## Upper Secondary Pure Chemistry – Subject Code: 6092

### How to use?

- This deck of notes can be used as a crash course across O Levels Pure Chemistry syllabus 6092.
   However, this deck of notes may not have sufficient content and examples for in depth learning.
- You are highly encouraged to create your own deck of Chemistry notes that covers more content, while adding in content that you find useful in this deck of notes.
- This deck of notes is highly recommended for final revision before exams and tests, as it allows students to cover all the chapters in a glance.
- The below is the breakdown of this attachment:
  - o Random overviews
  - Periodic Table
  - Qualitative Analysis Notes
  - List of Definitions (blanks are to be added by you if you find other definitions useful)
  - Physical State of substance at r.t.p. (blanks are to be added by you if you find other definitions useful)
  - Notes arranged by chapter

### **Final Tips**

- This deck of notes should NOT replace what you learn from your teachers. This can only act as a supplementary to aid your learning.
- When in doubt, ALWAYS FOLLOW what your CHEMISTRY TEACHERS say
- Spread the word and share the notes <sup>(2)</sup> (Sharing is caring guys!)
- I have other notes as well!
  - Pure Biology:
  - Social Studies:
  - History Elective:
- Further questions/ general queries:
   Reach out to me (<u>https://t.me/your101nolifer</u>)
   ~ I will try to help, but I do make mistakes at times ~
- ALL THE BEST FOR YOUR STUDIES!

1. Formula of ions

<sup>16</sup> Group I kns : + (Na<sup>+</sup>, k<sup>+</sup>)
<sup>16</sup> Group 2 ions : 2+ (Mg<sup>1+</sup>, Ca<sup>2+</sup>)
<sup>16</sup> Group IB ions : 3+ (Al<sup>1+</sup>)
<sup>16</sup> Group IB ions : 3- (N<sup>3+</sup>)
<sup>16</sup> Group IG ions : 2- (O<sup>2+</sup>)
<sup>16</sup> Group I7 ions : - (F<sup>+</sup>, CA<sup>+</sup>, I<sup>+</sup>, Br<sup>-</sup>)

unitiate - NO3 sultate - SO4 cabanate - CO3<sup>3-</sup> amponium - NH4<sup>7</sup> hydroxide - OH

• Roman numerale ~ only positive charge ( iron  $(\pi) \rightarrow Fe^{2\tau}$ )

$$\begin{array}{c} \circ & F \\ \hline \\ c_{4} \end{array} \Rightarrow H_{2}, N_{2}, O_{2}, F_{1} \ldots etc \\ \hline \\ \hline \\ \hline \\ \vdots \end{array}$$

3. Solubility table.

- all nittates are soluble
- all chbides are solube except Ager and Pb Cl. (indide solubility same)
- all sulfates are soluble except Bason, Caso+, Pb SO.
- all cabonates insouble except goup 1 and ammonium
- all metal acides I hydroxides are insoluble except

4. Inic Equations (a) Fault and + alkaliteactions  $H^{+}(aq) + O_{H^{+}(aq)} \longrightarrow H_{2}O(I)$ 

(b) For precipitate, all and but Is product Write famula of solid on RHS, wat backwords to see what ime on LHS

- 5. Colous of compaunds and QA cartions, mians test. - test for contron table (esp white procipitate)
  - " test far onion table

	Contraction of the second s
Substance & State	Colour
copper metal, Cu (s)	pint
copper(1) oxide, CuO (=)	block
copper (IL) carbonate, cu co3 (u)	green
copper (3) mitcate, Cu(NC3), [04)	<u>19. 39</u>
(0 pp (1) sufficie, CoSO4 (09)	blue
Copper (II) hydenide, Cu(Orn), (s)	
copper (3) chloride, CuCla (uq)	green
itan metal, re(2)	aur
iran (II) hydrauide, Fe (Orl), (4)	dirty grown
in (III) out that	( =a)=) oreen

Lon (II) hydroxide, Fe (or )3	reddish brown
Tran (III) solutions	Yellow
Rouine gas, Fa (g)	91000
Chlaine gas, Cla (g)	greeniet - veter
Branine liquid, Brz (1)	reddich - brown
Lodine solid, I = (1)	(put) = h = ) h = d
Indine aquecus, I, (aq)	bioun
Induce vopcur, I 2 (3)	violet (Purpe
The second states of the second states	

Colour	Example		Remarks
Colourless gas	Oxygen D. (s)	Water vapour H-O (e)	[except halogens:
	Hydrogen H <sub>2</sub> (g)	Ammonia NH <sub>4</sub> (g)	$F_2(g)$ —pale yellow, $Cl_2(g)$ —greenish-yellow,
	Nitrogen N <sub>2</sub> (g)	Sulfur dioxide SO <sub>2</sub> (g), etc	[except NO <sub>2</sub> (g)—brown]
	All Group Lcompounds (NaCl. Na.CO.,	K-SO KNO KL etc)	
	Group II compounds that are soluble in	n water (MgSO4, Mg(NO3)), CaCl), etc)	Compounds of <u>all main group</u> metals
	Group III compounds that are soluble	in water (Al <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub> , Al(NO <sub>3</sub> ) <sub>2</sub> , etc)	
	Silver compounds that are soluble		Compounds of some transition metals
Colourless	Zinc compounds that are soluble		(others: coloured compounds)
Solution (aq)	All ammonium compounds		
	All acids solutions		
	All alkalis solutions		
	Hydrogen peroxide H <sub>2</sub> O <sub>2</sub>		
	Mn <sup>2*</sup> (aq)		Redox reaction (purple $\rightarrow$ colourless)
	All Group I, II, III compounds		
(solid)	Most silver compounds (AgCl, Ag <sub>2</sub> O, A	g,CO <sub>1</sub> , etc)	[except Agi (s)—pale yellow]
	Most zinc compounds (ZnCl <sub>2</sub> , ZnCO <sub>3</sub> , Z	nSO <sub>1</sub> , Zn(OH) <sub>2</sub> , etc)	[except ZnO(s)—yellow when hot, white when cold]
,	Most transition metal oxides:		Nate:
	Copper(II) oxide CuO (s)	Iron(III) oxide Fe <sub>2</sub> O <sub>3</sub> (s) Manganese(IV) oxide MnO <sub>2</sub> (s)	$Fe_2O_3 - part of Iron ore, haematite$
Black	Iron(II) oxide FeO (s)		MnO <sub>2</sub> – catalyst in decomposition of H <sub>2</sub> O <sub>2</sub>
	Some non-metal elements:	Carbon, graphite, coke, soot, C (s)	
	Astatine crystals I <sub>2</sub> (s)		
	All metal elements:	·	lescent Au (s)-sold]
Grey/ Silver	K, Na, Ca, Mg, Al, Zn, Fe, Sn, Pb, Ag, et	¢	[except Cu (s)—pink (fresh), reddish-brown]
	Copper(II) sulfate CuSO4 (s, aq)		
	Copper(II) nitrate Cu(NO <sub>3</sub> ) <sub>2</sub> (s, aq)		Most copper(II) compounds
Blue	Copper(II) chloride CuCl <sub>2</sub> (s, aq)—blue- Copper(II) hydroxide Cu(OH), (s)—cati	green on test	
	Anhydrous cobalt(II) chloride CoCl <sub>2</sub> (s)		Test for water, turns pink when moist
	Iron(III) chloride FaCl, (s. aq)		
	Iron(II) sulfate FeSO <sub>4</sub> (s, aq)		Most Iron(II) compounds
	Iron(II) hydroxide Fe(OH) <sub>2</sub> (s) dirty-gr	reen, cation test	
Green	Nickel(II) chloride NiCl <sub>2</sub> (s, aq)		Most nickel/(II) compounds
	Nickel(II) sulfate NiSO4 (s, aq), etc		
	Copper(II) carbonate CuCO <sub>5</sub> (s)		
Greenish Yellow	Chlorine Cl <sub>2</sub> (g)		
	Leed(II) iodide Pbl <sub>2</sub> (s)		
Yellow	Silver iodide Agl (s) anion test		
Orange/Yellow	lron(III) chloride FeCi <sub>5</sub> (s, aq) lron(III) sulfate Fe.(SQ.). (s, aq)		Most Iron(III) compound, Orange/yellow colour depends on concentration
	Copper Cu (s)		Pink when fresh
	Iron (III) hydroxide Fe(OH); (s) cation	test	
Reddish Brown	Rust, hydrated Iron (III) oxide Fe <sub>2</sub> O <sub>3</sub> , xH	l2O (s)	
	Bromine Br <sub>2</sub> (aq, I)		
Brown	Iodine solution I <sub>2</sub> (aq)		
	Nitrogen dioxide NO <sub>2</sub> (g)		
Purple	Potassium manganate(VII) KMnO <sub>4</sub> (s, r	iq)	Oxidizing agent



Done by MF (completed in 2024)

(Ca. J)
(Ca. J)
(Ca. J)
(Ca. J) (BAII Sulfates, SO, " are soluble except calcumsulfate (Caso, ), Lead (II) sulfate (PbSO, ) and Bairum Sulfate (BaSO, ) (Pholes, C2. are soluble except sherchloride (Agc2) and lead (II) chloride (Pbc2.) @Ammoniumion - NH4 OZincion → Zn3+ O Silverion - Agt ⊕ Balance O atoms → adjust O<sub>2</sub> if possible 3 Balance Hatams Balance NON-METALS atoms, excluding H and O atoms. (14) Catorates, CO3, "are insoluble except group I catorates and Ammonium catorate ((14), 202) OAII Nitrates, NO3" are soluble **OBalance METAL atoms** CAmmonia - NH3 () Familarile equation - remaining tos In ag compand that is unaccessived ( remember to put chage) @Identify compounds which are in 'oq' an both LHS and RHS of the chemical equation O Carel the same jars in (aq) that oppear on both LHS and RHS --- spectato ions Caton Monovide --- co O Corbon Diavide - Co. HC2 (aq) , HNOs (aq) , H, SO4 (aq) , NOH (aq) , KOH (aq) Ounter | Steam - Hao **Aside Alltalia** Solubility table Lors to memorise Bolancing ionic equation Balancing chemical equation amulas to memories 2 ⊙Hydraide → OH-**ONHate** () Sulfate () Carbonate OEthone - CaHy Henne -- CH., @Ethone - CiHe ļ 100 - NOa-Double check LHS and RHS to ansure bolonce A Salang ş ĩ > ŧŞ 5 (Hydrogen )(H drasium (R) Gold (Au) Silver (cu) Load (Pb) In (Fe) daium (Ca) Lino (2n) Hintom (Pt appear (0) minium) (Ac) manum (IN) dium (No) (gldm3) 80 Mole (e) Moss (dml volume 4 Mole famulas dm 3 () cm 3 8 (mole/dn3) (dm3 3 Ę Mole Value -1013 24.04

QA Notes are...

1. GIVEN during PRACTICAL

2. MEMORISE during WRITTEN

#### 6092 CHEMISTRY GCE ORDINARY LEVEL SYLLABUS

## NOTES FOR QUALITATIVE ANALYSIS

### Test for anions

anion	test	test result
carbonate (CO32-)	add dilute acid	effervescence, carbon dioxide produced
chloride (C <i>l</i> <sup>-</sup> ) [in solution]	acidify with dilute nitric acid, then add aqueous silver nitrate	white ppt.
iodide (I <sup>_</sup> ) [in solution]	acidify with dilute nitric acid, then add aqueous silver nitrate	yellow ppt.
nitrate (NO₃ <sup>–</sup> ) [in solution]	add aqueous sodium hydroxide, then aluminium foil; warm carefully	ammonia produced
sulfate (SO₄²⁻) [in solution]	acidify with dilute nitric acid, then add aqueous barium nitrate	white ppt.

### Test for aqueous cations

cation	effect of aqueous sodium hydroxide	effect of aqueous ammonia
aluminium (A <i>l</i> <sup>3+</sup> )	white ppt., soluble in excess giving a colourless solution	white ppt., insoluble in excess
ammonium (NH₄⁺)	ammonia produced on warming	-
calcium (Ca <sup>2+</sup> )	white ppt., insoluble in excess	no ppt.
copper(II) (Cu <sup>2+</sup> )	light blue ppt., insoluble in excess	light blue ppt., soluble in excess giving a dark blue solution
iron(II) (Fe <sup>2+</sup> )	green ppt., insoluble in excess	green ppt., insoluble in excess
iron(III) (Fe <sup>3+</sup> )	red-brown ppt., insoluble in excess	red-brown ppt., insoluble in excess
zinc (Zn <sup>2+</sup> )	white ppt., soluble in excess giving a colourless solution	white ppt., soluble in excess giving a colourless solution

### Test for gases

gas	test and test result
ammonia (NH₃)	turns damp red litmus paper blue
carbon dioxide (CO <sub>2</sub> )	gives white ppt. with limewater (ppt. dissolves with excess CO <sub>2</sub> )
chlorine (Cl <sub>2</sub> )	bleaches damp litmus paper
hydrogen (H <sub>2</sub> )	'pops' with a lighted splint
oxygen (O <sub>2</sub> )	relights a glowing splint
sulfur dioxide (SO <sub>2</sub> )	turns aqueous acidified potassium manganate(VII) from purple to colourless

Definitions (this list is NON-EXHAUSTIVE)

Chapter	Term	Definition
2	Diffusion	Diffusion is the <u><b>net</b></u> movement of particles from a region of higher concentration to a region of lower concentration
3	Isotopes	Isotopes are <b>atoms</b> of the same element that have the same proton number but different nucleon number. This means they have different number of neutrons.
5	Allotropes	Different forms of the <u>same element</u> with different structural arrangement of atoms
	Alloys	A mixture of a metal with one or more other elements *(other elements can be non-metal)
8	Acid	An acid is a substance that produces hydrogen ions, H <sup>+</sup> , in aqueous solutions.
	Strong Acid	A strong acid is an acid that is completely ionized in an aqueous solution
	Weak Acid	A weak acid is an acid that is only partially ionized in an aqueous solution
	Base	A base is any metal oxide or hydroxide. They contain either the oxide ion (O <sup>2-</sup> ) or the hydroxide ion (OH <sup>-</sup> )
	Alkali	Alkalis are bases that are soluble in water that produces hydroxide ions, OH <sup>-</sup> , in aqueous solutions.
	Strong Alkali	A strong alkali is an alkali that is completely ionised in an aqueous solution
	Weak Alkali	A weak alkali is an alkali that is only partially ionised in an aqueous solution
14	Noble gases are UNREACTIVE	Noble gases have a <u>fully filled valence electron shell</u> and therefore has attained <u>stable electronic configuration</u> . They <u>do not have the</u> <u>tendency to lose, gain or share electrons</u> hence unreactive.
19	Hydrocarbons	Hydrocarbons are organic compounds that contain only carbon and hydrogen atoms
	Saturated Hydrocarbons	Saturated hydrocarbons are hydrocarbons that contain only carbon-carbon single bonds between carbon atoms

	Unsaturated Hydrocarbons	Unsaturated hydrocarbons are hydrocarbons that contain at least one carbon-carbon double bond between carbon atoms
	Isomers	Isomers are compounds that have the same molecular formula but different structural formula
21	Polymer	A large, long-chain molecule made from many units of monomers

*Physical States of common elements/compounds at room temperature and pressure (r.t.p)* 

Group number	Element	Physical State at r.t.p.
1		Solid
17	Fluorine / Chlorine	Gas
	Bromine	Liquid
	Iodine / Astatine	Solid
3 – 12 (transition metals)	Mostly except	Solid
	Mercury	Liquid
18 (Noble gases)		Gas
Ionic Compound		Solid
Simple Covalent Compound		Gas
Giant Covalent Compound		Solid
Metal / Alloys		Solid

Chapter 1: Experimental Chemistry

Apparatus	Pipette	Measures accurate fixed volumes (e.g. 10.0cm <sup>3</sup> or 25.0cm <sup>3</sup> ) – 1 d.p.
	Volumetric Flask	Measures accurate fixed volumes that are larger (e.g. $100 \text{ cm}^3 \text{ or } 250 \text{ cm}^3$ )
	Measuring Cylinder	Measures a range of volumes to the nearest 0.5 cm <sup>3</sup> (e.g. 31.5 cm <sup>3</sup> or 23.0 cm <sup>3</sup> )
	Burette	Measures a range of volumes to the nearest 0.05 cm <sup>3</sup> (e.g. 31.55 cm <sup>3</sup> or 23.00 cm <sup>3</sup> ) – most accurate (when 2 d.p. value, usually burette)
Collection Method	Water Displacement	Gas must be insoluble/slightly soluble in water (e.g. Hydrogen, Oxygen, Carbon Dioxide)
	Downward Delivery	Gas must be denser than air – Mr/Ar > 28 (e.g. chlorine, hydrogen chloride, sulfur dioxide) gas jar gas jar delivery gas delivery
	Upward Delivery	Gas must be less dense than air – Mr/Ar < 28 (e.g. Ammonia, helium, hydrogen) gas gas jar delivery tube gas
Drying Agent	Concentrated Sulfuric Acid	Most gases except basic gas (e.g. ammonia)
	Quicklime (Calcium Oxide)	Gases (ammonia can be dried here) except acidic gases (e.g. Sulfur Dioxide, Carbon Dioxide, Nitrogen Dioxide, Chlorine, Hydrogen Chlorine)
	Fused Calcium Chloride	Gases except those who react with Calcium Chloride (e.g. Ammonia) → must be freshly heated before use

Separation of Mixtures	Magnetic Attraction	A magnet can be used to separate magnetic solids from non- magnetic solids (Solid – Solid)
	Sieving	A sieve can be used to separate solids of different particle sizes (Solid – Solid)
	Suitable Solvents	A suitable solvent can be used to separate solid-solid mixtures in which only one of the solids is soluble in the solvent (Solid – Solid)
	Sublimation	Sublimation can be used to separate a substance that changes from the solid to gaseous state directly (Solid – Solid) (e.g. pure iodine, dry ice)
	Filtration	Filtration can be used to separate insoluble solids from liquids (Solid – Liquid)
	Evaporation to Dryness	Evaporation to dryness is used to separate a dissolved solid from its solvent by heating the mixture until all the solvent has vapourised (Solid – Liquid) (O levels, only have NaCl)
	Crystallisation	Crystallisation is used to obtain a pure solid from its saturated solution. A saturated solution is one in which no more solute can be dissolved (Solid – Liquid)
		This method is used instead of evaporation to dryness to prevent the crystals from losing its water of crystallization and becoming anhydrous
	Simple distillation	Simple distillation is used to separate a pure solvent from a solution (Solid – Liquid)
		Why bulb of thermometer at entrance of condenser? $ ightarrow$ to record the boiling point of vapour collected
		Why water in this direction (condenser)? $\rightarrow$ to ensure condenser is fully filled with water and allows efficient cooling of vapour
	Separating Funnel	A separating funnel is used to separate immiscible liquids (Liquid – Liquid) (immiscible = different density)

	Chromatography	Chromatography is used to separate a mixture of substances which have different solubilities in a given solvent - Why start line in pencil? $\rightarrow$ Graphite is insoluble in all solvents and will not be separated together with the samples - Why start line not in ink? $\rightarrow$ Ink is a mixture and dyes will be separated along with the sample $R_f$ value = $\frac{distance\ travelled\ by\ the\ solvent}{distance\ travelled\ by\ the\ solvent} \leq 1$ (no units, 2d.p) (smaller number over larger number)
	Fractional distillation	Fractional distillation is used to separate miscible liquids with different boiling points
Purity of a s	ubstance	A pure substance has a specific melting and/or boiling point under fixed conditions (impure substances melt/boil at a range of temperatures)

## Chapter 2: Kinetic Particle Theory

Kinetic Particle Theory		The kinetic particle theory states that all matter is made up of tiny			
		particles and these particles are particles and the particles are particles	rticles are in co	onstant randor	n motion
Solid, Liquid and Gas		Table 2.1 Summary of the differences betw	veen particles in solids, liquids	and gases.	
		State of Matter	Solid	Liquid	Gas
		Particle Arrangement	very closely packed in an orderly manner	closely packed in a disorderly manner	very far apart in a disorderly manner
		Attractive Forces Between Particles	very strong	less strong	very weak
		Kinetic Energy of Particles	very low	low	high high
		Particle Movement	vibrate and rotate about fixed positions	slide past one another freely throughout the liquid	move quickly and randomly in any direction
		Shape	definite	indefinite	indefinite
		Volume	definite	definite	indefinite
		Compressibility	, no - herei	no	yes
		- Why <u>temperature ren</u> energy provided is equ forces of attraction be - What happens when increases and melting temperatures) (substa	mains constan ual to the ener tween particle <u>impurities are</u> point decreas nce at liquid s	ts in change of gy needed to c as added? $\rightarrow$ The es (both occurs tate at wider te	<u>state</u> ? $\rightarrow$ The povercome the e boiling point s at a range of emp range)
Diffusion Definition		concentration to a region of lower concentration			egion of higher
	Conditions that affect R.O.D	Temperature $\rightarrow$ highe ROD Mr $\rightarrow$ higher Mr = hea	r temp, higher vier, slower R	· KE, movemen OD	t increase, higher

Chapter 3: Atomic Structure

Atoms	Definition	An atom is the smallest particle that can still have the chemical characteristics of an element		
	Charges	Atoms are electrically neutral (charge = 0)		
Number of proto		Number of protons in an atom = number of electrons in that atom		
	Sub-atomic particles	Table 3.1 Summary of the three types of sub-atomic particles		
		Sub-atomic Relative Mass Relative Charge Atom		
		proton 1 neutron 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1		
		electron $\frac{1}{1840}$ -1 electron shell -> surrounding Harriest compared to puters (P) and neutron (N)		
Sub-atomic particles	Proton number	The Proton Number of an atom is the number of protons in its nucleus of an atom.		
	Nucleon number	The nucleon number is the total number of protons and neutrons in the nucleus of an atom		
lons		An ion is the particle formed when an atom or a group of atoms gains or loses electron(s), but the number of protons and neutrons remains the same		
Isotopes Isotop numbe differe		Isotopes are <u>atoms</u> of the same element that have the same proton number but different nucleon number. This means they have different number of neutrons.		
Electrons	Electronic configuration	2,8,8, outermost electron shell = valence shell electrons in outermost electron = valence electrons		

Chapter 4: Chemical Bonding

lons	Positive ions (cations)	Positive ions (cations) have a net positive charge and usually have a noble gas electronic configuration
	Negative ions (anions)	Negative ions (anions) have a net negative charge and have a noble gas electronic configuration
lonic bonding	Ionic bond	An ionic bond is the mutual electrostatic attraction between ions of opposite charges (cation and anion)
	Ionic structures	A giant ionic crystal lattice is a three-dimensional structure of alternating positive and negative ions along the x, y and z axis
Covalent bonding	Valency (Covalent bond)	Valency refers to the number of electron(s) that must be lost, gained or shared in order for the atom to attain a noble gas electronic configuration
Metallic bonding	Metallic bond	The metallic bond is the mutual electrostatic attraction between positively charged ions in a metal and the "sea of delocalised electrons) (cation and electron)

# Chapter 5: Structure and Properties of material

EMC		Table 5.1 Comparison	between elements,	compounds and mixtures	
			Element	Compound	Mixture
		What Is It Made Of?	only one element	two or more elements that are chemically combined	two or more elements and/ or compounds that are not chemically combined
		How Is It Formed?	mostly naturally occurring	from a chemical reaction	usually from physical mixing
		What Is the Ratio of Its Constituents?	-	fixed ratio	no fixed ratio
		What Are Its Properties Like?	-	has different properties from its constituent elements	usually has similar properties to its constituent substances
		Melting and Boiling Points	fixed	fixed	melt and boil over a range of temperatures
Properties	lonic	<ul> <li>Giant ionic cruattraction</li> <li>High Melting electrostatic for</li> <li>Hard</li> <li>Soluble in war</li> <li>Conducts elections). Does not</li> </ul>	ystal lattice s point, High f prces of attra ter, insoluble ctricity in mo	structure → strong el Boiling Point → overc action between <u>(catio</u> e in organic solvents olten/liquid and aque ectricity in solid (held	ectrostatic forces of come strong n) and <u>(anion)</u> ous states (mobile in fixed position)

	Simple Covalent / Simple molecular	<ul> <li>Covalent bonds → weak intermolecular forces of attraction</li> <li>Low melting point, Low boiling point → overcome weak</li> <li>intermolecular forces of attraction between molecules</li> <li>Insoluble in water, Soluble in organic solvents</li> <li>Does not conduct electricity in any state</li> </ul>
	Giant covalent	<ul> <li>Tetrahedral arrangement (1 carbon atom is covalently bonded to four other carbon atoms) – Diamond, layered arrangement (1 carbon atom is covalently bonded to three other carbon atoms) – Graphite → break strong covalent bonds between atoms</li> <li>Diamond is hard, Graphite is soft and slippery</li> <li>Both have high boiling and melting point</li> <li>Insoluble in water and insoluble in organic solvents</li> </ul>
	Macromolecules	<ul> <li>Many covalent molecules joined into chains to form a larger molecule → overcome weak intermolecular forces of attraction</li> <li>High melting and High boiling point (melts over a range of temperatures)</li> <li>Insoluble in water and soluble in organic solvents</li> <li>Not able to conduct electricity in any states</li> </ul>
	Metals and Alloys	<ul> <li>Giant metallic lattice → lattice of strong metallic bonds</li> <li>Pure metals are malleable and ductile</li> <li>Alloys are harder and stronger than pure metals</li> <li>High melting and boiling point</li> <li>Both are good electrical conductors in any state → "sea of delocalized electrons"</li> </ul>
Allotropes		Different forms of the <u>same element</u> with different structural arrangement of atoms
Alloys		A mixture of a metal with one or more other elements (other elements can be non-metal)

Chapter 6: Chemical Formulae and Equation
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Balancing chemical equations	1. Balance Metal atoms	
	2. Balance Non-Metal atoms, excluding H and O atoms	
	3. Balance H atoms	
	4. Balance O atoms $\rightarrow$ adjust O <sub>2</sub> if possible	
Forming Ionic equations	1. Identify compounds which are in "aq" on both LHS and RHS of	
	the chemical equation	
	2. Cancel the same ions in (aq) that appear on both LHS and RHS $ ightarrow$	
	spectator ions	
	3. From ionic equation $ ightarrow$ remaining ions in aq compound that is	
	uncancelled	

Chapter 7: Mole concept and Stoichiometry

Mr and Ar	Relative Atomic	The relative atomic m	ass ( $A_r$ ) of an element is the average mass of
(definition	Mass	one atom of that elen	the mass of an atom of $\frac{1}{12}$ the mass of an atom of
not			
important)	Relative Molecular Mass	The relative molecula	r mass ( $M_r$ ) of a molecular substance is the
		average mass of one i an atom of carbon – 1	nolecule of that substance to $\frac{1}{12}$ the mass of 2
	Relative Formula	The relative formula r	nass ( $M_r$ ) of an ionic compound is the
		of an atom of carbon	-12.
Mole	Mole	One mole of any subs	tance will always contain 6.02 x 10 <sup>23</sup> particles
Calculations		even sub-atomic part	cles such as electrons.
	Molarmass	One male of any subs	tanco has a mass oqual to its relative atomic
		mass (A <sub>r</sub> ), relative mo	lecular mass or relative formula mass (M <sub>r</sub> ) in
		grams.	
	Concentration	The concentration of	a solution is the amount of a solute dissolved
		in a unit volume of th	e solvent
	Formulas	Mole famulas	
	(Most important)		Gas only 1
		Mass	Volume (Gm <sup>2</sup> )
		Mole Mr	Mole 24.00m?
		Mass dm <sup>3</sup> (a)	
		Conc Volume (gidm <sup>2</sup> ) (dm <sup>2</sup> )	(mole/du <sup>-3</sup> )
Empirical for	mula	Elonort I	1
(Most important)		%   mass	- girenin gn
		Ar	take Arof lation
		number of moles	mass 17.
			- + by smallest
			namper or moles
		mole ratio	" strating from
		1	qu eniol

# Chapter 8: Acid and Bases

Acids	Definition	An acid is a substance that produces hydrogen ions, H <sup>+</sup> , in aqueous solutions.
	Properties	<ol> <li>Acids have a sour taste</li> <li>*2. Acids produce ions (H<sup>+</sup> ion and anion) when dissolved in water. These ions are mobile and can act as mobile charge carries to allow the resulting aqueous solution to conduct electricity.</li> <li>*3. Acids turn blue litmus paper red (litmus paper MOIST)</li> </ol>
	Acid reactions	Metal + acid $\rightarrow$ salt + hydrogen gas (not all metals are reactive – copper, platinum, LEAD APPEARS UNREACTIVE) Base + Acid $\rightarrow$ salt + water (neutralisation)
		Carbonate + Acid $\rightarrow$ salt + water + carbon dioxide
	Strong vs weak acid	Strength refers to the extent of ionisation of an acid, when dissolved in water
		A strong acid is an acid that is completely ionized in an aqueous solution (e.g. HCl, $H_2SO_4$ , $HNO_3$ – only three in syllabus)
		A weak acid is an acid that is only partially ionized in an aqueous solution (e.g. $CH_3COOH$ , carboxylic acids)

Base	Definition	A base is any metal oxide or hydroxide. They contain either the oxide ion $(O^{2-})$ or the hydroxide ion $(OH^{-})$
	Base reactions	Base + Acid $\rightarrow$ salt + water (neutralisation)
Alkalis	Definition	Alkalis are bases that are soluble in water that produces hydroxide ions, OH <sup>-</sup> , in aqueous solutions.
	Strong vs weak alkali	Strength refers to the extent of ionisation of an alkali, when dissolved in water
		A strong alkali is an alkali that is completely ionised in an aqueous solution (e.g. NaOH)
		A weak alkali is an alkali that is only partially ionised in an aqueous solution (e.g. $NH_3$ )
	Properties	<ol> <li>Alkalis taste bitter</li> <li>Alkalis feel slippery and soapy</li> <li>*3. Alkalis dissolve in water to form solutions that contain mobile ions which conduct electricity (have OH<sup>-</sup> ions + cations)</li> <li>*4. Alkalis turn red litmus paper blue (litmus paper MOIST)</li> </ol>
	Alkali reactions	Alkali + Acid $\rightarrow$ Salt + Water (neutralisation)
		Alkali + Ammonium salt → salt + water + ammonia gas
		Ammonia gas: If no water present in litmus paper, litmus paper will not change colour. Ammonia remains a molecule and no OH <sup>-</sup> ions produced
	"Fertiliser question"	Qn: Fertilisers are usually ammonium salts. Farmers have been advised not to add fertilisers together with calcium oxide/hydroxide. Why?
		Ans: Calcium oxide/hydroxide reacts with ammonium salt to produce ammonia gas that escapes from the soil. Thus, less nitrogen for plants to absorb through their roots.

Oxides	Basic Oxides (Metal + O)	Most metal oxides are basic oxides. They are insoluble in water and exist as solids in room temperature. They react with acids to form a salt and water.
	Amphoteric Oxides	Metallic oxides that react with both acid and bases to form salts and water.
		Zinc Oxide Aluminum Oxide Lead (II) Oxide
	Acidic Oxides (Non-metal + O)	Most non-metal oxides are acidic oxides. They are able to dissolve in water to form acids. They do not react with acids but react with alkalis to form a salt
	Neutral Oxides	Some non-metal oxides form oxides that show neither basic nor acidic properties.
		Water Carbon Monoxide Nitric oxide

Chapter 9: Salts

Salt (not important)		A salt is an ionic compound that consists of a cation and an anion.
Salt	Reaction of acid	This is when the salt is soluble in water and it is not a group
preparation	with an insoluble	1/ammonium salt.
methods	substance	<ol> <li><u>Steps</u></li> <li>Add excess (named solid reactant) to a fixed volume of (name acid). Stir.</li> <li>Filter the mixture and collect (named salt) as the filtrate</li> <li>Heat the filtrate until saturated</li> <li>Let the saturated solution cool and crystallise</li> <li>Filter out the crystals, wash with a little cold distilled water and press dry with filter paper</li> </ol>
	Titration	This is when the salt is soluble in water and it is a group 1/ammonium salt.
		<ul> <li><u>Steps</u></li> <li>1. Pipette 25.0cm<sup>3</sup> (can be any value, but reasonable) of (named alkali) into a conical flask and add in a few drops of suitable indicator (common: Universal indicator)</li> <li>2. Add the (named acid) from the burette into the conical flask until the indicator changes colour (purple to green). Note the volume of acid used.</li> <li>3. Repeat the titration without the indicator and add in the predetermined volume from step 2.</li> <li>4. Heat the filtrate until saturated</li> <li>5. Let the saturated solution cool and crystallise</li> <li>6. Filter out the crystals, was with a little cold distilled water and press dry with filter paper</li> </ul>
	Ionic Precipitation	This is when the salt is insoluble in water (follow solubility table, once insoluble confirm ionic precipitation)
		<ul> <li><u>Steps</u></li> <li>1. Add aqueous (named reactant 1) to aqueous (named reactant 2)</li> <li>2. , stir</li> <li>3. Filter the mixture and collect (named salt) as a residue</li> <li>4. Wash the residue with cold distilled water and press dry with filter paper.</li> </ul>
	"Interesting" Question	Outline how a pure and dry sample of silver chloride (insoluble – ionic precipitation) can be obtained from silver carbonate (insoluble, need to change to soluble) as one of the starting reagents
		<ol> <li>Add excess nitric acid to silver carbonate (turn soluble)</li> <li>Add aqueous sodium chloride to the mixture and filter and collect silver chloride as residue</li> <li>Wash the residue with distilled water and dry with filter paper</li> </ol>

Chapter 10: Ammonia

Obtaining raw	Hydrogen gas	Hydrogen gas is obtained from the cracking of crude oil.		
materials	Nitrogen gas	Nitrogen gas is obtained from the fractional distillation of liquid air.		
Haber Process	The Haber process can go both forward and backward at the same time. $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$ Forward Reaction $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$ $Product$ $Description = 0$			
Optimal condition (MUST KNOW WHY THESE ARE THE OPTIMAL CONDITIONS)	Pressure	Pressure of 250atm Higher pressure leads to higher yield of ammonia and faster reaction, but high pressure is expensive to maintain		
	Temperature	Temperature of 450°C Lower temperature leads to higher yield of ammonia, but a lower temperature will slow down the reaction		
	Catalyst	Presence of a finely-divided iron catalyst Haber process is slow even with high temperature and pressure so catalyst speeds up reaction		











Oxidation and Reduction	Summary table - Redra opposite		
	0.S. 0	<mark>H</mark>   e <sup>-</sup>	
		Red + +	Qn ask why is a redox reaction, need to
	(memorise this table, *Oxidation state (cha *Oxidation gains oxy)	, can do all redox questions) arge) always decrease when reduced gen	explain which element oxidised and which element reduced (use answering structure).
Always Redox	<ol> <li>Respiration a</li> <li>The Haber Pr</li> <li>X – Acid Base Reaction</li> <li>X – Precipitation of Same</li> </ol>	nd Photosynthesis ocess on alts	Conclude with: Since both oxidation and reduction has occurred, is a redox reaction.
Answering strategy	Oxidation State         (Reactant) is oxidised/reduced as the oxidation state of (element) increases/decreases         from (charge) in (reactant) to (charge) in (product)         Electrons/Hydrogen         (Reactant) is oxidised/reduced as (reactant) loses/gains (no.) of electrons/hydrogen atoms to form (product)		
	<i>Oxygen</i> <u>(Reactant)</u> is <mark>oxidised</mark> /reduced as <u>(reactant)</u> gains/loses <u>(no.)</u> of oxygen atoms to form (product)		
Oxidising and Reducing Agent	Oxidising agent       -       Oxidises another substance, itself being reduced         -       Example: Acidified Potassium Manganate (VII) (KMnO         Acidified Potassium Dichromate (K₂Cr₂O7)         -       Test for oxidising agent (use reducing agent to test):         → Potassium Iodide (KI) – colourless to brown if position         → Sulfur dioxide (SO2) – N.A.		self being reduced Manganate (VII) (KMnO <sub>4</sub> ), te (K <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub> ) educing agent to test): purless to brown if positive
	Reducing agent	<ul> <li>Reduces another substance, it</li> <li>Example: Potassium Iodide (KI)</li> <li>Test for reducing agent (use of → Acidified Potassium Manga to colourless</li> <li>Acidified Potassium Dichrongreen</li> </ul>	self being oxidized ), Sulfur Dioxide (SO <sub>2</sub> ) xidising agent to test): nate (VII) (KMnO <sub>4</sub> ) – purple mate (K <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub> ) – Orange to

Chapter 13: Electrolysis

Electrolysis	Definition	Electrolysis is the process of passing an electric current through a compound to chemically separate its components.
Parts of an electrolytic cell	Battery	<ul> <li>Causes electrons to move from anode to cathode</li> <li>Negative terminal of battery produces electrons, electrons move from negative terminal of battery to positive terminal of battery</li> </ul>
	Electrolyte	<ul> <li>Electrically conductive substance in molten or aqueous state</li> <li>Contains mobile ions which act as mobile charge carriers to conduct electricity</li> </ul>
	Electrode	<ul> <li>Anode (positively charged) attracts anions, oxidation occurs (AnOx)</li> <li>Cathode (negatively charged) attracts cations, reduction occurs (RedCat)</li> </ul>
		<ul> <li>Inert electrodes do not take part in electrolysis (graphite/carbon, platinum)</li> <li>Reactive electrodes takes part in the process of electrolysis (all other metals except platinum) → only affects anode</li> </ul>
Electrolysis equations	Half equation at cathode	<ul> <li>Reduction equation (charge always decreases)</li> <li>Electrons can be used to balance charges</li> <li>Half equation is still a chemical equation, need to balance moles</li> <li>[e.g. 2H<sup>+</sup> (aq) + 2e<sup>-</sup> → H<sub>2</sub>(g)]</li> </ul>
	Half equation at anode	<ul> <li>Oxidation equation (charge always increases)</li> <li>Electrons can be used to balance charges</li> <li>Half equation is still a chemical equation, need to balance moles</li> <li>[e.g. 4OH<sup>-</sup> (aq) → O<sub>2</sub> (g) + 2H<sub>2</sub>O (I) + 4e<sup>-</sup>]</li> </ul>
	Overall equation	<ul> <li>Solving "simultaneous equation"</li> <li>Make number of moles of electrons the same on both sides, so they "cancel" out</li> <li>Overall equation = everything minus electrons on both sides</li> <li>[e.g. 2H<sub>2</sub>O (I) → 2H<sub>2</sub>(g) + O<sub>2</sub>(g)]</li> </ul>

Electrolysis with inert electrodes	Molten	<ul> <li>- 1 cation and 1 anion (molten state so no H₂O)</li> <li>- Cathode attracts cation (reduction), Anode attracts anion (oxidation) → Forms atoms or molecules</li> </ul>	
	Aqueous (dilute)	<ul> <li>2 cation and 2 anions (aqueous state so have H<sub>2</sub>O)</li> <li>Selective discharge of Cation (follow reactivity series), the less reactive the cation is, the easily discharged it is (usually compare H and "other cation")</li> <li>Selective discharge of Anion (most of the time hydroxide – sulfate and nitrate cannot be discharged)</li> </ul>	
	Aqueous (concentrated)	<ul> <li>2 cation and 2 anions (aqueous state so have H<sub>2</sub>O)</li> <li>Selective discharge of Cation (follow reactivity series), the less reactive the cation is, the easily discharged it is (usually compare H and "other cation")</li> <li>Selective discharge of Anion (**different from dilute → usually the more concentrated gets discharge)</li> </ul>	
Electrolysis with reactive electrodes	Reactive electrodes	<ul> <li>2 cation and 2 anions (usually aqueous state so have H<sub>2</sub>O) + reactive electrode</li> <li>Selective discharge of Cation (follow reactivity series), the less reactive the cation is, the easily discharged it is (usually compare H, the "other cation" and the reactive electrode)</li> <li>Reactive electrode will be oxidised</li> </ul>	
	Metal Purification/ electroplating	<ul> <li>Electroplating allows us to coat a thin layer of metal onto an object</li> <li>Object to be plated at cathode, material to plate at anode</li> <li>In general, mass in anode decrease and mass in cathode increase</li> <li>Solution needs to be the same cation as anode/cathode</li> </ul>	
Simple cell	<ul> <li>In a simple cell</li> <li>No batteries</li> <li>Electrons flow from the more reactive metal to the less reactive metal in the externa circuit (forms a closed loop in electrolyte)</li> <li>More reactive metal = anode, Less reactive metal = cathode</li> <li>The greater the difference in reactivity, the greater the voltage</li> </ul>		

Chapter 14: The Periodic Table

Arranging elements	Across a period	<ul> <li>Period number = number of electrons shells an electron has</li> <li>Same period number = same number of electron shells</li> <li>Increasing period number = increasing number of electron shells</li> <li>Metallic properties decrease, Non-metallic properties increase (travel from metal to non-metal) → less likely to lose electrons, more likely to gain electrons</li> </ul>
	Down the group	<ul> <li>Same group number = same number of valence electrons (thus similar chemical properties</li> <li>Down a group, metallic properties (how easy to lose electrons) increase → Valence electron shell further from nucleus</li> <li>Down a group, non-metallic properties (how easy to gain electrons) decrease → Valence electron shell further from nucleus</li> </ul>
Group 1 (alkali metal) → reducing agents	Physical	<ul> <li>low boiling point and melting point</li> <li>low density (Lithium, sodium and potassium float on water)</li> <li>soft (can be cut easily)</li> </ul>
	Chemical	<ol> <li>React with water to form soluble metal hydroxide and hydrogen gas [down the group: quickly (Li) – violently (Na) – very violently (K)]</li> <li>React with steam to form soluble metal oxide and hydrogen gas</li> <li>React with acid to form salt and hydrogen gas (metal-acid reaction)</li> </ol>
	Going down the group	<ul> <li>mass number increases →density increases</li> <li>melting point decreases</li> <li>reactivity increases (Fr most reactive)</li> </ul>
Group 17 (halogens) → oxidising agents	Physical	<ul> <li>low melting point and boiling point</li> <li>coloured</li> <li>exists as diatomic molecules</li> <li>(X<sub>2</sub>, always have the 2 when it's the only element)</li> </ul>
	Chemical	<ul> <li>reactivity of halogens decreases down the group (F most reactive)</li> <li>a more reactive halogen can displace ("replace") a less reactive halogen from its solution</li> <li>(e.g. Chlorine is more reactive than Bromine. So Chlorine displaces Bromine from its Bromide solution. The solution turns reddishbrown due to displaced Brome)</li> </ul>
	Going down the group	<ul> <li>melting point and boiling point of halogens increases</li> <li>(F &amp; Cl as gas, Br as liquid, I &amp; At &amp; Ts as gas)</li> <li>colour becomes darker (intensity increases)</li> <li>(Cl<sub>2</sub> is yellow-green, Br<sub>2</sub> is red-brown, I<sub>2</sub> is purple-black)</li> </ul>

Group 18 (noble gases)	Properties	<ul> <li>monoatomic non-metals (exists singular, by itself)</li> <li>colourless gas at room temperature</li> <li>low melting and boiling point (thus gas)</li> <li>insoluble in water</li> <li>unreactive</li> </ul>
	Why unreactive	Noble gases have a <u>fully filled valence electron shell</u> and therefore has attained <u>stable electronic configuration</u> . They <u>do not have the</u>
	(IMPORTANT)	tendency to lose, gain or share electrons hence unreactive.
	Uses	<ul> <li>Helium → balloons</li> <li>Neon → LED lamps</li> <li>Argon → fill light bulbs</li> </ul>
Transition elements (group 3 to group 12)	Properties	<ul> <li>High melting point</li> <li>High density</li> <li>Variable oxidation state (charges of element can vary)</li> <li>Forms coloured compounds (may not be coloured by itself)</li> <li>Able to act as catalysts</li> </ul>

Chapter 15: The Reactivity Series

Reactivity					
series	Potassium (K)	Most reactive	Please	7	
	Sodium (Na)		Stop		
	Calcium (Ca)		Calling		
	Magnesium (Mg)		Me		
	Aluminium (Al)		А		
	[ Carbon (C) ]		Cute	_	
	Zinc (Zn)		Zebra		
	Iron (Fe)		In		
	Tin (Sn)		Tamil	_	
	Lead (Pb)		Learning		
	[Hydrogen (H)]		How		
	Copper (Cu)		Copper		
	Silver (Ag)		Strengthen		
	Gold (Au)	•	Gold	_	
	Platinum (Pt)	Least reactive			
Reactions	Reaction with	Metal + Cold Water	→ Metal hydi	roxide + Hy	drogen gas
	cold water and	Metal + Steam $ ightarrow$ M	1etal oxide + H	ydrogen ga	as
	steam	Metal	With cold	water	With steam
		Potassium	Very viole	ntly	Explosive
		Sodium	Violently		
		Calcium	Readily		
		Magnesium	Very slow	ly	Violently
		Zinc	NIL		Readily
		Iron	NIL		Slowly
		Others below	NIL		NIL
		*Aluminium cannot	react as form	s insoluble	layer of aluminium
		oxide around it (whi	en in contact v	with oxygei	n) to prevent reaction
	Reaction with	Metal + HCl $ ightarrow$ Meta	al chloride (sal	t) + hydrog	gen gas
	dilute	Metal		With Hyd	rochloric Acid
	hydrochloric acid	Potassium		Explosive	
		Sodium			
		Calcium		Violently	
		Magnesium		Rapidly	
		Zinc		Moderate	ely
		Iron		Slowly	
		Others below		NIL	
		*Reaction between (II) Chloride	<u>Lead</u> and acid	form an in	soluble layer of Lead

Reduction of	Metal oxide + Carbon $\rightarrow$ (heat) Metal + Carbon dioxide			
carbon	*The lower the metal is in the rea	ctivity series from carbon (cannot		
	be above carbon), the more readi	ly the reduction of metal oxide		
	will occur			
Reduction of	Metal oxide + Hydrogen $ ightarrow$ Metal	+ Steam		
metal oxide with	*0.1.1	and an entry to the star offer t		
nydrogen	*Only lead and below can react (in provides enough energy for react)	ead can react as neat applied ion to occur)		
Displacement	A more reactive metal can displace	ce a less reactive metal from its		
Reaction between	salt solution (redox reaction due t	to oxidation and reduction)		
a metal and the	For metal oxide, a more reactive r	metal can reduce the oxide of a		
oxide of another	less reactive metal			
metar	e.g. Iron is more reactive than cop	oper		
	Iron + Copper (II) Sulfate $\rightarrow$ Iron (	II) Sulfate + Copper		
	Fe (s) + CuSO <sub>4</sub> (aq) $\rightarrow$ FeSO <sub>4</sub> (aq) + Fe (s) + Cu <sup>2+</sup> (aq) $\rightarrow$ Fe <sup>2+</sup> (aq) + Cu	+ Cu (s)		
		(3)		
	(more reactive) + (less reactive ca	tion)		
	$\rightarrow$ (more reactive cation) + (less r	eactive)		
Heating metal	The more reactive a metal is, the	more stable to heat it is (harder		
carbonates	to decompose)			
	Metal carbonate	Observation		
	Potassium Carbonate	Very reactive metals,		
	Sodium Carbonate	carbonates very stable to heat, cannot thermally decompose		
	Calcium Carbonate	Decomposes into metal oxide		
	Zinc Carbonate	heating		
	Iron (II) Carbonate			
	Lead (II) Carbonate			
	Silver Carbonate	Decomposes into silver and		
		carbon dioxide upon heating		
		(silver oxide thermally		
		unstable so will further		

Extraction					
of metal	Metal	Extraction method			
	Potassium	Electrolysis			
	Sodium	(compounds hard to break down as metal too reactive)			
	Calcium				
	Magnesium				
	Aluminium				
	Carbon	NIL			
	Zinc	Reduction with carbon reaction			
	Iron	(less reactive than carbon so reduced by carbon)			
	Lead				
	Hydrogen				
	Copper				
	Silver	Found naturally in element form, no need extraction			
	Gold				
Rusting	Conditions	1. Oxygen (in air)			
(hydrated		2. Water / Moisture			
iron (III)					
oxide)		- Boiled water $ ightarrow$ removes oxygen			
		- Oil $ ightarrow$ prevents oxygens from dissolving into water			
		- Anhydrous calcium chloride $ ightarrow$ remove moisture			
		- Sodium Chloride / Acidic substance (sulfur dioxide) $ ightarrow$ increase			
		rate of rusting			
		- Rust = only iron			
		- Corrode = all other metals			
	Rust Prevention	Barrier Methods			
		- Barrier prevents metal from coming into contact with oxygen and			
		moisture			
		- E.g. Painting, Oiling/Greasing, Coating with plastic, Tin-plating,			
		Chrome-plating			
		- Disadvantages: If barrier has hole/scratched/compromised, the			
		exposed iron will start to rust			
		- A more reactive metal will corrode in place of iron (usually Zinc or			
		Viagnesium)			
		- c.g. Gaivanising (zinc-plating), Attaching to more reactive metal			
		- Does not need to be coated 100%, if there is a scratch/hole, more			
		reactive metal bas corrected iron will then start to correcte			
		reactive metal has corroued, from will then start to corrode			
	1				

Chapter 16: Chemical Energetics

Exothermic	Endothermic	
Exothermic change refers to a reaction or process	Endothermic change refers to a reaction of	
which gives out thermal energy to the	process which absorbs thermal energy from the	
surroundings, hence causing an increase in the	surroundings, hence causing a decrease in the	
temperature of the surroundings.	temperature of the surroundings.	
Give out heat → surrounding feel warmer,	Absorbs heat → surrounding feel cooler,	
temperature increases	temperature decreases	
E.g. Combustion, respiration, neutralization, freezing, condensation, dissolving acid and alkali in water, ionisation	E.g. Thermal decomposition, photosynthesis, electrolysis of water, boiling, evaporation, melting, metaling sublimation, dissolving ionic compounds	
energy absorbed energy released	energy absorbed energy released	
during bond < during bond	during bond > during bond	
breaking forming	breaking forming	
Temperature / °C	Temperature / °C	
maximum temperature	room temperature	
room temperature	minimum temperature	
Time / min	Time / min	
Figure 16.14 Temperature changes in an	Figure 16.9 Temperature changes in an	
exothermic reaction.	endothermic reaction	
Energy reactants enthalpy change (AH = negative) products Figure 16.15 Energy level diagram of an exothermic reaction Energy (AH = negative) products Figure 16.16 Energy profile diagram of an exothermic reaction	Energy products enthalpy change (ΔH = positive) reactants Figure 16.10 Energy level diagram of an endothermic reaction Energy reactants Energy reactants Progress of reaction Figure 16.11 Energy profile diagram of an endothermic reaction	

Calculating enthalpy	Overall T enthalpy ( $\Lambda$ H) = at	otal energy Total energy
change	change b	ond breaking bond forming
	Exothermic	Negative enthalpy change
	Endothermic	Positive enthalpy change
	Units	Bond breaking = kJ or J
		Bond forming = kJ or J
		Enthalpy change = kJ or J / mol

Chapter 17: Rate of Reaction

Measuring rate of	Volume of gas	- Steepness of graph represents how fast the reaction is (the steeper the faster the reaction)
reaction	produced	- Graph needs to pass through origin (0.0)
		- When volume of gas does not change, no reaction occurs
	Mass loss (of reactant)	- Steepness of graph represents how fast the reaction is (the steeper the faster the reaction)
		- Graph does not need to pass through origin (0,0)
		- When mass does not change, no reaction occurs
Effects on	Changing the basicity of acid	- Basicity of acid = number of H+ ions each molecule of acid
reaction	busicity of uciu	- When HCl changed to $H_2SO_4$ , concentration of H+ is doubled,
(use rate of		concentration of acid increases, number of reacting particles per
effective		unit volume increases, frequency of effective collision increases, rate
collision to explain)		of reaction faster, graph steeper, volume of gas produced doubled
	Strong v.s. weak	- Strong acid, faster rate of reaction, strong acid undergoes complete
	acid	dissociation, concentration of H+ ions is higher than the weak acid,
		moles still constant so volume of gas the same just steeper graph)
	Concentration	- As concentration increases the number of reacting particles per
	(only for	unit volume increases, frequency of effective collision increases, rate
	solution)	of reaction increases. - Acid is in excess $\rightarrow$ final volume of gas the same steeper
		- Acid is limiting $\rightarrow$ final volume of gas different, steeper
	Pressure (only	- compressed, spacing between particles in the gas decreases,
	for gas)	effective collisions increases, rate of reaction increases
	Particle size	- smaller particles, more surface area, frequency of effective collision
	(only for solid)	increases, rate of reaction increases
		- (biggest) lumps -> granules -> powder (smallest)
	Temperature	<ul> <li>higher temperature, particles have more kinetic energy, move and vibrate faster, increase frequency of effective collision, rate of reaction faster</li> </ul>
		- higher temperature, more reactant particles possess energy equal
		to or greater than activation energy, increases frequency of effective collision, rate of reaction faster

	Catalysts	<ul> <li>A catalyst increases the rate of reaction without being chemically unchanged at the end of a reaction         <ul> <li>provision of an alternative pathway of lower activation energy, more reactant particles have energy greater to or equal to activation energy, increases frequency of effective collision, rate of reaction increases</li> </ul> </li> <li>* provides an <u>alternative</u> pathway of lower activation energy <i>≠</i>             causes the pathway to lower its activation energy             (catalyst makes one more path, they do not change original path)</li> </ul>
Reading graph	Steepness	Concentration of reactant
	Final volume / Final mass	Number of moles of reactants

Non-renewable sources of	- Gas: Natural	gas 🗲 mai	inly met	hane (CH <sub>4</sub> ) –	colourless, odou	urless
energy	- Liquid: Crude oil/ Petroleum $ ightarrow$ mixture of hydrocarbons					
Method of separation for						
crude oil (fractional				< 3 >		
distillation)	f	ractionating				
uistillation)				das —	<b>Memorising</b>	
		T.			Fractionating	
		52.52	└┌╻└═╼╸	petrol	column	
				nanhtha	Ping	
				hapitala	Dong	
	petroleum	التعادم		kerosene	Pulig	
	ů 🗌				NO	
	<u> </u>		<u>مط</u> اب د	diesel oil	Kicking	
		깨주			Delightful	
					Little	
		7 66 5	╩╝╩╞╸	lubricating oil	Balls	
	$\begin{bmatrix} 1 \end{bmatrix}$					
	$\sim$					
	hard and seen of					
				bitumen —		
				< <u>4</u>		
	Ston 1. Entire comp	lo of omido all	in hanted to			
	Step 1. Entire samp		is neated to	o about 400 °C an	d vapourised into a g	jas.
	Step 2: The gases p according to the boi	etroleum is the ling points of	en passed in the hydroc:	to the fractionatin arbons in the mixt	ig column and separa	ated
	Ston 2. Livideo orthou					
	it condenses and co	llected at the h	nigher level	of the fractionatin	ther up the column be g column.	fore
	Step 4: Hydrocarb	ons with the	highest ra	nge of boiling po	inte condoneo at his	hor
	temperature and are	collected at the	he lower lev	vel of the fractiona	tina column.	liter
Going down the fractionating			1	r	1	
column	Petroleum	Less	Lowest	t Shortest	Highest	Least
	gas	viscous	bp and	molecule	flammability	soot
			mp			
	Bitumen	More	Highes	t Longest	Lowest	Most
		viscous	hn and		flammahility	soot
		VISCOUS	mn		liaminaointy	3000
Lisos of different fractions			ΠP			
Uses of different fractions	640	otion	V-Department		and the second	
	Petroleum gas	iction	F	uel for cooking	se di la contra di la	
	Petrol	and the second	F	uel for car engine	s	
	Naphtha		R	aw material for po dustrv	etrochemical	
	Kerosene (parafi	fin)	F	uel for aircraft en	gines	
	Diesel		F	uel for diesel engi	nes	
	Bitumen	HALF & BALLARS		sed for resurfacir	g or paving road	
			SL	Infaces	a s par ng roud	

Chapter 18: Fuels and Crude Oil (Organic Chem part 1)

Chapter 19: Hydrocarbons (Organic Chem part 2)

Homologous series	Same general formula	<ul> <li>Same general formula = the nth term formula</li> <li>Subsequent members differ by a factor of CH<sub>2</sub> (the next member is just adding CH<sub>2</sub>)</li> <li>Same functional group = same chemical properties = undergo similar chemical reactions</li> <li>Same functional group <ul> <li>(e.g. carbon-carbon single bond, carbon-carbon double bond, hydroxyl group -OH, carboxyl group -COOH, carbonyl group -C=O)</li> </ul> </li> </ul>			
identify homologous series)	Same functional group				
	Trends	- As number of C atom compound increases ( molecule increases, m intermolecular forces o	s in molecule increase when number of C ato ore energy required to of attraction)	e, mp and bp of oms increases, size of o overcome stronger	
	Examples				
		Homologous series	General formula	Functional group	
		Alkanes (saturated hydrocarbon)	$C_n H_{2n+2}$ n $\geq 1$	Only has carbon- carbon single bond	
		Alkenes (unsaturated hydrocarbon)	$C_nH_{2n}$ $n \ge 2$	Carbon-Carbon double bond (C=C)	
		Alcohol	$C_n H_{2n+1}OH$ $n \ge 1$	Hydroxyl group (-O-H)	
		Carboxylic acids	$C_nH_{2n+1}COOH$ $n \ge 0$	Carboxyl group	
M/h at any hudu					
What are hydro	ocarbons?	Hydrocarbons are orga hydrogen atoms. (only	anic compounds that d	contain only carbon and	

Formulas	Name			
		Normal molecules (go Organic molecules (elements		
		according to general formula) that are not in the general		
		formula/others)		
		(1 word) 1) Identify longest continuous		
		C-chain in the molecule		
		2) Look for functional group in		
		Number of homologous C-chain		
		C atoms in series the 3) Identify non-H attached to		
		formula member belongs to the longest C-chain		
		CH₃ – methyl		
		<b>No. of C</b> Name $C_2H_5 - ethyl$		
		cl – Chloro		
		1 Meth- My F – Fluoro		
		2 Eth- Elephant Br – Bromo		
		3 Prop- Produces 4) Count the number of C that		
		4 But- Baby non-H is attached to		
		5 Pent- Penguins 5) Name of molecule $\rightarrow$		
		(4) – (3) (1) (2)		
		Homologous Name		
		e.g.		
		Alkane -ane		
		Alkene -ene		
		$\begin{array}{c c c c c c c c c c c c c c c c c c c $		
		Carboxylic -anoic acid $H H H H + 4c$		
		acid		
		Thus: 2 – Chlorobutane		
	Molecular	- total number of all elements (follow general formula and do		
	formula	substitution of numbers into n		
	Tormala			
	Structural	- Formula which shows how atoms are arranged in a molecule		
	formula	- Show bonds only for double bond		
		- Name from left side of molecule to right side, start with C		
		Molecular formula Drawing Structural formula		
		С <sub>3</sub> H <sub>7</sub> OH н н СH <sub>3</sub> CH <sub>2</sub> CH <sub>2</sub> OH		
		н-с-с-с-о-н		
		ĤĤĤ		
		H CH <sub>2</sub> =CH <sub>2</sub>		
		C==C		
	Full structural	- Show all bonds, including single bonds		
	formula /	ннн Н /Н		
	displayed	│ н-ҫ҅-ҫ҅-ѻ-н )́С==С́		
	formula	Н Н Н		

Alkanes ( $C_nH_{2n+2}$ ) $n \ge 1$	Characteristics	<ul> <li>Contain ONLY carbon-carbon single covalent bonds</li> <li>Saturated hydrocarbons = all their bonds are single covalent</li> </ul>			
	Physical properties	<ul> <li><i>m.p. and b.p.</i></li> <li>Low mp and bp because they are simple covalent molecules → overcome weak inter-molecular forces of attraction (gas @ r.t.p.)</li> <li>Going down the homologous series, number of C increases and mp and bp increases → size of molecule increases and there are stronger intermolecular forces of attraction to overcome</li> </ul>			
		<i>Solubility</i> - insoluble in water, soluble in orga	anic solvents (know can alr)		
		Viscosity (how easy for it to flow) - Going down the homologous series, number of C atoms increases so longer molecule and stronger intermolecular forces of attraction, so more difficult to flow thus viscosity increase (high viscosity = hard to flow)			
	Chemical	Combustion (burning in the presen	ce of oxygen, + O <sub>2</sub> ) - exothermic		
	properties	Complete combustion	Incomplete combustion		
		Qn: a lot of air, excess air, surplus air	Qn: limited air, insufficient air		
		Products: CO <sub>2</sub> (g) + H <sub>2</sub> O(g) *Heat produces during combustion boil water to steam	Possible products: CO and/or C (soot) + H <sub>2</sub> O(g) *Heat produces during combustion boil water to steam		
		Substitution – alkane with halogen         - Condition: UV light (MUST BE PRI         - Products: organic compound (alk         - Usually use Bromine and Chlorine         react too slow)         - Can keep happening (use product)         H+C+H + cl-cl         H+C+H + cl-cl         Ultraviolet         H+C+CI + cl-cl         Light         Cloromethane         Dichloromethane         Light       cl-c-CI + H+CI         Cloromethane         Light       cl-c-CI + H+CI         Cloromethane       Trichloromethane	e (element in group 17) ≠ addition ESENT) ane) + Hydrogen Chloride (HCI) e (Fluorine too reactive, iodine t as the reactant, e.g. below)		

Alkenes ( $C_nH_{2n}$ ) $n \ge 2$	Characteristics	<ul> <li>Contain carbon-carbon single covalent bonds + at least one carbon-carbon double bond</li> <li>Unsaturated hydrocarbons = at least one carbon-carbon double bond</li> </ul>			
	Physical properties (same as alkanes)	<ul> <li><i>m.p. and b.p.</i></li> <li>- Low mp and bp because they are simple covalent molecules → overcome weak inter-molecular forces of attraction (gas @ r.t.p.)</li> <li>- Going down the homologous series, number of C increases and mp and bp increases → size of molecule increases and there are stronger intermolecular forces of attraction to overcome</li> </ul>			
		Solubility - insoluble in water, soluble in organic solvents (know can alr)			
		Viscosity (how easy for it to flow) - Going down the homologous series, number of C atoms increases so longer molecule and stronger intermolecular forces of attraction, so more difficult to flow thus viscosity increase			
	Chemical	Combustion (burning in the presen	ce of oxygen, + O <sub>2</sub> ) - exothermic		
	properties	Complete combustion	Incomplete combustion		
		Qn: a lot of air, excess air, surplus air	Qn: limited air, insufficient air		
		Products: $CO_2(g) + H_2O(g)$	Possible products: CO and/or C (soot) + H <sub>2</sub> O(g)		
		*Heat produces during combustion boil water to steam	*Heat produces during combustion boil water to steam		
		<ul> <li>Addition of hydrogen – Hydrogenation</li> <li>Condition: 150°C temperature, presence of nickel catalyst (MUST BE PRESENT)</li> <li>Reaction: alkene + H<sub>2</sub> → alkane</li> <li>Application: Manufacturing margarine (solid) from vegetable oil</li> </ul>			
		<ul> <li>Addition of bromine – Bromination <ul> <li>(used to differentiate alkenes from other homologous series)</li> <li>Condition: room temperature and pressure (MUST BE PRESENT)</li> <li>Reaction: alkene + Br2 → halogenoalkane (don't need to know)</li> <li>Application: Differentiating between alkanes and alkenes <ul> <li>Alkenes: red-brown bromine solution turns colourless</li> <li>Alkanes: red-brown solution remains red-brown</li> <li>Number of C=C double bonds can be determines by the number of mole of Br2 reacted with</li> </ul> </li> </ul></li></ul>			

		Addition of steam – Hydration         - Condition: 300°C, 60atm, phosphoric (v) acid catalyst [H₃PO₄]         (MUST BE PRESENT)         - Reaction: alkene + H₂O → alcohol         - Steam and not water because need to break strong double bond         Addition polymerisation (forming a large molecule from many smaller molecules joined together)         - Condition: high temperature and pressure, suitable catalyst
		<ul> <li>(MUST BE PRESENT)</li> <li>Reaction: alkene monomers (repeat units of same alkene) → polymer (long chain of alkane)</li> <li>Name of polymer: poly(name of monomer)</li> <li>E.g. Ethene → poly (ethene)</li> </ul>
		$ \begin{array}{c c} H & H \\ i & i \\ n & C = C \\ i & i \\ H & H \end{array} \xrightarrow{\text{high temperature and pressure}} catalyst \qquad \begin{pmatrix} H & H \\ i & i \\ C - C \\ i & i \\ H & H \end{pmatrix}_n $
		H H -C - C - The repeat unit of polyethene is: H H
Cracking of p obtain alkane	etroleum to and alkene	<ul> <li>Cracking is the breaking down of long-chain hydrocarbons into smaller molecules (usually converts long-chain alkane into alkenes)</li> <li>Condition: High temperature</li> <li>A catalyst can be used to speed up = catalytic cracking</li> <li>→ catalyst: Aluminium Oxide (Al<sub>2</sub>O<sub>3</sub>) and Silicon Dioxide (SiO<sub>2</sub>)</li> </ul>
		1) Used to produce short-chain alkenes $C_{18}H_{38} \rightarrow C_{6}H_{14} + 6C_{2}H_{4}$
		2) Used to produce hydrogen
		C18H38 → C8H16 + C10H20 + H2
		3) Used to produce petrol (short-chain alkanes)

Alkene VS	<b>D</b>		A.II	Allerer	1
Alkane	Property	Orntala	Alkane	Alkene	
		bonds atoms	s only single between carbon	between carbon atoms	
	Reactivity	General	ly unreactive	Very reactive	
	Type of reaction	substitut	ion	Addition	
	Reaction with aqueou bromine	s Does aqueous room t pressure Decolou bromine	not react with s bromine under emperature and e urises aqueous e under presence	Decolourises aqueous bromine under room temperature and pressure	
	Flammability	flame th carbon	an an alkene with an an alkene with lar number of atoms	Produces a less smoky flame than an alkene with a similar number of carbon atoms	-
	Ability to underg polymerisation	o Does polymer	not undergo isation	Undergo addition polymerisation	]
Fats VS Oil			erenger i Le 1911		
	Eate		Oile		
	Solido at	room	Liquide at	room	
	temperature	and	temperature	and	
	Saturated fat mo	blecules	Unsaturated molecules	fat	
lsomers	Definition Isom diffe	ers are con rent structi	npounds that hav ural formula	e the same molecular for	nula but
	Characteristics- Isomers may or may not belong to the same homologous s - Isomers have different names - Isomers have different physical properties (e.g. mp and bp - To name isomers, follow steps of naming organic molecule)			series p) les	
	Example e.g. CdH H+C H+C H H+C H H H H H H H H H H H H	Main straigh chain 	Branched carbo chain (alkyl gr H H H H C C H H C C C H H H H 2-methylpropane (or just methylpropane)	n side roup) 	

Alcohols (C <sub>2</sub> H <sub>221</sub> OH)	Characteristics	- Contain hydroxyl functional group (*functional groups always at main carbon chain)
$n \ge 1$		
	Physical properties	<ul> <li><i>m.p.</i> and <i>b.p.</i></li> <li>- m.p. and b.p. increases as number of C atoms increases (due to stronger intermolecular force of attraction)</li> <li>- exist as volatile liquids at room temperature and pressure</li> </ul>
		<i>Solubility</i> - solubility decreases as the number of C increases
	Chemical properties	Combustion (burning in the presence of oxygen, $+ O_2$ ) – exothermic
		Complete combustion
		Qn: a lot of air, excess air, surplus air
		Products: CO <sub>2</sub> (g) + H <sub>2</sub> O(g) *Heat produces during combustion boil water to steam
		*Only have complete combustion for alcohols
		<ul> <li>Oxidation</li> <li>Condition: heat + oxidising agent (for oxygen) – usually acidified potassium manganate (VII) (MUST BE PRESENT)</li> <li>Reaction: Alcohol + [O] → Carboxylic acid + Water</li> <li>Observation: Purple acidified potassium manganate (VII) solution turns colourless</li> <li>Application: breath analyser to test for drink driving</li> </ul>
		Esterification – covered later
	Producing ethanol (used in hand sanitiser, alcoholic drinks, as a solvent, as a fuel)	<ul> <li>Catalytic addition of Steam to Ethene</li> <li>Condition: 300°C, 60atm, phosphoric (v) acid catalyst [H₃PO₄]</li> <li>Reaction: ethene + steam → ethanol</li> <li>Ethene required usually obtained from cracking of crude oil</li> <li>Not sustainable as tap on finite resources</li> </ul>
		<ul> <li>Fermentation of glucose (like to test this)</li> <li>Condition: 37°C, yeast catalyst, anaerobic condition (no oxygen present)</li> <li>Reaction: glucose → ethanol + carbon dioxide</li> <li>Usually will have an air lock → prevent oxygen from entering experiment, but allow carbon dioxide to escape</li> <li>Slower reaction, but more sustainable as starting material obtained from plants which is considered a renewable resource</li> </ul>

Chapter 20: Alcohols, Carboxylic Acids and Esters (Organic Chem part 3)

Carboxylic acids (C <sub>n</sub> H <sub>2n+1</sub>	Characteristics	- Contain carboxyl functional group (*functional groups always at main carbon chain)
COOH) n≥0	Physical properties	<ul> <li>m.p. and b.p.</li> <li>higher b.p and m.p compared to alcohols and hydrocarbons with same number of carbons</li> <li>boiling point increases ads molecular size increases (strong intermolecular forces of attraction)</li> </ul>
		- soluble in water $\rightarrow$ dissolve in water to form H <sup>+</sup> ions
	Chemical properties	Reaction with reactive metals
	(acid reactions)	Carboxylic acid + Reactive metal → salt + hydrogen gas
	(weak acids as only partially	Ethanoic acid + Magnesium → Magnesium Ethanoate + Hydrogen
	ionise in water)	Reaction with Carbonates
		Carboxylic acid + Carbonate $\rightarrow$ salt + carbon dioxide + water
		E.g. Methanoic acid + sodium carbonate → sodium methanoate + carbon dioxide + water
		Reaction with Bases (neutralisation)
		Carboxylic acid + Base → Salt + Water
		E.g. Propanoic acid + Calcium hydroxide $\rightarrow$ calcium propanoate + water
		Reaction with Alcohols to form esters – covered later
	Producing ethanoic acid	Oxidation of Ethanol by Atmospheric Oxygen (wine/beer turns sour after a few days exposed to air)
		Ethanol + Oxygen (from air) $(O_2) \rightarrow$ ethanoic acid + water
		Oxidation of Ethanol by Acidified potassium Manganate (VII)
		Ethanol + Oxygen from oxidising agent [O] $ ightarrow$ ethanoic acid + water
		Acidified potassium Manganate (VII) turns from purple to colourless

Esters	Characteristics	<ul> <li>Ester are compounds with small molecular sizes and are found in fruits and flowers</li> <li>Esters are sweet-smelling, colourless liquids that are insoluble in water. They are volatile.</li> <li>Esters contain the -COO- functional group</li> <li>Man-made esters are often used to make artificial flavouring for certain types of food</li> <li>Condition: warm, concentrated sulfuric acid (MUST BE PRESENT)</li> <li>Reaction: carboxylic acid + alcohol  ester + water</li> <li>Esterification reactions is also known as condensation reaction because two molecules react to form a single molecule with the loss of a small molecule</li> <li>Alcohol is not a base and esterification is not an acid-base reaction  a although alcohol have -OH group, it does not dissociate in water</li> </ul>				
	Esterification					
	Naming esters	- 2 parts of ester name. Front comes from alcohol while back comes from carboxylic acid yloate $\rightarrow$ two words H = C = C + H + O + C + H + C = C + H + C + C + H + C + C + H + C + C +				
		Number of C	Part from alcohol	Part from carboxylic acid		
		1	Methyl	Methanoate		
		2	Ethyl	Ethanoate		
		3	Propyl	Propanoate		
		4	Butyl	Butanoate		
		*can mix and match				
	Uses	<ul> <li>Preparation of perfur</li> <li>Artificial food flavour</li> <li>Solvents for cosmetic</li> <li>In soups → naturally</li> <li>vegetable oil are boile</li> </ul>	ne ing s and glues occurring esters like an d with sodium hydroxid	nimal fat and de to form soap		

Chapter 21: Polymers (Organic Chem part 4)

Macromolecules		<ul> <li>A very large molecule that is made up of small molecules</li> <li>A polymer is a type of long-chain macromolecule that is linked together by many small repeating units known as monomers</li> </ul>
Polymer		A <u>large, long-chain</u> molecule made from many units of monomers (textbook definition is not enough to score in o levels)
Addition polymerisation	Definition	Occurs when many unsaturated monomers join together to form a polymer, without losing any molecules or atoms in the process
	Condition	<ul> <li>Monomer needs to be unsaturated (contains C-C double bond or triple bond) – usually alkene</li> <li>High temperature, high pressure, catalyst</li> </ul>
	Naming	Poly ( <u>name of monomer, alkene)</u>
	Drawing structural formula, repeat unit, formula	1) Arrange monomer to C=C     2) Draw 3 monomers side by side 3) erase double bond and join all the C with a single bond $\frac{H}{C=C} + H + H + H + H + H + H + H + H + H + $



	Monomers for condensation polymerisation	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	ensation polymenisation H H hubstreadt (6 H-0 - [] - N-H http://www.analy.com j.itself
Polymers	Adv V.S. Disadv	Advantage: Polymer is durable and resistant Disadvantage: Polymers is disposed off by burn land pollution.	t to corrosion. hing in landfills which leads to
Plastics (plastic is a type of polymer)	Adv V.S. Disadv	Advantage Light, tough, waterproof Relatively cheap Easily molded Durable	Disadvantage Non-biodegradable (cannot be broken down by bacteria and other living organisms in the soil) Air pollution – produce poisonous gases during incineration Water pollution – endanger marine animals, clog up rivers and drains Land pollution – increases amount of built-up waste

	How they are		
	recycled	1) Division Method	
		<ol> <li>Physical Method</li> <li>Recycling of plastics can be carried out using the physical method or the chemical method. Before recycling is carried out, the plastic waste needs to undergo pre-treatment (Figure 18.17). This is because not all plastics can be recycled. The recycling method</li> <li>The cleaned plastics are shredded or ground intermediate plastic</li> </ol>	
		<ul> <li>Plastic waste is first sorted using different methods (e.g., manual sorting, sorting by density).</li> <li>The sorted plastics are washed to remove contaminants like food waste.</li> <li>The sorted plastics are washed to remove contaminants like food waste.</li> </ul>	
		2) Chemical Method	
		Cracking: plastic waste such as poly(ethene) waste can undergo cracking to form short chains of alkanes and alkenes. The short-chain alkanes can be used as fuel, while the	
		short-chain alkene can be used to make other useful chemicals. Cracking requires a high temperature and presence of catalyst.	
		Depolymerisation: A polymer can be converted to its monomers. This process is known as depolymerisation. After depolymerisation, the monomers can be converted to other useful <u>chemicals</u>	
	Issues	Environmental issues	
		- Steps involved in the recycling process may produce	
		wastewater containing harmful substances.	
		- If the wastewater is not treated before it enters the oceans,	
		lakes or rivers, it can cause water pollution	
		<ul> <li><i>Economic issues</i></li> <li>Recycling can be expensive, costing much more than disposal in landfills or incineration</li> <li>It may not be worthwhile or economically viable to recycle plastics if the cost of recycling is higher than the value of the recycled plastic</li> </ul>	
		Social issues - Many people do not know the proper way to use the recycling bins which affects the recycling process of plastic waste - Time and effort are required to remove the non-recyclable items before recycling. Thus, this slows down the process	

Chapter 22: Maintaining Air Quality

Components of air	Nitrogen – 78%		
components of an	Oxygen = 21%		
	Oxygen = 21%		
	Carbon dioxide – 0.04%		
	Noble gases (mainly argon), water vapour and others – 0.96%		
	X Hydrogen – explosive		
	(1005) Oph3 iran pouder		
	A B B B B B B B B B B B B B B B B B B B		
	millione followares (the) with a	planationed and another	
	I'l of air is made a	foxygen.	
	<ul> <li>Irmpouder reacts with axygen</li> </ul>	in air to produce iron (II) aride.	
	<ul> <li>Final volume of both syringes</li> </ul>	decrease by 21%	
	Component of air	Boiling point / °C	
	Nitrogen	-196	
	Argon	-186	
	Oxygen	-183	
	Qn: Compare and explain the difference in boiling point between Nitrogen and Oxygen Ans: Nitrogen has a lower boiling point whereas oxygen has a higher boiling point. Oxygen has a greater molecular size as compared to nitrogen so more energy required to overcome stronger intermolecular forces of attraction between oxygen molecules as compared to between nitrogen molecules.		

Air pollutants	What is air pollution	Air pollution is the introduction of unwanted and harmful chemicals into the atmosphere	
	Table 22.2 Some air pollutants and their barmful offects		
	Air Pollutant	Sources	Harmful Effects
	Sulfur dioxide (SO <sub>2</sub> ) • a colourless gas with a pungent odour	combustion of fossil fuels     volcanic eruptions	<ul> <li>Sulfur dioxide causes breathing difficulties in humans and animals.</li> <li>Sulfur dioxide and nitrogen oxides react with oxygen in the air to form acidic compounds which discolute in the air to form acidic</li> </ul>
	Nitrogen oxides (NO and NO <sub>2</sub> ) • NO is colourless and odourless • NO <sub>2</sub> is red-brown and has a pungent smell	<ul> <li>vehicle combustion engines</li> <li>lightning</li> </ul>	forming solutions of strong acids. This is called acid rain. Acid rain kills plants and aquatic life. It also corrodes buildings and structures made from limestone, marble and metals.
	Carbon monoxide (CO) • a colourless and odourless gas that is very toxic	<ul> <li>incomplete combustion of carbon-based fuels</li> </ul>	<ul> <li>Carbon monoxide binds irreversibly with the haemoglobin in our red blood cells. This lowers the ability of the haemoglobin to transport oxygen to the rest of our body. This can result in the loss of consciousness and even death.</li> </ul>
	Methane (CH₄) • a colourless and odourless gas that is highly flammable	<ul> <li>anaerobic (in the absence of oxygen) bacterial decay of organic substances</li> <li>waste gases from cattle</li> </ul>	<ul> <li>Methane is a major greenhouse gas that leads to global warming.</li> </ul>
	Unburnt hydrocarbons (C,H) • colourless gases that are naturally odourless, but may be pungent due to fuel additives	<ul> <li>vehicle combustion engines</li> </ul>	<ul> <li>Unburnt hydrocarbons can cause eye and respiratory tract irritation.</li> <li>Unburnt hydrocarbons react with nitrogen oxides in the presence of sunlight to form photochemical smog, which appears as a brown haze. The formation of smog also produces ozone, sulfur dioxide and nitrogen dioxide, which are other pollutants listed in this table.</li> </ul>
	Ozone (O3) • a pale blue gas with a pungent odour	<ul> <li>lightning</li> <li>from reactions between oxygen molecules and sunlight in the upper atmosphere</li> <li>from reactions between unburnt hydrocarbons and nitrogen oxides in the presence of sunlight in the lower atmosphere</li> </ul>	<ul> <li>Ozone can cause eye and respiratory tract irritation, leading to breathing difficulties.</li> <li>When inhaled, it also causes chest pains and headaches.</li> <li>Ozone slows down photosynthesis in plants, which can damage crops.</li> </ul>
	Acid rain	<ul> <li>Occurs when rain combined</li> <li>dioxide and nitrogen dioxide</li> <li>Acid rain leaches essential</li> <li>calcium from the sail which</li> <li>some may be killed</li> </ul>	es with excessive amounts of sulfur e produced by human activity nutrients like magnesium and affects health and growth of plants,

Control of air	Catalvtic	- Use Catalyst (platinum, palladium, rhodium) → arranged in	
pollution	Converters	honey comb structure $\rightarrow$ maximise surface area for gases to	
P		interact $\rightarrow$ speed up conversion of harmful substances to less	
		harmful substances	
		- Gases Present: Carbon Dioxide. Carbon Monoxide. Nitrogen.	
		Nitrogen Dioxide. Nitrogen Monoxide. Oxygen. Unburnt	
		Hydrocarbons, Water Vapour	
		- Reactions	
		$\sim 2CO(g) + 2NO(g) \rightarrow 2CO_2(g) + N_2(g)$	
		$\sim 2CO(g) + O_2(g) \rightarrow 2CO_2(g)$	
		$\sim 2N\Omega_2(g) \rightarrow N_2(g) + 2\Omega_2(g)$	
		$\sim 2C_{0}H_{10}(g)$ [octane] + 25O <sub>2</sub> (g) $\rightarrow$ 16CO <sub>2</sub> (g) + 18H <sub>2</sub> O(g)	
		- Even though catalytic converters increase the amount of	
		carbon dioxide, it is still a preferred air pollution control. The	
		original air pollutants are more harmful than carbon dioxide	
	Flue Gas		
	Desulfurisation		
	Destination	proportion of the sulfur dioxide from the flue gas before	
		It is released into the atmosphere.	
		wet scrubbing using a calcium carbonate (CaCO <sub>3</sub> ) slurry	
		(Figure 22.8). The slurry is formed when calcium carbonate, in the form of limestone, is mixed with water.	
		purification the block of the second s	
		flue gas	
		(sulfur dioxide)	
		calcium sulfite chimney	
		Figure 22.8 Flue gas desulfurisation	
		romovos sulfur diovido - calcium sulfito - calcium sulfato	
		- Peactions	
		$\simeq C_2(O_1, (c) + SO_2, (a) \rightarrow C_2(O_2, (c) + CO_2, (a))$	
		$\sim 2 \cos(1/2) + \cos(1/2)$	
		$2Cd_{3}O_{3}(s) + O_{2}(g) \rightarrow 2Cd_{3}O_{4}(s)$	
		$(a_3\cup 4_1(s) + 2\Pi_2\cup (1) \neq 2(a_3\cup 4 \circ 2\Pi_2\cup (s) \neq [b_1d_1+a_2d_1+a_3\cup 4 \circ 2\Pi_2\cup (s) \neq [b_1d_1+a_2d_1+a_3\cup 4 \circ 2\Pi_2\cup (s) \neq [b_1d_1+a_2d_1+a_3\cup 4 \circ 2\Pi_2\cup (s) \neq [b_1d_1+a_3\cup (s) \vdash (s) \neq [b_1d_1+a_3\cup (s) \vdash (s$	
		[Invulated calcium sunate/gypsum] -	
		- require large amounts of space to install and costly to run,	
		thus not practical to install in vehicles	
	Liming	- Liming = addition of calcium carbonate	
	L	- Carbonate is added to the soil and water bodies to remove	
		some of the excess acid contributed by acid rain	
		- Acid rain can affect many areas $\pm$ expensive $\pm$ temporary effect	
		Add rain can arred many areas + expensive + temporary effect	

Ozone layer	Where it is found	Ozone is harmful in the atmosphere because 1) Ozone can cause eye and respiratory tract irritation, leading to breathing difficulties 2) When inhaled, causes chest pain and headaches 3) Ozone slows down photosynthesis in plants, damages crops	
		Ozone is useful in the ozone layer / stratosphere because It absorbs harmful UV radiation, reducing the amount of UV radiation that reaches the Earth's surface	
		Harmful UV radiation causes sunburn, skin cancer, premature ageing and cataracts in the eyes	
	Depletion of ozone layer	Depletion of ozone layer is caused by Chlorofluorocarbons (CFCs) – found in aerosol propellants, refrigerants, and certain plastics	
		<ol> <li>UV radiation from the sun breaks up the CFC molecules in the stratosphere into chlorine atoms</li> <li>Chlorine atoms react with ozone to form oxygen and chlorine oxide. Chlorine oxide continues to break up another molecule. Chlorine atom is released and continue to attack ozone molecules in chain reactions</li> <li>Holes in the ozone layer start to form</li> </ol>	
Carbon cycle	The element carbon is espectial for iffe. All ergent correspondences and weak whet the opping carbon on activity constrained and weak whet is the opping carbon on activity constrained and weak whet is the plantic see make from them. Figure 22.15 The carbon cycle Cores up the Ocean up the Cores and other large backs of many plantic activity differences of a statistic activity of the plantic sector and activity of the plantic sector activity of the plantic s	where where the amount of carbon dioxide in atmosphere dioxide: photosynthesis, Ocean uptake (ocean and other large target to atom the sector to a se	

Global warming	Definition	The increase in the average temperature of the Earth's surface due to increasing amounts of greenhouse gases in the atmosphere
	Negative effects	<ol> <li>Areas might begin to receive too little rain and turn into deserts while other areas may receive too much rain and flood more often</li> <li>Heat waves become more common. Some parts of the world would become too hot for humans to live in. This also makes destructive wildfires more common, destroying entire ecosystems</li> <li>Tropical storms are stronger and occur more frequently</li> <li>Warmer Ocean waters also absorb carbon dioxide more quickly, forming carbonic acid which decreases pH of water. Acidified water removes carbonate minerals from ocean. Existing shells might also begin to dissolve, killing organisms or making them more vulnerable to injury and predation</li> <li>Increase in global temperatures have caused glaciers and polar ice caps to melt and shrink. Sea levels also rise and permanently flood coastal areas</li> </ol>