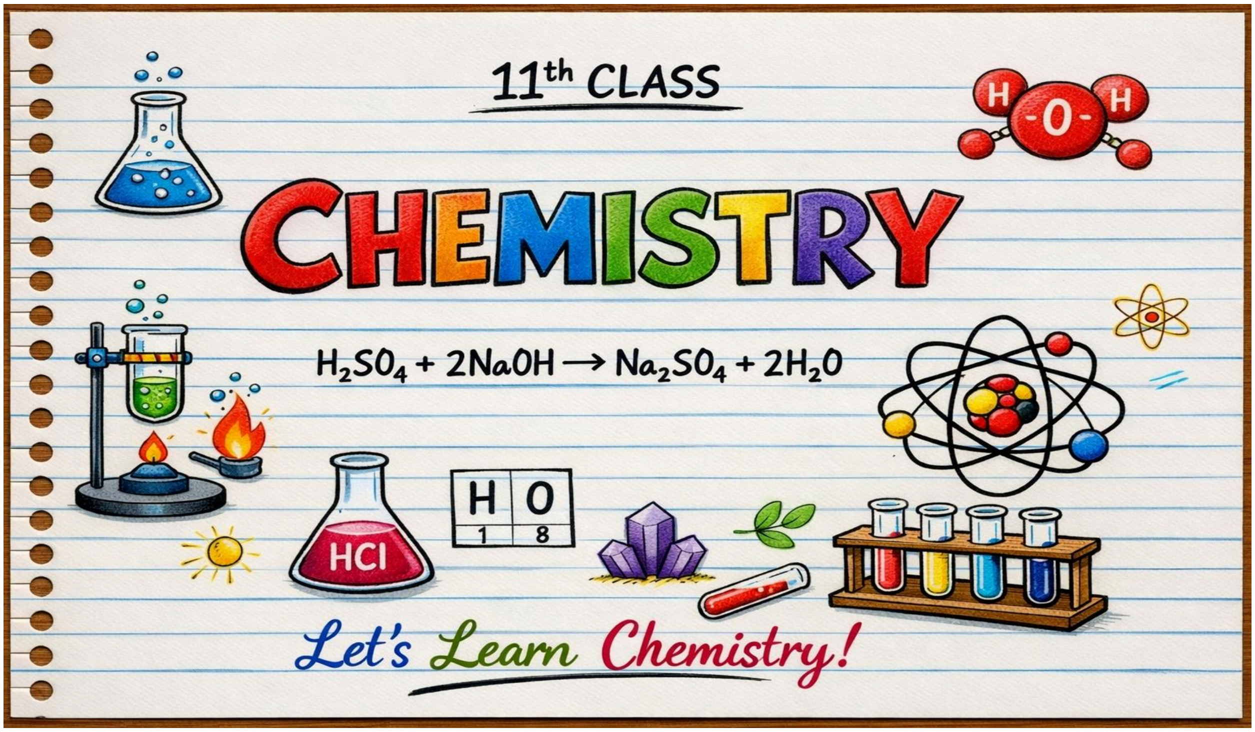

Class: 11th

Subject: Chemistry

Unit 13: HALOGENS

❖ Important Mcqs:

1. Group 17 elements are called halogens because they:

(a) Form only acidic oxides

(b) Produce salts when reacting with metals ✅

(c) Are inert gases

(d) Exist as metals in nature

2. The correct order of physical states at room temperature is:

(a) F_2 (liquid), Cl_2 (solid), Br_2 (gas), I_2 (gas)

(b) F_2 (gas), Cl_2 (gas), Br_2 (liquid), I_2 (solid) ✅

(c) F_2 (solid), Cl_2 (gas), Br_2 (solid), I_2 (liquid)

(d) All are gases

3. Halogens exist naturally as:

(a) Monatomic atoms

(b) Diatomic molecules (X_2) ✅

(c) Ionic lattices

(d) Metallic clusters

4. Bromine at room temperature is:

(a) Pale yellow gas

(b) Reddish-brown volatile liquid with toxic vapours ✅

(c) Grey solid

(d) Colourless gas

5. Iodine is characterized by:

(a) Being a liquid at room temperature

(b) Sublimation from solid to vapour on heating ✅

(c) Being a gas at room temperature

(d) Being highly reactive metal

6. The colour intensity of halogens from chlorine to iodine:

(a) Decreases

(b) Remains constant

(c) Darkens progressively ✅

(d) Becomes colourless

7. The main reason for colour change in halogens is:

(a) Nuclear reactions

(b) Electron transitions absorbing visible light ✅

(c) Ionic bonding strength

(d) Density variation

8. Fluorine and chlorine differ from bromine and iodine because they are:

(a) Liquids at room temperature

(b) Gases at room temperature ✅

(c) Solids at room temperature

(d) Metals

9. The corrosive nature of bromine is due to:

(a) Low atomic mass

(b) Toxic and reactive vapours ✅

(c) Solid state

(d) Inert behaviour

10. Astatine and tennessine are classified as:

(a) Stable halogens

(b) Rare and radioactive elements ✅

(c) Noble gases

(d) Alkali metals

11. Among halogens, the most volatile at room temperature is:

(a) Iodine

(b) Bromine

(c) Chlorine ✅

(d) Astatine

12. The correct order of volatility of halogens is:

(a) $I_2 > Br_2 > Cl_2$

(b) $Cl_2 > Br_2 > I_2$ ✅

(c) $Br_2 > Cl_2 > I_2$

(d) $I_2 > Cl_2 > Br_2$

13. The high volatility of chlorine is mainly due to:

(a) Strong covalent bonds

(b) Weak intermolecular forces (London forces) ✅

(c) High atomic mass

(d) Metallic nature

14. Bromine is less volatile than chlorine but more volatile than iodine because:

(a) It has ionic bonding

(b) It has intermediate molecular size and intermolecular forces ✅

(c) It is a gas

(d) It has no intermolecular forces

15. Iodine has the lowest volatility because it:

(a) Has the smallest atomic size

(b) Has strongest London dispersion forces due to large size ✅

(c) Is gaseous

(d) Has weak intermolecular forces

16. Volatility of halogens decreases down the group due to:

(a) Decrease in atomic mass

(b) Increase in molecular size and London dispersion forces ✅

(c) Increase in electronegativity

(d) Decrease in nuclear charge

17. Intermolecular forces responsible for volatility trend in halogens are:

(a) Ionic bonds

(b) Hydrogen bonds

(c) London dispersion forces (induced dipole forces) ✅

(d) Metallic bonds

18. A substance with weak intermolecular forces will have:

(a) High boiling point and low volatility

(b) Low boiling point and high volatility ✅

(c) High density only

(d) Strong ionic character

19. Fluorine and chlorine exist as gases mainly because:

(a) Strong intermolecular forces

(b) Weak id–id (London) forces due to small size and low polarizability ✅

(c) High molecular weight

(d) Metallic nature

20. Iodine exists as a solid at room temperature because:

(a) It has weak intermolecular forces

(b) It has strong London dispersion forces due to large size ✅

(c) It is highly volatile

(d) It is ionic in nature

21. Bond strength in halogens down the group generally:

(a) Increases

(b) Decreases ✅

(c) Remains constant

(d) Becomes ionic

22. The decrease in bond strength from chlorine to iodine is due to:

(a) Decrease in atomic size

(b) Increase in bond length and weaker overlap of orbitals ✅

(c) Increase in electronegativity

(d) Formation of ionic bonds

23. The bond energy of halogens generally:

(a) Increases down the group

(b) Decreases down the group ✅

(c) Remains constant

(d) Becomes zero

24. Fluorine is an exception in bond strength because:

(a) It has large atomic size

(b) Lone pair–lone pair repulsion weakens F–F bond despite high electronegativity ✅

(c) It forms ionic bonds

(d) It is least reactive

25. The weakest halogen bond is found in:

(a) Cl_2

(b) Br_2

(c) I_2

(d) F_2 (due to repulsion effect) ✅

26. Halogens act as oxidizing agents because they:

(a) Lose electrons easily in reactions

(b) Gain electrons to form halide ions (X^-) ✅

(c) Form metallic bonds with metals

(d) Exist as monatomic gases

27. During reaction with metals, halogens are converted into:

(a) Positive ions

(b) Neutral atoms

(c) Negative halide ions (X^-) ✅

(d) Oxides

28. The correct decreasing order of oxidizing power of halogens is:

(a) $I_2 > Br_2 > Cl_2 > F_2$

(b) $F_2 > Cl_2 > Br_2 > I_2$ ✅

(c) $Cl_2 > F_2 > Br_2 > I_2$

(d) $Br_2 > Cl_2 > I_2 > F_2$

29. The strongest oxidizing agent among halogens is:

(a) Chlorine

(b) Bromine

(c) Fluorine ✅

(d) Iodine

30. The weakest oxidizing agent among halogens is:

(a) Fluorine

(b) Chlorine

(c) Bromine

(d) Iodine ✅

31. A halogen can displace another halogen from its halide solution only if it:

(a) Has lower atomic mass

(b) Has higher oxidizing power ✅

(c) Has lower boiling point

(d) Is less reactive

32. Fluorine can displace which halide ions from solution?

(a) Only Cl^-

(b) Only Br^-

(c) Cl^-, Br^- and I^- ✅

(d) Only I^-

33. Chlorine can oxidize and displace:

(a) Only I^-

(b) Br^- and I^- only

(c) Cl^-, Br^- and I^-

(d) Br^- and I^- only, but not Cl^- or F^- ✅

34. The oxidizing power of halogens depends on:

(a) Only atomic size

(b) Only density

(c) Electron affinity, bond dissociation energy and hydration energy of ions ✅

(d) Only electronegativity

35. Standard electrode potential (E°) values of halogens from F_2 to I_2 indicate that:

(a) Oxidizing power increases down the group

(b) Oxidizing power remains constant

(c) Oxidizing power decreases down the group ✅

(d) All halogens have equal oxidizing power

36. General reaction of halogens with hydrogen produces:

(a) Hydroxides

(b) Hydrogen halides (HX) ✅

(c) Oxides

(d) Peroxides

37. The correct order of reactivity of halogens with hydrogen is:

(a) $I_2 > Br_2 > Cl_2 > F_2$

(b) $F_2 > Cl_2 > Br_2 > I_2$ ✅

(c) $Cl_2 > F_2 > I_2 > Br_2$

(d) $Br_2 > I_2 > F_2 > Cl_2$

38. Hydrogen halides in pure state are:

(a) Coloured solids

(b) Colourless gases ✅

(c) Metallic liquids

(d) Ionic crystals

39. Hydrogen halides dissolve in water to form:

(a) Salts

(b) Hydrohalic acids ✅

(c) Oxoacids

(d) Basic solutions

40. Fluorine reacts with hydrogen:

(a) Slowly in dark

(b) Explosively even at low temperature in dark ✅

(c) Only in sunlight

(d) Only with catalyst

41. Chlorine reacts with hydrogen in the presence of:

(a) Heat only

(b) UV light or spark ✅

(c) Water

(d) Acidic medium only

42. Hydrogen bromide is produced when bromine reacts with hydrogen:

(a) At room temperature rapidly

(b) On heating slowly and reversibly ✅

(c) Only in sunlight

(d) In absence of heat

43. The correct decreasing order of reactivity with hydrogen is:

(a) $I_2 > Br_2 > Cl_2 > F_2$

(b) $F_2 > Cl_2 > Br_2 > I_2$ ✅

(c) $Cl_2 > Br_2 > F_2 > I_2$

(d) $Br_2 > Cl_2 > I_2 > F_2$

44. Thermal stability of hydrogen halides decreases in the order:

(a) HI > HBr > HCl > HF

(b) HF > HCl > HBr > HI ✅

(c) HCl > HF > HI > HBr

(d) HBr > HF > HCl > HI

45. The most thermally stable hydrogen halide is:

(a) HCl

(b) HBr

(c) HI

(d) HF ✅

46. The weakest hydrogen-halogen bond is found in:

(a) HF

(b) HCl

(c) HBr

(d) HI ✅

47. High thermal stability of HF is mainly due to:

(a) Large atomic size of fluorine

(b) Strong H–F bond due to small size and high electronegativity of fluorine ✅

(c) Weak intermolecular forces

(d) Ionic bonding

48. Decrease in bond strength from HF to HI is mainly due to:

(a) Decrease in atomic size

(b) Poor orbital overlap due to increasing atomic size down the group ✅

(c) Increase in electronegativity

(d) Increase in covalent character

49. Bond dissociation energy is highest in:

(a) HI

(b) HBr

(c) HCl

(d) HF ✅

50. Hydrogen iodide is least thermally stable because:

(a) It has strongest bond

(b) It has weakest H–I bond due to large atomic size of iodine ✅

(c) It is ionic

(d) It is insoluble in water

51. Reducing ability of halide ions in aqueous solution:

(a) Increases down the group ✅

(b) Decreases down the group

(c) Remains constant

(d) Is highest for fluoride

52. The strongest reducing agent among halide ions is:

(a) F^-

(b) Cl^-

(c) Br^-

(d) I^- ✅

53. The weakest reducing agent among halide ions is:

(a) I^-

(b) Br^-

(c) Cl^-

(d) F^- ✅

54. The correct order of reducing power of halide ions is:

(a) $F^- > Cl^- > Br^- > I^-$

(b) $I^- > Br^- > Cl^- > F^-$ ✅

(c) $Cl^- > Br^- > I^- > F^-$

(d) $Br^- > Cl^- > F^- > I^-$

55. The increasing reducing ability of halide ions down the group is mainly due to:

(a) Increase in electronegativity

(b) Decrease in atomic radius

(c) Decrease in electronegativity and increase in ionic size ✅

(d) Increase in nuclear charge

56. Fluoride ion is a weak reducing agent because it:

(a) Has large size

(b) Has low charge density

(c) Has high electronegativity and high charge density stabilizing it strongly ✅

(d) Easily loses electrons

57. Which halide ion is most easily oxidized?

(a) F^-

(b) Cl^-

(c) Br^-

(d) I^- ✅

58. Aqueous silver nitrate is used to test for:

(a) Cations only

(b) Anions (halide ions) ✅

(c) Neutral molecules

(d) Metals

59. No precipitate is formed when $AgNO_3$ is added to fluoride ions because:

(a) AgF is insoluble

(b) AgF is soluble in water ✅

(c) Fluoride is oxidized

(d) Fluoride is metallic

60. White precipitate formed with Ag^+ and Cl^- is:

(a) AgBr

(b) AgCl ✅

(c) AgI

(d) AgF

61. Cream-coloured precipitate formed with Ag^+ and Br^- is:

(a) AgCl

(b) AgBr ✅

(c) AgI

(d) AgF

62. Silver iodide (AgI) is characterized by:

(a) Soluble in dilute NH_3

(b) Soluble in concentrated NH_3

(c) Insoluble in both dilute and concentrated NH_3 ✅

(d) Forms no precipitate

63. Silver chloride dissolves in dilute ammonia to form:

(a) $AgCl_2$ complex

(b) Diamminesilver(I) complex $[Ag(NH_3)_2]^+$ ✅

(c) Ag_2NH_3 complex

(d) AgOH

64. The reaction of chlorine with cold NaOH is an example of:

(a) Addition reaction

(b) Neutralization

(c) Disproportionation reaction ✅

(d) Polymerization

65. In cold NaOH, chlorine is simultaneously:

(a) Only oxidized

(b) Only reduced

(c) Both oxidized and reduced (disproportionation) ✅

(d) Neither oxidized nor reduced

66. Chlorine is used in water purification mainly because it acts as:

(a) A reducing agent

(b) A disinfectant agent ✅

(c) A catalyst

(d) A precipitating agent

67. The main purpose of chlorination of water is to:

(a) Increase hardness

(b) Kill harmful microorganisms ✅

(c) Increase pH

(d) Remove salts

68. Chlorine is harmful to humans in high concentration but in small amounts it is:

(a) Still toxic

(b) Harmless but kills bacteria in water treatment ✅

(c) Non-reactive

(d) A nutrient

69. When chlorine is added to water, it undergoes:

(a) Neutralization

(b) Hydrolysis ✅

(c) Combustion

(d) Reduction only

70. The products formed when Cl_2 reacts with water are:

(a) HCl and HNO_3

(b) HCl and HOCl (hypochlorous acid) ✅

(c) HCl and NaOH

(d) H_2 and O_2

71. The most effective disinfecting species formed in chlorinated water is:

(a) Cl^-

(b) HOCl (hypochlorous acid) ✅

(c) HCl

(d) O_2

72. HOCl is more effective disinfectant than OCl^- because:

(a) It has negative charge

(b) It is neutral and can easily penetrate cell walls ✅

(c) It is more basic

(d) It is less reactive

73. The main mechanism of disinfection by HOCl involves:

(a) Formation of salts

(b) Oxidation of proteins and lipids in microorganisms ✅

(c) Neutralization of acids

(d) Precipitation of bacteria

74. Chlorination kills microorganisms mainly by:

(a) Reducing enzymes

(b) Inactivating enzymes through oxidation ✅

(c) Increasing bacterial growth

(d) Forming glucose

75. At pH 6–7.5, the dominant disinfecting species is:

(a) OCl^-

(b) HOCl ✅

(c) Cl^-

(d) HCl

76. At higher pH (>7.5), the dominant species is:

(a) HOCl

(b) OCl^- (less effective disinfectant) ✅

(c) HCl

(d) Cl_2

77. The efficiency of water disinfection depends mainly on:

(a) Colour of water

(b) Chlorine dose and contact time ✅

(c) Temperature only

(d) Pressure only

78. Increasing chlorine dose in water results in:

(a) Decreased disinfection

(b) Increased formation of HOCl and OCl^- ✅

(c) No change

(d) Formation of salts only

79. Contact time in chlorination refers to:

(a) Time chlorine is stored

(b) Time water remains in contact with chlorine for disinfection ✅

(c) Time of filtration

(d) Time of boiling

80. Chlorination is considered economical because it:

(a) Requires expensive equipment

(b) Is a relatively inexpensive method of water disinfection ✅

(c) Uses rare chemicals

(d) Needs high energy input

❖ Important Short Questions

1. What are halogens?

Answer:

Halogens are the elements of Group 17 of the periodic table. These are highly reactive non-metals and readily form salts when they react with metals, which is why they are called "salt formers." They have 7 electrons in their outermost shell.

Example: Chlorine reacts with sodium to form sodium chloride (NaCl).

2. Name Group 17 elements.

Answer:

The elements of Group 17 are: Fluorine (F), Chlorine (Cl), Bromine (Br), Iodine (I), Astatine (At), and Tennessine (Ts). The first four are common, while At and Ts are rare and radioactive.

Example: Br_2 (bromine) is a halogen used in chemical reactions.

3. Why are halogens called reactive non-metals?

Answer:

Halogens are called reactive non-metals because they have 7 valence electrons and need only one electron to complete their octet. Therefore, they readily gain one electron and form negative ions (halide ions).

Example: $Cl + e^- \longrightarrow Cl^-$

4. Write the general formula of halogens.

Answer:

Halogens exist as diatomic molecules (X_2) because two atoms share electrons to complete their outer shells and become stable.

Example: F_2, Cl_2, Br_2

5. What is the physical state of fluorine and chlorine at room temperature?

Answer:

Fluorine and chlorine are gases at room temperature due to weak intermolecular (London dispersion) forces between their small molecules.

Example: Chlorine (Cl_2) is a greenish-yellow gas.

6. What is the physical state of bromine at room temperature?

Answer:

Bromine is a reddish-brown volatile liquid at room temperature. Its intermolecular forces are stronger than gases but weaker than solids.

Example: Br_2 gives off brown toxic fumes.

7. What is the physical state of iodine at room temperature?

Answer:

Iodine is a greyish-black solid at room temperature. It has strong intermolecular forces and sublimes on heating to form violet vapours.

Example: I_2 (solid) ⟶ violet vapour on heating.

8. Define volatility.

Answer:

Volatility is the ability of a substance to vaporize easily. Substances with weak intermolecular forces are more volatile and have lower boiling points.

Example: Chlorine is more volatile than iodine.

9. How does volatility change down Group 17?

Answer:

Volatility decreases down the group from chlorine to iodine because molecular size and intermolecular forces increase.

Example: Cl_2 (high volatility) > Br_2 > I_2 (low volatility)

10. Why does volatility decrease from chlorine to iodine?

Answer:

As we move down the group, molecular size and polarizability increase, leading to stronger London dispersion forces. These stronger forces hold molecules tightly, so more energy is required for vaporization, reducing volatility.

Example: Iodine has stronger intermolecular forces than chlorine, so it is less volatile.

11. What type of intermolecular forces exist in halogens?

Answer:

Halogen molecules (X_2) are non-polar, so they exhibit London dispersion forces (instantaneous dipole–induced dipole forces). These are weak forces that increase with molecular size.

Example: I_2 has stronger dispersion forces than Cl_2.

12. Why are fluorine and chlorine gases?

Answer:

Fluorine and chlorine are gases because they have small molecular size and weak intermolecular forces, so very little energy is needed to separate their molecules.

Example: F_2 and Cl_2 exist as gases at room temperature.

13. Why is iodine a solid at room temperature?

Answer:

Iodine is a solid because it has large molecular size and strong London dispersion forces, which hold the molecules tightly together.

Example: I_2 forms a greyish-black crystalline solid.

14. State the trend of bond strength in halogens.

Answer:

Bond strength generally decreases down the group:

$Cl_2 > Br_2 > I_2$ (Fluorine is an exception).

15. Why does bond strength decrease down the group?

Answer:

As atomic size increases down the group, bond length increases and overlap between orbitals becomes weaker, resulting in weaker bonds.

Example: I–I bond is weaker than Cl–Cl bond.

16. Why is the F–F bond relatively weak?

Answer:

Despite small size, F–F bond is weak due to strong lone pair–lone pair repulsion between closely packed fluorine atoms.

Example: F_2 has lower bond energy than expected.

17. Which halogen is the strongest oxidizing agent?

Answer:

Fluorine (F_2) is the strongest oxidizing agent because it has the highest tendency to gain electrons.

Example: F_2 can oxidize Cl^-, Br^- and I^-.

18. Which halogen is the weakest oxidizing agent?

Answer:

Iodine (I_2) is the weakest oxidizing agent due to its low electron affinity and large atomic size.

19. Define oxidizing agent.

Answer:

An oxidizing agent is a substance that gains electrons and gets reduced while causing oxidation of another substance.

Example: $Cl_2 + 2e^- \longrightarrow 2Cl^-$

20. Write the order of oxidizing power of halogens.

Answer:

$F_2 > Cl_2 > Br_2 > I_2$

21. Why does oxidizing power decrease down the group?

Answer:

Due to increase in atomic size and decrease in electron affinity, halogens become less able to gain electrons.

Example: Cl_2 is weaker oxidizing agent than F_2.

22. What products are formed when halogens react with hydrogen?

Answer:

They form hydrogen halides (HX).

Example: $H_2 + Cl_2 \longrightarrow 2HCl$

23. Write the general equation of halogens with hydrogen.

Answer:

$H_2 + X_2 \longrightarrow 2HX$

Example: $H_2 + Br_2 \longrightarrow 2HBr$

24. Which hydrogen halide is most thermally stable?

Answer:

Hydrogen fluoride (HF) is the most thermally stable hydrogen halide.

25. Why is HF most stable among hydrogen halides?

Answer:

Due to small size of fluorine and strong H–F bond, which has the highest bond dissociation energy among HX.

Example: HF is more stable than HCl, HBr, and HI.

📘 EXERCISE

Q.1 MULTIPLE CHOICE QUESTIONS

I. Which halogen molecule has the strongest bond?

(a) F_2

(b) Br_2

(c) I_2

(d) Cl_2 ✅

II. The volatility of halogens down the group:

(a) Increases

(b) Decreases ✅

(c) Remains the same

(d) Fluctuates unpredictably

III. Which halogen has the strongest oxidizing power?

(a) Br_2

(b) F_2 ✅

(c) I_2

(d) Cl_2

IV. Decreasing thermal stability down the group is due to:

(a) Increasing electronegativity

(b) Decreasing bond length

(c) Increasing atomic radius, leading to weaker bond ✅

(d) Increasing van der Waals forces

V. Which halide has the strongest reducing power?

(a) F^-

(b) Cl^-

(c) Br^-

(d) I^- ✅

VI. Correct statement about halogen + hydrogen reaction:

(a) Iodine reacts most vigorously

(b) Chlorine and hydrogen explode in darkness

(c) Fluorine reacts explosively even in cold and dark conditions ✅

(d) Bromine and hydrogen do not react

VII. Acidic strength of hydrogen halides down the group:

(a) Remains constant

(b) Decreases

(c) Increases from HF to HI ✅

(d) Fluctuates

VIII. Fluorine is most reactive due to:

(a) Bond length

(b) Bond strength

(c) Electronegativity ✅

(d) Number of electrons

IX. AgBr (cream precipitate) solubility in ammonia:

(a) Soluble in dilute ammonia

(b) Partially soluble in dilute ammonia

(c) Insoluble in dilute ammonia solution ✅

(d) Soluble only on heating

X. Reaction of NaCl with conc. H_2SO_4 gives:

(a) Reddish-brown fumes

(b) Purple vapour

(c) Steamy white fumes of HCl ✅

(d) Black solid

Q.2 Attempt the following short-answer questions:

a. Which halogen is the least reactive, which is the most reactive? Give reason.

- **Most reactive**: Fluorine (F_2)
- **Least reactive:** Iodine (I_2)

Reason: Reactivity depends on the ability to gain an electron. Fluorine has small atomic size and high electronegativity, so it gains electrons easily. Down the group, atomic size increases and electron affinity decreases, so reactivity decreases.

b. In the reaction: $Br_2 + 2I^- \longrightarrow 2Br^- + I_2$, which species is oxidized? Why?

Iodide ions (I^-) are oxidized.

Reason: Oxidation means loss of electrons. I^- loses electrons to form I_2.

Half reaction: $2I^- \longrightarrow I_2 + 2e^-$

c. What is the role of London dispersion forces in volatility of halogens?

London dispersion forces increase down the group due to larger size and higher polarizability. Stronger forces hold molecules tightly, so volatility decreases.

Example: I_2 has stronger forces $\longrightarrow$ less volatile than Cl_2.

d. How does the reactivity of halogens with hydrogen vary?

Reactivity decreases down the group:

$F_2 > Cl_2 > Br_2 > I_2$

Explanation: Smaller halogens react more readily due to stronger attraction for electrons.

Example: Fluorine reacts explosively, while iodine reacts very slowly.

e. Which halogen is used as an antiseptic? How does it work?

Iodine (I_2) is used as an antiseptic.

Working: It acts as an oxidizing agent and kills microorganisms by oxidizing proteins and enzymes in their cells.

f. What is the colour change when chlorine displaces bromine?

Solution changes from colourless to reddish-brown.

Explanation: Chlorine displaces bromine from bromide ions:

$Cl_2 + 2Br^- \longrightarrow 2Cl^- + Br_2$ (reddish-brown)

g. How are halogen acids ionized in water?

Hydrogen halides ionize in water to form hydrogen ions (H^+) and halide ions (X^-).

General equation:

$HX \longrightarrow H^+ + X^-$

Example: $HCl \longrightarrow H^+ + Cl^-$

h. Why is HF a weaker acid than HCl?

HF is weaker because the H–F bond is very strong due to the small size and high electronegativity of fluorine. This strong bond does not break easily in water, so ionization is low.

Example:

$HF \rightleftharpoons H^+ + F^-$ (partial ionization)

$HCl \longrightarrow H^+ + Cl^-$ (almost complete ionization)

i. Test to distinguish KBr and KI solutions

Reagent: Aqueous $AgNO_3$

Observations:

- KBr ⟶ cream precipitate (AgBr)
- KI ⟶ yellow precipitate (AgI)

Further test with NH_3:

- AgBr ⟶ dissolves in concentrated NH_3
- AgI ⟶ insoluble in NH_3

j. Explain chlorine as disinfectant (with equations)

Chlorine disinfects water by forming hypochlorous acid (HOCl), which is a strong oxidizing agent that kills bacteria by oxidizing cell components.

Equations:

$Cl_2 + H_2O \longrightarrow HCl + HOCl$

$HOCl \rightleftharpoons H^+ + OCl^-$

Working:

HOCl (neutral) easily enters bacterial cells and oxidizes proteins and enzymes, causing cell death.

k. One disadvantage of chlorine in water purification

Chlorine can react with organic matter to form harmful by-products (e.g., trihalomethanes) which may be hazardous to health.

l. What is disproportionation reaction? Give example.

A disproportionation reaction is one in which the same element is simultaneously oxidized and reduced.

Example:

$Cl_2 + H_2O \longrightarrow HCl + HOCl$

m. Chlorine reacts differently with NaOH depending on temperature because:

At different temperatures, chlorine forms different oxidation products due to changes in reaction conditions (kinetics and stability of products).

n. Balanced equations of chlorine with NaOH

i) Cold, dilute NaOH:

$Cl_2 + 2NaOH \longrightarrow NaCl + NaClO + H_2O$

ii) Hot, concentrated NaOH:

$3Cl_2 + 6NaOH \longrightarrow 5NaCl + NaClO_3 + 3H_2O$

o. Oxidation states and explanation (disproportionation)

Reactant:

$Cl_2 = 0$

i) Cold NaOH reaction:

- In NaCl ⟶ Cl = –1 (reduction)
- In NaClO ⟶ Cl = +1 (oxidation)

ii) Hot NaOH reaction:

- In NaCl ⟶ Cl = –1 (reduction)
- In $NaClO_3$ ⟶ Cl = +5 (oxidation)

Explanation:

In both reactions, chlorine is oxidized (0 ⟶ +1 or +5) and reduced (0 ⟶ –1) at the same time ⟶ hence the disproportionation reaction.

DESCRIPTIVE QUESTIONS

🌟 Q.3 Describe and explain the relative thermal stabilities of the hydrogen halides in terms of bond strength.

Introduction:

Hydrogen halides are compounds of hydrogen with halogens having general formula HX (where X = F, Cl, Br, I). Their thermal stability depends on how strongly hydrogen is bonded to the halogen atom.

Order of Thermal Stability:

HF > HCl > HBr > HI

This shows that thermal stability decreases down Group 17.

Explanation in terms of Bond Strength:

Thermal stability is directly related to bond dissociation energy (bond strength). A stronger bond requires more heat energy to break, so the compound is more stable.

As we move down the group from fluorine to iodine:

- Atomic radius increases
- Bond length (H–X) increases
- Orbital overlap between H and X decreases
- Result $\longrightarrow$ Bond strength decreases

Thus, less energy is required to break the bond, leading to lower thermal stability.

Detailed Comparison:

HF (Hydrogen Fluoride):

Has the strongest H–F bond due to small size and high electronegativity of fluorine. Strong overlap ⟶ with highest bond energy ⟶ most stable.

HCl (Hydrogen Chloride):

Chlorine is larger than fluorine, so overlap is less effective ⟶ bond is weaker than H–F.

HBr (Hydrogen Bromide):

Larger size of bromine further reduces overlap ⟶ weaker bond ⟶ lower stability.

HI (Hydrogen Iodide):

Iodine has the largest atomic size ⟶ poorest overlap ⟶ weakest bond ⟶ least stable.

Key Concept:

Bond strength ∝ Thermal stability

Stronger bond ⟶ more stable

Weaker bond ⟶ less stable

Summary:

The thermal stability of hydrogen halides decreases from HF to HI because bond strength decreases due to increasing atomic size and decreasing orbital overlap. Therefore, HF is the most stable while HI is the least stable hydrogen halide.

Example:

- HI decomposes easily on heating ⟶ low stability
- HF resists decomposition ⟶ high stability

🌟 **Q.4 Discuss the relative reactivity of halogens as oxidizing agents. Arrange F_2, Cl_2, Br_2, I_2 in increasing order of oxidizing power.**

Introduction:

Halogens act as oxidizing agents because they have a strong tendency to gain electrons and form halide ions (X^-). In doing so, they oxidize other substances.

Trend of Oxidizing Power:

$F_2 > Cl_2 > Br_2 > I_2$

Increasing order:

$I_2 < Br_2 < Cl_2 < F_2$

Explanation:

The oxidizing power of halogens depends on their ability to gain electrons, which is influenced by:

- Atomic size
- Electron affinity
- Bond dissociation energy

- Hydration energy of halide ions

Detailed Reasoning:

1. Atomic Size:

As we move down the group, atomic size increases, so the attraction for incoming electrons decreases. Hence, oxidizing power decreases.

2. Electron Affinity:

Halogens with higher electron affinity gain electrons more easily. Fluorine has very high tendency to gain electrons.

3. Hydration Energy:

Smaller ions (like F^-) have higher hydration energy, which stabilizes them more in solution, increasing oxidizing power.

4. Bond Dissociation Energy:

Lower bond energy helps easier formation of halide ions, enhancing oxidizing ability.

Displacement Reactions (Evidence):

- Fluorine displaces Cl^-, Br^- and I^-
- Chlorine displaces Br^- and I^-
- Bromine displaces I^-
- Iodine cannot displace any halide

Example:

$Cl_2 + 2Br^- \longrightarrow 2Cl^- + Br_2$

Summary:

Oxidizing power decreases down Group 17 due to increasing atomic size and decreasing ability to gain electrons. Therefore, fluorine is the strongest oxidizing agent, while iodine is the weakest.

🌟 **Q.5 Discuss the reducing power of halide ions with relevant reactions. Also explain the factors affecting it.**

Introduction:

Halide ions ($X^- = F^-, Cl^-, Br^-, I^-$) act as reducing agents because they can lose electrons and get oxidized to form halogen molecules. A stronger reducing agent loses electrons more easily.

Trend of Reducing Power:

$I^- > Br^- > Cl^- > F^-$

(Reducing power increases down the group)

Explanation:

As we move down Group 17:

- Atomic/ionic size increases
- Electronegativity decreases
- Attraction for outer electron becomes weaker

Therefore, halide ions can lose electrons more easily, so reducing power increases.

Relevant Oxidation Reactions:

Iodide (strongest):

- $2I^- \longrightarrow I_2 + 2e^-$

Bromide:

- $2Br^- \longrightarrow Br_2 + 2e^-$

Chloride:

- $2Cl^- \longrightarrow Cl_2 + 2e^-$

Fluoride (weakest):

- F^- does not easily lose electrons.

Example (Displacement Reaction):

$Cl_2 + 2Br^- \longrightarrow 2Cl^- + Br_2$

$\longrightarrow$ Br^- is oxidized (acts as reducing agent)

Factors Affecting Reducing Power:

1. Atomic/Ionic Size:

- Larger ions (like I^-) hold electrons less tightly $\longrightarrow$ easier to lose $\longrightarrow$ stronger reducing agent.

2. Electronegativity:

- Lower electronegativity means less attraction for electrons ⟶ easier oxidation.

3. Charge Density:

- Smaller ions (F^-) have high charge density ⟶ electrons are strongly held ⟶ weak reducing agent.

4. Bond Strength (X–X):

Weaker X–X bond (like I–I) favors formation of halogen ⟶ increases reducing power.

Summary:

Reducing power of halide ions increases down the group due to increasing size and decreasing electronegativity. Thus, I^- is the strongest reducing agent and F^- is the weakest.

Note:

This chapter is designed to provide a solid foundation of knowledge, with the goal of deepening understanding and encouraging further exploration of the subject. The content has been carefully selected to support effective learning and inspire students to engage with the topic more deeply.

Author: Muhammad Asghar

Purpose: To contribute to education by offering insightful, valuable content that enhances learning and understanding.