Limewater (white precipitate is formed)
Sulfur dioxide	Add acidified aqueous potassium dichromate (VI) The effervescence of colorless and pungent gas turn moist blue litmus paper red. Orange acidified potassium dichromate (VI) turns green
Chlorine	Observation: Effervescence of greenish-yellow and pungent gas which turns moist blue litmus paper red and then bleaches it.
Ammonia	Observation: Effervescence of colorless and pungent gas that turns moist red litmus paper blue

Chemical Calculation



(Source)

1 mol = 6.02 x 10^23

No of moles = Mass(in g)/Molar mass

-
  - Note: When facing diatomic molecules, need to multiply >.>

For finding Empirical Formula and Molecular Formula

Lithium forms a compound with a composition of 8.00% lithium, 36.8% sulfur, and 55.2% oxygen. (a) Find the empirical formula of this compound. (b) The relative molecular mass of the compound is 174. Find the molecular formula of the compound.

	Li	**S**	**O**
Mass [in 100g]	8	36.8	55.2
Molar mass	7	32	16
Mols	8/7 = 1.14	36.8/32 = 1.15	55.2/16 = 3.45
Mole ratio	1	1	3

Empirical formula = $LiSO_3$

Molecular formula = n x empirical formula

n = 174 / [7 + 32+ 16x3]

n = 2

Therefore, molecular formula is $(LiSO_3)$ x 2 = $Li_2S_2O_6$

Molar gas volume = 24 dm^3

Molarity

Concentration in mol/dm3 x molar mass = concentration in mass/dm3

Chemical Periodicity

Metals reactivity increase down the group

Atomic size of metals increases, atoms can lose valence electron easily to form positive charge ions

Non-metals reactivity decreases down the group

Electronegativity increase and up the group so F would be most electronegative

As Mr increases, Van Der Waal's force gets stronger and stronger, thus covalent compounds further on the table would have higher boiling and melting points.

Group I – Alkali Metals

Properties

- Shiny, silvery, metallic solid (metal)

- Soft

- Melting point decreases down group

- Li, Na, and K have low density, can float in water.

Reactivity increases down table

Group VII – Halogens

Appearances

Elements	Chemical Formula	Colour	State
Fluorine	F_2	Yellow	Gas
Chlorine	Cl_2	Greenish yellow	Gas
Bromine	Br_2	Reddish Brown	Liquid
Iodine	I_2	Black	Solid
Astatine	At_2	Black	Solid

Properties

Exists as diatomic molecules
Simple molecular structure with weak Van Der Waals' force existing between molecules
Reactivity decreases down table

Displacement reactions

More reactive halogen displaces less reactive halogen from compound

Cl2(g) + 2 NaBr (aq) -> 2 NaCl (aq) + Br2 (l)

Group VIII – Noble Gases

Unreactive monoatomic gases

Very stable electronic structure

All have low melting and boiling point- Van Der Waal's force

Gases can be used to act as inert atmosphere

Argon and helium	During welding, if aluminum is welded in the air, hot metal will catch fire and burn in oxygen. Argon and helium provide an unreactive atmosphere to prevent this.
Transition Metals	Strong hard metals with High Density High Melting and Boiling point – Metallic bonds Variable oxidation state Forms colored ion: Iron (II) – Pale green, Iron (III) – Pale yellow, Copper (II) – Blue Use as catalysts **Exceptions** Scandium, Zinc(Most likely one to be tested), Silver Only one oxidation state: Zn2+ Form white compounds in solid states Colored compounds in aqueous states

Atmosphere and Environment

Air: 79% Nitrogen, 20% Oxygen, 1% Noble gas, 0.03% Carbon Dioxide, 0.5% Water Vapour

Air pollution: Chemicals in air with high enough concentrations that it that harms living organisms

Pollutants : Harmful substances found in environment

Carbon monoxide

- Source: Forest fires, incomplete combustion of fuel in cars

- Reacts with haemoglobin, forming stable carboxyhaemoglobin which prevents blood from transporting oxygen

- Paralyzes brain activity, headaches, fatigue, impaired judgement

Colourless, tasteless, odourless

Sulfur dioxide

Source: Volcanic eruptions, burning of fossil fuels with sulfur as impurity

Poisonous choking gas: Irritates eyes, attacks lungs, causing breathing difficulties, leading to bronchitis

Forms acid rain

Sulfur dioxide dissolves in water, forming sulfurous acid, H_2SO_3

Sulfurous acid oxidizes to form sulphuric acid (sulphuric acid rain)

Corrodes metal and limestone structures

Poor health and stunted growth in fish

Absorption of needed nutrients by plants affected, replaced by toxic ions, killing plants/

Oxides of Nitrogen

Source: Car exhaust fumes (high temperature in the engine causes nitrogen and oxygen to react) and lightning (through heat released by lightning)

Nitrogen Dioxide: red-brown toxic gas, unpleasant pungent odour

Causes eye irritation, damage lung tissues, and blood vessels

Forms acid rain

$4NO_2 + 2H_20 + 0_2$à $4HNO_3$

Lead

Lead accumulates in the body, causing damage to the brain, liver, kidneys, central nervous system

Symptoms: Loss of appetite, vomiting, convulsions

Methane

Source: Bacterial decay of vegetation, fires, mining, decaying animal dung, rubbish in landfills

The colorless, odorless gas

Under strong sunlight, reacts with nitrogen dioxide forming photochemical smog

Greenhouse gas causes global warming

Unburnt hydrocarbons

Source: Incomplete combustion of petrol in car engines

The component in photochemical smog

> **Photochemical smog**
>
> A mixture of pollutants: dust, nitrogen oxides, ozone, unreacted hydrocarbons, peroxyacyl nitrates (PAN)
>
> Brownish haze, painful eyes, reduced visibility
>
> Causes headache, eye, nose, throat irritation, impaired lung function, coughing and wheezing.

Ozone

Combines with unburnt hydrocarbons to form PAN, which causes tearing of eyes

- Dangerous of asthmatic patients

- Damage rubber in car tires and fabrics

- Damage plants

Ozone layer depletion

The ozone layer acts as giant sunscreen to protect Earth’s surface from harmful UV radiation

CFCs: aerosol, refrigerators, cleaning solvents

CFC molecules rise into upper atmosphere, forming chlorine atoms, chlorine atoms react with ozone molecules

Ozone layer is destructed, UV rays are let through, causes skin cancer, eye cateracts , severely damages plant growth

Catalytic converter

Contain catalysts: platinum and rhodium

Carbon monoxide reacts with nitrogen oxide to form nitrogen and carbon dioxide

Unburnt hydrocarbons oxidized to carbon dioxide and water

Found in cars mostly to reduce pollution caused

Ways to minimize acid rain

Treat soil with calcium carbonate/calcium oxide to neutralize excess acidity

Flue gas desulfurization

- Sulfur dioxide is removed from flue/waste gases by reacting with an aqueous suspension of calcium carbonate, forming calcium sulphite

$$\mathbf{CaCO_3 + SO_2 \rightarrow CaSO_3 + CO_2}$$

Calcium sulphite oxidized to form calcium sulphate.