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ECZ GRADE 12 CHEMISTRY SUMMARISED NOTES (FOR 5070 & 5124) WITH QUESTIONS AND ANSWERS

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G12 CHEMISTRY SUMMARIZED NOTES(5070 & 5124)

This document summarizes Chemistry (5070 & 5124)) notes according to the ECZ (Examinations Council Syllabus).

The questions and answers are adapted from actual Cambridge past exam papers.

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UNIT 1. METALS

Topic 1.1- What is a Metal?

A metal is a chemical element that is an effective conductor of electricity and heat and good at forming cations with non-metals.

These elements are on the left side of the periodic table

Physical properties of metals;

- high densities
- high melting points / high boiling points
  – because atoms in metals are held together tightly, therefore it requires more energy(heat) to pull them apart
- are good conductors of heat
  – the moving electrons help carry heat energy
- good conductors of electricity
  – outer electrons easily move away from the metal atom, producing a sea of electrons
- high tensile strength
- are malleable
  -the layers of atoms can slip past each other
- are ductile (able to be drawn into thin wire)

METAL	DENSITY(g/cm^3)	MELTING POINT(^oC)	BOILING POINT(^oC)
Aluminium	2.7	659	2447
Gold	19.3	1063	2600
Iron	7.9	1540	3000
Magnesium	1.7	650	1110
Tungsten	19.4	3410	5930
Zinc	7.1	420	908

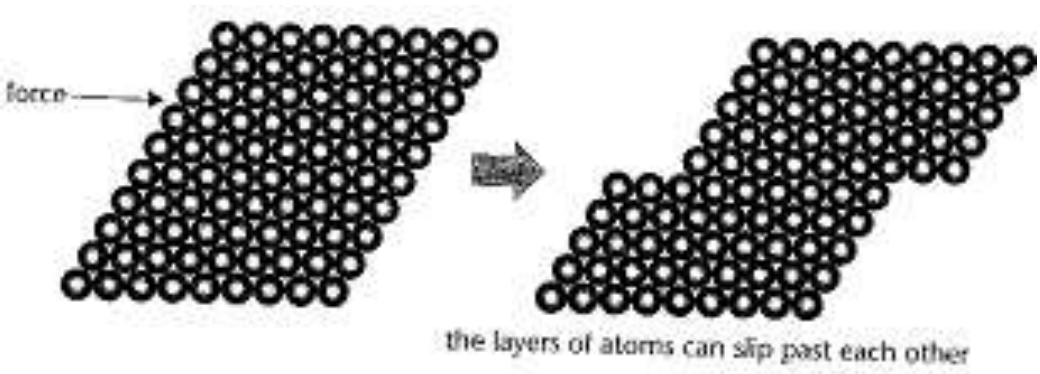
Structure of Metals

Metal atoms are arranged in rows, similar to how ions are arranged in ionic compounds.
Outer electrons in the atom can easily be lost because they are far away from the nucleus – hence these

electrons move freely.
This forms rows of positive ions surrounded by a sea of moving electrons

Metals can be stretched into wires when warm and soft because the particles vibrate faster and further away from each other in the metal

Metals are malleable because the layers of atoms do not move apart



Topic 1.2- Chemical Properties of Metals

Sodium is soft and reacts violently with both air and water. Iron also reacts with air and water but much more slowly, forming rust.

Remember:

- The reactivity of metals varies.
- More reactive metals displace less reactive metals. This happens in “displacement reactions”
- All reactions between water and a metal will produce hydrogen gas and a metal hydroxide.
- Aluminum is a reactive Metal but appears unreactive because it is coated with aluminium oxide which prevents further reaction
- Nitrates, carbonates and hydroxides of all metals (except Group 1) decompose on heating

Reaction between Metals and Water

METAL	REACTION WITH WATER
Potassium	**Potassium will burn on ice. It reacts rapidly with water**
Sodium	**Also reacts rapidly but does not burn on ice**
Calcium	**Reacts rapidly with water and produces hydrogen bubbles**
Magnesium	**Reacts slowly with cold water. Magnesium will burn in steam**
Zinc and Iron	**Reacts very slow with water**
Aluminium	**Will not react with water but corrosion is seen if water is impure**
Copper	**Will not react with water at all**

When water reacts with these metals, hydrogen gas is produced. We can test for hydrogen gas. Hydrogen will put out a burning splint with a pop sound.

An example of the reacting a metal with water

$Ca_{(s)} + 2H_2O_{(l)}$ ------→ $Ca(OH)_{2(aq)} + H_{2(g)2}$

Reactions between Metals and Acid

- Hydrogen gas and a salt is produced
- Heat is emitted, the reaction is exothermic.

Example

$Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$

The Reactivity Series

Shows the order of the most reactive metal to the least reactive metal.

The more reactive metal is the one that has the highest tendency to lose outer electrons to form a positive metal ion.

Potassium

Sodium

Calcium

Magnesium

Zinc

Iron

Lead

Copper

Silver

Gold

The arrow shows increasing reactivity

Reaction with Oxygen/Air.

Metals react directly with oxygen to form oxides.

e.g $2Mg(s) + O_2(g) \rightarrow 2MgO(s)$

Decomposition of Metal Nitrates, Carbonates, Oxides and Hydroxides.

The decomposition processes are different, depending on the position of the metal in the reactivity series.

Metal Nitrates,

Nitrates of reactive metals are heated and decompose to produce the Metal Nitrite and Oxygen gas.

e.g $2NaNO_3(s) \xrightarrow{heat} 2NaNO_2(s) + O_2(g)$

Nitrates of moderately reactive metals decompose to produce poisonous brown fumes of nitrogen dioxide gas and a metal oxide plus oxygen gas.

e.g $2Mg(NO_3)_2(s) \xrightarrow{heat} 2MgO(s) + 4NO_2(g)\ O_2(g)$

Unreactive metal nitrates decompose to give the metal, nitrogen dioxide gas and oxygen.

Metal Carbonates

They undergo decomposition to give the metal oxide and carbon dioxide gas.

$CaCO_3(s) \xrightarrow{heat} CaO(s) + CO_2(g)$

Very reactive metals e.g potassium and sodium do not easily undergo any decomposition reaction.

The less reactive the metal, the lower the temperature needed to make the carbonate decompose.

The carbonates of unreactive metals such as gold, silver and platinum are too unstable to exist.

Metal Hydroxides

Hydroxides of reactive metals show no decomposition when they are heated.

The hydroxides of moderately reactive metals decompose to produce: Metal oxide + Water.

This process is used to convert calcium hydroxide (slaked lime) into calcium oxide (lime).

$Ca(OH)_2(s) \xrightarrow{heat} CaO(s) + H_2O(g)$

Topic 1.3- Extraction of Metals

Metals are extracted from "ores"

Some common ores;

METAL	NAME OF ORE	CHEMICAL COMPOUND IN ORE	FORMULA	METHOD OF EXTRACTION
Aluminium	Bauxite	Aluminium Oxide	$Al_2O_32H_2O$	Electrolysis
Copper	Copper Pyrites	Copper Iron Sulfide	$CuFeS_2$	Roasting in air
Iron	Haematite	Iron(iii)oxide	Fe_2O_3	Heat oxide with carbon
Sodium	Rock salt	Sodium Cholride	NaCl	Electrolysis
Zinc	Zinc Blende	Zinc Sulfide	ZnS	Roasted in air and heated in carbon

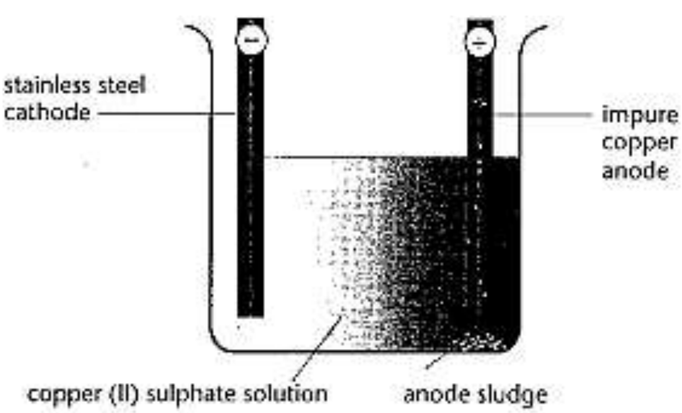
Making Copper from its Ore

This is how copper is extracted from Chalcopyrite, the most common copper ore in Zambia.

1. It is mixed with sand and heated strongly with air.
   $2CuFeS_2 + 2SiO_2\{Sand\} + 4O_2 \rightarrow Cu_2S + 2FeSiO_3 + 3SO_2$
2. The Copper Sulphide (Cu_2S) is heated again to produce blister copper (99% pure)

Making Pure Copper from Electrolysis

The electrolysis cell contains a stainless steel cathode (-) and an impure copper anode (+)



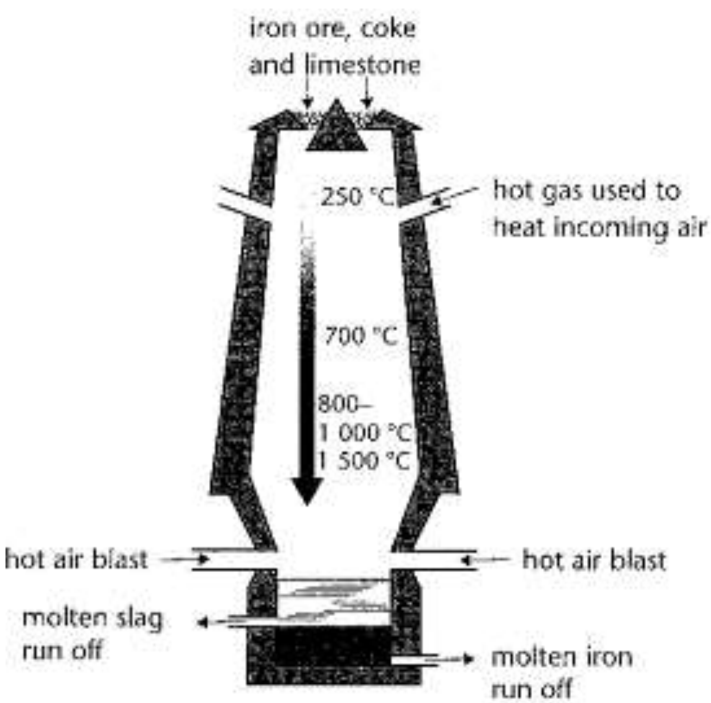
The positive copper ions are attracted to the cathode. A layer of copper is formed on each side of the cathode.

Making Iron from its Ore

Iron is extracted mainly from its oxides, hematite (Fe_2O_3) and magnetite (Fe_3O_4).

- Extraction occurs in the blast furnace. It is loaded with iron ore (usually haematite), coke (made by heating coal) and limestone (calcium carbonate). A blast of hot air is sent in near the bottom of the furnace through holes (tuyères) which makes the ore glow, as the coke burns in the preheated air.

a blast furnace



Reactions in the Blast Furnace

- The limestone begins to decompose:
  $CaCO_3(s)$ { calcium carbonate } → $CaO(s)$ {calcium oxide} + $CO_2(g)$

- The carbon dioxide gas produced reacts with more hot coke higher up in the furnace, producing carbon monoxide in an endothermic reaction.
  $CO_2(g) + C(s)$ { coke } → $2CO(g)$ { carbon monoxide }

- Carbon monoxide is a reducing agent. It rises up the furnace and reduces the iron(iii) oxide ore. This takes place at a temperature of around 700°C:
  $Fe_2O_3(s)$ { iron(iii) oxide } + $3CO(g)$ → $2Fe(l)$ { iron } + $3CO_2(g)$ { carbon dioxide }

- Calcium oxide is a base and this reacts with acidic impurities such as silicon(iv) oxide in the iron, to form a slag which is mainly calcium silicate.
  CaO(s) + SiO2(s){ silicon(iv) oxide } → CaSiO3(l){ calcium silicate }

  The slag trickles to the bottom of the furnace, but because it is less dense than the molten iron, it floats on top of it.

* Metallic oxides, such as calcium oxide (CaO), are basic and non-metallic oxides, such as silicon(iv) oxide (SiO2), are acidic.
* Certain oxides, such as carbon monoxide (CO), are neutral and others, such as zinc oxide (ZnO), are amphoteric

Making Zinc from its Ore

The main source of zinc is zinc sulfide or zinc blende.

- The zinc sulfide is heated very strongly in a current of air in a furnace to convert it to the oxide:

  $2ZnS(s)$ { zinc sulfide } + $3O_2(g)$ { oxygen } → $2ZnO(s)$ { zinc oxide } + $2SO_2(g)$ { sulfur dioxide }
- Sulfur dioxide is a useful co-product and is used in the manufacture of sulfuric acid.
- The zinc oxide is heated alongside coke in a furnace to a temperature of approximately 1400°C. The zinc oxide is reduced by the coke to zinc:

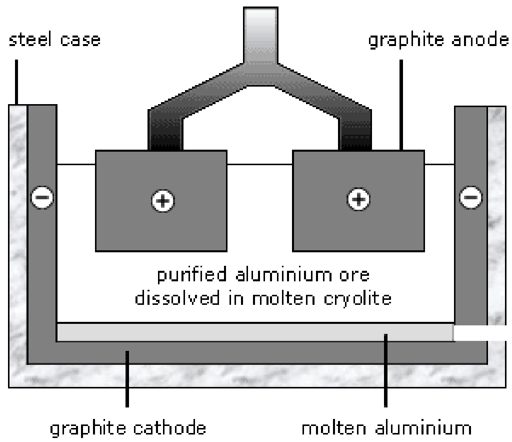
  ZnO(s) {zinc oxide} + C(s) {coke} → Zn(g) {zinc} + CO(g) {carbon monoxide}

- Zinc can also be extracted by electrolysis of Zinc Sulphate.
- Zinc is used in alloys such as brass. It is also used to galvanise steel and for electrodes in batteries

Extraction of aluminium

- Aluminium is the most **abundant** metal on Earth. Despite this, it is **expensive**, largely because of the amount of **electricity** used up in the extraction process.
- Aluminium ore is called **bauxite.** The bauxite is purified to yield a white powder, aluminium oxide, from which aluminium can be extracted.
- The extraction is done by **electrolysis.** But first the aluminium oxide must be made **molten** so that electricity can pass through it. Aluminium oxide has a very high melting point (over

2,000°C), so it would be expensive to melt it. Instead, it is **dissolved** in **molten cryolite**, an aluminium compound with a lower melting point than aluminium oxide. The use of cryolite reduces some of the energy costs involved in extracting aluminium.



The diagram shows an aluminium oxide electrolysis tank. Both the negative electrode (cathode) and positive electrode (anode) are made of **graphite,** a form of carbon.

Aluminium metal forms at the negative electrode and sinks to the bottom of the tank, where it is tapped off.

Oxygen forms at the positive electrodes. This oxygen reacts with the carbon of the positive electrodes, forming carbon dioxide, and they gradually burn away. Consequently, the positive electrodes have to be replaced frequently, which adds to the cost of the process

Topic 1.4- Alloys

What is an Alloy?

The majority of the metallic substances used today are alloys.
Alloys are mixtures of two or more metals and are formed by mixing molten metals thoroughly.

Types of Steel Alloys

Steel is the most widely used alloy of Iron. It is mixed with carbon

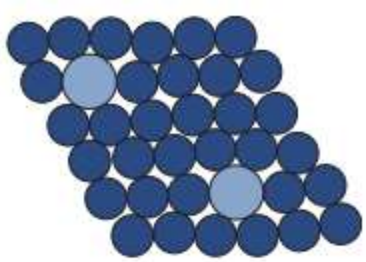
Carbon Steels;

KIND OF STEEL	PERCENTAGE OF CARBON %	USES
Cast Iron	4+	Engine blocks, drain covers
High Carbon	0.8 to 1.5	Knives, razor blades
Medium Carbon	0.3 to 0.8	Railway lines, springs
Low Carbon	Less than 0.3	Car bodies, rivets

Steel is mixed with other metals to form Alloy Steels;

NAME	COMPOSITION	USES
Chromium Steel	Up to 5% chromium	Ball bearings
Colbalt Steel	Up to 10% cobalt	Magnets
Molybdenum Steel	Up to 4% molybdenum	Gun barrels
Vanadium Steel	Up to 2% vanadium	Spanners, tools
Tungsten Steel	Up to 18% tungsten	Amour plate
Stainless Steel	18& chromium, 8% nickel	Sinks, cutlery, vessels to hold corrosive chemicals and foodstuffs

Metals can be made stronger when they are mixed with a small amount of another metal that has atoms of different size;



Atoms of different sizes

Some Useful Alloys:

ALLOY	COMPOSITION	SOME USES	PROPERTIES
Duralumin	**Aluminium, copper, magnesium**	**Aeroplanes**	**Light and Strong**
Brass	**Copper, zinc**	**Doorknobs, ornaments**	**Corrosion resistant and hard, readily pressed into shapes**
Bronze	**Copper, tin, zinc**	**Ships' propellers, church bells, statues**	**Corrosion resistant, looks like silver**
Cupro-nickel	**Copper, nickel**	**Silver coins**	**Corrosion resistant, looks like silver**
Titanium alloy	**Titanium, iron, carbon**	**Aeroplanes**	**Light and strong, low expansion when heated**

Solder	**Lead, zinc**	**Joining wires, copper pipes**	**Very low melting point**

Uses of Some Metals

Copper

- Electrical wires
- Electrical equipment
- Domestic water pipes

Zinc

- Coat steel to stop it from rusting (galvanizing)
- Making brass

Aluminium

- Make objects for lightness and corrosion resistance
- Aircraft, car engines, pans, kitchen foil, window frames, some coins

Iron

- Making steel because pure iron is weak

Topic 1.5- Corrosion of Metals

Rusting is the most common form of corrosion but this term is used for iron and steel.

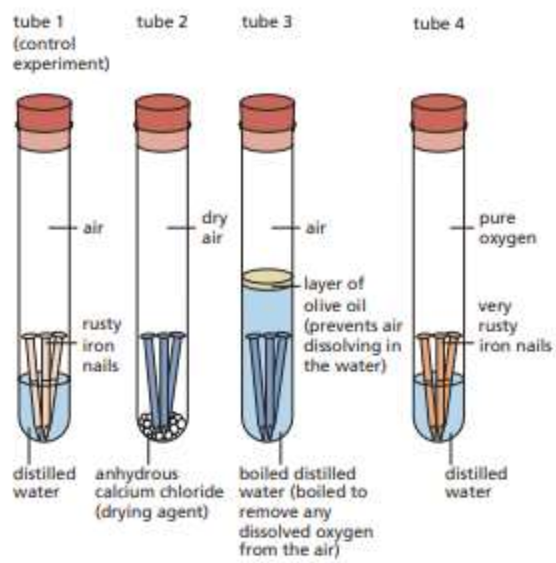
Corrosion is the process which takes place when metals and alloys are chemically attacked by oxygen, water or any other substances found in their environment.

- The higher the metal is in the reactivity series, the more rapidly it will corrode.
- Gold and platinum are unreactive and do not corrode, even after thousands of years.

Causes of Rusting of Iron

1. Air(Oxygen)
2. Water

- The nail in the dry air did not rust at all
- The nail in the water with no dissolved air did not rust either
- The nail in the one with water and air rusted alot



Prevention of Corrosion

METAL OBJECT	METHOD	ADVANTAGE OF USING THIS METHOD
Car bodies	**Paint**	**Easily applied; looks attractive**
Bicycle chain	**Oil**	**Protects moving parts, other coatings will wear off**
Iron roofing	**Galvanizing (the sheet is coated with a layer of zinc, which corrodes first)**	**Long-lasting; easy to apply**
Food can	**Tin plating(steel is coated with a layer of tin)**	**Tin does not corrode easily**
Cutlery	**Silver electroplating(using electricity)**	**very attractive, even and hard wearing**

EXAM TYPE QUESTIONS AND ANSWERS

INSTRUCTIONS:

Attempt the questions before you look at the answers

1. Gallium is a metallic element in Group III. It has similar properties to aluminium.

(a) (i) Describe the structure and bonding in a metallic element. You should include a labelled diagram in your answer.

....

.... [3]

(ii) Explain why metallic elements such as gallium are good conductors of electricity.

.... [1]

(b) Give the formula of gallium(III) chloride,

....

gallium(III) sulfate.

.... [2]

(c) Gallium(III) oxide, Ga_2O_3, is amphoteric.

(i) Write the chemical equation for the reaction between gallium(III) oxide and dilute nitric acid to form a salt and water only.

.... [2]

(ii) The reaction between gallium(III) oxide and sodium hydroxide solution forms only water and a salt containing the negative ion $Ga_2O_4^{2-}$. Write the chemical equation for this reaction.

.... [2]

(d) Alloys of gallium and other elements are often more useful than the metallic element itself.

Suggest two reasons why alloys of gallium are more useful than the metallic element.

....

.... [2]

ANSWERS

1. (a) (i) Diagram must have positive ions (labelled/named) [1 mark]
Diagram must have electrons (labelled/named) [1 mark]
Diagram must show attraction between positive and negative [1 mark]

(a)(ii) Conduction due to movement of electrons/mobile electrons [1 mark]

(b) $GaCl_3$ [1 mark]
$Ga_2(SO_4)$ [1 mark]

(c) (i) $O_3 + 6HNO_3 \rightarrow 2Ga(NO_3)_3 + 3H_2O$ [2 marks]
formula of $Ga(NO_3)$; all formulae and balancing correct

(c) (ii) $O_3 + 2NaOH \rightarrow Na_2Ga_2O_4 + H_2O$ [2 marks]
formula of $Na_2Ga_2O_4$; all formulae and balancing correct

(d) any 2 from: [2 marks]

- (do not) corrode
- Strong
- Hard
- (improved) appearance

2. Zinc is extracted from an ore called zinc blende, which consists mainly of zinc sulfide, ZnS.

(a) (i) The zinc sulfide in the ore is first converted into zinc oxide.

Describe how zinc oxide is made from zinc sulfide.

....

.... [1]

(ii) Write a chemical equation for the reaction in (a)(i).

.... [2]

(b) Zinc oxide is converted into zinc. Zinc oxide and coke are fed into a furnace. Hot air is blown into the bottom of the furnace.

Zinc has a melting point of 420 °C and a boiling point of 907 °C. The temperature inside the furnace is over 1000 °C.

(i) Explain how zinc oxide is converted into zinc. Your answer should include details of how the heat is produced and equations for all the reactions you describe.

....

....

....

....

.... [3]

(ii) Explain why the zinc produced inside the furnace is a gas.

.... [1]

(iii) State the name of the physical change for conversion of gaseous zinc into molten zinc.

.... [1]

(c) Rusting of steel can be prevented by coating the steel with a layer of zinc.

Explain, in terms of electron transfer, why steel does not rust even if the layer of zinc is scratched so that the steel is exposed to air and water.

....

....

....

....

.... [4]

(d) When a sample of steel is added to dilute hydrochloric acid, an aqueous solution of iron(II) chloride, $FeCl_2$, is formed. When a sample of rust is added to dilute hydrochloric acid, an aqueous solution of iron(III) chloride, $FeCl_3$, is formed.

(i) Aqueous sodium hydroxide is added to the solutions of iron(II) chloride and iron(III) chloride.

Complete the table below, showing the observations you would expect to make.

	iron(II) chloride solution	iron(III) chloride solution
aqueous sodium hydroxide		

[2]

Solutions of iron(II) chloride and iron(III) chloride were added to solutions of potassium iodide and acidified potassium manganate(VII). The results are shown in the table.

	iron(II) chloride solution	iron(III) chloride solution
potassium iodide solution	no change	solution turns from colourless to brown
acidified potassium manganate(VII) solution	solution turns from purple to colourless	no change

(ii) What types of substance cause potassium iodide solution to turn from colorless to brown?

.... [1]

(iii) What types of substance cause acidified potassium manganate(VII) solution to turn from purple to colourless?

.... [1]

(iv) Which ion in iron(III) chloride solution causes potassium iodide solution to turn from colourless to brown?

.... [1]

(v) Which ion in iron(II) chloride solution causes acidified potassium manganate(VII) solution to turn from purple to colourless?

.... [1]

ANSWERS

2(a)(i) /heat and in air / oxygen [1 mark]

(a)(ii) $2ZnS + 3O_2 \rightarrow 2ZnO + 2SO_2$

SO_2 on right of equation; all formulae and balancing correct [1 mark]

(b)(i) heat produced by carbon/coke (burning in) oxygen/air [1 mark]

OR

$C + O_2 \rightarrow CO_2$ produces heat / exothermic

OR

$2C + O_2 \rightarrow 2CO$ produces heat/exothermic

$C + CO_2 \rightarrow 2CO$ [1 mark]

OR

$2C + O_2 \rightarrow 2CO$

$ZnO + CO \rightarrow Zn + CO_2$ [1 mark]

OR

$ZnO + C \rightarrow Zn + CO$

OR

$2ZnO + C \rightarrow 2Zn + CO_2$

(b)(ii) temperature (inside the furnace) is above 907^oC/temperature (inside furnace) is above the boiling point (of zinc) 1000^oC is above the boiling point (of zinc) [1 mark]

(b)(iii) condensing/condense [1 mark]

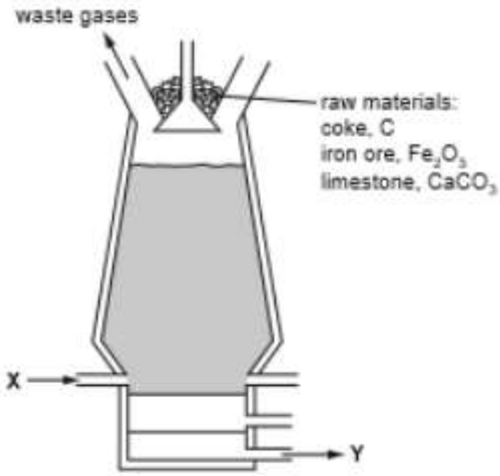
(c) zinc is more reactive than iron / zinc is higher in the reactivity series in the reactivity series [4marks]

zinc loses electrons
iron/steel/oxygen/air/water gains electrons OR electrons move to iron/steel/oxygen/air/water
(therefore) iron does not lose electrons/get oxidized/form Iron

(d)(i) green precipitate [1 mark]
red-brown/brown/orange precipitate [1 mark]

(d)(ii) oxidizing agent/oxidant [1 mark]
(d)(iii)reducing agent/reductant [1 mark]
(d)(iv)iron(iii)/Fe^{3+} [1 mark]
(d)(v) iron(ii)/Fe^{2+} [1 mark]

3. The diagram shows a blast furnace.



(a) The following equations represent reactions which take place in the blast furnace.

A. $C + O_2 \rightarrow CO_2$

B. $CaCO_3 \rightarrow CaO + CO_2$

C. $CaO + SiO_2 \rightarrow CaSiO_3$

D. $CO_2 + C \rightarrow 2CO$

E. $Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$

(i) Which reaction is used to increase the temperature inside the blast furnace? .... [1]

(ii) Which reaction is an example of thermal decomposition? .... [1]

(iii) In which reaction is carbon both oxidised and reduced? .... [1]

(iv) Which equation shows the removal of an impurity from the iron? .... [1]

(v) Which equation shows the reaction of an acidic substance with a basic substance?...........[1]

(b) Use the diagram of the blast furnace to help you answer these questions.

(i) What enters the blast furnace at X?

.... [1]

(ii) What leaves the blast furnace at Y?

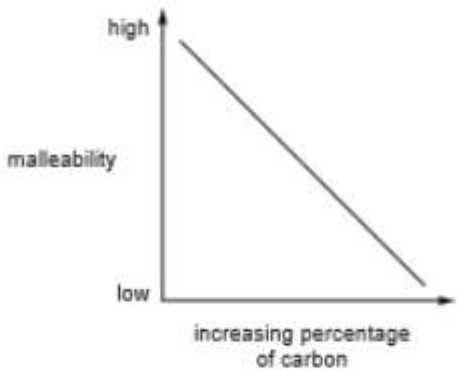
.... [1]

(iii) Name two waste gases that leave the blast furnace.

1. ....

2. .... [2]

(c) The graph shows how the malleability of iron changes as the percentage of carbon in the iron changes.



(i) D escribe how the malleability of iron changes as the percentage of carbon changes.

....

.... [1]

(ii) Iron obtained from the blast furnace contains high levels of carbon.

Explain how the amount of carbon in the iron can be decreased.

....

....

.... [2]

ANSWERS

3. (a)(i) A [1 mark]
(ii) B [1 mark]
(iii) D [1 mark]
(iv) E [1 mark]
(v) C [1 mark]

(b)(i) air [1 mark]
(b)(ii) iron [1 mark]
(b)(iii) any two from: [2 marks]
carbon dioxide; carbon monoxide; nitrogen
(c)(i) as the percentage of carbon increases, the malleability decreases [1 mark]

(c)(ii) m1 oxygen (gas) blown in [1 mark]
m2 carbon dioxide formed/ $C + O_2 \rightarrow CO_2$ [1 mark]

4. W, X and Y are metals, one of which is copper and one of which is iron.

• W has a coloured oxide which can be reduced by carbon.

• X has a black oxide and is also found in nature as a pure metal.

• Y has an oxide which cannot be reduced by carbon.

Which metal is the most reactive and what is the possible identity of W?

	most reactive metal	possible identity of W
A	X	C
B	X	F
C	Y	C
D	Y	F

5. Tin is a metal that is less reactive than iron and is extracted from its ore cassiterite, SnO_2.

Which statements about tin are correct?

1 Tin can be extracted from cassiterite using carbon.

2 Tin does not conduct electricity.

3 Tin is hard and shiny.

A. 1, 2 B. 1 and 2 only C. 1 and 3 only D. 2 and 3 only

6. Some chemical properties of three metals W, X and Y and their oxides are shown.

metal	reaction with steam	reaction with dilute hydrochloric acid	reaction of metal oxide with carbon
W	reacts	reacts	reacts
X	no reaction	no reaction	reacts
Y	reacts	reacts	no reaction

What is the order of reactivity of these metals? Most reactive first.

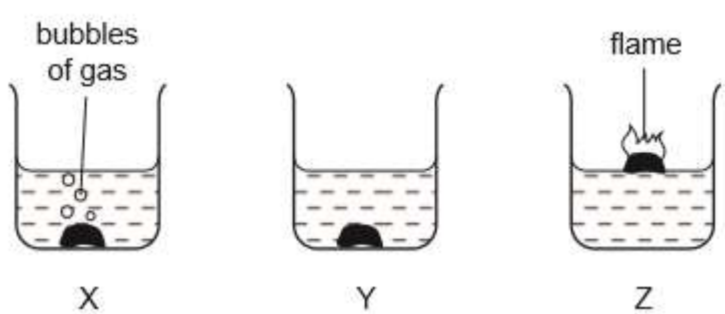
A. W → Y → X

B. X → Y → W

C. Y → W → X

D. Y → X → W

7. The diagrams show what happens when three different metals are added to water.



What are X, Y and Z?

	X	Y	Z
A	calcium	copper	potassium
B	copper	calcium	potassium
C	potassium	calcium	copper
D	potassium	copper	calcium

8. Which substances do not react together?
   A . calcium + water
   B . copper + dilute hydrochloric acid
   C . sodium + water
   D . zinc + dilute hydrochloric acid

9. In an experiment, three test-tubes labelled X, Y and Z were half-filled with dilute hydrochloric acid. A different metal was added to each test-tube. After a few minutes the following observations were made.
   In tube X, bubbles slowly rose to the surface.
   In tube Y, there was a rapid release of bubbles.
   In tube Z, no bubbles were produced.
   Which three metals match the observations?

	tube X	tube Y	tube Z
A	copper	zinc	iron
B	magnesium	iron	copper
C	zinc	magnesium	copper
D	zinc	magnesium	iron

10. Iron from a blast furnace is treated with oxygen and with calcium oxide to make steel.

Which substances in the iron are removed?

	oxygen removes	calcium oxide removes
A	carbon	acidic oxides
B	carbon	basic oxides
C	iron	acidic oxides
D	iron	basic oxides

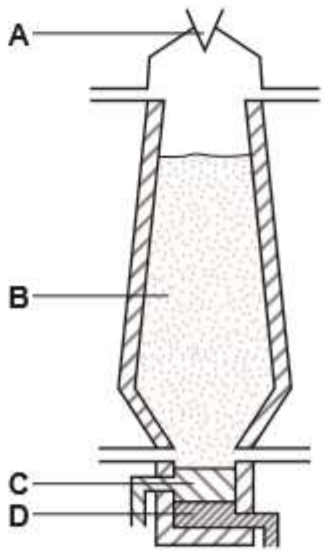
11. Iron is obtained from its ore in a blast furnace and is used to make steel.
    Iron obtained from the blast furnace is contaminated with ....(1).........
    In order to remove this substance, ...(2)........ is passed through the molten iron.
    ....(3)........ is also added to remove oxides of phosphorus and silicon which are ....(4).........
    Which words complete the sentences about the conversion of iron to steel?

	1	2	3	4
A	carbon	nitrogen	calcium carbonate	acidic
B	carbon	oxygen	calcium oxide	acidic
C	carbon	oxygen	calcium oxide	basic
D	sand	oxygen	calcium oxide	basic

12. Iron is extracted from its ore (hematite) in the blast furnace.
    Which gas is produced as a waste product?

    A. carbon dioxide
    B. hydrogen
    C. nitrogen
    D. oxygen

13. The diagram shows a blast furnace.
    In which part is iron ore changed to iron?



14. Which statement is incorrect?
    A. Carbon dioxide is a waste product in the extraction of iron.
    B. Carbon monoxide is a reducing agent.
    C. The extraction of iron from hematite involves reduction.
    D. When iron is converted into steel, oxygen is used to oxidise the iron.

15. Many metals are extracted from their ores by heating the metal oxide with carbon.
    Which metal cannot be extracted using this method?
    A. aluminium
    B. copper
    C. iron
    D. zinc

16. Some metals react readily with dilute hydrochloric acid.
    Some metals can be extracted by heating their oxides with carbon.
    For which metal are both statements correct?

    A. calcium
    B. copper
    C. iron
    D. magnesium

17. Which statement about the uses of metals is correct?

A. Aluminium is used in the manufacture of aircraft because of its strength and high density.
B. Copper is used in electrical wiring because of its strength and high density.
C. Mild steel is used in the manufacture of car bodies because of its strength and resistance to corrosion.
D. Stainless steel is used in the construction of chemical plant because of its strength and resistance to corrosion.

18. Copper is sometimes used to make cooking utensils.

Three properties of copper are given.

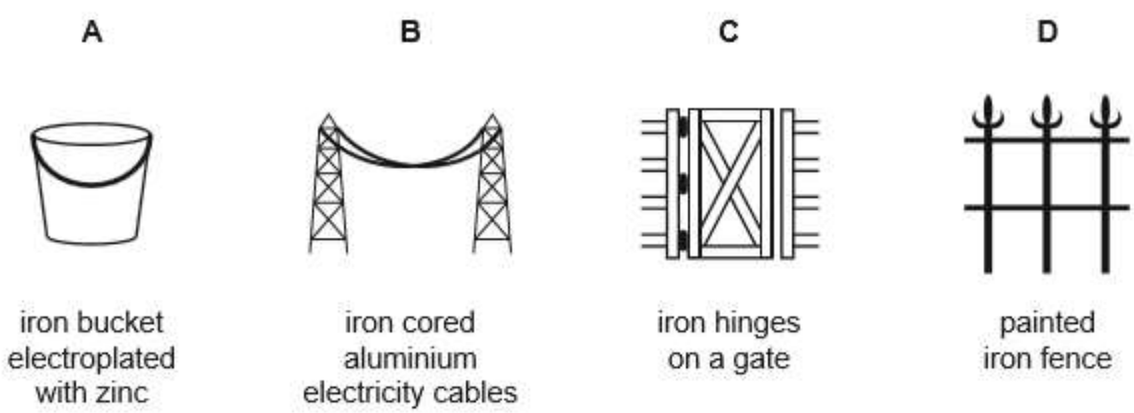
1. corrosion resistant
2. good conductor of electricity
3. good conductor of heat

Which properties make copper a suitable metal for making cooking utensils?

A. 1 and 3 B. 1 only C. 2 and 3 D. 2 only

19. The diagrams show four uses of iron.

In which of these uses is the iron most likely to rust?



20. Duralumin is an alloy. It contains aluminium, copper and magnesium.
It has many uses including the manufacture of cooking utensils and ships.
Which statement about duralumin and its properties is correct?
A. It is a good conductor of electricity.
B. It is brittle.
C. It is soluble in water.
D. The aluminium, copper and magnesium are chemically combined.

ANSWERS

4. D	**12. A**	**20. A**
5. C	**13. B**	
6. C	**14. D**	
7. A	**15. A**	
8. B	**16. C**	
9. C	**17. D**	
10. A	**18. A**	
11. B	**19. C**	

UNIT 2. NON METALS

Topic 2.1- Non Metals: Key Points

- Non-metal elements usually have low melting and boiling points, are poor conductors of heat and electricity, and have low densities

- They are found in Groups IV to VIII of the Periodic Table. They form negative ions in ionic compounds with metals and covalent compounds with each other

- Hydrogen is prepared by the action of a reactive metal with an acid

- Properties of Hydrogen; lighter than air, explodes when mixed with oxygen and ignited, has no effect on red or blue litmus paper
- Hydrogen is manufactured from natural gas and also from water

- Main uses of Hydrogen; manufacture of ammonia, filling balloons, hydrogen is used as a fuel

- Properties of Oxygen; Colourless and odourless, slightly soluble in water

- Oxygen is manufactured by fractional distillation.

- Main uses of Oxygen; welding metals, as a chemical reagent in industries, in hospitals, space-crafts and scuba-diving where it is used for breathing and respiration

- Ozone (O_3) is a form of oxygen,that forms in the upper atmosphere. It forms a protective layer that keeps out harmful radiation

- Water is the oxide of hydrogen.

- Water turns white copper sulphate blue

- Nitrogen makes 80% of the atmosphere. It is very unreactive

- Nitrogen is manufactured by fractional distillation of liquid air

- Main uses of Nitrogen: refrigeration, particularly in machinery such as electrical transformers

- Ammonia is a useful compound of Nitrogen. It is made by the Haber Process in which hydrogen and nitrogen combine at a pressure of 200 atm and a temperature of 450°C. Ammonia can be converted to nitrates by mixing it with air and passing the mixture over a platinum gauze catalyst

- Nitrates are used as fertilizers

- Ammonia is a gas with a very unpleasant smell, and which dissolves readily in water to form ammonium hydroxide

- The test for ammonia gas is that it turns moist red litmus paper blue

- Acids react with Ammonium Hydroxide to form Ammonium Salts. Ammonium Salts decompose when heated to form ammonia

- Carbon exists in different forms called Allotropes. The 2 common allotropes being diamond and graphite

- Carbon dioxide is colourless, odourless and heavier than air. It is slightly soluble in water and turns moist blue litmus paper red
- Carbon dioxide turns clear lime water milky

- Carbon dioxide Uses; soft drinks, dry ice and photosynthesis

- Limestone is calcium carbonate. It is used to make cement, quicklime(calcium hydroxide) and slaked lime(calcium oxide)

- Carbon monoxide is colourless, odourless, poisonous and does not dissolve in water. It is a neutral oxide.
- Carbon monoxide Uses: It is the reducing agent in many furnaces

Topic 2.2- What are Non Metals?

Elements on the right side of the Periodic Table and have the following properties;

- Low melting points
- Low boiling points
- Lower densities than metals
- Electrical insulators
- Not ductile

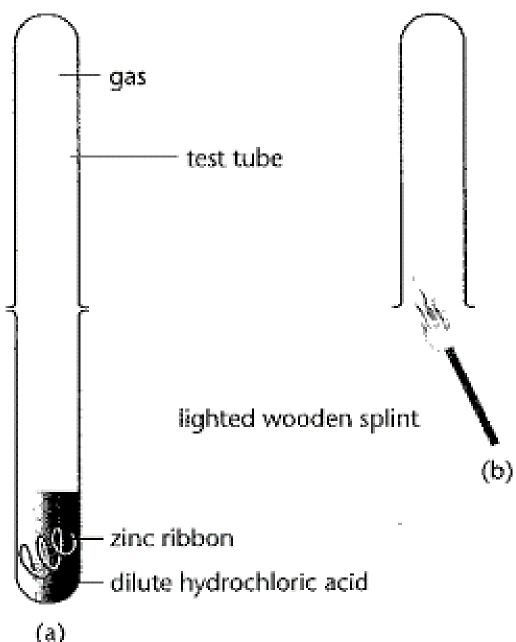
- Poor conductors of heat
- Brittle when solid

Examples;

- Water (H_2O)
- Methane (CH_4)
- Oxygen (O)

Topic 2.3- Hydrogen

Preparing and Testing for Hydrogen



Hydrogen puts out a burning split with a pop sound

The reaction summarized is

$Zn(s) + 2HCl(aq) \rightarrow H_2(g) + ZnCl_2(aq)$

Industrial Preparation of Hydrogen

Method 1: Using Methane

1. Methane is heated with steam at a high temperature (1000°C) in the presence of nickel to give a mixture of carbon monoxide and hydrogen
   $CH_4 + H_2O \rightarrow CO + 3H_2$

2. Additional hydrogen is generated through another reaction at a temperature of (360°C)
   $CO + H_2O \rightarrow CO_2 + H_2$

   The waste product is carbon dioxide

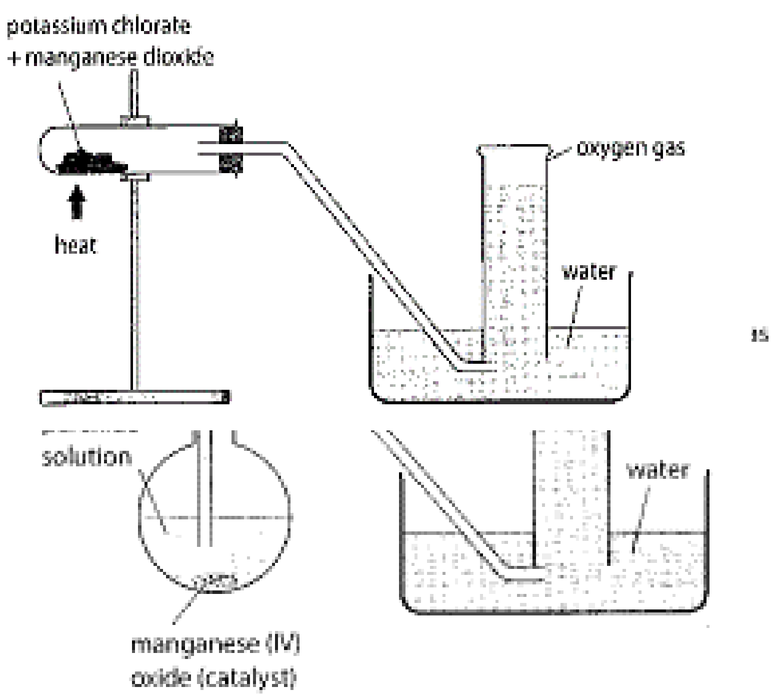
Method 2: Electrolysis of Water

Hydrogen is produced at the cathode and oxygen at the anode.

Topic 2.4- Oxygen

It is the most common element in the earth's crust. 50% of rocks are made of compounds of oxygen

Preparing Oxygen



In both situations, the oxygen is collected 'over water'. This is a common way of collecting a gas that is not soluble in water and has a similar density to air

The chemical reactions that take place are as follows;

Potassium chlorate → potassium chloride + oxygen

$2KClO_3(s) \rightarrow 2KCl(s)$

Hydrogen peroxide → water + oxygen

$2H_2O_2 \rightarrow 2H_2O + O_2$

Industrial Manufacture of Oxygen

Fractional distillation of air is used. Nitrogen changes to gas at -196°C. Oxygen boils off next at -183°C

Topic 2.5- Ammonia

Ammonia is produced through the Haber Process.

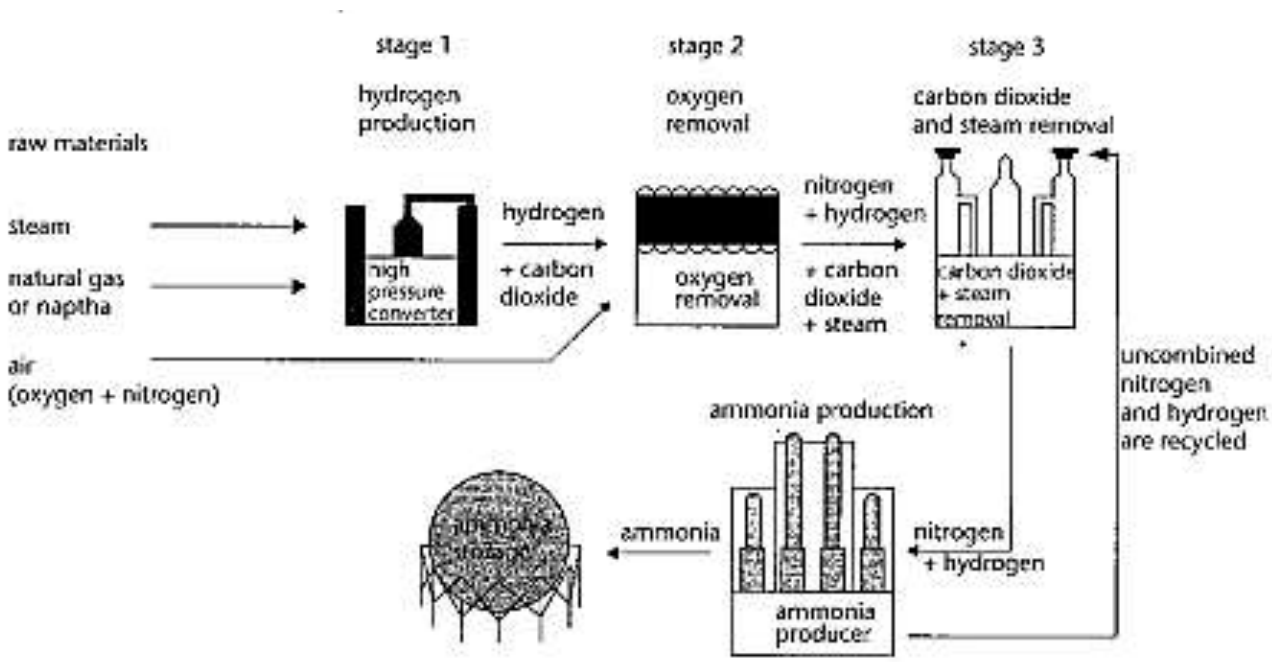
The Haber Process

In the Haber process, nitrogen and hydrogen in the correct proportions (1:3) are pressurised to approximately 200 atm and passed over a catalyst of Iron at a temperature of between 350°C and 500°C.

The reaction in the Haber process is:

Nitrogen + Hydrogen → Ammonia
$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g) \quad \Delta H = -92kJmol{-1}$

The reaction is exothermic.



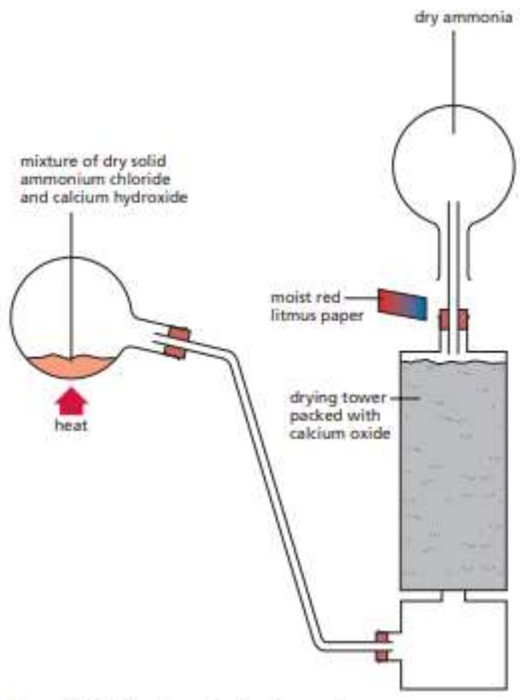
Under these conditions the gas mixture leaving the reaction vessel contains about 15% ammonia, which is removed by cooling and condensing it as a liquid.

The unreacted nitrogen and hydrogen are re-circulated into the reaction vessel to react together once more to produce further quantities of ammonia.

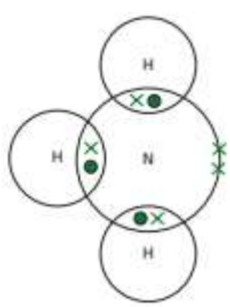
The 15% of ammonia produced does not seem a great deal. The reason for this is the reversible nature of the reaction. Once the ammonia is made from nitrogen and hydrogen, it decomposes to produce nitrogen and hydrogen.

There comes a point when the rate at which the nitrogen and hydrogen react to produce ammonia is equal to the rate at which the ammonia decomposes. This situation is called a chemical equilibrium. Because the processes continue to happen, the equilibrium is said to be 'dynamic'

Laboratory Preparation of Ammonia



The Ammonia Molecule



Properties of Ammonia

The reason ammonia is so soluble in water is that some of it reacts with the water.

Ammonia solution is a weak alkali, although dry ammonia gas is not. This is because a little of the ammonia gas has reacted with the water, producing ammonium ions and hydroxide ions.

The solution is only weakly alkaline because of the reversible nature of this reaction, which results in a relatively low concentration of hydroxide ions

Ammonia gas dissolved in water is usually known as aqueous ammonia.

Aqueous ammonia can be used to identify salts of Cu2+, Fe2+, Fe3+, Al3+, Zn2+, Cr3+ and Ca2+ ions.

The colour of the precipitate or solution formed identifies the metal present

Topic 2.6- Carbon

Carbon is a non-metallic element which exists in more than one solid structural form.

Its allotropes are called graphite and diamond.

Each of the allotropes has a different structure and so the allotropes exhibit different physical properties

The different physical properties that they exhibit lead to the allotropes being used in different ways

Property	Graphite	Diamond
Appearance	A dark grey, shiny solid	A colourless transparent crystal which sparkles in light
Electrical conductivity	Conducts electricity	Does not conduct electricity
Hardness	A soft material with a slippery feel	A very hard substance
Density/$g\,cm^{-3}$	2.25	3.51

Uses of Diamond

- Jewellery
- Glass cutters
- Drill bits
- Polishers

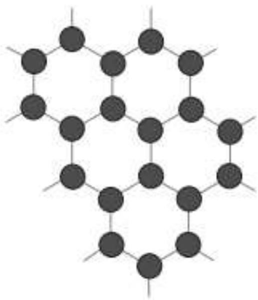
Uses of Graphite

- Pencils
- Electrodes
- Lubricant

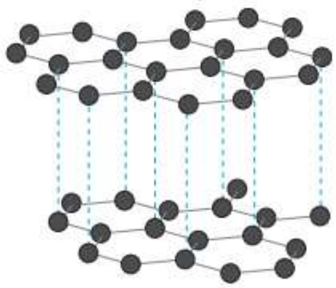
Structure of Graphite

Within each layer, each carbon atom is bonded to three others by strong covalent bonds.
Each layer is therefore like a giant molecule.
Between these layers there are weak forces of attraction (van der Waals' forces) and so the layers will pass over each other easily.

With only three covalent bonds formed between carbon atoms within the layers, there is an 'unbonded' electron



one layer



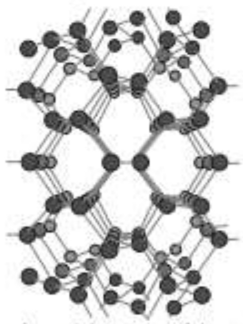
showing how the layers fit together

Structure of Diamond

Each of the carbon atoms in the giant structure is covalently bonded to four others.

They form a tetrahedral arrangement similar to that found in silicon(iv) oxide.


a small part of the structure


a view of a much larger part of the structure

Topic 2.7 Limestone and its Uses

Limestone is composed of calcium carbonate ($CaCO_3$)

Limestone has a variety of uses in, for example, the making of cement, road building, glass making and the extraction of iron

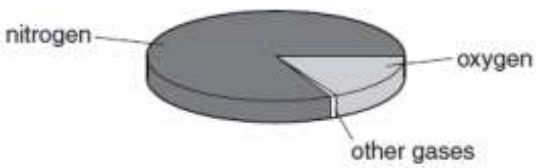
EXAM TYPE QUESTIONS AND ANSWERS

INSTRUCTIONS:

Attempt the questions before looking at the answers

1.

The pie chart shows the composition of air.



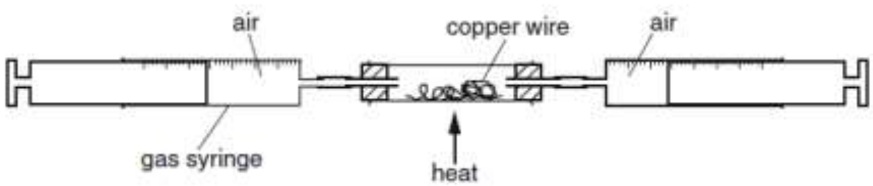
(a) **(i)** What is the percentage of nitrogen in the air?

.... [1]

(ii) Apart from nitrogen and oxygen, state the names of **two** gases present in unpolluted air.

.... and .... [2]

(b) The percentage of oxygen in air can be found using the apparatus shown below.



Air is passed backwards and forwards over the heated copper using the syringes. The copper reacts with oxygen in the air.

copper + oxygen → copper(II) oxide

As the experiment proceeds, suggest what happens to

(i) the total volume of air in the gas syringes,

.... [1]

(ii) the mass of the wire in the tube.

.... [1]

ANSWERS

1 (a) (i) 78 (%) allow: 78–80
(ii) Any two of: carbon dioxide; argon; neon; xenon; helium; radon; water; not: hydrogen
(b) (i) decreases /gets less /gets lower/gets used up
(ii) increases /gets more/greater

2. (a) Ammonia is an alkaline gas and it reacts readily with dilute sulphuric acid to produce a solution of ammonium sulphate.

(i) Describe the test you would carry out to confirm the presence of the sulphate ion.

Name of reagent used: …………………………… [1]

Result of test: …………………………………………..
……………………………………………………………………………… [2]

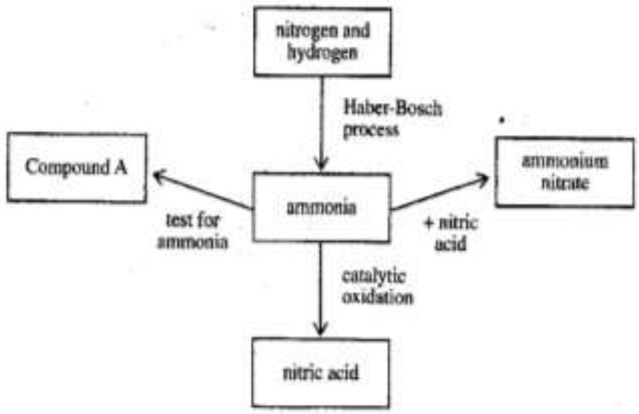
(ii) Ammonia sulphate reacts with sodium hydroxide when heated. Write a balanced equation for the reaction.

……………………………………………………………………………… [2]

(b) Ammonia dissolves readily in water to form aqueous ammonia. Aqueous ammonia is used to test for metal cations in solution.

(i) What would you observe if aqueous ammonia was added dropwise to a solution of copper (II) sulphate $CuSO_{4(aq)}$?
………………………………………………………………………………………[2]

(c) The diagram shows some of the essential reactions and industrial processes associated with ammonia



(i) Describe a chemical test for ammonia, giving the result of the test.
……[3]

(ii) Name the compound A.

……[1]

(iii) Describe the production of ammonia in the Haber-Bosch process. Your answer should include the name of the catalyst used, the approximate temperature and pressure and a balanced, symbol equation. ………………………………………………………………………
……
……
……
…… [7]

(d) Garden lawn fertiliser often contains ammonium nitrate in addition to iron (II) sulphate, which is used to kill moss.

(i) Write a balanced, symbol equation for the reaction of ammonia and nitric acid to produce ammonium nitrate.

…………………………………………………………………… [2]

(ii) Describe, giving practical details, how you would prove that lawn fertiliser pellets contain iron(II) sulphate and not iron(III) sulphate. Give the expected result…………………………………………………………………………………………………
……
……
……
…… [5]

ANSWERS

(2)(a)(i)Name of reagent used: barium chloride [1 mark]

Result of test: white precipitate [2 marks]

(ii)$(NH_4)_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2NH_3 + 2H_2O$ [2 marks]

(b)(i)Blue precipitate [2 marks]

(c)(i)Hydrogen chloride/concentrated hydrochloric acid [1] white[1]smoke/fumes/solid[1 mark]

(ii)Ammonium Chloride [1 mark]

(iii) The key points of this answer are:

nitrogen [1]hydrogen [1] catalyst = iron [1 mark],

temperature = 450°C [1], pressure = 200 atm [1 mark],

$N_2 + 3H_2 \Leftrightarrow 2NH_3$ [2 marks]

Cool to liquify ammonia [1 mark]

Unreacted gases recycled [1 mark]

(d)(i) $NH_3 + HNO_3 \rightarrow NH_4NO_3$ [2 marks]

(ii) Add water [1], add ammonia solution/NaOH solution [1], green[1], precipitate [1], red brown precipitate indicates Fe^{3+} [1 mark]

3.

(a) State **two** uses of water in the home.

1. ....

2. ....[2]

(b) State the boiling point of pure water.

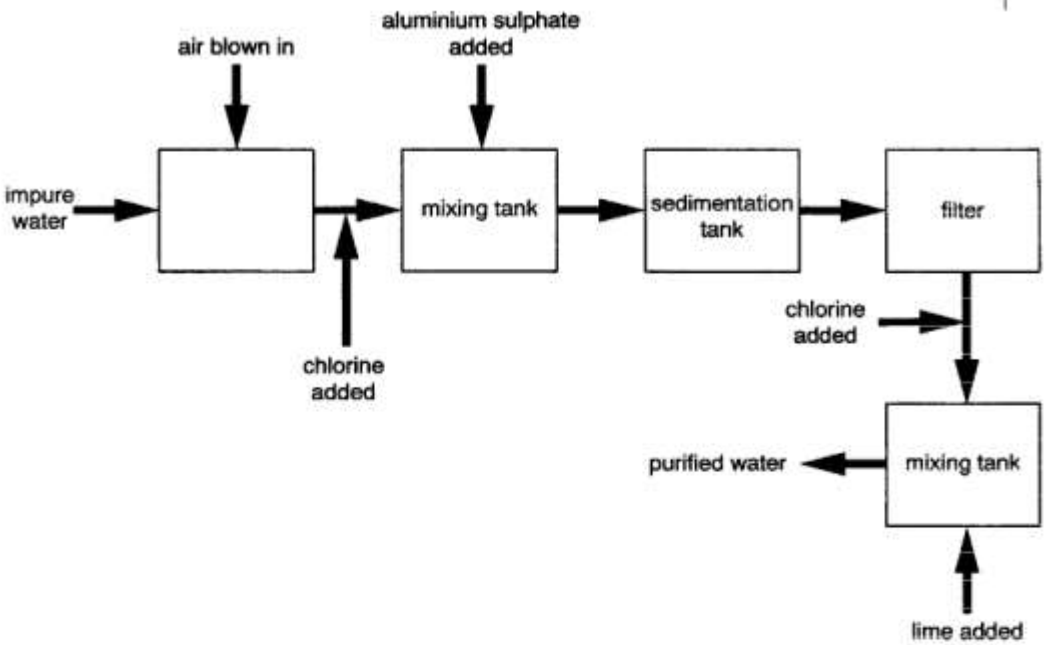
....[2]

(c) Describe a **chemical** test for water.

Test ....

Result ....[2]

The flow chart shows the stages in water purification.



(d) Air is blown into impure water to help remove dissolved iron compounds.

(i) How could you test for iron(III) ions in the water?

Test ....

Result ....[2]

(ii) Which **two** gases make up most of the air?

.... and ....[2]

(e) When chlorine is added during the water purification process, the water becomes acidic.

(i) Why is chlorine added during the water purification process?

....[1]

(ii) Suggest why lime is added after chlorination.

....

....[2]

(f) The filter consists of a mixture of sand and stones.

Suggest how the filter helps purify the water.

....

....

....

....[3]

ANSWERS

3(a) any two uses e.g. washing, drinking, sanitation, growing plants, etc.

(b) 100°C

(c) test add anhydrous / white copper sulphate or anhydrous / blue cobalt chloride result copper sulphate goes blue/ cobalt chloride goes pink

(d) (i) test add (sodium/potassium/other suitable) hydroxide or add ammonia result brown/red-brown precipitate

(ii) nitrogen, oxygen

(e) (i) to kill bacteria/germs/to disinfect the water

(ii) lime is alkaline to neutralise the acid/ chlorine/to increase the pH

(f) impure water contains some solids trapped on stones/ sand water drains through

UNIT 3. ORGANIC CHEMISTRY

Topic 3.1- Organic Chemistry: Key Points

- The element carbon forms many compounds found in living things. The study of these compounds is called organic chemistry.
- Hydrocarbons are organic compounds consisting entirely of hydrogen and carbon.
- Alkanes are saturated hydrocarbons. Therefore all carbon to carbon bonds are single.
- The general formula of alkanes: C_nH_{2n+2}
- Alkenes are unsaturated hydrocarbons that contain at least one double carbon to carbon bond
- A homologous series is a series of compounds with the same functional group and similar chemical properties
- Alkenes undergo addition reactions with reagents such as halogens, hydrogen, steam and hydrogen halides, to form compounds in which the reagents have added onto the double bond
- Alkenes undergo addition polymerization at high temperatures and pressure, and in the presence of a catalyst
- Alkanes and alkenes show structural isomerism (same empirical formula but different structure).
- Alkenes show positional isomerism (same empirical formula but different position of the double carbon to carbon bond).
- Alkanes are made by fractional distillation of crude oil. They are used as fuel and as basic chemicals from which many other organic chemicals are made
- Alkenes are made by cracking alkanes by heating alkanes at high temperatures in the presence of a catalyst.

Topic 3.2- Alkanes

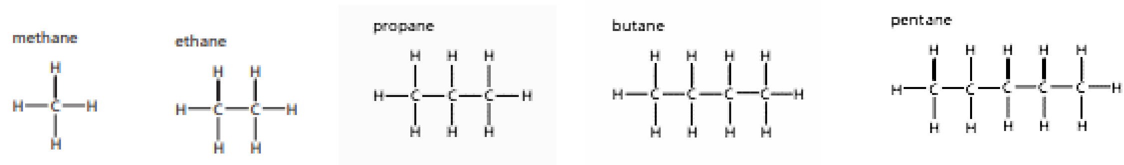
Most of the hydrocarbons in crude oil belong to the family of compounds called alkanes. The molecules within the alkane family contain carbon atoms covalently bonded to four other atoms by single bonds. Because these molecules possess only single bonds they are said to be saturated, as no further atoms can be added.

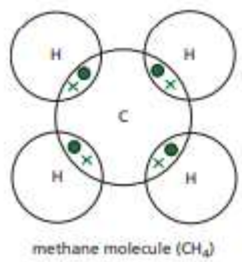
You will notice from the diagrams below that the compounds have a similar structure and similar name endings. They also behave chemically in a similar way. A family with these factors in common is called a homologous series. All the members of a homologous series can also be represented by a general formula.

In the case of the alkanes the general formula is:

C_nH_{2n+2} where n is the number of carbon atoms present.

As you go up a homologous series, in order of increasing number of carbon atoms, the physical properties of the compounds gradually change. For example, the melting and boiling points of the alkanes shown in the following table gradually increase. This is due to an increase in the intermolecular forces (van der Waals' forces) as the size and mass of the molecule increases. Under normal conditions molecules with up to four carbon atoms are gases, those with between five and 16 carbon atoms are liquids, while those with more than 16 carbon atoms are solids.





Alkane	Formula	Melting point/ °C	Boiling point/ °C	Physical state at room temperature
Methane	CH_4	−182	−162	Gas
Ethane	C_2H_6	−183	−89	Gas
Propane	C_3H_8	−188	−42	Gas
Butane	C_4H_{10}	−138	0	Gas
Pentane	C_5H_{12}	−130	36	Liquid
Hexane	C_6H_{14}	−95	69	Liquid

The Names of Alkanes:

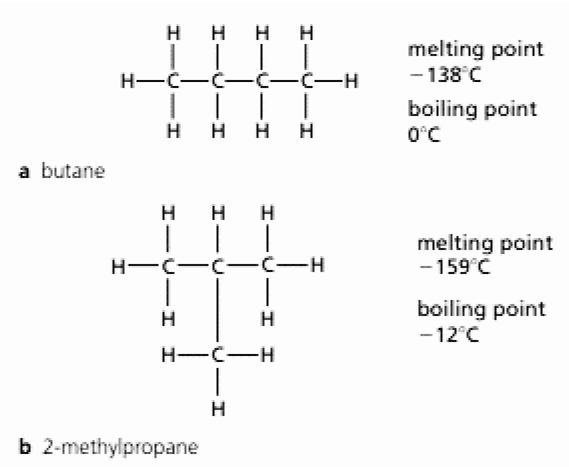
The name of an alkane is based on the latin names for the numbers.

meth- has one carbon atom i.e **methane**
eth- has two carbon atoms i.e **ethane**
prop- has three carbon atoms
but- has four carbon atoms
pent- has five carbon atoms
hex- has six carbon atoms
hept- has seven carbon atoms
oct- has eight carbon atoms
non- has nine carbon atoms i.e **nonane**
dec- has ten carbon atoms i.e **decane**

Topic 3.3- Isomers: Branched Chain Alkanes

More than one structural formula can represent a molecular formula. The structural formula of a compound shows how the atoms are joined together by the covalent bonds. E.g, there are two different compounds with the molecular formula C_4H_{10}.

The structural formulae of these two substances along with their names and physical properties are shown below.



a butane

b 2-methylpropane

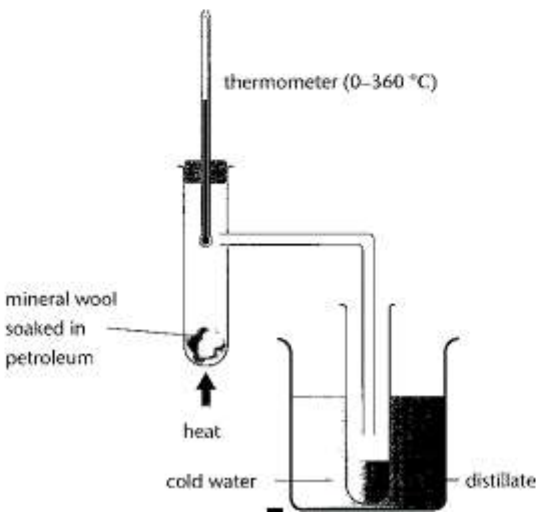
These are known as isomers. **Isomers are substances which have the same molecular formula but different structural formulae**.

The different structures of the compounds have different melting and boiling points. Molecule **b** contains a branched chain and has a lower melting point than molecule **a**, which has no branched chain.

All the alkane molecules with four or more carbon atoms possess isomers.

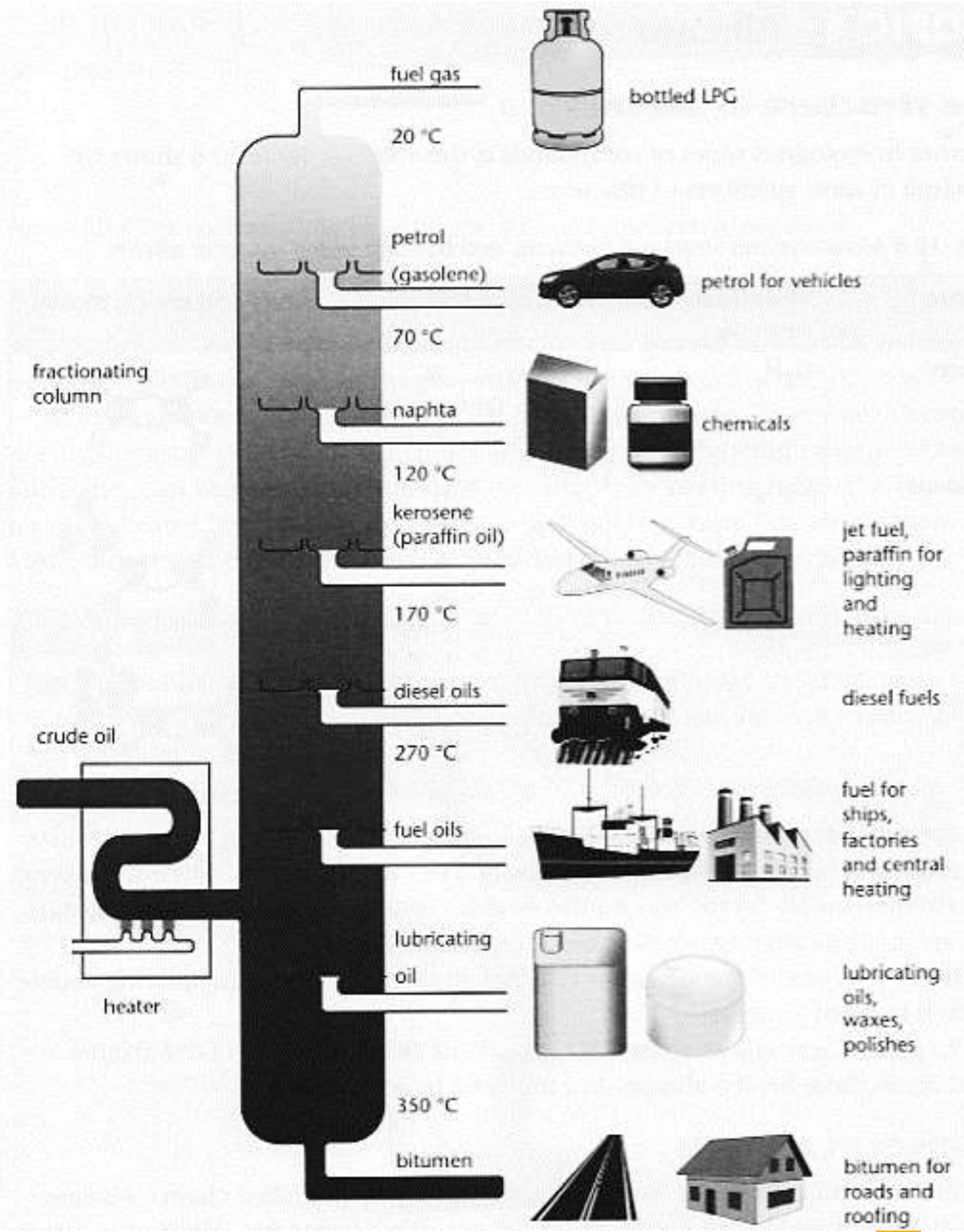
Topic 3.4- Making Alkanes

Crude oil, often called petroleum, can be distilled using the simple equipment shown below



in industrial manufacture of alkanes, the fractions with the lowest boiling points burn easily with clear flame. The fractions with the higher boiling points need a wick to burn well and they have a smoky flame. The following table shows the commercial names and properties of common fractions from crude oil.

Boiling Range	20- 70°C	70- 120°C	120- 170 °C	170- 240 °C	Over 240 °C (left behind in heating tube)
Name of Fraction	Petrol	Naphtha	Paraffin	Diesel oil	Bitumen
Colour	Pale yellow	Yellow	Dark yellow	Brown	Black
Viscosity	Runny	Fairly Runny	Fairly Viscous	Viscous	Very Viscous
How does it burn?	Easily with clear yellow flame	Quite easily with yellow flame, some smoke	Harder to burn, quite smoky flame	Hard to burn, smoky flame	Very difficult to ignite
Number of carbon atoms in the molecules	5-10	8-12	9-16	15-30	Over 25
Uses	Fuel for vehicles, chemicals	Chemicals	Fuel for heating, jet engines, chemicals	Fuel for diesel engines, trains and heating, lubricants	Roofing, waterproofing, roads


fuel gas
bottled LPG
20 °C
petrol
(gasolene)
petrol for vehicles
70 °C
fractionating
column
naphta
chemicals
120 °C
kerosene
(paraffin oil)
jet fuel,
paraffin for
lighting
and
heating
170 °C
diesel oils
diesel fuels
crude oil
270 °C
fuel for
ships,
factories
and central
heating
fuel oils
lubricating
oil
heater
lubricating
oils,
waxes,
polishes
350 °C
bitumen
bitumen for
roads and
roofing

Topic 3.5- Chemical Behaviour of Alkanes

Alkanes are rather unreactive compounds. For example, they are generally not affected by alkalis, acids or many other substances. Their most important property is that they burn easily.

Chlorine atoms react with methane molecules, and a hydrogen chloride molecule is produced along with a methyl free radical.

chlorine + methane → methyl + hydrogen atom radical chloride

$Cl(g) + CH_4(g) \rightarrow CH_3(g) + HCl(g)$

The methyl free radical reacts further.

methyl + chlorine → chloromethane + chlorine radical gas atom

$CH_3(g) + Cl_2(g) \rightarrow CH_3Cl(g) + Cl(g)$

This chlorine free radical, in turn, reacts further and the process continues until all the chlorine and the methane have been used up. This type of process is known as a chain reaction and it is very fast.

The overall chemical equation for this process is:

methane + chlorine → chloromethane + hydrogen chloride

$CH4(g) + Cl_2(g) \rightarrow CH_3Cl(g) + HCl(g)$

This type of reaction is known as a **substitution reaction**.

Because we cannot control the chlorine free radicals produced in this reaction, we also obtain small amounts of other 'substituted' products;

CH2Cl2 (dichloromethane)

CHCl3 (trichloromethane or chloroform) and

CCl4 (tetrachloromethane) – by further reactions such as those shown below.

chloromethane + chlorine →chloromethyl + hydrogen atom radical chloride

CH3Cl(g) + Cl(g) → CH2Cl(g) + HCl(g)

chloromethyl + chlorine →dichloromethane + chlorine radical gas atom

CH2Cl(g) + Cl2(g) → CH2Cl2(g) + Cl(g)

Many of these so-called 'halogenoalkanes' are used as solvents. For example, dichloromethane is used as a solvent in paint stripper

Topic 3.6- Alkenes

This is another homologous series of compounds, with general formula:

C_nH_{2n} where n is the number of carbon atoms.

The alkenes are more reactive than the alkanes because they each contain a double covalent bond between the carbon atoms.

Molecules that possess a double covalent bond of this kind are said to be **unsaturated**, because it is possible to break one of the two bonds to add extra atoms to the molecule.

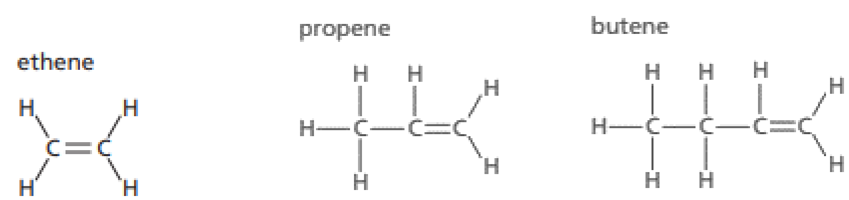
All alkenes have names ending in -ene. Alkenes, especially ethene, are very important industrial chemicals.

They are used extensively in the plastics industry and in the production of alcohols such as ethanol and propanol

The first 3 alkenes:

Alkene	Formula	Melting point/°C	Boiling point/°C	Physical state at room temperature
Ethene	C_2H_4	−169	−104	Gas
Propene	C_3H_6	−185	−47	Gas
Butene	C_4H_8	−184	−6	Gas

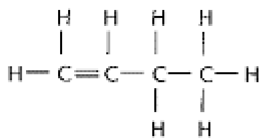
Ethene has 2 carbon atoms
Propene has 3 carbon atoms
Butene has 4 carbon atoms

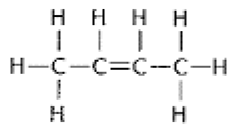


Isomer of Alkenes:

Alkenes show isomerism caused by branched chains (structural isomerism) and also another kind of isomerism called **positional isomerism.**

The following shows the systematic names of the two isomers of butane. The numbers in front of the '-ene' is the number in the carbon chain where the double bond starts





Where do we get Alkenes from?

Very few alkenes are found in nature. Most of the alkenes are obtained by breaking up larger alkane molecules

This is usually done by a process called **catalytic cracking**.

In this process the alkane molecules to be 'cracked' (split up) are passed over a mixture of aluminium and chromium oxides heated to about 500°C.

dodecane $\mathbf{C_{12}H_{26}(g)}$ *(found in kerosene)* → decane $\mathbf{C_{10}H_{22}(g)}$ *shorter alkane* + ethene $\mathbf{C_2H_4(g)}$ *alkene*

Another possibility is:

$C_{12}H_{26}(g) \rightarrow C_8H_{18}(g) + C_4H_8(g)$

There is a further cracking process which is more versatile, called **thermal cracking**.

Thermal cracking is carried out at a higher temperature than catalytic cracking, 800–850°C. Larger alkane molecules can be more successfully cracked using this process than by the catalytic method.

Note that in these reactions hydrogen may also be formed during cracking. The amount of hydrogen produced depends on the conditions used.

Topic 3.7- Chemical Behaviour of Alkenes

The double bond makes alkenes more reactive than alkanes in chemical reactions.

For example, hydrogen adds across the double bond of ethene, under suitable conditions, forming ethane

The following table summarizes the properties of alkenes

REACTION	**Set fire to ethene**	**Add some drops of bromine water to ethane then shake**	**Adds some drops of potassium permanganate solution and shake**
OBSERVATION	Burns with yellowish flame and the gas produced turns lime water milky;	The brown bromine water turns colourless	Solution turns colourless (a little should be added)
EXPLANATION	Ethene burns to form carbon dioxide and water	The bromine has reacted with the ethane	The potassium permanganate has reacted with the ethane

Topic 3.8- Addition Reactions:

These are reactions where two or more molecules combine to form a larger one

- **Hydrogenation**
  The conditions necessary for this reaction to take place are a temperature of 200 °C in the presence of a nickel or platinum catalyst.

  $C_2H_4(g) \ + \ H_{2(}g) \rightarrow \ C_2H_6(g)$

  Hydrogenation reactions like the one shown with ethene are used in the manufacture of margarines from vegetable oils.

  Vegetable oils contain fatty acids, such as linoleic acid (C18H32O2).

  These are unsaturated molecules, containing several double bonds. These double bonds make the molecule less flexible.

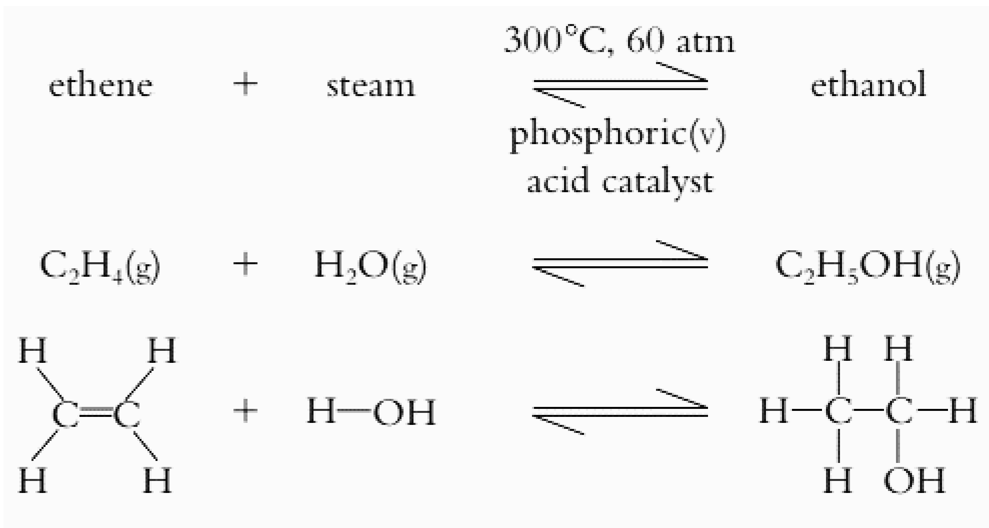
  Hydrogenation can convert these molecules into more saturated ones. Now the molecules are less rigid and can flex and twist more easily, and hence pack more closely together.

  This in turn causes an increase in the intermolecular forces and so raises the melting point.

- **Hydration**
  Another important addition reaction is the one used in the manufacture of ethanol.
  Ethanol has important uses as a solvent and a fuel.

  It is formed when water (as steam) is added across the double bond in ethene.

For this reaction to take place, the reactants have to be passed over a catalyst of phosphoric(v) acid (absorbed on silica pellets) at a temperature of 300 °C and pressure of 60 atmospheres (1 atmosphere = 1×10^5 pascals)



This reaction is reversible as is shown by the equilibrium sign.
The conditions have been chosen to ensure the highest possible yield of ethanol. In other words, the conditions have been chosen so that they favour the forward reaction.

- **Halogenation** – a test for unsaturated compounds.

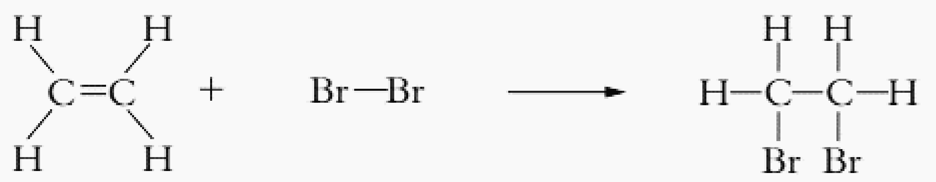
  The addition reaction between bromine dissolved in an organic solvent, or water, and alkenes is used as a chemical test for the presence of a double bond between two carbon atoms.

  When a few drops of this bromine solution are shaken with the hydrocarbon, if it is an alkene, such as ethene, a reaction takes place in which bromine joins to the alkene double bond. This results in the bromine solution losing its red/brown colour.

  If an alkane, such as hexane, is shaken with a bromine solution of this type, no colour change takes place. This is because there are no double bonds between the carbon atoms of alkanes.

ethene + bromine $\longrightarrow$ dibromoethane

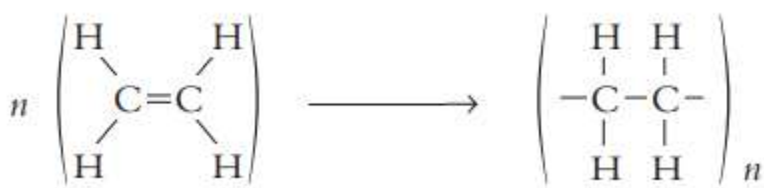
$C_2H_4(g) + Br_2$ (in solution) $\longrightarrow C_2H_4Br_2$(in solution)



An atom of bromine adds to each carbon at both ends of the double bond. All the halogens react with alkenes this way.

- **Polymerisation**

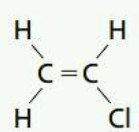
Polythene is a plastic. It is made by heating ethene to a relatively high temperature under a high pressure in the presence of a catalyst.



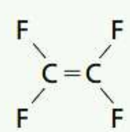
where n is a very large number

In polyethene the ethene molecules have joined together to form a very long hydrocarbon chain. The ethene molecules are able to form chains like this because they possess carbon to carbon double bonds.

Many other addition polymers have been produced. Often the plastics are produced with particular properties in mind, for example PVC (polyvinyl chloride or poly(chloroethene)) and PTFE (poly(tetrafluoroethene)). Both of these plastics have monomer units similar to ethene.



PVC monomer (vinyl chloride or chloroethene)



PTFE monomer (tetrafluoroethene)

If we use chloroethene, the polymer we make is slightly stronger and harder than poly(ethene) and is particularly good for making pipes for plumbing.

The following table summarizes the reactions of alkenes

Reagent	What is happening
Bromine water (Br_2)	An atom of bromine adds to each carbon at both ends of the double bond. All the halogens react like this
Hydrogen (H_2)	An atom of hydrogen adds to each carbon at both ends of the double bond. This is quite a difficult reaction requiring heat and a catalyst. It is an important industrial reaction used, for example, to convert vegetable oils into margarine
Hydrogen chloride(HCl)	An atom of hydrogen adds to one carbon and an atom of chlorine adds to the other carbon. The usual reagent used is not the gas hydrogen chloride, but concentrated hydrochloric acid
Water (H_2O)	An atom of hydrogen adds to one carbon and the group –OH, called the hydroxyl group, adds to the other carbon. This is what happens when potassium permanganate solution is added to an alkene

Topic 3.10- Alcohols, Carboxylic Acids, Esters: Key Points

- Alcohols (alkanols) are compounds that have a carbon and hydrogen structure similar to alkanes, and also contain a hydroxyl group. The general formulae of alcohols is $C_nH_{2n+1}OH$
- Alcohols show both positional and structural isomerism. Structural isomers have branched carbon chains; with positional isomers, the hydroxyl group is different carbon atoms in the chain
- Alcohols can be made from alkenes by their reaction with steam and by the hydrolysis of esters. Ethanol is made industrially by the fermentation of sugar using yeast
- Alcohols burn in air to give carbon dioxide and water. They can be dehydrated to give alkenes, oxidised to carboxylic acids and they form esters when they react with carboxylic acids
- Ethanol is a useful fuel, solvent and disinfectant
- Carboxylic acids are compounds containing the –COOH group. The hydrogen atom in this group can readily be ionised, and these compounds are acids. They are weak acids (pH mainly around 3) and react with metals, carbonates and alkalis in the same way that other acids do
- Carboxylic acids can be prepared from alcohols by heating the alcohol with an oxidizing agent such as potassium permanganate or potassium dichromate
- Carboxylic acids react with alcohols to form esters
- There are many carboxylic acids and they have many uses. Many are present in food or are used in cooking. Soaps are salts of carboxylic acids
- Esters are made by heating carboxylic acids with alcohol in the presence of an acid catalyst. They are mainly liquids and usually have sweet smells

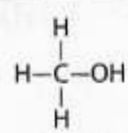
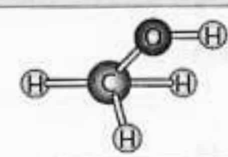
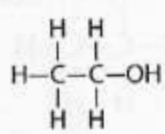
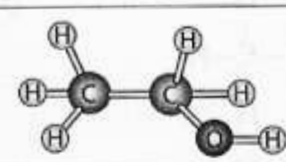
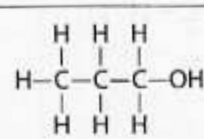
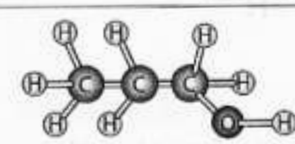
- Esters are constructed from two alkyl groups joined with the ester (-CO — O-) linkage. They take their names from the alcohol and carboxylic acid from which they are made
- Esters can be hydrolysed to form a carboxylic acid and alcohol. Animal fats and vegetable oils are examples of esters and these can be hydrolysed to make soaps, which are the salts of carboxylic acids
- Esters are common in nature, often causing the taste and smell of foods, such as fruit

Topic 3.11 – Alcohols

The alcohols (alkanols) form another homologous series with the general formula

$C_nH_{2n+1}OH$ (or R— OH, where R represents an alkyl group)

All the alcohols possess an –OH as the functional group.

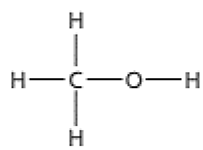
Name	Molecular structure	Structural formula	Ball and spring formula
Methanol	CH_3OH		
Ethanol	C_2H_5OH		
Propanol	C_3H_7OH		

The following table shows the names and condensed formulae of the first four members along with their melting and boiling points.

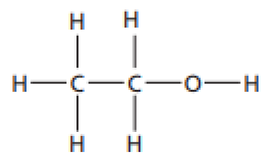
Alcohol	Formula	Melting point/ °C	Boiling point/ °C
Methanol	CH_3OH	–94	64
Ethanol	CH_3CH_2OH	–117	78
Propanol	$CH_3CH_2CH_2OH$	–126	97
Butanol	$CH_3CH_2CH_2CH_2OH$	–89	117

The alcohols are named by reference to the corresponding alkane.

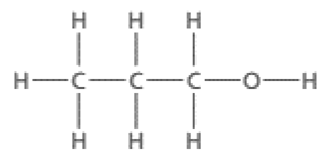
methanol



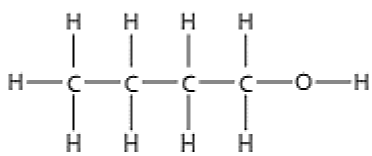
ethanol



propanol

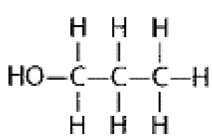


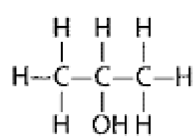
butanol



Isomers of Alcohols

C_3H_7 is propanol. There are 2 possible structures of propanol.





These two isomers are different because the –OH group is attached to a different carbon in the chain. Isomerism can also be caused by branched chains. The following are all the possible isomers of pentanol, C_5H_{11}

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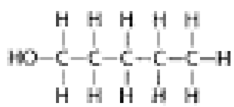
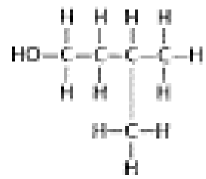
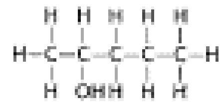
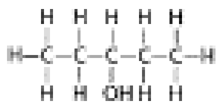
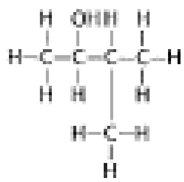
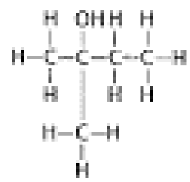
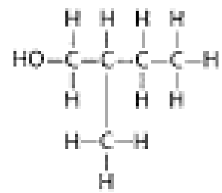

(b)

(c)

(d)

(e)

(f)

(g)


Preparation of Alcohols

Alcohols can be made in the lab in 2 ways:

1. By the reaction between steam and an alkene

2. By the hydrolysis of esters

1. The Reaction between Steam and an Alkene

Ethene is heated to 300°C under pressure with steam and phosphoric acid. Most of the ethanol used in industries is made this way

2. The Hydrolysis of Esters

The ethanol in wines and beers is made from sugars by **fermentation**. This is a process carried out by organisms called yeast. The following equation represents the reaction

Sugar $\xrightarrow{\text{yeast}}$ Ethanol + Water
$C_6H_{12}O_6\,(l) \rightarrow 2C_2H_5OH(l) + H_2O(g)$

Topic 3.12- Properties of Alcohols

-Alcohols have relatively high boiling points and relatively low volatility compared to other organic compounds.

-Alcohol molecules are polar because of the presence of the –OH group

-Ethanol is by far the most important of the alcohols and is often just called 'alcohol'.

-It is a neutral, colourless, volatile liquid which does not conduct electricity. The more concentrated forms of alcoholic drinks such as the spirits whiskey and brandy contain high concentrations of ethanol.

Combustion

Ethanol burns quite readily with a clean, hot flame.

ethanol + oxygen → carbon + water + energy dioxide

$CH_3CH_2OH(l)$ + $3O_2(g)$ → $2CO_2(g)$ + $3H_2O(g)$ + energy

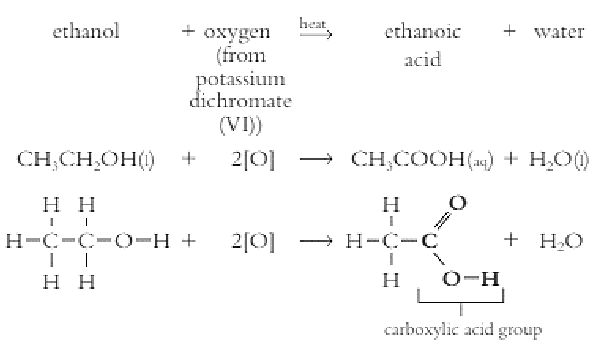
As methylated spirit, it is used in spirit (camping) stoves. Methylated spirit is ethanol with small amounts of poisonous substances.

It is also used as fuel.

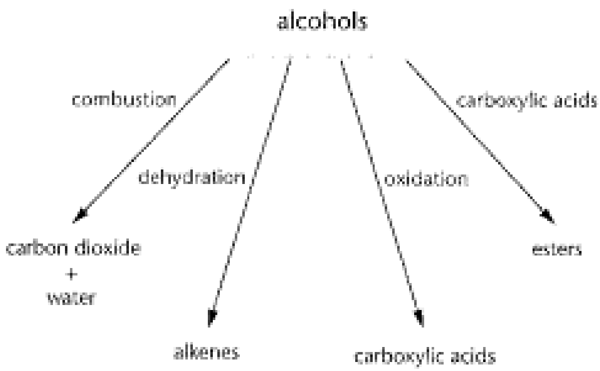
Oxidation

Ethanol can be oxidised to ethanoic acid (an organic acid also called acetic acid) by powerful oxidising agents, such as warm acidified potassium dichromate(vi), or potassium manganate(vii).

During the reaction the orange colour of potassium dichromate(vi) changes to a dark green as the ethanol is oxidised to ethanoic acid.



Other Reactions of Alcohols



Preparation of Carboxylic Acids

The oxidation of alcohols produces carboxylic acids.

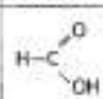
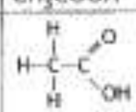
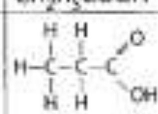
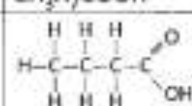
All alcohols will react with an oxidizing agent to give a carboxylic acid. For example, butanol will give butanoic acid

Topic 3.13 Carboxylic Acids

The carboxylic acids form another homologous series, with the general formula

$C_nH_{2n+1}COOH$ where n = number of carbon atoms

All the carboxylic acids possess –COOH as their functional group

Name of acid	Methanoic	Ethanoic	Propanoic	Bdutanoic
Formula	$HCOOH$	CH_3COOH	CH_2H_5COOH	CH_3H_7COOH
Structural formula				
Number of carbon atoms	1	2	3	4
Boiling point	101 °C	118 °C	141 °C	165 °C

Carboxylic acids have strong smells

Each member of the series has one –CH2- more than the previous one

All carboxylic acids have a systematic name that ends in 'oic acid'

The most common carboxylic acid is ethanoic acid. It is found in vinegar.

Ethanoic acid affects indicators and will react with metals e.g magnesium.

Ethanoic acid is a weak acid. Even though it is a weak acid, it will still react with bases to form salts. For example, the salt sodium ethanoate is formed when ethanoic acid reacts with dilute sodium hydroxide

ethanoic acid + sodium hydroxide → sodium ethanoate + water

$CH_3COOH(aq)$ + $NaOH(aq)$ → $CH_3COONa(aq)$ + $H2O(l)$

Carboxylic acids will react with alcohols to produce an ester.

Therefore, ethanoic acid will react with ethanol, in the presence of a few drops of concentrated sulfuric acid, to produce ethyl ethanoate – an ester.

$$\text{ethanoic acid} + \text{ethanol} \underset{H_2SO_4}{\overset{\text{conc}}{\rightleftharpoons}} \text{ethyl ethanoate} + \text{water}$$

$$CH_3COOH(l) + C_2H_5OH(l) \rightleftharpoons CH_3COOC_2H_5(aq) + H_2O(l)$$

This reaction is called esterification. Members of the 'ester' family have strong and pleasant smells. They have the general formula

$C_nH_{2n+1}\,COOC_xH_{2x+1}$

Uses of Carboxylic Acids

Name of acid	Use
Formic acid (methanoic acid)	The sting in an ant bite (the ant actually bites you, then quickly turns round and squirts the acid into the bite from a gland in its tail)
Acetic acid (ethanoic acid)	Vinegar
Citric acid	Orange and lemon juice
Tartaric acid	Used in cooking
Malic acid	In sharp-tasting apples
Lactic acid	In milk. It is also made in your muscles when you are tired and cannot get enough oxygen. It causes muscle cramp. If you run upstairs quickly, it is the substance that causes pain in your knees.
Aspirin (acetyl salicylic acid)	Originally found in the bark of a tree. These days it is made artificially and used as a medicine.
Stearic acid (and others)	Soaps

Topic 3.14 Esters

Members of the ‘ester’ family have strong and pleasant smells. Many esters occur naturally and are responsible for the flavours in fruits and the smells of flowers. They are used, therefore, in some food flavourings and in perfumes

Esters are named after the acid and alcohol from which they are derived:

• name – alcohol part first, acid part second, e.g. propyl ethanoate

• formula – acid part first, alcohol part second, e.g. $CH_3COOC_3H_7$

some examples of esters;

Hydrolysis of Esters

Alkane		Alkyl group	
Formula	Name	Formula	Name
CH_4	Methane	$-CH_3$	Methyl-
C_2H_6	Ethane	$-C_2H_5$	Ethyl-
C_3H_8	Propane	$-C_3H_7$	Propyl-
C_4H_{10}	Butane	$-C_4H_9$	Butyl-
C_5H_{12}	Pentane	$-C_5H_{11}$	Pentyl-

In hydrolysis reactions, the ester is split into the carboxylic acid and the alcohol parts of the molecule. This is the reaction used to make soap.

Uses of Esters

- The solvent is nail vanish is a solvent called amyl acetate

- Manufacture of soap

- Animal fat and vegetable oils are made of esters

UNIT 4 MACROMOLECULES

Topic 4.1- Macromolecules: Key Points

- Macromolecules are large molecules that contain a long chain of carbon atoms. Some occur naturally, while others are synthetic plastics and fibres.

- Synthetic macromolecules are polymers such as ployethene, trylene and nylon. These are long chains of small molecules called monomers, joined together end to end.

- Addition polymers are formed from alkenes using high pressure and a catalyst. Common examples are polyethene, polyvinyl chloride and polypropylene

- Condensation polymers are formed from two different monomers that react, eliminating water in the process. The polymer contains a chain of the monomers, one after the other. E.g nylon and terylene. Nylon contains an **amide** link between the monomers. Terylene contains an ester link between the monomers

- Thermoplastic polymers soften on heating and can be reused. Thermosetting polymers undergo a chemical change when they are heated and will not soften when they are heated again. Thermosetting polymers are hard polymers, and used to cast plastic objects such as electrical goods.

- Most plastics are not **biodegradable** and can cause pollution if not recycled

- **Examples of natural macromolecules are proteins;** carbohydrates and fats. In proteins, the monomer is one of 20 amino acids and they are linked together by amide bonds. Carbohydrates are ploymers of **glucose** linked by a **glycosidic bond** formed by one oxygen atom. Fats are esters made from fatty acids and an alcohol called **glycerol**

- Proteins, carbohydrates and fats can all be broken down by hydrolysis. This happens in our bodies, usually with the help of enzymes. It can also be carried out in laboratories, and the products of the hydrolysis can be identified using chromatography

- The hydrolysis of fats is an important commercial reaction called **saponification.** It is used to make soap by hydrolysing fats or oils.

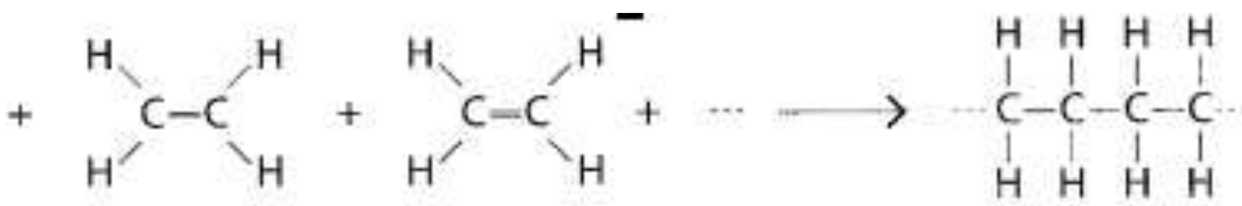
Topic 4.2- Synthetic Polymers

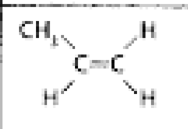
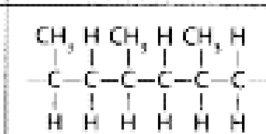
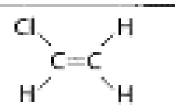
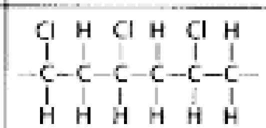
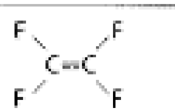
Synthetic means these polymers are made by people. The molecules are called polymers because they are made up of many small parts joined end to end like links in a chain. Each of the individual parts of the polymer is called a **monomer**

Addition Polymers:

Polyethene is a very common material. The polymerization of ethene is an adittion reaction. The equation below shows how two ethene molecules join together.

Common polymers are made from alkenes as shown below:



Monomer		Polymer		
Name	**Structure**	**Name**	**Structure**	**Use**
Propene (propylene)		Polypropylene		Water pipes
Chloroethene (vinyl chloride)		Polyvinyl chloride (PVC)		Electrical insulation
Tetrafluoroethene (tetrafluoro-ethylene)		Polytetrafluoro-ethylene ('Ptfe') ('teflon')		Non-stick pans

Condensation Polymers

Not all polymers are formed by addition reactions. Nylon is an example of a condensation polymer. It is made by reacting two different chemicals together, unlike poly(ethene) which is made only from monomer units of ethene.

Poly(ethene), formed by addition polymerisation, can be represented by:

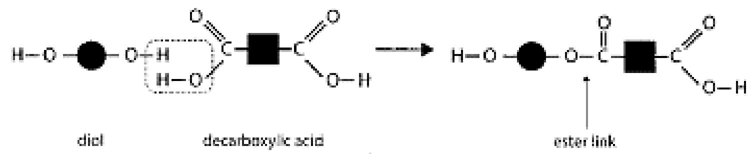
–A–A–A–A–A–A–A–A–A–A–

Terylene another condensation polymer, is a condensation polymer. It has two monomer units. A basic representation of terylene:

–A–B–A–B–A–B–A–B–A–B–

A **polyester** is a long chain compound, containing alternately the alcohol part and then acid part of the ester. How the parts combine to form a polyester is shown below.

Diol is the alcohol part and **dicarboxylic acid** is the acid part.

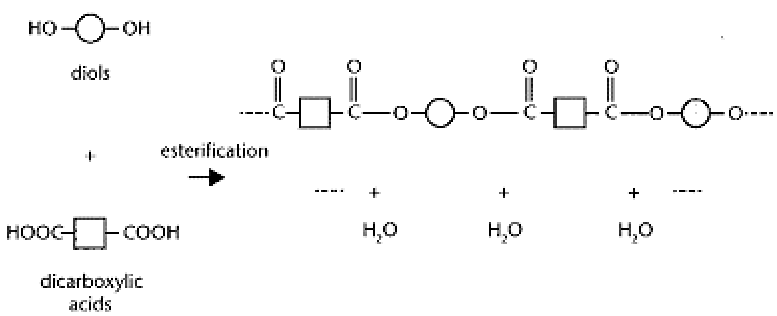


The link between the monomers is the **ester link** , -CO-O- . Many more links can form in the same way to make long polymer chains.

The squares shown above represents the dicarboxylic acid and the diol is represented by a circle.

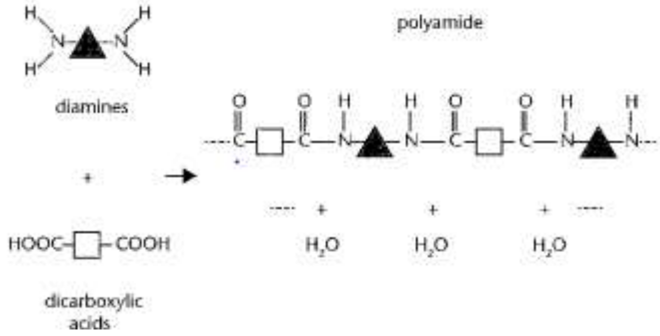
Terylene is a polyester made by condensation reactions. The monomers used are;
ethanediol (the diol) and **terephtallic acid** (the carboxylic acid)
The link between the monomers is the ester link –CO-O-

The following shows how terylene is formed



Nylon is another well-known condensation polymer. It is not a polyester but a polyamide. It has the –OH group instead of an alcohol. They use a substance called an **amine**, -NH_2 . However the reaction is the same.

The structure of the polymer that is formed is almost the same as a polyester, but a nitrogen atom replaces the place of the oxygen atom. This link is called an amide link: -CO-NH-



Both terylene and nylon are used as fabrics.

Topic 4.3 – Natural Macromolecules

Proteins

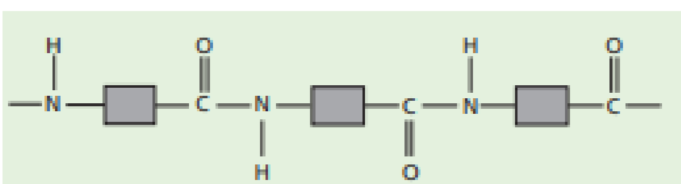
Proteins are natural polymers with a polyamide structure. Proteins are made up of amino acids.

There are 20 different amino acids and they each possess two functional groups. One is the carboxylic acid group, –COOH. The other is the amine group, $–NH_2$

Amino acids are the building blocks of proteins. Similar to nylon, proteins are polyamides, as they contain the –CONH– group, which is called the amide or, in the case of proteins, the peptide link.

Proteins are formed by condensation polymerisation.

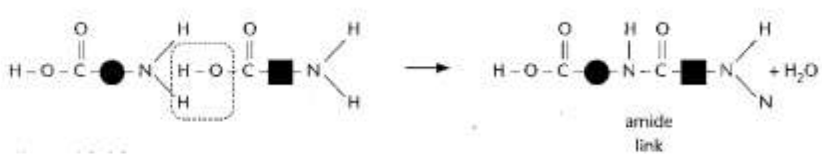
Protein chains formed by the reaction of many amino acid molecules have the general structure shown below.



Further reaction with many more amino acids takes place at each end of each molecule to produce the final protein

For a molecule to be a protein, there must be at least 100 amino acids involved. Below this number, they are called polypeptides.

Water is produced during the creation of protein. Therefore, it is a condensation reaction. The condensation is shown below



Reactions of Proteins

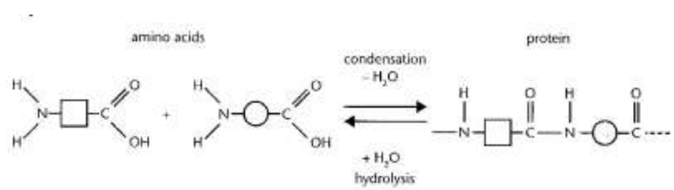
Proteins can be broken down into the amino acids from which they were made. This is called **hydrolysis**

Hydrolysis is the reverse reaction of condensation.

Condensation is the reaction in which two compounds join together with water as the only by-product

Hydrolysis is the process in which a substance is broken down by heating it with water.
The water is usually made either acidic or alkaline, which makes the reaction proceed faster.

The following shows condensation and hydrolysis:



We can tell which amino acid is present in a protein. First, the protein is hydrolysed in acidic solution. The mixture of amino acids is then separated using chromatography. The paper used in the chromatography is covered in a **locating agent** that changes colour when amino acids react with it.

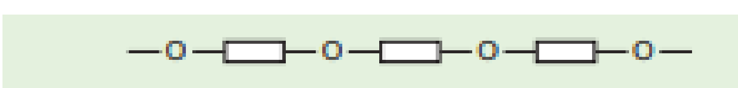
Another way of hydrolyzing a protein is to use an enzyme. Enzymes are also proteins.

Carbohydrates

These are substances that are usually made by plants. The name tells us that they contain the elements; carbon(carbo-), hydrogen(hydr-), oxygen(-ate)

Starch, cellulose etc are carbohydrates. Starch and cellulose are both condensation polymers of glucose.

The structure of starch is shown below.

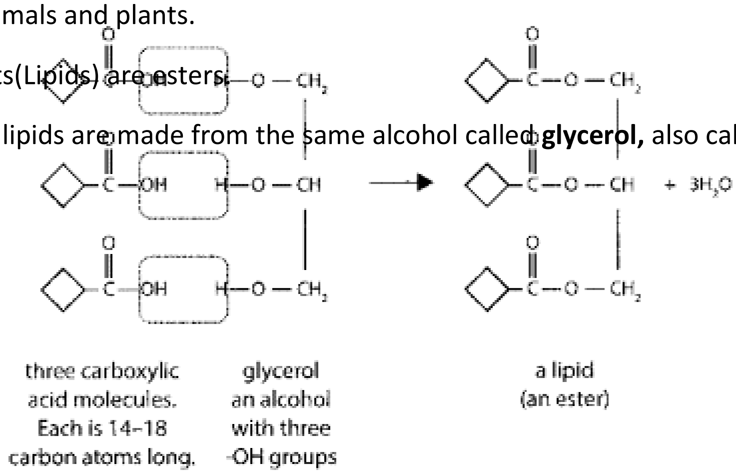


Fats and Oils (Lipids)

Fats and oils are well-known macromolecules. We use them in cooking, and they are found in almost all animals and plants.

Fats(Lipids) are esters.

All lipids are made from the same alcohol called **glycerol,** also called **glycerine**



Making Soap

Fats are esters. Fat is hydrolysed, in other words, **saponified** to break it down into glycerol and fatty acids. The fatty acids in fats are used to react with other substances to make salts. These salts are actually what we know as soap.

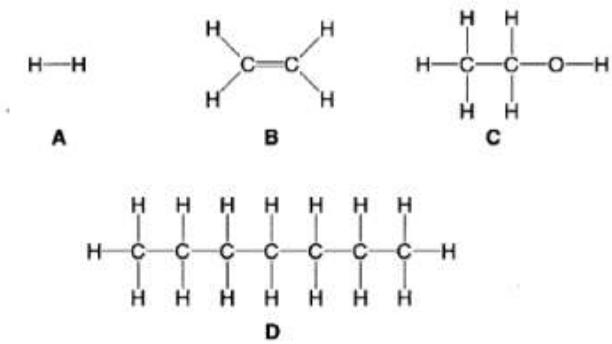
EXAM TYPE QUESTIONS AND ANSWERS

Instructions:

**attempt to answer these questions before looking at the answers*

1. Petroleum is a mixture of many different hydrocarbons.

(a) Which **two** of the structures **A**, **B**, **C** and **D** are hydrocarbons?



structure 1 ....

structure 2 .... [1]

(b) The mixture of hydrocarbons in petroleum is separated into different fractions.

(i) What is meant by the term *fraction*?

....

....[1]

(ii) What is the name of the process used to separate these fractions?

....[1]

(iii) During this process, the mixture of hydrocarbons is vaporised and then condensed. Explain what is meant by

vaporised, ...

condensed. ....
[2]

(iv) The separation of the fractions depends on one physical property of the hydrocarbons.
State this property.

....[1]

(c) Octane is a hydrocarbon which can be cracked to produce two different hydrocarbons, hexane and ethene.

$$\underset{\text{octane}}{C_8H_{18}} \rightarrow \underset{\text{hexane}}{C_6H_{14}} + \underset{\text{ethene}}{C_2H_4}$$

(i) State two conditions which are used to crack octane.

1. ....

2. .... [2]

(ii) Which of the three hydrocarbons in the equation above is used to make a polymer?

....[1]

(d) In the diagram below, the boxes on the left give the names of some petroleum fractions.
The boxes on the right show some uses of these fractions.
Draw lines between the boxes to link the fractions to their correct uses.
The first one has been done for you.

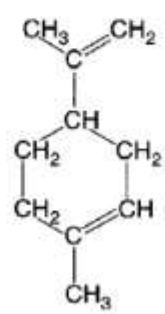
fraction	use
diesel fraction	aircraft fuels
petrol fraction	making roads
lubricating fraction	fuel for diesel engines
paraffin fraction	fuel for cars
bitumen	waxes and polishes

[4]

ANSWERS

1. (a) B and D
   (b)(i) Substance or group of substances with a specific boiling range or condensed at a similar temperature
   (ii) Distillation/fractional distillation/fractionation
   (iii) Vaporised – change of state to gas
   Condensed – change of state from gas to liquid
   (iv)boiling point
   (c)(i) high temperature
   (ii) ethene/C_2H_4
   (d) petrol → fuel for cars
   lubricating fraction → waxes and polishes
   paraffin(also called kerosene) → aircraft fuels
   bitumen → making roads

(a) The structure of limonene is shown below.



(i) What is the molecular formula of limonene?

....[1]

(ii) Some limonene was added to a few drops of aqueous bromine.
What colour change would you see in the aqueous bromine?

....[2]

(iii) What feature of a limonene molecule is responsible for this colour change?

....[1]

(iv) Name the two substances formed when limonene is burnt in an excess of oxygen.

.... and ....[2]

ANSWERS

2. (a)(i) $C_{10}H_{16}$
   (ii) brown/orange/red to colourless
   (iii) C = C bond / carbon – carbon double bond
   (iv) carbon dioxide and water

Ethene, C_2H_4, is manufactured by cracking petroleum fractions.

3. (a) (i) What do you understand by the term *fraction?*

....

.... [1]

(ii) Complete the symbol equation for the manufacture of ethene from dodecane, $C_{12}H_{26}$.

$$C_{12}H_{26} \rightarrow C_2H_4 + \ldots\ldots\ldots\ldots$$

[1]

(b) Two fractions obtained from the distillation of petroleum are refinery gas and gasoline. State **one** use of each of these fractions.

refinery gas ....

gasoline .... [2]

(c) Ethene is an unsaturated hydrocarbon. What do you understand by the following terms?

unsaturated ....

hydrocarbon .... [2]

(d) Ethene is used to make ethanol.

(i) Which of these reactions is used to make ethanol from ethene? Tick one box.

catalytic addition of steam ☐

fermentation ☐

oxidation using oxygen ☐

reduction using hydrogen ☐

[1]

(ii) Draw the structure of ethanol, showing all atoms and bonds.

[2]

(e) Ethene is used to make poly(ethene).
Complete the following sentences about this reaction.
Use words from the list below.

additions **carbohydrates** **catalysts** **monomers** **polymers**

The ethene molecules which join to form poly(ethene) are the ....

The poly(ethene) molecules formed are .... [2]

[Total: 11]

ANSWERS

3.(a)(i) (group of) molecules with similar boiling points/ (group of) molecules with similar relative molecular masses / molecules with limited range of boiling points / molecules coming off at the same place in the fractionation column / owtte

(ii) $C_{10}H_{12}$

allowed: reasonable mixtures, e.g $C_7H_{16} + C_3H_6$

(b) refinery gas: (fuel) for cars / (fuel) for cooking; cooking ;

gasoline: (fuel) for cars / mowers etc.

(c) unsaturated: contains double bonds / contains C = C bonds

hydrocarbon: containing carbon and hydrogen **only**

(d) (i) 1st box down ticked (catalytic addition of steam)

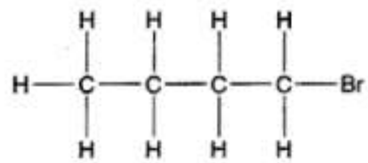
(ii) correct structure of the ethanol; bond between O-H

(e) monomers;

Polymers;

4. Organic compounds that contain the halogens can have chloro, bromo or iodo in their names.

(a) The following diagram shows the structure of 1-bromobutane.



(i) Draw the structure of an isomer of this compound.

(ii) Draw a possible structure of a dibromobutane.

(iii) Name two chemicals that react together to make only one product – dibromobutane.

.... and ....

[4]

(b) Draw a diagram to show the arrangement of the valency electrons in the covalent compound chloromethane.
Use o to represent an electron from carbon
Use x to represent an electron from hydrogen
Use ⊗ to represent an electron from chlorine

ANSWERS

4. (a) (i) correct formula of an isomer[1 mark]
$CH_3.CH_2.CHBr.CH_3$ [1 mark]
or $CH_3.CH(CH_3).CH_2Br$
or $(CH_3)_3$ CBr

(ii) any correct formula for a dibromomethane [1 mark]
(iii) butene
bromine
(b) correct formula CH_3Cl showing 8e around C and Cl and 2e around

5. The alcohols form an homologous series.

(a) Give **three** characteristics of an homologous series.

....

....

....

.... [3]

ANSWERS

5. (a) Any three from:

same general formula;

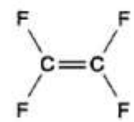
consecutive members differ by CH_2;

similar chemical properties;

same functional group;

physical properties vary in a predictable way/give trend such as mp

6. (a) The structure of tetrafluoroethene is shown below.

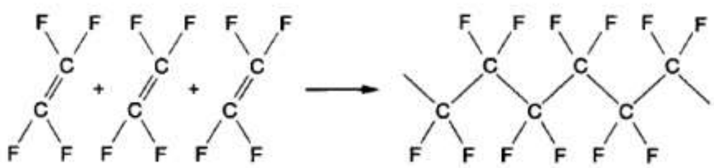


(i) Use the Periodic Table to help you calculate the relative molecular mass of tetrafluoroethene.

[2]

(ii) Teflon is used to make non-stick coatings for saucepans.

Teflon is made when many molecules of tetrafluoroethene join together.



What type of chemical reaction is shown in this equation?

ANSWERS

(a)(i) 100

(ii) addition or polymerisation

7 (a) The structure of the synthetic polymer *Terylene* is given below.

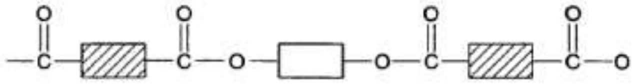


Fig. 2

(i) Name the type of linkage in this polymer.

....[1]

(ii) What naturally occurring substance contains the same linkage?

....[1]

(b) Another synthetic polymer is nylon. Draw the structure of a nylon.

[3]

(c) Complex carbohydrates such as starch are natural polymers.

(i) Name the **three** elements present in carbohydrates.

....[1]

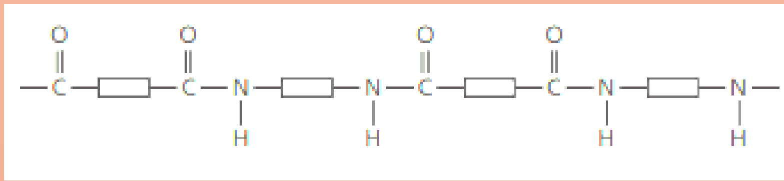
(ii) Draw the structure of a complex carbohydrate.

ANSWERS

7. (a) (i) ester or polyester

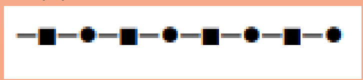
(ii) fats or vegetable oils

(b)



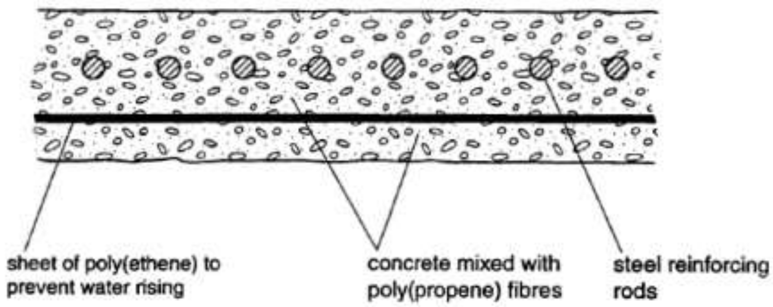
(c) (i) carbon, hydrogen, oxygen

(ii)



8

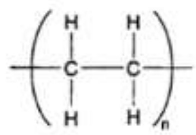
The diagram below shows a correctly constructed concrete floor.



(a) (i) What type of reaction is used to make both of the polymers, poly(ethene) and poly(propene)?

....

(ii) A diagram of the structure of poly(ethene) is given below.



Draw a similar diagram to show the structure of poly(propene).

ANSWERS

8. (a) (i) addition or addition polymerisation

(ii) correct repeat unit showing branched CH_3

9 There are two types of polymerisation, addition and condensation.

(a) Explain the difference between these two types of polymerisation.

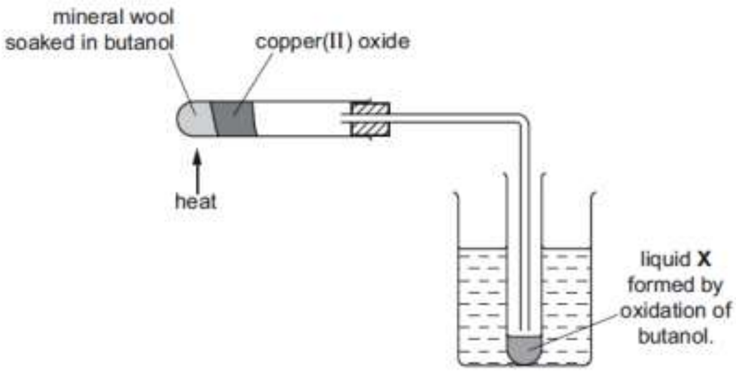
....

....

.... [2]

Copper(II) oxide can oxidise butanol to liquid **X**, whose pH is 4.

(e)



(i) Give the name of another reagent which can oxidise butanol.

.... [1]

(ii) Which homologous series does liquid **X** belong to?

.... [1]

(iii) State the formula of liquid **X**.

.... [1]

ANSWERS

9. (a) addition: polymer is the only product/only one product
condensation: polymer and water formed/small molecule

(e) (i) (acidified) potassium manganate (VII)
allowed: oxygen/air/(acidified) potassium chromate(VI)
(ii) carboxylic acid
allowed: aldehyde/ketone

(iii) $C_4H_8O_2$
allowed: C_4H_7OOH

Atomic Number — 6
Symbol — C
Name — Carbon
Average Atomic Mass — 12.011

metals
nonmetals
metaloids

1 H Hydrogen 1.008																		2 He Helium 4.003
3 Li Lithium 6.94	4 Be Beryllium 9.012												5 B Boron 10.81	6 C Carbon 12.011	7 N Nitrogen 14.007	8 O Oxygen 15.999	9 F Fluorine 18.998	10 Ne Neon 20.180
11 Na Sodium 22.990	12 Mg Magnesium 24.305												13 Al Aluminum 26.982	14 Si Silicon 28.085	15 P Phosphorus 30.974	16 S Sulfur 32.06	17 Cl Chlorine 35.45	18 Ar Argon 39.948
19 K Potassium 39.098	20 Ca Calcium 40.078		21 Sc Scandium 44.956	22 Ti Titanium 47.867	23 V Vanadium 50.942	24 Cr Chromium 51.996	25 Mn Manganese 54.938	26 Fe Iron 55.845	27 Co Cobalt 58.933	28 Ni Nickel 58.693	29 Cu Copper 63.546	30 Zn Zinc 65.38	31 Ga Gallium 69.723	32 Ge Germanium 72.630	33 As Arsenic 74.922	34 Se Selenium 78.97	35 Br Bromine 79.904	36 Kr Krypton 83.798
37 Rb Rubidium 85.468	38 Sr Strontium 87.62		39 Y Yttrium 88.906	40 Zr Zirconium 91.224	41 Nb Niobium 92.906	42 Mo Molybdenum 95.95	43 Tc Technetium [97]	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.906	46 Pd Palladium 106.42	47 Ag Silver 107.868	48 Cd Cadmium 112.414	49 In Indium 114.818	50 Sn Tin 118.710	51 Sb Antimony 121.760	53 Te Tellurium 127.60	53 I Iodine 126.904	54 Xe Xenon 131.293
55 Cs Cesium 132.905	56 Ba Barium 137.327	* 57 - 70	71 Lu Lutetium 174.967	72 Hf Hafnium 178.49	73 Ta Tantalum 180.948	74 W Tungsten 183.84	75 Re Rhenium 186.207	76 Os Osmium 190.23	78 Ir Iridium 192.217	79 Pt Platinum 195.084	80 Au Gold 196.997	81 Hg Mercury 200.592	81 Tl Thallium 204.38	82 Pb Lead 207.2	83 Bi Bismuth 208.980	84 Po Polonium [209]	85 At Astatine [210]	86 Rn Radon [222]
87 Fr Francium [223]	88 Ra Radium [226]	** 89 - 102	103 Lr Lawrencium [262]	104 Rf Rutherfordium [267]	105 Db Dubnium [270]	106 Sg Seaborgium [269]	107 Bh Bohrium [270]	108 Hs Hassium [270]	109 Mt Meitnerium [278]	110 Ds Darmstadtium [281]	111 Rg Roentgenium [281]	112 Cn Copernicium [285]	113 Nh Nihonium [286]	114 Fl Flerovium [289]	115 Mc Moscovium [289]	116 Lv Livermorium [293]	117 Ts Tennessine [293]	118 Og Oganesson [294]

*Lanthanide series	57 La Lanthanum 138.905	58 Ce Cerium 140.116	59 Pr Praseodymium 140.908	60 Nd Neodymium 144.242	61 Pm Promethium [145]	62 Sm Samarium 150.36	63 Eu Europium 151.964	64 Gd Gadolinium 157.25	65 Tb Terbium 158.925	66 Dy Dysprosium 162.500	67 Ho Holmium 164.930	68 Er Erbium 167.259	69 Tm Thulium 168.934	70 Yb Ytterbium 173.045
**Actinide series	89 Ac Actinium [227]	90 Th Thorium 232.038	91 Pa Protactinium 231.036	92 U Uranium 238.029	93 Np Neptunium [237]	94 Pu Plutonium [244]	95 Am Americium [243]	96 Cm Curium [247]	97 Bk Berkelium [247]	98 Cf Californium [251]	99 Es Einsteinium [252]	100 Fm Fermium [257]	101 Md Mendelevium [258]	102 No Nobelium [259]

References

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