CHEMISTRY

Unit 13

HALOGENS

MCQs • Short Questions • Long Questions

Complete Study Booklet with Answer Keys

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Section 1 | Multiple Choice Questions

Tick the correct option. Correct answers are highlighted in green with a check mark.

1. Which halogen molecule has the strongest bond?

(a) F2
(b) Br2
(c) I2
✓ **(d) Cl2**

2. The volatility of the halogens (Group 17) generally _____ as you move down the group (from Fluorine to Iodine).

(a) Increases
✓ **(b) Decreases**
(c) Remains the same
(d) Fluctuates unpredictably

3. Which one of the following halogen molecules has strongest oxidizing power?

(a) Br2
✓ **(b) F2**
(c) I2
(d) Cl2

4. The decreasing thermal stability of the halogens down the group is primarily due to the:

(a) Increasing electronegativity of the atoms
(b) Decreasing bond length between the halogen atoms
✓ **(c) Increasing atomic radius, leading to a weaker covalent bond**
(d) Increasing strength of van der Waals forces

5. Which one of the following has strongest reducing power?

(a) F-
(b) Cl-
(c) Br-
✓ **(d) I-**

6. Which statement about the reaction between halogens and hydrogen is correct?

(a) Iodine reacts most vigorously with hydrogen
(b) Chlorine and hydrogen explode in darkness
✓ **(c) Fluorine combines explosively with hydrogen even in cold and dark conditions**
(d) Bromine and hydrogen do not react at all

7. How does the acidic strength of hydrogen halides change as you move down the group?

(a) It remains constant
(b) It decreases from HF to HI
✓ **(c) It increases from HF to HI**
(d) It fluctuates erratically

8. Why is fluorine the most reactive halogen?

(a) Bond length in the halogen molecule
(b) Bond strength in the halogen molecule
✓ **(c) Electronegativity of the halogen**
(d) Number of electrons in the halogen molecule

9. When aqueous silver nitrate is added to a solution containing bromide ions, a cream precipitate forms. What is the solubility of this precipitate in aqueous ammonia solution?

(a) Soluble in dilute ammonia solution
✓ **(b) Partially soluble in dilute ammonia solution**
(c) Insoluble in dilute ammonia solution
(d) Soluble only upon heating with ammonia

10. Concentrated sulfuric acid is added to solid sodium chloride. What is the initial observation?

(a) Reddish-brown fumes are evolved
(b) A purple vapor is evolved
✓ **(c) Steamy white fumes of hydrogen chloride are evolved**
(d) A black solid is formed

11. Which of the following halogens is radioactive?

(a) Chlorine
(b) Fluorine
✓ **(c) Astatine**
(d) Iodine

12. The term "halogen" means:

(a) Salt destroyer
✓ **(b) Salt producer**
(c) Acid former
(d) Water purifier

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

(a) Gas
(b) Liquid
✓ **(c) Solid**
(d) Plasma

14. Why are halogens highly reactive?

(a) They have full outer shells
✓ **(b) They gain one electron easily**
(c) They lose electrons easily
(d) They have low electronegativity

15. Which halogen exists as a volatile liquid at room temperature?

(a) Iodine
(b) Chlorine
(c) Fluorine
✓ **(d) Bromine**

16. Why are halogens diatomic in nature?

✓ **(a) To complete their octet**
(b) To share lone pairs
(c) To reduce size
(d) To lose electrons

17. Which halogen has the highest boiling point?

(a) Fluorine
(b) Chlorine
(c) Bromine
✓ **(d) Iodine**

18. What trend in volatility is observed in halogens from chlorine to iodine?

(a) Increases
(b) Remains constant
✓ **(c) Decreases**
(d) Fluctuates

19. The decreasing volatility down the group is due to:

(a) Decreasing molecular mass
✓ **(b) Increasing London forces**
(c) Decreasing atomic radius
(d) Increasing electronegativity

20. Which force governs the volatility trend in halogens?

(a) Dipole-dipole
(b) Hydrogen bonding
✓ **(c) Instantaneous dipole-induced dipole**
(d) Ionic bonding

21. Fluorine is a gas at room temperature due to:

(a) Strong intermolecular forces
(b) High molecular mass
✓ **(c) Weak id-id forces**
(d) High boiling point

22. What causes different colors in halogens?

(a) Different atomic radii
✓ **(b) Electron transitions**
(c) Presence of d-orbitals
(d) Ionization energy

23. The weakest halogen-halogen bond is in:

✓ **(a) F2**
(b) Cl2
(c) Br2
(d) I2

24. The bond energy of Cl2 is:

(a) 156 kJ/mol
✓ **(b) 243 kJ/mol**
(c) 193 kJ/mol
(d) 151 kJ/mol

25. Why is F-F bond weaker than Cl-Cl?

(a) Larger atomic radius of F
(b) Stronger id-id forces in Cl
✓ **(c) Lone pair repulsion in F**
(d) Lower electronegativity of Cl

26. Bond strength in halogens generally:

(a) Increases down the group
✓ **(b) Decreases down the group**
(c) First increases, then decreases
(d) Remains constant

27. Which is the strongest oxidizing agent?

(a) I2
(b) Br2
(c) Cl2
✓ **(d) F2**

28. Oxidizing power of halogens decreases due to:
(a) Increasing bond strength
(b) Increasing hydration energy
✓ **(c) Increasing atomic size**
(d) Increasing ionization energy

29. Which of the following halogens can displace all others from their salts?
(a) Cl2
(b) Br2
✓ **(c) F2**
(d) I2

30. The standard reduction potential of fluorine is:
(a) +1.36 V
(b) +1.07 V
(c) +0.54 V
✓ **(d) +2.87 V**

31. The ability of halogens to oxidize depends on:
(a) Ionization energy
(b) Electronegativity only
✓ **(c) Energy of dissociation, EA & hydration energy**
(d) Boiling point

32. The product of halogen and hydrogen is:
(a) Alkyl halide
(b) Hydrogen peroxide
✓ **(c) Hydrogen halide**
(d) Haloalkane

33. Which halogen reacts explosively with hydrogen even in the dark?
(a) Cl2
(b) Br2
✓ **(c) F2**
(d) I2

34. Hydrogen halides in water form:
(a) Salts
✓ **(b) Hydrohalic acids**
(c) Bases
(d) Amides

35. The reaction between H2 and I2 is:
(a) Fast and exothermic
(b) Explosive
✓ **(c) Reversible and slow**
(d) Photochemical

36. The most thermally stable hydrogen halide is:
✓ **(a) HF**

(b) HCl
(c) HBr
(d) HI

37. Which factor explains thermal stability of HX?
(a) Solubility
(b) Boiling point
✓ **(c) Bond dissociation energy**
(d) Enthalpy of vaporization

38. Which HX has the weakest H-X bond?
(a) HF
(b) HCl
(c) HBr
✓ **(d) HI**

39. Which halide ion is the strongest reducing agent?
(a) F-
(b) Cl-
(c) Br-
✓ **(d) I-**

40. The weakest reducing halide ion is:
✓ **(a) F-**
(b) I-
(c) Br-
(d) Cl-

41. AgNO3 with Cl- gives:
(a) Yellow ppt
(b) Cream ppt
✓ **(c) White ppt**
(d) No ppt

42. Which halide does not form ppt with Ag+?
(a) Cl-
(b) Br-
(c) I-
✓ **(d) F-**

43. AgBr is:
(a) Soluble in dilute ammonia
✓ **(b) Soluble in conc. ammonia**
(c) Insoluble
(d) Volatile

44. Reaction of NaCl and conc. H2SO4 gives:
(a) Br2 fumes
✓ **(b) Steamy white HCl fumes**
(c) Yellow ppt
(d) Violet vapor

45. In cold NaOH, Cl2 gives:
✓ **(a) Cl- and ClO-**
(b) Cl- only

(c) ClO- only
(d) ClO2-

46. In hot conc. NaOH, Cl2 gives:
(a) ClO-
✓ **(b) Cl- and ClO3-**
(c) HCl
(d) O2

47. Cl in Cl2 is both oxidized and reduced. This is:
(a) Displacement
(b) Substitution
(c) Redox
✓ **(d) Disproportionation**

48. Chlorine disinfects by forming:
(a) HCl only
✓ **(b) HClO and ClO-**
(c) NaOCl
(d) Cl2 gas

49. The active species that kill bacteria are:
(a) O2 and O3
✓ **(b) HClO and ClO-**
(c) Cl2 and Cl-
(d) NO2 and SO2

50. A disadvantage of chlorine use is:
(a) Expensive
(b) Evaporates quickly
✓ **(c) Forms toxic byproducts**
(d) Decomposes easily

51. Bleaching powder is a mixture of:
(a) CaCl2 and Ca(OH)2
✓ **(b) Ca(OCl)2 and CaCl2**
(c) CaCO3 and NaOCl
(d) NaCl and CaO

52. Which gas is released when bleaching powder reacts with dilute acid?
(a) O2
(b) HCl
✓ **(c) Cl2**
(d) CO2

53. What is the bleaching action of chlorine due to?
(a) Cl- ions
(b) Liberation of O2
✓ **(c) Formation of nascent oxygen**
(d) HCl

54. Chlorine is prepared in lab by:
(a) Heating NaCl
(b) Heating KMnO4
✓ **(c) Reacting MnO2 with conc. HCl**

(d) Dehydration of HCl

55. Halogens are used in:

(a) Cooking
(b) Semiconductor production
✓ **(c) Water sterilization**
(d) Electroplating

56. Teflon is a polymer of:

(a) Cl_2
(b) CCl_4
✓ **(c) $CF_2=CF_2$**
(d) $CH_2=CH_2$

57. Which compound is used in the treatment of goiter?

✓ **(a) NaI**
(b) KCl
(c) NaBr
(d) CaF_2

58. Fluorine is used in:

✓ **(a) Toothpaste**
(b) Water purification
(c) Bleaching powder
(d) Fertilizer

59. Iodine is used in:

(a) Welding
(b) Ink
✓ **(c) Tincture**
(d) Batteries

60. Chlorofluorocarbons (CFCs) contribute to:

(a) Ozone formation
(b) Air purification
✓ **(c) Ozone depletion**
(d) Global warming directly

61. Which halogen is most electronegative?

(a) Cl
(b) Br
✓ **(c) F**
(d) I

62. Down the group, the oxidizing power of halogens:

(a) Increases
(b) Remains constant
✓ **(c) Decreases**
(d) Shows no trend

63. Which halogen reacts least vigorously with hydrogen?

(a) Cl_2
(b) Br_2
✓ **(c) I_2**
(d) F_2

64. The acidic strength of hydrogen halides increases in the order:

✓ **(a) HF < HCl < HBr < HI**

(b) HI < HBr < HCl < HF

(c) HCl < HF < HBr < HI

(d) HF < HBr < HCl < HI

65. Which halogen compound contributes to ozone depletion?

(a) NaCl

(b) HCl

✓ **(c) CFCs**

(d) Cl2

66. Iodine is added to salt to prevent:

(a) Anemia

✓ **(b) Goiter**

(c) Asthma

(d) Arthritis

67. Test for halide ions using silver nitrate involves:

(a) Color change

✓ **(b) Formation of precipitate**

(c) Evolution of gas

(d) Smell

68. Which halide gives a white precipitate with AgNO3?

(a) Br-

✓ **(b) Cl-**

(c) I-

(d) F-

69. Which halide does not react with AgNO3?

(a) Br-

(b) I-

✓ **(c) F-**

(d) Cl-

70. Silver halides are photosensitive because:

(a) They contain free electrons

(b) They form peroxides

✓ **(c) They decompose in sunlight**

(d) They are oxidizing agents

Section 2 | Short Questions

Q1. Which halogen is the least reactive, which is the most? Give reasons.

Fluorine is most reactive: smallest atom, highest electronegativity (3.98), attracts electrons most strongly, and is a very powerful oxidizing agent.

Iodine is least reactive: larger atomic radius, lower electronegativity (2.66), attracts electrons less strongly.

Trend: F2 > Cl2 > Br2 > I2 (reactivity decreases down the group).

Q2. For Br2 + 2I- -> 2Br- + I2, explain which species is oxidized and why.

This is a redox displacement reaction. Bromine is more reactive than iodine, so it oxidizes iodide ions to iodine while being reduced to bromide ions itself.

Oxidation: 2I- -> I2+2e- (I- loses electrons). Reduction: Br2+2e- -> 2Br-. The iodide ion (I-) is oxidized because it loses electrons.

Q3. What is the role of London dispersion forces in the volatility trend of halogens?

London dispersion forces are weak intermolecular forces that increase with molecular size and mass, since larger atoms have more electrons giving stronger temporary dipoles.

Going down the group, size/mass increase, giving stronger dispersion forces, more energy needed to separate molecules, and hence lower volatility - fluorine is most volatile, iodine least volatile.

Q4. How does the reactivity of halogens with hydrogen vary?

Reactivity decreases down the group (F2 > Cl2 > Br2 > I2) because the H-X bond weakens with increasing atomic radius, and oxidizing power decreases.

Fluorine reacts explosively even in cold and dark; chlorine reacts vigorously in light/spark; bromine needs heating; iodine reacts very slowly and incompletely.

Q5. Which halogen is used as an antiseptic? How does it work?

Iodine (I2) is used as an antiseptic - it kills or inactivates bacteria, viruses, and fungi by oxidizing vital proteins and enzymes in microbial cells, disrupting cell structure and function.

Commonly used as tincture of iodine (iodine in alcohol), applied to cuts, wounds, and skin before surgery/injections to prevent infection.

Q6. What is the colour change when chlorine displaces bromine?

The solution changes from colourless to orange-brown, since chlorine displaces bromine from bromide solution: Cl2+2Br- -> 2Cl-+Br2, and the released Br2 gives the orange-brown colour.

Q7. How are halogen acids ionized in water?

HX(aq) -> H+(aq)+X-(aq). HCl, HBr, and HI are strong acids that ionize completely; HF is a weak acid that only partially ionizes due to strong hydrogen bonding and high bond strength.

Acid strength increases: HF < HCl < HBr < HI.

Q8. Why is HF a weaker acid than HCl in aqueous solution?

The H-F bond is much stronger (about 569 kJ/mol) than H-Cl (about 431 kJ/mol), so more energy is needed to break it, releasing fewer H+ ions.

HF also forms extensive hydrogen bonds with water that stabilize the molecule, further resisting ionization - so HF only partially ionizes (weak acid) while HCl ionizes completely (strong acid).

Q9. Describe a chemical test to distinguish aqueous KBr from KI.

Add chlorine water to both solutions, then shake with hexane to extract the displaced halogen.

KBr gives an orange colour (Br2 formed); KI gives a purple colour (I2 formed) - this distinguishes the two.

Q10. Explain the chemical principles behind chlorine as a disinfectant in water purification.

Cl2(g)+H2O(l) -> HCl(aq)+HOCl(aq). HOCl (hypochlorous acid) is neutral and penetrates microbial cell walls easily, oxidizing proteins, enzymes, lipids, and nucleic acids to disrupt cell function and kill microorganisms.

HOCl <=> H++OCl-; OCl- is also a disinfectant but less effective. Optimal conditions: pH 6-7.5 (more HOCl), sufficient contact time, and adequate chlorine dose.

Q11. Describe a significant disadvantage of using chlorine in water purification.

Chlorine reacting with natural organic matter (e.g. decaying plant material) can form trihalomethanes (THMs) such as chloroform (CHCl3), which are carcinogenic and pose long-term health risks.

Q12. What is a disproportionation reaction? Give an example.

A redox reaction in which a single substance is simultaneously oxidized and reduced, forming two products with different oxidation states.

Example: Cl2(g)+2NaOH(aq) -> NaCl(aq)+NaClO(aq)+H2O(l). Chlorine is oxidized (0 to +1 in NaClO) and reduced (0 to -1 in NaCl).

Q13. How does chlorine's reaction with NaOH change with temperature/concentration?

With cold dilute NaOH: disproportionation gives NaCl and NaClO (sodium hypochlorite, the active ingredient in bleach): Cl2(g)+2NaOH(aq) -> NaCl(aq)+NaClO(aq)+H2O(l).

With hot concentrated NaOH: disproportionation gives NaCl and NaClO3 (sodium chlorate): 3Cl2(g)+6NaOH(aq) -> 5NaCl(aq)+NaClO3(aq)+3H2O(l).

Q16. Why are halogens placed in Group VIIA (17) of the periodic table?

Halogens have 7 valence electrons (ns2np5), one electron short of a stable octet - this high reactivity and shared valence configuration places them in Group VIIA (17).

Q17. Why do halogens exist as diatomic molecules (X2)?

To achieve a stable electron configuration via covalent bonding - e.g. Cl2 has a Cl-Cl single bond where each atom shares one electron to complete its octet.

Q18. Why does reactivity decrease from fluorine to iodine?

Because atomic size increases and electronegativity decreases down the group, weakening the ability to attract electrons. Order: F2 > Cl2 > Br2 > I2.

Q32. Which hydrogen halide is the strongest acid in aqueous solution and why?

HI is the strongest acid, due to the weakest H-I bond, which allows easier ionization into H+ and I-. Order: HF < HCl < HBr < HI.

Q33. Why is HF a weak acid despite high bond polarity?

The H-F bond is very strong and short (bond dissociation energy about 569 kJ/mol), making HF resistant to dissociation in water despite its high polarity.

Q34. What is the trend in acid strength of hydrogen halides?

Increases from HF < HCl < HBr < HI, due to decreasing bond strength down the group.

Q35. What are halide salts? Give an example.

Salts formed by neutralizing hydrogen halides with bases. Example: NaCl from HCl and NaOH.

Q36. What happens when chlorine is exposed to sunlight in the presence of hydrogen?

An explosive reaction occurs, forming HCl: $H_2+Cl_2 \rightarrow 2HCl$ (in presence of sunlight/spark).

Q37. What are common uses of chlorine in industry?

Disinfection of water; manufacturing PVC; manufacture of bleach; production of chlorinated solvents.

Q38. Why is iodine used in antiseptics?

Iodine has antimicrobial properties and kills pathogens by disrupting protein and enzyme function through oxidation.

Q39. How is bromine used commercially?

In flame retardants; in photography (silver bromide); in water treatment; and in various extraction and preparation processes.

Q40. How is chlorine prepared in the lab?

By reacting manganese dioxide (MnO_2) with hydrochloric acid (HCl): $MnO_2 + 4HCl \rightarrow MnCl_2 + Cl_2 + 2H_2O$

Q41. Why is electrolysis used to obtain fluorine?

Due to fluorine's extremely high reactivity, it cannot be prepared by chemical displacement and must be obtained by electrolysis of HF.

Q42. What is the role of manganese dioxide in chlorine preparation?

It acts as an oxidizing agent to liberate Cl_2 gas from HCl.

Q43. Why are halogens not found free in nature?

Due to their high reactivity, halogens exist in nature as halide ions (Cl^-, Br^-, etc.) combined with metals or hydrogen, rather than as free elements.

Section 3 | Descriptive Questions

Q3 (Descriptive). Describe and explain the relative thermal stabilities of hydrogen halides in terms of bond strength.

Thermal stability order: HF > HCl > HBr > HI, determined by bond dissociation energy, which decreases down the group (H-F=569, H-Cl=431, H-Br=366, H-I=299 kJ/mol).

HF is most stable due to fluorine's small atomic radius and high electronegativity giving strong orbital overlap; HI is least stable due to iodine's large radius and poor orbital overlap.

Q4 (Descriptive). Describe the relative reactivity of halogens as oxidizing agents. Arrange F2, Cl2, Br2, I2 in increasing order.

Increasing order of oxidizing power: I2 < Br2 < Cl2 < F2.

This follows from decreasing electronegativity and standard reduction potential (E deg) down the group: F2 (+2.87V) > Cl2 (+1.36V) > Br2 (+1.07V) > I2 (+0.54V), so fluorine is the strongest oxidizer and iodine the weakest.

Q5 (Descriptive). Discuss the reducing power of halide ions with relevant reactions, and the factors affecting it.

Reducing power order: I- > Br- > Cl- > F-.

Factors: electronegativity decreases down the group (inversely related to reducing power); ionic radius increases down the group (directly related to reducing power, since larger ions have lower charge density and donate electrons more easily). I- is the strongest reducing agent; F- is the weakest.

Section 4 | Long Questions

Q1. Why are halogens placed in Group 17 of the periodic table? Describe their physical states.

Group 17 (VIIA) Elements

Group 17/VIIA elements are the halogens: Fluorine (F), Chlorine (Cl), Bromine (Br), Iodine (I), Astatine (At), and Tennessine (Ts).

General characteristics: highly reactive non-metals, highly electronegative, similar chemical properties, and they exist as diatomic molecules (X2) in all phases.

Name origin: 'halogen' comes from Greek 'halos' (salt) and 'gen' (to make). Chlorine was the first halogen isolated; though poisonous, small amounts of chloride are essential to human health.

Physical States and Appearance

F2: pale yellow gas, highly reactive. Cl2: greenish-yellow gas, poisonous and irritating. Br2: reddish-brown liquid, volatile, corrosive, toxic fumes. I2: shiny greyish-black solid, sublimes to violet vapour. At and Ts are rare and radioactive, with limited data due to instability.

Volatility Trend

Volatility decreases from chlorine to iodine, due to: increasing molecular mass (heavier molecules evaporate less easily), increasing atomic size (larger surface area for attraction), and stronger London dispersion (instantaneous dipole-induced dipole) forces down the group.

Factors affecting London forces: molecular size (larger = stronger forces), shape (compact shapes enhance attraction), and polarizability (more polarizable = stronger forces). Volatility is inversely related to boiling point.

Q2. What is the oxidizing power of halogens? How does standard reduction potential relate to it?

Oxidizing Power of Halogens

All halogens are good oxidizing agents because they readily gain electrons to form halide ions. Order of oxidizing power: F2 > Cl2 > Br2 > I2.

Standard reduction potentials E deg (X2/X-): F2 = +2.87 V, Cl2 = +1.36 V, Br2 = +1.07 V, I2 = +0.54 V - E deg becomes less positive from F to I, matching the decrease in oxidizing power.

Factors Affecting Oxidizing Power

Bond dissociation energy (lower means better oxidizer); electron affinity (higher means better oxidizer); hydration energy of halide ions (higher means better oxidizer); heat of vaporization (relevant for Br2 and I2).

Quick Check 13.2

(a) The F-F bond is weaker than Cl-Cl despite fluorine's higher electronegativity, because of strong lone-pair repulsion between the small fluorine atoms, which weakens the bond.

(b) F2(g)+2NaCl(aq) -> 2NaF(aq)+Cl2(g) is possible, since fluorine is more reactive than chlorine and can displace it from solution.

(c) Higher standard reduction potential means greater oxidizing power - fluorine has the highest value and is the strongest oxidizing agent.

Q4. Explain the reaction of halogens with hydrogen.

Reactions with Hydrogen

All halogens react with hydrogen to form hydrogen halides: H2+X2 -> 2HX (X = F, Cl, Br, I). These are colourless gases that form hydrohalic acids when dissolved in water.

Reactivity with hydrogen decreases down the group: F2 > Cl2 > Br2 > I2.

Detailed Reactions

Fluorine: reacts explosively with hydrogen at low temperature, even in the dark - H2(g)+F2(g) -> 2HF(g).

Chlorine: reacts in the presence of light (UV or spark) - H2(g)+Cl2(g) -> 2HCl(g) (with light).

Bromine: requires heating (exothermic) - H2(g)+Br2(g) -> 2HBr(g) (upon heating).

Iodine: reacts very slowly at high temperature with a catalyst, and is reversible - H2(g)+I2(g) <=> 2HI(g) (catalyst, high temperature).

Q5. Describe the relative thermal stabilities of hydrogen halides in terms of bond strength.

Thermal Stability Trend

HF > HCl > HBr > HI. Bond dissociation energy is the main factor - it decreases down the group, so thermal stability decreases: a stronger bond means higher stability, a weaker bond means lower stability.

Bond dissociation energies: H-F = 569, H-Cl = 431, H-Br = 366, H-I = 299 (kJ/mol).

Detailed Analysis

HF: most thermally stable - small atomic radius and high electronegativity of fluorine give strong orbital overlap and the strongest H-X bond.

HCl: less stable than HF but more than HBr/HI, since chlorine has a larger atomic radius.

HBr: weaker than H-Cl and H-F, due to bromine's even larger atomic radius and reduced orbital overlap.

HI: least thermally stable, since iodine's large atomic radius gives poor orbital overlap and the weakest bond.

Quick Check

H2+F2 is explosive while H2+I2 is slow and reversible, because the H-F bond releases much more energy on formation (very exothermic), while the weaker H-I bond makes the reaction far less exothermic.

H2+Cl2 -> 2HCl is more exothermic than H2+Br2 -> 2HBr, since the H-Cl bond formed is stronger than H-Br, releasing more energy.

Higher bond dissociation energy always means greater thermal stability.

Q6. Discuss the relative reactivity of halide ions as reducing agents.

Reducing Power Trend

Reducing power of halide ions increases down Group 17, from fluorine to iodine: I- > Br- > Cl- > F-.

Explanation of the Trend

1. Electronegativity: decreases down the group, inversely related to reducing power - lower electronegativity means a greater tendency to lose electrons (stronger reducing agent).

2. Atomic/Ionic radius: increases down the group, directly related to reducing power - larger ions have lower charge density and donate electrons more easily.

3. Charge density: F- (smallest, highest charge density) is the weakest reducing agent; I- (largest, lowest charge density) is the strongest.

Detailed Analysis

F-: high electronegativity and strong bonding of the extra electron, small size gives high charge density, stabilizing the ion and reducing its tendency to lose electrons - weakest reducing agent.

Cl-: stronger reducing agent than F-, due to larger size and lower electronegativity, but still weaker than Br- and I-.

Br-: stronger than Cl-, since bromine is less electronegative with a larger ionic radius and lower charge density.

I-: much stronger than Cl- and Br-, with the lowest electronegativity, largest ionic radius, and lowest charge density - strongest reducing agent.

Q7. Give the reactions of halides with aqueous silver ion, followed by aqueous ammonia.

Silver Nitrate Test

Halide ions react with aqueous AgNO3 to form insoluble silver halides (AgX), used in qualitative analysis: X-(aq)+Ag+(aq) -> AgX(s) (X- = Cl-, Br-, I-; F- does not precipitate).

Detailed Reactions

F-: no visible reaction - AgF is soluble in water.

Cl-: white precipitate - Ag+(aq)+Cl-(aq) -> AgCl(s).

Br-: cream-coloured precipitate - Ag+(aq)+Br-(aq) -> AgBr(s).

I-: yellow precipitate - Ag+(aq)+I-(aq) -> AgI(s).

Reactions with Aqueous Ammonia

AgCl (white): dissolves in dilute ammonia - AgCl(s)+2NH3(aq) -> [Ag(NH3)2]+(aq)+Cl-(aq).

AgBr (cream): dissolves only in concentrated ammonia - AgBr(s)+2NH3(aq) -> [Ag(NH3)2]+(aq)+Br-(aq).

AgI (yellow): does not dissolve in dilute or concentrated ammonia.

Q8. Explain what happens when concentrated H2SO4 is added to solid sodium halides.

Overview

Adding concentrated H_2SO_4 to solid sodium halides (NaCl, NaBr, NaI) first produces hydrogen halides (HX), which may undergo further redox reactions depending on their reducing power.

Reaction with Chloride

Observations: steamy white fumes of HCl gas.

$NaCl(s)+H_2SO_4(l) \rightarrow NaHSO_4(l)+HCl(g)$. No further reaction occurs, since HCl is too weak a reducing agent to reduce H_2SO_4.

Reaction with Bromide

Observations: steamy fumes of HBr, brown fumes of Br_2, and the smell of SO_2.

$NaBr(s)+H_2SO_4(l) \rightarrow NaHSO_4(l)+HBr(g)$; $2HBr(g)+H_2SO_4(l) \rightarrow Br_2(g)+SO_2(g)+2H_2O(l)$. This is a redox reaction: HBr acts as a reducing agent, H_2SO_4 is reduced to SO_2, and HBr is oxidized to Br_2.

Reaction with Iodide

Observations: fumes of HI, purple fumes of I_2, and the smell of H_2S (rotten egg).

$NaI(s)+H_2SO_4(l) \rightarrow NaHSO_4(l)+HI(g)$; $8HI(g)+H_2SO_4(l) \rightarrow 4I_2(s)+H_2S(g)+4H_2O(l)$. HI is a strong reducing agent: H_2SO_4 is reduced to H_2S, and HI is oxidized to I_2.

Q9. Describe the reactions when chlorine is bubbled through (i) cold and (ii) hot aqueous NaOH.

Disproportionation Reactions

A disproportionation reaction is one where a single element undergoes both oxidation and reduction simultaneously.

(i) Cold Aqueous NaOH

$Cl_2(g)+2NaOH(aq) \rightarrow NaCl(aq)+NaClO(aq)+H_2O(l)$. Oxidation states of chlorine: Cl_2 (0, elemental) -> NaCl (-1, reduced) and NaClO (+1, oxidized).

Products: sodium chloride (chloride ion) and sodium chlorate(I) - also called sodium hypochlorite (hypochlorite ion, OCl^-).

(ii) Hot Aqueous NaOH

$3Cl_2(g)+6NaOH(aq) \rightarrow 5NaCl(aq)+NaClO_3(aq)+3H_2O(l)$. Oxidation states of chlorine: Cl_2 (0) -> NaCl (-1, reduced) and $NaClO_3$ (+5, oxidized).

Products: sodium chloride and sodium chlorate(V) (chlorate ion, ClO_3^-).

Q10. Explain the use of chlorine in water purification.

Overview

Chlorine gas (Cl_2) is poisonous, but in small amounts it is safe for humans and lethal to microbes, so it is widely used in water treatment plants and swimming pools.

Primary active species: hypochlorous acid (HOCl) and hypochlorite ion (OCl^-).

Chlorine Addition to Water

Cl2(g)+H2O(l) -> HCl(aq)+HOCl(aq). HOCl is a weak acid that partially dissociates: HOCl <=> H++OCl-.

Disinfection Activity

Both HOCl and OCl- are active disinfectants; HOCl is more effective since it is neutral and penetrates bacterial cell walls more easily.

Both oxidize essential cellular components (proteins, lipids, enzymes), destroying cell membranes, enzymes, and nucleic acids (DNA/RNA), preventing bacterial replication and vital functions.

Factors Affecting Disinfection

pH: at pH 6-7.5, HOCl predominates (more effective); above pH 7.5, OCl- predominates (less effective but still disinfects).

Chlorine dose: higher doses give more effective disinfection.

Contact time: must be long enough for disinfectants to penetrate and kill bacteria, viruses, and protozoa.

Quick Check 13.6

HOCl is more effective than OCl- because its neutral charge lets it penetrate microbial cell walls far more easily than the negatively charged hypochlorite ion; once inside, it oxidizes cellular components and disrupts cell function.

Section 5 | Answer Key & Formula Summary

MCQ Answer Key (Q1-Q70)

Q.No	Ans	Q.No	Ans	Q.No	Ans	Q.No	Ans
1	D	19	B	37	C	55	C
2	B	20	C	38	D	56	C
3	B	21	C	39	D	57	A
4	C	22	B	40	A	58	A
5	D	23	A	41	C	59	C
6	C	24	B	42	D	60	C
7	C	25	C	43	B	61	C
8	C	26	B	44	B	62	C
9	B	27	D	45	A	63	C
10	C	28	C	46	B	64	A
11	C	29	C	47	D	65	C
12	B	30	D	48	B	66	B
13	C	31	C	49	B	67	B
14	B	32	C	50	C	68	B
15	D	33	C	51	B	69	C
16	A	34	B	52	C	70	C
17	D	35	C	53	C		
18	C	36	A	54	C		

Important Formulas

Formula	Description
H2 + X2 -> 2HX	General reaction of halogens with hydrogen
X-(aq) + Ag+(aq) -> AgX(s)	Silver nitrate test for halide ions (F- gives no precipitate)
Cl2(g) + 2NaOH(aq) -> NaCl(aq) + NaClO(aq) + H2O(l)	Cold dilute NaOH + Cl2 (disproportionation)
3Cl2(g) + 6NaOH(aq) -> 5NaCl(aq) + NaClO3(aq) + 3H2O(l)	Hot concentrated NaOH + Cl2 (disproportionation)
Cl2(g) + H2O(l) -> HCl(aq) + HOCl(aq)	Chlorine hydrolysis in water purification
HOCl <=> H+ + OCl-	Dissociation of hypochlorous acid
MnO2 + 4HCl -> MnCl2 + Cl2 + 2H2O	Laboratory preparation of chlorine

Key Constants & Notes

Constant/Note	Value

Bond Dissociation Energy H-F	569 kJ/mol
Bond Dissociation Energy H-Cl	431 kJ/mol
Bond Dissociation Energy H-Br	366 kJ/mol
Bond Dissociation Energy H-I	299 kJ/mol
E deg (F2/F-)	+2.87 V
E deg (Cl2/Cl-)	+1.36 V
E deg (Br2/Br-)	+1.07 V
E deg (I2/I-)	+0.54 V
Electronegativity of Fluorine	3.98
Electronegativity of Iodine	2.66

Physical Properties of Halogens

Halogen	State	Colour	Volatility
F2	Gas	Pale yellow	Most volatile
Cl2	Gas	Greenish yellow	High
Br2	Liquid	Reddish-brown	Moderate
I2	Solid	Shiny greyish black	Least volatile

Silver Halide Precipitate Tests

Halide	Precipitate Colour	Solubility in Ammonia
Cl-	White	Soluble in dilute ammonia
Br-	Cream	Slightly soluble in conc. ammonia
I-	Yellow	Insoluble in ammonia

Reactivity Trends Summary

Property	Trend	Explanation
Reactivity	F2 > Cl2 > Br2 > I2	Decreasing electronegativity
Oxidizing Power	F2 > Cl2 > Br2 > I2	Decreasing E deg values
Reducing Power of Halides	I- > Br- > Cl- > F-	Increasing ionic size
Acid Strength of HX	HI > HBr > HCl > HF	Decreasing bond strength
Thermal Stability of HX	HF > HCl > HBr > HI	Decreasing bond strength

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