Topic 4. 2. Elements 17 (7A) group. Study of the properties of halogens and the determination of halide ions in aqueous solution.

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Лантаноиды	57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu
Актиноиды	89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr

Introduction

Halogens are elements of group VIIA of the periodic table: fluorine F, chlorine Cl, bromine Br, iodine I and astatine At.

Astatine is a radioactive element and is rare in nature.

All halogens are non-metals.

In the halogen atoms at the external energy level there are 7 electrons each:

$F \quad +9 \;))$
$\quad\quad 2\,7$

$Cl \quad +17 \;)))$
$\quad\quad 2\,8\,7$

$Br \quad +35 \;))))$
$\quad\quad 2\,8\,18\,7$

$I \quad +53 \;)))))$
$\quad\quad 2\,8\,18\,18\,7$

Introduction

The valence electrons of the halogens form three electron pairs, and one electron of the external energy level remains unpaired.

As the atomic number increases from fluorine to iodine, the radii of the atoms increase, and their electronegativity decreases. This means that the non-metallic properties of halogens in the group weaken from top to bottom.

To fill of the outer electron layer, halogen atoms lack only one electron, so they are most characterized by the oxidation state –1.

Introduction

Fluorine has a higher electronegativity than other elements, and therefore the oxidation state –1 is its only possible oxidation state in compounds.

Atoms of other halogens are also capable of donating valence electrons, while exhibiting positive oxidation states +1, +3, +5, +7. Thus, chlorine atoms exhibit positive oxidation states in compounds with more electronegative fluorine, oxygen and nitrogen.

Halogens form compounds with an ionic bond with metals, and compounds with a covalent polar bond with other non-metals.

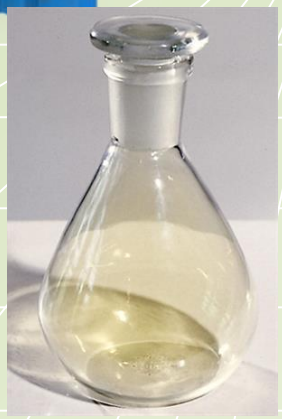
General characteristics of simple substances

Halogen atoms combine in pairs and form diatomic molecules: F_2, Cl_2, Br_2, I_2.

The bond in molecules is covalent, non-polar, single. The crystal lattice is molecular. Therefore, halogens have low boiling and melting points.

Under normal conditions, fluorine is a light yellow gas, chlorine is a yellow-green gas, bromine is a red-brown liquid, and iodine is dark purple crystals.

General characteristics of simple substances



Fluorine

Chlorine

Bromine

Iodine

General characteristics of simple substances

When heated, solid iodine easily sublimes (goes into a gaseous state and back to a solid, without turning into a liquid).

Sublimation of the iodine

General characteristics of simple substances

All halogens have a strong, unpleasant odor and are highly toxic.

In the series of halogens, with an increase in the relative molecular weight, the boiling and melting points increase, the density increases, and the color becomes more intense.

Halogens are slightly soluble in water.

Fluorine enters into a chemical reaction with water and displaces oxygen from it:

$$2F_2 + 2H_2O = 4HF + O_2 \uparrow.$$

2. Chemical properties of halogens

Halogens are reactive substances. In reactions with metals and most non-metals, as well as with complex substances, halogens exhibit strong oxidizing properties. Fluorine is the most active in chemical reactions. With increasing molecular weight, the activity of halogens decreases.

2. Chemical properties of halogens

Interaction with metals

When halogens interact with metals, salts are formed: fluorides, chlorides, bromides, iodides.

Fluorine reacts with all metals (even with gold and platinum), with most - under normal conditions:

$Ca + F_2 = CaF_2$,

$2Au + 3F_2 \xrightarrow{t} 2AuF_3$.

The rest of the halogens react with metals when heated:

$2Fe + 3Cl_2 \xrightarrow{t} 2FeCl_3$,

$Cu + Br_2 \xrightarrow{t} CuBr_2$,

$2Al + 3I_2 \xrightarrow{t} 2AlI_3$.

2. Chemical properties of halogens

Interaction with hydrogen

In the reactions of halogens with hydrogen, gaseous hydrogen halides are formed.

Fluorine reacts with hydrogen explosively to form hydrogen fluoride:

$$H_2 + F_2 = 2HF.$$

A mixture of chlorine and hydrogen explodes only when ignited or illuminated. As a result of the reaction, hydrogen chloride is formed:

$$H_2 + Cl_2 \overset{t}{=} 2HCl.$$

Bromine begins to react with hydrogen only when heated, and the reaction proceeds without explosion. The reaction product is hydrogen bromide:

$$H_2 + Br_2 \overset{t}{=} 2HBr.$$

2. Chemical properties of halogens

The reaction of iodine with hydrogen is slow, even when heated. Iodine with hydrogen form hydrogen iodide gas:

$$H_2 + I_2 \overset{t}{=} 2HI.$$

By the example of these reactions, a decrease in the chemical activity of substances in the series: fluorine - chlorine - bromine - iodine is traced.

All hydrogen halides are readily soluble in water. Their solutions are acids:
HF - hydrofluoric, HCl - hydrochloric, HBr - hydrogen bromide, HI - hydrogen iodide.

The strength of acids in this series increases. The weakest of them is hydrofluoric acid, the strongest is hydroiodic acid.

2. Chemical properties of halogens

The each other displacements of Halogens from salts

In the reactions of halogens with halides, the following pattern appears: the more active halogen displaces the less active from its salts. So, chlorine interacts with aqueous solutions of bromides and iodides, acting as an oxidizing agent in these reactions:

$$2KBr^{-1} + Cl^{0}_{2} = Br^{0}_{2} + 2KCl^{-1},$$

$$2Na^{-1} + Cl^{0}_{2} = I^{0}_{2} + 2NaCl^{-1}.$$

2. Chemical properties of halogens

Bromine is able to displace iodine from iodides, but does not react with chlorides:

$$2KI^{-1} + Br^{0}_{2} = I^{0}_{2} + 2KBr^{-1}.$$

Iodine has no ability to displace other halogens, since its oxidizing properties are the weakest among halogens.

Reactions of fluorine with aqueous solutions of salts are impossible due to its interaction with water.

3. Chlorine and its compounds

Chlorine

Chlorine is a poisonous, yellow-green gas with an unpleasant odor. It is 2.5 times heavier than air.

Chlorine is slightly soluble in water. At room temperature, 2.5 volumes of chlorine are dissolved in 1 volume of water. The resulting solution is called chlorine water.

Chlorine is an oxidizing agent in chemical reactions.

3. Chlorine and its compounds

An industrial method for producing chlorine is electrolysis of a melt or sodium chloride solution:

$2NaCl = 2Na + Cl_2 \uparrow$,

$2NaCl + 2H_2O = 2NaOH + Cl_2 \uparrow + H_2 \uparrow$.

In the laboratory, it is obtained by the reaction of hydrochloric acid with manganese (IV) oxide:

$4HCl + MnO_2 = MnCl_2 + Cl_2 \uparrow + 2H_2O$.

3. Chlorine and its compounds

Hydrogen chloride

Hydrogen chloride is formed by the interaction of chlorine with hydrogen:

$$H_2 + Cl_2 \overset{t}{=} 2HCl.$$

It can also be obtained by the action of concentrated sulfuric acid on solid chlorides: v

$$H_2SO_4\ (c) + 2NaCl \overset{t}{=} 2HCl\uparrow + Na_2SO_4.$$

The chemical bond in the hydrogen chloride molecule is covalent polar: $H^{\delta+} \rightarrow Cl^{\delta-}$. It is a colorless gas with a pungent odor, heavier than air. Hydrogen chloride dissolves very well in water: up to 500 volumes of hydrogen chloride are dissolved in 1 volume of water.

3. Chlorine and its compounds

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Hydrochloric acid

A solution of hydrogen chloride in water is called hydrochloric acid. It is a colorless odorless liquid. The maximum content of hydrogen chloride in it is 37%. Hydrochloric acid belongs to strong monobasic acids with properties characteristic of these substances.

Hydrochloric acid:
changes the color of indicators;
interacts with metals located in the line of activity up to hydrogen:

$Fe + 2HCl = H_2 + FeCl_2$;

interacts with basic and amphoteric oxides:

$ZnO + 2HCl = H_2O + ZnCl_2$;

3. Chlorine and its compounds

interacts with bases and amphoteric hydroxides:

$KOH + HCl = H_2O + KCl$;

interacts with salts if the reaction product is a gas, a precipitate or a weak electrolyte (with carbonates, silicates, sulfides, soluble silver salts, etc.):

$CaCO_3 + 2HCl = CaCl_2 + H_2O + CO_2 \uparrow$,

$Na_2S + 2HCl = 2NaCl + H_2S \uparrow$,

$AgNO_3 + HCl = HNO_3 + AgCl \downarrow$.

3. Chlorine and its compounds

Chlorides

Most hydrochloric acid salts are readily soluble in water. Silver chloride is insoluble. It precipitates in the form of a white curdled precipitate when a solution of silver nitrate interacts with hydrochloric acid or chloride solutions. This reaction is used as a qualitative reaction for chlorine ions. Short ionic equation:

$Ag^{+} + Cl^{-} = AgCl \downarrow$.

4. Halogens in nature. The use of halogens and their compounds

Halogens in nature

Halogens are chemically active substances, so in nature they are found only in the form of compounds.

Fluorine occurs in the form of fluorite CaF_2, cryolite Na_3AlF_6, and some other minerals.

Fluorite

Cryolite

4. Halogens in nature. The use of halogens and their compounds

The most common chlorine compounds are rock salt (halite) NaCl and sylvinite KCl · NaCl.

rock salt (halite)

sylvinite

4. Halogens in nature. The use of halogens and their compounds

Bromine and iodine do not form their own minerals. Their compounds are found in sea water and accumulate in algae.

Brown algae

4. Halogens in nature. The use of halogens and their compounds

Halogens in living organisms

All halogens are poisonous, but their compounds are vital for living organisms, including humans.

Fluoride compounds are part of the bone tissue and tooth enamel. With a lack of fluoride, tooth enamel is destroyed and caries appears.

Chlorine is one of the macronutrients and is necessary for the normal functioning of organisms. Sodium chloride is a part of blood plasma, supports the activity of all cells. It forms hydrochloric acid, which is contained in gastric juice.

4. Halogens in nature. The use of halogens and their compounds

Bromine compounds regulate the processes of inhibition and excitation of the nervous system.

Iodine must necessarily enter the body, as it participates in the formation of thyroid hormones that control metabolism. With its lack, goiter develops - a disease of the thyroid gland. For the prevention of goiter, iodized salt is used (potassium iodide is added to table salt).

4. Halogens in nature. The use of halogens and their compounds

The use of halogens and their compounds

Oxygen fluoride is used as a rocket fuel oxidizer. Teflon (fluorinated polymer) is used for heat resistant coatings. Fluoride compounds are included in toothpastes for the prevention of caries.

4. Halogens in nature. The use of halogens and their compounds

Molecular chlorine is used for water disinfection, for bleaching fabrics, paper, wood.

A large amount of chlorine is consumed in the production of hydrochloric acid, as well as plastics, rubbers, solvents, and dyes.

4. Halogens in nature. The use of halogens and their compounds

Table salt is added to food, and potassium salt (potassium chloride) is added to the soil as a potassium fertilizer.

Bromine and iodine compounds are used in medicine for the treatment and prevention of certain diseases. An alcohol solution of iodine is used to treat wounds and scratches.

1.Cl_2 reacts with substance (s):

A)CuCl2

B)LiI

C)CuBr2

D)FeF3

2.Note the property of hydrogen chloride:

A)forms a white precipitate with silver nitrate

B)insoluble in water

C)discolors indicators

D)heavier than air

3.Choose the correct statements:

A)living organisms do not contain halogen atoms

B)a decrease in the production of thyroid hormones occurs when there is a lack of bromine in the body

C)hydrochloric acid is a part of gastric juice

D)bromine compounds are used in medicine

4.In the series F - Cl - Br - I, it decreases:

A)number of protons in the nucleus

B)the number of electrons required to complete the outer layer

C)Electronegativity

5. Fluorine has the highest melting point among halogens.

A)False

B)True

6.Bromine has the highest electronegativity among halogens.

A)False

B)True

7. Hydrochloric acid does not react with the substance:

A)Mg

B)$Cu(OH)_2$

C)$AgNO_3$

D)K_2SO_4

8.All substances of the series enter into a reaction with hydrochloric acid:

A)Ag, Cu, Au

B)$Ca(OH)_2$, CaO, $CaCO_3$

C)$MgCO_3$, MgO, CO_2

D)$Ba(OH)_2$, $AgNO_3$, Na_2S

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