Iron and its Compounds.

(1) Ores of iron:Haematite Fe_2O_3, Magnetite (Fe_3O_4), Limonite $(Fe_2O_3.3H_2O)$, Iron pyrites (FeS_2), Copper pyrities $(CuFeS_2)$ etc.

(2) Extraction: Cast iron is extracted from its oxides by reduction with carbon and carbon monoxide in a blast furnace to give pig iron.

Roasting: Ferrous oxide convert into ferric oxide.

$Fe_2O_3.3H_2O \rightarrow Fe_2O_3 + 3H_2O$; $2FeCO_3 \rightarrow 2FeO + 2CO_2$; $4FeO + O_2 \rightarrow 2Fe_2O_3$

Smelting: Reduction of roasted ore of ferric oxide carried out in a blast furnace.

(i) The reduction of ferric oxide is done by carbon and carbon monoxide (between 1473k to 1873k)

$2C + O_2 \rightarrow 2CO$

Note: The CO is the essential reducing agent.

(ii) $Fe_2O_3 + 3CO \xrightleftharpoons{673K} 2Fe + 3CO_2$. It is a reversible and exothermic reaction. Hence according to $Le-$chatelier principle more iron will be produced in the furnace at lower temp.

$\underset{\text{(it is not reversible)}}{Fe_2O_3 + CO \rightarrow 2FeO + CO_2}$

(iii) $FeO + C \xrightarrow[\text{endothermic reaction}]{1073\ K} Fe + CO$

Note: The gases leaving at the top of the furnace contain up to 28% CO, and are burnt in cowper's stove to pre-heat the air for blast

Varieties of iron: The three commercial varieties of iron differ in their carbon contents.

These are:

(1) Cast iron or Pig-iron: It is most impure form of iron and contains highest proportion of carbon (2.5–4%).

(2) Wrought iron or Malleableiron: It is the purest form of iron and contains minimum amount of carbon (0.12–0.25%).

(3) Steel: It is the most important form of iron and finds extensive applications. Its carbons content (Impurity) is mid-way between cast iron and wrought iron. It contains 0.2–1.5% carbon. Steels containing 0.2–0.5% of carbon are known as mild steels, while those containing 0.5–1.5% carbon are known as hard steels.

Steel is generally manufactured from cast iron by three processes, viz, (i) Bessemer Process which involves the use of a large pear-shaped furnace (vessel) called Bessemer converter, (ii) L.D. process and

(iii) Open hearth process, Spiegeleisen (an alloy of Fe, Mn and C) is added during manufacture of steel.

Heat treatment of steels: Heat treatment of steel may be defined as the process of carefully heating the steel to high temperature followed by cooling to the room temperature under controlled conditions.

Heat treatment of steel is done for the following two purposes,

(i) To develop certain special properties like hardness, strength, ductility etc. without changing the chemical composition.

(ii) To remove some undesirable properties or gases like entrapped gases, internal stresses and strains. The various methods of heat treatment are,

(a) Annealing : It is a process of heating steel to redness followed by slow cooling.

(b) Quenching or hardening: It is a process of heating steel to redness followed by sudden cooling by plunging the red hot steel into water or oil.

(c) Tempering: It is a process of heating the hardened or quenched steel to a temperature much below redness (473–623K) followed by slow cooling.

(d) Case-hardening: It is a process of giving a thin coating of hardened steel to wrought iron or to a strong and flexible mild steel by heating it in contact with charcoal followed by quenching in oil.

(e) Nitriding: It is a process of heating steels at about $700\ ^{o}C$ in an atmosphere of ammonia. This process imparts a hard coating of iron nitride on the surface of steel.

Properties of steel: The properties of steel depend upon its carbon contents. With the increase in carbon content, the hardness of steel increases while its ductility decreases.

(i) Low carbon or soft steels contain carbon upto 0.25%.

(ii) Medium carbon steels or mild steels contain 0.25–0.5% carbon.

(iii) High carbon or hard steels contains 0.1 – 1.5 percent carbon.

(iv) Alloy steels or special steels are alloys of steel with Ni, Cr, Co, W, Mn, V etc., For example – stainless steel is an alloy of Fe, Cr and Ni and it is used for making automobile parts and utensils. Tool steel is an alloy of Fe, W, V etc.

Uses of steel: In general, steels are used for making machinery parts, girders, tools, knives, razors, household utensils, etc. The specific use of steel depend upon the nature of metal added to iron.

Compounds of iron

(1) Oxides of Iron: Iron forms three oxides FeO, Fe_2O_3 (Haematite), Fe_3O_4 (magnetite also called magnetic oxide or load stone).

(i) Ferrous oxide, FeO : It is a black powder, basic in nature and reacts with dilute acids to give ferrous salts.
$FeO + H_2SO_4 \rightarrow FeSO_4 + H_2O$; It is used in glass industry to impart green color to glass.

(ii) Ferric oxide Fe_2O_3 : It is a reddish brown powder, not affected by air or water; amphoteric in nature and reacts both with acids and alkalis giving salts. It can be reduced to iron by heating with C or CO.

$Fe_2O_3 + 3C \rightarrow 2Fe + 3CO$; $Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$

It is used as red pigment to impart red color to external walls and as a polishing powder by jewellers.

(iii) Ferrosoferricoxide $Fe_3O_4 (FeO.Fe_2O_3)$: It is more stable than FeO and Fe_2O_3, magnetic in nature and dissolves in acids giving a mixture of iron (II) and iron (III) salts.

$Fe_3O_4 + 4H_2SO_4$ (dil) $\rightarrow FeSO_4 + Fe_2(SO_4)_3 + 4H_2O$

(2) Ferrous sulphide FeS : It is prepared by heating iron filing with sulphur. With dilute H_2SO_4, it gives H_2S. $FeS + H_2SO_4$ (dil) $\rightarrow FeSO_4 + H_2S \uparrow$

(3) Ferric chloride $FeCl_3$: It is prepared by treating $Fe(OH)_3$ with HCl

$$Fe(OH)_3 + 3HCl \rightarrow FeCl_3 + 3H_2O$$

The solution on evaporation give yellow crystals of $FeCl_3.6H_2O$

Properties: (i) Anhydrous $FeCl_3$ forms reddish-black deliquescent crystals.

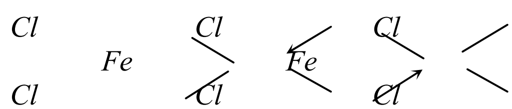
(ii) $FeCl_3$ is hygroscopic and dissolves in H_2O giving brown acidic solution due to formation of HCl

$$FeCl_3 + 3H_2O \rightarrow \underset{\text{(Brown)}}{Fe(OH)_3} + 3HCl$$

(iii) Due to oxidizing nature Fe^{3+} ions $FeCl_3$ is used in etching metals such as copper

$$2Fe^{3+} + Cu \rightarrow 2Fe^{2+} + Cu^{2+}(aq)$$

(iv) Invapor state $FeCl_3$ exists as a dimer, Fe_2Cl_6



(4) Ferrous sulphate, $FeSO_4,7H_2O$ (Green vitriol) : It is prepared as follow ,

$$Fe + H_2SO_4 \rightarrow FeSO_4 + H_2$$

(i) One pressure to moist air crystals become brownish due to oxidation by air.

$$4FeSO_4 + 2H_2O + O_2 \rightarrow 4Fe(OH)SO_4$$

(ii) On heating, crystals become anhydrous and on strong heating it decomposes to Fe_2O_3, SO_2 and SO_3.

$$FeSO_4.7H_2O \xrightarrow{\text{heat}} FeSO_4 + 7H_2O; \quad 2FeSO_4 \xrightarrow[\text{heating}]{\text{Strong}} Fe_2O_3 + SO_2 + SO_3$$

(iii) It can reduce acidic solution of $KMnO_4$ and $K_2Cr_2O_7$

(iv) It is generally used in double salt with ammonium sulphate.

$$(NH_4)_2SO_4 + FeSO_4 + 6H_2O \rightarrow \underset{\text{Mohr's salt}}{FeSO_4.(NH_4)_2SO_4.6H_2O}$$

Mohr’s salt is resistant to atmospheric oxidation.

(v) It is used in the ring test for nitrate ions where it gives brown colored ring of compound $FeSO_4.NO$.

$$FeSO_4 + NO \rightarrow FeSO_4.NO$$

(5) Mohr's salt $FeSO_4.(NH_4)_2SO_4.6H_2O$: It is also known as ferrous ammonium sulphate and is a light green colored double salt.