

ZINC AND ITS COMPOUNDS

Atomic Number 30

Its electronic configuration is $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2$

Ores of Zinc

- Zinc Blend (ZnS)
- Zinc Calamite (ZnCO₃)

Extraction process from sulphide ores

These ores contains traces of lead sulphide and silica as impurities

Concentration

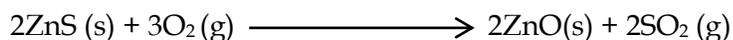
The ore is first crushed and mixed with water and oil (frothing agent) so as to remove the unwanted earthly materials.

The oil wets the sulphide particles and the water wets the impurities

Air is then blown through the mixture producing froth. The oiled sulphide particles float on the surface while the impurities sink to the bottom. The ore is collected, washed and dried.

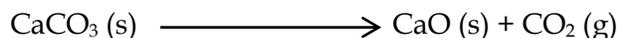
Roasting

The concentrated ore is then heated strongly in air to form zinc oxide



Reduction

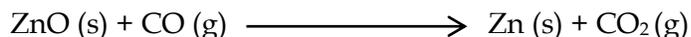
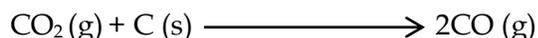
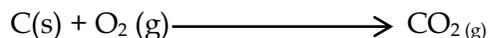
Zinc oxide, limestone (CaCO₃) and excess coke are then heated in a blast furnace. Limestone decomposes in to calcium oxide and carbon dioxide.



The calcium oxide reacts with silica, one of the impurities to form calcium silicate (slag)



Coke burns to carbon dioxide which is reduced by burnt unburnt coke to carbon monoxide. The carbon monoxide reduces zinc oxide to zinc.



The slag sinks to the bottom and can be removed whereas Zinc produced leaves as vapour at the top of the blast furnace where its cooled and allowed to solidify.

Reactions of Zinc

(a) With Air

On exposure to air zinc develops a thin layer of zinc oxide. This layer prevents further reaction with the oxygen present in air. Zinc burns in oxygen to form zinc oxide.



(b) With water

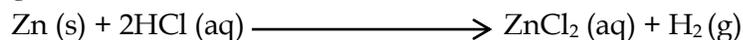
Zinc (red hot) reacts with steam to form zinc oxide and hydrogen gas



(c) With acid

(i) Hydrochloric acid

Zinc reacts with dilute and conc. hydrochloric acid forming salt and hydrogen gas.

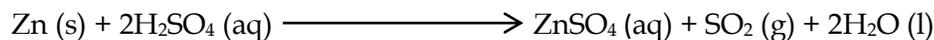


(ii) Sulphuric acid

Zinc reacts with dilute sulphuric acid to form salt and hydrogen gas



With concentrated sulphuric acid zinc forms zinc sulphate sulphur dioxide and water as the products.



(d) With alkalis

Zinc reacts with aqueous alkalis to form zincates complex and hydrogen gas



COMPOUNDS OF ZINC

(i) Zinc Oxide

Preparation

(i) Decomposing either zinc hydroxide, zinc carbonate and zinc nitrate



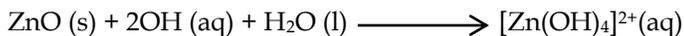
(ii) By passing steam over strongly heated zinc metal



Chemical properties

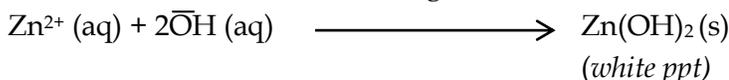
(a) Is yellow when hot and white when cold.

(b) It is an amphoteric oxide that is yellow when hot and white when cold.



(ii) Zinc Hydroxide

Preparation: By precipitation on addition of a little sodium hydroxide or aqueous ammonia to a solution containing zinc ions.

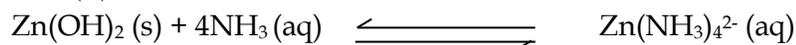


Properties:

- The hydroxide is amphoteric; dissolves in excess sodium hydroxide to form zincates complex ion



- In aqueous ammonia zinc hydroxide dissolves forming a colourless tetraamine zinc (II) ion.

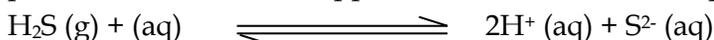


(iii) Zinc sulphide

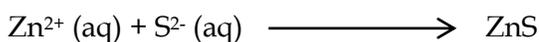
Preparation: By passing hydrogen sulphide through a solution of zinc ions. A metallic sulphide salt is formed. However if H₂S is passed through an acidic solution of a metallic salt the sulphide may not be formed.

Explanation

If before bubbling the Hydrogen sulphide the solution is acidified, the excess H⁺ ion present in the solution suppresses the formation of sulphide ions in the equation:

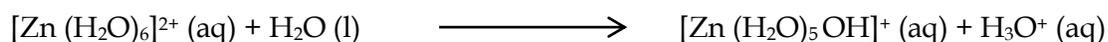


Thus the concentration of the sulphide ions will be low to precipitate zinc sulphide.



Note:

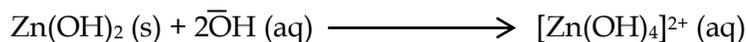
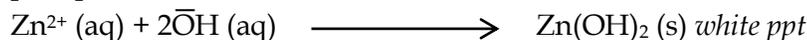
Aqueous solution of zinc chloride is acidic due to hydrolysis of [Zn (H₂O)₆]²⁺



Test for Zinc Ions

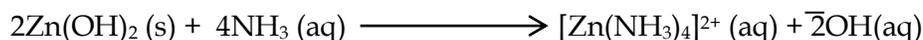
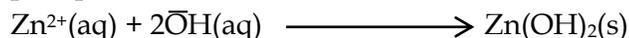
(i) *Addition of sodium hydroxide solution*

Sodium hydroxide is added drop wise to a solution of zinc (II) ions produces a white precipitate which dissolves in excess alkali to form a colourless solution.



(ii) *Addition of ammonia*

Addition of ammonia solution drop wise to a solution of zinc ions produces a precipitate soluble in excess to form a colourless solution



(iii) *Addition of ammonium sulphide*

A white precipitate soluble in dilute hydrochloric acid

(iv) *Addition of potassium ferrocyanide (confirmatory test)*

A white precipitate soluble in sodium hydroxide

(v) *Using disodium hydrogen phosphate (confirmatory test)*

White precipitate is formed with zinc ions

Uses of Zinc

- Making alloys e.g. Brass is alloy of zinc and copper
- Galvanizing iron

Zinc is higher than iron in electrochemical series, if a galvanized piece of iron developed a small scratch and the iron is exposed, iron does not rust.

This is because the zinc in the neighborhood of the exposed iron undergoes oxidation in preference to iron forming a thin layer of Zinc oxide which prevents further attack.

Questions

(a) *Write the electronic configuration of zinc (atomic number 30)*

(b) *State*

(i) *Two reasons why zinc is not considered a typical transition element*

(ii) *One property in which zinc behaves as a transition element*

(c) (i) *Name one ore from which zinc can be extracted and write its formula*

(ii) *Briefly describe how pure zinc can be obtained from the ore you have named in (c)(i)*

(d) *Describe the reactions of zinc with*

(i) *Air*

(ii) *Sodium hydroxide*

(Your answer should include equations for the reactions)

Solution

- (a) Electronic configuration of zinc is $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2$
- (b) (i) Zinc is not considered as a typical transition element because
- Zinc atoms or ions have completely filled 3d sub energy level
 - Zinc does not form coloured compounds
- (ii) Zinc forms complex compounds similar to transition elements

- (c) (i) Zinc can be extracted from zinc blend
- (ii) Extraction of Zinc from Zinc blende.

The ore is crushed and agitated with water mixed with a frothing agent. Air is passed through the mixture. The impurities sink to the bottom and the ore with frothing agent float, which are skimmed off or removed. Dilute acid is added to break it down. It is filtered and dried. The purified ore is roasted in air to form zinc oxide and sulphur-dioxide.



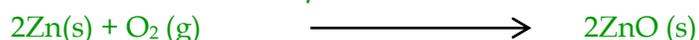
A mixture of zinc oxide, limestone and coke is put in the blast furnace and hot air blown in to the furnace. Zinc oxide is reduced to zinc by carbon.



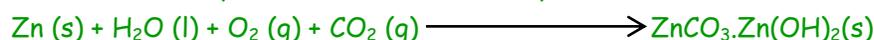
Zinc vapour distills off from the furnace, it is cooled by a spray of molten lead. It is then purified by re-distillation.

- (d) Reactions of Zinc

- (i) Air: Heated zinc reacts with dry air to form zinc oxide



Zinc reacts slowly with moist air to form hydrated zinc carbonate



- (ii) Sodium hydroxide

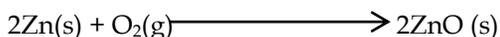
Zinc reacts with hot concentrated sodium hydroxide solution to form sodium zincate and hydrogen gas



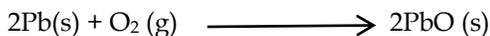
Compare the chemistry of Zinc and lead

- (a) Reaction with air

Zinc when heated in air forms its oxide.



Lead also reacts with air when heated strongly to form Lead(II)oxide



(b) With water

Heated zinc reacts with steam to form zinc oxide and hydrogen



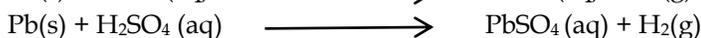
Lead however reacts with water in the presence of dissolved oxygen to form lead (II) hydroxide



(c) With dilute acids

Both lead and zinc react with dilute acids liberating hydrogen gas and forming respective salts.

However lead forms precipitates with dilute hydrochloric acid and sulphuric acid



(d) With conc. acids

(i) *concentrated sulphuric acid*

Zinc reacts with hot concentrated sulphuric acid as follows



Lead only slightly dissolves in concentrated sulphuric acid

(ii) *Concentrated nitric acid*

Zinc reacts with conc. Hot nitric acid to form zinc nitrate, nitrogen dioxide and water.



Lead reacts with hot conc nitric acid and its oxidized to lead (II) nitrate and itself reduced to nitrogen monoxide and water

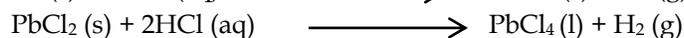


(iii) *Concentrated hydrochloric acid*

Zinc reacts with concentrated hydrochloric acid with evolution of hydrogen gas

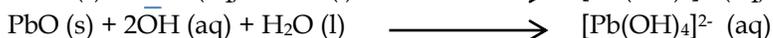
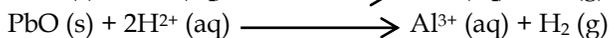


Lead reacts with concentrated hydrochloric acid to form a white precipitate which dissolves in excess acid to form a colourless solution



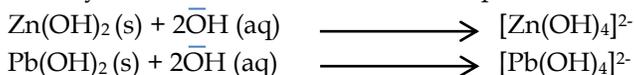
(e) Properties of oxides

Both of the oxides of lead and zinc are amphoteric in nature

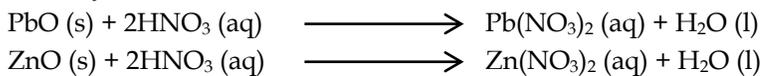


(f) Properties of hydroxides

Both hydroxides of lead and zinc are amphoteric in nature



Their hydroxides, like their oxides, also react with dilute acids to form salt and water

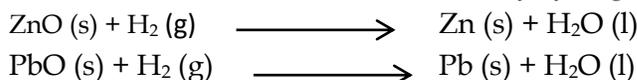


Similarities between Zn and Pb

- (i) Zinc nitrate like lead nitrate when heated in air decompose to form nitrogen dioxide gas and their respective oxides.

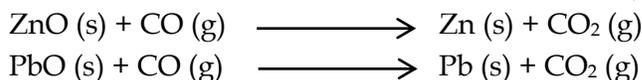


- (ii) Zinc oxide and lead oxide can be reduced by hydrogen gas on heating



- (iii) Lead hydroxide like zinc hydroxide are amphoteric

- (iv) Both zinc oxide and lead oxide can be reduced by carbon monoxide gas



Differences between Zn and Pb

- Zinc metal is an amphoteric metal dissolves in hot concentrated alkali with the evolution of hydrogen gas whereas lead metal does not.
$$\text{Zn} (\text{s}) + 2\bar{\text{O}}\text{H} (\text{aq}) + 2\text{H}_2\text{O} (\text{l}) \longrightarrow \text{Zn(OH)}_4^{2-} (\text{aq}) + \text{H}_2 (\text{g})$$
- Most salts of lead (II) ion such as lead (II) sulphate, lead (II) chloride etc are insoluble in water where as salts of zinc (II) ion are highly soluble in water
- Lead (II) oxide is orange when hot and yellow on cooling while zinc oxide is yellow when hot and white on cooling.
- Zinc hydroxide dissolves in ammonia solution to form tetraaminezinc(II) ions while lead(II)hydroxide is insoluble in excess ammonia solution.
- Lead dissolves in dilute mineral acids to form a white precipitate for example in HCl, H₂SO₄ while zinc dissolves in these acids to form colourless solutions

Compare the chemistry of Zinc and Aluminium

(i) Reaction with air

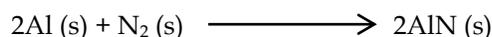
Zinc when heated in air forms its oxide.



Aluminium like zinc when strongly heated in air forms its oxide

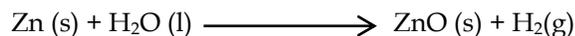


Strongly heated aluminium in air also may combine with nitrogen gas to form aluminium nitride.



(ii) Reaction with water

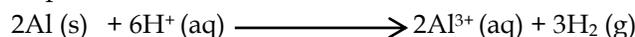
Heated zinc reacts with steam to form zinc oxide and hydrogen



Aluminium however doesn't react with water neither with steam.

(iii) Reaction with dilute acids

Both zinc and aluminium react with dilute acids liberating hydrogen gas and forming respective salts.



Reaction with concentrated acids

(a) Concentrated sulphuric acid

Both zinc and aluminium dissolve in hot concentrated sulphuric acid with evolution of sulphur dioxide gas



(b) Concentrated nitric acid

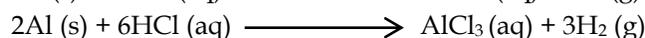
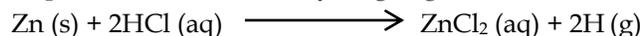
Zinc dissolves in hot concentrated nitric acid



Aluminium however does not react with hot conc nitric acid

(c) Concentrated hydrochloric acid

Both zinc and aluminium react with hot concentrated hydrochloric acid to form respective chlorides and hydrogen gas.



(iv) Properties of the oxides

The oxides of both zinc and aluminium are amphoteric in nature.



(v) **Properties of the hydroxides**

The hydroxides of both zinc and aluminium are amphoteric in nature.

