2014-2015 KNEC APPROACH

Chemistry of CHLORINE

Comprehensive tutorial notes

POWERPOINT VERSION

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A.HALOGENS-

Periodicity of the halogens

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E. SAMPLE REVISION QUESTIONS

-This is the inorganic chemistry of Chlorine
-Chlorine compounds are very widely used in human and veterinary medicine
-In agriculture, most herbicides use chlorine derivatives.
-Chlorine is a highly **poisonous/toxic** gas.
-Its preparation and investigative experimentation should be in:

(i)the open

(ii)a fume chamber

(iii)very small amounts.

A:THE HOLOGENS

a) What are halogens?

These are elements in group VII(17) of the periodic table.They include...

Element	**Symbol**	**Atomic number**	**Electric configuration**	**Charge of ion**	**Valency**	**State at Room Temperature**
Fluorine	F	9	2:7	F^-	1	Pale yellow Gas
Chlorine	Cl	17	2:8:7	Cl^-	1	Pale green gas
Bromine	Br	35	2:8:18:7	Br^-	1	Red liquid
Iodine	I	53	2:8:18:18:7	I^-	1	Grey Solid
Astatin	At	85	2:8:18:32:18:7	At^-	1	Radioactive

ionic radius of chloride ion and chlorine. Explain.

The atomic radius of chlorine is **smaller** than the ionic radius o the chloride ion.

Effective nucleus attraction on outer energy level in chloride ion is **less** than chlorine atom

Extra gained electron is **repelled** thus causes the outer energy level to **expand** /increase to minimize/reduce the repulsion.

c) Compare the atomic radius of chlorine and fluorine Explain.

Atomic radius of Fluorine is **smaller** than that of chlorine.

Chlorine has **more** energy levels than fluorine occupied by more electrons.

d) Chlorine is a gas, Bromine is a liquid, Iodine is a solid. Explain the above observations.

Bromine, Chlorine and Iodine exists as diatomic molecules bonded by strong covalent bond.

Each molecule is joined to the other by **weak** intermolecular forces/ Van-der-waals forces.

The strength of intermolecular/Van-der-waals forces of attraction increase with **increase** in molecular size/atomic radius.

Iodine has therefore the **largest** atomic radius and thus **strongest** intermolecular forces to make it a **solid**.

Electronegativity is the tendency/ease of acquiring /gaining **extra** electrons by an element during chemical reaction.

It is measured using Pauling's scale ,where fluorine with Pauling scale 4.0 is the **most** electronegative element in the periodic table and thus the **highest** tendency to acquire/gain extra electron.

(ii)The table below shows the electronegativity of the halogens.

Halogen	F	Cl	Br	I	At
Electronegativity (Pauling's scale)	4.0	3.0	2.8	2.5	2.2

Explain the trend in electronegativity of the halogens

Decrease down the group from fluorine to Astatine

Atomic radius **increase** down the group decreasing **electron – attracting** power down the group from fluorine to astatine.

(i) What is electron affinity?

Electron affinity is the energy required to gain an electron in an atom of an element in its gaseous state.

(ii) Study the table below showing the election affinity of halogens for the process:

$$X\ (g) + e \rightarrow X^{-}\ (g)$$

Halogen	F	Cl	Br	I
Electron affinity ($kJmole^{-1}$)	-333	-364	-342	-295

(iii)Explain the trend in electron affinity of the halogens.

-**Decrease** down the group

-Atomic radius of halogens **increase** down the group thus incoming/gained electron is attracted **less** strongly by the progressively larger atoms with a decreasing effective nuclear charge on outer electrons.

(iv) Which is the more stable ion Cl^- or Br^- ? Explain

-Cl^- ion because it has a **more negative**/exothermic electron affinity than Br^-

Sodium bromide and Sodium iodide solutions were put separately in test tubes.

5 drops of chlorine water was added to each test tube.

State and explain the observation made.

Observations

-**Pale green** colour of chlorine water fades in all test tubes except with sodium chloride.

-Coloured solutions formed.

(ii) The experiment in g (i) was repeated with 5 drops of bromine water instead of chlorine water Explain the observation made.

Observations –

yellow colour of bromine water fades in sodium iodide.

Brown solution formed in sodium iodide

Explanations –

Bromine is more electronegative than iodine but less than chlorine.

On adding Bromine water, iodine is displaced from its solution but chlorine is not displaced.

(iii) Using the knowledge in g(i) and (ii) above,

Complete the table below using (√) to show a reaction to complete the table.

Halogen ion in solution/Halogen	F^-	Cl^-	Br^-	I^-
F_2	X	√	√	√
Cl_2	X	X	√	√
Br_2	X	X	X	√
I_2	X	X	X	X

where there is (√)

$F_{2\ (g)} + 2Cl^-_{(aq)} \rightarrow 2F^-_{(aq)} + Cl_{2(g)}$

$F_{2\ (g)} + 2Br^-_{(aq)} \rightarrow 2F^-_{(aq)} + Br_{2(aq)}$

$F_{2\ (g)} + 2I^-_{(aq)} \rightarrow 2F^-_{(aq)} + I_{2(aq)}$

$Cl_{2\ (g)} + 2Br^-_{(aq)} \rightarrow 2Cl^-_{(aq)} + Br_{2(aq)}$

$Cl_{2\ (g)} + 2I^-_{(aq)} \rightarrow 2Cl^-_{(aq)} + I_{2(aq)}$

$Br_{2\ (aq)} + 2I^-_{(aq)-} \rightarrow 2Br^-_{(aq)} + I_{2(aq)}$

(ii) Uses of halogens

(i)**Fluorine** is used to manufacture P.T.F.E (Polytetrafluoroethene) synthetic fibre.
-**Fluorine** is added in small amounts/quatities in tooth paste to reduce tooth decay.
(large quantities of fluorine /fluoride ions in water cause browning of teeth/flourosis)
-Hydrogen fluoride is used to **engrave** words pictures in glass.

(ii)Uses of **Bromine** :Silver bromide is used to make light sensitive photographic paper/films.

(ii) **Iodine** dissolved in alcohol is used as medicine to kill bacteria in skin cuts. It is called **tincture** of iodine.

Some compounds of the Halogens

Element / Halogen	H	Na	Mg	Al	Si	C	P
F	**HF**	**NaF**	**MgF_2**	**AlF_3**	**SiF_4**	**CF_4**	**PF_3**
Cl	**HCl**	**NaCl**	**$MgCl_2$**	**$AlCl_3$**	**$SiCl_3$**	**CCl_4**	**PCl_3**
Br	**HBr**	**NaBr**	**$MgBr_2$**	**$AlBr_3$**	**$SiBr_4$**	**CBr_4**	**PBr_3**
I	**Hl**	**Nal**	**Mgl_2**	**All_3**	**SiI_4**	**Cl_2**	**Pb_3**

Bond	Bond energy kj mole
Cl-Cl	242
Br-Br	193
I-I	151

What do you understand by the term “bond energy”

Bond energy is the energy required to break/ form one mole of chemical bond

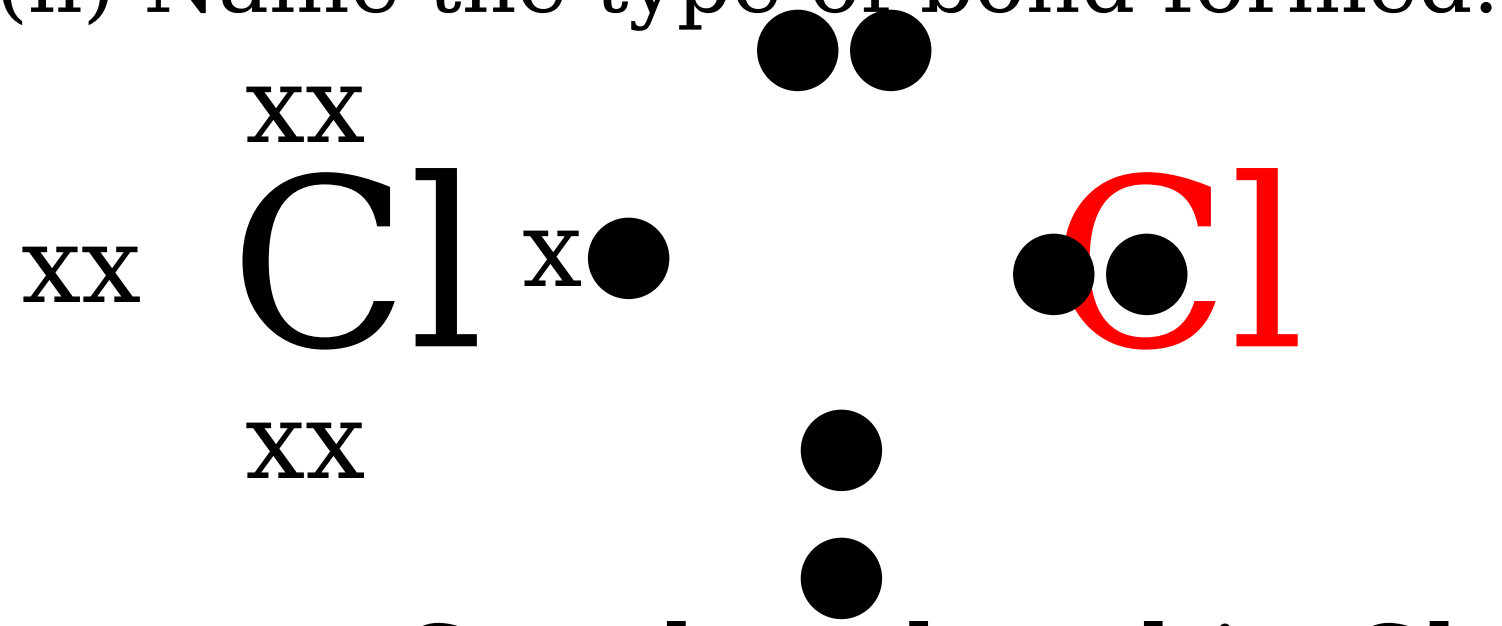
- Explain the trend in bond Energy of the halogens above

-Decrease down the group from chlorine to Iodine

-Atomic radius increase down the group decreasing the energy required to break the covalent bonds between the larger atom with reduced effective nuclear charge on

j) (i) Using dot (●) and cross (x) to represent electrons, show the bonding in chlorine molecule

(ii) Name the type of bond formed.



Covalent bond in Cl_2

(diatomic molecule)

Compound Oxidation state Name of compound

$NaClO_3$ +5 Sodium chlorate (V)

ClO_2 +4 Chloric (IV) oxide

$KClO_2$ +3 Potassium chlorate (III)

NaClO +1 Sodium Chlorite (I)

Cl_2 0 Chlorine Molecule

NaCl -1 Sodium Chloride (I)

B.CHLORINE

-Chlorine is a non-metallic element in group VII (Group 17) of the periodic table.

-It has electronic configuration 2:8:7.

-It gains one valence election to form stable Cl^- ion

-It belongs to the chemical family of halogens.

A) Occurrence

-As **Brine**-concentration sodium chloride solution dissolved in salty seas water, oceans and lakes e.g. Lake Magadi in Kenya is very salty.

-As **rock-salt** solid sodium chloride crystals in the earths crust all over the world.

B) Preparation

Chlorine gas may be prepared from the following:

a)Heating solid **Manganese (IV) Oxide** and Concentrated Hydrochloric acid.

b) Heating **Lead (IV)Oxide** and Conc. hydrochloric acid.

c)Reacting **Potassium/sodium manganate (VII)** with concentrated Hydrochloric acid.

d)Reacting **Potassium /sodium dichromate (VI)** with concentrated Hydrochloric acid.



Preparation of Chlorine from Conc. HCl and Oxidizing agent

1. What is the colour of chlorine?

Pale green.

2. Describe the smell of chlorine.

Pungent irritating smell.

3. What method is used in collection of chlorine gas explain.

Downward delivery.

Chlorine is $1^1/_2$ denser than air.

4.(i) What is the purpose of concentrated sulphuric (VI) acid?

-To dry the gas.

(ii) Name two other substances that can be used in place of concentrated sulphuric (VI) acid.

(iii) Name a substance that cannot be used in place of concentrated sulphuric (VI) acid explain.

-Calcium oxide reacts with chlorine.

5.(a)Write three possible reactions between solution A and solid B:

$2KMnO_4(s)+16HCl(aq)\rightarrow 2KCl(aq)+2MnCl_2(aq)$
$8H_2O(l)+5Cl_2(g)$

$K_2Cr_2O_7(s)+14HCl(aq)\rightarrow 2KCl(aq)+2CrCl_3(aq)+7H_2O(l)+3Cl_2(g)$

$Na_2Cr_2O_7(s)+14HCl(aq)\rightarrow 2NaCl(aq)+2CrCl_3(aq)+7H_2O(l)+3Cl_2(g)$

$PbO_2(s)+4HCl(aq)\rightarrow PbCl_2(aq/s)+Cl_2(g)+2H_2O(l)$

$MnO_2(s)+4HCl(aq)\rightarrow MnCl_2(aq)+Cl_2(g)+2H_2O(l)$

Oxidizing agents $KMnO_4$ /PbO_2 /MnO_2 /$K_2Cr_2O_7$ / $Na_2Cr_2O_7$ readily oxidize hydrochloric acid to chlorine themselves reduced to their chlorides.

Generally:

$2HCl\ (aq) + [\mathbf{O}] \rightarrow Cl_2\ (g) + H_2O\ (l)$

(from oxidizing agent)

6. State and explain the observation made when chlorine is bubbled in water..

Observation:

-Pale yellow colour of chlorine fades.

-yellow solution formed.

Explanation:

Chlorine dissolves then reacts with water to form yellow chlorine water.

hydrochloric acid and chloric (I)acid (hypochlorous acid)

Chemical equation:

$Cl_2(g) + H_2O(l) \rightarrow HCl(aq) + HOCl(aq)$

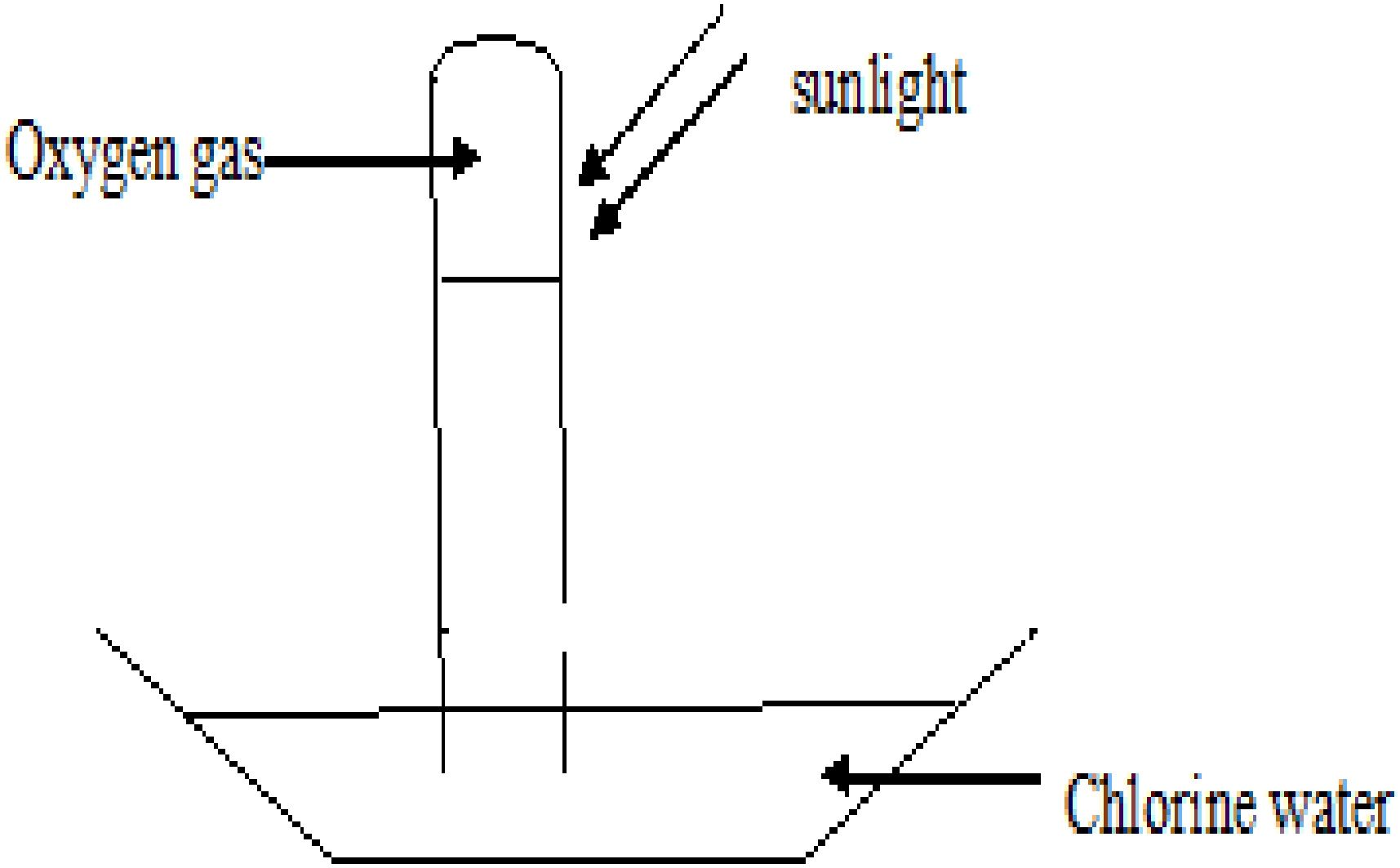
7. Chlorine water was exposed to sunlight for two hours in an inverted boiling tube inserted into a trough.

Draw a diagram to show the set up of the apparatus after two hours.

Explain the observations made.

Chlorine (I) acid is an unstable compound.

After two hours the chloric (I) acid in chlorine water decomposes to hydrochloric acid and releases oxygen gas.


sunlight
Oxygen gas
Chlorine water

8. State and explain the observation made when chlorine gas is bubbled in gas jar containing damp/wet/moist litmus papers.

Observations:

The blue litmus turns red then both the red / blue litmus papers are bleached/ decolourized.

Explanations:

Chlorine reacts with water in the litmus papers to form acidic hydrochloric acid and chloric (l) acid that turns blue litmus papers red.

Chemical Equation:

$Cl_2(g) + H_2O(l) \rightarrow HCl(aq) + HOCl(aq)$

Explanations:

Unstable chloric (I) acid **oxidizes** the dye/colured litmus paper to colourless material

Chemical Equation-

HOCl(aq + dye -> HCl(aq) + (dye + O)

(coloured) (colourless)

HOCl(aq + (dye - O) -> HCl(aq) + dye

(coloured) (colourless)

NB **Chlorine does not therefore**

9. Blue litmus papers were put in a flask containing cold dilute sodium hydroxide.

Chlorine gas was bubbled into the solution. State and explain the observations made.

Observations

-blue litmus papers were bleached /decolorized.

-Pale green colour of chlorine fades.

Explanations

-Sodium hydroxide reacts with chlorine to form sodium chloride and sodium

(aq)+ H_2O (l)

NaOCl (aq) + dye → NaCl (aq) + (dye + O)

(coloured) **(Colourless)**

NaOCl (aq) + (dye-O) → NaCl (aq) + dye

(Coloured) **(Colourless)**

10.Blue litmus papers were put in flask containing hot concentrated sodium hydroxide. Chlorine gas was bubbled into the solution. State and explain the observations made.

<u>Observations.</u>

blue litmus papers were bleached.

Pale green colour of chlorine fades

with chlorine to form sodium chloride and sodium chlorate (V)

- Sodium chlorate (V) bleaches by oxidation.

Chemical equations:

$3Cl_2(g) + 6NaOH(aq) \rightarrow 5NaCl(aq) + NaClO_3(aq) + 3H_2O(l)$

$NaClO_3(aq) + 3(dyes) \rightarrow NaCl(aq) + 3(dye + O)$

$NaClO_3$ is a weed killer and bleaching agent

11. State three main use of chlorine gas.

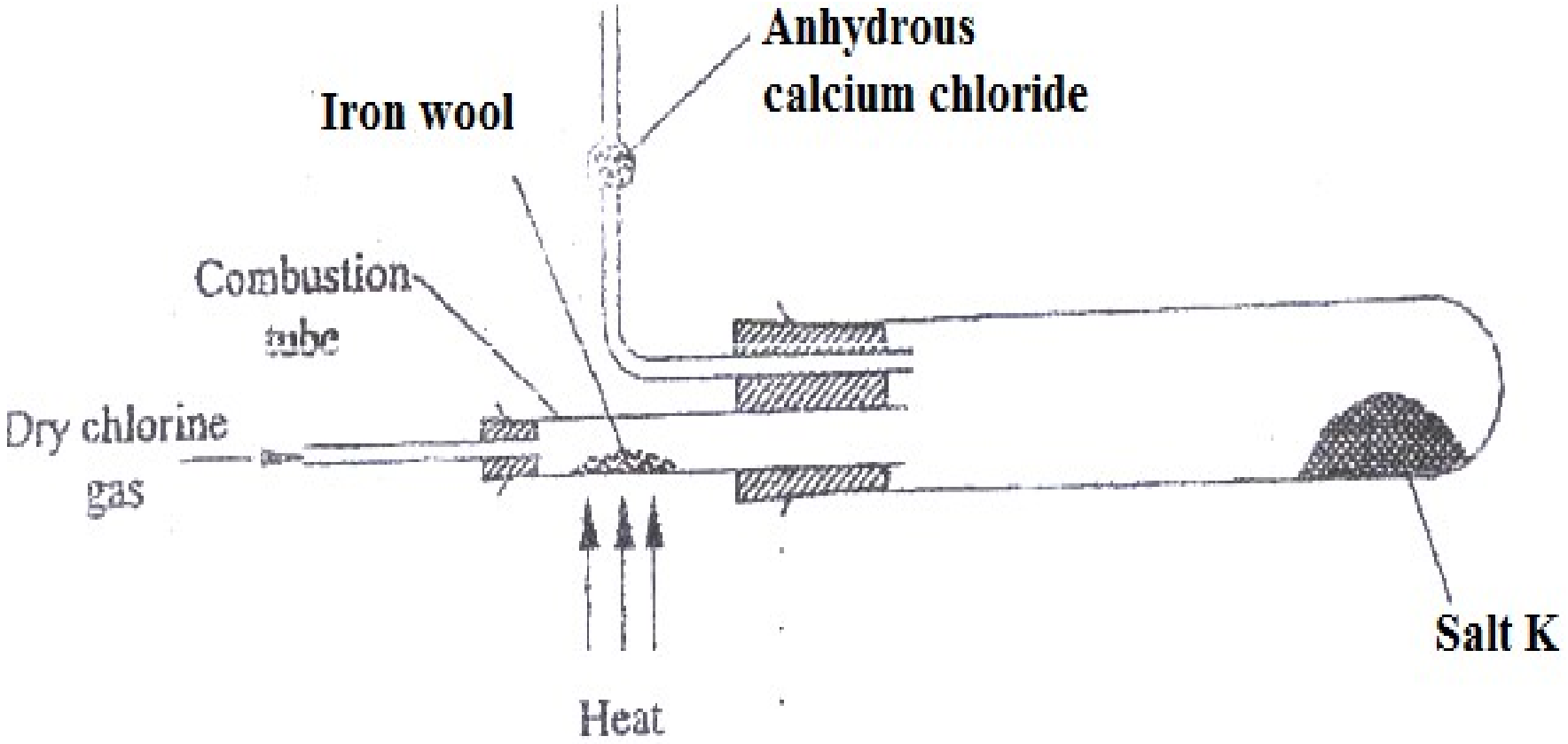
-Manufacture of polyvinyl chloride (P.V.C) // polychloroethene pipes.

-Manufacture of hydrochloric acid used in “Pickling” of metals.

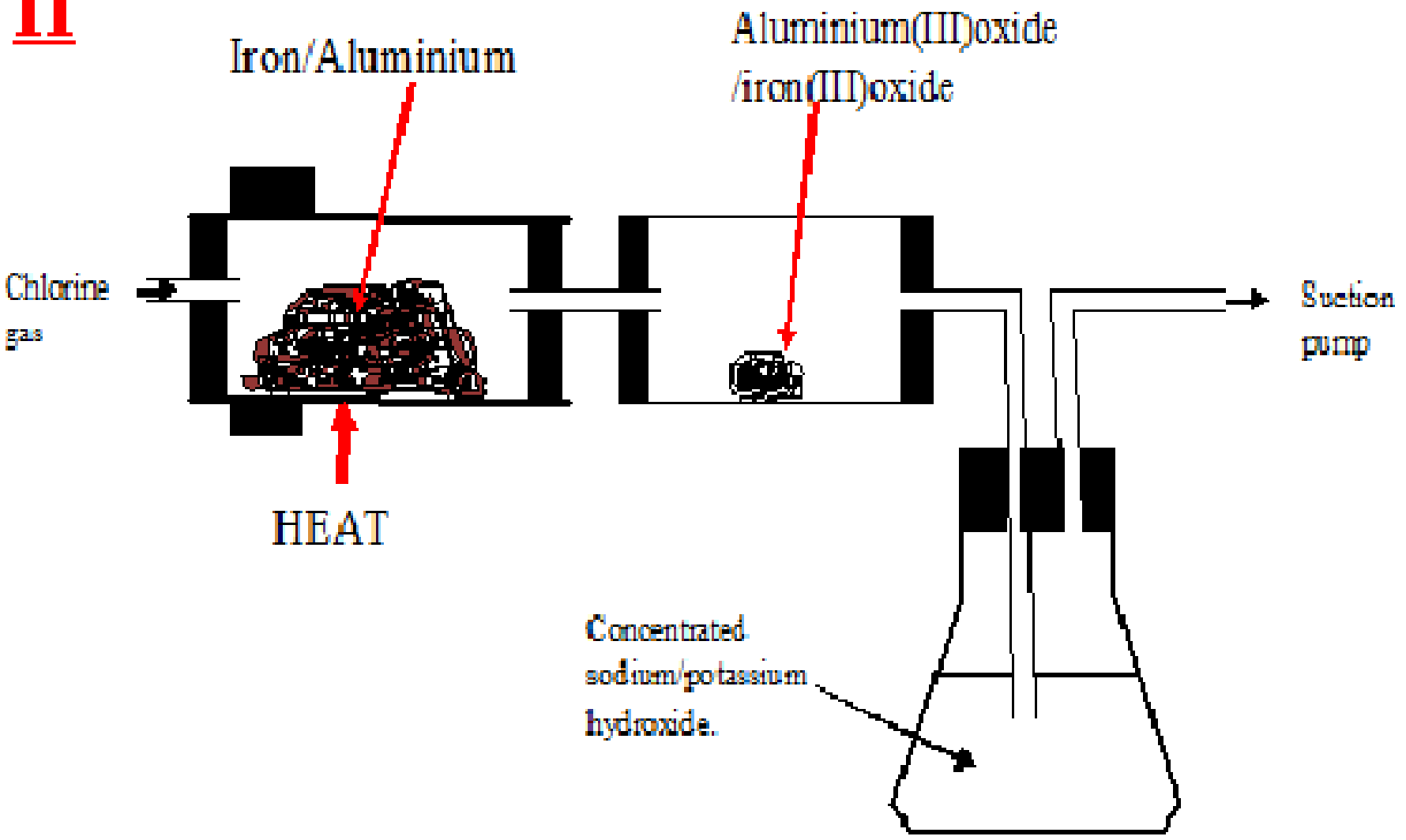
-Manufacture of bleaching agents

12. The diagram below shows the effect of chlorine on heated iron wool.

Method I



Method II



Reaction of chlorine with Iron/Aluminium

gas.

-Conc. H_2SO_4 / Concentrated sulphuric (VI) acid.

-Anhydrous Calcium (II) Chloride.

-Silica gel

b) State and explain the observations made in combustion tube in method I and II

Observation

Iron glows red hot

Brown crystals are formed

Explanation

Iron reacts with chlorine to form dark brown crystals of iron (III) Chloride.

This reaction is exothermic and requires no farther heating once started.

Iron (III) Chloride sublimes away ensuring the unreacted Iron completely reacts with chlorine gas.

Chemical equation

$2Fe(s) + 3Cl_2(g) \rightarrow 2FeCl_3(g)$

c) (i) Why is the brown solid collected at the point as shown in method I and II.

-Heated iron (III) Chloride crystals sublime to gas and solidify/deposits on the cooler parts.

(ii) Name another metal that can be used in place of iron to react with chlorine and collected at similar point on heating explain.

Metal Aluminum

Explanation

Aluminum reacts with chlorine to form a white sublimate of aluminum (III) chloride at the cooler parts

Chemical equation

d) What is the purpose of suction pump?

To pull the gaseous products into the set up.

e) What is the function of:

(i) Sodium hydroxide in method II. Explain.

To absorb poisonous/toxic excess unreacted chlorine gas.

Sodium hydroxide reacts with chlorine to form sodium chloride, Sodium hypochlorite and water.

Chemical equation:

$2NaOH(aq) + Cl_2(g) \rightarrow NaCl(aq) + NaOCl(aq) + H_2O(l)$

$2KOH(aq) + Cl_2(g) \rightarrow KCl(aq) + KOCl(aq) + H_2O(l)$

oxide in method I. Explain.

To absorb moisture/water in the set up to prevent it from hydrolyzing iron (III) chloride/aluminium oxide.

Explanation

Iron (III) chloride and Aluminium chloride fumes and reacts with small traces of water to form a solution of iron (III) hydroxide/aluminium hydroxide and hydrogen chloride gas.

Chemical equation

$FeCl_3(s) + 3HCl(aq) \rightarrow Fe(OH)_3(aq) + 3HCl(g)$

$AlCl_3(s) + 3HCl(aq) \rightarrow Al(OH)_3(aq) +$

i) Based on e (i) and (ii) above what precaution should be made in:

(i) method II to ensure correct results.

-Tube B should be completely dry to prevent hydrolysis of iron (III) Chloride to iron (III) hydroxide.

(ii) Carrying out method I

-Should be done in a fume chamber or in the open because chlorine gas is poisonous/toxic.

(g) Name another substance that can be used place of Sodium hydroxide in method I

Potassium hydroxide

(h) Calcium oxide cannot be used in place of calcium chloride during preparation of chlorine. Explain.

/absorbs water to form calcium hydroxide solution.

Calcium hydroxide reacts with chlorine to form a mixture of calcium chloride and calcium hypochlorite.

Chemical equation

$2Ca(OH)_2(aq) + 2Cl_2(g) \rightarrow CaCl_2(aq) + CaOCl_2(aq) + H_2O(l)$

13. (a)State and explain the observation made when a piece of burning magnesium ribbon is lowered in a gas jar containing chlorine gas.

Observation

-Magnesium continues burning with a bright flame.

-White solid formed.

-Pale green colour of chlorine fades

Explanation:

Magnesium reacts with chlorine forming a white solid of magnesium chloride.

Chemical Equation:

$$Mg(s) + Cl_2(g) \rightarrow MgCl_2(s)$$

14. Burning phosphorus was lowered in a gas jar containing chlorine gas using a deflagrating spoon with

-Phosphorus continues to burn.

-Dense white fumes formed.

-Pale green colour of chlorine fades.

b) Write two possible equations that take place.

$P_4(s) + 6Cl_2(g) \rightarrow 4\ PCl_3(s)$ (**Limited** $Cl_2(g)$)

$P_4(s) + 10Cl_2(g) \rightarrow 4\ PCl_5(s)$ (**Excess** $Cl_2(g)$)

(c) State two reasons why the deflagrating spoon has a lid/cover.

-Chlorine in the gas jar is poisonous /toxic.

-Burning phosphorus produces poisonous/toxic phosphorus (**III**) chloride //phosphorus (**V**) chloride.

-Ensure the reaction is not affected by air/oxygen from the atmosphere.

(d) After the reaction is complete, 2cm^3 of distilled water were added. The solution formed was tested with both blue and red litmus papers.

(i) State the observations made.

-Red litmus paper remain red

(ii) Explain the observation made in d(i) above

-Phosphoric (V) Chloride **hydrolyses** in water to phosphoric (V) acid and produce hydrogen chloride gas. -Both are **acidic**.

Chemical Equation:

$$PCl_5\ (l) + 4H_2O(l) \rightarrow H_3PO_4(aq) + 5HCl(g)$$

15. State and explain the observations made when gas jar containing chlorine is inverted over another containing hydrogen sulphide gas.

Observation – **Yellow** solid formed.

-Pale **green** colour of chlorine fades.

Chlorine oxidizes hydrogen sulphide to sulphur

Itself reduced to hydrogen chloride gas.

A little water catalyzes the reaction.

Chemical Equation:

$H_2S(g) + Cl_2(g) \rightarrow S(s) + 2HCl(g)$

(yellow solid) (White Fumes)

16. Chlorine was bubbled in aqueous ammonia solution in a beaker state and explain the observation made.

Observation

White fumes evolved.

Pale green colour of chlorine fades.

Explanation

Chlorine reacts with ammonia gas to form a dense white fume of ammonia chloride and Nitrogen gas is produced.

<u>Chemical equation</u>

$8NH_3(g) + 3Cl_2(g) \rightarrow 6NH_4Cl(s) + N_2(g)$

17. (a) Dry chlorine gas was bubbled in cold dilute sodium hydroxide solution. Explain the observations made

<u>Observation</u>

Pale **green** colour of chlorine fades.

Pale **yellow** solution is formed.

Chlorine reacts with hot concentrated sodium hydroxide / Potassium hydroxide solution to form pale yellow solution of metal chlorate (V) and chlorides of the metal

Chemical equation

$Cl_2(g) + 2NaOH \rightarrow NaCl(aq) + NaOCl(aq) + H_2O(l)$

$Cl_2(g) + 2KOH \rightarrow KCl(aq) + KOCl(aq) + H_2O(l)$

(b)The experiment in 17(a) was repeated with hot concentrated sodium hydroxide solution. Explain the observation made.

Observation

Pale green colour of chlorine fades.

Explanation

Chlorine reacts with hot concentrated sodium hydroxide/Potassium hydroxide solution to form pale yellow solution of metal chlorate (v) and chlorides of metals.

Chemical equation:

$6NaOH + 3Cl_2(g) \rightarrow NaClO_3(aq) + 5NaCl(aq) + 3H_2O(l)$ **(Sodium Chlorate (V)**

$6KOH + 3Cl_2(g) \rightarrow KClO_3(aq) + 5KCl(aq) + 3H_2O(l)$ **(Potassium Chlorate (V)**

NB

The products formed when chlorine reacts with alkalis depend thus on temperature and the concentration of alkalis.

calcium chlorate (I) and calcium chlorate (V).

$2Ca(OH)_2(aq) + 2Cl_2(g) \rightarrow CaCl_2(aq) + CaOCl_2(aq) + H_2O(l)$

(Cold/dilute) (Calcium Chlorate(I))

$Ca(OH)_2(aq) + Cl_2(g) \rightarrow CaCl_2(aq) + Ca(ClO_3)_2(aq) + H_2O(l)$

(Hot/Concentrated) (Calcium Chlorate(V))

C. HYDROGEN CHLORIDE

- **Occurrence**

Hydrogen Chloride does not occur free in the atmosphere or in nature

- **Preparation**

Hydrogen chloride may be prepared by reacting **solid chloride** crystals with **concentrated sulphuric** (VI) acid

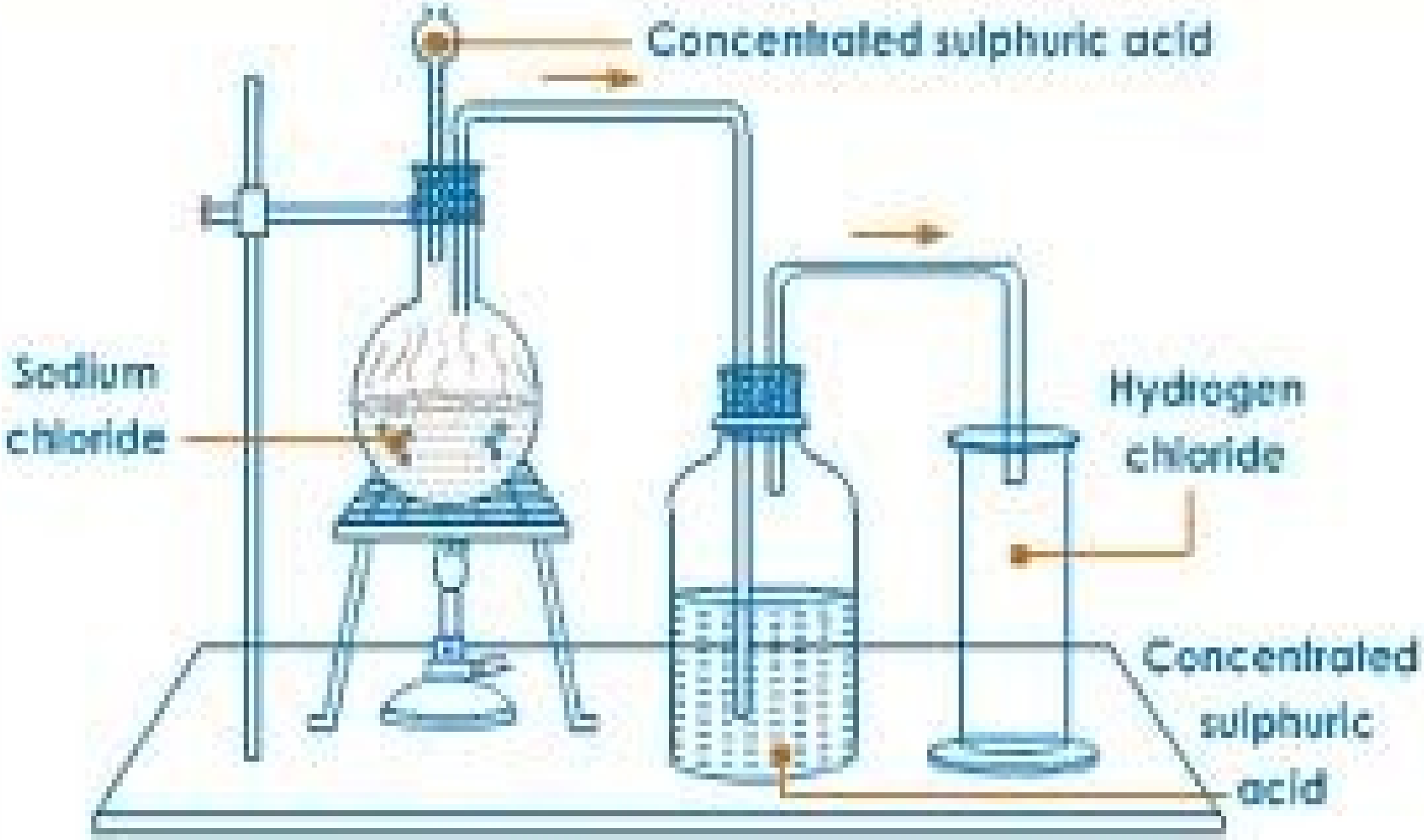


Fig. 5.3 Preparation of dry hydrogen chloride

(questions)

1.What precautions should be taken when handling concentrated sulphuric(VI) acid? Explain.

-Wear protective clothing/gloves to avoid accidental contact with skin.

-Concentrated sulphuric (VI) acid is highly corrosive-it causes painful wounds when in contact with skin.

2.What method of gas collection is used? Explain.

-Downward delivery// upward displacement of water

-Hydrogen chloride is denser than air.

that takes place.

$NaCl(s) + H_2SO_4(l) \rightarrow NaHSO_4(aq) + HCl(g)$

$KCl(s) + H_2SO_4(l) \rightarrow KHSO_4(aq) + HCl(g)$

(b) What property of concentrated sulphuric (VI) acid is used during the above reaction

is the least volatile mineral acid, thus displace the more volatile hydrogen chloride from its salt (KCl/NaCl)

i) What is the purpose of concentrated sulphuric (VI) acid in the second bottle.

ii) What property of concentrated sulphuric (VI) acid is used during the above use

Is hygroscopic – absorbs water but do not form solution.

iii, Name another substance that can be used in place of concentrated sulphuric (VI) acid in the second bottle.

anhydrous Calcium chloride and silica gel

iv) Using a chemical equation, explain why anhydrous calcium oxide cannot be used in the second bottle .

<u>Explanation:</u>

-Calcium oxide reacts with water /moisture to

$CaO(s) + H_2O(l) \rightarrow Ca(OH)_2(aq)$

$Ca(OH)_2(aq) + 2HCl(g) \rightarrow CaCl_2(aq) + 2H_2O(l)$

This reduces the amount of HCl produced.

d)Blue and red litmus papers were dipped in the hydrogen chloride prepared above.
The Procedure was repeated with damp/wet/moist litmus papers.
Explain the differences in observations

Observation

-Dry blue litmus papers remain blue

-Dry red litmus papers remain red

-Damp/moist/wet blue litmus papers turn red

-Damp/moist/wet red litmus paper turns red.

Explanations

-Dry hydrogen chloride is a **molecular** compound that is joined by covalent bonds between the atoms.

It has **no effect** on dry litmus papers.

The gas is **polar** thus dissolves in water and ionize/dissociate completely to **free H^+** that are responsible for turning wet/damp/moist **blue** litmus paper **red**.

Dry hydrogen chloride gas was bubbled in two separately beakers containing water and in methylbenzene.

i)Classify the two solvents as either "polar" or "non-polar"

Water – polar

Methylbenzene – non-polar

(ii) State and explain the observations made in the beaker containing:

(i)Methylbenzene

Colour of litmus solution **remain**.

Hydrogen chloride is a **molecular** substance. When dissolved in non-polar solvent, it does not dissociate / ionize to release H^+ ions that cause the colour of litmus solution to turn **red**.

(ii)Water

Colour of litmus solution change to **red.**

Hydrogen chloride is a molecular substance. When dissolved in polar solvent like water, it dissociate / ionize to release H^+ ions that changes litmus solution to **red**.

(iii)Why should an inverted filter funnel be used when dissolving the gas.

The filter funnel is dipped **just** below the water surface to increase the surface area of dissolving the gas and prevent suck back.

(iv)Name the solution formed when hydrogen chloride dissolves in water.

Hydrochloric acid

Dip a glass rod in ammonia.
Bring it to the mouth of a gas jar containing a gas suspected to be hydrogen chloride

-White fumes(of ammonia chloride) are formed.

Chemical equation

$$HCl(s) + NH_3(g) \rightarrow NH_4Cl(s)$$

(g) Place 5cm³ of dilute hydrochloric acid into a four separate test tubes To separate test tube add zinc, magnesium iron and copper metals. State and explain the observations

except copper

-Colourless solution formed with zinc and magnesium.

-Green solution formed with ion

-Gas produced that extinguishes splint with explosion.

Explanations:

Metals above hydrogen in reactivity series react with hydrochloric and liberating hydrogen gas.

Chemical equation

$Fe(s) + 2HCl(aq) \rightarrow FeCl_2(aq + H_2(g)$

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

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

Concentrated hydrochloric acid is a **weaker** oxidizing agent than other concentrated acids i.e
Sulphuric (VI) acid and nitric (V) acid that react with all metals even those **lower** in the reactivity series.

(h) Place 5cm³ of dilute hydrochloric acid into five separate test tubes . To separate test tubes, add calcium carbonate, silver carbonate, copper carbonate, iron (II) carbonate and Sodium hydrogen carbonate . Explain the observations made.

- Effervescence/bubbles/fizzing vigorously except in silver carbonate and lead (II) carbonate that stop later.
- **Colourless** solution formed except with iron (II) carbonate and copper (II) carbonate
- **Green** solution formed with iron (II) carbonate
- **Blue** solution formed with copper (II) carbonate

Explanations.

Carbonates and hydrogen carbonate react with dilute hydrochloric acid to produce carbon (IV) oxide, water and form **chlorides**.

All chlorides formed are **soluble** except :

Lead (II) Chloride (soluble on heating/warming)

1. Chemical equation:

$CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + H_2O(l) + CO_2(g)$

(Colourless solution)

Ionic equation:

$CaCO_3(s) + 2H^+(aq) \rightarrow Ca^{2+}(aq) + H_2O(l) + CO_2(g)$

2.Chemical equation:

$Ag_2CO_3(s) + 2HCl(aq) \rightarrow 2AgCl(\mathbf{s}) + H_2O(l) + CO_2(g)$

(Coats/Cover Ag_2CO_3)

3.Chemical equation:

$NaHCO_3(s) + HCl(aq) \rightarrow NaCl(aq) + H_2O(l)$

(Blue Solution)

Ionic equation:

$CuCO_3(s) + 2H^+(aq) \rightarrow Cu^{2+}(aq) + H_2O(l) + CO_2(g)$

5.Chemical equation:

$FeCO_3(s) + 2HCl(aq) \rightarrow FeCl_2(aq) + H_2O(l) + CO_2(g)$

(green solution)

Ionic equation:

$FeCO_3(s) + 2H^+(aq) \rightarrow Fe^{2+}(aq) + H_2O(l) + CO_2(g)$

6.Chemical equation:

$(NH_4)_2CO_3(s) + 2HCl(aq) \rightarrow 2NH_4Cl(aq) + H_2O(l) + CO_2(g)$

Ionic equation

Potassium hydroxide and aqueous ammonia solution into three separate test tubes

Add one drop of phenolphthalein indicator drop wise, dropwise add dilute hydrochloric acid until there is an observable change.

State and explain the observations made.

Observations

Colour of Phenolphthalein indicator change from pink to colourless.

Explanations

Hydrochloric acid **neutralizes** alkalis to salt and water

When all the alkali has reacted with the acid, an **extra** slight excess acid turns the colour of

Chemical equation:

$$NaOH(aq) + HCl(aq) \rightarrow NaCl(aq) + H_2O(l)$$

Ionic equation:

$$OH^-(aq) + H^+(aq) \rightarrow H_2O(l)$$

Chemical equation:

$$KOH(aq) + HCl(aq) \rightarrow KCl(aq) + H_2O(l)$$

Ionic equation:

$$OH^-(aq) + H^+(aq) \rightarrow H_2O(l)$$

Chemical equation:

$$NH_4OH(aq) + HCl(aq) \rightarrow NH_4Cl(aq) + H_2O(l)$$

Ionic equation:

$$OH^-(aq) + H^+(aq) \rightarrow H_2O(l)$$

four separate test tube tubes separately. add about 1g of each of copper (II) Oxide, Zinc (II) Oxide, Lead (II) Oxide and Calcium (II) Oxide.
What happens in each test tube? Explain.

Observations:

-All Solid dissolves except Lead (II) Oxide

-Colourless solution formed with zinc Oxide and calcium (II) Oxide - Blue solution formed with copper (II) Oxide.

Explanations:

Metal oxides dissolves in dilute hydrochloric acid to form water and chloride salt.

-Insoluble Lead (II) chloride and silver chloride once formed cover/coat unreacted oxides stopping further reaction

Chemical equation:

$CuO(s) + 2HCl\,(aq) \rightarrow CaCl_2(aq) + H_2O(l)$

Ionic equation:

$CuO\,(s) + 2H^+(aq) \rightarrow Cu^{2+}(aq) + H_2O(l)$

Chemical equation:

$CaO(s) + HCl\,(aq) \rightarrow CaCl_2\,(aq) + H_2O\,(l)$

Ionic equation:

$CuO\,(s) + 2H^+(aq) \rightarrow Cu^{2+}(aq) + H_2O(l)$

Chemical equation:

$PbO(s) + 2HCl\,(aq) \rightarrow PbCl_2\,(s) + H_2O\,(l)$

No ionic equation

Chemical equation:

$ZnO(s) + HCl\,(aq) \rightarrow ZCl_2\,(aq) + H_2O\,(l)$

Ionic equation:

$ZnO\,(s) + 2H^+(aq) \rightarrow Zn^{2+}(aq) + H_2O(l)$

acid.

(i) Raw Materials

1. Hydrogen gas
2. Chlorine gas
3. Water

1. **Hydrogen**

- From **electrolysis** of Brine in the flowing mercury-cathode cell during the manufacture of sodium hydroxide solution.

- From **water gas –** passing steam in heated charcoal.

$$C(s) + H_2O \rightarrow CO(g) + H_2(g)$$

- From partial **oxidation** of natural gas methane

$$2CH_4(g) + O_2(g) \rightarrow 2CO(g) + 4H_2(g)$$

chloride in the Downs process during extraction of sodium

- From **electrolysis** of brine/concentrated sodium chloride **solution** in the flowing mercury-cathode during the manufacture of sodium hydroxide solution.

(ii) Chemical processes.

Hydrogen and chlorine gases are passed through concentrated sulphuric(VI) acid which act as a **drying agent**.

Small amount of pure hydrogen is continuously **ignited** in a chamber with continuous supply of pure dry chlorine.

Large amount of hydrogen explodes.

Hydrogen **burns** in chlorine to form hydrogen

$H_2(g) + Cl_2(g) \rightarrow 2HCl(g)$

The hydrogen chloride produced is then passed **up** to meet a downward flow of water in absorption chambers.

Hydrogen chloride is very soluble in water and **dissolves** to form **35%** concentrated hydrochloric acid.

Chemical equation

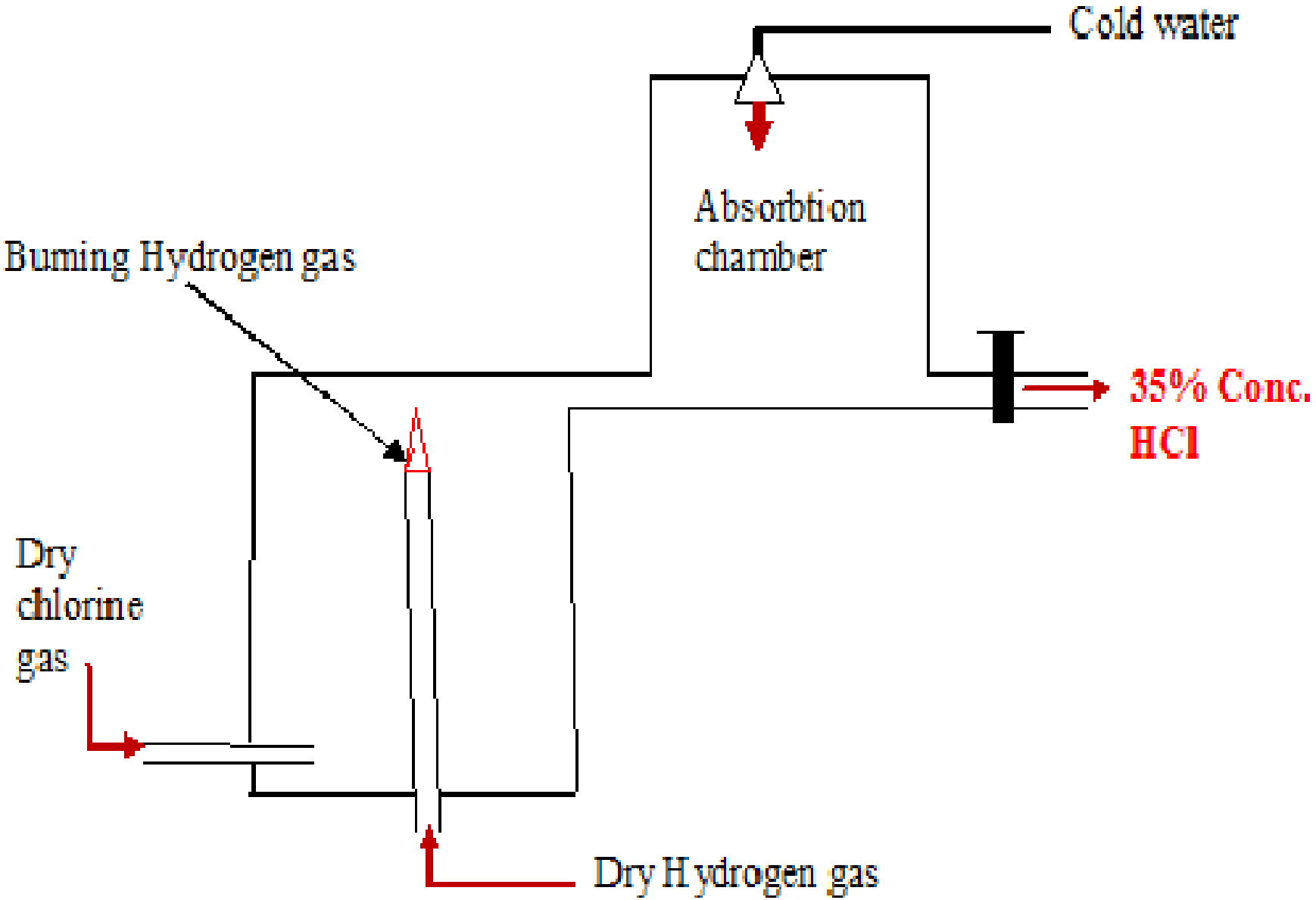
$$HCl(g) + (aq) \rightarrow HCl(aq)$$

The absorption chamber is **shelved** /packed with broken glass beads to:

(i)Slow down the downward flow of water.

(ii)Increase **surface area** over which the water dissolves /reacts with hydrogen chloride.

HCl is transported in rubber –lined steel tanks ready for sale



Industrial manufacture of Hydrochloric acid

Acid

1.To standardize the pH of (alcohol and wines)

2.Regenerating ion-exchange resin during removal of hardness of water.

3.Pickling of metals to remove oxide layers on their surfaces.

4.In the manufacture of dyes and drugs.

5.Making zinc chloride for making

(4) Environmental effects of manufacturing HCl.

Hydrochloric acid is **acidic**.

Any leakage from a manufacturing plant to nearby rivers /lake causes excess acidity that **lowers** pH of water **killing** marine life.

If Hydrogen chloride leak into atmosphere it dissolves to form "acidic rain" that accelerates corrosion in buildings, breathing problems to human beings and kill fauna and flora around the paint.

A Chlorine leakage can cause breathing and sight problems to human being.

It accelerates bleaching of dyed metals.

-Hydrogen leakage can cause an **explosion** because impure hydrogen explodes on ignition.

hydrochloric acid manufacturing plant.

Nearness to the manufacturing of sodium hydroxide because the byproducts of electrolysis of brine are the raw materials for hydrochloric acid plant.

Availability of natural gas for extraction of hydrogen.

Nearness/availability of water to dissolve the hydrogen chloride gas.

Availability of labour, market, capital and good means of transport.

D: CHLORIDE (Cl^-)SALTS

Occurrence.

Chlorides are salts derived from hydrochloric acid.

HCl is monobasic and thus all chlorides are therefore **normal** salts.

1. All metals exist as chloride salts **except** platinum and gold
2. (i) Both $FeCl_2$ and $FeCl_3$ exists, but $FeCl_2$ is readily oxidized to eCl_3 because it is **more stable.**

(ii) $PbCl_2$ and $PbCl_4$ exist, but $PbCl_4$ is only oxidized from $PbCl_2$ by using **excess**

(**thermodynamically**) more **stable** than CuCl.

CuCl disproportionate to Cu and $CuCl_2$.

i.e. $2CuCl(aq) \rightarrow Cu(s) + CuCl_2(aq)$

-HgCl and $HgCl_2$exists as **molecular** compounds.

All chlorides are **soluble/dissolves** in water **except:**

-**silver chloride** **(AgCl).**

- Copper (I) chloride CuCl ,Mercury (I) chloride Hg_2Cl_2 and **lead (II) chloride**

PbCl$_2$ dissolves in **warm/hot** water

Most chlorides are very stable compounds.
They do **not decompose** on gentle or strong Bunsen burner heating in a school laboratory **except Ammonium Chloride**.

Heating ammonium chloride

Place about 2g of solid ammonium chloride crystals in a clean dry boiling tube

Place wet/moist blue and red litmus papers on the mouth of the boiling tube

Heat for three minute using a strong bunsen flame

Observations

-red litmus paper turn blue-blue litmus paper remains blue

-both blue litmus papers turn red.

Explanation

sublimation to ammonia and hydrogen chloride gas.

Ammonia gas is less dense than hydrogen chloride.

It is a **basic gas** and diffuses out **faster** to turn **red** litmus paper to **blue**.

Hydrogen chloride is an **acidic gas** .It is denser than ammonia gas and thus diffuses **slower** than ammonia gas to turn the already both **blue** litmus paper to **red**.

Chemical equation

$NH_4Cl(s) \rightarrow HCl(g) + NH_3(g)$

The following experiment shows the test for the presence of Cl^- ions in **solids** chloride salts.

Procedure:

Place about 1g of sodium chloride, Zinc chloride and copper (II) chloride in separate boiling tubes.

Place moist blue and red litmus papers on the mouth of the test tube.

Carefully,

Add three drops of concentrated sulphuric (VI) acid.

Dip a glass rod in aqueous ammonia solution then bring it to the mouth of the

Observation	Inference
-red litmus paper remain red -blue litmus paper turn red	H^+ ions
-vigorous effervescence/fizzing /bubbling	Cl^- ions
-white fumes produced	HCl gas suspected
(b)Explanation:	

It vigorously displaces chlorine in metal chlorides to evolve acidic hydrogen chloride gas fumes.

Chemical equation

$NaCl(s) + H_2SO_4(l) \rightarrow NaHSO_4(aq) + HCl(g)$

$CuCl_2(s) + H_2SO_4(l) \rightarrow CuSO_4(aq) + 2HCl(g)$

$ZnCl_2(s) + H_2SO_4(l) \rightarrow ZnSO_4(aq) + 2HCl(g)$

Hydrogen chloride and ammonia gases react and form **white fumes** of ammonium chloride that confirms presence of **Cl^-** ions in the **solid** substance.

Chemical equation

2.(b)Test for Cl^- ions(in aqueous salts /compounds)

The following experiment shows the test for the presence of Cl^- ions in **solution/aqueous** chloride salts.

(i)Using aqueous Lead (II) nitrate(V)

(a)Procedure:

I. Place about 5cm3 of sodium chloride, Iron (III) chloride and copper (II) chloride in separate test /boiling tubes.

Add four drops of Lead (II) nitrate(V) solution to each. Preserve.

Observation	Inference
White precipitate/ppt persist	SO_4^{2-}, Cl^- , SO_3^{2-}, CO_3^{2-}

III. To the preserved sample, add 6 drops of nitric(V) acid. Preserve.

Observation	Inference
White precipitate/ppt persist/remains	Cl^-, SO_4^{2-},

III. To the preserved sample, heat to boil

Observation	Inference
White precipitate/ppt dissolves on boiling/warming	Cl^-

Explanation:

I. When Lead(II) nitrate(V) solution is added to an unknown salt , a white precipitate/ppt of Lead(II) sulphate(VI) Lead(II) carbonate(IV) Lead(II) sulphate(IV) Lead(II) chloride(I) are formed.

Ionic equation:

$Pb^{2+}(aq) + SO_4^{2-}(aq) \rightarrow PbSO_4(s)$

$Pb^{2+}(aq) + SO_3^{2-}(aq) \rightarrow PbSO_3(s)$

$Pb^{2+}(aq) + CO_3^{2-}(aq) \rightarrow PbCO_3(s)$

$Pb^{2+}(aq) + 2Cl^{-}(aq) \rightarrow PbCl_2(s)$

acidified with dilute nitric(V) acid, the white precipitate of Lead(II) sulphate (VI) and Lead(II) chloride(I) persist/remain while that of Lead(II) carbonate(IV) and Lead(II) sulphate(IV) dissolves.

III.On heating /warmingLead (II) chloride (I) dissolves but on cooling it recrystallizes.

This shows the presence of **Cl^- ions** in aqueous /solutions

(ii)Using aqueous silver(I)nitrate(V)

Procedure

I.Place about 5cm3 of sodium chloride, Iron (III) chloride and copper (II) chloride in separate boiling tubes.

Add four drops of silver(I) nitrate(V) solution to each. **Preserve.**

To the preserved sample, add six drops of nitric (V) acid. Preserve.

Observation	**Inference**
White precipitate/ppt persist	**Cl^-**

Explanation:

I.When silver(I) nitrate(V) solution is added to an unknown salt , a white precipitate/ppt of silver(I) carbonate(IV) and silver(I) chloride(I) are formed.

Ionic equation:

$2Ag^+(aq) + CO_3^{2-}(aq) \rightarrow Ag_2CO_3(s)$

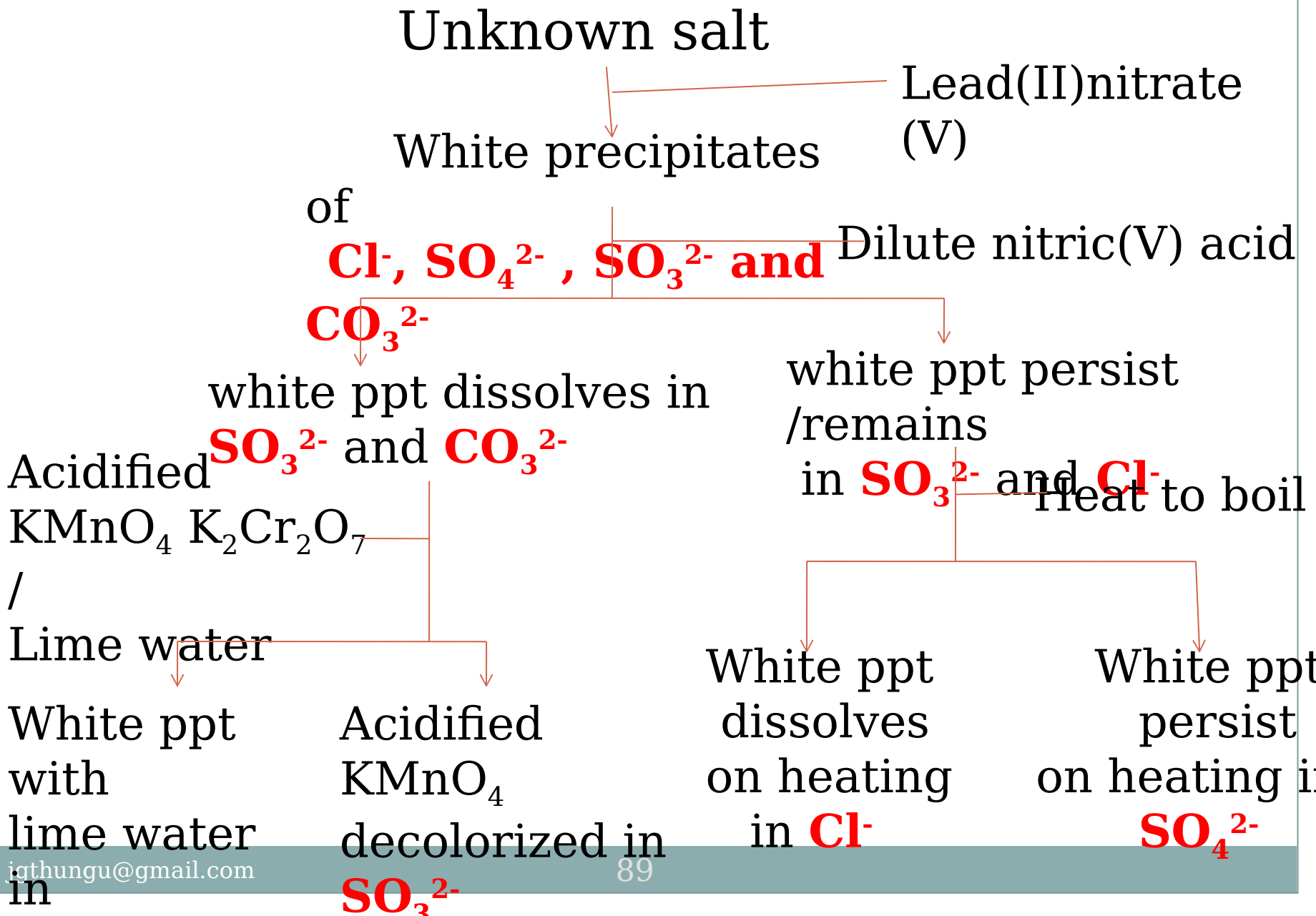
$Ag^+(aq) + Cl^-(aq) \rightarrow AgCl(s)$

II.When the white precipitate/ppt formed is acidified with dilute nitric (V) acid, the white precipitate of silver (I) chloride (I) persist/remain.

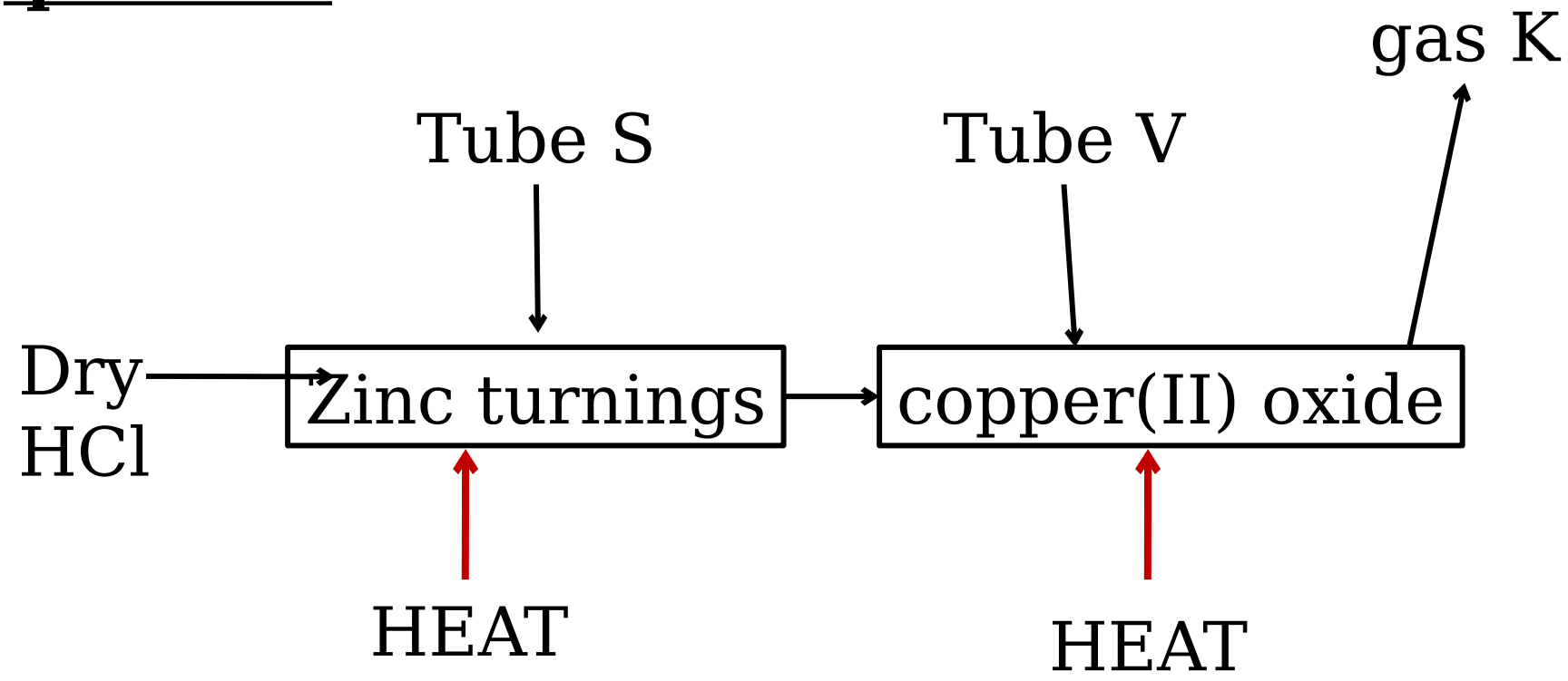
This shows the presence of Cl^- ions in aqueous solutions.

Silver (I) carbonate (IV) dissolves when reacted with nitric (V) acid.

Summary test for Chloride (Cl^-) salts



E. Sample revision question



1.Write the equation for the reaction :
(i)For the school laboratory preparation of hydrogen chloride gas.

(ii)in tube S

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

b)State and explain the observation made in tube V.

Observations

-colour of solid changes from black to brown

-colourless liquid forms on the cooler parts of tube V

Explanation

Hydrogen produced in tube S reduces black copper(II) oxide to brown copper metal and the gas oxidized to water vapour that condense on cooler parts.

V and their contents compare before and after the experiment.

Tube S

Mass increase/rise because Zinc combine with chlorine to form heavier Zinc Chloride.

Tube V

Mass decrease/falls/lowers because copper (II) oxide is reduced to lighter copper and oxygen combine with hydrogen to form water vapour that escape.

2. Chlorine is prepared by using solid sodium chloride, concentrated sulphuric(VI) acid and potassium manganate(VII)

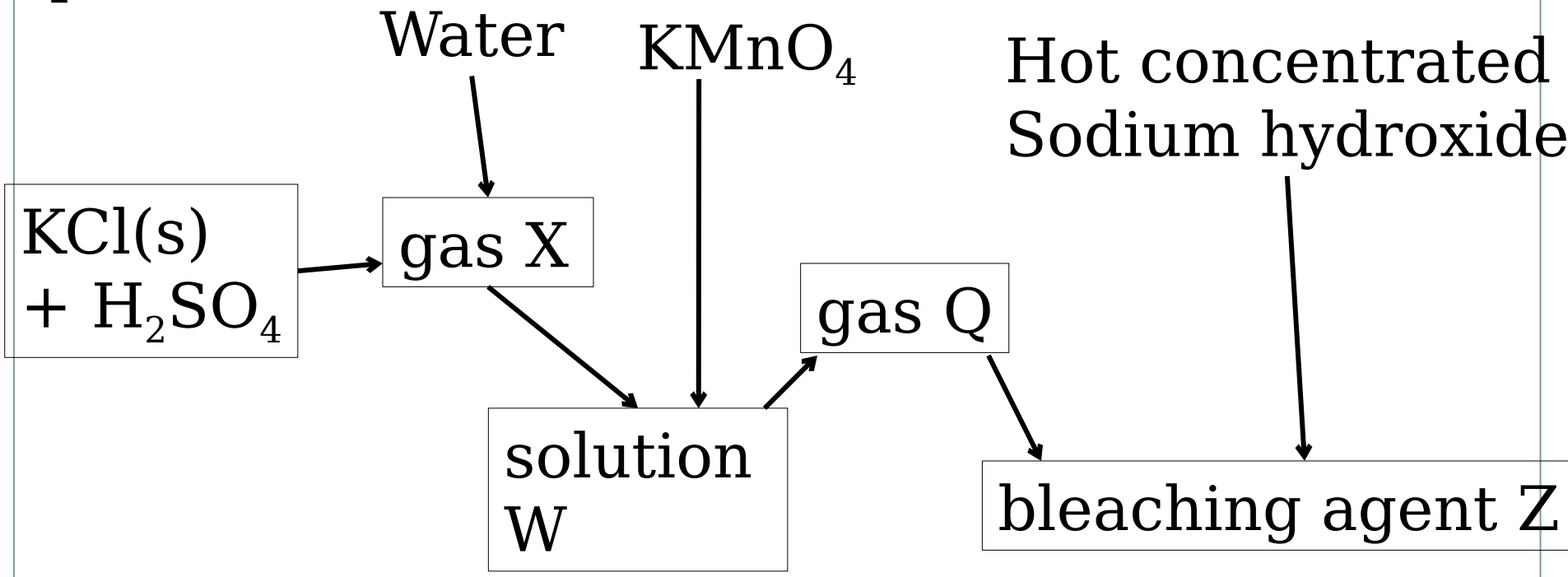
a)What is the role of the following in the reaction;

To produce hydrogen chloride gas by reacting with the solid sodium chloride.

(ii)potassium manganate(VII)

To oxidize hydrogen chloride gas to chlorine

3.Use the flow chart below to answer the questions that follow.



gas X

Hydrogen chloride

solution W

Hydrochloric acid

gas Q

Chlorine

bleaching agent Z

Sodium chlorate(V)

b)Write the chemical equation for the formation of :

(i) gas X

$NaCl(s) + H_2SO_4(l) \rightarrow NaHSO_4(aq) + HCl(g)$

(ii)solution W

HCl(g) + (aq) -> HCl(aq)

(iii)gas Q

$2KMnO_4 + 16HCl(aq) \rightarrow 2KCl(aq) + 2MnCl_2(aq) + 8H_2O(l) + 5Cl_2(g)$

(iv)bleaching agent Z

$6NaOH(aq) + 3Cl_2(g) \rightarrow NaCl(aq) + NaClO_3(aq) + 3H_2O(l)$

c)State and explain the following observations;

(i) a glass rod dipped in aqueous ammonia is brought near gas X

Observation:

Dense white fumes

Explanation:

Ammonia gas reacts with hydrogen chloride gas to form dense white fumes of ammonium chloride.

Chemical equation:

$NH_3(g) + HCl(g) \rightarrow NH_4Cl(s)$

Observations:

Blue litmus paper turned red the both are bleached /decolorized.

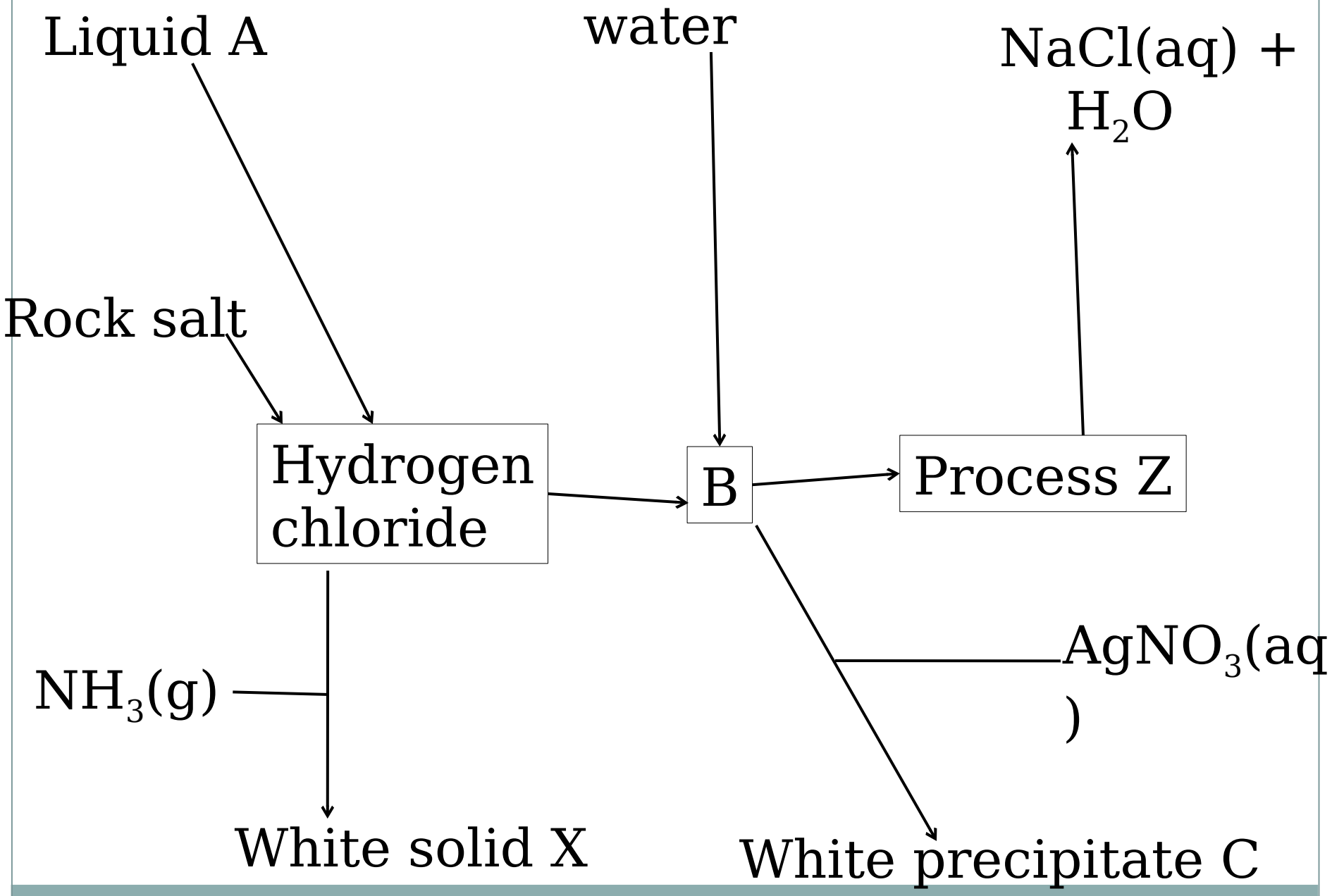
Explanations:

Chlorine reacts with water to form both acidic hydrochloric and chloric (I) acids that turn blue litmus paper red. Unstable chloric (I) acid oxidizes the dye in the papers to colourless.

Chemical equations

$Cl_2(g)$ + HCl(aq) -> HCl(aq) + HClO(aq)

dye +HClO(aq) -> HCl(aq) + (dye +O) **or:**


Liquid A
water
NaCl(aq) + H_2O
Rock salt
Hydrogen chloride
B
Process Z
$AgNO_3$(aq)
NH_3(g)
White solid X
White precipitate C

(a)Name

Liquid A

Concentrated sulphuric(VI) acid

Process Z

Neutralization

White solid X

Ammonium chloride

b)Write the equation for the formation of:

(i) Hydrogen chloride

$NaCl(s) + H_2SO_4(l) \rightarrow NaHSO_4(aq) + HCl(g)$

(ii) B

$HCl(g) + (aq) \rightarrow HCl(aq)$

(iii)process Z (using ionic equation)

$H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$

(iv)C (using ionic equation)

$Ag^+(aq) + Cl^-(aq) \rightarrow AgCl(s)$

c)Describe how solution B is obtained.

Bubbling hydrogen chloride gas through inverted funnel into distilled water until no more dissolve.

5 The results obtained when halogens are bubbled into test tubes containing solutions of halide A,B and C is as in the table below. Tick(v) means a reaction took place.Cross(x) means no reaction took place.

Halogens	Halide ions in solution		
	A	B	C
I_2	x	-	x
Br_2	x	v	-
Cl_2	-	v	v

a)Identify the halide ions represented by letter

a)Identify the halide ions represented by letter A, B, C.

A	**Cl^-**
B	**I^-**
C	**Br^-**

b)Write the ionic equation for the reaction that take place with halide:

(i) C

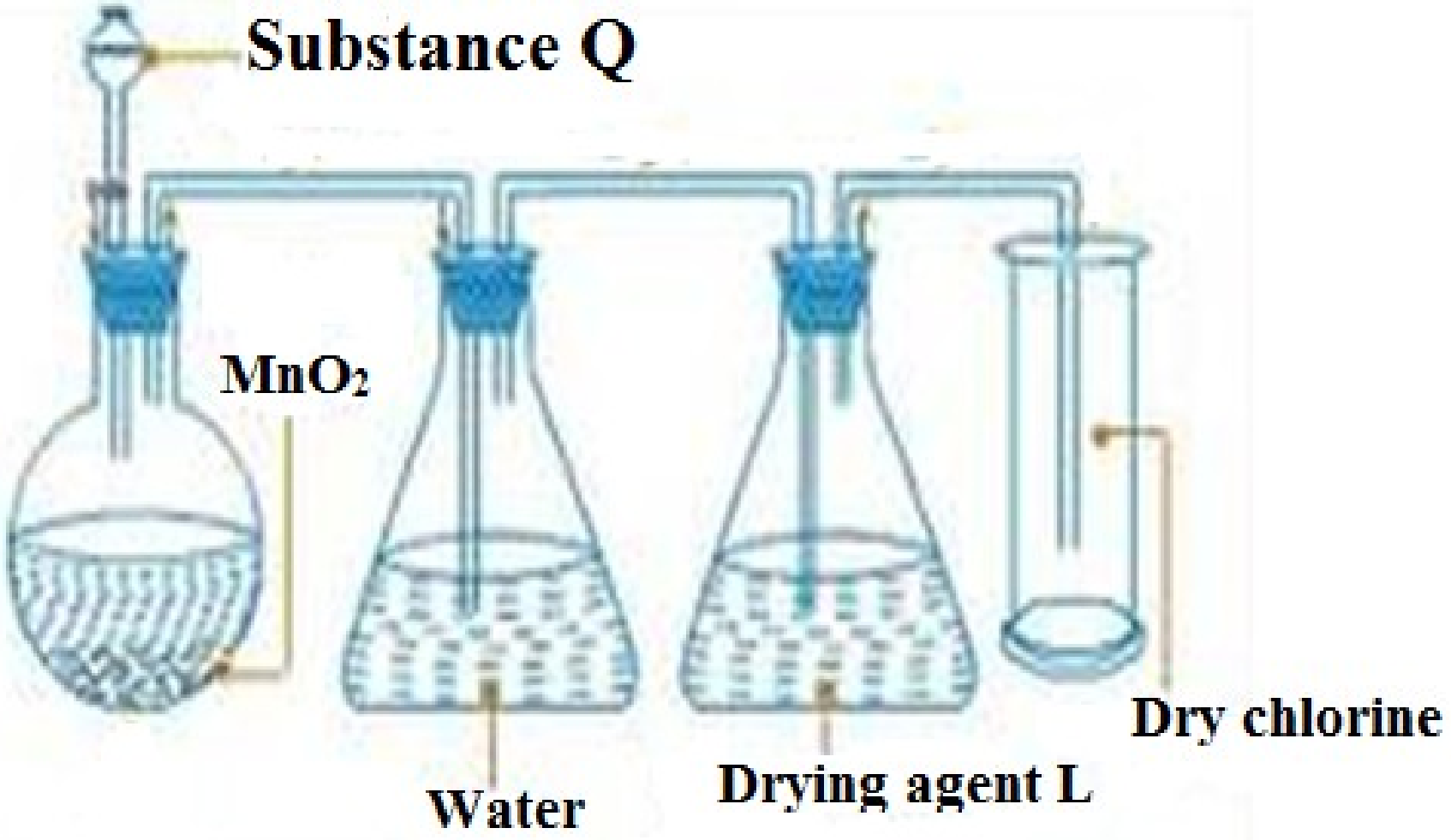
$Cl_2(g) + 2Br^-(aq) \rightarrow 2Cl^-(aq) + Br_2(aq)$

(ii) B

$Cl_2(g) + 2Br^-(aq) \rightarrow 2Cl^-(aq) + Br_2(aq)$

$Cl_2(g) + 2I^-(aq) \rightarrow 2Cl^-(aq) + I_2(aq)$

6.The diagram below shows a set up of apparatus for the school laboratory collection of dry chlorine gas.



a)Name:

(i) substance Q

Concentrated hydrochloric acid

(ii)suitable drying agent L

-Concentrated sulphuric(VI) acid

-anhydrous calcium chloride

-silica gel

b) State a missing condition for the reaction to take place faster.

-Heat/Heating

c)Red and blue litmus papers were dipped into the chlorine gas from the above set up .State and explain the observations made.

Observation:

Blue litmus paper remain blue.

Red litmus paper remain red.

Explanation:

Dry chlorine has no effect on dry litmus papers.

d)Write the equation for the reaction taking place in the conical flask

MnO_2 (s) + 4HCl(aq) -> $MnCl_2$(aq) +2H_2O(l) + Cl_2(g)

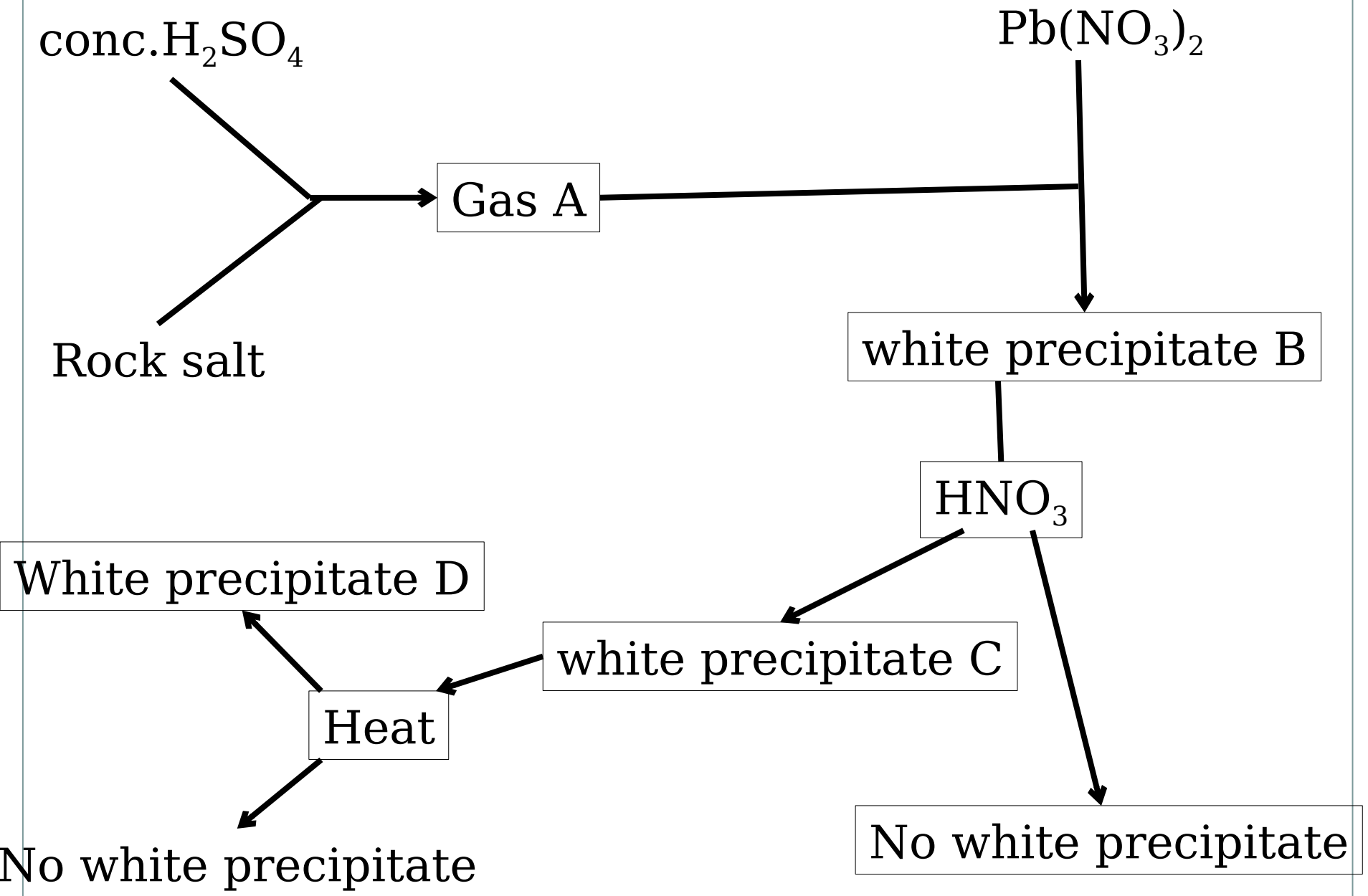
e)Name two other substances that can be used in place of MnO_2

Lead(IV) oxide (PbO_2)

Potassium manganate(VI)($KMnO_4$)

Potassium dichromate($K_2Cr_2O_4$)

Bleaching powder($CaOCl_2$)


conc.H_2SO_4
$Pb(NO_3)_2$
Gas A
Rock salt
white precipitate B
HNO_3
White precipitate D
white precipitate C
Heat
No white precipitate
No white precipitate

formation of gas A

$NaCl(s) + H_2SO_4(l) \rightarrow NaHSO_4(aq) + HCl(g)$

b)Identify:

(i) four possible ions that can produce white precipitate B

SO_4^{2-},SO_3^{2-}, CO_3^{2-}, Cl^-

(ii)two possible ions that can produce;

I.White precipitate C

SO_4^{2-},Cl^-

II.colourless solution D

SO_3^{2-}, CO_3^{2-}

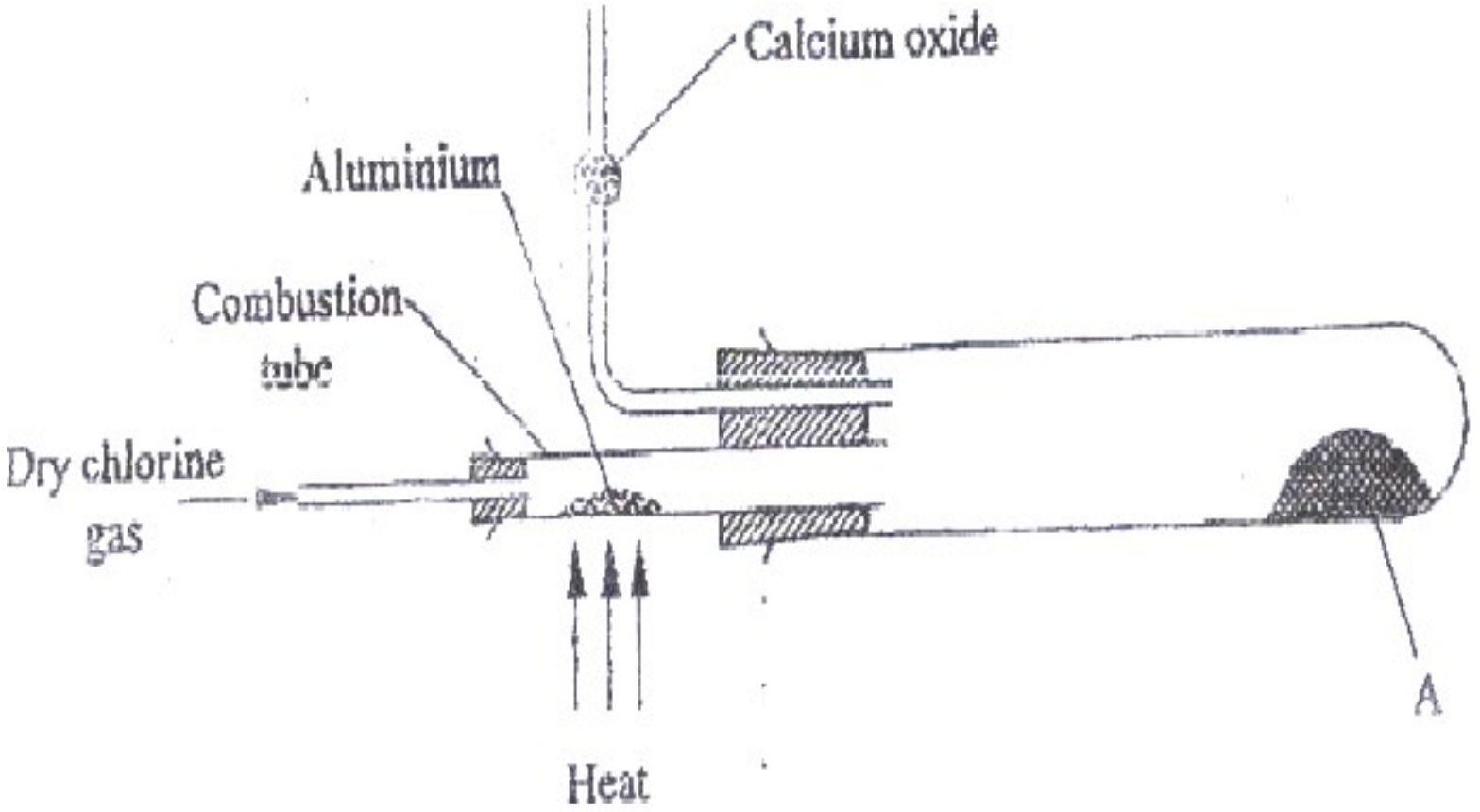
(iii)possible ions present in

I. White precipitate E

SO_4^{2-}

II. colourless solution F

10. Study the flow chart below and use it to answer the questions that follow.



wool is heated.

Glows red hot.

b)(i) Identify salt A

aluminium(III) chloride// $AlCl_3$

(ii)Write the equation for the formation of salt A

$$2Al\mathbf{(s)} + 3Cl_2\mathbf{(g)} \rightarrow 2AlCl_3\mathbf{(s/g)}$$

(iii)What property of salt A is exhibited as shown in the experiment.

It sublimes//sublimation .

(iv)Calculate the minimum volume of chlorine required to form 700kg of iron(III) chloride at room temperature. (Fe= 56.0, Cl=35.5,1 mole of a gas =24000cm3,1000g = 1kg)

$FeCl_3 = 162.5g$

Method 1

$2 \times 162.5\ g\ FeCl_3 \rightarrow 3 \times 22400\ cm^3\ Cl_2$

$700 \times 1000\ g\ FeCl_3 \rightarrow$

$$\frac{(700 \times 1000 \times 3 \times 22400)}{2 \times 162.5} = 1.4474 \times 10^{-8}\ cm^3$$

Method 2

Moles of $FeCl_3$ = mass/ molar mass

=> (700 x 1000) / 162.5 = 4307.6923 moles

Moles of Cl_2 = 3/2 moles of $FeCl_3$

=>3/2 x 4307.6923 = 6461.5385 moles

Volume of chlorine= moles x molar gas volume

=> 6461.5385 x 24000

Iron

d)(i) What is the purpose of anhydrous calcium chloride.

-ensure the apparatus are water free.

-prevent water from the atmosphere from entering and altering//hydrolysing salt A

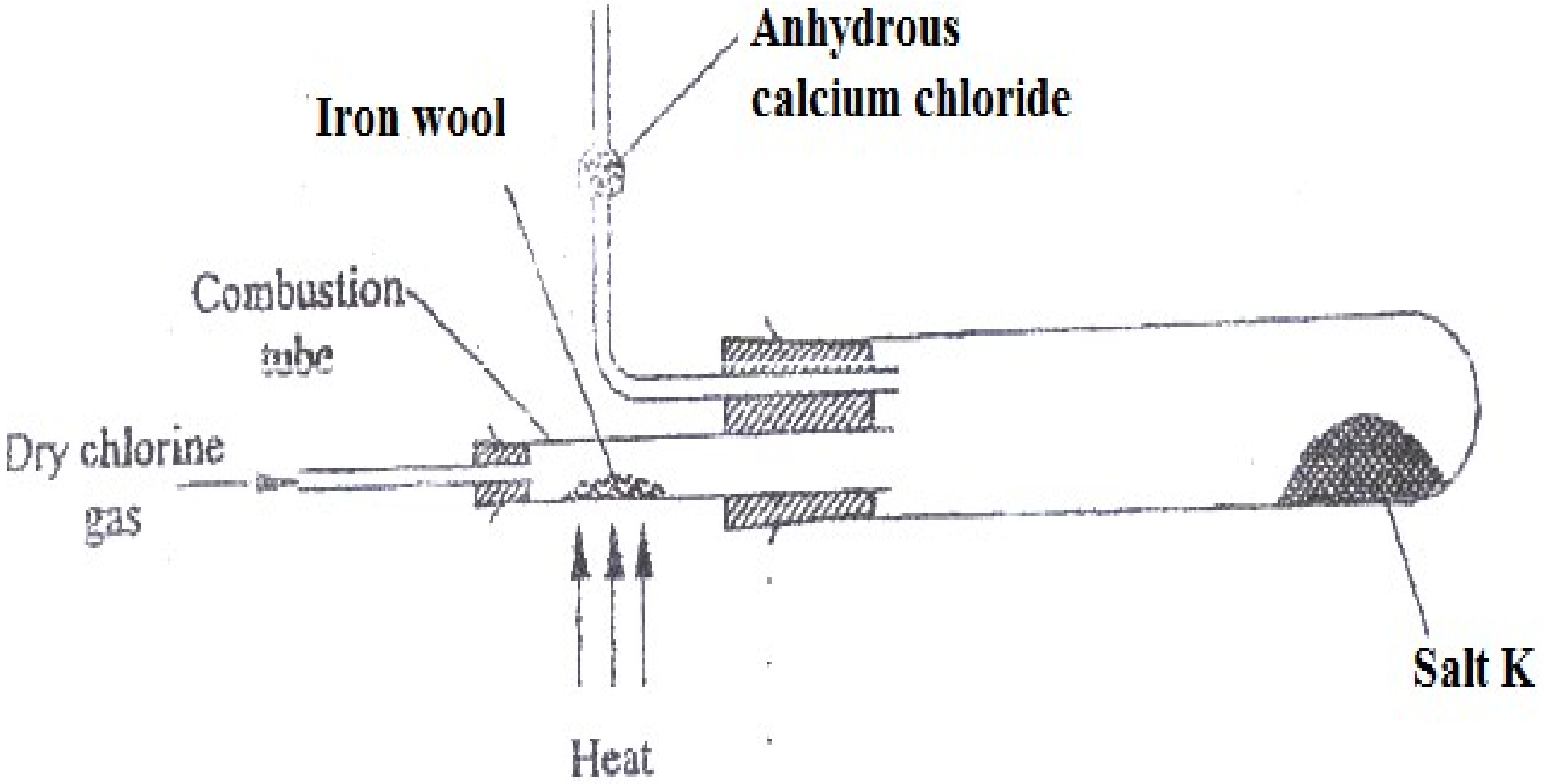
(ii) Write the equation for the reaction that take place if anhydrous calcium chloride is not used in the above set up.

$AlCl_3(s) + 3H_2O(l) \rightarrow Al(OH)_3(aq) + 3HCl(g)$

(ii) Write the equation for the reaction that take place when Iron metal is reacted with dry hydrogen chloride gas.

$Fe(s) + 2HCl(g) \rightarrow FeCl_2(s) +$

The set up below shows the apparatus used to prepare and collect salt K.



Iron(III)chloride

Write the equation for the reaction for the formation of salt K

$$2Fe(s) + 3Cl_2(g) \rightarrow 2FeCl_3(s/g)$$

b)State and explain the following

(i)Small amount of water is added to iron (II) chloride in a test tube then shaken

Solid dissolves to form a green solution.

Iron(II) chloride is soluble in water

(ii)I.Three drops of aqueous sodium hydroxide is added to aqueous iron(II) chloride and then added excess of the alkali.

Observation:

Green precipitate is formed that persist/remain /insoluble in excess akali.

Explanation:

Iron(II) chloride reacts with aqueous sodium hydroxide to form a green precipitate of iron(II) hydroxide.

Ionic equation:

$Fe^{2+}(aq) + 2OH^{-}(aq) \rightarrow Fe(OH)_2(s)$

II.Six drops of hydrogen peroxide is added to the mixture in d(ii) above.

Observation:

Effervescence/bubbling/fizzing take place and the green precipitate dissolve to form a yellow/brown solution.

Explanation:

completely reacted. (1 mole of a gas =24dm3 at r.t.p, Fe = 56.O, Cl= 35.5)

Chemical equation

$Fe(s) + 2HCl(g) \rightarrow FeCl_2(s) + Cl_2(g)$

Mole ratio HCl: $FeCl_2$ = 1:1 molar mass $FeCl_2$ = 127g

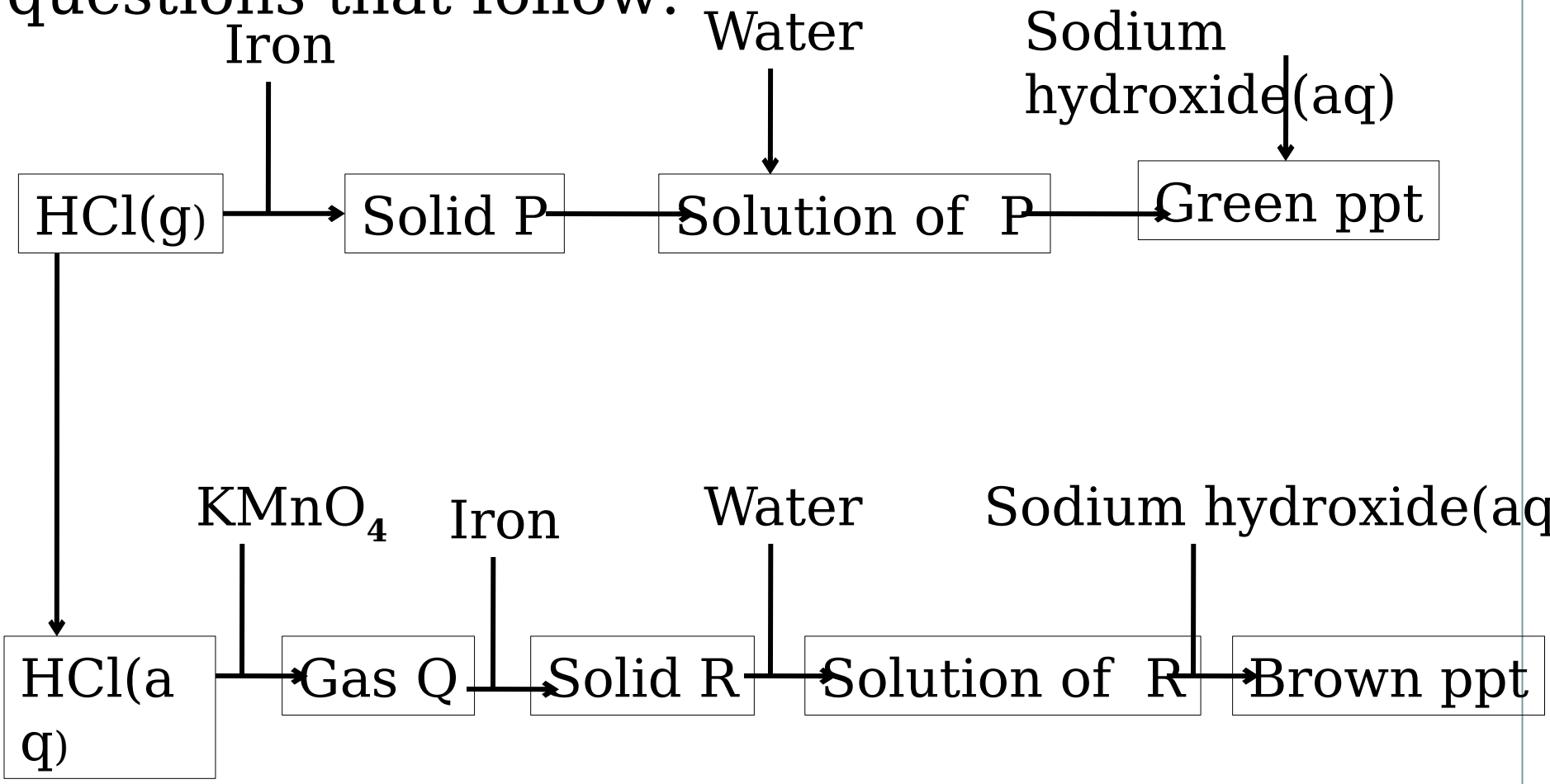
Moles of HCl used = 60cm3 /24000cm3 = 2.5×10^{-3} moles

Moles of $FeCl_2$ = Moles of HCl => 2.5×10^{-3} moles

Mass of $FeCl_2$ = moles x molar mass

=> $2.5 \times 10^{-3} \times 127$

Use the flow chart below to answer the questions that follow:



P

Iron(II) chloride//$FeCl_2$

Q

Chlorine // Cl_2

R

Iron(III) chloride//$FeCl_3$

b)Write the equation for the reaction for the formation of:

(i) gas Q

$2KMnO_4(s)+16HCl(aq) \rightarrow 2KCl(aq) +2MnCl_2(aq) +8H_2O(l)+ 5Cl_2(g)$

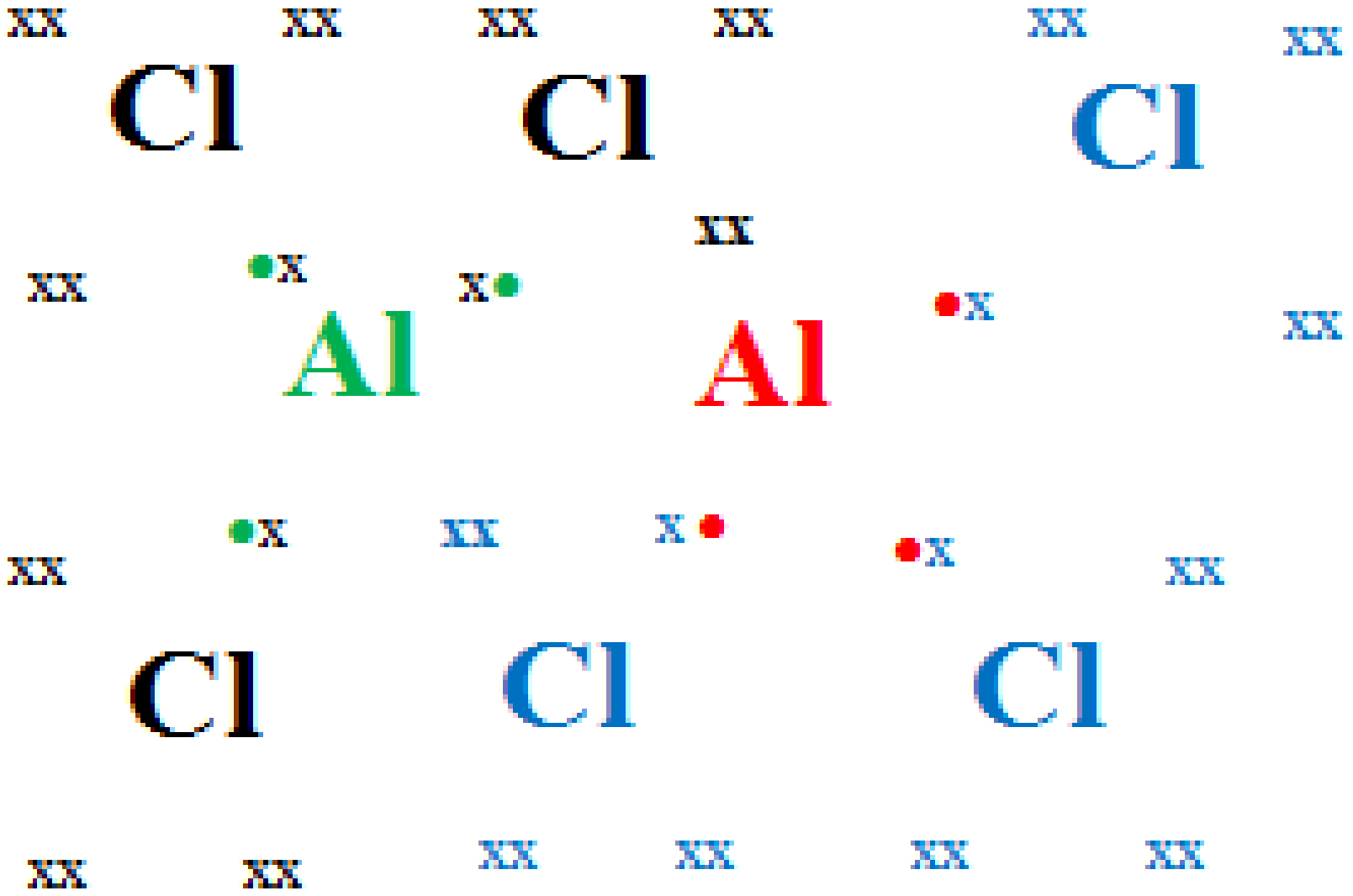
(ii) the green precipitate (using ionic equation)

$Fe^{2+}(aq) + 2OH^-(aq) \rightarrow Fe(OH)_2(s)$

(ii) the brown precipitate (using ionic equation)

$Fe^{3+}(aq) + 3OH^-(aq) \rightarrow Fe(OH)_3(s)$

13.Using dot(.)and cross(x)to represent electrons show the bonding in aluminium chloride in vapour


Cl
Cl
Cl
Al
Al
Cl
Cl
Cl

(i)aluminium atoms are used in bonding.

Six electrons(three valence electrons in each aluminium atom)

(ii)chlorine atoms atoms are used in dativebonding.

four electrons(two lone pairs of valence electrons in two chlorine atoms)

(iii)the molecule are used in bonding.

Sixteen electrons

-six electrons from aluminium atom by covalent bond

-six valence electrons from chlorine atoms covalent bond.

-four valence electrons from chlorine atoms

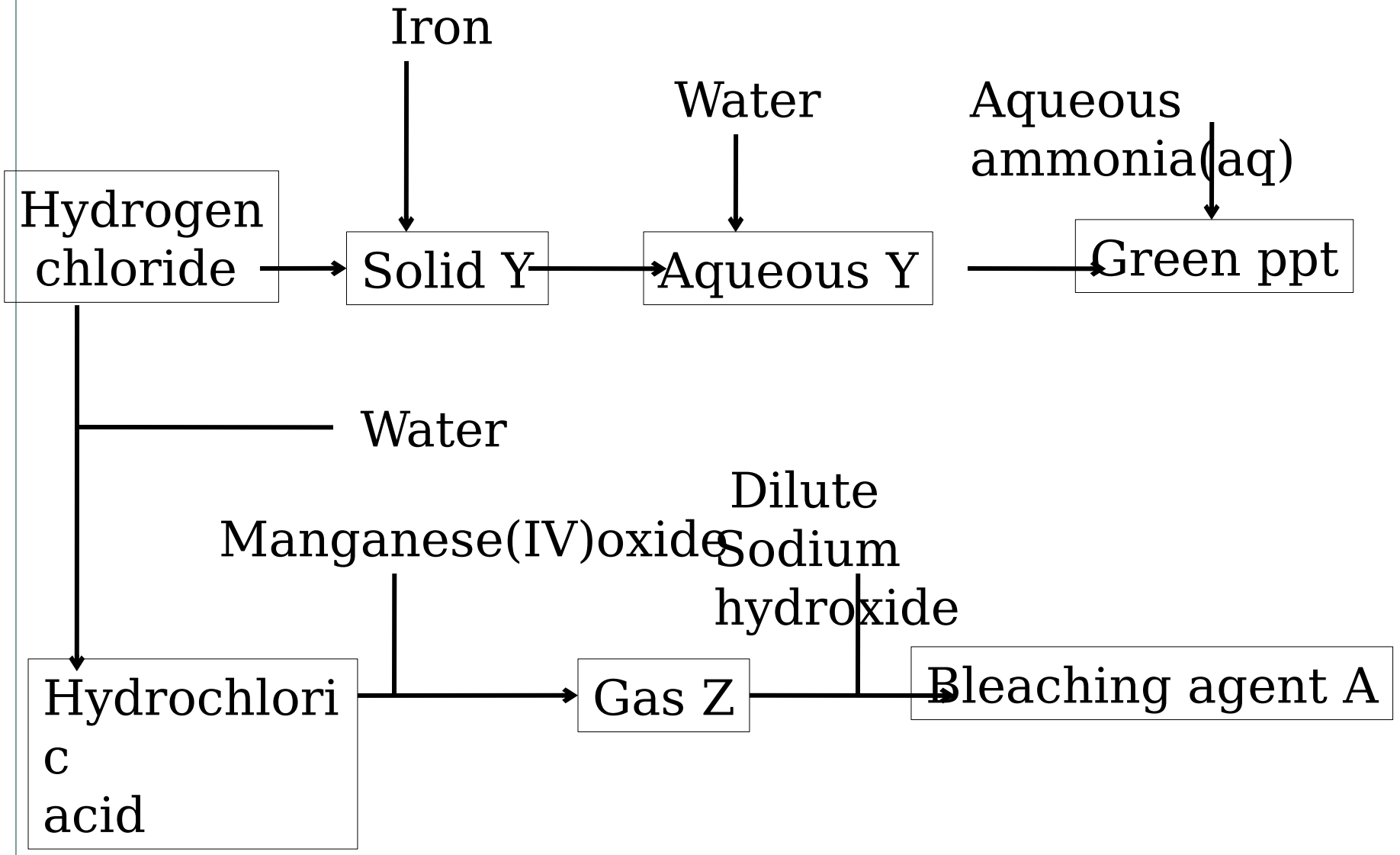
(c)How many lone pair of electrons do not take part in bonding within the molecule.

Sixteen(16) lone pairs from six chlorine atoms(32 electrons)

(d)Aluminium chloride does not conduct electricity in molten state but Magnesium chloride conduct.

Aluminium chloride is a molecular compound that has no free mobile Al^{3+} and Cl^{-} ions which are responsible for conducting electricity.

Magnesium chloride has free mobile Mg^{2+} and Cl^{-} ions because it is an ionic compound.


Iron
Water
Aqueous ammonia(aq)
Hydrogen chloride
Solid Y
Aqueous Y
Green ppt
Water
Dilute Sodium hydroxide
Manganese(IV)oxide
Hydrochloric acid
Gas Z
Bleaching agent A

of hydrogen chloride gas

$NaCl(s) + H_2SO_4(l) \rightarrow NaHSO_4(aq) + HCl(g)$

$KCl(s) + H_2SO_4(l) \rightarrow KHSO_4(aq) + HCl(g)$

b)Name:

I. solid Y

Iron (II) chloride ($FeCl_2$)

II green precipitate

Iron (II) hydroxide ($Fe(OH)_2$

III Gas Y

Chlorine (Cl_2)

IV. Bleaching agent A

Sodium hypochlorite (NaOCl)

c)Blue and red litmus papers were dipped into bleaching agent A. Write the equation for the reaction that takes place.

Coloured dye +NaOCl(aq) ->NaCl(aq) + (Colourless dye + O)

(Coloured dye-O) + NaOCl(aq) ->NaCl(aq)

THE END

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