

## Short Answers and Questions

**Q1: Why are they called transition elements?**

**Answer**

The elements which have partially filled d or f-orbital either in their atomic states or in other common oxidation states are called transition elements.

They are called d-block or f-block elements. They are also called transition elements because they show such properties which are transitional between highly reactive and strongly electropositive elements of s-block which form ionic bonds and p-block elements which form covalent compounds.

**Q2: Write down the general features of transition elements.**

**Answer**

- 1) They are metallic in nature.
- 2) Some of the transition elements play an important role in the industry. These metals are Ti, Cr, Fe, Ni, Cu, Mn, W and Th etc.
- 3) They are all hard and metal with high melting and boiling points. They are good conductors of heat and electricity.
- 4) They form alloys with one another and other elements of periodic table as well.
- 5) With a few exceptions, they show variable oxidation states.
- 6) Their ions and compounds are colored in the solid state and the solution state.

**Q3: Why is Zn group included in transition elements?**

**Answer**

Zn, Cd and Hg are not regarded as transition elements because they have completely filled d orbitals. It is appropriate to include these in transition elements they form complexes with ammonia halide ions and amines and their chemical behaviour is similar to transition elements.

**Q4: What is oxidation state of transition elements?**

**Answer**

Transition elements are electropositive, so they have positive oxidation states. All 3d series elements show an oxidation state of +2 in addition to higher oxidation states when the electrons of 4s orbital take part in bonding.

They show variable oxidation states. The reason is that they have d electrons in addition to s-electron for the purpose of bond formation. These elements have several (n-1) d and ns electrons. The energies of (n-1) d and ns orbitals are way close to each other. The (n-1) d electrons are easily lost as ns electrons. In the higher oxidation states of first five elements, all s and d-electrons are used for bonding. Among the 3d series Mn has maximum oxidation states, and goes up to +7.

**Q5: Why transition elements are used as catalyst?**

**Answer**

Most of the transition elements are used as catalyst. The compounds of transition metals are also catalyst. The reason is that the transition metals show variety of oxidation states. In this way, they can form intermediate products with various reactants.

They also form interstitial compounds which can absorb an activator to the reacting species. Some of the important catalyst.

- 1) A mixture of ThO and CrO is used for the manufacture of methyl alcohol.
- 2) Ni, Pt and Pd are catalyst for the hydrogenation of vegetable oil and saturation of alkenes and alkynes to alkanes.
- 3) MnO<sub>2</sub> can be used as catalyst for the decomposition of H<sub>2</sub>O<sub>2</sub>.
- 4) TiCl<sub>4</sub> is used as catalyst for the manufacture of plastics.
- 5) N<sub>2</sub>O<sub>5</sub> is used to oxidize SO<sub>2</sub> to SO<sub>3</sub> in the manufacture of H<sub>2</sub>SO<sub>4</sub>.

**Q6: Why transition metals form alloy with each other and write down the properties of alloy?**

**Answer**

Alloy is mixture of two or more than two metals. Transition metals form alloy with each other.

Transition elements have almost similar sizes and atoms of the one metal can easily take up positions in crystal lattice of the each other. They form substitution alloy among themselves. E.g. Brass, bronze and coinage alloys are the base alloys.

Properties:

As alloys are prepared according to the requirements, their characteristics are different yet few properties are common which are as follows

- 1) Alloys are comparatively cheap.
- 2) They are strong and flexible but hard alloys can also be prepared.
- 3) They have long life because they do not corrode.
- 4) They are durable.
- 5) They have high melting points.

**Q7: Define coordination compounds, and explain them.**

**Answer**

Those compounds which contain complex molecules or complex ions capable of independent existence are called coordination compounds or complex compounds. Such compound is formed by the coordination of an electron pair donor to metal atom or ion.

In order to understand let us mixture substances that is KCN and Fe (CN)<sub>2</sub>. When this evaporated a new compound is obtained. This compound when dissolved in 1-120 ionizes into K<sup>+</sup> and [Fe(CN)<sub>6</sub>]<sup>4-</sup> On this basis the new compounds have been given the formula K<sub>4</sub>[Fe (CN)<sub>6</sub>].



Complex compound is consisted of these compounds

- 1) A positively or negatively charged ion which is not complex.
- 2) A central metal atom or ion which is consisted transition elements.
- 3) Electron pair donor which is negatively charged, positively charged or neutral.

**Q8: Define ligand? and write down its types?****Answer**

The atom ion or neutral molecule which surrounds the central metal atom or ion by donating the electron pair is called ligand.

**Examples**

In K<sub>4</sub>Fe(CN)<sub>6</sub> and K<sub>3</sub>Fe(CN)<sub>6</sub> CN<sup>-</sup> is the ligand.

**Types**

- 1) Monodentate ligands. Those ligands which have only one donatable electron pair. Such ligand may be negatively charged or neutral. E.g. Negatively charged ligands F<sup>-</sup>, Cl<sup>-</sup>,

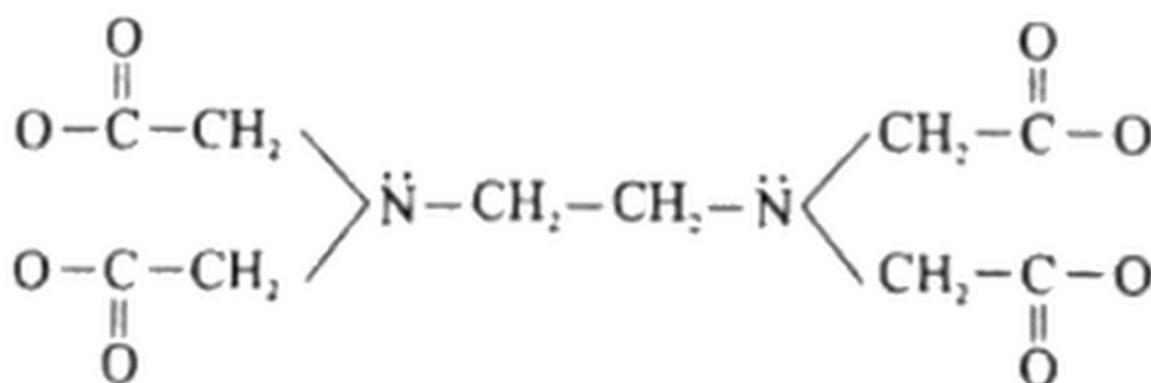
Neutral ligand HO, NH<sub>3</sub>, CO.

2) Bidentate ligands. Those ligands which have two donatable pairs are called bidentate ligands. E.g. CO<sub>3</sub><sup>2-</sup>, SO<sub>4</sub><sup>2-</sup>, NH<sub>2</sub> - CH<sub>2</sub> - CH<sub>2</sub> - NH<sub>2</sub>.

3) Tridentate ligands. Those ligands which have 3 donatable electron pairs.

E.g. H<sub>2</sub>NCH<sub>2</sub> - NH - CH<sub>2</sub> - CH<sub>2</sub> - NH<sub>2</sub>.

4) Hexadentate ligands. Those ligands which have six donatable electron pairs e.g. ethylenediaminetetracetate (EDTA).



**Q9: Define charge on coordination sphere or ligancy with examples?**

**Answer**

It is the algebraic sum of charges present on the central metal ion and total charge on the ligands.

**Examples**

In K<sub>4</sub> [Fe (CN)<sub>6</sub>] the charge present on the metal ion and total charge on the ligands.

Example: In K<sub>4</sub> [Fe (CN)<sub>6</sub>] the charge on the coordination sphere can be calculates as follow



Since charge on each ligand is = -1

Charge on 6CN<sup>-</sup> = -6

Charge on iron = +2

So the charge on the coordination sphere =  $-6 + 2 = -4$

**Q10: Define coordination number 6 with example?**

**Answer**

Complexes with C.N = 6 are the most common ones formed by transition metal ions.

Six ligands in a 6-coordination compound may be arranged round the metal ion M either at the corners of a hexagonal plane or at the apices of a trigonal prism or at the apices of a regular octahedron. These arrangements together with members of designating substitution positions may be depicted. C.N= 6 has the following arrangement - of 6 ligands in a 6-coordination are tetrahedral oxoanions such as  $\text{VO}_4^{3-}$ ,  $\text{CrO}_4^{2-}$ ,  $\text{FeO}_4^{2-}$  and  $\text{MnO}_4^{2-}$  are also tetrahedral. Square planar geometry is found in complexes of  $\text{Cu}^{2+}$ ,  $\text{Ni}^{2+}$ ,  $\text{Pt}^{2+}$  and  $\text{Au}^{2+}$  etc ions.

**Q 11: Write down the Re-oxidation of the vanadium (III)?**

**Answer**

The vanadium (III) ion is very easily oxidized if you remove the cotton wool from the flask and pour some solution into a test tube, it turns green because of its contact with oxygen in the air. It is oxidized back to vanadium (IV).

If it is allowed to stand for a long time the solution eventually turns blue as the air oxidized it back to the vanadium (IV). state  $\text{VO}^{2+}$  ions.

The first stage of this series of equations



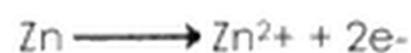
The corresponding equilibrium for the zinc is



So if you mix together zinc and  $\text{VO}_2^+$  ions the presence of acid to provide the ions.



You can write these down and combine them to give the ionic equations for the reaction if you want to.



The other stage of the reaction

$E^{\circ}$  values for all the steps of the reduction from vanadium (V) to Vanadium (II).



And here is the zinc value again.



**Q12: Write down the oxidation of vanadium (II) by nitric acid?**

**Answer**

First step:



The vanadium reaction has the more negative  $E^\ominus$  value and so while move to the left the nitric acid reaction moves to the right.

Nitric acid will oxidize vanadium (II) to vanadium (III).

The second stage is



The nitric acid again has the more positive  $E^\ominus$  value and so moves to the right. The more negative (less positive) vanadium reaction moves to the left.

Nitric acid will certainly oxidize vanadium (III) to vanadium (IV)



**Q13: Write down the uses of potassium dichromate (VI) as an oxidizing agent in organic chemistry?**

**Answer**

Potassium dichromate (VI) solution acidified with dilute sulphuric acid is commonly used as an oxidising agent in organic chemistry. It is a reasonably strong oxidising agent without being so powerful that it takes the whole of the organic molecule. It is used to

Oxidise secondary alcohols to ketones.

Oxidise primary alcohols to aldehydes.

Oxidise primary alcohols to carboxylic acid.

If the alcohol is in excess and you distill off the aldehyde as soon as it is formed you get ethanol as the main product.



If the oxidising agent is in excess and you don't allow the product to escape for example by heating the mixture under reflux



In organic chemistry these equations are often simplified to concentrate on what is happening to the organic molecules. For example the last two could be written.



The oxygen written in square bracket means oxygen from an oxidising agent.

**Q14: Write down the reaction of manganese (II) ions in solutions oxidation states.**

**Answer**

Hydroxide ions remove hydrogen ions from the  $\text{H}_2\text{O}$  ligands attached to the manganese ion.

Once a hydrogen ion has been removed from two of the  $\text{H}_2\text{O}$  molecules, you are left with a complex with no charge a neutral complex.

This is insoluble in  $\text{H}_2\text{O}$  and a precipitate is formed.



The reaction of hexaaquamanganese (II) ions with ammonia solution. Ammonia can act as both as base and a ligand. In this case at usual lab concentrations it simply acts as base removing hydrogen ions from the aqua complex.



**Q15: Write down the using potassium manganate (VII) as an oxidising agent in organic chemistry?**

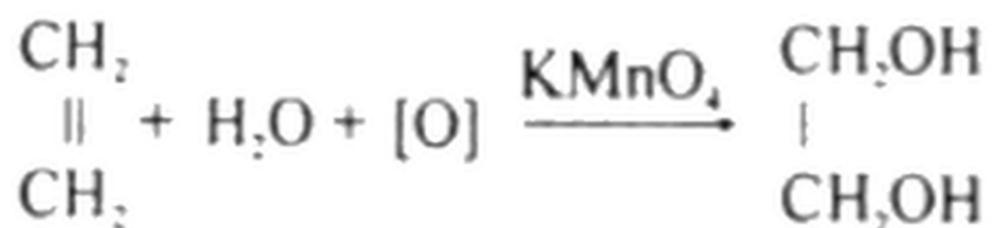
**Answer**

Potassium manganate (VII) is usually used in neutral or alkaline solution in organic chemistry. Acidified potassium manganate (VII) tends to be a rather destructively strong oxidising agent, breaking carbon-bonds. The potassium manganate (VII) solution is usually made mildly alkaline with sodium carbonate solution, and the typically colour changes are.

In testing for a C=C double bond.

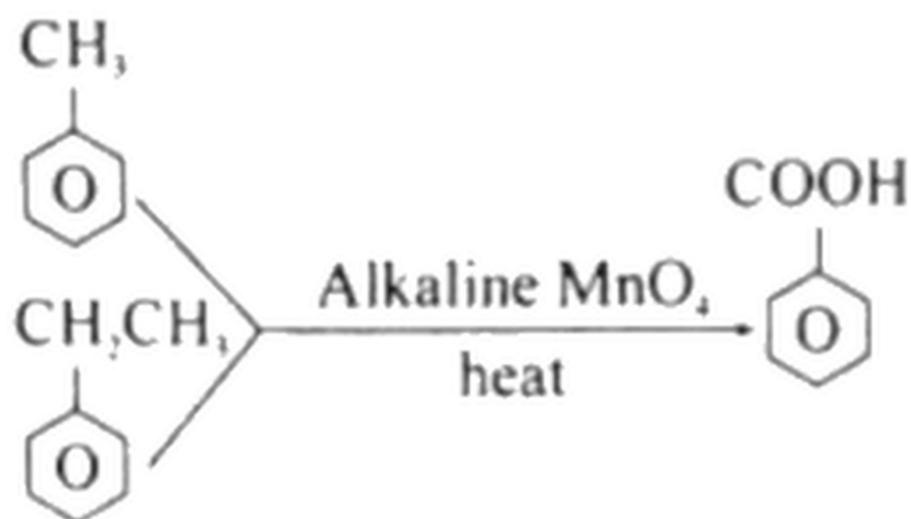
Potassium manganate (VII) oxidizes carbon, carbon double bond, and so goes through the colour change.

Ethane for example is oxidised to ethane 1-2 diols.



The oxygen in square brackets is taken to mean oxygen from an oxidising agents. Oxidation of aromatic side chains.

Alkaline potassium manganate (VII) solution oxidizes any hydrocarbon side chain attached to a benzene ring back to a single — COOH group prolonged heating is necessary. E.g.



In case of the ethyl side chain you will also get  $\text{CO}_2$  with longer side chains, you will get a mixture of other products but in each case the main product will be benzoic acid.

**Q16: Discuss the problems related the use of potassium manganate (VII) solution.**

**Answer**

There are two things you need to be aware of potassium manganate (VII) can't be used in titrations in the presence of ions like chloride or bromide which it oxidizes. In unknown amount of the potassium manganate (VII) would be used in side reaction and so the titration result would be inaccurate. That is way we don't acidify the solution with hydrochloric acid.

Potassium manganate (VII) isn't a primary standard. That means that it can't be made up to give a stable to solution accurately known concentration.

It is so strongly coloured that it is impossible to see when all the crystals you have used have dissolved, and over period of time it oxidizes the  $\text{H}_2\text{O}$  it is dissolved into oxygen. Bottles of potassium manganate (VII) solution usually have a brown precipitate around the top.

This is manganese (IV) oxide and is produced when the manganate (VII) ions react with  $\text{H}_2\text{O}$ .

**Q17: Discuss iron as catalyst in the Haber process.**

**Answer**

The Haber process combines nitrogen and hydrogen into ammonia. The nitrogen comes from the air and the hydrogen is obtained mainly from natural gas (methane) iron is used as a catalyst.



**Q18: Discuss iron ions as a catalyst in the reaction between per sulphate ions and iodide ions?**

**Answer**

The reaction between per sulphate ions (peroxodisulphate ions)  $\text{S}_2\text{O}_8^{2-}$  and iodide ions in solution can be catalyzed using either iron (II) or iron (III) ions. The overall equation for the reaction is



Iron is very easily oxidised under alkaline conditions. Oxygen in the air oxidizes the iron (II) hydroxide precipitate to iron (III) hydroxide especially around the top of the tube. The darkening of the precipitate comes from this effect.

In the iron (III) case.



**Q19: Write down the reaction of the iron ions with ammonia solution.**

**Answer**

Ammonia can act as both a base and a ligand. In these cases, it simply act as a base removing ions from the aqua complex.

In the iron (II) case.



On standing precipitate darkens and turns orange around the top.

The appearance is just the same as in when you add sodium hydroxide solution. The precipitate again changes colour as the iron (II) hydroxide complex is oxidised by the air to iron (III) hydroxide.

In the iron (III) case.



**Q20: Write down the oxidation state and reaction, of hexaaqua copper (II) ions with carbonate ions?**

**Answer**

Oxidation state

The colour changes are



The reaction of hexaaqua copper (II) ions with carbonate ions.

You simply get a precipitate of copper (II) carbonate



