Colour of solid:

Black	CuO, Fe_3O_4
Yellow	PbO, AgI, $FeCl_3 \bullet nH_2O$
Blue	$CuSO_4 \bullet nH_2O$
Green	$FeCl_2 \bullet nH_2O$ $CuCl_2 \bullet nH_2O$

Colour of aqueous solution:

Cu^{2+}	Blue/green
Fe^{2+}	Pale green
Fe^{3+}	Yellow
MnO_4^-	Purple
$Cr_2O_7^{2-}$	Orange
Main group ions	Colourless

Colour of gas:

Cl_2	Greenish yellow
Br_2	Reddish brown
I_2	Purple
NO_2	Brown
SO_2	Colourless
HCl	Colourless

Colour of precipitate:

$BaSO_4$	White
$CaCO_3$	White
AgCl	White
Ag_2SO_4	White

Solubility of salt:

Soluble	Insoluble
K^+, Na^+, NH_4^+ salts	
NO_3^- salt	
HCO_3^- salt	
Cl^-, Br^-, I^- salt	Except: AgX, PbX_2
SO_4^{2-} salt	Except: Ag_2SO_4, $PbSO_4$, $BaSO_4$, $CaSO_4$
Except: K_2CO_3, Na_2CO_3 $(NH_4)_2CO_3$	CO_3^{2-}

Smells of gas:

NH_3	Pungent
Cl_2	Pungent smell of bleaching solution
SO_2	Choking
H_2S	Bad egg smell
NO_2, HCl	Pungent

Test cation -- Flame test (procedures):

1.	Moisten a clean Pt wire wih conc. HCl
2.	Dip the platinum wire into the sample
3.	Heat the Pt wire with non-luminous Bunsen flame

Test cation -- Flame test (colour):

Na^+	Golden Yellow
Ca^{2+}	Brick Red
K^+	Lilac
Cu^{2+}	Bluish Green

Heating of solid:

NH_4Cl	Sublime $NH_4Cl \rightarrow NH_3 + HCL$
I_2	Sublime $I_2 (g) \rightarrow$ purple vapor
ZnO (White)	Turns to yellow
PbO (Yellow)	Turns to orange

Test cation – using hydroxide ion:

Al^{3+} gives white precipitate which dissolve in excess NaOH (aq) to give a colourless solution

Zn^{2+} gives white precipitate which dissolve in excess NaOH (aq) to give a colourless solution

Pb^{2+} gives white precipitate which dissolve in excess NaOH (aq) to give a colourless solution

Test cation – using excess ammonia:

Zn^{2+} gives white precipitate which dissolve in excess NH_3 (aq) to give a colourless solution

Cu^{2+} gives pale blue precipitate which dissolve in excess NH_3 (aq) to give a deep blue solution

Ag^+ gives dark brown precipitate which dissolve in excess NH_3 (aq) to give a colourless solution

Test for ammonium ion: (procedure)

1.	Warm with NaOH (aq) in a test tube $NH_4^+ + OH^- \rightarrow NH_3 + H_2O$
2.	Place a moist red litmus paper at the opening of the test tube
3.	Pungent smell gas turns the red litmus paper blue

Test of halide ions:

Procedures:

1. Add [acidified] silver nitrate solution to the sample

2. Add dilute nitric acid to the sample

Result:

Chloride	White ppt.
Bromide	Pale yellow ppt.
Iodide	Yellow ppt.

Test for carbonate:

Procedures:

1. Add dilute HCl (aq) to the sample

2. Pass the colourless gas produced into lime water

Result:

The colourless gas turns limewater milky

Test for chlorine gas:

Turns moist blue litmus paper red (HCl) and then white (OCl⁻)

Test for hypochlorite ion:

Turns blue/red litmus paper white

Give greenish-yellow gas with pungent smell of bleachy solution upon addition of HCl (aq)

Test for sulphite ion:

Add HCl (aq) to the sample and warm
A gas with choking smell will form and turn acidified $K_2Cr_2O_7$ (aq) from orange to green

Test for sulphur dioxide:

Turns acidified $K_2Cr_2O_7$ (aq) from orange to green

Test of hydrogen:

Gives a pop sound with a burning splint

Test of oxygen:

Relights a glowing splint

Test for hydrogen chloride gas:

Turns blue litmus paper red

Test of water:

Turns dry $CoCl_2$ paper from blue to pink

Turns anhydrous $CuSO_4$ (s) from white to blue

Test for carbon dioxide gas:

Turns limewater milky

Test for ammonia gas:

Turns moist red litmus paper blue

Reacts with HCl (g) evolved from conc. HCl (aq) to give a dense white fume

Test for C=C:

Add the mixture into bromine solution/in organic solvent.

The solution turns from orange to colourless

Turns acidified $KMnO_4$ (aq) from purple to colourless

Test for -CHO:

Add Tollen's reagent to the sample in a clean test tube.

A silver mirror is formed on the inner layer of the test tube

Test for hydroxyl group (-OH):

Turns acidified $K_2Cr_2O_7$ (aq) from orange to green

Reflux with ethanoic acid in the presence of conc. H_2SO_4. A pleasant fruity smell is detected

Test for >C=O :

Mix the sample with 2,4-dinitrophenylhydrazine solution

An orange/yellow precipitate is given out

Test for -COOH:

Add Na_2CO_3 to the sample

Colourless gas bubbles are given out which turns limewater milky

Reflux with ethanol in the presence of conc. H_2SO_4. A pleasant fruity smell is detected

Part I: Planet Earth Part II: Microscopic World I			
Air: Nitrogen is most abundant	Test for O_2:		Glowing splint into test tube, relight
Fractional distillation of liquid air:	Test for H_2O:		Turn anhydrous $CuSO_4$ white to blue
1. Air first filtered to remove dust			Turn dry cobalt (II) chloride paper blue to pink
2. Purified air compressed and cooled	Test for Cl^-:		Add excess dilute HNO_3, $AgNO_3$, white precipitate
3. Heated up slowly. Separated by b.p.	Test for CO_3^{2-}		Turn limewater [$CaOH$ (aq)] milky
Filtration: Powder: Residue; Liquid: Filtrate	Flame test:		Heat platinum wire with non luminous flame
Crystallization Purity > Evaporation	Test compound		Lilac; Golden Yellow; Brick Red; Bluish Green

Calcium carbonate cycle:

Limewater test: $Ca(OH)_2(aq) + CO_2(g) \rightarrow CaCO_3(s) + H_2O(l)$

If excess CO_2: $CaCO_3(s) + H_2O(l) + CO_2(g) \rightarrow Ca(HCO_3)_2(aq)$
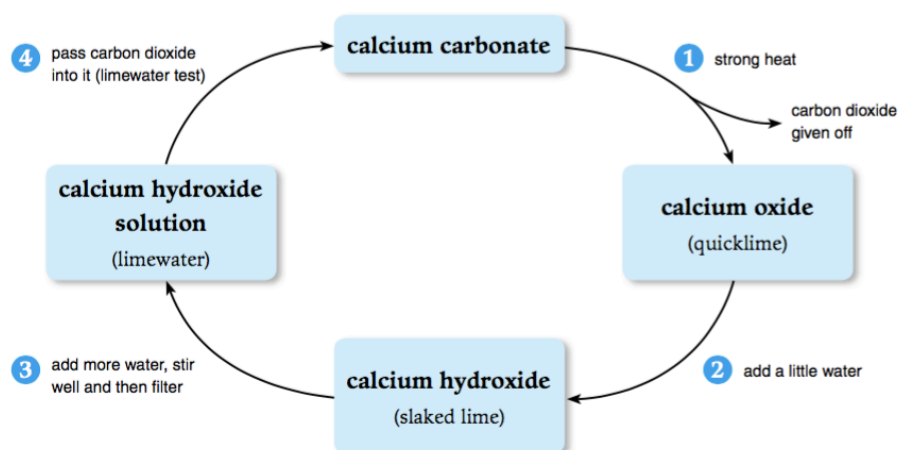
mass number
= number of protons + number of neutrons

^A_Z X ← atomic symbol

atomic number
= number of protons
= number of electrons of an atom
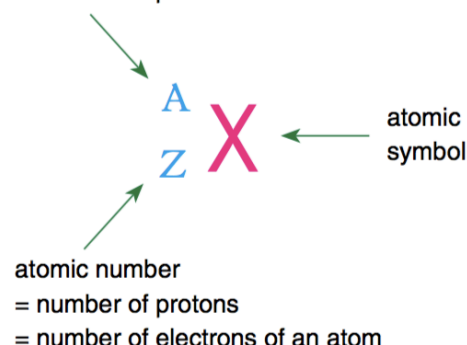
Isotopes: Atoms of the same element that have same number of protons but different number of neutrons	Relative atomic mass: (no unit)	Iso. Weighted mean
	Number in periodic table: ($gmol^{-1}$)	Relative abundance
→ Same chemical properties, similar phy. properties	Electron shell:	Group: I: Alkali metals; II: Alkaline earth
Octet: 8 in outermost; Duplet: 2 in only e^- shell	2, 8, 18, 32 → $2n^2$	metals; VII: Halogens; 0: Noble gas

Giant metallic   [Metal]

metal ions (positively charged)

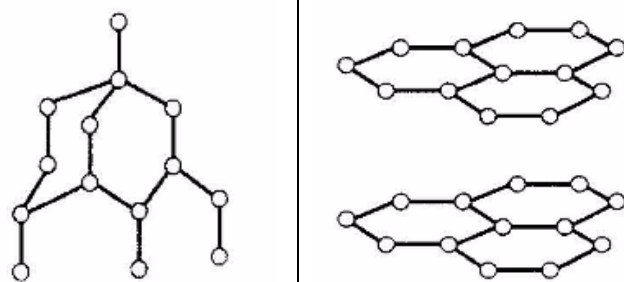delocalized electrons (negatively charged)
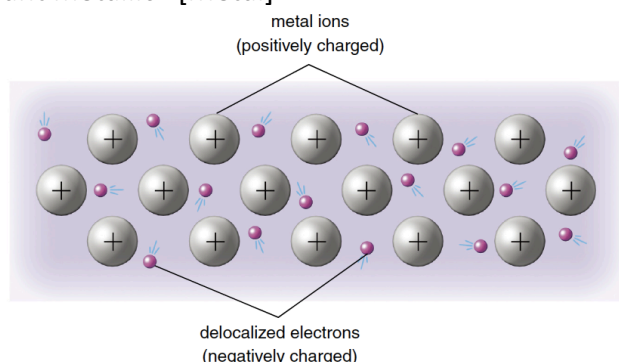
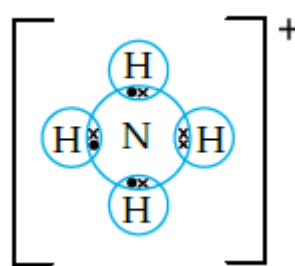Giant ionic   [Metal + Non metal]   H is not a metal

$CsCl_2$
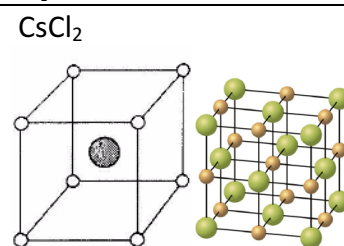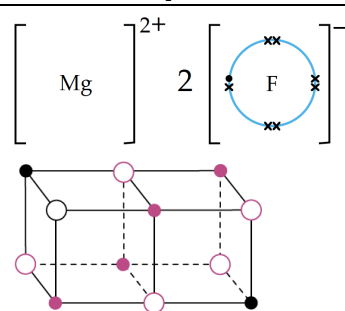
Giant covalent   [C (graphite) C (diamond) Si $SiO2$ B]
Graphite: VDW force between layers, free electron

Dative covalent bond   [Ozone O_3, NH_4^+] ($O \rightarrow O = O$)
Indistinguishable from regular covalent bond

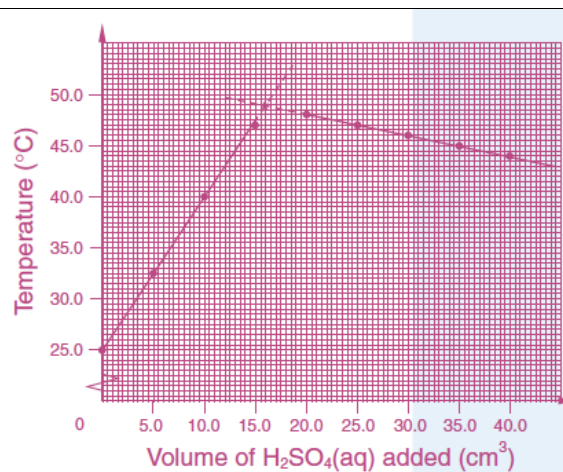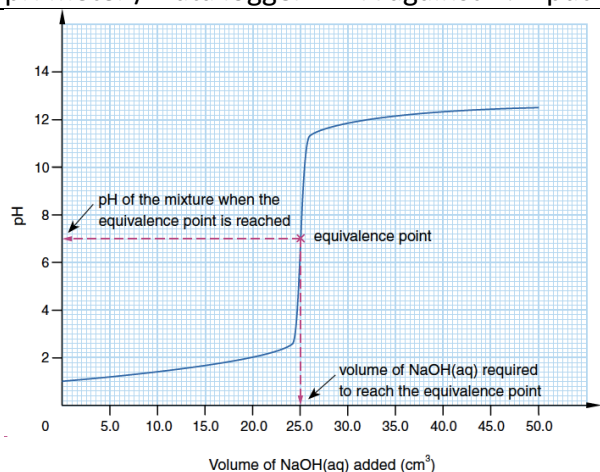

Simple molecular   Special case: BeCl2

weak Van Der Waals force, need few energy to break bonds

Conductivity: Free electron/Mobile ions

mortar and pestle

Part III: Metals			**Part IV: Acid and Bases**	

Electrolysis	K	$M + H_2O$ (l) $\rightarrow H_2 + MOH$	Displacement reaction: More reactive $\rightarrow$ Less reactive	
	Na		Al: Protective oxide layer, anodization	
KC NM AZ FP CHAP	Ca		Towngas: Carbon monoxide, hydrogen	
	Mg	$M + H_2O$ (g) $\rightarrow H_2 + MO$	Need to burn off (dangerous)	
	Al		Empirical formula: Find mole ratio, divide by smallest	
$MO + C \rightarrow CO_2 + M$	Zn		Rust: Existence of water and air (oxygen) [$Fe_2O_3 \bullet nH_2O$], reddish brown solid	
$Fe_2O_3 + CO \rightarrow$	Fe			
$Fe + CO_2$	Pb	$M + H^+ \rightarrow H_2 + M^+$	Soluble ionic compounds, sacrificial protection (lose electrons more rapidly than iron), cathodic prot. (-ve d.c.)	
	Cu	$M + O_2 \rightarrow MO$		
$MO \rightarrow M + O_2$	Hg		Galvanizing: Zn	Tin plating: Tin ions are not poisonous
	Ag	No reaction	Rust indicator:	
Physical Extraction	Pt		Blue: Fe^{2+} ions, Pink: OH^- ions, White solid: OH^- salts	

Acid + Metal	$\rightarrow$ Salt + H_2	Acid in water $\rightarrow$ Ionize $\rightarrow$ acidic properties	
Acid + Metal Hydroxide	$\rightarrow$ Salt + H_2O	Basicity: No. of H^+ ions produced by one molecule of acid	
Acid + Metal Oxide	$\rightarrow$ Salt + H_2O	Electrolytes: conducts electricity by changing into ions when melted or dissolved into a solution.	
Acid + Carbonate	$\rightarrow$ Salt + $CO_2 + H_2O$		
Acid + Hydrogen Carbonate	$\rightarrow$ Salt + $CO_2 + H_2O$	Alkaline: Turn moist red litmus paper blue, disassociation	
Acid + Alkali	$\rightarrow$ Salt + Water, exothermic	Reaction with OH^-: Redissolve: AZ LGPC, else insoluble $Fe(OH)_2$: Dirty Green, $Fe(OH)_3$: Reddish Brown	
Alkali + Carbon Dioxide	$\rightarrow$ Metal Carbonate + H_2O		
$NH_3 + H_2O$	$\leftrightarrow$ $NH_4^+ + OH^-$	$Cu(OH)_2$: Pale blue / Deep Blue	
$4HNO_3$ (light)	$\rightarrow$ $2H_2O + 4NO_2 + O_2$ (volatile)	$2Ag^+ + 2OH^- \rightarrow Ag_2O + H_2O$ (Dark Brown)	

Diluting an acid: Add acid slowly into cold water while stirring, else highly exothermic, splash out	MV=MV

pH = -log [H+]   Concentration of OH^- is higher/lower than H^+ | Strong/weak acid: Ionize completely/slightly

Indicators: | Methyl orange: Red, Orange, Yellow | Litmus: Red, purple, blue | Phenolphthalein: Colorless, pink

Preparation/solubility of salts: Refer to Analytical Chem. Ba^{2+}: Used to test SO_4^{2-}, $CaSO_4$ sparingly soluble

Bleach: NaClO | Drain cleaner/caustic soda: NaOH | Toilet Cleanser: HCl | surface insoluble

Soluble salts:	1. Determine the volume of acid needed to neutralize the acid.
	2. Repeat with same volume without indicator 3. heat solution and perform crystallization
Insoluble:	1. Mix two solutions 2. Filtration 3. Evaporate until dry

Standard solution: Accurately known concentration, high purity, chemically stable (involatile), non toxic

Titration: Volumetric flask / Pipette / Burette / Stopcock   Washing: Distilled water, (acid: Pipette, burette)
"Until the bottom of the meniscus reaches the graduation mark"
Strong acid: Methyl orange   Strong alkali: Phenolphthalein
Do not take first trial: Only take last 3 tries average volume
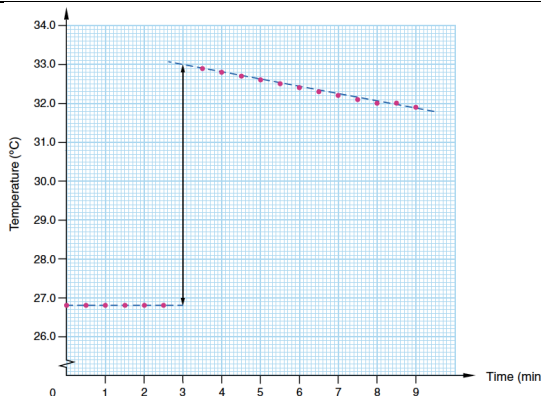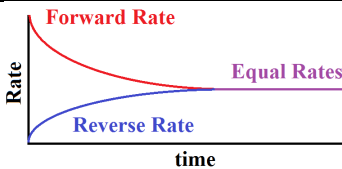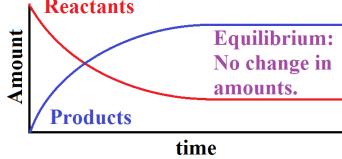pH meter / Data logger   A against B: B put on top

Part V: Fossil fuels and carbon Compounds			
Coal: Remains of plants that lived hundreds of millions of years ago, mixture of hydrocarbons Petroleum/Natural gas: From sea animals and plants that lived hundreds of millions of years ago			Fractional distillation of crude oil
Aliphatic: Straight chains, branched chains, no benzene ring		Aromatic: Contain benzene ring	
Refinery gas/LPG, Petrol/Naphtha, Kerosene (aeroplanes), Diesel oil (bus), Fuel oil (ships), Lubricating oil, bitumen			
More carbon $\rightarrow$ Volatility, Viscosity, harder to burn, sooty flame, flammable, boiling point			
CO	Motor vehicles	Poisonous gas even at low concentrations	Catalytic converter LPG instead of diesel
SO2	Power plants, factories, incinerators	Irritates eyes, respiratory systems Acid rain	Scrubber Fuel of low S content
NOx	Motor vehicles, power plants, factories	Irritates eyes, respiratory systems Acid rain, photochemical smog	Catalytic converter
Unburnt hydrocarbons	Motor vehicles	Causing cancer, Photochemical smog	Catalytic converter
Suspended particulates	Motor vehicles, factories, power plants, incinerators	Irritates respiratory systems, Damage nervous system, Reduce visibility	Using electrostatic precipitators, Unleaded petrol, Mechanical filtering
Acid rain:	$CO_2 + H_2O \leftrightarrow H_2CO_3$ $SO_2 + H_2O \leftrightarrow H_2SO_3$ $4NO + 2H_2O + O_2 \leftrightarrow 4HNO_2$ $2NO_2 + H_2O \leftrightarrow HNO_3 + HNO_2$	Damage plants, Kill aquatic life, corrode building materials, corrode metal objects	
Catalytic converter:	$2CO + 2NO$ [Pt] $\rightarrow 2CO_2 + N_2$ $2CO + O_2$ [Pt] $\rightarrow 2CO_2$ $C_xH_y + (x+y/4)O_2 \rightarrow xCO_2 + (y/2) H_2O$	Can only work effectively on unleaded petrol Catalyst easily poisoned by lead or lead compounds	
Scrubber:	$Ca(OH)_2 + SO_2 \rightarrow CaSO_3 + H_2O$	Limewater	
Functional group: Atom or group of atoms responsible for most chemical properties			
Homologous series: Can be represented by a general formula, differ by CH_2 group, similar chemical properties			
Combustion: H_2O, CO_2, Incomplete: CO_2, H_2O, CO, H_2		Complete: Non luminous flame	
Cracking: To produce alkenes/extra petrol Aluminium oxide mixed with silicon dioxide, Endothermic, Break down large molecules into smaller ones (1x alkene + alkane) Heat, absence of air, Catalyst (Al_2O_3 or SiO_2)			
Addition reaction: Two or more molecules react to give a single molecule Free radical: Atom or a group of atoms with at least one unpaired electron, highly reactive Substitution reaction: Atom of a molecule is replaced by another atom			
Addition polymerization: Monomer molecules join together repeatedly to form polymer molecules without elimination of small molecules			

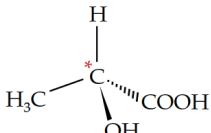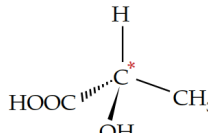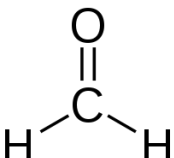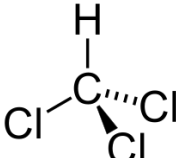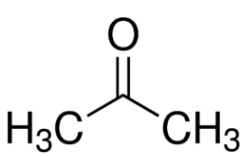| Polyethene (PE)	X: H	LDPE: Low density, Softens in boiling water, flexible	Plastic bags, cold water pipes
		HDPE: Higher density than HDPE, rigid, higher melting point than LDPE	Bottles, buckets, boxes
Polypropene (PP)	X: CH_3	Low density, high melting point, resistant to many chemicals	Ropes and fibres, boxes, food containers
Polystyrene (PS)	X: Benzene ring	Transparent: Transparent, hard but brittle	Transparent containers, CD cases
		Expanded: Low density, rigid, good heat insulator, non toxic, shock absorbent	Foam cups and food boxes
Polyvinyl chloride (PVC)	X: Cl	Stiff, brittle, water resistant, good electrical insulator, poisonous	Pipes, floor tiles, raincoats, insulating covering for wires
Perspex	Refer to Diagram	Hard, tough, rigid, not easily scratched, highly transparent	Optical fibres, aeroplane windows
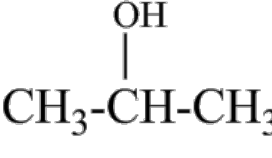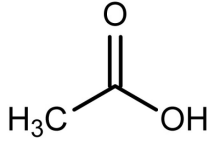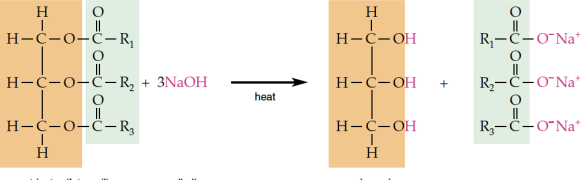
Part VI: Microscopic World II   Part XII: Patterns in the Chemical World

Linear: $O=C=O$	Trigonal Planar:	(structure)	Tetrahedral:	(structure)	Trigonal Pyramidal:	(structure)

V-shaped:	(structure)	Trigonal Biprymadial:	(structure)	Octahedral:	(structure)

Electronegativity: The power of that atom in a molecule to attract bonding electrons	F: Most electronegative element
	More electronegative element has a partial negative charge, while less electronegative element has a partial positive charge
Charged rod: Electrostatic attraction, attract polar molecules, deflected	A ____ molecule is ____ in shape. As the polarities of the polar ____ bonds (cannot) cancel out each other, ____ is (non) polar.

van der Waals force: weak, exist between all molecules

Polar: Partial positive/negative charge, positive end of molecule attracted to negative end of another molecule

Non polar: Molecular size, greater chance for uneven electron distribution, partial positive/negative charge

Molecular shape: M.p: Spherical higher, pack more rigid   B.p: Rod shaped higher, have greater surface area

Hydrogen bond: When a hydrogen atom is directly bonded to a highly electronegative atom (N O F), a highly polar bod forms. There is a large difference in electronegativity. H has partial positive charge. H bond forms when this partially positively charged H atom attracts a lone pair of electrons on a highly electronegative atom.

(diagram of hydrogen bonding between water molecules)	Water: Extensive hydrogen bonding, lot of energy is required to overcome → High surface tension, high viscosity, high boiling point
	Miscible: State whether the forces between the molecules, and the forces between molecules and solvent are comparable or not → Non polar molecules insoluble in polar solvents Evaporation: Liquid gain heat, endothermic, stronger forces, longer time

Ice: Open structure, extensive hydrogen bonding, less dense
Ice as insulating layer on pond: Allow fish and other organisms to live under the ice
Fullerenes: Molecules composed entirely of carbon atoms, hollow spheres or tubes, C_{60} / carbon nanotube
C_{60}: Simple molecular structure, low melting point, non polar→ insoluble in H_2O, solid, strong and hard
Have delocalized electrons but hindered in the structure of molecule, so does not conduct electricty well
Combine with potassium to make superconducting material

Li → Ne Giant metalic → Giant covalent → Simple molecular	Na → Ar Metalic → Covalent
Oxides: Na → Cl Ionic → Covalent, Giant ionic → Simple molecular	Al: Predominatly ionic, amphoteric oxide

$Na_2O + H_2O → 2NaOH$	Vigorous, alkaline		$SiO_2 + 2OH^- → SiO_3 + H_2O$	Slow, acid
$MgO + H_2O → Mg(OH)_2$	Slow, alkaline		$P_4H_{10} + 6H_2O → 4H_3PO_4$	Vigorous, weak acid
$Al_2O_3 + 2NaOH + 3H_2O → 2NaAl(OH)_4$	Alkaline	Al_2O_3 insoluble	$SO_2 + H_2O → H_2SO_3$	Fairly, weak acid
$Al_2O_3 + 3H_2SO_4 → Al_2(SO_4)_3 + 3H_2O$	Acid		$Cl_2O + H_2O → 2HOCl$	Readily, weak acid

Transition metals:	High melting point, density		Colored ions, Variable oxidation states, Catalytic properties	
	High electrical conductivity, high thermal conductivity, high tensile strength			
	Ti^{3+}: Purple	V^{2+}: Violet	V^{3+}: Green	Mn^{3+}: Red	MnO_4^{2-}: Green

Part VII: Redox Reactions, Chemical Cells and Electrolysis
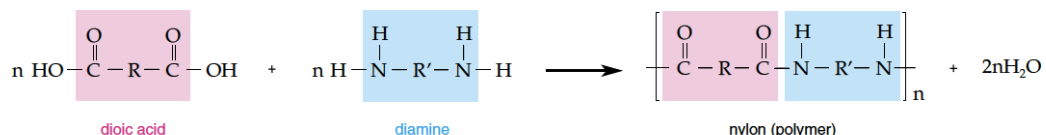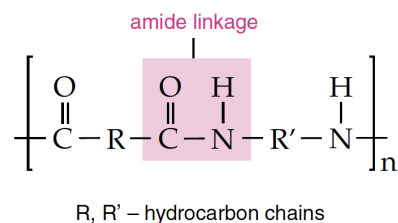
Zinc carbon cell (P)	Low cost, long shelf life, poor in high drain devices/low temp., unsteady volatage
Alkaline manganese cell	Low internal resistance, long shelf life, high discharge rate, Expensive
Silver oxide cell	Lightweight, small, wide temp. Range, Expensive
Lithium ion cell (S)	Lightweight, very expensive [Computers, mobile phones]
Nickel metal hydride cell	Low resistance, expensive
Lead acid accumilator	Extremely high current, very expensive, toxic [car batteries]

Simple chemical cell: Dipping two different metals (metal couple) in an electrolyte (conduct electricity in aq)

Electrons flow from higher in electrochemical series to lower (release electons more readily)

Voltage: difference in electron losing tendencies

A direct displacement reaction will occur on the _____ surface and some _____ deposits form on the _____ electrode. The voltage of the cell drops rapidly → Metal electrodes in solutions of their own ions, half cells

Salt bridge: Filter paper soaked in solution of an electrolyte, does not react with the substances of the cell
Function: 1. Complete the circuit   2. Provide ions to balance charge in both cells

Porus device: 1. Prevent direct mixing of the two electrolytes
                2. Complete circuit by allowing ions to move from one electrolyte to the other

Redox: Change in oxidation number of reacting substances | An Ox/Red Cat

Disproportination: Simultaneously oxidized and reduced

Oxidizing agent (self reduce):	$MnO_4^-/H^+ \to Mn^{2+}$	$Cr_2O_7^{2}/H^+ \to Cr^{3+}$	Dilute $NO_3^- \to NO$		Conc. $NO_3^- \to NO_2$
	$H_2SO_4 \to SO_2$	O_2	Cl_2	Br_2	$Fe^{3+} \to Fe^{2+}$
Reducing agent: (self oxidize)	$SO_2 \to SO_4^{2-}$	$Fe^{2+} \to Fe^{3+}$	$H_2 \to H^+$	Big table: Refer to calculator	
	$I^- \to I_2$	$C \to CO$	$C \to CO_2$	Upper right react with lower left	

Chlorine as oxidizing agent	$Cl_2 + 2I^- \to 2Cl^- + I_2$	Iodine is brown	Cold dilute NaOH: $Cl_2 \to Cl^-$, $Cl_2 \to OCl^-$	Add OH-
	$Cl_2 + 2Br^- \to 2Cl^- + Br_2$	Yellowish brown	Hot conc. NaOH: $Cl_2 \to Cl^-$, $Cl_2 \to ClO_3^-$	on left

Nitric acid as oxidizing agent	On metals: Oxidize all metals	Dilute: $Cu \to Cu^{2+}$, $NO_3^- \to NO$, $2NO + O_2 \to 2NO_2$ (brown at mouth)
		Conc.: $Cu \to Cu^{2+}$, $NO_3^- \to NO_2$
	Non metals:	Conc: $C \to CO_2$, $S \to SO_2$, $NO_3^- \to NO_2$
	Iron (II) salts:	Conc: $Fe^{2+} \to Fe^{3+}$, $NO_3^- \to NO$, $2NO + O_2 \to 2NO_2$
	Sulphites:	Conc: $SO_3^{2-} \to SO_4^{2-}$, $NO_3^- \to NO_2$

Conc. H_2SO_4 as oxidizing agent	Oxidize all metals $H_2SO_4 \to SO_2$ $C \to CO_2$, $S \to SO_2$	Sulphite ion as reducing agent	$SO_2 + H_2O \leftrightarrow H_2SO_3$, $H_2SO_3 \leftrightarrow 2H^+ + SO_3^{2-}$ $SO_3^{2-} \to SO_4^{2-}$ Br_2, $Cr_2O_7^{2-}$, MnO_4^-

Chemical cells: 1. See metal couple/redox couple   2. Deduce flow of electrons
                3. Half equations on both sides   4. Further reaction with electrolyte / Colour change

Zinc carbon cell:	$Zn \to Zn^{2+} + 2e^-$ $2NH_4^+ + 2e^- \to 2NH_3 + H_2$ $2MnO_2 + H_2 \to Mn_2O_3 + H_2O$
	Drawbacks: Zinc cup becomes thinner, electrolyte may leak out
	Hydrogen gas produced around graphite rod, form an insulating layer, voltage of cell drops

Fuel cell:	$H_2 + 2OH^- \to 2H_2O + 2e^-$ $O_2 + 2H_2O + 4e^- \to 4OH^-$ Unreacted oxygen/hydrogen, steam
	Porous electrodes: Connect to external circuit, Allow flow of H_2, O_2 and steam, Catalyse reaction
	Adv: Steady supply of electricity, High efficiency of energy conversion, Only Water → Non polluting
	Dis: Not easy to store and transport H_2 and O_2, Very expensive for Pt electrodes and H_2 O_2

Electrolysis:	Preferentially discharge: Position of ions, Conc. of ions, Electrodes (Na/Hg Sodium amalgam)
Purification	Molten or aqueous state	≠2:1 → Some gas dissolved	Add acid: Ionize water into H^+ and OH^-
	Brine: conc. NaCl	Water: Prevent Hg from spilling out	Plating: Cu^{2+} ions replenish, not fade
	Plating coat with Cu: Increase electrical conductivity, Cu is a conductor of electricity
	Plating metal: NOT the object to be plated (NOT key)
	Platinum electrode: Expensive, easily poisoned by Cl_2 gas → Use carbon (graphite from pencil)

Part VIII: Chemical Reactions and Energy   **Part IX: Rate of Reaction**   **Part X: Equilibrium**

Conservation of energy: Energy can neither be created nor destoyed

System: Cup of solution	Surroudings: Beaker, air, lab

Release heat: Exothermic, bond form > bond break, ΔH<0	Combustion, Precipitation, Neutraliaztion
Absorb heat: Endothermic, bond break > bond form, ΔH>0	Cracking, Thermal decomposition of $CaCO_3$

Enthalpy change = Change in internal energy + Work done on surroundings (pressure) (+ve)

Standard conditions: 1 atm, 25°C, 1.0M, Standard states [C (graphite), Red Phosphorus, Oxygen]

MUST WRITE STATES   Thermochemical equation: Normal chemical eqt, add ΔH kJ mol^{-1}

Standard enthalpy change of combustion: Enthalpy change when 1 mol of the substance is completely burnt in oxygen under standard conditions   mcΔt   Always negative

Standard enthalpy change of neutralization: Enthalpy change when 1 mole of water is produced from neutralization between an acid and an alkali under standard conditions Always negative
Weak acid/alkali → Less heat released   Some energy has to be supplied for complete ionization

Standard enthalpy change of formation: Enthalpy change when 1 mole of the substance forms from its constituent elements in their standard states under standard conditions

$$\Delta H^{\ominus}_{c}$$

(Right side graph: H_r reactants, Enthalpy, H_p products)

kJ mol^{-1} RMB ADD ±!!	Errors: Heat loss to surroundings, heat capacity of metal can and thermometer, incomplete combustion, specific heat capacity/density not same as water, not under standard conditions

Formation cannot directly: Highly exothermic, cannot safely carry out, hard to mix well, side products formed

Draw line: When add acid/reactant into system

mol: Number of times reaction occur, X no. of mol of reactants

Hess's law:
Sol 1: Equations
1. List out all equations in ratio, given on top, flip with reference to products and reactants
2. Cross and destroy
3. Sum up

Sol 2: Draw enthalpy cycle, mark down eqt 1234

Sol 3: Identities: Formation: F=P-R   Products - Reactants
                    Combustion: C=R-P   Reactants - Products

Rate of reaction: Change of concentration/time	Instataneous rate: Find slope of tangent of conc-time graph

Following rate: Change in Volume of gas / Pressure / Mass / Color intensity (colorimeter) / Titrimetic analysis

Quenching: Cooling reaction mixture wih ice, diluting reaction mixture → Prevent further changes in conc.
1. Mix solutions   2. At regular time intervals, withdraw small portions using pipette
3. Quench using ice-cold distilled water   4. Titrate the quenched portions against _____

Factors affecting rate: Concentration of reactants, temperature, surface area, presence of catalyst

Effective collision: High enough activation energy (Ea) to break bonds, Correct orientation, chance of collision

Number of effective collision per unit time increase → Rate increase	Slow rate: Like charged ions, hard to react

$S_2O_3^{2-}$ + 2H^+ → SO_2 + S + H_2O	Average rate is inversely proportional to time taken to blot out cross

Catalyst: Increase rate of chemical reaction by lowering Ea of reaction, remains chemically unchanged at the end

Slope decrease: Concentration of reaction decrease	Levels off: Reaction stop, one of the reactants is used up

At eqm: Rate of forward reaction = Rate of backward reaction, NOT STOPPED

No change in concentration of reactants and products

K_c=($[C]^y_{eqm}$ + $[D]^z_{eqm}$)/($[A]^w_{eqm}$ + $[B]^x_{eqm}$) For some temperature	Unit: Cross mol dm^{-3}

ICE Table: RMB Concentrations, NOT VOLUME	Let y: When K_c given, find eqm con

Large K_c: eqm lies to product side	Small K_c: eqm lies to reactant side	Q_c: No eqm

Effects: Concentration / Temperature change / Volume / Pressure

| Concentration:	Reactants/Products conc. ↑: Shift to right/left		K_c Unchanged
Temperature:	ΔH and ΔT 負負得正		K_c Changed
Volume/Pressure:	pV=nRT Find p ±	Shift to side with less/more mol of gas to counter change of pressure	K_c Unchanged

Part XI: Chemistry of Carbon Compounds

meth eth prop but	fluoro chloro bromo iodo	methyl ethyl	cis trans tri tetra	1,1-dichloropropana-1,3-diol

Alkane (Alkyl):	Free radical substitution: Excess → Deduce Major products

Alkene (Alkenyl)	Addition reaction: Add HX X_2 H_2 with Pt	change to haloalkane → Decolourize bromine
	Oxidation by $KMnO_4^-/H^+$ → Form diol	Decolourize solution
Benzene [ring]	Chain polymerization (addition polymerization)	Refer to part 3

Alcohol (hydroxyl)	High boiling point/viscosity: H bond Substitution reaction with PX_3, reflux
	Elimination reaction/dehydration: Form alkene, <mark>dehydrating agent</mark>
	Major product: Most substituted alkene (count more number of alkyl groups attached)
	Oxidation to ketone/aldehyde: Primary/Secondary/Tertiary alcohol
	Distil at boiling point of aldehyde to prevent further oxidation
	Thermometer: Control temperature of vapor to boiling point of alcohol
	<mark>Reflux purpose: Prevent the loss of reactants and products with low boiling point</mark>

Aldehyde/Ketone (carbonyl)	~al ~one	Tollen's reagent / 2,4-dinitrophenylhydrazine

Alkanoic acid (carboxyl)	Higher boiling point than alcohol: Can form more extensive H bond

Ester	Naming: Alcohol (yl) + Acid (oate) Two words Hydrolysis: Turn back to acid and alcohol	
Esterification	Extraction:	1. Heat mixture of ester and NaOH (aq) under reflux Left in flask: methanoate ion, water, NaOH (aq), CH_3OH
		2. Fractional distillation (they have different boiling points Alcohol is evaporated first, Acid can be obtained by adding HCl (distil)

Amine (amino) (RNH_2)	High boiling point: Hydrogen bond	Amide: No need state position, always 1st
Amide (carboxamide) ($CONH_2$)	Boiling point of amide > amine: Presence of C=O increase polarity of amide	

Structural isomerism:	Isomers: Same molecular formula but different structures or different arrangements of atoms Chain/Position/Functional group isomerism
Stereoisomerism: (Cis-trans)	Boiling Point Cis>Trans, polar, stronger van der waals force Draw the cis trans MP T>C, more symmetrical structure, packed more closely, stronger intermolecular forces

Stereoisomerism: (enantiomerism)		Chiral carbon: No double bond, 4 different bonds <mark>Rotate the plane of polarization of plane polarized light, opcially active</mark> Clockwise: +, Anticlockwise: -

Formaldehyde	Chloroform	Acetone	Isopropyl Alcohol	Acetic acid

Detergents: The hydrophobic tails (($CH_2)_n$) of detergent anions dissolve in grease, with the hydrophylic heads (=OO⁻) in water. The surrounding water molecules attract the ionic heads. As a result, the grease is lifted off the surface to be cleansed.

The negatively charged oil droplets repel each other. By stirring, the grease can be broken down into tiny droplets (negatively charged) to form an emulsion

Detergents: Increase wetting power of water, by reducing the surface tension, water spreads over the surface, wetting agent

Saponification (soapy detergents): Made from fats or oil, Na/K salts of long chain COOH acids

triester (fat or oil)   alkali   glycerol   soap

Soapless detergents: made from hydrocarbons derived from petroleum, treat with conc. H_2SO_4 and NaOH (aq) [SO_3^- or OSO_3^- ionic head]

Condensation polymerization: A reaction in which monomer molecules join together to form polymer molecules with the elimination of small molecules   [condensation polymer]
The molecule formed still has unreacted functional groups at both ends. Repeated condensations lead to the formation of a long polymer chain.

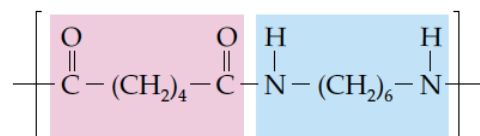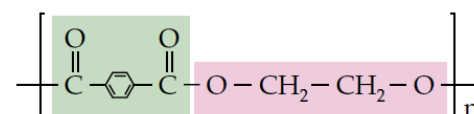| Nylon: Polyamide, containing many amide linkages	
amide linkage R, R' – hydrocarbon chains	n HO—C—R—C—OH + n H—N—R'—N—H → ...nylon (polymer) + 2nH$_2$O dioic acid diamine Nylon 6.6: Hexanedioic acid / hexanediamine / hexanedioyl dichloride → X HCl Polymer: Repeating unit: C—(CH$_2$)$_4$—C—N—(CH$_2$)$_6$—N
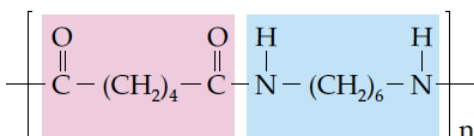
Very strong, elastic, water proof, high tensile strength, very smooth, easy to wash, can be dyed → Make ropes

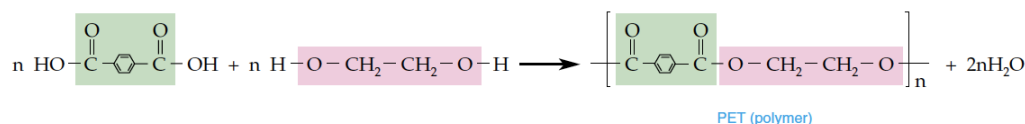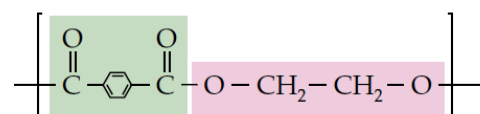| Polyester: Containing ester linkages	PET: Terephthalic acid / Ehane-1,2-diol
ester linkage C—R'—C—O—R—O R and R' are hydrocarbon chains	Polymer: Repeating unit: C—◯—C—O—CH$_2$—CH$_2$—O n HO—C—◯—C—OH + n H—O—CH$_2$—CH$_2$—O—H → ...PET (polymer) + 2nH$_2$O
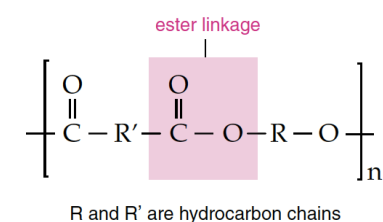
Strong, tough, smooth, resistant to water and chemicals, low density → Make clothes, drink bottles, fibres

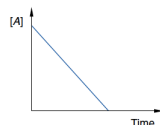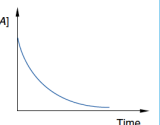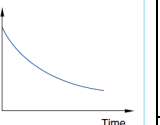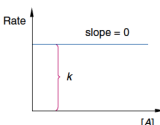| Aspirin (acetylsalicylic acid):

 Painkiller, Relieve pains, reduce fever
 Anti-inflammatory drug
 Blood thinning effect
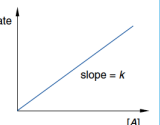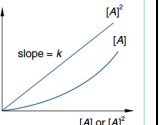
 Side effects:
 Stomach upset, ulcer, increased bleeding | carboxyl group <br> benzene ring <br> ester group
  |
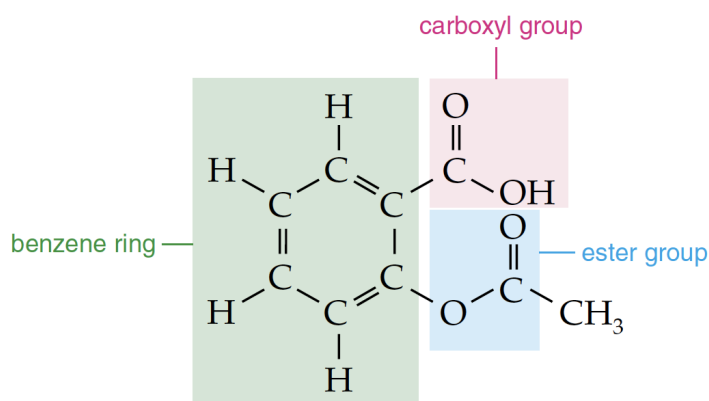
Part XIII: Industrial Chemistry

Rate=k[X]^a[Y]^b	overall order=a+b	k: Rate constant at temp, increases with temp, larger faster reaction

a,b=0,1,2 can only determine from experiment	**Method of initial rate:**
	Repeating the same experiment several times, but using a different initial concentration of a particular reactant

	Zeroth order	First order	Second order
Rate equation	Rate = k	Rate = $k[A]$	Rate = $k[A]^2$
Concentration-time graph			
Rate-concentration graph	slope = 0	slope = k	slope = k
Unit of rate constant, k	mol dm^{-3} s^{-1} M s^{-1}	s^{-1}	mol^{-1} dm^3 s^{-1} M^{-1} s^{-1}

Used because the initial concentrations of reactants are known. When reaction proceeds, the concentrations of reactants at a particular time are not easy to determine.
Repeat the experiment by using reactants of different initial concentrations. For each initial concentration of reactants, a curve showing the rate of change of [???] with time is obtained. A tangent is drawn to each curve at time t = 0. The initial rate can be determined from the slope of the tangent.

A graph of initial rate against initial concentration of [reactants] gives a straight line passing through the origin. The reaction is first order wrt. to reactant.	Catalyst: substance that changes the rate of a reaction without being chemically changed at the end of reaction
Add a small and fixed amount of $S_2O_3^{2-}$ and starch indicator to the reaction mixture.	Chemically unchanged at the end of reaction Needed in very small amounts, Very specific in action, Improved catalytic effect as the surface area increases, Poisoned by small amounts of impurities
Once I_2 is produced, it is consumed immediately. However, when all the added $S_2O_3^{2-}$ has been consumed, any free I_2 immediately forms a dark blue complex with the starch indicator.	Increases the rates of both forward and backward reactions to the same extent. Shortens the time for the reaction to reach eqm. No effect on the eqm position

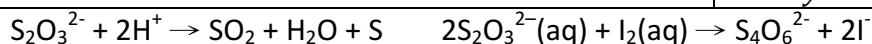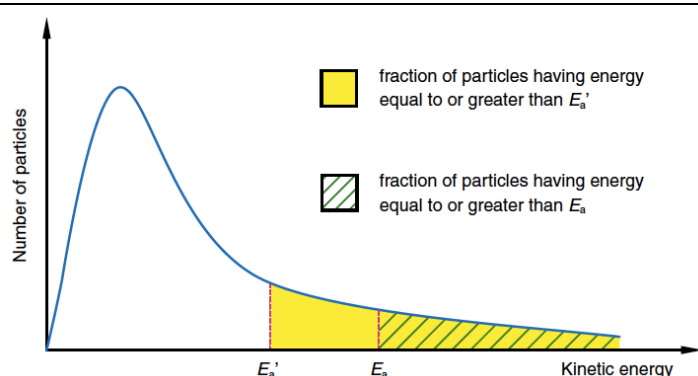|		
The time taken to [blot out the cross / blue black colour to appear] [absorbance of reaction mixture to reach a certain level] is inversely proportional to the rate of reaction / time needed for certain amount of [???] to appear.	T: In Kelvin scale (+273) $$k = Ae^{-\frac{Ea}{RT}}$$ $$\log k = \log A - \frac{Ea}{2.3\,RT}$$ $$y = mx + c$$	$$\log\frac{k_1}{k_2} = -\frac{Ea}{2.3Rt}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)$$ Remember axis 10^{-3} Ea: 5-6 places

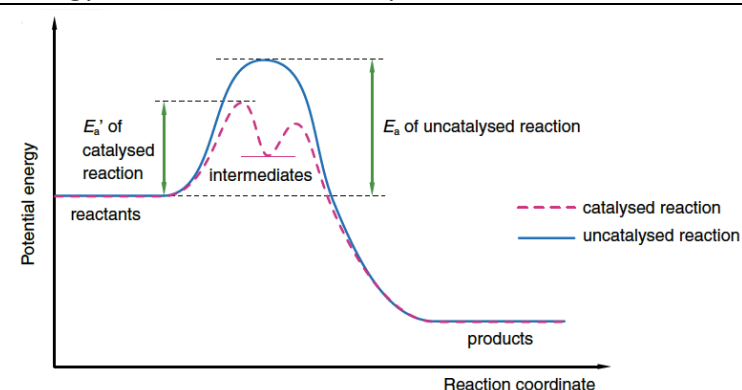| |
|---|
| $S_2O_3^{2-} + 2H^+ \rightarrow SO_2 + H_2O + S$ $2S_2O_3^{2-}(aq) + I_2(aq) \rightarrow S_4O_6^{2-} + 2I^-$ |
| Ea: Min energy needed to start a reaction |
| Temp increase $\rightarrow$ Average KE of particles increase $\rightarrow$ Number of particles having energy $\geq$ Ea increase $\rightarrow$ No. of effective collision per unit time increase $\rightarrow$ Rate increase |

Maxwell Boltzmann Distribution: Distribution of KE	Energy Profile: Lbl reactants, products, intermediate, Ea

Green chemistry:

Less chemical steps, less wate of chemicals

Atom economy: Desired mass / total mass of atoms of reactants $\rightarrow$ Less waste of chemicals

Yield: Acutal yield / Theoretical yield $\rightarrow$ Possible for 100% yield but may have a lot of waste
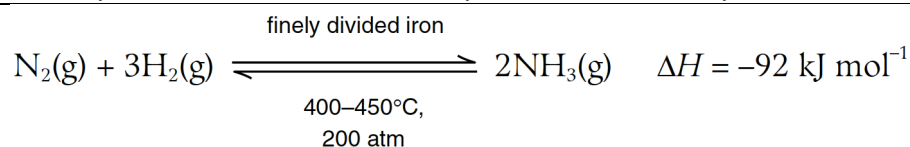
Less hazardous products and reactants / Safer solvents and auxiliaries: Non toxic, non flammable

Renewable/degradable raw materials/products

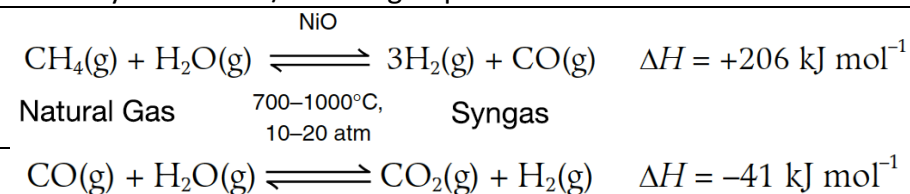Reducing derivatives: Avoid chemical syntheses that require protection of functional groups

Energy efficiency / Using catalysts: Lower activation energy, use less fuels   OR   heavy metals $\rightarrow$ toxic catalyst

Haber process: Produce fertilizers, provide nutriens to plants to enhance plant growth

finely divided iron

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \qquad \Delta H = -92 \text{ kJ mol}^{-1}$$

400–450°C, 200 atm

Nitrogen: Fractional distillation of liquid air
Hydrogen: Steam methane reforming → Water gas shift reaction / Electrolysis of brine / Cracking of petroleum

NiO

$$CH_4(g) + H_2O(g) \rightleftharpoons 3H_2(g) + CO(g) \qquad \Delta H = +206 \text{ kJ mol}^{-1}$$

Natural Gas   700–1000°C,   Syngas
                   10–20 atm

$$CO(g) + H_2O(g) \rightleftharpoons CO_2(g) + H_2(g) \qquad \Delta H = -41 \text{ kJ mol}^{-1}$$

Production of fertilizers:
- Ostwald process: Nitric acid
  - $4NH_3 + SO_2 \rightarrow 4NO + 6H_2O$
  - [Pt, 900°C, 200atm]
  - $2NO + O_2 \rightarrow 2NO_2$
  - $4NO_2 + O_2 + 2H_2O \rightarrow 4HNO_3$
- NH_4SO_4
- NH_4NO_3: Explosive
- Uera:
  - $2NH_3 + CO_2 \rightarrow H_2NCOONH_4$
  - $H_2NCOONH_4 \rightarrow (NH_2)_2CO + H_2O$

Volume ratio of $N_2 : H_2 = 1 : 3$
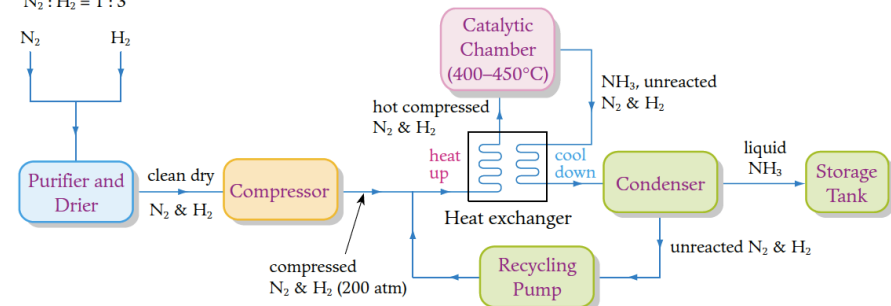
Purifier: Remove imputities, remove water from steam-methane reforming	
Compressor: Increase pressure, rate	
High pressure: Eqm shift to right, higher concentration and rate but higher maintenance cost	
Low temperature: Eqm shift to right But slow rate, "as a compromise"	
Catalyst: Speed up reaction, yield const.	

Chloroalkali Industry: Produce NaOH → Soaps, Cl_2 → PVC, H_2 → Rocket fuel	HCl / Bleach ($Cl_2 + NaOH \rightarrow OCl^-$)
Flowing mercury cell: Brine (conc. NaOH) flow	Mercury: Prevent NaOH from reacting with Cl_2

| Anode: (Titanium or graphite → Resistant to Cl attack): $2Cl^- \rightarrow Cl_2 + 2e^-$		Sodium amalgam
Cathode: (Mercury): $Na^+ + e^- + Hg \rightarrow Na/Hg$ (l)	Na/Hg(l) + $2H_2O \rightarrow 2NaOH(aq) + H_2(g) + 2Hg(l)$	

Mercury may vaporize in the laboratory. Prolonged inhalation may lead to mercury poisoning. Cl gas is toxic. Distilled water is produced from distillation of sea water, which is an energy consuming process

Membrane cell: Ion-permeable membrane, prevent products from mixing together, only allow passage of Na^+
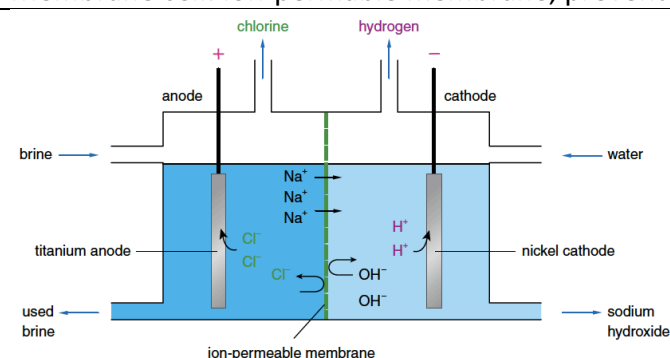

Anode (Titanium): $2Cl^- \rightarrow Cl_2 + 2e^-$
Cathode (Nickel): $2H^+ + 2e^- \rightarrow H_2$

Does not contain poisonous mercury
Requires a lower voltage to operate
No sodium chloride impurity

The membrane in the set up only allows cations to pass through. Therefore, Na^+ in the anode compartment passes through the membrane. On the other hand, H^+ ions were reduced and discharge at the cathode compartment. Thus, OH^- ions left behind. Therefore high concentration of NaOH forms at cathode compartment

Production of methanol: As a fuel, solvent, feedstock for chemical industry. $CH_4 \rightarrow$ Methanol (easier to store)

1. Remove any sulphur impurity (desulphurization), steam methane reforming (refer to Haber process)
2. Conversion of syngas to ethanol, unreacted gases and heat are recycled

Cu/ZnO/Al₂O₃

$$CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g) \qquad \Delta H = -90 \text{ kJ mol}^{-1}$$

1 : 2   250°C, 50–100 atm
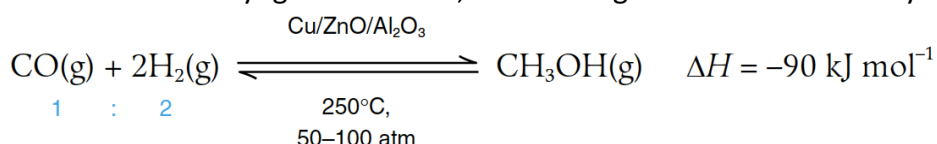
3. Distillation of liquid products to give pure methanol

Lower pressure → Lower maintenance cost	Use of catalyst → Lower cost of fuel, lower operating temp	
Recycling of unreacted feedstock or heat energy	Ammonia, Chlorine, Methanol are toxic	
Use low-NO_x burners	Use natural gas instead of coal → less SO_2	Recycle and convert CO to methanol

Part XV: Analytical Chemistry

Crystalisation (separation/purification):

Crystallization by slow cooling a hot saturated solution:
To obtain crystals from an aqueous solution, we may concentrate the solution by boiling away some water from it until it becomes saturated. As a hot saturated solution cools down, the solvent can no longer dissolve all of the solute. The extra solute comes out as crystals

Recrystalization:
1. Dissolve the crude solid product in a minimum amount of hot solvent $\rightarrow$ saturation
[Water, ethanol and propanone (acetone)]. Filter to remove the insoluble impurities.
2. Allow the filtrate to cool slowly to form crystals. (only saturated solute crystalize)
3. Collect the crystals by suction filtration under reduced pressure using a Buchner funnel connected to a suction pump. Wash with a little cold water to remove any soluble impurities. Dry the crystals in an oven.
[When the pump is turned on, the pressure inside the filtering flask is reduced. The solution is sucked through the filter paper. The crystals remain on filter paper]

Simple/Fractional distillation: Obtain lower boiling point first	Vapourize/condense on cold surface

Obtain a solvent from a solution containing solutes with high boiling points.
Separate a mixture of two or more liquids with a great difference in boiling points.

If two miscible liquids have close boiling points (usually with boiling point difference between 10°C and 25°C), separation by simple distillation is incomplete or ineffective. For fractional distillation to be effective, the difference in boiling points of the liquids in the mixture must be greater than 10°C.

The beads provide a large surface area for repeated vaporization and condensation of the mixture.

Liquid-liquid extraction: extraction of a substance from one liquid to another immiscible liquid:
1. Add the mixture into a separating funnel and add sodium hydrogen carbonate solution to it and mix well
(release the gas pressure developed by opening the stopcock of the separating funnel after each shaking)
2. Allow mixture to stand until distinct layers are formed. Collect the aqueous layer which contain sodium ???
3. Add excess HCl to regenerate ??? acid from aqueous layer.
4. Filter off the aquaous layer and collect the residue.

Chromatographic methods: Paper / Thin layer / Column chromatography (eluting solvent) (SiO_2 or Al_2O_3)	
Rf value: <0, base line / solvent front	Invisible: Spray ninhydrin solution onto chromatogram / UV

Stationary/mobile phase: Absorbed water on paper / Developing solvent $\rightarrow$ Greater speed, smaller amount

The components have different solubilities in the mobile developing solvent and stationary phase
The components that are more soluble in the mobile phase/developing solvent move faster.

Purity by mp: To determine the melting point of a solid, place a little of the dry powdered solid in a thin-walled glass melting point tube with paraffin oil. The tube is attached to a thermometer. Then heat the paraffin oil gently. A pure solid has a sharp melting point and melts over a very narrow temperature range.

Purity by bp: simple distillation apparatus, thermometer in liquid, water bath, pure $\rightarrow$ narrow boiling range

Advanced titration: Conductivity (conc. of mobile ions), colour change

Test end of reaction: Retain some portions and allow large period of time, perform titration again, consitent

Standard solution: Large formula mass, stable in air, high solubility, involatile, does not react with surroundings

Starch solution/Iodine: Colourless to blue-black	Methyl orange: Red to orange

Instrumental analytical methods:	Colour must be intense enough
Colorimetry: Light absorbance, compare to calibration curve	Filter: Absorb some colour to the greatest extent

Use colorimeter to measure absorbance of reaction mixture at diff. time, directly proportional to concentration

Infrared spectrum: <1500: Fingerprint reigon, unique to all compounds, identify different functional groups
From the IR spectrum, the presence of a sharp absorption peak at [??]cm^{-1} indicates the presence of a [??] group

Mass spectrum: Frament/molecular ion, determine relative molecular mass   m/e can have isotopes (e.g. ^{2}H)
Short analysis time, very few sample needed, whatever state, high accuracy
From the mass spectrum, the peak at m/e = [??] corresponds to [???]$^+$

Alkane:	Aldehyde/Ketone:	m/e=91: $[C_6H_5CH_2]^+$

Part ∞: Diagrams and Setup

hydrogen

water

inverted funnel

calcium

wet sand

magnesium ribbon

delivery tube

hydrogen

water

heat

trough

glass rod

a mixture of sand and sea water

filter paper

residue

filter funnel

filtrate

thermometer

clamp

boiling tube

delivery tube

sea water

receiver test tube

heat

anti-bumping granule (to prevent 'bumping' of solution)

water (cooling agent)

end of delivery tube should be *above* the distillate

pure water (distillate)

sea water

evaporating dish

steam

beaker

water

tripod

heat

thermometer

3 Indicate the correct direction of water flow in the condenser

1 Place the bulb of the thermometer near to the side-arm of the still head

water out

Liebig condenser

4 Make sure that the set-up is open to air

sea water

anti-bumping granule

water in

heat

2 Indicate the heat source by adding an upward arrow and the word 'heat'

pure water

crucible

pipe-clay triangle

mixture of carbon and lead(II) oxide

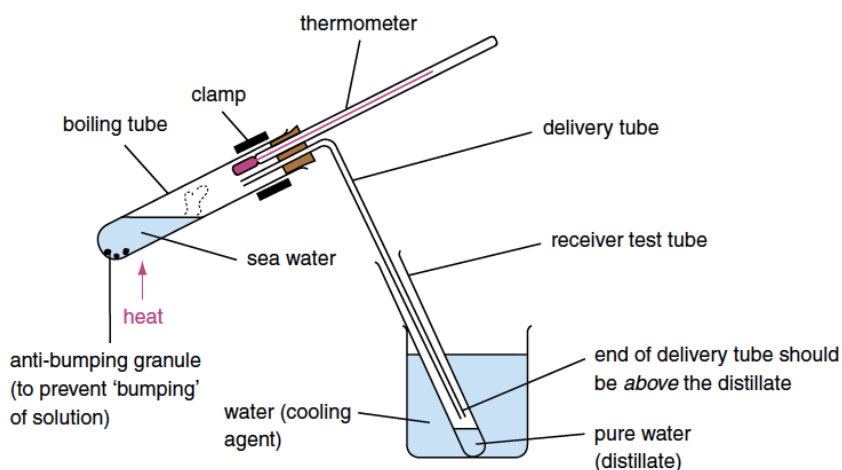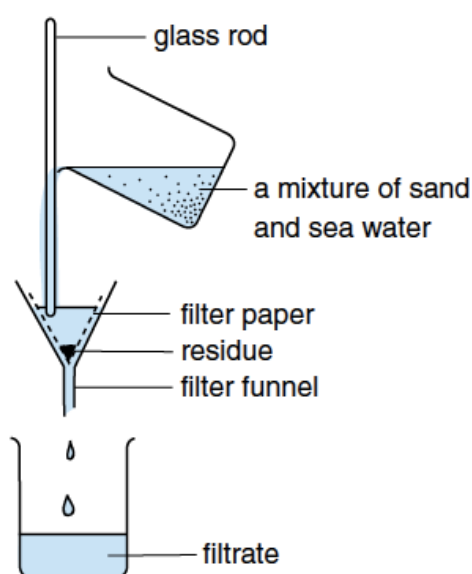tripod

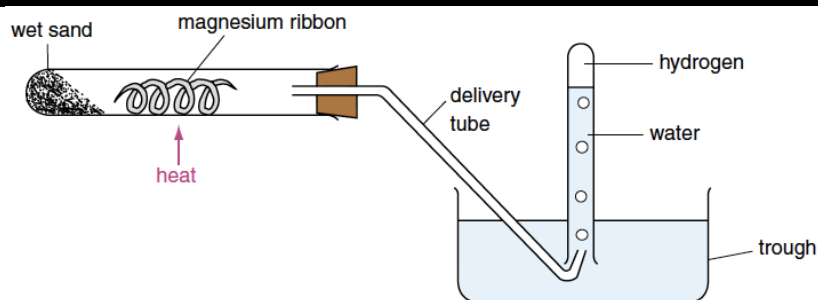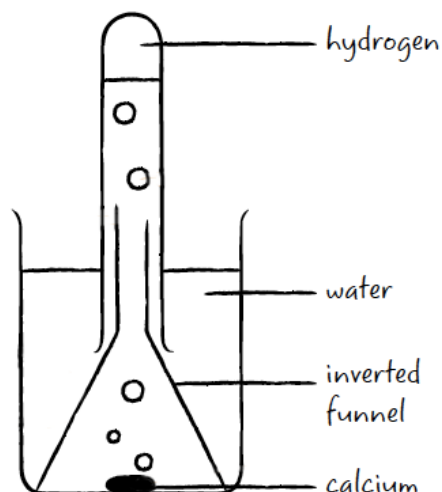heat

delivery tube

carbon dioxide

calcium carbonate

limewater

heat

Figure 4.18 Test for carbon dioxide using limewater.

Figure 12.4 To find the empirical formula of an oxide of magnesium by heating magnesium in air.

crucible
pipe-clay triangle
magnesium ribbon
rocksil
tripod
heat very strongly

stand
acid solution
burette
conical flask
white tile
aqueous alkali

oxide of copper
hole
excess town gas burns here
town gas supply
heat
combustion tube

thermometer
mineral wool soaked with petroleum
delivery tube
heat
ice
water
petroleum fraction

glass wool soaked with liquid paraffin
broken pieces of unglazed porcelain
products
Give the correct position of heating
Else may not be hot enough
strong heat
water

water out
water in
mixture of ethanol, ethanoic acid and conc. H_2SO_4
anti-bumping granules
heat

① Indicate the correct direction of electron flow in the external circuit

electron flow

② A voltmeter (or light bulb), but NOT an ammeter is drawn

V

magnesium

copper

③ Make sure that the electrodes are immersed in the electrolyte, but NOT totally immersed

electrolyte (e.g. dilute sulphuric acid)

---

d.c. power supply – in the laboratory, a battery is often used. This acts as an 'electron pump'.

ammeter – used to measure the electric current passing through the circuit. The unit of current is ampere, A.

A

+ −

variable resistor – used to vary the resistance of the circuit, hence to regulate the current.

anode

cathode

−)))

+ (((

−)))

+ (((

electrolyte (in molten state or aqueous solution)

anion

cation

Figure 32.2 A basic set-up for electrolysis.

---

thermometer

water out

condenser

fractionating column

glass bead

water in

petroleum

anti-bumping granule

heat

ice

water

petroleum fraction

---

load

e^-

e^-

−

+

hydrogen

oxygen

H_2O

porous electrode (anode)

K^+

porous electrode (cathode)

unreacted hydrogen and steam

OH^-

unreacted oxygen

hot concentrated potassium hydroxide solution as electrolyte

---

voltmeter

electron flow

V

connecting wire

salt bridge (soaked in $KNO_3(aq)$)

magnesium

copper

magnesium sulphate solution

copper(II) sulphate solution

thermometer

calorimeter

water

flame

ethanol

thermometer

stirrer

lid

expanded polystyrene cup

beaker

HCl(aq) + NaOH(aq)

cotton wool

stopwatch

cotton wool plug

solid MnO_2

measured volume of standard H_2O_2(aq)

120.50 g

electronic balance

stopwatch

rubber connecting tubing

plunger

cotton thread

gas syringe

magnesium ribbon

dilute hydrochloric acid (usually an excess is used)

pressure sensor

suction flask

dilute hydrochloric acid

magnesium ribbon

thermometer

clamp

stirrer

boiling tube

rubber band

melting point tube

test sample

paraffin oil

heat

Buchner funnel

filter paper disc

clamp

to water pump

rubber tubing

Buchner flask

filtrate

stand

1. You are provided with common laboratory apparatus and rust indicator gel. Design experiments to investigate the following factors that influence rate of rusting.
    Temperature   Connection with metals with lower reactivity

2. Design an experiment to show the role of water in exhibiting properties of acids.

    Dissolve solid citric acid in 1,1,1-trichloroethane and solid calcium carbonate in it. There should be no observable change. Dissolve solid citric acid in 50cm^3 water and add solid calcium carbonate in it. There should be colourless gas bubbles formed as citric acid can ionize in water to give H$^+$, and the reaction
    $2H^+ + CO_3^{2-} \rightarrow H_2O + CO_2$ gives gas bubbles.

3. Aluminium hydroxide is the active ingredient in a drug tablet. Aluminium hydroxide is insoluble in water. Describe an experiment using back titration to determine the mass of aluminium hydroxide in the drug tablet.

    Dissolve a drug tablet in a certain volume (excess) of hydrochloric acid of known concentration. Place the resulting solution in a 250.0 cm^3 volumetric flask and make up to 250.0 cm^3 with distilled water. The excess hydrochloric acid added will react with all the aluminium hydroxide in the drug tablet.
    Titrate 25.0 cm^3 portions of the diluted solution against standard sodium hydroxide solution using a suitable indicator. Record the volume of sodium hydroxide solution required to reach the end point each time.
    The amount of acid left over after reaction is determined from the data obtained from the titration.
    The acid used up by the aluminium hydroxide is the acid originally added minus the acid left over.
    By comparing the mole ratio for the reaction between aluminium hydroxide and hydrochloric acid, the number of mole of alumiumium hydroxide, and hence its mass can be calculated.

4. Describe how you would electroplate silver on an iron object.

5. You are provided with the following materials and equipment: strips of filter papers, graphite rod, saturated potassium nitrate solution, saturated sodium sulphite solution, potassium permanganate, sodium dichromate, digital multimeter, connecting wires, common laboratory apparatuses (including glasswares, electronic balance, deionized water, etc.)

    Outline how you would perform a fair experiment to compare the oxidizing power of potassium permanganate and sodium dichromate. (Details of the manipulation of the common laboratory apparatuses is not required)

    Prepare a beaker of potassium permanganate solution. Insert a graphite rod in potassium permanganate solution and connect the rod to the (positive terminal of) digital multimeter.
    Connect another graphite rod to the (negative terminal of) digital multimeter, dip it into a beaker of saturated sodium sulphite solution.
    Prepare a salt bridge by soaking a filter paper strip with saturated potassium nitrate solution, connect the two beakers of solution with the salt bridge.
    Measure the voltage of the cell by using the digital multimeter.
    Repeat the experiment by replacing the solution with sodium dichromate solution with same concentration. (Accept "same depth of graphite rod immersed in the solution in each case". DO NOT accept irrelevant controlled variables like: volume of solution, size of the beaker…etc.)
    The larger the (absolute) voltage of the cell, the higher is the oxidizing power.

6. Design an experiment to determine the standard enthalpy change of acid-base neutralization.

Mix 50 cm^3 of 1M HCl(aq) and 50 cm^3 of 1M NaOH(aq) in a polystyrene cup.
Measure the maximum temperature rise ($\triangle$T) of the reaction mixture.
Calculate the amount of heat given out by the following equation:
E = mc$\triangle$T
Divide the amount of heat by the number of mole of water(0.05mol) formed in the reaction to get the standard enthalpy change of neutralisation.
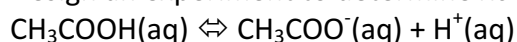$\triangle$H = -(100 x 4.2 x $\triangle$T / 0.05)

7. Design an experiment to determine the standard enthalpy change of combustion of CH_3CH_2OH.
The standard enthalpy change of combustion of CH_3CH_2OH is the enthalpy change when 1 mole of CH_3CH_2OH is completely burnt in oxygen under standard conditions. Preweigh the mass of ethanol lamp. Burn the ethanol to heat up 50cm^3 of water in a calorimeter. Measure the temperature rise of the water. Weigh the ethanol lamp again and calculate the no. Of mol of ethanol burnt. Calculate the amount of heat released per mol of ethanol to obtain the standard enthalpy change of combustion.

8. Design an experiment to determine Kc of the following chemical equilibrium
$CH_3COOH(aq) \Leftrightarrow CH_3COO^-(aq) + H^+(aq)$
Dissolve 0.1 mole of ethanoic acid in 100cm^3 of water.
Allow the solution to settle and reach equilibrium at room temperature.
Measure the pH of the solution to find the equilibrium concentration of H^+(aq). (x moldm^{-3})
The equilibrium concentration of CH_3COOH and CH_3COO^- can be calculated by comparing the coefficients in the chemical equation.
($CH_3COOH = (1-x)$mol dm^{-3} and $CH_3COO^- = x$ mol dm^{-3})
The value of $K_c = [CH_3COO^-(aq)]_{eqm}$ x $[H^+(aq)]_{eqm}$ / $[CH_3COOH(aq)]_{eqm}$

9. You are provided with common laboratory apparatus, H_2O_2 solution and some MnO_2. Outline how you would perform a fair comparison in studying the effect of [i. concentration, ii. temperature, iii. surface area, and iv. Catalyst] on the rate of production of O_2 from the following reaction:
$2H_2O_2(aq) \rightarrow 2H_2O(l) + O_2(g)$
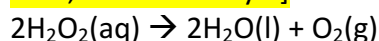
2014

*10. You are provided with common laboratory apparatus, calcium carbonate and 1M hydrochloric acid. Outline how you would perform a fair comparison in studying the effect of different concentrations of acid on the rate of production of carbon dioxide from the following reaction:
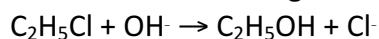
$CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + H_2O(l) + CO_2(g)$

(5 marks)

10. • Proper way to follow the progress of the reaction (e.g. measure the volume of CO_2 evolved / measure the loss in mass of the reaction mixture over a certain time interval / measure the pressure of the CO_2 formed in a sealed reaction vessel.) (accept graphical representation) (no communication mark if no description about "time")   1
    • Dilute 1M HCl to different concentrations by adding water.   1
    • Repeat the experiment with the diluted HCl
    • State one requirement for carrying out fair comparison (e.g $CaCO_3$ used should be of the same   1
      amount / under same experimental conditions such as same temperature or pressure)   1
    • Communication mark
      (chemical knowledge = 0 to 2, communication mark = 0   1
      chemical knowledge = 3 to 4, communication mark = 0 or 1
      incomplete answer / difficult to understand, communication mark = 0)

10. You are provided with common laboratory apparatus, 1M HCl(aq) and some magnesium ribbon. Design an experiment to find the molar volume of gas under room temperature and pressure.

Dissolve a known amount of Mg ribbon in excess HCl in an air tight conical flask connected to a gas syringe.
The following reaction will be carried out: $Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$. Record the volume of H_2 given out when the Mg ribbon is completely dissolved. The number of mole of H_2 given out can be calculated by comparing the coefficient of Mg : H_2 in the chemical equation shown above. Finally, the molar volume of H_2 can be calculated by: Volume of H_2 given out from the reaction / no. of mole of H_2 produce from the reaction.

11. Consider the following reaction:
$C_2H_5Cl + OH^- \rightarrow C_2H_5OH + Cl^-$
Outline a chemical method that can monitor the progress of the reaction.

Mixed known volume of standard C_2H_5Cl and NaOH.
At regular time interval, withdraw 10 cm^3 of sample from the reaction mixture and transfer to a clean conical flask with ice-cold distilled water.
Titrate the sample solution with known concentration of H_2SO_4 with methyl orange as an indicator.

12. Describe how you can show experimentally Fe^{2+} is a positive catalyst of the reaction. State the reagents used and measurements you take.

Prepare two beakers of [???] solutions of the same volume and molarities. Add a few drops of $FeSO_4$ into one beaker only. Add the same known amount of [???] and [starch indicator?] into the beakers. If it takes longer for a [blue black colour?] to appear without $FeSO_4$, Fe^{2+} is a positive catalyst.

2012

Outline the steps in preparing solid lead (II) sulphate from solid lead (II) nitrate. You have to state the additional chemical reagents that are required, but need not mention the apparatus involved. (4 marks)