

Module - 25.2

Occurrence and Principles of extraction of Fe

A. Occurrence:

Iron is the second most abundant metal after Al and fourth most abundant element in the earth's crust. The earth's core is believed to consist mainly of iron and nickel, and the occurrence of iron meteorites suggests that it is abundant also in the solar system. It mostly occurs in the combined state.

The major iron ores are given here under

Name of the mineral	Formula
Haematite (Reddish brown coloured)	Fe_2O_3
Magnetite (Magnetic oxide)	Fe_3O_4
Limonite (Hydrated oxide)	$2\text{Fe}_2\text{O}_3 \cdot 3\text{H}_2\text{O}$
Siderite (Spathic iron ore)	FeCO_3
Iron pyrites	FeS_2
Copper pyrites	CuFeS_2

B. Principles of extraction of Fe:

The chemistry of iron can be studied under three sections depending upon the type of iron required. The sections are

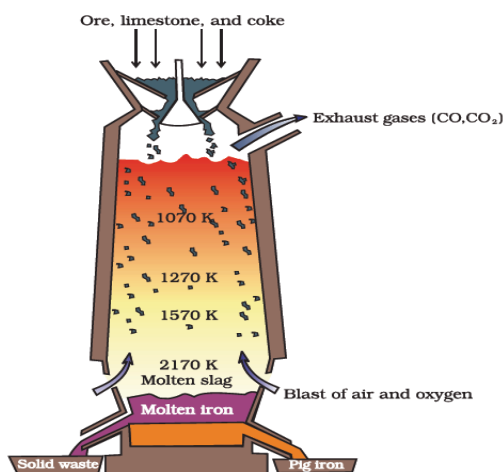
- Manufacture of cast iron
- Manufacture of wrought iron and
- Manufacture of steel.

a. Manufacture of cast iron:

Iron is extracted from its oxides in a blast furnace. This is an almost cylindrical furnace, lined inside with fire bricks. It is charged from the top with an iron ore (8 parts), desulphurised coke (4 parts) and lime stone (1 part) and is mixed in 8:4:1 parts by weight. Air is blown from the bottom. The coke burns producing heat and CO. The temperature range in the furnace is 300° - 1600°C . Various

reactions take place in the blast furnace at different temperature and different zones.

S.No	Temperature range	Name of zone	Changes occurring in the zone	Chemical reaction
1	400 ⁰ -700 ⁰ C	Zone of reduction	Spongy iron is formed iron oxide is reduced	$\text{Fe}_2\text{O}_3 + 3\text{C} \rightarrow 2\text{Fe} + 3\text{CO}$ $\text{Fe}_2\text{O}_3 + 3\text{CO} \rightarrow 2\text{Fe} + 3\text{CO}_2$
	800 ⁰ -1000 ⁰ C	Zone of slag formation.	CO ₂ is reduced to CO. Limestone decomposes to lime and CO ₂ .Lime combines with SiO ₂ to form the slag, CaSiO ₃ .	$\text{CO}_2 + \text{C} \rightarrow 2\text{CO} -163\text{kJ}$ $\text{CaCO}_3 \xrightarrow{\Delta} \text{CaO} + \text{CO}_2$ $\text{CaO} + \text{SiO}_2 \rightarrow \text{CaSiO}_3$
	1200 ⁰ -1300 ⁰ C	Zone of fusion	Coke burns to CO ₂ . Porous iron melts. Any iron oxide remaining is completely reduced to Fe.	$\text{C} + \text{O}_2 \rightarrow \text{CO}_2$
	Above 1400 ⁰ C		Molten iron collects in the bottom of the hearth. Slag floats on iron molten.	

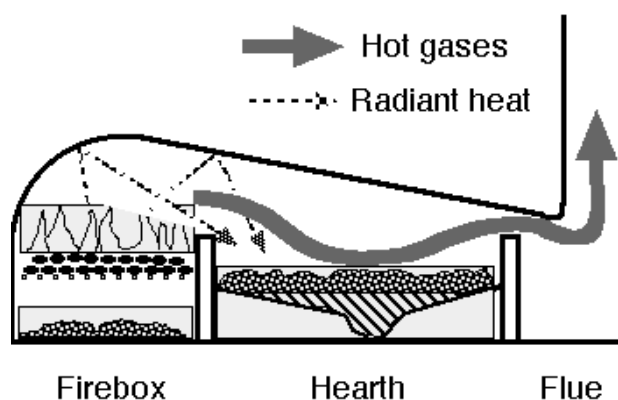


Blast furnace – Manufacture of cast iron

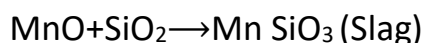
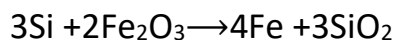
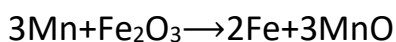
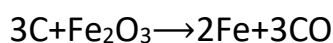
The iron obtained is known as Pig iron". The pig iron is melted and poured into moulds. The solid iron obtained by cooling pig iron is called as "cast iron" It contains nearly 4% C.

b. Manufacture of wrought iron:

Wrought iron is the purest form of iron containing about 0.2 % C. It is prepared by heating cast iron in a reverberatory furnace. The furnace is given a basic lining of iron oxide. The impurities and the carbon present in cast iron combine with the lining. The impurities form a slag and carbon is oxidized to CO and escapes. It burns with a blue flame. The flames are known as "puddler's candles". Hence the process is known as puddling process.



Carbon and various impurities present combine with lining and form slag.



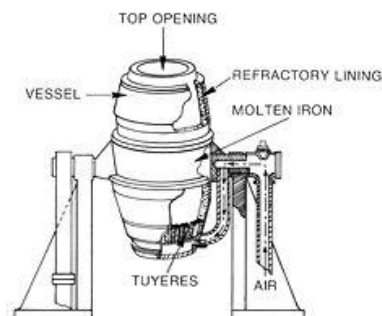
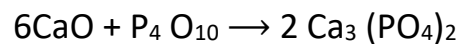
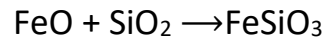
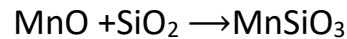
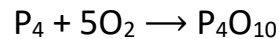
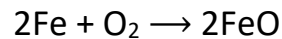
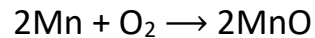
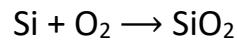
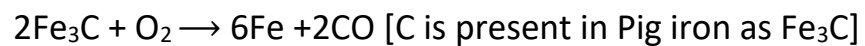
c. Manufacture of steel:

Steel contains a lower percentage of carbon and other impurities than the pig iron. It is prepared by blowing air through molten pig iron taken in Bessemer converter.

Bessemer converter process:

The Bessemer converter is a pear shaped furnace. It is constructed with steel. It is lined with silica or lime depending on the proportions of impurities (P, Si, Mn and C) present in the iron (P, Si, Mn and C). It is mounted on trunnions so that it can be tilted as one desires. Air is forced through the inlets at the bottom.

Carbon and various other impurities present combine with oxygen and form slag.



The basic slag containing $\text{Ca}_3(\text{PO}_4)_2$ is known as Thomas slag. It is used as phosphatic fertilizer the CO burns with a blue flame. As soon as the CO is completely burnt out, the Bessemer converter is tilted to take some more substances in to it. A calculated amount of carbon is added in the form of

spiegeleisen (an alloy of iron with 15-20% Mn; 60% C and the rest iron). Manganese reduces the loss of iron. Also the ferromanganese unites with O_2 caught in the steel after Bessemerization process.

Example set:

1. Hematite is _____
- Fe_3O_4
 - Fe_2O_3
 - $FeCO_3$
 - $2Fe_2O_3 \cdot 3H_2O$

Solution: b)

2. Pig iron is also called _____
- Cast Iron
 - Graft Iron
 - Steel
 - Stainless steel

Solution: a)

3. Which of the following is the least pure form of Iron?
- Bessemer Iron
 - Steel
 - Pig Iron
 - Wrought Iron

Solution: c)

4. Which of the following is prepared by puddling process?
- Pig Iron
 - Wrought Iron
 - Steel
 - All the above

Solution: b)

5. Write any three minerals of Fe?

Solution:

Haematite (Reddish brown coloured) Fe_2O_3

Magnetite (Magnetic oxide) Fe_3O_4

Limonite (Hydrated oxide) $2\text{Fe}_2\text{O}_3 \cdot 3\text{H}_2\text{O}$

6. Describe a method for the manufacture of Pig iron from the ore.

Solution:

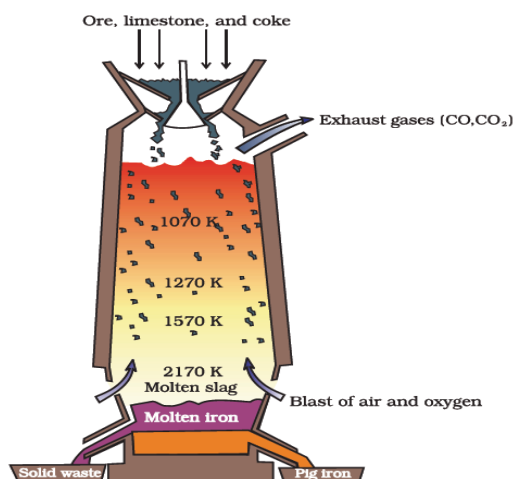
a. Manufacture of cast iron

Iron is extracted from its oxides in a blast furnace. This is an almost cylindrical furnace, lined inside with fire bricks. It is charged from the top with an iron ore (8 parts), desulphurised coke (4 parts) and lime stone (1 part) and is mixed in 8:4:1 parts by weight. Air is blown from the bottom. The coke burns producing heat and CO. The temperature range in the furnace is 300° - 1600° c. Various reactions take place in the blast furnace at different temperature and different tones.

The iron obtained is known as Pig iron". The pig iron is melted and poured into moulds. The solid iron obtained by cooling pig iron is called as "cast iron" It contains nearly 4% C.

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	1200 ⁰ - 1300 ⁰ C	Zone of fusion	Coke burns to CO ₂ . Porous iron melts. Any iron oxide remaining is completely reduced to Fe.	$C + O_2 \rightarrow CO_2$
	Above 1400 ⁰ C		Molten iron collects in the bottom of the hearth. Slag floats on iron molten.	



Blast furnace – Manufacture of cast iron

Assignment questions:

1. Compare “Bessemer process” and “open – hearth process” for the preparation of steel
2. Draw a neat diagram of Blast furnace. Indicate the temperature zones and their names in it
3. Draw a neat diagram of a reverboratory furnace and label it neatly

Example set:

1. Spiegeleisen used in steel making is a form of _____
 - a. Ferro – vanadium
 - b. Ferro – chromium

- c. Ferro – silicon
- d. Ferro - manganese

Solution: d)

2. In which one of the following smelting is carried out
- a. Blast furnace
 - b. Open hearth furnace
 - c. Bessemer converter
 - d. All of these

Solution: a)

3. The hottest part of the blast furnace is
- a. Hearth
 - b. Tuyers
 - c. Outlet for gases
 - d. Entrance for charge

Solution: a)

4. Which of the following process involves the smelting process
- a. $\text{ZnCO}_3 \rightarrow \text{ZnO} + \text{CO}_2$
 - b. $2\text{PbS} + 3\text{O}_2 \rightarrow 2\text{PbO} + 2\text{SO}_2$
 - c. $\text{Fe}_2\text{O}_3 + 3\text{C} \rightarrow 2\text{Fe} + 3\text{CO}$
 - d. $\text{Al}_2\text{O}_3 \cdot 2\text{H}_2\text{O} \rightarrow \text{Al}_2\text{O}_3 + 2\text{H}_2\text{O}$

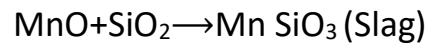
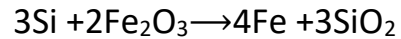
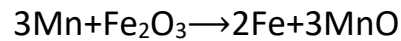
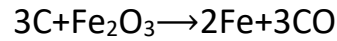
Solution: c)

5. The important oxide ore of iron is
- a. Siderite
 - b. Haematite
 - c. Pyrites
 - d. Bauxite

Solution: b)

6. Write the equations for the chemical reactions that take place in the manufacture of wrought iron.

Solution:



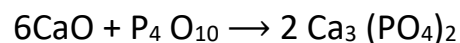
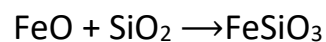
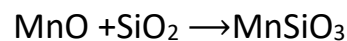
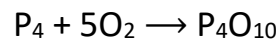
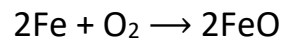
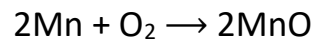
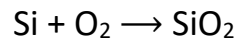
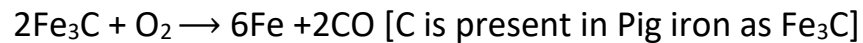
7. Describe a method to convert cast – iron into steel of high quality.

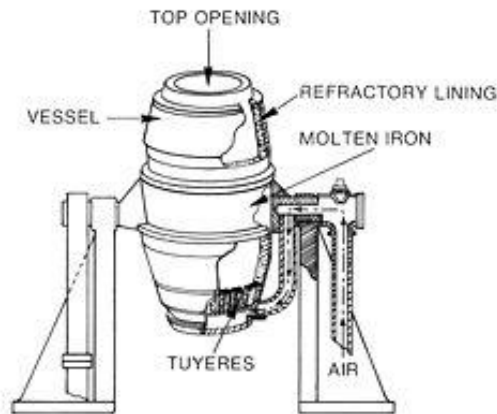
Solution:

Bessemer converter process

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Exercise questions:

1. Differentiate between “minerals” and “ores”.
2. How is ‘cast iron’ different from ‘pig iron’?
3. a. What is name and formula of slag formed from P_2O_5 impurity in the metallurgy of iron
 b. In what form carbon is present in white cast iron?
 c. Which molten metals are found in the core of earth?
4. What is the chemical formula of fool’s gold
5. Give the names of two metals for which Bessemerisation is used

Solutions to exercise questions:

1. Minerals are naturally occurring chemical substances containing metals. They are found in the Earth’s crust and are obtained by mining.

Ores are rocks and minerals viable to be used as a source of metal.

For example, there are many minerals containing zinc, but zinc cannot be extracted profitably (conveniently and economically) from all these minerals.

Zinc can be obtained from zinc blende (ZnS), calamine (ZnCO_3), Zincite (ZnO) etc.

Thus, these minerals are called ores of zinc.

2. The iron obtained from blast furnaces is known as pig iron. It contains around 4% carbon and many impurities such as S, P, Si, Mn in smaller amounts.

Cast iron is obtained by melting pig iron and coke using a hot air blast. It contains a lower amount of carbon (3%) than pig iron. Unlike pig iron, cast iron is extremely hard and brittle.

3.
 - a. Thomas slag $\text{Ca}_3(\text{PO}_4)_2$
 - b. Cementite Fe_3C
 - c. Nickel and iron
4. FeS_2
5. Fe and Cu