Zinc and its compounds

Electron configuration
$[Ar]4s^2 3d^{10}$

Properties of zinc as a transition element
a) Forms complexes, e.g. $Zn(NH_3)_4^{2+}$.
b) ZnO is a catalyst in formation of methanol from carbon monoxide and hydrogen.

Reasons why zinc is not a true transition element
- has full d-orbital.
- Has a single oxidation state of +2
- Does not form colored ions

Trial 2
Explain the following observations
Although zinc belongs to the d-block elements in the periodic table, it does not behave as a typical transition element. (3 marks)

Extraction of Zinc
zinc blende, ZnS
calamine, $ZnCO_3$

Extraction of Zinc
1. Concentration of the ore by floatation method
The finely pulverized ore is mixed with water, containing 'frothing' agent (s).
Air is blown into the mixture, froth is produced and the earthly material is "wetted" and sinks.

The sulphide ore particles, rise to the surface in the froth and are skimmed off the surface.

Anti- frothing agent agent is added to break up the froth, the concentrated ore is filtered

and dried

2. Roasting

The concentrated ore is then roasted in air to convert it into the oxide:

$$2ZnS\,(s) + 3O_2\,(g) \rightarrow 2ZnO\,(s) + 2SO_2\,(g)$$

$$ZnCO_3\,(s) \rightarrow ZnO\,(s) + CO_2\,(g)$$

3**. Reduction of the oxide**

The zinc oxide is reduced by heating with coke. The zinc is led off as a vapour, which is then cooled.

$$ZnO\,(g) + C\,(g) \rightarrow Zn\,(g) + CO\,(g)$$

Trial 2

(a) Name one ore of zinc and give its formula. (2 marks)

(i) Describe briefly how the ore you named in is concentrated . (3 marks)

(ii) What further treatment of the ore is required immediately after concentration? (1 mark)

(iii) Outline the process, giving equations for the production of zinc metal from the treated ore. (5 marks)

(b) Zinc belongs to the d-block in the periodic table yet it is not a transition element. Explain this statement. (3 marks)

Trial 3

(a) Zinc chloride readily dissolves in water to form a solution with pH less than 7. Give a reason for this observation and write an equation for the reaction that takes place. (3 marks)

(b) A piece of zinc metal was suspended in a solution of copper (II) sulphate in water. State what was observed and write an equation for the change that took place. (3 marks)

Trial 4

(a)(i) Write the formula and name of one ore of zinc (2 marks

(ii) Briefly describe how pure zinc can be obtained from the ore you have named in (i). (7 marks)

(b)(i) Name one reagent that can be used to distinguish between zinc ions and aluminium ions in solution. (1 mark)

(ii) State what would be observed when zinc and aluminium ions are separately treated with the reagent. Write equations for the reactions. (5 marks)

(iii) Explain how zinc protects iron from rusting. (5 marks)

Properties of Zinc

Zinc is a white lustrous metal.

It melts at 419.5^0C and boils at 906^0C.

It is a good conductor of heat and electricity.

Action of air on zinc

Zinc is stable in air. In moist air, a protective covering of basic zinc carbonate is formed. When heated to 500^0C, it catches fire with a bluish white flame forming zinc oxide which is very light and is called philosopher's wool.

$2Zn(s) + O_2(g) \rightarrow 2ZnO(s)$

Action of water on zinc

Pure zinc does not react with water, but displaces hydrogen from steam.

$Zn\ (s) + H_2O\ (g) \rightarrow ZnO\ (s) + H_2\ (g)$

Reaction of zinc with Hydrochloric acid

Dilute or concentrated hydrochloric acid form zinc chloride with the evolution of hydrogen.

$Zn(s) + 2HCl(aq) \rightarrow ZnCl_2(aq) + H_2(g)$

Reaction of zinc with Sulpuric acid:

Dilute sulphuric acid reacts with zinc evolving hydrogen. Hot and concentrated sulphuric acid attacks zinc giving of sulphur dioxide

$Zn(s) + (dil.)\ H_2SO_4 \rightarrow ZnSO_4(aq) + H_2(g)$

$Zn(s) + 2H_2SO_4\ (Hot\ and\ concentrated) \rightarrow ZnSO_4(ag) + SO_2(g) + 2H_2O(l)$

Reaction of zinc with Sulpuric acid:

A moderately concentrated acid (20%) when heated with the metal evolves hydrogen sulphide and precipitates a little sulphur.

$4Zn(s) + 5H_2SO_4\ (heat) \rightarrow 4ZnSO_4(aq) + H_2S(g) + 4H_2O(g)$

$3Zn(s) + 4H_2SO_4\ (heat) \rightarrow 3ZnSO_4(aq) + S(s) + 4H_2O(l)$

Reaction of zinc with Nitric acid

Zinc reacts with very dil. HNO_3 (6%) and is oxidized to $Zn(NO_3)_2$. Nitric acid is reduced to NH_4NO_3.

$4Zn(s) + 10HNO_3\ (very\ dilute) \rightarrow 4Zn(NO_3)_2(aq) + NH_4NO_3(aq) + 3H_2O(l)$

Or $4Zn(s) + NO_3^-(aq)\ 10H^+(aq) \rightarrow 4Zn^{2+}(aq)\ NH^+_4(aq) + 3H_2O(l)$

Reaction of zinc with Nitric acid

Zn reacts with cold and conc. HNO_3 (70%) and is oxidized to $Zn(NO_3)_2$. Nitric acid is reduced to nitrogen dioxide gas, NO_2.

$Zn(s) + 4HNO_3\ (cold\ and\ conc.) \rightarrow Zn(NO_3)_2(aq) + 2NO_2(g) + 2H_2O(l)$

Reaction of zinc with Nitric acid.

Zinc also reacts with cold and moderately conc. HNO_3 (50%). In this reaction Zn is oxidized to $Zn(NO_3)_2$ and nitrogen monoxide, NO, gas is evolved

$3Zn(s) + 8HNO_3 \rightarrow 3Zn(NO_3)_2(aq) + 2NO(g) + 4H_2O(l)$

Action of alkalis on zinc

Zinc reacts with hot and concentrated caustic alkalis forming alkali zincates with the evolution of hydrogen.

$Zn\ (s) + 2OH^-\ (aq) + 2H_2O\ (l) \rightarrow Zn(OH)_4^{2-}\ (aq) + H_2\ (g)$

Displacement of the metal

Zinc displaces less electropositive metal from their salts, e.g. copper.

$Zn(s) + Cu^{2+}\ (aq) \rightarrow Zn^{2+}(aq) + Cu(s)$

Reaction of zinc with non metals

Zinc reacts with halogens and sulphur directly on heating.

$Zn(s) + Cl_2(g) \rightarrow ZnCl_2(s)$

$Zn(s) + S(s) \rightarrow ZnS(s)$

Reaction of zinc with ammonia

Zinc nitride is formed.

$3Zn(s) + 2NH_3(g) \rightarrow Zn_3N_2(s) + 3H_2(g)$

Reducing action of zinc

It acts as a powerful reducing agent e.g, it reduces ferric salts to ferrous salts and nitrate to ammonia.

$Fe_2(SO4)_3 + Zn(s) \rightarrow 2FeSO_4(aq) + ZnSO_4(aq)$

$NaNO_3(aq) + 4Zn(s) + 7NaOH \rightarrow 4Na_2ZnO_2(aq) + 2H_2O(l) + NH_3(aq)$

Use of zinc

Zinc is used as a protective coating for steel. In galvanization, the steel is first cleaned by dipping it in sulphuric acid and then coated by dipping it in molten zinc or by electroplating. Zinc is also used in alloys such as brass. It is also used in preparation of hydrogen, paints, manufacture of conduits and pipes.

Trial 4

(a) Describe using equations the reactions of zinc with:

Air.

Water.

Sodium hydroxide. (10 marks)

(b) Explain why it is not considered a typical transition metal. (3 marks)

(i) *State three ways in which the Chemistry of zinc is similar to that of magnesium. (3 marks)*

(ii) *State what is observed when dilute aqueous ammonia is added drop wise to the solution containing zinc ions. (2 marks)*

(iii) *Write equation(s) for the reaction that take place in (c)(i). (2 marks)*

Qualitative analysis of Zn^{2+}

Addition of sodium hydroxide

Forms a white precipitate soluble in excess.

$Zn^{2+}(aq) + 2OH^{-}(aq) \rightarrow Zn(OH)_2(s)$

then,

$Zn(OH)_2(s) + 2OH^{-}(aq) \rightarrow Zn(OH)_4^{2-}(aq)$

Addition of ammonia

White precipitate soluble in excess

$Zn^{2+}(aq) + 2OH^{-}(aq) \rightarrow Zn(OH)_2(s)$

then,

$Zn(OH)_2(s) + 4NH_3(aq) \rightarrow Zn(NH_3)_4^{2+}(aq) + 2OH^{-}(aq)$

Distinguishing Zn^{2+} from Al^{3+}

1. **Zn^{2+}** f*orms a white precipitate with potassium hexacyanoferrate II whereas Al^{3+}* does not.
2. **Al^{3+}** gives of effervescence with sodium carbonate solution whereas zinc II do not.