

Halogens or Group 7B elements

These are fluorine, chlorine, bromine, iodine and astatine. Table 14.0 gives some properties of group 7B elements.

Table 14.0 Some properties of Group VIIB elements

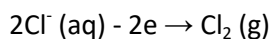
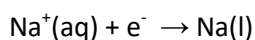
Element	Electron configuration	M.P. (°C)	B.P. (°C)
F	2:7	-233	-118
Cl	2:8:7	-103	-34.6
Br	2: 8:18:7	-7.2	58.8
I	2:8:18:18:7	113.5	184.3

General comment

1. Halogens are diatomic nonmetals
2. Melting and boiling point increase down the group due to increase in molecular mass, chlorine is a greenish-yellow gas, bromine is yellow volatile liquid and iodine is a dark shiny solid.
3. They react by accepting an electron to form octet configuration and they form ions of the form X^-
4. They are the most reactive nonmetals, but the reactivity decreases down the group due to **reduction of nonmetallic character**

Preparation of chlorine.

Chlorine occurs as NaCl, KCl, $MgCl_2$, and so on in sea water, salt lakes and as deposits originating from the prehistoric evaporation of salt lakes. Chlorine is obtained by electrolysis of brine - older technology employed a mercury cathode in which the sodium is dissolved.



However, this process entailed a hazard because of the loss of mercury to the environment, and some newer process employing membrane cells and not requiring mercury is now common.

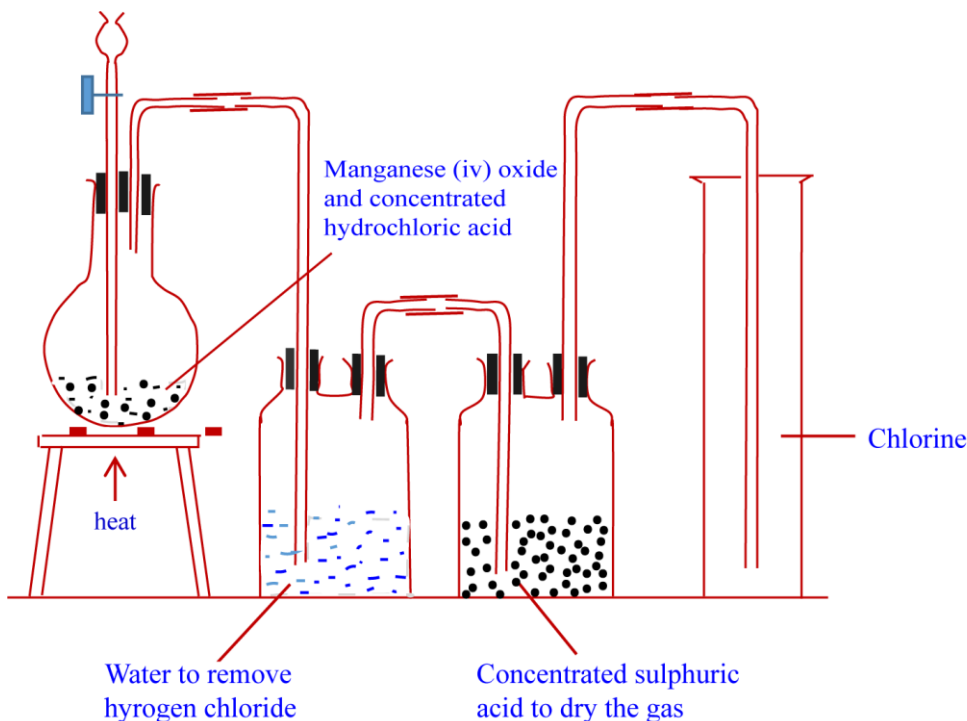
In the laboratory:

it is obtained by oxidation of concentrated hydrochloric acid with potassium permanganate (VII) or with manganese (iv) Oxide.





Apparatus for laboratory preparation of dry chlorine gas

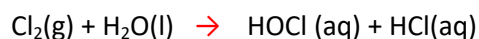


Note that chlorine is collected by downward delivery or upward displacement of air because it is denser than air

Chemical properties

a. Chlorine as bleaching agent

Chlorine bleaches a few drops of litmus solution dropped in a jar of chlorine. The bleaching property is due to presence of hypochlorous acid(HOCl) from the reaction of chlorine with water.



Hypochlorous acid is very reactive compound and readily give up its oxygen to the dye, to form a colorless compound



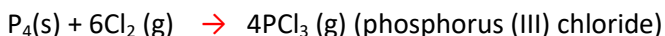
b. Reactions with turpentine

When a filter paper dipped in turpentine is dropped into a jar of chlorine; Chlorine and turpentine react violently with a red flash giving of a black cloud of solid particles of carbon and hydrogen chloride



c. Reaction with phosphorus

When a piece of phosphorus is dropped into a jar of chlorine, it burns spontaneously, giving off white fumes of chlorides of phosphorus, mainly PCl_3 .



d. Reaction with hydrogen sulphide

When a jar of hydrogen sulphide is inverted on a jar of chlorine, yellow particles of sulphur form due to oxidation of hydrogen sulphide to sulphur by chlorine.



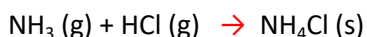
e. Reaction with hydrogen

Chlorine reacts with hydrogen to form hydrogen chloride gas

Chlorine, bromine and iodine combine with many non-metals for example.

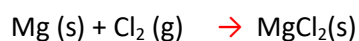


Hydrogen chloride forms white fumes in damp air and white fumes with ammonium chloride.

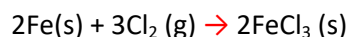


f. Reaction with metals

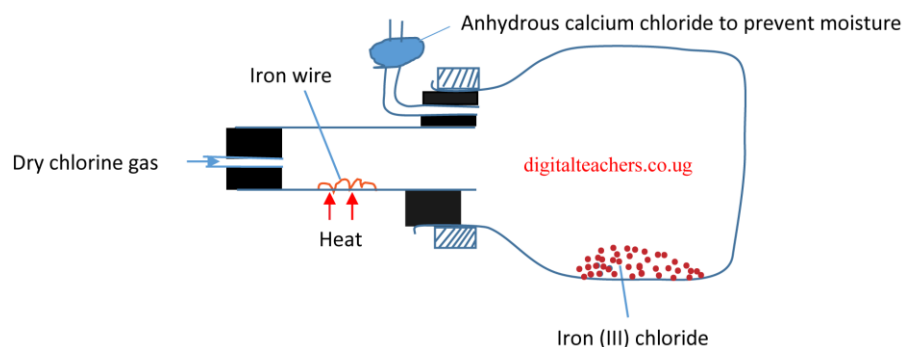
Chlorine reacts with many metals to form chloride, for instance, magnesium burns in chlorine to form a chloride



Being a strong oxidizing agent it forms chloride with metal in the highest oxidation state. For instance, chlorine reacts violently with iron (III) chloride and not iron (II) chloride



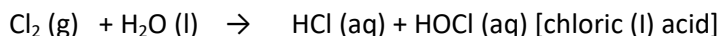
Apparatus for preparation Iron (III) chloride



Iron (III) chloride is delinquent it absorbs moisture from air to form a brown solution.

g. Reaction with water.

Chlorine and bromine are moderately soluble in water (bromine more so than chlorine); while iodine is only sparingly soluble. Chlorine is hydrolyzed in water to some extent.

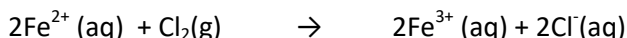


When chlorine water is exposed to sunlight, chloric acid (I) decomposes to liberate oxygen



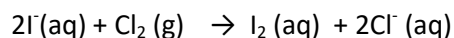
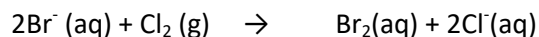
h. Reaction with iron II salts

When chlorine is bubbled through a green solution of Iron II salt solution, the color changes to yellow due to oxidation of iron II salt ions to brown solution of Iron III salt ions.



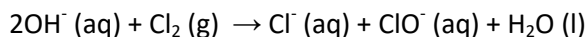
i. Displacement of bromine and iodine from bromides and iodides.

When chlorine is bubbled into potassium bromide and potassium iodide, a yellow solution and brown solution respectively form due to oxidation of bromide and iodide ions to bromine and iodine.

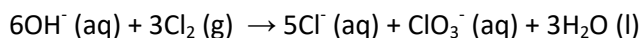


j. Reaction with alkalis.

Chlorine reacts with cold dilute sodium hydroxide solution to form pale yellow solution a chloride and sodium chlorate (I).



Chlorine reacts with warm concentrated sodium hydroxide solution to give sodium chloride and sodium chlorate (V):



Chlorate (V)

Uses of chlorine

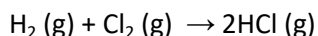
1. To make bleaching agents
2. Formation of polymer
3. It is a disinfectant in swimming pool

Hydrogen chloride

a) Preparation

(i) Direct synthesis:

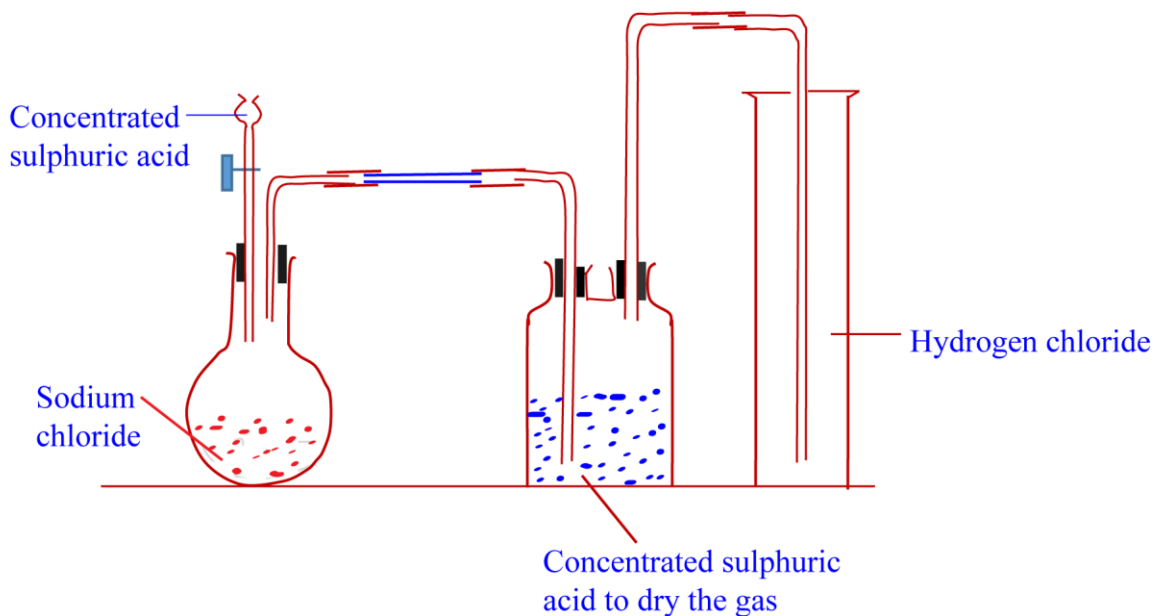
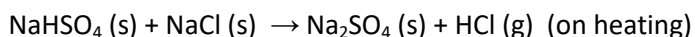
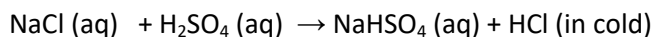
By reacting chlorine with hydrogen to form hydrogen chloride gas which dissolve in water to form the acid.



Laboratory preparation

ii) Reaction of an ionic halide with concentrated sulphuric acid.

Sodium chloride reacts with concentrated sulphuric acid to form hydrogen chloride gas. The gas is dried by concentrated sulphuric acid and collected by downward delivery because it is denser than air.



b) Physical properties of hydrogen chloride

- It has a choking irritating smell, is an acidic gas which is very soluble in water to form hydrochloric acid.
- In water it is completely ionized to form hydrogen and chloride ions. Due to complete ionization in water, it is a strong electrolyte and conducts electricity. However, in solution with methylbenzene, it is unionized and does not conduct electricity.

- Being an acid:
 - (i) liberates hydrogen with electropositive metals such magnesium, zinc and iron.

$$\text{Mg (s)} + 2\text{H}^+(\text{aq}) \longrightarrow \text{Mg}^{2+}(\text{aq}) + \text{H}_2(\text{g})$$
 Note that hydrochloric acid does not react with copper because copper is below hydrogen in the reactivity series.
 - (ii) neutralizes bases

$$\text{H}^+(\text{aq}) + \text{OH}^-(\text{aq}) \longrightarrow \text{H}_2\text{O}(\text{l})$$
 - (iii) liberates carbon dioxide from hydrogen carbonates and carbonates

$$\text{H}^+(\text{aq}) + \text{HCO}_3^-(\text{aq}) \longrightarrow \text{H}_2\text{O}(\text{l}) + \text{CO}_2(\text{g})$$

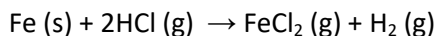
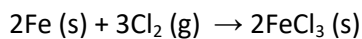
$$2\text{H}^+(\text{aq}) + \text{CO}_3^{2-}(\text{aq}) \longrightarrow \text{H}_2\text{O}(\text{l}) + \text{CO}_2(\text{g})$$

- Halides

Preparation:

By reacting metals with chlorine or hydrogen chloride

For instance, when iron reacts chlorine it gives iron (III) chloride whereas hydrogen chloride gas reacts with iron to form iron (II) chloride.



Exercise

Section A

Numbers 1 -23 circle the correct alternative

- Which of the following procedures is used to confirm the presence of chlorides ions in solution?
 - Addition of lead (II) nitrate solution followed by nitric acid
 - Addition of barium nitrate solution followed by nitric acid
 - Addition of silver nitrate followed by nitric acid and then ammonia.
 - Addition of iron (II) sulphate followed by concentrated sulphuric acid
- Which one of the following gases is formed when turpentine $C_{10}H_{16}$ is burnt in chlorine?
 - Methane
 - Hydrogen
 - Hydrogen chloride
 - Carbon dioxide
- Which one of the following substances will form white fumes with hydrogen chloride?
 - Concentrated sodium hydroxide solution
 - Concentrated nitric acid
 - Concentrated sulphuric acid
 - Concentrated ammonia solution
- Which one of the following substances is the bleaching agent in chloride water?
 - $HOCl$
 - HCl
 - Cl_2
 - $HClO_3$
- Which of the following chlorides can best be prepared in the anhydrous form by passing dry passing hydrogen chloride over the heated metal?
 - $CuCl_2$
 - $FeCl_2$
 - $FeCl_3$
 - $AlCl_3$
- Which one of the following ions when reacted with aqueous lead (II) nitrate form a precipitate which dissolves on heating?
 - OH^-
 - SO_4^{2-}
 - Cl^-
 - CO_3^{2-}
- Which one of the following is not a property of hydrogen chloride?
 - Forms a white precipitate with silver nitrate
 - It turns moist blue litmus paper red
 - It forms white fumes with ammonia gas
 - It bleaches colored flowers

8. Which of the following substances is not formed when chlorine is bubbled through cold dilute sodium hydroxide solution?
- Sodium chloride
 - Sodium hypochlorite
 - Sodium chloride
 - water
9. Which one of the following acids is not used in the manufacture of fertilizers?
- Hydrochloric acid
 - Sulphuric acid
 - Phosphoric acid
 - Nitric acid
10. Which one of the following is characteristic of the gas formed when chlorine water is exposed to sun light?
- Extinguishes a burning splint
 - Bleaches moist litmus paper
 - Explodes when heated
 - Relights a glowing splint
11. Which of the following gases forms misty fumes when exposed to damp air?
- Ammonia
 - Sulphur dioxide
 - Nitrogen monoxide
 - Hydrogen chloride
12. Which one of the following substances are components of chlorine water?
- Chlorine and water
 - Hydrochloric acid and chlorine
 - Hydrochloric acid and hypochlorous acid
 - Hypochlorous acid and water
13. Which one of the following is likely to be the pH of dilute hydrochloric acid?
- 2
 - 6
 - 7
 - 9
14. Which one of the following pairs of substances will not react to produce chlorine?
- Potassium manganate (VII) and concentrated hydrochloric acid
 - Hydrogen chloride and potassium manganate (VII) solution
 - Sodium chloride and concentrated sulphuric acid.
 - Manganese (IV) oxide and concentrated hydrochloric acid
15. Which of the following is true about group VII element?
- Forms ions of formula X^-
 - Forms ions of formula X^+
 - They are colorless
 - They exist in monoatomic molecules

16. Which of the following will not oxidize concentrated hydrochloric acid to chlorine?
- A. Potassium manganate (VII)
 - B. Manganese (IV) oxide
 - C. Lead (IV) oxide
 - D. Lead (II) oxide
17. The gas which when passed over strongly heated iron can oxidize the iron to iron (II) only is
- A. Oxygen
 - B. Hydrogen chloride
 - C. Carbon monoxide
 - D. chlorine
18. chlorine can be prepared in the laboratory by heating concentrated hydrochloric acid with
- A. lead (II) chloride
 - B. iron (II) oxide
 - C. copper (II) oxide
 - D. manganese (IV) oxide
19. Which one of the following salts can be prepared from its elements by direct synthesis?
- A. Potassium sulphate
 - B. Copper carbonate
 - C. Magnesium chloride
 - D. Lead (II) nitrate
20. Which of the following will not reduce copper (II) oxide?
- A. Ammonia
 - B. Carbon monoxide
 - C. Hydrogen
 - D. Chlorine
21. Which one of the following methods is the most suitable for preparing a pure dry sample of silver chloride?
- A. Direct synthesis
 - D. neutralization
 - C. precipitation
 - D. reacting silver with acid
22. Chlorine dissolves in cold aqueous solution of sodium hydroxide to produce the following substance
- A. sodium chlorate
 - B. sodium chloride
 - C. sodium hypochlorite
 - D. sodium hydrogen chloride
23. which one of the following substances oxidize Iron (II) sulphate in aqueous solution?
- A. Chlorine
 - B. Hydrogen
 - C. Ammonia
 - D. Nitrogen

Each of the questions 23 to 30 consist of an assertion (statement) on the left hand side and a reason on the right hand side.

Select

- A. If both assertion and reason are true statements and the reason is a correct explanation of the assertion.
- B. If both assertion and reason are true statements and the reason is **not** a correct explanation of the assertion
- C. If the assertion is true but the reason is not correct statement.
- D. If the assertion is not correct but the reason is a correct statement.

Instruction summarized

Assertion	
A. True	True and a correct explanation
B. True	True but not a correct explanation
C. True	Incorrect
D. Incorrect	Correct

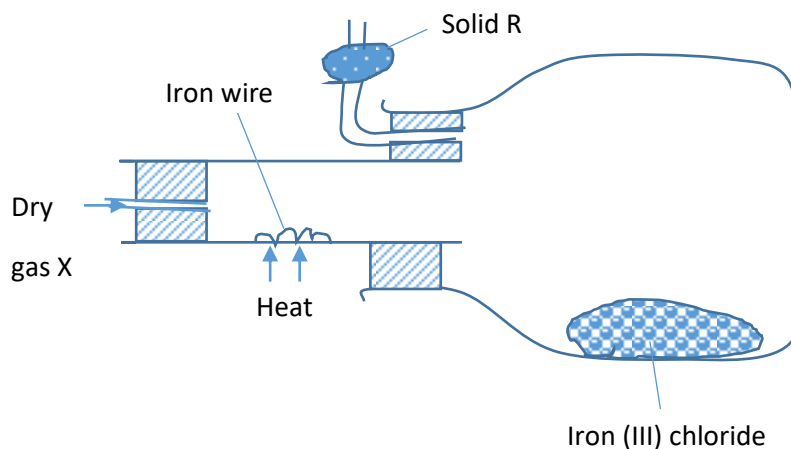
- | | | |
|----------------------------------------------------------------------------------------------------|---------|-------------------------------------------------|
| 24. When chlorine gas is bubbled through sodium bromide solution, the solution turns reddish brown | because | Bromine is more reactive than chlorine |
| 25. A solution of chlorine in water turns blue litmus paper red | Because | Chlorine is a bleaching agent |
| 26. When a piece of phosphorus is lowered into a jar of chlorine, white fumes are observed. | Because | Hydrogen chloride is formed during the reaction |
| 27. A solution of hydrogen chloride in methylbenzene does not conduct electricity. | Because | Methylbenzene does not conduct electricity |
| 28. Hydrogen chloride conducts electricity | because | Hydrogen chloride is soluble in water |
| 29. Iodine is formed when chlorine gas is bubbled into a solution of potassium iodide | because | Chlorine reduces the iodide ions in solution. |
| 30. Chlorine bleaches dyes | because | Chlorine is an oxidizing agent |

In each of the questions 31 to 34 one or more of the answers given may be correct. Read each questions carefully and then indicate the correct answer according to the following

- A. If 1, 2, 3, only are correct
- B. If 1 and 3 only are correct
- C. If 2 and 4 only are correct
- D. If 4 only is correct

31. Which of the following substances is/are formed when sodium hydrogen carbonate is reacted with dilute hydrochloric acid?
2. Hydrogen
 3. Sodium chloride
 4. Sodium hydroxide
 5. Carbon dioxide
32. Which of the following anions when in solution will react with lead (II) nitrate solution to form a white precipitate?
1. CO_3^{2-}
 2. SO_4^{2-}
 3. Cl^-
 4. I^-
33. Which of the following gases can react with water to form acidic solution?
1. Chlorine
 2. Nitrogen monoxide
 3. Nitrogen dioxide
 4. hydrogen
34. which of the following properties is/are shown by hydrochloric acid?
- The acid reacts with
1. copper to form hydrogen
 2. zinc to form hydrogen
 3. sodium hydroxide to give an acid salt
 4. Calcium carbonate to form carbon dioxide

35. Anhydrous Iron (III) chloride was prepared using the setup of apparatus in figure below



- (a) Identify
- (i) X (1mark)
- (ii) R (1mark)
- (b) Write equation for the reaction leading to the formation of iron (III) chloride 1 ½ marks)
- (c) (i) State what would be observed if iron (III) chloride is exposed to air (1mark)
- (ii) Give a reason for your answer in(c) (i) above (1mark)
36. (a) (i) Name two substance which can react to produce hydrogen chloride. (1mark)
- (ii) Write equation for the reaction leading to the formation of hydrogen chloride (1 ½ mark)
- (b) Hydrogen chloride reacts with lead (II) nitrate to form lead II chloride according to the following equation. (2 ½ mark)
- $$\text{Pb}(\text{NO}_3)_2 (\text{aq}) + 2\text{HCl} (\text{aq}) \longrightarrow \text{PbCl}_2(\text{s}) + 2\text{HNO}_3 (\text{aq})$$
- Calculate the volume of hydrogen chloride measured at s.t.p that would be required to form 5.53g of lead (II) chloride. (Pb = 207, N=14, O = 16, H = 1, Cl = 35.5)
37. (a) Chlorine can be prepared from concentrated hydrochloric acid
- (i) Name the substance that reacts with hydrochloric acid to produce chlorine (1mark)
- (ii) Write equation for the reaction (1 ½ marks)
- (b) Chlorine is passed through cold dilute sodium hydroxide solution
- (i) State what is observed (1mark)
- (ii) Write equation for the reaction that took place (1 ½ marks)
38. (a) Briefly describe how dry sample of hydrogen chloride can be prepared in the laboratory. (diagram not required) (5½ marks)
- (b) Hydrogen chloride was bubbled through a solution of lead (II) nitrate
- (i) state what was observed and explain your answer (2½ marks)
- (ii) write equation for the reaction that took place. (1½ marks)
- (c) Concentrated hydrochloric acid is commonly used for removing oxides from metal surfaces (pickling). Explain why concentrated nitric acid is not used for the same purpose (1 ½ mark)

- (d) A sample of hydrogen chloride gas was dissolved in water to make 250cm³ of solution. 25.0cm³ of this solution required 46cm³ of 2M sodium hydroxide for complete neutralization. Determine the mass of hydrogen chloride that was dissolved to make 250cm³ of solution (H = 1, Cl = 35.5) (4marks)
39. (a) Chlorine can be prepared in the laboratory using potassium manganate (VII), KMnO₄.
- (i) Name one substance that react with potassium manganate (VII) to produce chlorine (01mark)
- (ii) State the conditions for the reaction. (½ marks)
- (iii) Write an equation for the reaction leading to the formation of chlorine. (03marks)
- (b) Damp blue litmus paper was dropped in a jar containing chlorine. State what was observed and explain your observation(s). (03marks)
- (c) A boiling tube filled with chlorine was inverted into a beaker containing chlorine water and exposed to sunlight for some time.
- (i) State what was observed (½ mark)
- (ii) Explain with the aid of equation, your observations. (03 marks)
- (d) Write equation to show how chlorine can react with
- (i) dilute potassium hydroxide (1 ½ marks)
- (ii) turpentine, C₁₀H₁₆. (1 ½ marks)
- (e) Briefly describe a test you would carry out to confirm the presence of chloride ions in solution. State what would be observed and write an equation for the reaction that would take place (2 ½ marks)
40. (a) Describe how a pure dry sample of chlorine can be prepared in the laboratory from potassium manganate (VII). Your answer should include a well labelled diagram and equation for the reaction. (06marks)
- (b) What would be observed if chlorine is bubbled through
- (i) Blue litmus solution (01 mark)
- (ii) Potassium bromide solution (01 mark)
- (iii) Solution of iron (II) ions (01 mark)
- (c) Write equations in (b) (ii) and (iii) (03 marks)
- (d) Write equation for the reaction of chloride and

- (i) Heated iron
 - (ii) Cold sodium hydroxide solution
41. (a) Describe how a pure dry sample of chlorine can be prepared in the laboratory from potassium manganate (VII). Diagram not required but your description should include conditions and equation for the reaction. (07marks)
- (b) State what is observed and write equation(s) for the reaction(s) that would occur if
- (i) Chlorine was bubbled into an aqueous sodium hydroxide (2marks)
 - (ii) Burning magnesium is lowered into a jar of dry chlorine (3marks)
 - (iii) Chlorine was passed through a solution of potassium iodide (2 ½ marks)
- (c) State one use of chlorine (½ mark)
42. (a) State the conditions under which iron can react with hydrochloric acid and write equation for the reaction. (2 ½ mark)
- (b) DRAW a fully labelled diagram for a setup of apparatus which can be used to generate iron (III) chloride in the laboratory. (4marks)
- (c) A student left a slasher made of iron on the compound for two weeks. State what was observed and explain your answer. (2 ½ marks)
- (d) (i) Name one reagent that can be used to distinguish between iron (II) sulphate and iron (III) sulphate (1mark)
- (ii) State what would be observed if the reagent you have named in (d)(i) above were separately treated with the two iron salts and write equations for the reaction (5marks)
43. (a) Hydrogen chloride can be prepared from sodium chloride according to the following equation
- $$\text{Cl}^- (\text{s}) + \text{H}^+ (\text{aq}) \longrightarrow \text{HCl} (\text{g})$$
- Calculate the mass of sodium chloride that would be required to produce 3.60 dm³ of hydrogen chloride at room temperature, (H = 1, Na = 23, Cl = 35.5: 1mole of a gas at room temperature occupies 24dm³)
- (b) State what would be observed and in each case write an equation for the reaction that would take place when
- (i) An aqueous solution of hydrogen chloride is added to a solution of lead (II) ions. (03marks)

- (ii) Excess hydrogen chloride is passed over strongly heated iron wire (2 ½ mark)
- (c) Briefly explain the following observation in each case illustrate your answer with equation(s).
- (i) Anhydrous iron (II) chloride cannot be prepared by direct synthesis using chlorine and iron (2 ½ marks)
- (ii) An aqueous solution of hydrogen chloride gives a white precipitate with silver nitrate whereas a solution of hydrogen chloride in tetrachloromethane show no observable change when reacted with silver nitrate solution. (4marks)
44. (a) Write equation to show how hydrogen chloride can be prepared from sodium chloride (2marks)
- (b) Draw a labeled diagram to show how aqueous hydrogen chloride can be prepared in the laboratory. (3 ½ marks)
- (c) State what would be observed and write equation for the reaction that would take place when aqueous hydrogen chloride is reacted with
- (i) Solid calcium carbonate
- (ii) Silver nitrate solution
- (iii) Magnesium (8 ½ marks)
- (d) State why aqueous hydrogen chloride does not react with copper (01mark)
45. (a) (i) Describe with aid of a well labelled diagram how a sample of iron (III) chloride can be prepared in the laboratory from concentrated hydrochloric acid and potassium permanganate. Include equation for the reaction in your description
- (ii) What happens when water is added to Iron (III) chloride?
- (iii) State the confirmatory test for Iron (III) ions
- (b) Hydrogen gas was used to reduce 32.1g of Iron (III) chloride
- (i) Write equation for the reaction that took place
- (ii) Calculate the minimum volume of hydrogen at s.t.p. required to react completely with the chloride.
46. (a) A substance X reacts with solid sodium chloride to produce hydrogen chloride
- (i) Identify X

- (ii) State the conditions for the reaction
- (iii) Write equation for the reaction
- (b) (i) Name the substance formed when hydrogen chloride is dissolved in water
- (ii) Explain why an aqueous solution of hydrogen chloride is an electrolyte whereas a solution of the gas in methylbenzene is non-electrolyte. (Equations not required)
- (c) An aqueous solution of hydrogen chloride was added drop wise to 4.2 g of calcium carbonate until there was no further change. A colorless gas was evolved.
 - (i) State what was observed
 - (ii) Write equation for the reaction between the gas and calcium hydroxide
 - (iii) Calculate the volume of the gas measured at s.t.p. that was evolved
- 47. (a) Draw a labelled diagram of an apparatus you would use to prepare chlorine in the laboratory, using potassium permanganate.
- (b) State what is observed when
 - (i) A piece of yellow phosphorus is lowered in a jar of chlorine
 - (ii) Turpentine ($C_{10}H_{16}$) is lowered in chlorine
 - (iii) Chlorine is bubbled in the solution of potassium bromide

Answers

1	C	11	D	21	A	31	C
2	C	12	C	22	C	32	A
3	D	13	A	23	A	33	B
4	A	14	C	24	C	34	C
5	C	15	A	25	D	35	
6	C	16	D	26	C		
7	D	17	B	27	D		
8	B	18	D	28	B		
9	A	19	C	29	D		
10	D	20	D	30	A		

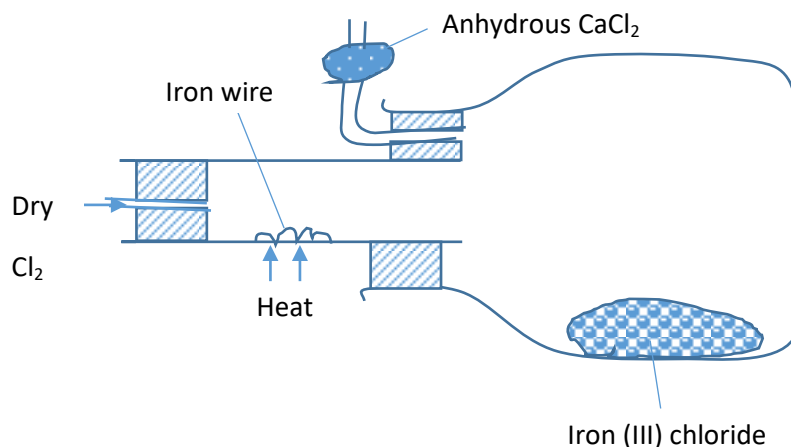
- 35. (a) (i) X = dry chlorine
- (ii) Y = anhydrous calcium chloride
- (b) $2Fe(s) + 3Cl_2(g) \longrightarrow 2FeCl_3(s)$
- (c) (i) Absorbs water to form a brown solution

- (ii) It is deliquescent
36. (a) Sodium chloride and concentrated sulphuric acid
 $\text{NaCl (s)} + \text{H}_2\text{SO}_4(\text{aq}) \longrightarrow \text{NaHSO}_4(\text{aq}) + \text{HCl(g)}$
- (b) Rfm of $\text{PbCl}_2 = 207 + 35.5 \times 2 = 278$
 278g of PbCl_2 require $2 \times 22400\text{cm}^3$ of HCl gas
- $\therefore 5.53\text{g of PbCl}_2$ will require $\frac{2 \times 22400 \times 5.53}{278} = 891\text{cm}^3$ of HCl
- 37 (a) Potassium manganate (VII)
 $2\text{KMnO}_4(\text{aq}) + 16\text{HCl(aq)} \longrightarrow 2\text{KCl(aq)} + 8\text{H}_2\text{O(l)} + 5\text{Cl}_2(\text{g})$
- (b) (i) Yellowish solution formed
 (ii) $\text{Cl}_2(\text{g}) + 2\text{NaOH(aq)} \longrightarrow \text{NaCl(aq)} + \text{NaOCl(aq)} + \text{H}_2\text{O(l)}$
- 38 (a) Concentrated sulphuric acid is added to solid sodium chloride to for hydrogen chloride gas. The gas is dried with concentrated sulphuric acid
 $\text{NaCl (s)} + \text{H}_2\text{SO}_4(\text{aq}) \longrightarrow \text{NaHSO}_4(\text{aq}) + \text{HCl(g)}$
- (b) White precipitate
 $\text{Pb}^{2+}(\text{aq}) + 2\text{Cl}^-(\text{aq}) \longrightarrow \text{PbCl}_2(\text{s})$
- (c) Nitric acid is a strong oxidising agent it thus oxidise substances to form oxides
- (d) Moles of NaOH = $\frac{2 \times 46}{1000} = 0.092\text{moles}$
 Moles of HCl = moles of NaOH = 0.092 moles
- Mole of HCl in $250\text{ cm}^3 = \frac{0.092 \times 250}{25} = 0.92\text{ moles}$
- Mass = moles x formula mass = $0.92 \times 36.5 = 33.58\text{g}$
- 39 (a) (i) Concentrated HCl
 (ii) Heat
 (iii) $2\text{KMnO}_4(\text{aq}) + 16\text{HCl(aq)} \longrightarrow 2\text{KCl(aq)} + 8\text{H}_2\text{O(l)} + 5\text{Cl}_2(\text{g})$
- (b) Litmus solution decolorize
 Reason
 Chlorine react with water to form hypochlorous acid which oxidize the dye to make it colorless
 $\text{Cl}_2(\text{g}) + \text{H}_2\text{O(l)} \longrightarrow \text{HOCl(aq)} + \text{HCl(aq)}$
 $\text{Dye} + \text{HOCl} \longrightarrow \text{dye-O} + \text{HCl(aq)}$
- (c) (i) A gas collect in the test tube
 (ii) Hypochlorous acid decompose to liberate oxygen
 $\text{Cl}_2(\text{g}) + \text{H}_2\text{O(l)} \longrightarrow \text{HOCl(aq)} + \text{HCl(aq)}$
 Then
 $2\text{HOCl(aq)} \longrightarrow 2\text{HCl(aq)} + \text{O}_2(\text{aq})$
- (d) (i) $\text{KOH(aq)} + \text{Cl}_2(\text{g}) \longrightarrow \text{KCl(aq)} + \text{KOCl(aq)}$
 (ii) $\text{C}_{10}\text{H}_{16}(\text{g}) \longrightarrow 10\text{C(s)} + 16\text{HCl(g)}$
- (e) To a solution a few drops of silver nitrate is added followed by dil nitric acid and excess ammonia solution. White precipitate soluble in ammonia indicates presence of chloride ions.
- 40 (a) Potassium manganate (VII) is heated with concentrated hydrochloric acid, chlorine produced is passed through water to remove hydrogen chloride gas and then

through concentrated sulphuric acid to dry chlorine.



- (b) (i) decolorize
(ii) Turns yellow
(iii) Solution turns from green to yellow
- (c) $2\text{Br}^-(\text{aq}) + \text{Cl}_2(\text{g}) \longrightarrow \text{Br}_2(\text{aq}) + 2\text{Cl}^-(\text{aq})$
 $2\text{Fe}^{2+}(\text{aq}) + \text{Cl}_2(\text{g}) \longrightarrow 2\text{Fe}^{3+}(\text{aq}) + 2\text{Cl}^-(\text{aq})$
- (d) (i) $2\text{Fe}(\text{s}) + 3\text{Cl}_2(\text{g}) \longrightarrow 2\text{FeCl}_3(\text{g})$
(ii) $\text{Cl}_2(\text{g}) + 2\text{NaOH}(\text{aq}) \longrightarrow \text{NaCl}(\text{aq}) + \text{NaOCl}(\text{aq}) + \text{H}_2\text{O}(\text{l})$
- 41 (b) (i) Yellow solution formed
 $\text{Cl}_2(\text{g}) + 2\text{NaOH}(\text{aq}) \longrightarrow \text{NaCl}(\text{aq}) + \text{NaOCl}(\text{aq}) + \text{H}_2\text{O}(\text{l})$
(ii) Magnesium burns with bright light forming white crystals
 $\text{Mg}(\text{s}) + \text{Cl}_2(\text{g}) \longrightarrow \text{MgCl}_2(\text{s})$
(iii) Brown solution formed
 $2\text{I}^-(\text{aq}) + \text{Cl}_2(\text{g}) \longrightarrow \text{I}_2(\text{aq}) + 2\text{Cl}^-(\text{aq})$
- (c) For making plastic
For making bleaching agents
In making antiseptic disinfectant
- 42 (a) Heat
 $\text{Fe}(\text{s}) + 2\text{HCl}(\text{g}) \longrightarrow \text{FeCl}_2(\text{s}) + \text{H}_2(\text{g})$



- (c) A brown coat on the slasher due to rusting
- (d) (i) Ammonium thiocyanate
(ii) Fe^{3+} turns red solution
 $\text{Fe}^{3+}(\text{aq}) + 3\text{SCN}^-(\text{aq}) \longrightarrow \text{Fe}(\text{SCN})_3(\text{aq})$
 Fe^{2+} no observable change
- 43 (a) Rfm of NaCl = $23 + 35.5 = 58.5\text{g}$
 24dm^3 of HCl require 58.5 g of NaCl
 $\therefore 3.60\text{ dm}^3$ of HCl will require $\frac{58.5 \times 3.60}{24} = 8.79\text{g}$
- (b) (i) White precipitate
 $\text{Pb}^{2+}(\text{aq}) + 2\text{Cl}^-(\text{aq}) \longrightarrow \text{PbCl}_2(\text{s})$

- (ii) Green solid formed
 $\text{Fe(s)} + 2\text{HCl(g)} \longrightarrow \text{FeCl}_2\text{(s)} + \text{H}_2\text{(g)}$
- (c) (i) Chlorine oxidizes iron II ions to Iron III ions
 $2\text{Fe}^{2+}(\text{aq}) + \text{Cl}_2(\text{g}) \longrightarrow 2\text{Fe}^{3+}(\text{aq})$
- (ii) In water, hydrogen chloride ionizes and chloride ions form white precipitate with silver ions
 $\text{Ag}^+(\text{aq}) + \text{Cl}^-(\text{aq}) \longrightarrow \text{AgCl(s)}$
 In methylbenzene hydrogen chloride does not form ions
- 44 (c) (i) $2\text{H}^+(\text{aq}) + \text{CO}_3^{2-}(\text{aq}) \longrightarrow \text{H}_2\text{O(l)} + \text{CO}_2\text{(g)}$
- (ii) $\text{Ag}^+(\text{aq}) + \text{Cl}^-(\text{aq}) \longrightarrow \text{AgCl(s)}$
- (iii) $\text{Mg(s)} + 2\text{H}^+(\text{aq}) \longrightarrow \text{Mg}^{2+}(\text{aq}) + \text{H}_2(\text{g})$
- 46 (a) (i) Concentrated sulphuric acid
- (ii) Heat
- (iii) $\text{NaCl(s)} + \text{H}_2\text{SO}_4(\text{aq}) \longrightarrow \text{NaHSO}_4(\text{aq}) + \text{HCl(g)}$
- (b) (i) Hydrochloric acid
- (ii) HCl ionizes in water but not in methylbenzene
- (c) (i) Solid dissolves
- (ii) $\text{Ca(OH)}_2(\text{aq}) + \text{CO}_2(\text{g}) \longrightarrow \text{CaCO}_3(\text{s}) + \text{H}_2\text{O(l)}$
 Then
 $\text{CaCO}_3(\text{s}) + \text{CO}_2(\text{g}) + \text{H}_2\text{O(l)} \longrightarrow \text{CaHCO}_3(\text{aq})$
- (iii) $\text{CaCO}_3(\text{s}) + 2\text{HCl(aq)} \longrightarrow \text{CaCl}_2(\text{aq}) + \text{CO}_2(\text{g}) + \text{H}_2\text{O(l)}$
 $\text{Rfm of CaCO}_3 = 40 + 12 + 16 \times 3 = 100$
 $\Rightarrow 100\text{g of CaCO}_3 \text{ produce } 22.4\text{dm}^3 \text{ of CO}_2 \text{ gas}$
 $\Rightarrow 4.2\text{g of CaCO}_3 \text{ will produce } \frac{22.4 \times 4.2}{100} = 0.94\text{dm}^3$
- 47 (b) (i) Phosphorous burns spontaneously to produce white fumes
 $\text{P}_4(\text{s}) + 6\text{Cl}_2(\text{g}) \longrightarrow 4\text{PCl}_3(\text{s})$
- (ii) Turpentine burns spontaneously to produce black soot
 $\text{C}_{10}\text{H}_{16}(\text{l}) + 8\text{Cl}_2(\text{g}) \longrightarrow 10\text{C(s)} + 16\text{HCl(g)}$
- (iii) Yellow solution produced
 $\text{Cl}_2(\text{g}) + 2\text{Br}^-(\text{aq}) \longrightarrow 2\text{Cl}^-(\text{aq}) + \text{Br}_2(\text{aq})$