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Based on, best for sciences

Group 7: Fluorine, chlorine, bromine, iodine

Members

Elements

Symbols

Fluorine

F

Chlorine

Cl

Bromine

Br

Iodine

I

General comment

- The halogens are one electron short of the noble gas configurations, and the elements form the anion X^- or a single covalent bond.
- They are all non-metals
- The changes in behavior with increasing size are gradual. i.e., fluorine and chlorine are gases, bromine is a volatile liquid and iodine is a dark shiny dark solid.

Generally the properties of fluorine are different from those of other halogens because it

- (i) Has small atomic radius
- (ii) Has high electronegativity
- (iii) Has abnormally low F-F bond energy (158kJ/mol) due to high electron repulsion of non bonding electron pairs.

NB: Generally bond energy decreases down the group from chlorine to iodine due to decrease in electronegativity as the size of the atoms increase, i.e,

Cl-Cl = 242

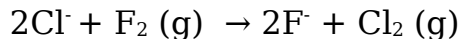
Br-Br = 193

I-I = 151

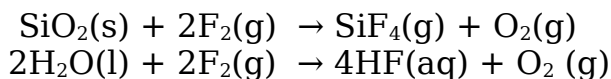
Properties

Fluorine is the most chemically reactive of all the elements and combines directly (often with extreme vigor), at ordinary or elevated temperatures, with all elements other than O_2 , He, Ne, and Kr.

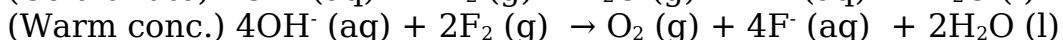
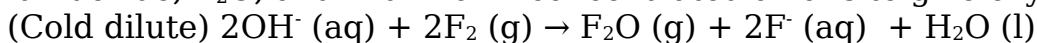
- (i) Fluorine is the most electronegative element and displaces all other halogens from their ionic halides.



- (ii) Fluorine substitutes oxygen from silicon dioxide and water.



- (iii) Fluorine reacts with cold dilute solutions of alkalis to give oxygen difluoride; F_2O , and with warm concentrated alkalis to give oxygen.



Reason for high reactivity of fluorine

1. It has abnormally low (F-F) bond energy by comparison with other halogens (i.e., F_2 , 158; Cl_2 , 247; Br_2 , 193; I_2 , 151 kJ mol^{-1}).

The low (F-F) bond energy is probably due to greater repulsion between nonbonding electrons.

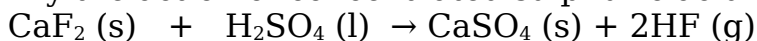
2. Fluorine forms strong covalent bonds with other elements, e.g., C-F, 484; C-Cl, 338; C-Br, 276; C-I, 238 kJ mol^{-1} .
3. Fluorine has the highest electronegativity of all elements.

Trial 1

- (a) Explain why fluorine shows some differences in its properties from the rest of the group 7 elements (chlorine, bromine, and iodine) of the periodic table: (3marks)
- (b) State the different between the chemistry of fluorine and the rest of the elements of group VII of PT. (8 marks)

Preparation of fluorine

- (i) By the action of concentrated sulphuric acid on calcium fluoride.

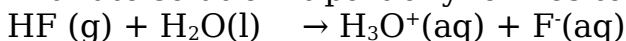


- (ii) By heating acid fluoride in a copper or platinum tube, e.g.,

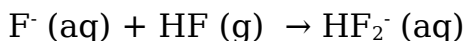


Chemical properties of fluorine

- (i) In dilute solution it partially ionizes to form a weak acid



- (ii) In concentrated solution, partially ionizes as in dilute solution but excess HF molecules complex with F^- ions leading to further ionization of the acid producing more H^+ .



This makes concentrated HF stronger acid than dilute solution

Trial 2

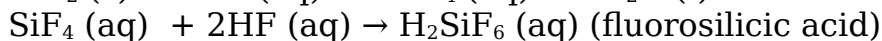
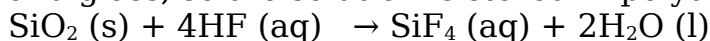
Write the equations for the ionization of aqueous hydrogen fluoride in.

(i) Dilute solution. (1marks)

(ii) Concentrated solution. (1mark)

In which of the solutions in (a) above would you expect hydrogen fluoride to be relatively more acidic? Explain your answer.

(iii) Moist hydrogen fluoride and aqueous solutions of the acid attack silica and glass, so the solution is stored in polythene containers.



Trial 3

Write an equation for the reaction between hydrofluoric acid and silicon dioxide (1½ marks)

Uses fluorine and its compounds

- (i) Calcium fluoride is used in toothpastes to prevent tooth decay.
- (ii) Cryolite, Na_3AlF_6 , is added to aluminium oxide to lowers its melting point to about 900°C and improves conduction during extraction of aluminium metal by electrolysis of bauxite.

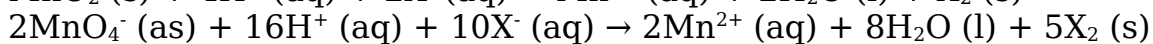
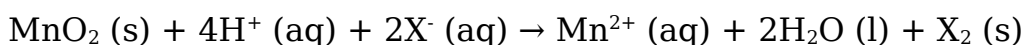
Chlorine, bromine and iodine

Industrial preparation

- (i) Chlorine is prepared by electrolysis of brine (concentrated sodium chloride solution)
- (ii) Bromine and iodine are prepared by displacement with chlorine from sea water.

Laboratory preparation

By oxidation of acidified solutions of the halides with manganese dioxide or potassium permanganate (VII).



Trial 4

(a) Describe one general method for preparing the halogens (excluding

fluorine) in the laboratory and write equations for the reactions.
(4½ marks)

- (b) How can you distinguish between sodium bromide and sodium iodide, given chlorine water and tetrachloromethane.
(3½ marks)

Physical properties of chlorine, bromine and iodine

Chlorine is a greenish - yellow poisonous gas with an extremely irritant smell. Chlorine is easily liquefied at room temperature under a pressure of about 7 atmospheres to a yellow liquid.

Bromine is a dark red liquid with an unpleasant and poisonous vapour, and iodine is a dark shiny solid which produces purple vapors on heating.

Chemical properties of chlorine, bromine and iodine

(a) Reactions with other elements.

Chlorine, bromine and iodine combine with many metals and non-metals. Usually, the combination with chlorine is most vigorous and with iodine is least vigorous.

Metals that form more than one chloride form the higher one in combination with chlorine, e.g., iron forms iron (III) chloride and not iron (II) chloride because chlorine is a strong oxidizing agent.

Trial 5

(a) Explain why chlorine reacts with iron to form FeCl_3 but not FeCl_2 .

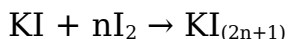
(b) Describe the process for the formation of $\text{FeCl}_3(\text{s})$.

b) 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.



Iodine is more soluble in KI than in water due to formation of complexes.



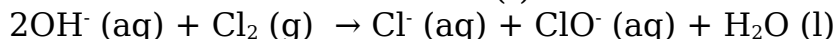
Trial 6

Explain the following observation.

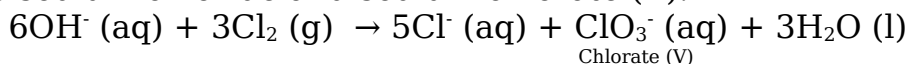
Iodine is more soluble in potassium iodide than in water. (3 marks)

c) Reaction with alkalis.

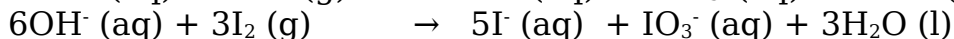
Chlorine reacts with cold dilute sodium hydroxide solution to give sodium chloride and sodium chlorate (I).



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



Bromine and iodine react with sodium hydroxide solution to give the halide and halate (V):



Trial 7

Discuss the reactions between the elements of group (VII) of the periodic table (fluorine, chlorine bromine and iodine) with

(i) water. (5 marks)

(ii) sodium hydroxide. (7 marks)

Trial 8

Write equations to show how fluorine and chlorine react with:

(a) water. (3 marks)

(b) cold dilute sodium hydroxide solution. (3 marks)

(c) hot concentrated sodium hydroxide solution. (3 marks)

Trial 9

Describe briefly how chlorine can be converted to potassium chlorate (V) crystals in the laboratory. (5 marks)

The hydrides of chlorine, bromine and iodine

(a) Ease of oxidation:

Hydrogen iodide is very easily oxidized even by atmospheric oxygen, it is therefore, a strong reducing agent, and is used as a test for oxidizing agents.

Hydrogen bromide is a less strong reducing agent but is oxidized fairly easily, e.g., both hydrogen bromide and hydrogen iodide are oxidized by concentrated sulphuric acid to corresponding free halogens.



(b) Acidity

Pure hydrogen halides are covalent, but polar; they ionize in water to give acidic solutions.

The three acids - hydrochloric, hydrobromic and hydroiodic are all strong acids in water.

In other solvents, however, the strengths of these acids decrease in the order $\text{HI} > \text{HBr} > \text{HCl}$: due to the decrease in the H-X bond energy in the order $\text{HCl} > \text{HBr} > \text{HI}$.

Trial 11

Explain the following observation;

The acidity of halogens acids decrease in the order $\text{HI} > \text{HBr} > \text{HCl}$ although their ionic characters increase in the reverse order. (4 marks)

Trial 12

The melting points of chlorine, bromine and iodine are in the order; iodine>bromine>chlorine but the temperatures at which the molecules of the halogens dissociate into atoms are in the reverse order.

Explain the trend in the melting points of the elements. (3 marks)

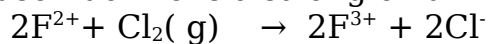
Suggest answers

Trial 1 (a)

- It has high electronegativity
- Has small atomic radius
- Has very low F-F bond

Trial 5 (a)

Because fluorine is a strong oxidizing agent it oxidizes Fe^{2+} to Fe^{3+} .



(b) By passing chlorine over hot iron.

