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CHEMISTRY NOTES FOR IGCSE

By Sarah Jamil

Topic 1

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The Particulate Nature of Matter

Impurities lower the melting point or freezing point and increase the boiling point of a substance

Topic 2

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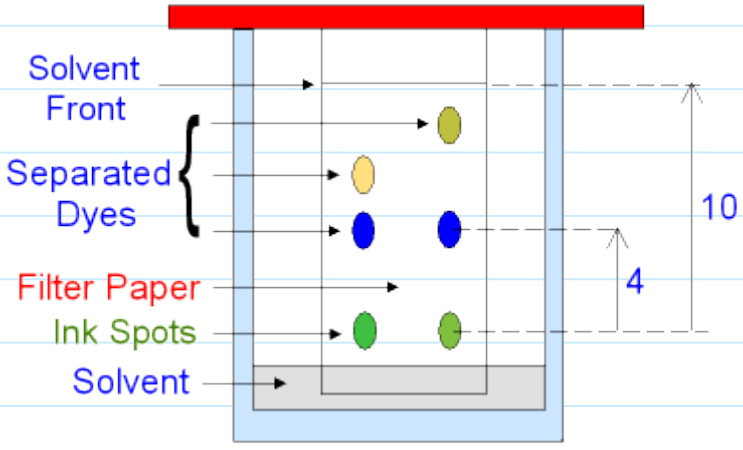
Methods of Separation

1. Filtration/ Decanting
2. Evaporation
3. Crystallization
4. Selective Solubility
5. Magnet
6. Simple Distillation
7. Separating Funnel
8. Fractional Distillation
9. Paper Chromatography
10. Diffusion

Solid + Solid = 4,5
Solid + Liquid = 1,2,3,6
Liquid + Liquid = 7,8
Liquid = 9
Gas + Gas = 10

Paper Chromatography



Rf= Distance moved by compound/ Distance moved by solvent front

Topic 3

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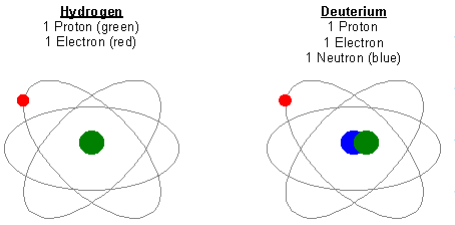
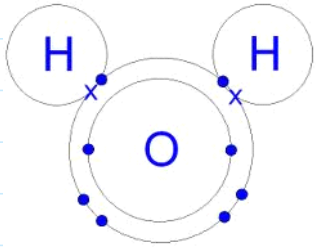
Atoms, Elements, and Compounds

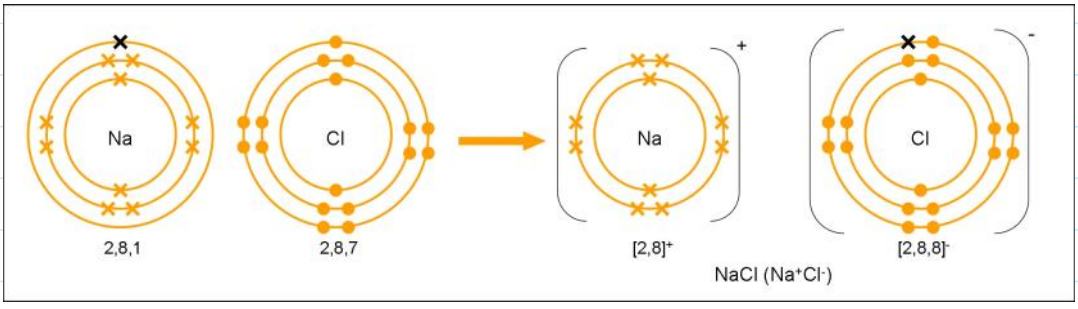
Isotope- atoms of the same element with the same number of protons and electrons, but with a different number of neutrons.



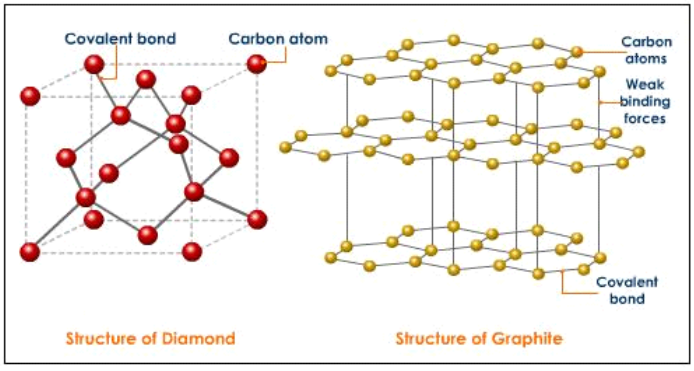
Covalent Bonding- between a NON METAL and a NON METAL.



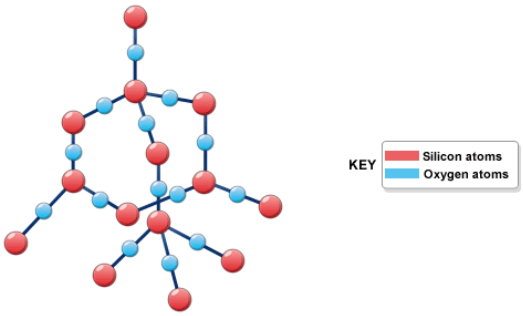
Ionic Bonding- between a METAL and a NON METAL. The metal loses electrons and the non metal gains electrons.



Allotropes- Different structures of the same element with different physical properties.
e.g. graphite and diamond.



Silicon IV Oxide Structure



Metallic Bonding- a lattice of positive ions in a sea of electrons

Topic 4

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Stoichiometry

Percentage yield= actual yield / theoretical yield

$n = \frac{v}{24}$ $n = c \times v$ $n = \frac{m}{mr}$

How to find empirical formula

Find mass of elements
Find moles by dividing by mr
Divide number of moles by the smallest number to get ratio

e.g.	Carbon		Hydrogen
mass	80 g		20 g
Mr	12		1
	6.67		20
	6.67		6.67
ratio	1	:	3

so empirical formula is CH3

How to find molecular formula

Find Mr of compound using empirical formula.
Divide this by the formula mass of the compound.
So the formula is : $\frac{\text{Formula Mass}}{\text{Mr of comp}}$

e.g. Formula mass for a compound is 30. It's empirical formula is CH3. What is it's molecular mass?

Mr of compound = 15
So 30/ 15 = 2 so molecular formula is C2H6

Finding the mass of a substance using mole ratio

Find the mole ratio
Find n of substance with known values
Multiply the number you get with the mole ratio
Multiply the Mr of each substance to the number you get to get mass

e.g. In the complete combustion of methane, what mass of oxygen combines with 64 g of methane and how much carbon dioxide is produced?

$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$

Mr of CH_4 = 16
N of CH_4 = 64 g/ 16 = 4

1 2 1 2
4 8 4
x 32 x 44 ← x Mr to get mass
=256 = 176

So 256 g of O_2 and 176 g of CO_2 combine with 64 g of CH_4

Calculating the volume of a solution in a reaction

Find the mole ratio
Find n of the known substance
Multiply the number you get with the mole ratio
Divide by the concentration to get volume

e.g. What volume of 0.5 mol/dm³ hydrochloric acid reacts with 0.12 g of magnesium?

$Mg + 2HCl \rightarrow MgCl_2 + H_2$

1 2 ← n of Mg = 0.12/ 24 = 0.005
0.005 0.01
0.5 ← divide by c to get v

0.01/ 0.5 = 0.02 dm³ x 1000
So 20 cm³ of 0.5 mol/dm³ hydrochloric acid reacts with 0.12 g of magnesium.

Topic 5

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Electrolysis

In a concentrated solution always take the halogen instead of the hydroxide ion, but in a dilute solution, do the opposite.

Electrolysis of copper with copper electrodes, the anode is impure and the cathode is pure. The copper in the anode dissolves, and a layer of pure copper builds up on the cathode

When you have hydrogen or a metal at the cathode, if the metal is more reactive than hydrogen, hydrogen is formed. If it's less reactive than hydrogen, the metal forms.

In electroplating the object to be plated is at the cathode, the metal to plate with is the anode, and the electrolyte is the anode metal nitrate.

Extracting aluminium

Bauxite ore is purified (Al_2O_3)
Alumina is dissolved in cryolite to lower melting point.
Electrolysis using carbon electrodes is carried out.

Topic 6

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Chemical Energetics

ΔH =Heat of product - Heat of reactant.
If product is negative the reaction is exothermic, if positive, endothermic.

Exo= combustion, neutralization.
Endo= photosynthesis, thermal decomposition.

Topic 7

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Chemical Reactions

If you increase anything on the left side of the reaction (except temperature and pressure), equilibrium will shift to the right, and vice versa for increasing anything on the right.

If heat is on the left side of the equation, the reaction is endothermic, and exothermic for opposite.

In an exothermic reaction if you decrease the temperature, the equilibrium will shift to the right. In an endothermic reaction if you decrease the temperature, the equilibrium will shift to the left.

Topic 8

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Acids, Bases, and Salts

Calcium is insoluble in sodium hydroxide and ammonia.
Zinc is soluble in both NaOH and NH3
Aluminum is soluble in NaOH but insoluble in NH3

To make a insoluble salt, use an soluble reactant. Take A from a nitrate, and B from sodium.
e.g. To prepare calcium fluoride, take calcium nitrate and sodium fluoride

To make an soluble salt, use a insoluble reactant. Use titration or precipitation.

Metal oxide and hydroxide plus acid gives salt plus water
Metal carbonate plus acid gives salt plus carbon dioxide plus water
Metal plus acid gives salt plus hydrogen

All G1 salts are soluble
All ammonium salts are soluble
All nitrates are soluble
All chlorides are soluble except lead and silver chloride
All sulphates are soluble except calcium, barium, and lead sulphate
All carbonates are insoluble except G1 or ammonium carbonates

Topic 9

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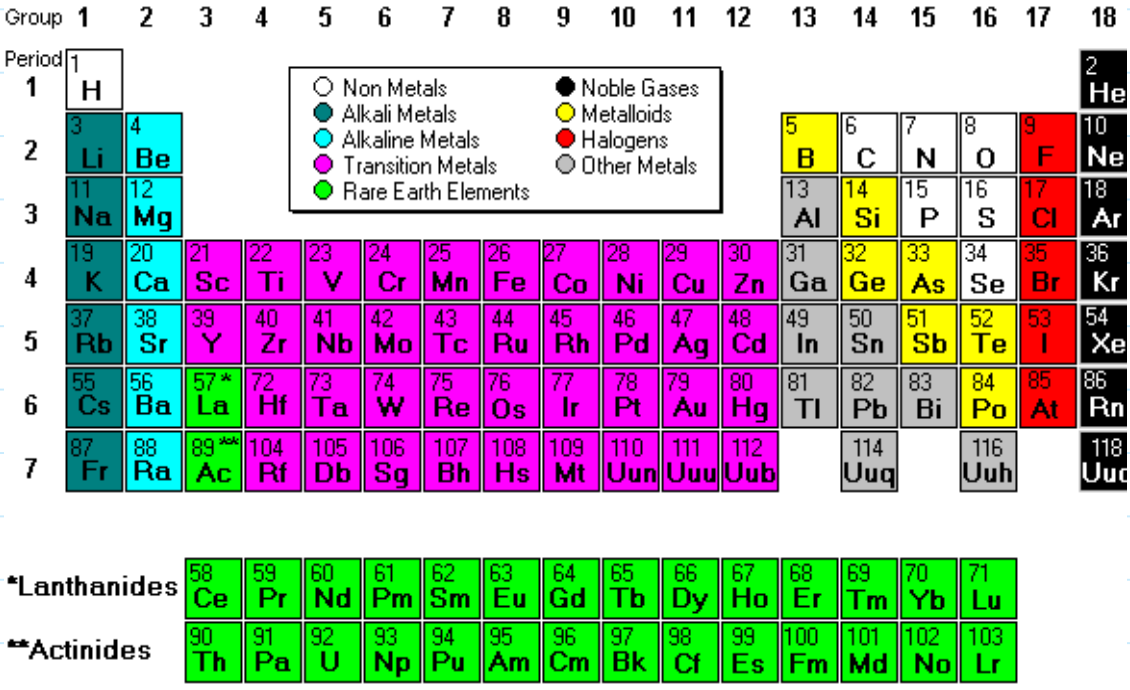
Periodic Table



Topic 10

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Metals

Reactivity Series

K
Na
Li
Ca
Mg
Al
C
Zn
Fe
Pb
Cu
Ag
Au

If metals react with cold water they form hydroxides. If they react with steam they form oxides.
When metals react with cold water, steam, or acids, they always form hydrogen.

Thermal decomposition of metal carbonate gives metal oxide plus carbon dioxide.
Thermal decomposition of metal hydroxide gives metal oxide plus water(except G1!).
Thermal decomposition of G1 nitrates gives G1 metal nitride plus oxygen.
Thermal decomposition of metal nitrate gives metal oxide plus nitrogen dioxide plus oxygen

Extraction of zinc

The ore is zinc blende(ZnS)
Zinc blende is burnt in oxygen to form sulphur dioxide and zinc oxide.
The zinc oxide is reduced by coke to give zinc and carbon dioxide.

Extraction of iron

Takes place in blast furnace.
Raw materials: limestone, haematite, and coke.

1. Coke burns with oxygen to form carbon dioxide
2. The carbon dioxide reacts with coke to form carbon monoxide
3. The carbon monoxide reacts with the haematite to form iron and carbon dioxide
4. The limestone decomposes to calcium oxide and carbon dioxide
5. The calcium oxide reacts with the impurities (SiO_2) to form slag ($CaSiO_3$)

Uses of zinc

Galvanizing
Making brass
Sacrificial protection

Uses of copper

Hot water pipes- coz it cant reduce water
Electric wires
Making brass

Uses of aluminium

Airplane bodies- low density, strong, no corrosion
Containers- non toxic
Cans- non toxic
Overhead cables- low density, strong, ductile.

Voltaic Cell

Cell- a device that convert chemical energy to electrical energy.
Direction of electron flow is always from less reactive metal to more reactive metal.
Anode: More reactive metal
Cathode: Less reactive metal

To increase voltage

Increase concentration of electrolyte
Use two metals that vary greatly in the reactivity series

What happens to electrodes

Anode: gets thinner (more reactive)
Cathode: gets thicker OR stays the same with bubbles (less reactive)

e.g. when the anode reacts with sulphuric acid it forms hydrogen and zinc sulphate and the hydrogen bubbles. OR the zinc is oxidised and hydrogen reduced, so hydrogen is the oxidising agent and it gains electrons so the cathode gets thicker.

Oxidising agent : gains electrons but gets reduced
Reducing agent: loses electrons but gets oxidised

To prove metal X is more reactive than Y

Metal X gets thinner
Metal X reacts with hydrogen

Cathode gets thicker when electrolyte has same metal as anode e.g. Cu and CuSO4

Topic 11

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Air and Water

Pollutants in air

Pollutant	Source	Harmful Effect	Solution
Carbon Monoxide	Incomplete combustion of fuel.	Takes O2 from cells, causes death.	Use catalytic converter in car.
Sulphur Dioxide	Burning coal, factories, combustion of sulphur based fuel.	Acid rain.	Uses a catalytic converter in chimney.
Oxides of Nitrogen	Car engine, under high temp and pressure N2 reacts w/ O2 to form oxides of nitrogen.	Acid rain.	Use a catalytic converter in car.
Lead Vapour	Combustion of leaded petrol.	Causes brain damage in young children	Use unleaded petrol.

Haber Process

Conditions-

Catalyst Vanadium (V) Oxide
Temp 450°C
Pressure 200 atm

Reaction-

$N_2 + 3H_2 \rightleftharpoons 2NH_3 + Heat$

To recycle gases pass them over the catalyst again.

Reaction in catalytic converter

$2CO + 2NO \longrightarrow N_2 + 2CO_2$

Uses of ammonia

Making nitric acid
Making fertiliser

Uses of oxygen

Oxyacetylene flame
In hospitals
Making steel

Topic 12

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Sulphur

Contact Process

Conditions-

Catalyst Iron
Temp 450°C
Pressure 2 atm

Reactions-

reversible

$S + O_2 \rightarrow SO_2$
$2SO_2 + O_2 \rightarrow 2SO_3 + heat$
$SO_3 + H_2SO_4 \rightarrow H_2S_2O_7$
$H_2S_2O_7 + H_2O \rightarrow 2H_2SO_4$

Uses of SO_2

Making paper (bleaches wood pulp)
Food preservative (kills bacteria)
Making sulphuric acid

Uses of H_2SO_4

Making paints
Making fertilisers
Making detergents
In car batteries

Topic 13

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Carbonates

CaO- quicklime/lime
CaCO3- limestone
Ca(OH)2$_{(s)}$- slaked lime
Ca(OH)2$_{(s)}$- limewater

All G1 carbonates don't decompose except lithium carbonate, and all metal carbonates decompose to form MO and CO2.

CaO and CaCO3 are used to neutralise soil acidity coz they are insoluble and slightly soluble respectively so they don't get washed away

Heat limestone to get lime, add a little water to it to get slaked lime, add even more water to get limewater, add carbonic acid get limestone.

Topic 14

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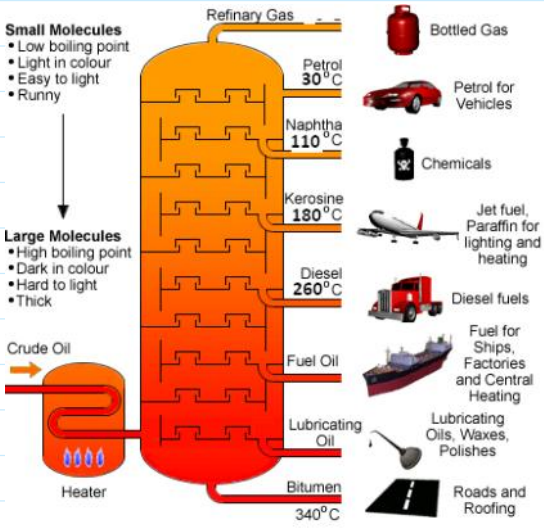
Organic chemistry



Monomer- a small molecule that can be polymerised into a polymer.

Isomer- compound with the same molecular formula but different structural formula.

Homologous Series- Have same general formula and functional group, and differ by CH2

Functional Group- group of atoms in an organic compound that determines its chemical reactions or properties. Alkane doesn't have one.

Alkane- C_nH_{2n+2}
Alkene- C_nH_{2n}
Carboxylic Acid- $C_nH_{2n+1}COOH$
Alcohol- $C_nH_{2n+1}OH$

Reactions of Alkanes

Combustion-

Complete(excess O2)= CO2 + H2O
Incomplete(lack of O2)= CO + H2O

Help for balancing:

Complete- $C_nH_{2n+2} + 3n+1/2 + O2 \rightarrow nCO2 + (n+1)H2O$
Incomplete- $C_nH_{2n+2} + 2n+1/2 + O2 \rightarrow nCO + (n+1)H2O$

Cracking-

Conditions: High temp/ pressure, catalyst SiO2 or Al2O3

Alkane gives- shorter alkane + alkene (shorter than alkane)
OR 2 or more alkenes and hydrogen

Substitution-

Condition- light

Hydrogen is replaced by halogen

$CH_4 + Cl_2 \rightarrow CH_3Cl + HCl$
chloromethane

$CH_3Cl + Cl_2 \rightarrow CH_2Cl_2 + HCl$
dichloromethane

$CH_2Cl_2 + Cl_2 \rightarrow CHCl_3 + HCl$
trichloromethane

$CHCl_3 + Cl_2 \rightarrow CCl_4 + HCl$
tetrachloromethane

Test to distinguish between Ethanol and Ethanoic Acid

Litmus paper will go from blue to red in ethanoic acid
Lighted splint will catch fire when exposed to ethanol

Reactions of Alkenes

All alkene reactions are based on the double bond except combustion.

Addition of hydrogen (hydrogenation)

Alkene + H2 gives alkane (using nickel catalyst and 140°C temp)

Addition of chlorine (chlorination)

Alkene + Cl2 gives 1,2 dichloroalkane

Addition of bromine(bromination, test for alkene)

Alkene + Br2 gives 1,2, dibromoalkane
Colour change from orange to colourless

Addition of water (hydration)

Alkene + H2O gives alcohol (using phosphoric acid catalyst and 250°C temp)

Addition of HCl

Alkene + HCl gives 1,2 hydrochloroalkane

2 ways to get chloroethane

Substitution- ethane + chlorine gives chloroethane
Better as it gives pure product

OR ethene + HCl gives chloroethane + HCl

Disadvantages of monomers

Non biodegradable
Form toxic gases when burning or combusting

Esters

Reversible

Alkyl Alkanoate
Alkyl comes from alcohol
Alkanoate comes from alkanoic acid

e.g. propyl propanoate
So we use propanol and propanoic acid
CH3CH2CH2COO/CH2CH2CH3
The alcohol part goes at the end and the acid part at the beginning.

e.g. ethyl methanoate
So we use ethanol and methanoic acid
CH3COO/CH2CH3

Reactions of ethanol

Combustion

ethanol + 3 oxygen (excess) gives 2 carbon dioxide + 3 water

Oxidation

ethanol + [O](warm) gives ethanoic acid

How to distinguish between the two? If it says excess that means its combustion.

Hydrolysis

Alkaline Hydrolysis

H2O/ NaOH (any base)
Breaking by H2O in presence of alkali/alkali medium
Gives you back the alcohol and acid from which the ester was formed
e.g.

$CH_3COOCH_2CH_3 + NaOH \longrightarrow CH_3COONa + CH_3CH_2OH$

ethyl ethanoate — sodium ethanoate — ethanol

Acid Hydrolysis

H2O/ HCl (any acid)
Breaking by H2O in presence of acid/ acidic medium
Gives you 2 acids and an alcohol as neither acid nor alcohol reacts with acids
e.g.

$CH_3COOCH_2CH_3 + H_2O \rightleftharpoons^{H^+_{(aq)}} CH_3COOH + CH_3CH_2OH$

ethyl ethanoate — ethanoic acid — ethanol

Making Soap(alkaline hydrolysis)

C17H35COOH + NaOH gives C17H35COONa + H2O

General formula

RCO/OR' + water(add OH to RCO and H to OR') gives RCOOH + R'OH

NaOH gives RCOONA
SOAP

Preparation of Alcohols

Fermentation

sugar ethanol + CO2
Add yeast at 37°C

Carried out in airlock vessel bcoz in contact with oxygen the alcohol will turn to carboxylic acid.

For concentrated ethanol use fractional distillation.

Uses of ethanol: Fuel, Drinks, Solvent

Hydration

Alkene + H2O gives alcohol (using H3PO4 and 250°C temp)

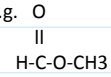
Hydration is better as it gives one product.

alcohol + acid gives ester plus water (reversible rxn)

Concentrated H2SO4 is added as it is a powerful dehydrating agent that prevents a backward rxn.

Ester general formula is

R can't be H or it will be a carboxylic acid
e.g.



methyl methanoate

Condensation Polymerisation

Elimination of H2O molecules

Addition	*Condensation*
1 monomer	*2 types*
Monomer A	*Monomer AB*
Polymer AAAA	*Polymer ABABAB*

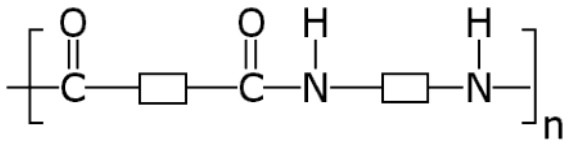
Starch(complex carb)

Glucose is monomer
HO-□-OH
-O-□-O-□-O-

By acid hydrolysis you get the monomer
To identify monomer use paper chromatography

Polyesters
Proteins are n co n co
Nylon is n n co co
Terylene is co co co

NaOH gives RCOONA
SOAP



Nylon