Introduction to Group 17 Elements

Group seventeen elements include **fluorine, chlorine, bromine, iodine** and **astatine**.

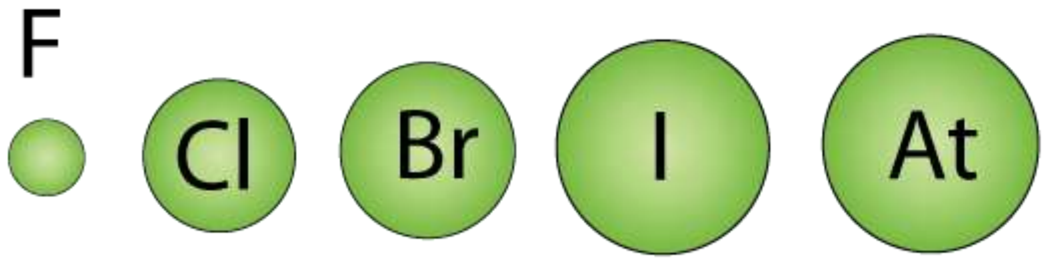
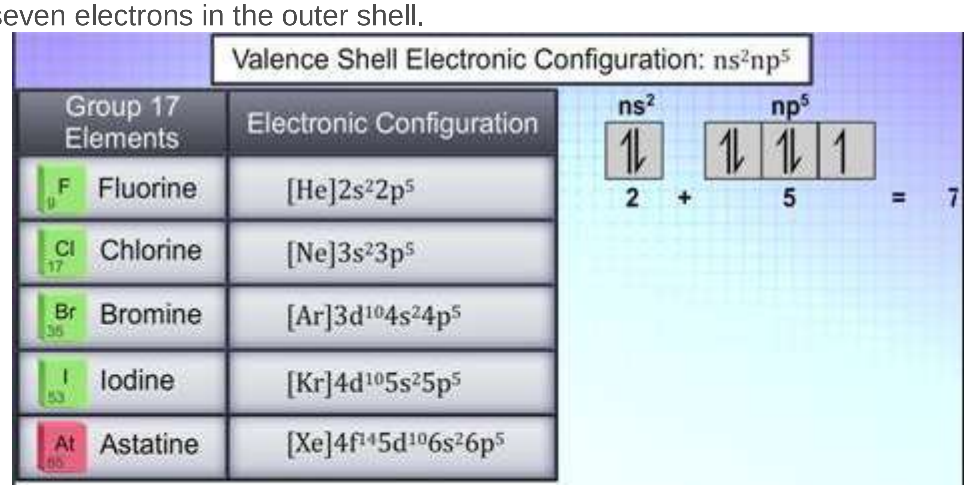


Fig. 1: Group 17 elements

These elements are on the whole alluded to as the "**halogens**" as they react with metals to give salts.

Electronic Configuration

ns^2 np^5 is the valence shell electronic configuration of these elements which makes clear why there are seven electrons in the outer shell.



Group 17 Elements	Electronic Configuration
F 9 Fluorine	$[He]2s^22p^5$
Cl 17 Chlorine	$[Ne]3s^23p^5$
Br 35 Bromine	$[Ar]3d^{10}4s^24p^5$
I 53 Iodine	$[Kr]4d^{10}5s^25p^5$
At 85 Astatine	$[Xe]4f^{14}5d^{10}6s^26p^5$

Fig. 2: Electronic configuration of group 17 elements

The valence shell is short of an octet configuration by one electron. As these elements require one electron to achieve stable octet or closest ideal gas configuration, they have a strong inclination to either increase one electron to shape an ionic bond or impart an electron to another atom to frame a covalent bond.

The halogens constitute the most reactive group of non-metals. The high reactivity of the halogens is credited to their strong inclination to pick up or share an electron to accomplish closest inert gas configuration.

Occurrence

Inferable from their high reactivity, the halogens do not exist in Free State, yet in the consolidated state in nature, aside from astatine.

Astatine is radioactive in nature.
Fluorine is the 13th and **chlorine** the 20th most rich element by weight in the crust of the world.
Fluorineexist broadly as insoluble fluorides, for example, cryolite(Na_3AlF_6), fluorspar(CaF_2), and fluoroapatite ($Ca_5(PO_4)_3F$). Of these, the primary source is fluorspar. Little measures of fluorine are available in soil, plants of stream water, and the bones and teeth of creatures.
Chlorine, bromine, and i**odine** are available in ocean water as chlorides, bromides, and iodides of profoundly dynamic metals like sodium, potassium, magnesium and calcium. Of these, the richest is sodium chloride. Ocean water comprises around 1.5 % by weight of sodium chloride.

The dry beds of oceans additionally contain vast stores of sodium chloride alongside littler extents of calcium chloride and carnallite ($KCl.MgCl_2.6H_2O$).

Iodides are found in trace amounts in ocean water. The primary wellspring of iodine is ocean weeds and crude chile salt petre.

Atomic Properties

Patterns of a portion of the atomic properties of group 17 elements:

Atomic properties incorporate ionic and atomic radii, electron gain enthalpy, ionization enthalpy, and electro-negativity.

Trend of Ionic and Atomic Radii

As we move down the group, the nuclear radii, and ionic radii increment because of the addition of another vital energy level in each progressive element.

These elements have the smallest atomic radii when contrasted with different elements in the relating periods. This is a direct result of greatest powerful atomic charge.

Atomic size	**Increases down group**	**F**	**C*l***	**Br**	**I**
	Covalent radius / nm	0.064	0.099	0.111	0.128
Ionic size	**Increases down group**	**F^-**	**Cl^-**	**Br^-**	**I^-**
	Ionic radius / nm	0.136	0.181	0.195	0.216

Fig. 3: Trends in atomic and ionic radii

Ionisation Enthalpy

Group 17 Elements	Ionisation Enthalpy ($kJ\ mol^{-1}$)	Atomic Radius (pm)
F Fluorine	1680	64
Cl Chlorine	1256	99
Br Bromine	1142	114
I Iodine	1008	133
At Astatine	890	-

These elements demonstrate high estimations of ionization enthalpy. As an outcome, the molecules of these elements tend to lose electrons and frame positive particles. As we move down the group, the value of ionization energy diminishes. This is because of the steady increment in the nuclear size, which decreases the drive of fascination between the valence electrons and the core.

The ionization enthalpy of fluorine is considerably higher than any other halogen, which is ascribed to its little size.

Fig. 4: Ionization enthalpy of group 17 elements

Electron Gain Enthalpy

Halogens have the most extreme negative electron pick up enthalpy in the particular time frames.

The electron gain enthalpy turns out to be less negative on moving down the group.

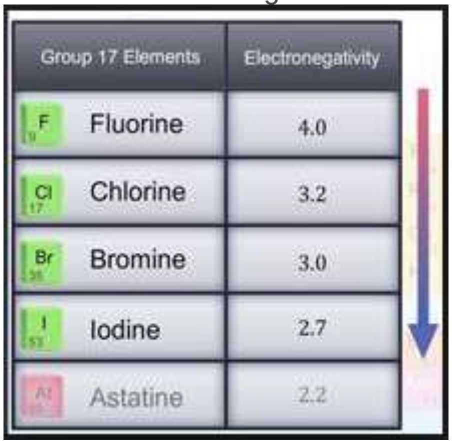
Fluorine has less negative electron pick up enthalpy than chlorine. I.e. chlorine has the most extreme negative electron pick up enthalpy among every one of the elements. It is a result of the small size and reduced 2p sub-shell of the fluorine atom. Attributable to the small size of the fluorine particle, the approaching electron encounters a more noteworthy measure of repulsion from the electrons that are now present. The electron-electron repulsion between the approaching electron and the electrons officially introduced exceed the magnetism between the additional electron and the nucleus.

Electron Gain Enthalpy	$kJ\ mol^{-1}$
F	-333
CI	-348
Br	-324

Electro-Negativity

The halogens have high electro-negativity values. You can see from the estimations of electro-negativity in the table that the electro-negativity diminishes slowly on moving down the group from fluorine to iodine because of the relative increase in the nuclear radii.

Fluorine, in the periodic table, is the most electronegative element.



Group 17 Elements	Electronegativity
F 9 Fluorine	4.0
Cl 17 Chlorine	3.2
Br 35 Bromine	3.0
I 53 Iodine	2.7
At Astatine	2.2

Fig. 5: Electronegativity of group 17 elements

Physical Properties and Oxidation States

Group 17 elements are called halogens.Halogens are the most electronegative elements in the periodic table.

Physical Properties

Physical properties includephysical state, color, solubility, metallic character, density, melting and boiling point, bond dissociation energy.

Physical state: The group 17 elements exist in various physical state

F,Cl are gases

Br is a liquid

I is a solid

All these are diatomic in nature.

Color: These elements displays diverse colors

F→ Pale yellow color

Cl → Greenish yellow color

Br → Reddish brown color

I → Dark violet color

Solubility: F, Cl are soluble in water

Br, I are sparingly dissolvable in water yet totally dissolvable in organic solvents.

Halogen	Color in water	Organic Solvent
Fluorine	Plae Yellow	Yellow
Chlorine	Greenish Yellow	Green
Bromine	Reddish Brown	Brown
Iodine	Brown	Purple
Astatine		

Metallic Nature: The metallic nature increases as we move down the group. Due to high ionization enthalpy values all these elements are non metallic in nature.
Density: The densities increases moving from F to I

Halogen	Density
Fluorine	0.0017
Chlorine	0.0032
Bromine	3.1028
Iodine	4.933
Astatine	

Melting and boiling points: Melting and boiling points of these elements increase regularly from Fluorine to Iodine.
Bond dissociation energy: Bond dissociation energies of these elements step by step diminishes from top to base with the exception of fluorine.
Oxidation states: General electronic configuration: **ns^2 np^5**
These elements have 7 electrons in their valence shell. They require 1 electron to finish their octet. It can be accomplished by picking up or by sharing the electron. Hence, the normal oxidation state of these elements is – 1.
These elements likewise show +1, +3, +5 oxidation states alongside - 1 oxidation state.
Exception: Fluorine shows - 1 oxidation state simply because it doesn't have any d-orbital in their valence shell.

Cl, Br &I all displays distinctive oxidation states +1, +3, +5, +7. This is because of the nearness of empty d-orbital in their valence shells.

These positive oxidation states are seen in interhalogens, oxoacids, and oxides.

Selected Properties of the Group 7 Halogens					
Symbol and Name	Atomic Number	Electron arrangement	State and color at room temperature, color of vapor when heated	Melting point	Boiling point
F Fluorine	9	2.7		-220°C, 53K	-188°C 85K
Cl Chlorine	17	2.8.7		-101°C, 172K	-34°C, 239K
Br Bromine	35	2.8.18.7		-7°C, 266K	59°C, 332K
I Iodine	53	2.8.18.18.7		114°C, 387K	185°C, 458K
At Astatine	85	2.8.18.32.18.7		302°C 575K	337°C 610K

Fig. 6: Selected properties of group 17 elements

Chemical Properties

Oxidizing Power

Since all halogens have a strong inclination to acknowledge electrons, they go about as great oxidizing agents. Out of the considerable number of halogens, fluorine is the most grounded oxidizing agent and can oxidize all other halide particles to halogen in a solution. As we move down the group from F to I, oxidizing power diminishes. Henceforth chlorine can oxidize bromide particle to bromine and in addition iodide particles to iodine.

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

$$Cl_2 + 2I^- \rightarrow I_2 + 2Cl^-$$

Similarly, bromine can oxidize iodide particle to iodine.

$$Br_2 + 2\ I^- \rightarrow I_2 + 2Br^-$$

	Cl_2(aq)	Br_2(aq)	I_2(aq)
Cl^-(aq)		Stays yellow solution (no reaction)	Stays brown solution (no reaction)
Br^- (aq)	Yellow solution forms (Br_2 forms) $Cl_2 + 2\ Br^- \rightarrow 2\ Cl- + Br_2$		Stays brown solution (no reaction)

I^-(aq)	Brown solution forms (I2 forms) $Cl_2 + 2 I^- \rightarrow 2 Cl^- + I^2$	Brown solution forms(I_2 forms) $Br^2 + 2 I^- \rightarrow 2 Br^- + I_2$	

Despite what might be expected, halide particles act as reducing agents. Their reducing capacity diminishes from fluoride particle to iodide particle.

Reaction with Hydrogen

All halogens react with hydrogen to form acidic hydrogen halides. The acidity of these hydrogen halides reduces from HF to HI. Regardless, the reactivity of halogens towards hydrogen lessens from fluorine to iodine. Fluorine in dark reacts brutally; chlorine requires the sunshine, while bromine reacts with hydrogen just on heating. Iodine reacts with hydrogen on heating in the presence of a catalyst.

In dark

$$H_2 + F_2 \rightarrow 2HF$$

In sunlight

$$H_2 + Cl_2 \rightarrow 2HCl$$

Δ

$$H_2 + Br_2 \rightarrow 2HBr$$

Δ

$$H_2 + I_2 \rightarrow 2HI$$

Reaction with Oxygen

Like diverse elements, halogens in similar manner form oxides with oxygen. But, by far most of the oxides of halogen are not steady. Beside oxides, halogens also shape halogen oxoacids and oxoanions. The general condition for oxides is in the range from X_2O to X_2O_7, while the general condition for oxoacids is in the scope of HOX to $HOXO_3$ (there is just HOF with fluorine) and for oxoanions are shaped in the range from XO^- to XO_4^-.

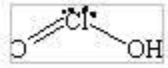
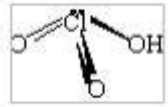
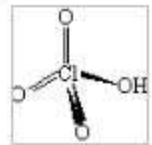
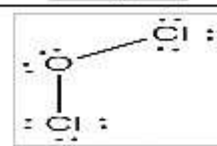
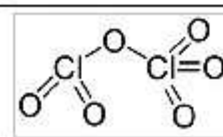
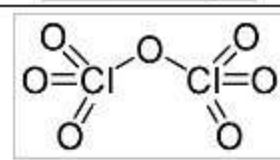
HOCl	hypochlorite	
HOClO	chlorite	
$HOClO_2$	chlorate	
$HOClO_3$	perchlorate	
Cl_2O	Dichlorine monoxide	
ClO_2	Chlorine oxide	O=Cl=O
Cl_2O_6	Dichlorine hexoxide	
Cl_2O_7	Dichlorine heptoxide	

Fig. 7: Oxides of halogens

Reaction with Metals

In view of the high reactivity of halogens, they instantly react with most of the metals to form the resulting metal halides. For example, sodium reacts with chlorine gas to shape sodium chloride. Making of sodium chloride is an exothermic reaction and produces a splendid yellow light with a great deal of heat energy.

$$2Na_{(s)} + Cl_{2(g)} \rightarrow 2NaCl_{(s)}$$

Metal halide is ionic in nature in light of the high electro negativity of halogen and high electro positivity of metals. The ionic character of metal halides reduces from fluorine to iodine.

Reaction with other Halogens

Halogens reacts with each other to shape **Interhalogen compounds**. The general recipe of these compounds is XYn, where n = 1, 3, 5 or 7. In a given equation, "X" must be the less electronegative halogen contrasted with "Y".

XY	XY_3	XY_5	XY_7
ClF, BrF, BrCl, ICl, IBr, IF	ClF_3, BrF_3,IF_3, ICl_3	BrF_5	IF_7

Anomalous Behaviour of Fluorine

The anomalous behaviour in properties like **ionization energy**, **bond dissociation energy**, **electro-negativity**, **electrode potentials**, **ionic and covalent radii**, **electron gain enthalpy**, **melting point**, and **boiling point** is because of the **small nuclear size**, **high electro-negativity**, **low bond separation energy** and **no accessibility of d-orbitals** in the valence shell of Fluorine.

Uses of Halogens

- Fluorine compounds are utilized as a part of toothpaste and some drinking water supplies since fluoride compounds react with teeth enamel and counteract tooth rotting.
- Chlorine is utilized for bleaching reasons, in the metallurgy of gold and platinum, furthermore in the arrangement of natural halogen compounds.
- Chlorine is utilized as a part of the cleansing of drinking water.
- Since iodine kills the germs on the skin without harming the skin itself, it is utilized as an antiseptic.

Selected properties of group 17 are tabulated below:

Property	Fluorine	Chlorine	Bromine	Iodine	Astatine
Atomic Symbol	Fluorine	Cl	Br	I	At
Atomic Number	9	17	35	53	85
Atomic Mass (AMU)	19	35.45	79.9	126.9	210
Valence Electron Configuration	$2s^2\ 2p^5$	$3s^2 3p^5$	$4s^2\ 4p^5$	$5s^2\ 5p^5$	$6s^2 6p^5$
Melting Point/Boiling Point (°C)	-220/-188	-102/-34.0	-7.2/58.8	114/84	302/-
Density (g/cm3) at 25°C	1.55 (g/L)	2.90 (g/L)	3.1	4.93	-
Atomic Radius (PM)	42	79	94	115	127
First Ionization Energy (KJ/mol)	1681	1251	1140	1008	926
Normal Oxidation State(s)	-1	-1 + (+1, +3, +5, +7)	-1(+1, +3, +5, +7)	-1(+1, +3, +5, +7)	-1, +1
Ionic Radius (PM)$^+$	133	181	196	220	-

Electron Affinity (kJ/mol)	-328	-349	-325	-295	-270
Electrone Gravitiy	4.0	3.2	3.0	2.7	2.2
Standard Reduction Potential (E°, V) ($X_2 \rightarrow X^-$ in the basic solution)	+ 2.87	+1.36	+10.7	+0.54	+0.30
Dissociation Energy of X_2(g) (kJ/mol)	158.8	243.6	192.8	151.1	80
Product of Reaction with O_2	O_2F_2	None	None	None	None
Type of Oxide	Acidic	Acidic	Acidic	Acidic	Acidic
Product of Reaction with N_2	None	None	None	None	None
Product of Reaction with H_2	HF	HCI	HBr	HI	Hat
The configuration shown does not include filled d and f subshells.					
[+]**The value cited are ffor the six-coordinate anion (X^-)**					