

CHEMISTRY: THEORY ANALYSIS

CONTENT OF PRESENTATION

1. Examinable areas (in-depth analysis)
2. Anomalies and gaps between practical and theory
3. Currents dynamics and emerging trends in setting and marking of paper P1 & P2
4. Common errors by students
5. Teachers effects in SETTING examinations
6. Advise to students

REVISION WIZARD : concept mapping

1. FORM ONE :
CLASSIFICATION OF SUBS ,
AIR AND COMBUSTION
WATER AND HYDROGEN
2. FORM TWO : PERIODIC
TABLE
3. FORM THREE . MOLE
CONCEPT,CHEM OF

PILLARS OF CHEMISTRY

1. Reactivity Series First 20 Elements
2. Writing balanced chemical equations
3. Solubility Of Salts
4. The Mole
5. Organic Chemistry

DELIMITATORS

1. PERIODIC TABLE 25MARKS
 2. ORGANIC 30MARKS
 3. SALTS30MARKS
 4. RATE ,
 5. RADIOACTIVITY
 6. ,THERMOCHEMISTRY
 7. ELECTROCHEMISTRY
- NONMETALS INDUSTRIAL
CHEMISTRY
4. FORM FOUR :
 - I. ACID,BASES SALTS AND SOLUBILITY
 - II. ELCTROCHEMISTRY AND THERMOCHEMISTRY
 - III. RATES AND RADIOACTIVITY
 - IV. ORGANIC CHEMISTRY

(USE BURNING, BROMINE WATER, $K_2Cr_2O_7$, $KMnO_4$, $NaHCO_3$, Na or Mg metal to differentiate chemically)

Use Bp,MP and solubility to diffentiate physically)

Flow charts

what is asked

Combustion

Oxidation

Substitution

Addition(reaction with halogens and HCl)

Hydrogenation Hydration hydrolysis

Cracking of long chains

Esterification

Fermentation

Polymerization

Dehydration

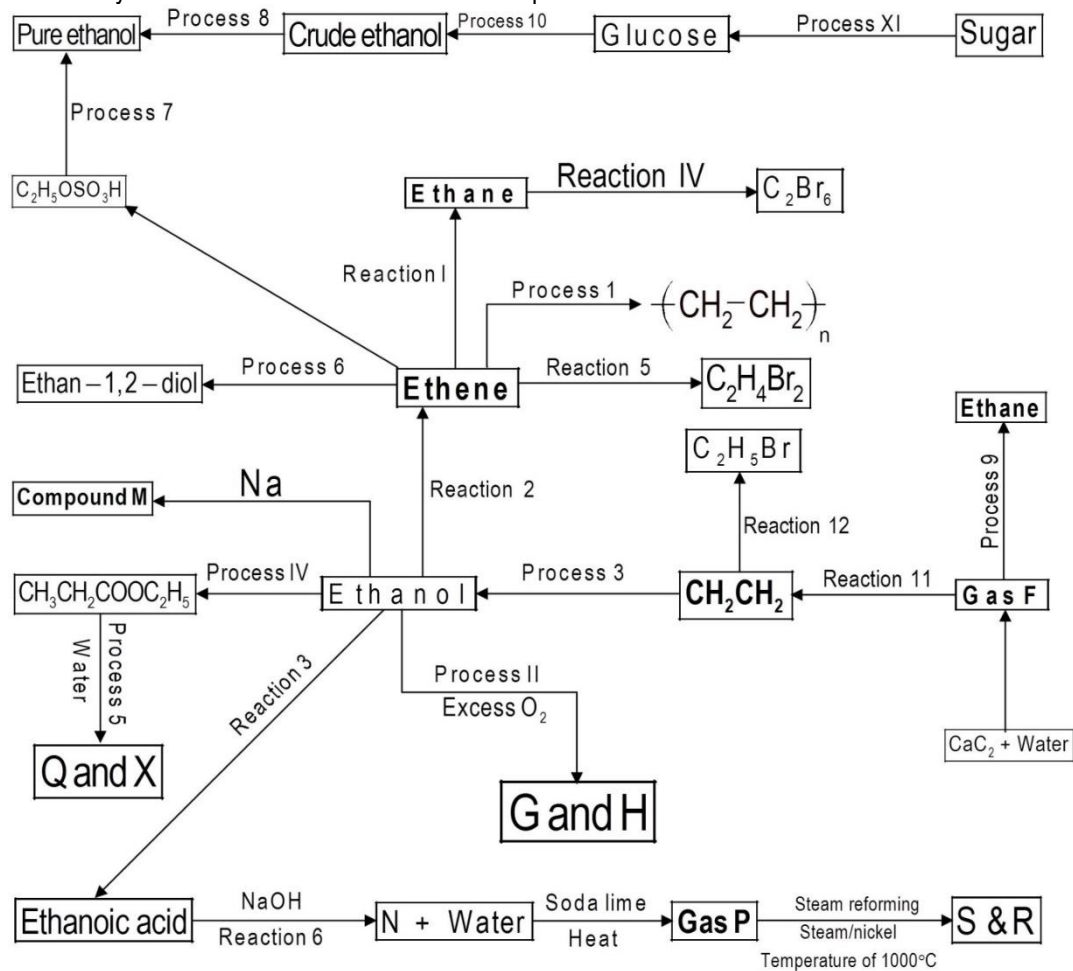
Neutralization

- Reagents and conditions
- For temp-warm/heat mention the correct temperature except in polymerization where we say high temp/high pressure
- Name of homologous series alkanes/alkenes use plural
- Name the product-give only the major product
- Soaps and detergents-
- Preparations –only for soaps
- Mode of action
- Advantages and disadvantages

2. Study the flow chart below and answer the questions that follow

4.0: ORGANIC CHEMISTRY REVISION QUESTIONS

1. Study the flow chart below and answer the questions that follow.



a) Name process I – X and state the reagents and conditions necessary for each condition to take place.

	Name	Reagents	Conditions
Process XI			
Process 8			
Process 7			
Process 1			
Process 10			

Process IV			
Process 3			
Process 9			
Process II			
Process 6			

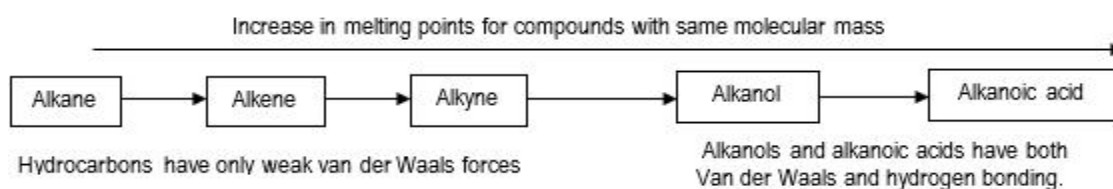
- b) Name and write formulae of the substances G, H, Q, X, N, M, P, S and R.
- c) Name type of reactions I – XI, state the reagents and conditions necessary.

State the differences between reaction IV and reaction 5.

	Reaction IV	Reaction 5
1		
2		

- d) Write equations for the reactions I – XI and for process IV, V and VI.

- 👉 To differentiate members of same homologous series (use physical properties only)... solubility and M.P and B.P.
- 👉 To differentiate substances in different homologous series (use chemical tests)... add bromine water, acidified $\text{KMnO}_4/\text{K}_2\text{Cr}_2\text{O}_7/ \text{NaHCO}_3/ \text{Mg}/\text{Na}/\text{K}$, red and blue litmus/universal indicator.



- e) Describe how you can differentiate the following compounds using both physical and chemical test where applicable.
- i. Methanol and pentan-1-ol
 - ii. Pentane and pentan-1-ol
 - iii. Ethene and ethane
 - iv. Methanol and methanoic acid
 - v. Propane and hexan
- f) To what homologous series does substance F belong?
- g) Name the fourth member of the homologous series to which F belongs.
- h) The molecular formula of compound $(\text{CH}_2\text{CH}_2)_n$ is 3556. Calculate the number of the value of n.

- Comparison use comparatives and superlatives
- Use unknown

SUMMARY OF TRENDS IN PROPERTIES OF ELEMENTS DOWN AND ACROSS PERIODIC TABLE

1) Down the group

a. Atomic radius

- For all elements the atomic radii increase down the group due to increase in number of occupied energy levels down the group

b. Atomic mass

- For all elements the atomic mass increase down the group due to increase in number of protons and neutrons down the group

c. Reactivity

Trend in reactivity down the group depends on whether it is a metal or non-metal

I. For metals

Reactivity/ Ionization energy /Electropositivity/metallic character

Increases down the group due to the weakening of attraction between the positive nuclei and the outer most electrons with increase in atomic radii. which makes it easier to remove the outermost electrons

Note: strongest reducing agent/ most electropositive element/most reactive metal /element with least ionization energy -this is an element that easily loses electron. Here you select the metal with the largest atomic radius and with fewer electrons in the outermost energy level. Mostly group one

II. For non metals

Reactivity of non metals decreases down the group due to decrease in effective nuclear attraction and shielding effect with increase in atomic radii/ number of occupied energy levels.

d. Melting point and boiling point:

I. For metals

M.P and B. P decreases down the group due to decrease in strength of metallic bonding with increase in atomic radii, increase in atomic radii leads to decrease in attraction between outermost electrons and positive nucleus.

II. For non metals

Melting point and boiling point increases down the group due to increase in strength of Vander Waals forces with increase in molecular mass

Electron affinity/reactivity/electronegativity

Electron affinity decrease down the group with increase in atomic radius and increase in shielding effect with increase in atomic radii.

2. ACROSS THE PERIOD

a. Atomic radius

Generally for all elements the atomic radius decreases across the period due to increase in number of protons that attracts the outermost electrons more strongly towards the nucleus, hence decreasing the atomic radius. **a. Reactivity** In Metals

Reactivity decreases across the period due to increase in the number of electrons to be lost and also decrease in atomic radii.

Ionization energy

Increase across the period due to increase in attraction between the positive nucleus and outermost electrons with decrease in atomic radius and increase in nuclear charge.

Electropositivity

Increase across the period due to increase in attraction between the positive nucleus and outermost electrons with decrease in atomic radius and increase in nuclear charge.

Melting and boiling point increase across the periods due to increase in the strength of metallic bond with increase in valence electrons and decrease in atomic radius.

Electric conductivity increase from sodium to Aluminium due increase in number of delocalized electrons.

b) Strongest oxidizing agent/ most electronegative element /most reactive non-metal /element with highest electron affinity-, this is usually the non-metal with the smallest atomic radius and requires fewer electrons to be stable, mostly halogens

1. The grid below represents part of the periodic table. The letters do not represent the actual symbols of the elements. Study it and answer the questions that follow:

L						L	
M	P			T		J	U X
N	Q		R	S		B	V Y
H							W
K							

- Explain why element **L** appears in two different groups in the grid above (1mk)
 - State the name of the chemical family to which **P** and **Q**, **X** and **Y** belong (1 mk)
 - Write the formula of the compound formed between **P** and **V** (1mk)
 - Name the bond type of compound above
 - Compare the melting points of, **N** and **K**, **S** and **B**, **V** and **W** Explain(6mks)
- ii). Compare the atomic radius of **H** and **W** (2mks)
- Select the element with the smallest and largest atomic radius ,explain (2mks)
 - Identify an element whose oxide dissolves in both acids and alkalis (1 mark)
 - Write the equation for the burning of **T** in excess air (1 mark)
 - Using dots (**•**) and cross (**x**) to represent electrons, draw a diagram to illustrate bonding in sulphide of **Q** and chloride of **R** (2 marks)
 - State **one** use of element **X** (1 mark)
 - Select the most electronegative and the most electropositive element
 - Select the strongest reducing and the strongest oxidizing agen
 - Compare the melting point and boiling point of the oxide **T** and **S**
 - Give two commercial uses of element **J** (2 marks)
 - Select an element that exist as :
 - Diatomic molecule
 - Monoatomic gas
 - Tetraatomic molecule
 - Octatomic molecule
 - Compare the atomic mass of **H** and **M** (2 marks)
 - Compare the reactivity of **H** and **M** (2mks)
 - Element **Z** is in the third period and forms ions with charge of -3, place it in the grid above
 - Element **Z** forms two ions, write the formula and configuration of the ions
 - Elements **P**,**Q**,**R**,and **S** have atomic numbers 2,14,18 and 20 respectively select two elements in the same chemical family
 - Write the configuration of phosphorus in the following
 - PH_3
 - PO_3^{3-}
 - PO_4^{3-}
 - Write the configuration of
 - Ca^{2-}
 - Al^{+2}
 - O^-

j. Compare the melting points of the following

- i. Chloride of H and chloride of
- ii. Oxide of Q and oxide of B
- iii. Chloride of Q and chloride of R

6. SPECIAL ANALYSIS OF SALTS

These are special notes prepared in order to demystify the concept of salt as tested in the KCSE exam, it is my hope students will find them helpful and will help them to unravel the mystery of salts and consequently improve in their grades in chemistry because chapter of salts is a core topic and is always tested in KCSE. However these notes should be used together with the teachers notes and practical manual notes in demystifying chemistry practical guide book. Also it is important to that it will be almost impossible to answer any question on salts without knowledge on solubility of salts.

Questions on salts will be based on three main areas:

Preparation Separation

action of heat and other properties eg, hygroscopy, efflorescence, and deliquescence

questions on preparation of salts

QUESTIONS ON PREPARATION

1. To answer question on preparation of salts you need to have solubility of salts on your nerves if not on your fingertips, but most questions test on preparation of insoluble salts of which the concept of precipitation must be used. Also when reacting acid with a base, metal or carbonate you must make sure all the acid is used up by adding excess metal or excess carbonate to the acid and always filter to remove the unreacted solid
2. When preparing salts, the method used is determined by starter reagent and if it is soluble, insoluble or a double salt.
3. For soluble salt preparation, add excess reagent to dilute acid, filter, evaporate the filtrate to saturation, cool it to crystallize, filter
4. For insoluble salt the method must involve precipitation by reacting two soluble salt, for instance: to get the insoluble salt whereby the starter reagent is metal/metal oxide/metal hydroxide or metal carbonate. Add excess of the metal/metal oxide or metal carbonate to dilute nitric acid (because all nitrates are soluble), filter then add a soluble salt of sodium or potassium (because all salts of potassium and sodium are soluble) to precipitate the insoluble salt. Filter, wash the residue with distilled water and dry it between filter papers.
5. In case the salt to be prepared is a salt of copper or silver (metals below hydrogen in the reactivity series) first burn the metal in air to form metal oxide (because metals below hydrogen in reactivity series don't react with dilute acids), then add excess metal oxide to dilute acid, filter and add soluble salt of sodium or potassium. filter wash the residue with distilled water and dry it between filter papers.
6. In preparation of insoluble salt whereby you are given the solid soluble salt to use, first dissolve the salt in water to obtain its solution
7. NB when considering insoluble salts remember oxides like CuO, and other metal oxides are insoluble except those of Na and

CONCEPT MAPPING ON INDUSTRIAL PROCESSES AND PREPARATION OF GASES

THIS AREA CONTRIBUTES BETWEEN 30 TO 45 MARKS IN KCSE

INDUSTRIAL PROCESS

- Solvay process
- Contact process
- Oswald process
- Frasch process
- Bayers process
- Large scale manufacture of HCl
- Fractional distillation of air
- Extraction of metals-reduction Zn/Pb/Cu/Fe
- Electrolysis Na/Al/

what is asked

- ❖ Raw materials and their sources
- ❖ Impurities name and how and why they are removed
- ❖ Chemical reactions involved
- ❖ Pollution effects
 - NO,NO₂,SO₂..... acid rain
 - CO₂global warming
- ❖ Name another industry located near
Effect on plant on the environment-pollution, land degradation
- ❖ Recycling what is recycled and why
- ❖ Conditions necessary(contact,harber and Oswald)
- ❖ Catalysts-iron catalyst/platinum/temperature give range
- ❖ Pressure relate it on equilibrium
- ❖ Uses of product
- ❖ For metals composition of alloy
- ❖ Properties-light

SUMMARY OF INDUSTRIAL PROCESSES FLOW CHART DIAGRAMS

Process	Raw materials	conditions	Main reactions
Solvay process	Brine Ammonia Coke Limestone		<p><i>Solvay tower reactions</i></p> $\text{NH}_3(\text{s}) + \text{CO}_2(\text{g}) + \text{H}_2\text{O}(\text{l}) \longrightarrow \text{NH}_4\text{HCO}_3(\text{aq})$ $\text{NH}_4\text{HCO}_3(\text{aq}) + \text{NaCl}(\text{aq}) \longrightarrow \text{NH}_4\text{Cl}(\text{aq}) + \text{NaHCO}_3(\text{s})$ <p>overall reaction</p> $\text{NH}_3(\text{g}) + \text{CO}_2(\text{g}) + \text{H}_2\text{O}(\text{l}) + \text{NaCl}(\text{aq}) \longrightarrow \text{NH}_4\text{Cl}(\text{aq}) + \text{NaHCO}_3(\text{s})$ <p>Filter/or use fractional crystallization to separate the products at solvay tower. To obtain NaHCO₃ as residue ,</p> <p>Ammonia generator</p> $2\text{NH}_4\text{Cl}(\text{aq}) + \text{Ca}(\text{OH})_2(\text{s}) \longrightarrow \text{CaCl}_2(\text{aq}) + 2\text{NH}_3(\text{g}) + \text{H}_2\text{O}(\text{l})$ <p>kiln</p> $\text{CaCO}_3(\text{s}) \xrightarrow{\text{heat}} \text{CaO}(\text{s}) + \text{CO}_2(\text{g})$ $\text{C}(\text{s}) (\text{coke}) + \text{O}_2(\text{g}) \longrightarrow \text{CO}_2(\text{g})$ <p>Roaster</p> $\text{NaHCO}_3(\text{s}) \xrightarrow{\text{heat}} \text{Na}_2\text{CO}_3(\text{aq}) + \text{H}_2\text{O}(\text{l}) + \text{CO}_2(\text{g})$ <p>Slaker.</p> $\text{CaO}(\text{s}) + \text{H}_2\text{O}(\text{l}) \longrightarrow \text{Ca}(\text{OH})_2(\text{aq})$ <p>uses of sodium carbonate</p> <ul style="list-style-type: none"> ☞ glass making ☞ in paper industry to soften wood pulp ☞ used to make sodium silicate used to make detergents <p>name two substances recycled water</p>

		carbon (IV) oxide	
	Raw materials	Conditions	
Haber process	Hydrogen Nitrogen	Iron catalyst 200-500atm pressure 450°C	<p>Purifier hydrogen and nitrogen is mixed in the ratio 3:1 respectively Impurities removed : dust particles , water vapour, sulphur (IV) oxide, CO₂ Compressor Gases are compressed to increase the pressure which favours high yield of ammonia</p> <p>Catalytic chamber $N_{2(g)} + 3H_{2(g)} \longrightarrow 2NH_3$</p>
Oswald process	Ammonia Air	Platinum-rhodium catalyst 9atm pressure 700-900°C	<p>Impurities removed : dust particles , water vapour, sulphur (IV) oxide, CO₂</p> <p>Catalytic chamber $4NH_{3(g)} + 5O_{2(g)} \longrightarrow 4NO_{(g)} + 6H_2O_{(g)}$ oxidizer $2NO_{(g)} + O_{2(g)} \longrightarrow 2NO_{2(g)}$ absorption tower $2NO_{2(g)} + H_2O \longrightarrow HNO_3 + HNO_3$</p>
Contact process	Air Sulphur/metal sulphide	catalysts Vanadium (V) oxide Or platinum 2-3atm pressure Temp; 450-500°C	<p>Impurities removed : dust particles , water vapour, arsenic oxides</p> <p>Roaster $S_{(s)} + O_{2(g)} \longrightarrow SO_{2(g)}$ $ZnS_{(s)} + O_{2(g)} \longrightarrow ZnO_{(s)} + SO_{2(g)}$ $ZnS_{(s)} + O_{2(g)} \longrightarrow ZnO_{(s)} + SO_{2(g)}$</p> <p>catalytic chamber $2SO_{2(g)} + O_{2(g)} \longrightarrow 2SO_{3(g)}$ absorption tower $SO_{3(g)} + H_2SO_{4(l)} \longrightarrow H_2S_2SO_7(l)$ Dilution chamber $H_2S_2SO_7(l) + H_2O(l) \longrightarrow 2H_2SO_{4(l)}$ Scrubber $Ca(OH)_{2(aq)} + SO_{2(g)} \longrightarrow CaSO_{3(aq)} + H_2O(l)$</p>

<p>Fractional Distillation Of air</p>	<p>air</p>	<p>-200°C 200 atmospheres</p>	<p><u>Dust particles</u> removed through electrostatic precipitation/filtration <u>Removal of CO₂</u> by passing air through concentrated NaOH or KOH <u>Water vapour</u> removed by cooling to -25°C to remove it as ice The air is then repeatedly compressed and allowed to expand at -200°C and 200 atmospheres to liquefy it Liquid air is fractionally distilled to obtain oxygen gas at -183 °C, argon at -186 °C and nitrogen at -196 °C</p> <p><i>Points to note</i> <u>Water vapour</u> and CO₂ are removed before liquifaction because they liquify at lower temperatures hence may cause clogging of pipes, hence interfere with flow of liquid air</p>
<p>Frasch process</p>	<p>Water Compressed air</p>	<p>-</p>	<p>Frasch process uses three concentric pipes drilled into the sulphur deposits Outermost pipe- allows super heated water under pressure (170°C, 10atm) into the sulphur deposit to melt the sulphur The high pressure keeps the water in liquid state even at high temperature) Innermost pipe- is used to allow hot compressed air into the sulphur deposit to push the molten sulphur up through the middle pipe Middle pipe- used to allow the molten sulphur up to the collecting tanks Properties of Sulphur that make it possible to be extracted through this method Sulphur is insoluble in water Sulphur has a low melting point</p> <p><i>impurities found in sulphur</i> soil, silica carbon</p>

Important points to note

Impurities are removed to avoid poisoning the catalyst

Roles of heat exchanger

- Maintain reaction temperature
 - Recycle heat
 - Heat the reactants (mention specific reactants e.g ammonia and air in Ostwald process)
 - Remove heat/cool the product (from the catalytic chamber not the final product e.g NO in manufacture of nitric acid not nitric (V) acid)
 - ✍ In contact process excess oxygen is used to completely convert SO₂ to SO₃
 - ✍ In contact process excess oxygen is used to completely oxidize NH₃ to NO
- Recycling is important in industrial process because
- ✍ It helps reduce running cost/cost of production
 - ✍ Help minimize pollution

The plant that can be located near the industrial process, look at the raw materials and uses of the product

Solvaly	Contact	Haber	Fractional distillation of air	frasch	Ostwald
haber process	Ferrilizer plant	Ferrilizer plant		Ferrilizer plant	Ferrilizer plant
Manufacture of detergents	Frasch process				

1. PREPARATION OF GASES

2.. PREPARATION OF GASES

FORM 1 O₂ and H₂ g

FORM 2 CO, CO₂,

FORM 3 Cl₂, HCl, N₂, N₂O, NO,
NO₂, NH₃, SO₂, SO₃, H₂S

FORM 4 CH₄, C₂H₆, C₂H₄, C₂H₂

what is asked

- *Method of collection ,mistake ,justify*
- *Over water-Gases are slightly soluble in water except H₂ gas which is insoluble*
- *Reagents conditions and drying agent*
- *Equation for the reaction*
- *Catalyst ₂H₂,C₂H₄*
- *Setting set up drawn but incomplete(complete the set to prepare, purify ,dry and collect the gases*
- *Slanting position...common mistakes*
- *Set up drawn with mistakes(CASE OF cl₂ INTERCHANGE water with H₂SO₄*
- *Describe chemical test for the gas*
- *Know which oxides they reduce e.g CO,NH₃ and H₂PbO and CuO*
- *Uses of the gases*

Special similarities

- CO,H₂,NH₃ --they are reducing agents reduce CuO /PbO Black copper (II) oxide turns to brown copper
- Cl₂,SO₂ are bleaching agents(compare and contrast)
- .Cl₂ , NO₂,H₂S, SO₂,CO – poisonous gases precaution should be collected in open or in a working fume chamber
- Most of the coloured gases are poisonous
- Cl₂,HCl, , NO₂,NH₃ SO₂, are highly soluble in water and are collected over inverted funnel
- HCl and Cl₂ formation of salt where they react with a metal

$$\text{Fe} + \text{HCl} \longrightarrow \text{FeCl}_2 + \text{H}_2$$

$$\text{Fe} + \text{Cl}_2 \longrightarrow \text{FeCl}_3$$
- H₂S, SO₂, -oxidizing agent oxidize Fe²⁺ green to Fe³⁺ yellow
- Only CO and H₂ are burnt during a reaction because CO is very poisonous and hydrogen explodes when mixed with air
- N₂O,O₂, relight a glowing splint
- Coloured gases NO₂ (brown) and Chlorine (green –yellow)
- Note; in preparation of gases in many a times there will be drawn a diagram and be required to in identify the mistakes made in preparation of certain gas. In such questions you look for;

- When asked to identify the mistake in the diagram look for wrong reagents, wrong drying agents especially use of CaO to dry acidic gases, reagents that lead to formation of insoluble salts, wrong method of gas collection, orientation of the apparatus e.g slanting upwards instead of downwards.

SUMMARY ON PREPARATION OF GASES

1. OXYGEN GAS	2. HYDROGEN GAS
reagents and conditions hydrogen peroxide and manganese (IV) oxide as a catalyst sodium peroxide and water KClO ₃ (heat required) Na NO ₃ (heat required) KMnO ₄ (heat required)	reagents and conditions zinc metal plus dilute HCl or dilute H ₂ SO ₄ with copper (II) sulphate crystals as a catalyst Mg can also be used but expensive
drying agent : concentrated sulphuric (VI) acid fused calcium chloride calcium oxide	drying agent : concentrated Sulphuric (VI) acid fused calcium chloride calcium oxide
method of collection . over water use of syringe if needed dry	method of collection . over water upward delivery if needed dry
test for the gas : lower a glowing splint into a gas jar full of oxygen it will relight .	test for the gas : lower a burning splint into a gas jar full of the gas it will be extinguished with a pop sound
use of the gas . as respiratory aid for patients with breathing difficulties by deep sea divers and mountain climbers in arc welding in steel making to remove iron impurities	use of the gas . manufacture of ammonia manufacture of hydrochloric acid manufacture of margarine in welding
3. carbon (II) oxide	4. carbon (IV) oxide
reagents and conditions Dehydration of methanoic acid or ethanoic acid using concentrated sulphuric (VI) acid.	reagents and conditions reaction between CaCO ₃ and dilute HCl
drying agent : concentrated sulphuric (VI) acid fused calcium chloride calcium oxide	drying agent : concentrated Sulphuric (VI) acid fused calcium chloride
Method of collection. over water use of syringe if needed dry	Method of collection . downward delivery
Test for the gas: lower a glowing splint into a gas jar full of oxygen it will relight.	Test for the gas : bubble the gases through Ca(OH) ₂ white precipitate is formed .
Use of the gas. manufacture of methanol as a reducing agent in extraction of metals like copper, iron, zinc as a fuel	in fizzy drinks to add flavor in fire extinguisher as a refrigerant in ice-cream boxes in seeding of clouds to induce rain

RATE OF REACTION

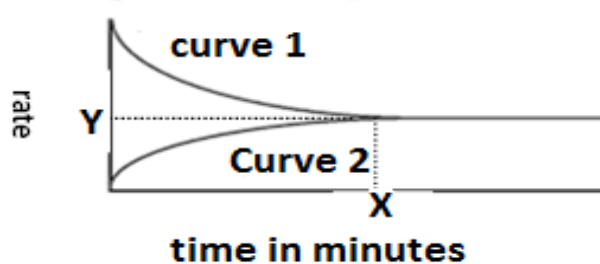
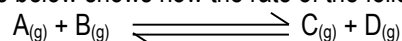
- state the factors that affect the rate of reaction and mention how they affect rate of reaction
- drawing curves that show effects of various of concentration, surface area, temperature, pressure on the rate of reaction
- be able to interpret graphs of rate of reactions
- calculate rate of reactions at a particular time (by drawing a tangent)
- be able to calculate $\frac{1}{time}$ and draw a rate against time/ volume of acid
- state the Le Chatelier's principle
- state and explain the factors that affect chemical equilibrium
- define dynamic equilibrium

interpret graphs of reversible reactions, by identifying forward and reverse/backward reaction, time taken to establish equilibrium,.

1. The table below shows the volumes of nitrogen (IV) oxide gas produced when different volumes of 1M nitric acid were each reacted with 2.07g of lead at room temperature.

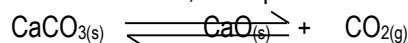
Volume of 1M nitric acid (cm ³)	Volume of nitrogen (iv) oxide (cm ³)
5	60
15	180
25	300
35	420
45	480
50	480

- a) Give a reason why nitric acid is not used to prepare hydrogen gas. (1mk)
- b) Explain how the rate of the reaction between lead and nitric acid would be affected if the temperature of the reaction mixture was raised. (2mks)
- c) On the grid provided below, plot a graph of the volume of the gas produced (vertical axis) against volume of the acid. (3mks)
2. (a) The figure below shows how the rate of the following reaction varies with time.

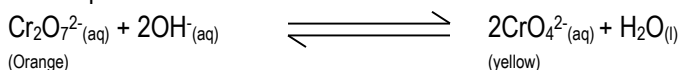


- (i) Which of the two curves represents the rate of reverse reaction? Give a reason. (2mks)
- (b) State and explain the effect of an increase in pressure on the rates of the following reactions.
- i. $H_{2(g)} + Cl_{2(g)} \longrightarrow 2HCl_{(g)}$ (2mks)
- ii. $CH_3OH_{(l)} + CH_3COOH_{(l)} \longrightarrow CH_3COOCH_3_{(l)} + H_2O_{(l)}$ (1mk)

(b) When calcium carbonate is heated, the equilibrium shown below is established.



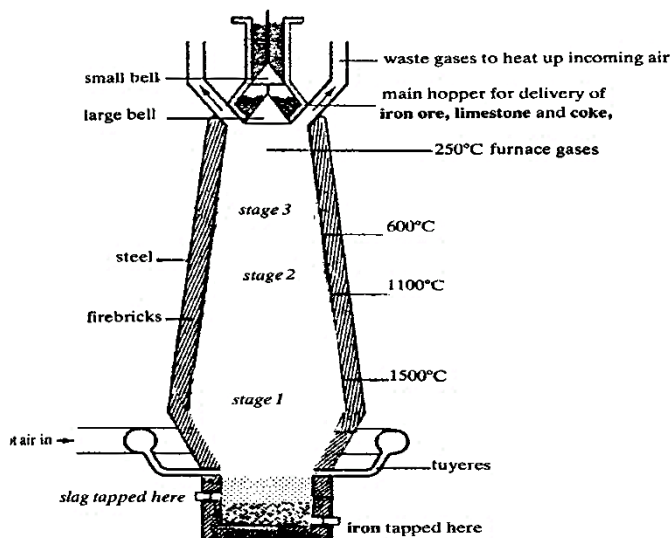
- I. How would the position of equilibrium be affected if small amount of dilute potassium hydroxide is added to the equilibrium mixture? Explain (2mks)
 - II. State and explain how increase in pressure affect the yield of carbon (IV) oxide
3. A dynamic equilibrium between dichromate and chromate ions is established as shown in the equation below.



- a) What is meant by dynamic equilibrium? (1mk)
 - b) State and explain the observation that would be made if a few pellets of potassium hydroxide are added to the equilibrium mixture. (2mks)
- 4.
- a. Other than concentration ,state factors that determine the rate of a reaction (2mks)
 - b. In an experiment to determine the rate of reaction ,excess lambs of calcium carbonate were added to 2M hydrochloric acid .The mass of calcium carbonate left was recorded after every 30 seconds . the results are shown in the table below .

time seconds	0	30	60	90	120	150	180	210
mass of CaCO ₃	2.00	1.60	1.30	1.00	0.85	0.8	0.8	0.8

- i) Write the equation for the reaction that place(1mk)
 - ii) On the grid provided ,plot a graph of mass of calcium carbonate vertical axis against time
5. The diagram below shows a blast furnace which is used for the extraction of iron. Study it and answer the questions.



- a. Name two major ores from which iron is extracted. (1 mark)
- b. Give a reason why the temperature at the bottom of the furnace is very high. (1 mark)
- c. State two properties of slag that allows it to be separated from molten iron. (1 mark)

- d. What is the role of limestone in the blast furnace? (1 mark)
- e. Write an equation for the reaction responsible for the fall in temperature at stage 2. (1 mark)
- f. Write an equation in which iron is formed. (1 mark)
- g. State two uses of iron. (1 mark)
- h. State the effect of iron extraction on the environment. (1 mark)
- i. The iron obtained from blast furnace is 95-99%.
- I. What name is given to this type of iron? (1 mark)
 - II. Name the impurities found in this type of iron(1 mark)
 - III. State the effect of impurities found in this type of iron(1 mark)
 - IV. How are impurities removed? (1 mark)
 - V. Give one use of slag(1 mark)
- j. Name four raw materials that are fed into the blast furnace. (1 mark)
- k. Name three waste gases that come out blast furnace. (3 mark)
- l. What is the role of hot air(1 mark)
- m. Iron that comes out of the blast furnace cannot be used directly to make railway lines. Explain
- n. Some rocky material is suspected to be an iron ore. Describe how you could establish the presence of iron(1 mark)-
- o. Name:
- (i) One of the substances in the slag. (1 mark)
 - (ii) Another iron ore material used in the blast furnace. (1 mark)
 - (iii) One gas which is recycled. (1 mark)
- p. Describe the process which leads to the formation of iron in the blast furnace. (3 marks)
- q. Give a reason why the melting point of the iron obtained from the blast furnace is 1200°C while that of pure iron is 1535°C. (1 mark)
- r.
- (i) State two uses of steel. (2 marks)
 - (ii) Write an equation for the reaction in which carbon (IV) oxide is converted into carbon (II) oxide. (1 mark)
 - (iii) State one physical property of molten slag other than density that allows it to be separated from molten iron as shown in the figure 1. (1 mark)
 - (iv) One of the components of the waste gases is nitrogen (IV) oxide. Describe the adverse effect it has on the environment. (2 marks)
- (s)** Iron from the blast furnace contains about 5% carbon.
- (i) Describe how the carbon content is reduced. (2 marks)
 - (ii) Why is it necessary to reduce the carbon content? (1 mark)

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PRACTICAL

PART TWO

CHEMISTRY PRACTICAL NOTES

Practical exam in chemistry clearly aims in testing whether the learner has acquired the following:

- 👉 Appropriate manipulative skills.
- 👉 Skills in making accurate observations and accurate recording of results.
- 👉 Ability to analyze and interpret scientific data.
- 👉 Ability to follow a sequence of instructions and carry out experiments.

The following are the major areas which can be tested on chemistry practical.

- a) **Heating/cooling curve** e.g. heating naphthalene refer KCSE 2005
- b) **Qualitative Analysis**-test for cations/anions (a must).
- c) **Qualitative Analysis**-Organic test (a must).
- d) **Rate of reaction** refer to KCSE 2002, 2012,2016
- e) **Thermo chemistry**,2000,2001,2003,2004,2005,2007,2008,2010,2013,2014,2017
- f) **Solubility** 2006,2015
- g) **Titration** (a must) except 1995,2002,2005,2016

QUALITATIVE ANALYSIS

Introduction

In qualitative analysis this practical will require a candidate to be able to identify or test for cations and anions in inorganic qualitative analysis. In qualitative analysis you look for;

- a) What you hear the sound produced e.g. a cracking sound.
- b) What you see; the colour of the product, precipitate, colour of filtrate, colour of residue, colour of the gas produced, Colour of the sublimate, the colour of the liquid formed when a vapour condenses, effervescence, effect on red and blue litmus papers.
- c) What you smell; e.g. a choking irritating smell, a pleasant smelling compound, odourless gas etc.

Qualitative analysis is the only part of chemistry practical that requires specific answers, marking is very strict on this part and students must be very keen when answering such questions, students need to do as many questions as possible in order to familiarize themselves with carrying out experiments, the practical language and be able to make correct observations

The ions tested are as given below

PRELIMINARY TESTS

These are the initial test in a chemistry practical question. The initial test on chemistry practical are summarized below.
Heating – in a boiling tube; here you look for gas produced, its color, smell, and effect on blue and red litmus paper. You also look for the sound produced, does the solid melt, the colour of the residue, you look for water of crystallization. Or even a sublimate

NB, when told to heat gently you are only looking for the water of crystallization (which can be tested using blue dry cobalt (II) chloride paper which turns pink)

When told to heat strongly you are looking for gases evolved (test them with litmus papers or wooden splint), colour of residue, sublimate etc.

Possible results

Observations	Inferences
A colourless vapour that condenses on the cooler parts of test-tube to form a colourless liquid, or blue dry cobalt (II) chloride paper turns pink	Hydrated salt/water of crystallization present

A gas that that turns a moist red litmus paper blue, blue litmus paper remains blue	NH ₄ ⁺ present
A gas that that turns a moist red litmus paper blue and a blue litmus paper turns red, White sublimate formed on cooler parts of the test-tube	NH ₄ ⁺ present Reasoning NH ₄ Cl decomposes on heating to NH ₃ and HCl gases, NH ₃ is lighter and diffuses faster Hence the litmus first turns from red to blue, and later the HCl reaches the upper end of test-tube and turns blue litmus red
The solid melts, brown gas is evolved, Cracking sound, yellow residue remained	NO ₃ ⁻ Pb ²⁺
A colourless gas is evolved which relights a glowing splint and no effect on both red and litmus papers	ClO ₃ ⁻ , NO ₃ ⁻ , MnO ₄ ⁻ , O ₂ ⁻ . Neutral substance Tied to no effects on litmus paper Tied to a gas that relights a glowing splint
A colourless ,odourless gas that extinguishes a burning splint is produced	CO ₃ ²⁻ produced
A colourless gas is evolved the will turn a filter paper soaked in potassium chromate (VI) from orange to green	SO ₄ ²⁻ present

- a) **Burning using a metallic spatula**-here you look for how the solid burns, does it melt, the color of flame it produces, and whether the flame is sooty or not. This is normally used to test organic substances (see organic tests).

Burning using a nichrome wire/ or a glass rod dipped in a solution, here you look for flame color' normally to test for cations

Observation	Inference
Yellow flame	Na ⁺
Pale green flame	Ba ²⁺
Green flame	Cu ²⁺
Red flame	Ca ²⁺
Colourless	Mg ²⁺
Lilac flame/purple	K ⁺

- b) **Put a portion of the solid provided in a boiling tube add distilled water:** here you look for whether the solid dissolves and the colour of the resulting solution.

The solid dissolves to form a colourless solution	Solid is a soluble salt/substance Fe ²⁺ , Cu ²⁺ , Fe ³⁺ absent
Dissolves to form a green solution	Fe ²⁺ , Cu ²⁺ , p Solid is a soluble salt/substance present
Dissolves to form a blue solution	Cu ²⁺ , Solid is a soluble salt/substance present
Dissolves to form a brown or yellow solution	Fe ³⁺ , Solid is a soluble salt/substance present

- c) **Put the liquid in a watch glass and ignite**- this is used to test for organic compounds whereby if a blue flame is produced it means there is presence of low carbon organic compound a yellow sooty flame indicates presence of high carbon and unsaturated organic compound (see organic test)
- d) **You can also be told to place the solid provided in a boiling tube then add distilled water and shake and then filter.** In such a case you have to mention the colour of residue and colour of filtrate.

Observation	Inference
Colourless filtrate, White residue	Solid is a mixture of soluble and insoluble salt Fe ²⁺ , Cu ²⁺ , Fe ³⁺ absent (tied to colourless filtrate)

green filtrate	Fe^{2+} Cu^{2+}
Blue filtrate	Cu^{2+}

There is a wrong assumption that only Fe^{2+} salts are green, that is a misnomer as some copper (II) salts are green e.g. copper (II) chloride and copper (II) carbonate. So if you add dilute HCl to a green solid or black solid and you get a green solution the correct inference for such is Fe^{2+} , Cu^{2+} present, the ions can be further differentiated by adding aqueous ammonia dropwise till excess, whereby green ppt insoluble confirms presence of Fe^{2+} and blue ppt soluble in excess ammonia to form deep blue solution

e) You can also be told to describe the appearance of a solid, and the following are possible observations.

Observations	Observations
A colourless crystalline solid	A blue crystalline solid
A white powder	A brown crystalline solid
A white crystalline solid	A green crystalline solid

TEST FOR CATIONS

The cations tested are group into four major groups:

TEST FOR CATIONS

The cations tested are group into four major groups

- Coloured ions - Fe^{2+} Cu^{2+} Fe^{3+} (**CuFeFe**)
- Na^+ , K^+ , NH_4^+ (**POS0AM** - this cations don't form any precipitate with all the reagents (NaOH, NH_4OH))
- Pb^{2+} Zn^{2+} and Al^{3+} (**ZAP**) these cations ions will form a white precipitate with NaOH soluble in excess this is due to the amphoteric nature
- Mg^{2+} and Ca^{2+} (**CaM**) these ions form a white precipitate with NaOH insoluble in excess
- Pb^{2+} Mg^{2+} and Al^{3+} (**PAM**) these forms a white ppt insoluble in aqueous ammonia
- Pb^{2+} Ca^{2+} and Ba^{2+} (**CaLeB**) these forms a white ppt with a soluble sulphate eg, Sulphuric (VI) acid, sodium sulphate e.t.c

NOTE

The only solution you are supposed to mention effect of addition drop wise and in excess is only NaOH and NH_4OH but not any other reagent.

Effect of adding NaOH and NH₄OH dropwise till in excess on solutions containing cations

Cation	Add NaOH dropwise till in excess	Cation	Add NH ₄ OH dropwise till in excess
Na ⁺ , K ⁺ , NH ₄ ⁺	No precipitate	Ca ²⁺ , Ba ²⁺ , Na ⁺ , K ⁺ , NH ₄ ⁺	No precipitate
Pb ²⁺ , Zn ²⁺ and Al ³⁺	White precipitate soluble in excess to form a colourless solution	Pb ²⁺ , Al ³⁺ , Mg ²⁺	White precipitate insoluble in excess
		Zn ²⁺	White precipitate soluble in excess to form a colourless solution
Fe ²⁺ ,	Green precipitate insoluble in excess	Fe ²⁺ ,	Green precipitate insoluble in excess
Fe ³⁺ ,	Brown precipitate insoluble in excess	Fe ³⁺ ,	Brown precipitate insoluble in excess
Cu ²⁺ ,	Blue precipitate insoluble in excess	Cu ²⁺ ,	Blue precipitate soluble in excess to form a deep blue solution

Note;

- ♣ Silver Ag⁺ will also form a white precipitate insoluble in excess NaOH but forms White precipitate soluble in excess NH₄OH to form a colourless solution.
- ♣ Anions tested in KCSE are SO₃²⁻, SO₄²⁻, CO₃²⁻, Cl⁻, S²⁻, I⁻ and NO₃⁻ - these are usually tested with
- ♣ BaCl₂, Pb(NO₃)₂, AgNO₃, dilute acids, acidified, KMnO₄, acidified K₂Cr₂O₇ and also litmus papers
NB; it is important to note that the examiner is testing the ability of the student to identify cations and anions, some students lose marks because they write the wrong answers.
- ♣ A student is told to heat a solid in a test tube and the observations are that, a brown gas evolved, a colourless gas that relights a glowing splint, a cracking sound and a yellow residue, then students infers that lead (II) nitrate is present, this is wrong because the student has not identified the ions present, **the correct inference is that Pb²⁺, NO₃⁻ present.**
- ♣ Also it should be noted that when giving the inference it is wrong to give the answer in words the answer should be given using chemical formulae e.g. it is wrong to write zinc (II) ion present but **should be Zn²⁺ present.**

NB. The only solution you are supposed to mention effect of addition dropwise and in excess is only NaOH and NH₄OH but not any other reagent.

I. Test for cations; how to test and differentiate for Pb²⁺, Zn²⁺ and Al³⁺ ions

❖ **Add NaOH dropwise till in excess**

Observations	Inferences
White precipitate dropwise soluble in excess	Pb ²⁺ , Zn ²⁺ , Al ³⁺ present

❖ **Add NH₄OH dropwise till in excess**

White precipitate dropwise soluble in excess	Zn ²⁺
White precipitate insoluble in excess	Pb ²⁺ , Al ³⁺ present

To differentiate Pb²⁺ and Al³⁺ you use dilute HCl, dilute H₂SO₄, NaCl, Na₂SO₄ (any soluble Cl⁻/SO₄), KI or NaHCO₃

❖ **Add dilute HCl, dilute H₂SO₄, NaCl, Na₂SO₄ (any soluble Cl⁻/SO₄)**

White precipitate	Pb ²⁺ present
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No white precipitate	Al^{3+} present
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❖ **Add aqueous solution of potassium iodide (KI)**

Yellow precipitate	Pb^{2+} present
No precipitate/no yellow precipitate	Al^{3+} present

❖ **Dip red and blue litmus papers into the solution**

Observations	Inference
Blue litmus paper turns red, no effect on blue litmus paper	Al^{3+} present
No effect on both red and blue litmus papers	Pb^{2+} present

TEST FOR ANIONS

The most commonly tested are HCO_3^- , SO_3^{2-} , SO_4^{2-} , CO_3^{2-} , Cl^- , S^{2-} , and NO_3^-

- Barium nitrate is used to test for sulphate, sulphite and carbonates
- Lead nitrate or Lead acetate is used to test for sulphates, sulphites, chlorides, iodide, sulphides and carbonates
- Silver chloride is used to test for chloride ion
- In most cases the reagents are acidified to differentiate between carbonates, sulphites and sulphates and chlorides, it is important to note that if the acid is added this test is usually used to differentiate SO_3^{2-} and CO_3^{2-} as both will give a white precipitate with both $\text{Pb}(\text{NO}_3)_2$, $\text{Ba}(\text{NO}_3)_2$ which will dissolve on addition of dilute nitric acid.

Note: Remember PbCl_2 is soluble on hot water so if you are told to add dilute HCl / NaCl and heat to boil and the observation is a white precipitate is formed soluble on boiling that confirms that Pb^{2+} is present also if you add $\text{Pb}(\text{NO}_3)_2$, and heat to boil and the observation is a white precipitate is formed soluble on boiling that confirms that Cl^- is present

- Dilute acids can be used to test for presence of CO_3^{2-} , SO_3^{2-} , HCO_3^- as they react with effervescence, but CO_3^{2-} , HCO_3^- produce odourless gas while SO_3^{2-} produce a gas with a pungent smell which also turns KMnO_4 from purple to colourless and $\text{K}_2\text{Cr}_2\text{O}_7$ turn from orange to green
- Potassium permanganate (VII) and potassium dichromate (VI) is also used to test for presence of SO_3^{2-} whereby the KMnO_4 turns from purple to colourless and $\text{K}_2\text{Cr}_2\text{O}_7$ turn from orange to green

Use of lead (II) nitrate

<i>Add lead(II) nitrate (if not specified as acidified it means it is not acidified)</i>	
White precipitate	SO_3^{2-} , SO_4^{2-} , CO_3^{2-} , Cl^- , present
Yellow precipitate	I^- present
Black precipitate	S^{2-} present
No white precipitate	SO_3^{2-} , SO_4^{2-} , CO_3^{2-} , Cl^- , absent

Use of acidified lead (II) nitrate

<i>Add acidified $\text{Pb}(\text{NO}_3)_2$ (both SO_3^{2-}, CO_3^{2-} destroyed by acids)</i>	
White precipitate	SO_4^{2-} , Cl^- , present but CO_3^{2-} and SO_3^{2-} , is contradictory
No precipitate	SO_4^{2-} , Cl^- , absent

Addition of lead (II) nitrate followed by dilute nitric (V) acid

Add Pb(NO₃)₂ followed by dilute HNO₃	
White precipitate insoluble on addition of dilute nitric (V) acid	SO ₄ ²⁻ , Cl ⁻ , present
White precipitate which dissolve on addition of dilute nitric acid	CO ₃ ²⁻ SO ₃ ²⁻ present

Dilute HCl or HNO₃ can also be added to differentiate SO₄²⁻, Cl⁻ and CO₃²⁻ SO₃²⁻ e.g. add to dilute HNO ₃ to 2 cm ³ of solution	
No effervescence	SO ₄ ²⁻ , Cl ⁻ , present
Effervescence of colourless gas	CO ₃ ²⁻ SO ₃ ²⁻ present

You can also be told to add HNO₃ followed by Pb(NO₃)₂

No effervescence on adding dilute HNO ₃ , White precipitate	Cl ⁻ , SO ₄ ²⁻ present
Effervescence of colourless gas, No White precipitate	SO ₃ ²⁻ , CO ₃ ²⁻ present

Add few drops of KMnO₄ of dichromate (VI) to solution obtained above here you look for colour changes to differentiate CO₃²⁻ and SO₃²⁻	
KMnO ₄ turns from purple to colourless /dichromate (VI) turns form orange to green	- SO ₃ ²⁻ present
Purple colour of acidified KMnO ₄ persist /is not decolourised or orange colour of dichromate (VI) persist/remains	CO ₃ ²⁻ present

Add acidified Pb(NO₃)₂ and heat the resulting solution this is used to differentiate SO₄²⁻ and Cl⁻,	
White precipitate soluble on warming /heating	Cl ⁻ , present
White precipitate which does not dissolve on warming	SO ₄ ²⁻ present

Use of Barium nitrate or Barium chloride

This reagent is usually used to test for SO₃²⁻, SO₄²⁻, CO₃²⁻

Note; when an acid is added to a solution containing SO₃²⁻ or CO₃²⁻ there is effervescence due to evolution of SO₂ or CO₂ respectively.

♣ Add Ba(NO₃)₂/BaCl₂ followed by few drops of dilute nitric acid	
White precipitate insoluble on addition of dilute nitric (V) acid	SO ₄ ²⁻ present
White precipitate which dissolve on addition of dilute nitric acid	CO ₃ ²⁻ SO ₃ ²⁻ present

Add acidified Ba(NO₃)₂/BaCl₂(both SO₃²⁻, CO₃²⁻ destroyed by acids)	
White precipitate	SO ₄ ²⁻ , present but -, CO ₃ ²⁻ and SO ₃ ²⁻ , is contradictory
No precipitate	SO ₄ ²⁻ , absent

Add of Ba(NO₃)₂/BaCl₂	
White precipitate	SO ₃ ²⁻ , SO ₄ ²⁻ , CO ₃ ²⁻ present
No White precipitate	SO ₃ ²⁻ , SO ₄ ²⁻ , CO ₃ ²⁻ absent

You can also be told to add HNO₃ followed by Ba(NO₃)₂

No effervescence on adding dilute HNO ₃ , White precipitate	SO ₄ ²⁻ , present
Effervescence of colourless gas, No White precipitate	SO ₃ ²⁻ , CO ₃ ²⁻ , HCO ₃ ⁻ present

Note, the use of Ba (NO₃)₂ /BaCl₂ and (PbNO₃)₂ is similar the only difference is that adding Ba (NO₃)₂ or BaCl₂ cannot test for Cl⁻, S²⁻ ions.

Complex Qualitative Analysis

This complex qualitative require high order thinking skills (HOTS) and application of mixed concept, ie. First you can carry out to determine the identity of the first ion present then use it to identify the ion present in the other unknown see (KCSE 2010 Q2).

Test for nitrates

One can use the brown ring test or Devarda's test

- In **brown ring test** -Freshly prepared iron (II) sulphate is added followed by Conc. sulphuric acid formation of brown ring indicates presence of NO₃⁻
- In **Devarda's alloy** test: NaOH solution is added to the test solution followed by Aluminium foil and warm, bubbles of a colorless gas that turn red litmus blue and blue litmus paper remain blue indicates presence of NO₃⁻ (refer KCSE 2012 Q2 a(ii)).

Observations	Inference
<p>✍ Effervescence ½ /Bubbles of Colourless gas produced ½ Turns red litmus blue ½</p> <p>✍ Blue litmus remained blue ½</p> <p>✍ (2 marks)</p>	<p>✍ NO₃⁻ present</p> <p>✍ (tied to red litmus turning blue)</p> <p>✍ Penalize fully for any contradictory ion 1 mark</p>

Reasoning; Devarda's alloy (Cu/Al/Zn) is a reducing agent. When reacted with nitrate in NaOH solution and then add aluminum foil, NH₃ gas is liberated. The ammonia formed may be detected by its characteristic odour, and by damp red litmus paper's turning blue, signaling that it is an alkali — very few gases other than ammonia evolved from wet chemistry are alkaline.

NB: details of the reaction are not important.

Questions on displacement reactions.

Qualitative analysis on displacement reaction will involve adding and a more reactive metal into a solution to bring about displacement. Also displacement of halogens using chlorine water and bromine water. Refer to KCSE 2008 For example; to a portion of solution add solid G

Observations	Inference
Effervescence Brown solid deposited	G is more reactive element than P Or G displaces ions of P from its solution

Note:

For displacement involving halogens refer to KCSE 2004

Remember qualitative analysis requires application of knowledge of solubility of salts.

Solubility of salts

- ☞ All nitrates NO_3^- , chlorates ClO_3^- , perchlorates ClO_4^- , acetates CH_3CHOO^- and HCO_3^- are soluble
- ☞ All salts of Na^+ , K^+ , and NH_4^+ are soluble
- ☞ All chlorides are soluble except PbCl_2 and AgCl but PbCl_2 is soluble in hot water
- ☞ All sulphates are soluble except PbSO_4 , CaSO_4 , and BaSO_4 but CaSO_4 is sparingly soluble
- ☞ All carbonates metal oxides and hydroxides are insoluble except those of Na^+ , K^+ , and NH_4^+

Qualitative analysis involving coloured ions

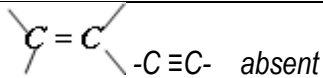
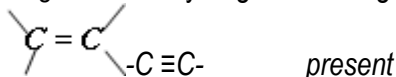
- ☞ Fe^{2+} , Cu^{2+} are usually tested together as they give a **green solution**, the ions can be further differentiated by adding aqueous ammonia dropwise till excess, whereby green ppt insoluble confirms presence of **Fe^{2+} and blue ppt soluble in excess ammonia to form deep blue solution confirms presence of Cu^{2+}**
- ☞ If the substance being tested contained Fe^{2+} ions, then it can further be subjected to oxidation reaction whereby an oxidizing agent like concentrated nitric (V) acid or hydrogen peroxide can be added, the expected observation will be green solution turns yellow, and if aqueous ammonia or aqueous sodium hydroxide is added then a brown precipitate is formed, the correct inference for such test is **Fe^{2+} oxidized to Fe^{3+}** , not Fe^{3+} present. refer to **KCSE 1999 and 2011 question 2**
- ☞ If the substance being tested contained Cu^{2+} ions, then it can further be subjected to further test like displacement involving using zinc metal/iron metal powder, the expected observations are effervescence and brown solid is deposited. **refer to KCSE 2008 question 2**
- ☞ If the substance being tested contained Fe^{3+} ions it will form a brown precipitate insoluble in both aqueous ammonia and aqueous sodium hydroxide, it can further be subjected to further test like test for pH whereby being acidic will give pH 1, also sodium carbonate can be added, and the expected observation is bubbles/effervescence, Fe^{3+} are oxidizing agent and a reducing agent like potassium iodide can be added of which the expected observation will be brown solution formed /black solid deposited, the correct inference will be I^- oxidized to I /iodide ions oxidized to iodine. Refer kcse **2007 question 2**

ORGANIC QUALITATIVE TESTS

Most organic test will test your understanding on saturated and unsaturated compound, how they react with bromine water, how they burn, colour of flame and sooty or non-sooty, effect on acidified KMnO_4 , $\text{K}_2\text{Cr}_2\text{O}_7$. The test on esterification and action on $\text{NaHCO}_3/\text{NaCO}_3$ if a carbonate is added you look for effervescence, the pH is also tested using either universal indicator solution or pH reel (paper).

How the compound burns

Scoop a portion and ignite it using a non-luminous flame /put a few drops of the liquid in a watch glass and ignite

Burns with a blue flame	 low carbon: hydrogen ratio organic compound present
Burns with a yellow sooty flame	<i>High carbon:</i> hydrogen ratio organic compound present 

Testing the solubility of the compound

Here you look if the solid dissolves in water to form a colourless solution then the inference is a polar compound/ but if you add ethanol /acetone and the solid dissolves to form a colourless solution the inference is that the compound is non-polar. In case it is a liquid you look for formation of two layers/ immiscibility or homogenous mixture.

NB: Test for solubility of organic compound where you add ethanol is sometimes confused by students with esterification but in esterification addition of ethanol is followed by addition of few drops of concentrated sulphuric (VI) acid with gentle warming e.g.

a) If it is a solid

Place the solid in a test tube add distilled water/ethanol

The solid dissolves in water form a colourless solution	Polar organic compound
The solid dissolves in ethanol to form a colourless solution	The compound is non-polar

b) If it is a liquid

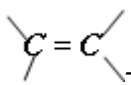
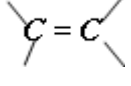
To 2cm³ of the liquid add few drops of water

The liquid miscible in water to form a uniform solution/homogenous mixture	Polar compound
The liquid is immiscible with water and forms two layers	Non-polar compound present

To 2cm³ of the liquid add few drops of ethanol or acetone

The liquid miscible in ethanol to form a uniform solution/homogenous mixture	Non-polar compound present
The liquid is immiscible with ethanol and forms two layers	polar compound present

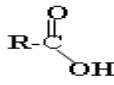
Add acidified potassium manganate(VII)

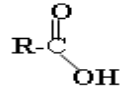
Purple acidified KMnO ₄ decolourised/changes from purple to colourless	 -C≡C- R-OH present
Purple acidified KMnO ₄ not decolourised / does not change to colourless	 -C≡C- R-OH absent

Add acidified potassium chromate(VI)

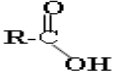
Potassium chromate(VI) changes from orange to green	R-OH present
Orange colour of Potassium chromate(VI) persist/does not change green	R-OH absent

Add NaHCO₃/Na₂CO₃

Effervescence to evolve a colourless, odourless gas	H ₃ O ⁺ , H ⁺ , present 
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No effervescence	$\text{H}_3\text{O}^+, \text{H}^+$,  absent
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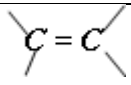
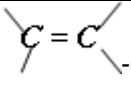
Add ethanol followed by a few drops of conc. sulphuric acid/2M sulphuric (VI) acid

Pleasant smell Reject sweet smell	 present
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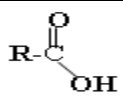
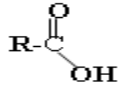
Add ethanoic acid followed by a few drops of conc. sulphuric acid

Pleasant smell	R-OH present
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Add bromine water

Yellow bromine water decolourised	 -C≡C- present
Yellow bromine water not decolourised Nb/ reject brown as colour of Bromine water Yellow is the most appropriate colour for bromine water	 -C≡C- absent

Place 2cm³ of F in a test-tube and add all the magnesium metal provided

Observations	Inferences
effervescence of colourless odourless gas that puts off a burning splint with a pop sound (2mks)	$\text{H}_3\text{O}^+, \text{H}^+$,  present Reject COOH
No effervescence/no bubbles	$\text{H}_3\text{O}^+, \text{H}^+$,  absent

Test the pH. pH is tested using universal indicator and in the observation column you are supposed to write the correct pH and inference column you deduce whether the substance is strongly acid/alkaline or weakly acidic/alkaline or neutral

Observation	Inference
pH 1,2,3	Strongly acidic
pH 4,5,6	Weakly acidic
pH 7	neutral
pH 8,9,10	Weakly alkaline/basic
pH 11,12,13,14	Strongly alkaline/basic

NOTE: Methyl orange can also be used or phenolphthalein

- 👉 If methyl turn orange it means the compound is neutral; if it turns yellow the inference is OH⁻ present; if it turns pink the inference is H⁺ or H₃O⁺ present
- 👉 If phenolphthalein is used colourless means it is neutral or H⁺ H₃O⁺ is present but if it turns pink, then it is OH⁻ present

You can also be told to describe how to test the pH of a solid or a liquid

a) If it is solid

Dissolve the solid in distilled water and dip the universal paper or add 2 drops universal indicator solution to the resulting solution then match the colour with the universal indicator paper

b) If it is liquid

If it is a liquid dip the universal paper or add 2 drops universal indicator solution to the liquid then match the colour with the universal indicator paper

Common mistakes in qualitative analysis, changes in marking trends and emerging issues in p3

- Many students infer that acidified potassium chromate (VI) tests for R-OH, $-C \equiv C-$, $C=C$, present. This is wrong as acidified $K_2Cr_2O_7$ is **only used to test for R-OH** and does not test for unsaturation, the candidate loses all the marks for contradictory functional group.
- Bromine water is not brown or red brown but the correct acceptable colour is red/yellow or orange, if a candidate commits him/herself to brown as colour of bromine he/she loses all the marks. The most suitable colour for bromine water is yellow.
- pH students must give a specific pH and not pH range, When inferring for nature of solution, correct terms to use is strongly acidic/alkaline/basic not strong acid/base/alkali, weakly acidic not weak acid as shown in the table below
- Test for hydrogen gas —hydrogen puts off /extinguishes a burning splint with a pop sound, but it does not burn with a pop sound
- Always mention the initial colour and final colour of reagent, e.g acidified $K_2Cr_2O_7$ turns from orange to green, not acidified $K_2Cr_2O_7$ turns green or solution turns green
- Ester has a pleasant smell not sweet smell; this is because the term sweet is only invoked when referring to sense of taste whereby you use the tongue.
- There is also a wrong assumption that only concentrated sulphuric acid can be used during esterification, this is not factual because dilute sulphuric acid can also be used as the acid just acts as a catalyst and hence dilute acid is being preferred due to safety purposes
- There is a misplaced assumption that all organic acids are weak acids, this is not true as some acids like oxalic acid and maleic acid are strong acids and have a pH of 1.**
- If the examiner has identified the substance being tested and you add $NaHCO_3/Na_2CO_3$ and observation is effervescence /no effervescence the correct inference is R-COOH present and absent respectively, H^+ , H_3O^+

Does not score