PERIOD 3 ELEMENTS

A LEVEL CHEM
INORGANIC NOTES 1

1. **With water;**

Sodium and magnesium are ***reducing agents***, they are ***oxidized*** by ***cold water*** to ***hydroxides*** *and itself* ***reduced*** *to* ***hydrogen gas.***

$$Na_{(s)} + H_2O_{(l)} \rightarrow NaOH_{(aq)} + \frac{1}{2}H_{2(g)}$$

$$Mg_{(s)} + 2H_2O_{(l)} \rightarrow Mg(OH)_{2(s)} + H_{2(g)}$$

Magnesium is a ***reducing agent***, it is ***oxidized*** by ***steam on heating*** to form ***magnesium oxide*** *and itself* ***reduced*** *to* ***hydrogen gas***.

$$Mg_{(s)} + H_2O_{(g)} \rightarrow MgO_{(s)} + H_{2(g)}$$

Aluminium doesn't react with water due to the presence of an ***insoluble oxide layer on its surface.***

Silicon is a reducing agent, it is ***oxidized*** by ***steam on heating*** to form ***silicon dioxide*** and *itself* ***reduced*** *to* ***hydrogen gas***

$$Si_{(s)} + 2H_2O_{(g)} \rightarrow SiO_{2(s)} + 2H_{2(g)}$$

Phosphorous is a reducing agent, it is ***oxidized*** by ***steam on heating*** to form ***phosphorous acid*** *and itself* ***reduced*** *to* ***hydrogen gas.***

$$P_{(s)} + 3H_2O_{(g)} \rightarrow H_3PO_{3(aq)} + \frac{3}{2}H_{2(g)}$$

Chlorine gas ***disproportionates*** in ***cold water*** to form ***hypochlorous acid*** *and* ***hydrochloric acid***.

$$Cl_{2(g)} + H_2O_{(l)} \rightarrow HCl_{(aq)} + HOCl_{(aq)}$$

Sulphur does not react with water due to its ***octa-atomic structure*** which is stable with strong ***Van der Waal's forces of attraction***.

2. **With alkalis**

Sodium and magnesium are ***basic,*** they ***do not react with alkalis.***

Aluminium is ***amphoteric,*** it reacts with ***hot concentrated alkalis*** to form ***aluminate ions*** *and* ***hydrogen gas.***

$$Al_{(s)} + OH^-_{(aq)} + 3H_2O_{(l)} \rightarrow Al(OH)^-_{4\,(aq)} + \frac{3}{2}H_{2\,(g)}$$

Or $$Al_{(s)} + OH^-_{(aq)} + H_2O_{(l)} \rightarrow AlO^-_{2\,(aq)} + \frac{3}{2}H_{2\,(g)}$$

Silicon is ***acidic,*** it reacts with ***hot concentrated alkalis*** to form a ***silicate ion*** *and* ***hydrogen gas***

$$Si_{(s)} + 2OH^-_{(aq)} + H_2O_{(l)} \rightarrow SiO^{2-}_{3\,(aq)} + 2H_{2\,(g)}$$

Phosphorus is ***acidic,*** it reacts with ***hot concentrated alkalis*** to form a ***hypophosphite ion*** *and* ***phosphine gas.***

$$P_{4(s)} + 3OH^-_{(aq)} + 3H_2O_{(l)} \rightarrow 3H_2PO^-_{2\,(aq)} + PH_{3(g)}$$

Sulphur is ***acidic,*** it reacts with ***hot concentrated alkalis*** to form a ***sulphite, sulphide*** and ***water***.

$$3S_{(s)} + 6OH^-_{(aq)} \rightarrow SO^{2-}_{3(aq)} + 2S^{2-}_{(aq)} + 3H_2O_{(l)}$$

Chlorine ***disproportionates*** in ***cold dilute alkalis*** to form a ***chloride, chlorate(I)*** *and* ***water***.

$$Cl_{2(s)} + 2OH^-_{(aq)} \rightarrow Cl^-_{(aq)} + ClO^-_{(aq)} + H_2O_{(l)}$$

Chlorine also ***disproportionates*** in ***hot concentrated alkalis*** to form a ***chloride, chlorate(V)*** and ***water.***

$$3Cl_{2(s)} + 6OH^-_{(aq)} \rightarrow 5Cl^-_{(aq)} + ClO^-_{3(aq)} + 3H_2O_{(l)}$$

3. **With acids**

Sodium and magnesium are ***basic***, they react with ***cold dilute acids*** to form a ***salt*** and ***hydrogen gas***

$$Na_{(s)} + H^+_{(aq)} \rightarrow Na^+_{(aq)} + \frac{1}{2}H_{2(g)}$$
$$Mg_{(s)} + 2H^+_{(aq)} \rightarrow Mg^{2+}_{(aq)} + H_{2(g)}$$

Aluminium is ***amphoteric***, it reacts with ***cold dilute acids*** to for a ***salt*** and ***hydrogen gas.***

$$Al_{(s)} + 3H^+_{(aq)} \rightarrow Al^{3+}_{(aq)} + \frac{3}{2}H_{2(g)}$$

Silicon is ***acidic,*** it reacts with ***cold dilute hydrofluoric acid*** to form ***silicon tetrafluoride*** (***or hexafluorosilicic acid***) and ***hydrogen gas*** due to formation of ***stable silicon to fluorine bonds***.

$$Si_{(s)} + 4HF_{(aq)} \rightarrow SiF_{4\,(g)} + 2H_{2(g)}$$

Or

$$Si_{(s)} + 6HF_{(aq)} \rightarrow H_2SiF_{6\,(aq)} + 2H_{2(g)}$$

OXIDES OF PERIOD 3 ELEMENTS

1. **With water.**

Sodium oxide and magnesium oxide are ***basic anhydrides,*** they react in ***cold water*** to form the corresponding ***hydroxides.***

$$Na_2O_{(s)} + H_2O_{(l)} \rightarrow 2NaOH_{(aq)}$$
$$MgO_{(s)} + H_2O_{(l)} \rightarrow Mg(OH)_{2(s)}$$

Aluminium oxide is **amphoteric**, it does not react with water.

Silicon dioxide is an ***acidic anhydride***, it reacts with water on ***heating and high pressure*** to form ***silicic acid***.

$$SiO_{2(s)} + H_2O_{(l)} \rightarrow H_2SiO_{3(aq)}$$

Phosphorous trioxide and phosphorous pentoxide are ***acidic anhydrides***, they react with ***cold water*** to form ***phosphorous acid*** and ***phosphoric acid*** respectively.

$$P_2O_{3(s)} + 3H_2O_{(l)} \rightarrow 2H_3PO_{3(aq)}$$
$$P_2O_{5(s)} + 3H_2O_{(l)} \rightarrow 2H_3PO_{4(aq)}$$

Sulphur dioxide and sulphur trioxide are ***acidic anhydrides***, they react with ***cold water*** to form ***sulphurous acid*** and ***sulphuric acid*** respectively.

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$$SO_{2(g)} + H_2O_{(l)} \rightarrow H_2SO_{3(aq)}$$
$$SO_{3(g)} + H_2O_{(l)} \rightarrow H_2SO_{4(aq)}$$

Chlorine(I) oxide, and chlorine(VII) oxide are ***acidic anhydrides*** they react with ***cold water*** to form ***chloric(I) acid*** and ***chloric(VII) acid*** respectively.

$$Cl_2O_{(g)} + H_2O_{(l)} \rightarrow 2HOCl_{(aq)}$$
$$Cl_2O_{7(g)} + H_2O_{(l)} \rightarrow 2HClO_{4(aq)}$$

2. **With alkalis**

Sodium and magnesium oxides are ***basic***, they **do not react** with alkalis.

Aluminium oxide is **amphoteric**, it reacts with ***hot concentrated alkalis*** to form ***aluminate ions***.

$$Al_2O_{3(s)} + 2OH^-_{(aq)} + 3H_2O_{(l)} \rightarrow 2Al(OH)^-_{4\,(aq)}$$

Silicon dioxide is ***acidic***, it reacts with ***hot concentrated alkalis*** to form a ***silicate*** and ***water.***

$$SiO_{2(s)} + 2OH^-_{(aq)} \rightarrow SiO^{2-}_{3\,(aq)} + H_2O_{(l)}$$

Phosphorous trioxide and phosphorus pentoxide are ***acidic***, they react with ***cold dilute alkalis*** to form a ***phosphite*** and ***phosphate ion*** *respectively* and ***water.***

$$P_2O_{3\,(s)} + 6OH^-_{(aq)} \rightarrow 2PO^{3-}_{3\,(aq)} + 3H_2O_{(l)}$$

$$P_2O_{5\,(s)} + 6OH^-_{(aq)} \rightarrow 2PO^{3-}_{4\,(aq)} + 3H_2O_{(l)}$$

Sulphur dioxide and sulphur trioxide are **acidic,** they react with ***cold dilute alkalis*** to form a ***sulphite*** and **sulphate** respectively and ***water***.

$$SO_{2(g)} + 2OH^-_{(aq)} \rightarrow SO^{2-}_{3\,(aq)} + H_2O_{(l)}$$

$$SO_{3(g)} + 2OH^-_{(aq)} \rightarrow SO^{2-}_{4\,(aq)} + H_2O_{(l)}$$

Chlorine(I) oxide and Chlorine(VII) oxide are ***acidic***, they react with ***cold dilute alkalis*** to form a ***chlorate(I)*** and ***chlorate(VII)*** respectively and ***water.***

$$Cl_2O_{(g)} + 2OH^-_{(aq)} \rightarrow 2ClO^-_{(aq)} + H_2O_{(l)}$$

$$Cl_2O_{7(g)} + 2OH^-_{(aq)} \rightarrow 2ClO^-_{4(aq)} + H_2O_{(l)}$$

3. **With dilute acids;**

Sodium oxide and magnesium are ***basic***, they react with ***cold dilute acids*** to form the corresponding ***salts and water.***

$$Na_2O_{(s)} + 2H^+_{(aq)} \rightarrow 2Na^+_{(aq)} + H_2O_{(l)}$$

$$MgO_{(s)} + 2H^+_{(aq)} \rightarrow Mg^{2+}_{(aq)} + H_2O_{(l)}$$

Aluminium oxide is ***amphoteric***, it reacts with ***cold dilute acids*** to form ***a salt*** and ***water.***

$$Al_2O_{3(s)} + 6H^+_{(aq)} \rightarrow 2Al^{3+}_{(aq)} + 3H_2O_{(l)}$$

Silicon dioxide is ***acidic***, it reacts with ***cold dilute hydrofluoric acid*** to form ***silicon tetrafluoride*** or ***hexafluorosilicic acid*** and ***water*** due to the formation of *stable silicon to fluoride bonds.*

$$SiO_{2(s)} + 4HF_{(aq)} \rightarrow SiF_{4\,(g)} + 2H_2O_{(l)}$$

Or

$$SiO_{2(s)} + 6HF_{(aq)} \rightarrow H_2SiF_{6\,(aq)} + 2H_2O_{(l)}$$

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CHLORIDES OF PERIOD 3 ELEMENTS.

1. **With water**

Sodium chloride is strongly ionic, it ***dissociates*** in ***cold water*** to form ***sodium ions*** and **chloride ions**.

$$NaCl_{(s)} \rightarrow Na^+_{(aq)} + Cl^-_{(aq)}$$

Magnesium chloride is **partly covalent**, when ***heated*** undergoes **hydrolysis** to form ***magnesium oxide*** and ***hydrogen chloride gas***

$$MgCl_{2(s)} + H_2O_{(l)} \rightarrow MgO_{(S)} + 2HCl_{(g)}$$

Magnesium chloride is **partly covalent**, it undergoes ***partial hydrolysis*** in ***cold water*** to form ***basic magnesium chloride*** and ***hydrogen chloride gas.***

$$MgCl_{2(s)} + H_2O_{(l)} \rightarrow Mg(OH)Cl_{(s)} + HCl_{(g)}$$

Aluminium chloride is ***partly covalent*** due to its ***high charge density*** hence it undergoes ***hydrolysis in cold water*** to form ***aluminium hydroxide*** and ***hydrogen chloride gas.***

$$AlCl_{3(s)} + 3H_2O_{(l)} \rightarrow Al(OH)_{3(s)} + 3HCl_{(aq)}$$

$$Or\ Al^{3+}_{(aq)} + 3H_2O_{(l)} \rightarrow Al(OH)_{3(s)} + 3H^{+}_{(aq)}$$

Silicon (IV) chloride is covalent, it undergoes hydrolysis in cold water due to the presence of empty d orbitals which accommodate lone pair of electrons from water to form silicon dioxide and hydrogen chloride gas.

$$SiCl_{4(l)} + 2H_2O_{(l)} \rightarrow SiO_{2(S)} + 4HCl_{(g)}$$

Phosphorus trichloride is ***covalent,*** it undergoes ***hydrolysis*** in ***cold water*** to form ***phosphorous acid*** and ***hydrogen chloride gas.***

$$PCl_{3(l)} + 3H_2O_{(l)} \rightarrow H_3PO_{3(aq)} + 3HCl_{(g)}$$

Phosphorus pentachloride is ***covalent***; it undergoes ***hydrolysis*** in ***cold water*** to form ***phosphoric acid*** and ***hydrogen chloride gas.***

$$PCl_{5(s)} + 4H_2O_{(l)} \rightarrow H_3PO_{4(aq)} + 5HCl_{(g)}$$

Di-Sulphur-dichloride is ***covalent***, it undergoes ***hydrolysis*** in ***cold water*** to form ***sulphur, hydrogen chloride gas*** and ***sulphur dioxide.***

$$2S_2Cl_{2(l)} + 2H_2O_{(l)} \rightarrow 3S_{(s)} + SO_{2(g)} + 4HCl_{(g)}$$

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GROUP II ELEMENTS

1. **With air**

   All the elements are ***reducing agents***; they are ***oxidized*** by *air* on **heating** to form ***oxides*** and ***nitrides***.

$$X_{(S)} + \frac{1}{2}O_{2(g)} \rightarrow XO_{(S)}$$
$$3X_{(S)} + N_{2(g)} \rightarrow X_3N_{2(s)}$$

($X = Be, Mg, Ca, Sr, Ba$)

2. **With water**

   Beryllium ***doesn't react*** with water due to the presence of an ***insoluble oxide layer*** on its ***surface***.

   Magnesium, Calcium, Strontium and Barium are ***reducing agents,*** they are ***oxidized*** by **cold water** to ***hydroxides*** and itself **reduced** to ***hydrogen gas.***

$$X_{(S)} + 2H_2O_{(l)} \rightarrow X(OH)_{2(S)} + H_{2(g)}$$

($X = Mg, Ca, Sr, Ba$)

   Magnesium is a ***reducing agent***, it is ***oxidized*** by ***steam on heating*** to form ***magnesium oxide*** *and itself* ***reduced*** *to* ***hydrogen gas***.

$$Mg_{(s)} + H_2O_{(g)} \rightarrow MgO_{(s)} + H_{2(g)}$$

3. **With dilute acids**

   Beryllium is **amphoteric**, it reacts with **warm dilute** acids to **form salt** and **hydrogen gas.**

   Magnesium, Calcium, Strontium and Barium are ***basic***, they react with ***cold*** **dilute** acids to form ***salts*** and ***hydrogen gas***

$$X_{(g)} + 2H^+_{(aq)} \rightarrow X^{2+}_{(aq)} + H_{2(g)}$$

(X = Be, Mg, Ca, Sr, Ba)

EFFECT OF HEAT ON GROUP 2 COMPOUNDS

1. **Hydroxides**

   They ***decompose*** on ***heating*** to form ***oxides*** and ***water***.

$$X(OH)_{2(S)} \rightarrow XO_{(S)} + H_2O_{(l)}$$

(X =Be, Mg, Ca, Sr, Ba)

2. **Sulphates**

   They **decompose** on **heating** to form **oxides** and **Sulphur trioxide.**

$$XSO_{4(S)} \rightarrow XO_{(S)} + SO_{3(g)}$$

(X =Be, Mg, Ca, Sr, Ba)

3. **Nitrates**

   They ***decompose*** on ***heating*** to form ***oxides***, ***nitrogen dioxide*** and ***oxygen***

$$2X(NO_3)_{2(S)} \rightarrow 2XO_{(S)} + 4NO_{2(g)} + O_{2(g)}$$

(X =Be, Mg, Ca, Sr, Ba)

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4. **Carbonates**

   They ***decompose*** on ***heating*** to form ***oxides*** and ***carbon dioxide***

$$XCO_{3(S)} \rightarrow XO_{(S)} + CO_{2(g)}$$

(X =Be, Mg, Ca, Sr, Ba)

REACTION OF GROUP 2 COMPOUNDS WITH DILUTE ACIDS

1. **Hydroxides**

They are ***basic***, they react with ***cold dilute acids*** to form ***salts*** and ***water***.

$$X(OH)_{2(S)} + 2H^+_{(aq)} \rightarrow X^{2+}_{(aq)} + 2H_2O_{(l)}$$

(X =Be, Mg, Ca, Sr, Ba)

2. **Carbonates**

They are **basic**, they react with **cold dilute acids** to form ***salts***, ***carbon dioxide*** and ***water***.

$$XCO_{3(S)} + 2H^+_{(aq)} \rightarrow X^{2+}_{(aq)} + CO_{2(g)} + H_2O_{(l)}$$

(X =Be, Mg, Ca, Sr, Ba)

GROUP 14 ELEMENTS

1. **With water.**

Carbon is a ***reducing agent,*** it is ***oxidized*** by ***steam on heating*** to form ***carbon monoxide*** and itself **reduced** to ***hydrogen gas.***

$$C_{(s)} + H_2O_{(g)} \rightarrow CO_{(g)} + H_{2(g)}$$

Silicon is a ***reducing agent,*** it is **oxidized** by ***steam on heating*** to form ***silicon dioxide*** and itself **reduced** to ***hydrogen gas.***

$$Si_{(s)} + 2H_2O_{(g)} \rightarrow SiO_{2(s)} + 2H_{2(g)}$$

Germanium ***does not react water*** due to the formation of an ***insoluble germanium dioxide.***

Tin is a ***reducing agent,*** it is ***oxidized*** by ***steam on heating*** to form ***tin dioxide*** and itself **reduced** to ***hydrogen gas.***

$$Sn_{(s)} + 2H_2O_{(g)} \rightarrow SnO_{2(s)} + 2H_{2(g)}$$

Lead is a ***reducing agent,*** it is ***oxidized*** by ***soft water*** in the presence of dissolved **oxygen** to form ***lead(II) hydroxide***.

$$Pb_{(s)} + H_2O_{(l)} + \frac{1}{2}O_{2(g)} \rightarrow Pb(OH)_{2(s)}$$

2. **With air.**

Carbon, silicon, germanium and tin are **reducing agents**, they are ***oxidized*** by oxygen ***on heating*** to form ***dioxides.***

$$X_{(s)} + O_{2(g)} \rightarrow XO_{2(s)}$$

$$X = C, Si, Ge, Sn$$

Lead is a ***reducing agent,*** it is ***oxidized*** by oxygen ***on heating*** to form ***lead tetraoxide.***

$$Pb_{(s)} + \tfrac{1}{2}O_{2(g)} \rightarrow PbO_{(s)}$$

$$3PbO_{(s)} + \tfrac{1}{2}O_{2(g)} \rightarrow Pb_3O_{4(s)}$$

3. **With halogens.**

Silicon, germanium and tin are **reducing agents,** they are ***oxidized*** by ***dry chlorine gas*** on **heating** to form ***tetrachlorides.***

$$X_{(s)} + 2Cl_{2(g)} \rightarrow XCl_{4(l)}$$

$$X = Si, Ge, Sn$$

Lead is a **reducing agent**, it is o***xidized*** by ***dry chlorine gas*** on **heating** to form ***lead(II) chloride***

$$Pb_{(s)} + Cl_{2(g)} \rightarrow PbCl_{2(s)}$$

Carbon does not react with chlorine.

GROUP 14 DIOXIDES

1. **With water.**

   Carbon dioxide is an **acidic anhydride**, it reacts with **cold** water to form **carbonic acid**.

   $$CO_{2(g)} + H_2O_{(l)} \rightarrow H_2CO_{3(aq)}$$

   Silicon dioxide is an ***acidic anhydride***, it reacts with water on ***heating*** *and* ***high pressure*** to form ***silicic acid***.

   $$SiO_{2(s)} + H_2O_{(l)} \rightarrow H_2SiO_{3(aq)}$$

   The rest of the dioxides don not react with water under any conditions.

2. **With alkalis.**

   Carbon dioxide is ***acidic***, it reacts with ***cold dilute alkalis*** to form a ***carbonate*** and ***water.***

   $$CO_{2(g)} + 2OH^-_{(aq)} \rightarrow CO^{2-}_{3(aq)} + H_2O_{(l)}$$

   Silicon dioxide is ***acidic***, it reacts with ***hot concentrated alkalis*** to form a ***silicate*** and ***water.***

   $$SiO_{2(s)} + 2OH^-_{(aq)} \rightarrow SiO^{2-}_{3(aq)} + H_2O_{(l)}$$

   Germanium(IV) oxide, tin(IV) oxide and lead(IV) oxide are ***amphoteric,*** they react with ***hot concentrated alkalis*** to form ***germanate(IV)***, ***stannate(IV)*** and ***plumbate(IV)*** **ions** respectively and ***water***.

   $$XO_{2(s)} + 2OH^-_{(aq)} \rightarrow XO^{2-}_{3(aq)} + H_2O_{(l)} \qquad (X = Ge, Sn, Pb)$$

3. **With acids.**

   (a) With dilute acids.

   Silicon dioxide is ***acidic***, it reacts with ***cold dilute hydrofluoric acid*** to form ***silicon tetrafluoride*** or ***hexafluorosilicic acid*** and ***water*** due to the formation of *stable silicon to fluoride bonds.*

   $$SiO_{2(s)} + 4HF_{(aq)} \rightarrow SiF_{4\,(g)} + 2H_2O_{(l)}$$

   Or

   $$SiO_{2(s)} + 6HF_{(aq)} \rightarrow H_2SiF_{6\,(aq)} + 2H_2O_{(l)}$$

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   (b) With concentrated hydrochloric acid.

   Lead(IV) oxide being **amphoteric,** it reacts with ***cold concentrated hydrochloric acid*** to form ***lead(IV) chloride*** and ***water.***

   $$PbO_{2(s)} + 4HCl_{(aq)} \rightarrow PbCl_{4(l)} + 2H_2O_{(l)}$$

   Lead(IV) oxide is an **oxidizing agent**, it is **reduced** by ***hot concentrated hydrochloric acid*** to ***lead(II) chloride*** *and itself* ***oxidized*** *to* ***chlorine*** and ***water.***

   $$PbO_{2(s)} + 4HCl_{(aq)} \rightarrow PbCl_{2(aq)} + Cl_{2(g)} + 2H_2O_{(l)}$$

(c) With concentrated sulphuric acid

Lead(IV) oxide is an ***oxidizing agent***, it is ***reduced*** by ***hot concentrated sulphuric acid*** to ***lead(II) sulphate*** *and itself* ***oxidized*** to **oxygen** and **water.**

$$PbO_{2(s)} + H_2SO_{4(aq)} \rightarrow PbSO_{4(s)} + \frac{1}{2}O_{2(g)} + H_2O_{(l)}$$

GROUP 14 MONOXIDES

1. **With alkalis.**

Carbon monoxide is ***weakly acidic***, it reacts with ***hot dilute alkalis*** to form ***methanoate ions.***

$$CO_{(g)} + OH^-_{(aq)} \rightarrow HCOO^-_{(aq)}$$

Germanium monoxide, Tin monoxide and lead monoxide are ***amphoteric,*** they react with ***hot concentrated alkalis*** to form **germinate(II)**, ***stannate(II)*** and ***plumbate(II) ions*** respectively.

$$XO_{(s)} + 2OH^-_{(aq)} \rightarrow XO^{2-}_{2\,(aq)} + H_2O_{(l)} \qquad (X = Ge, Sn, Pb)$$

2. **With acids.**

Germanium monoxide, Tin monoxide and lead monoxide are ***amphoteric,*** they react with ***cold dilute acids*** to form **salts** and **water**.

$$XO_{(s)} + 2H^+_{(aq)} \rightarrow X^{2+}_{(aq)} + H_2O_{(l)} \qquad (X = Ge, Sn, Pb)$$

GROUP 14 CHLORIDES

1. **Reactions of dichlorides with water**

Germanium dichloride is ***covalent,*** it undergoes ***hydrolysis*** in ***cold water*** to form ***germanium(II) oxide*** and ***hydrogen chloride gas.***

$$GeCl_{2(s)} + H_2O_{(l)} \rightarrow GeO_{(s)} + 2HCl_{(g)}$$

Tin dichloride is ***partly covalent***, it undergoes ***partial hydrolysis*** in ***cold water*** to form ***basic tin(II) chloride*** and ***hydrogen chloride gas.***

$$SnCl_{2(s)} + H_2O_{(l)} \rightarrow Sn(OH)Cl_{(s)} + HCl_{(g)}$$

Tin dichloride is ***partly covalent***, it undergoes ***complete hydrolysis*** in ***hot water*** to form ***tin(II) hydroxide*** and ***hydrogen chloride gas.***

$$SnCl_{2(s)} + 2H_2O_{(l)} \rightarrow Sn(OH)_{2(s)} + 2HCl_{(g)}$$

2. **Reactions of tetrachlorides with water**

Carbon tetrachloride does ***not hydrolyze*** in water because the carbon lacks ***vacant d-orbitals*** to accommodate the lone pair of electrons from water.

Silicon tetrachloride, germanium tetrachloride, tin tetrachloride and lead tetrachloride are ***covalent***, they undergo ***hydrolysis*** to form the corresponding ***dioxides and hydrogen chloride*** gas since the elements have ***vacant d-orbitals*** to accommodate lone pairs of electrons from water.

$$XCl_{4(l)} + 2H_2O_{(l)} \rightarrow XO_{2(s)} + 4HCl_{(g)} \qquad (X = Si, Ge, Sn, Pb)$$

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GROUP 17 ELEMENTS

1. **With water**

   Fluorine is a ***strong oxidizing agent***, it is ***reduced*** by ***cold water*** to ***hydrofluoric acid and*** *itself* ***oxidized*** *to* ***oxygen gas.***

   $$F_{2(g)} + H_2O_{(l)} \rightarrow 2HF_{(aq)} + \frac{1}{2}O_{(g)}$$

   Chlorine and bromine ***disproportionate*** in ***cold water*** to form ***hydrohalic acids and hypohalous acids.***

   $$Cl_{2(g)} + H_2O_{(l)} \rightarrow HCl_{(aq)} + HOCl_{(aq)}$$
   $$Br_{2(g)} + H_2O_{(l)} \rightarrow HBr_{(aq)} + HOBr_{(aq)}$$

   Iodine does not react with water since it is non polar.

2. **With alkalis**

   (a) With cold dilute alkalis

   Fluorine ***disproportionates*** in ***cold dilute alkalis*** to form a ***fluoride, oxygen difluoride and water.***

   $$2F_{2(g)} + 2OH^-_{(aq)} \rightarrow 2F^-_{(aq)} + OF_{2(g)} + H_2O_{(l)}$$

   Chlorine, bromine and iodine ***disproportionate*** in ***cold dilute alkalis*** to form the corresponding ***halides, halate(I) and water***.

   $$X_{2(g)} + 2OH^-_{(aq)} \rightarrow X^-_{(aq)} + XO^-_{(aq)} + H_2O_{(l)}$$
   $$X = Cl, Br, I$$

   (b) With hot concentrated alkalis

   Fluorine is an ***oxidizing agent***, it is ***reduced*** by ***hot concentrated alkalis*** to form a ***fluoride*** *and itself* ***oxidized oxygen gas*** *and* ***water***.

   $$2F_{2(g)} + 2OH^-_{(aq)} \rightarrow 2F^-_{(aq)} + \frac{1}{2}O_{2(g)} + H_2O_{(l)}$$

   Chlorine, bromine and iodine ***disproportionate*** in ***hot concentrated alkalis*** to form the corresponding ***halides, halate(V) and water***.

   $$3X_{2(g)} + 6OH^-_{(aq)} \rightarrow 5X^-_{(aq)} + XO^-_{3(aq)} + 3H_2O_{(l)}$$
   $$X = Cl, Br, I$$

3. **With metals.**

   Halogens are ***oxidizing agents***, they ***are reduced*** *by metals* on ***heating*** to **metal *halides.***

   $$Fe_{(s)} + \frac{3}{2}Cl_{2(g)} \rightarrow FeCl_{3(s)}$$
   $$Sn_{(s)} + 2Cl_{2(g)} \rightarrow SnCl_{4(l)}$$

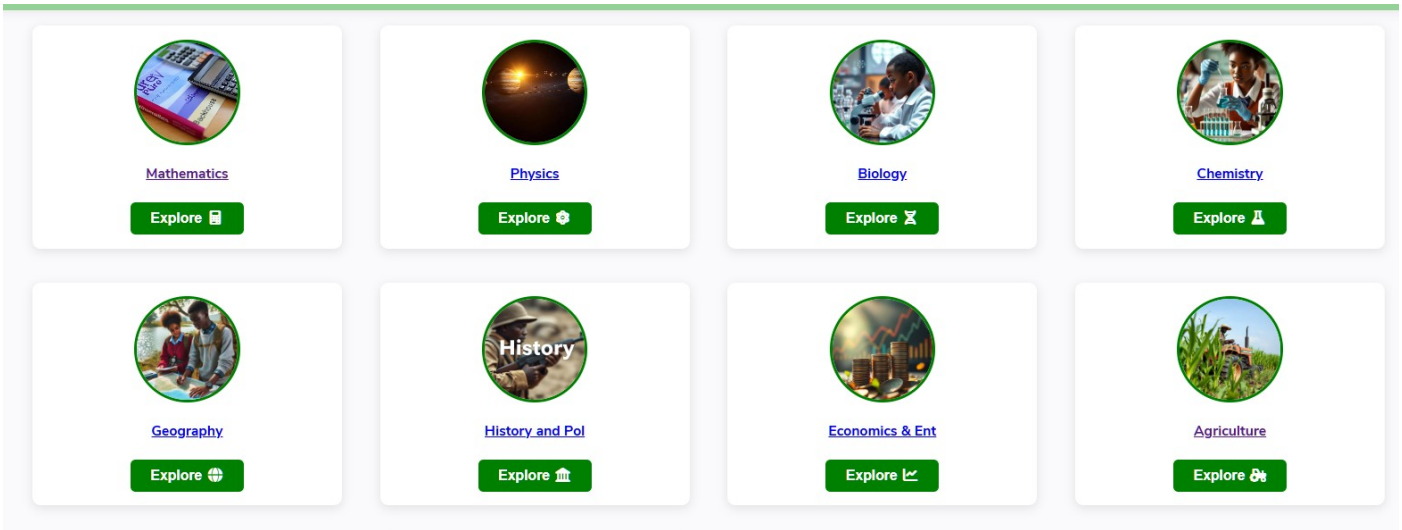
4. **With hydrogen.**

   Halogens are ***oxidizing agents***, they are ***reduced*** by ***dry hydrogen*** gas to ***hydrides.***

   $$X_{2(g)} + H_{2(g)} \rightarrow 2HX_{(g)}$$
   X= F, Cl, Br, I

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