

# **METALLURGY-II**

- 4Hrs X1.5 =6 marks

# Nernst distribution law

**Q 1. Define partition coefficient** (march-2011)

*“At a constant temperature, a solute distribute itself between two immiscible solvents in such a way that the ratio of its concentration in two solvents is a constant” (distribution ratio or partition co-efficient)*

**For example;** Silver is 300 times more soluble in molten zinc than in molten lead at **800°C**

$$\text{partition co-efficient} = \frac{\text{Conc. of silver in molten Zinc}}{\text{Conc. of silver in molten lead}} = \frac{300}{1} = 300$$

**Q 2. Name the process used for desilverisation of lead [April-07 & june-08] (1Mark)**

- **Parke's process**

$$\text{partition co-efficient} = \frac{\text{Conc. of silver in molten Zinc}}{\text{Conc. of silver in molten lead}} = \frac{300}{1} = 300$$

**Q 3. Describe Parke's process of desilverisation of lead.**

**[March-08 &09] (3Marks)**

**Parke's process is based on the following facts(Principle):**

- \* Argentiferous lead contains up to 2% silver**
- \* Molten zinc & molten lead can become immiscible liquid mixture**
- \* According to distribution law at 800°C, Silver 300 times more soluble in the "molten Zn" layer compared to that of molten lead**
- \* Zn-Ag alloy solidifies more readily compared to that of molten lead, when cooled.**

## Alexander Parkes

Date of birth : 1831-12-29

Date of death : 1890-06-29

Birthplace : Birmingham, England

Nationality : British

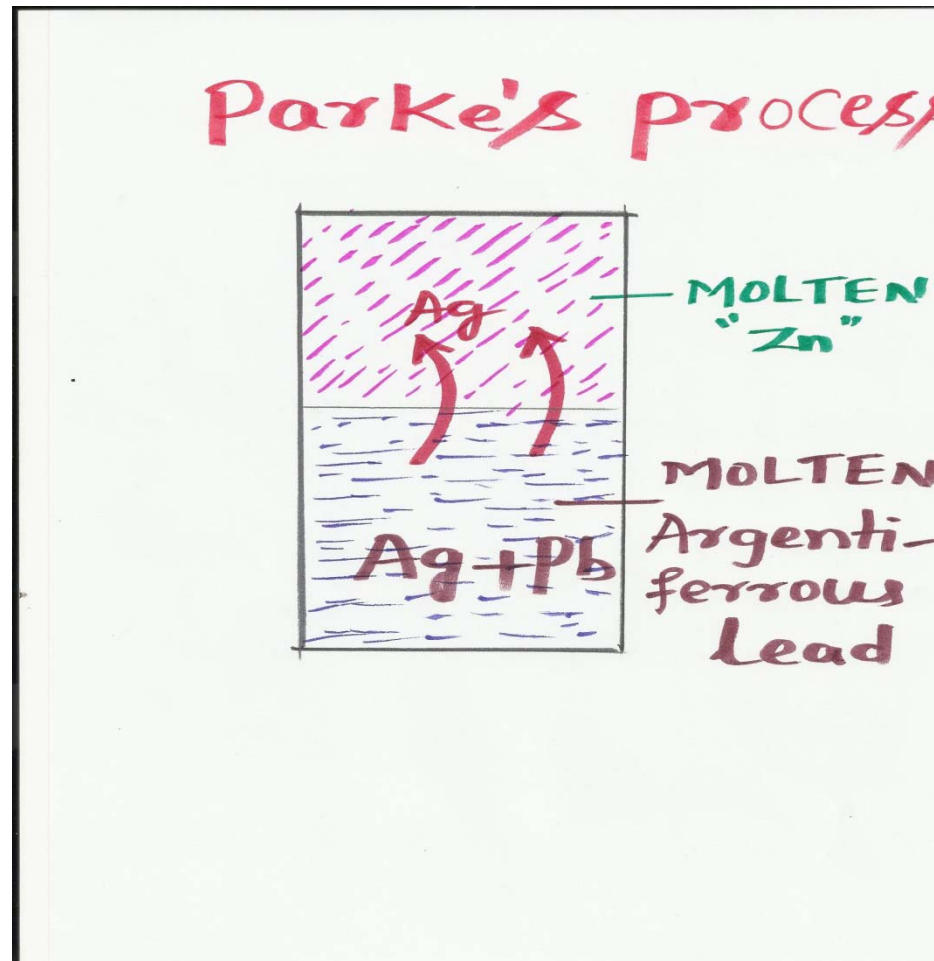
Credited as : Engineer-metallurgist, invented the earliest form of plastic,

\* The son of a brass lock manufacturer, Parkes was born on December 29, 1831, in Birmingham, England.

\* Parkes held 66 patents on processes and products related to electro-plating and plastic development



# PARKE'S PROCESS-desilverisation of lead



# Process:

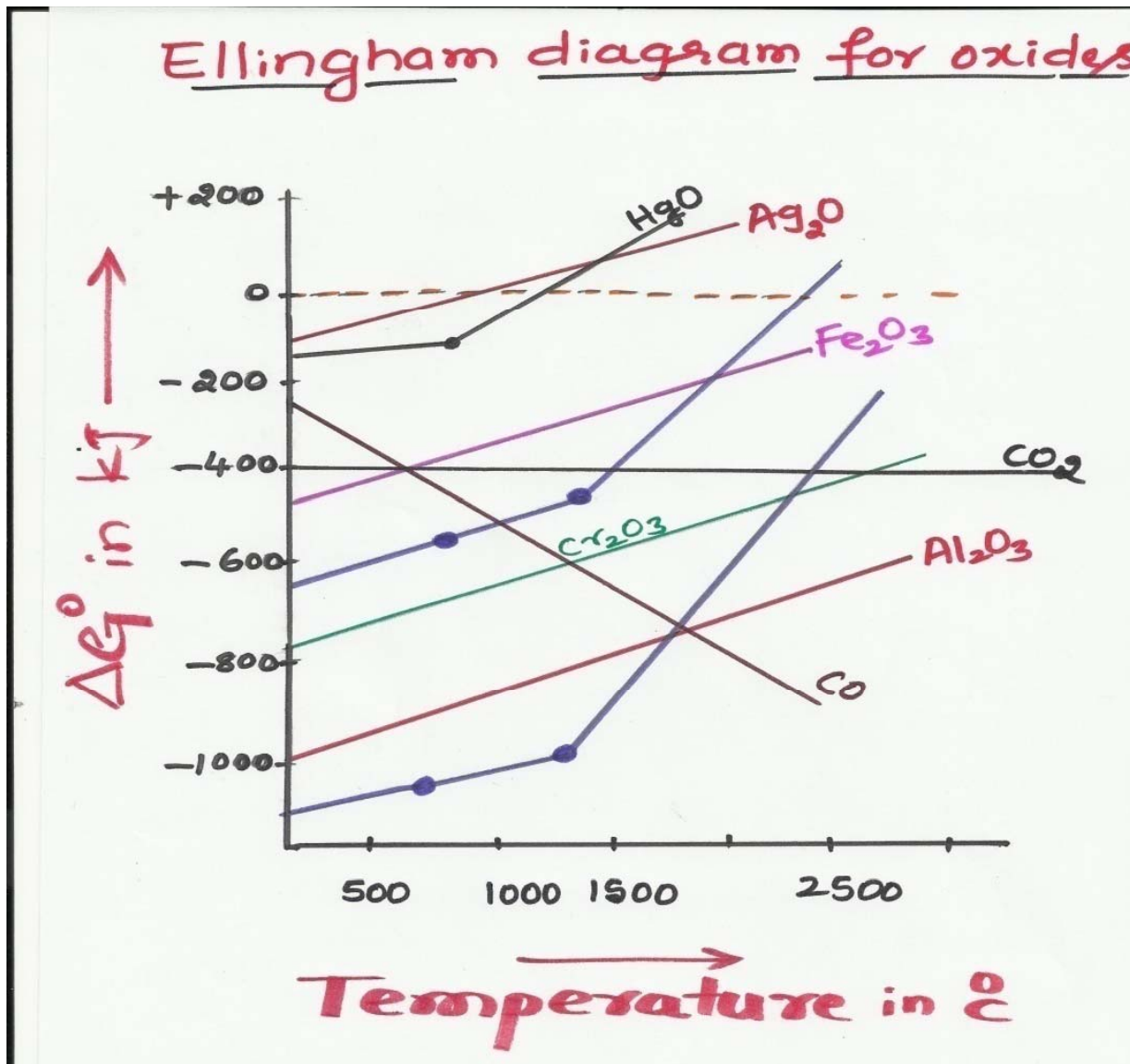
- Argentiferous lead is melted to 800°C. It is mixed with molten zinc
- As silver 300 times more soluble in molten zinc, most of the “Ag” moves in to the “Zn” layer.
- On cooling, the upper “Zn-Ag” alloy solidifies first. It is skimmed off.
- The “Zn-Ag” alloy is distilled in retort to separate zinc from silver
- The traces of lead impurity is removed by “Cupellation”

## Ellingham diagrams

- *Ellingham diagrams are plots of change in standard free energy change with temperature for various reactions like the formation of oxides ,sulphides etc..of various elements*
- Ellingham diagrams for the formation of oxides obtained by plotting the standard free energy change v/s Temperature for the oxidation process involving one mole of oxygen at various temperatures.



# Ellingham diagrams



## SALIENT FEATURES OF ELLINGHAM DIAGRAM

- The graphs for the formation of metal oxides slope upwards as std. free energy change increases with temperature
- The sudden change in the slope of the graphs indicate M.P & B.P
- For oxides of “Ag” and “Hg” the std.free energy change becomes greater than zero at high temperatures



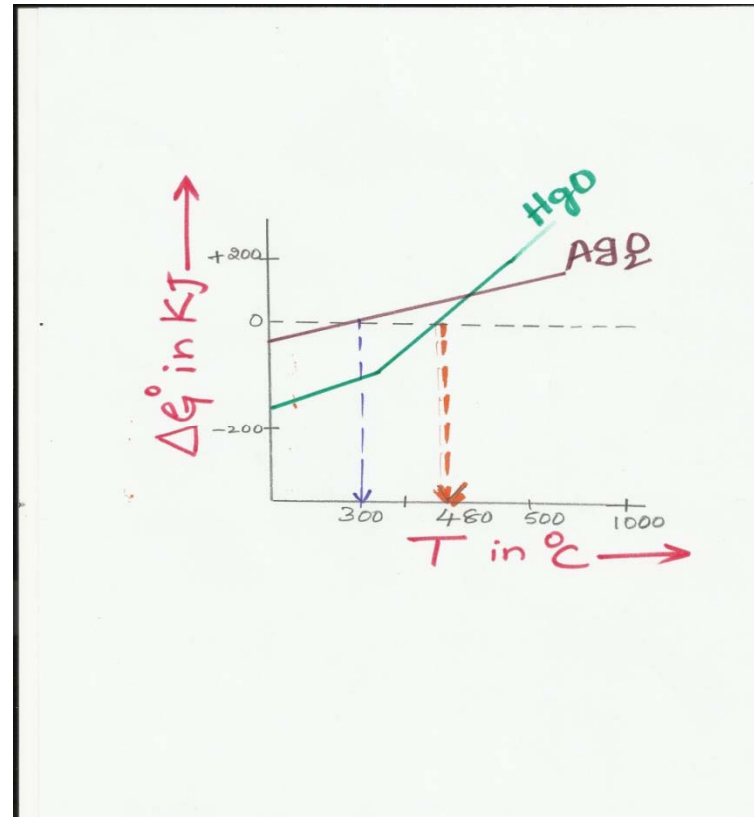
- The metal oxides placed below are stable

## SALIENT FEATURES OF ELLINGHAM DIAGRAM

- The metal of metal oxide placed below can reduce the metal oxide placed above in the diagram
- The line for the formation of  $\text{CO}_2$  is parallel to temperature axis as change in free energy remains constant.
- $\text{C}_{(s)} + \text{O}_{2(g)} \longrightarrow \text{CO}_{2(g)}$
- The graph for the formation of CO has negative slope as entropy increases and free energy decreases
- $2\text{C}_{(s)} + \text{O}_{2(g)} \longrightarrow 2\text{CO}_{(g)}$

**Q.5 With the help of the Ellingham's diagram, explain why silver oxide can be thermodynamically decomposed at relatively lower temperature [july-2009] (2 Marks)**

- **Change in std.free energy change v/s Temperature curves for the oxidation of Ag & Hg crosses zero line & their change in std. free energy become +ve even at lower temperature**
- **So these oxides become unstable & readily decompose on heating**

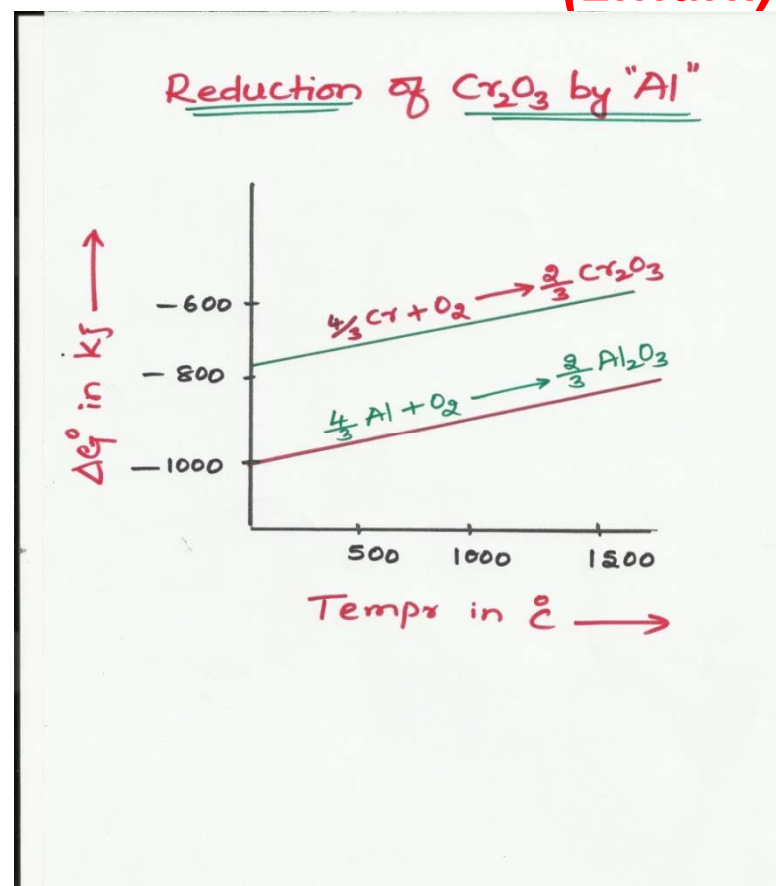


**Q.6 With the help of the Ellingham's diagram, explain why Aluminium is used as a reducing agent in the manufacture of chromium from chromic oxide. [April-2007]**

- Std. Change in free energy value for the formation of  $\text{Al}_2\text{O}_3$  is always less than that of  $\text{Cr}_2\text{O}_3$ .

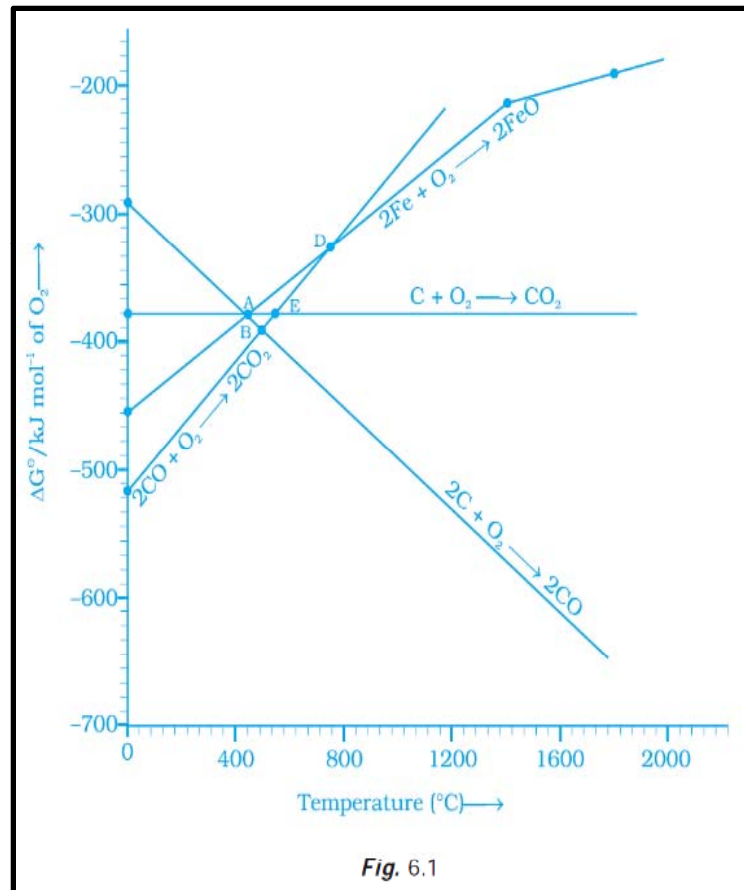
(2Mark)

- $\text{Al}_2\text{O}_3$  is more stable
- Hence "Al" is used to reduce  $\text{Cr}_2\text{O}_3$  (Chromic oxide)
- This process is called "Goldschmidt aluminothermic" process

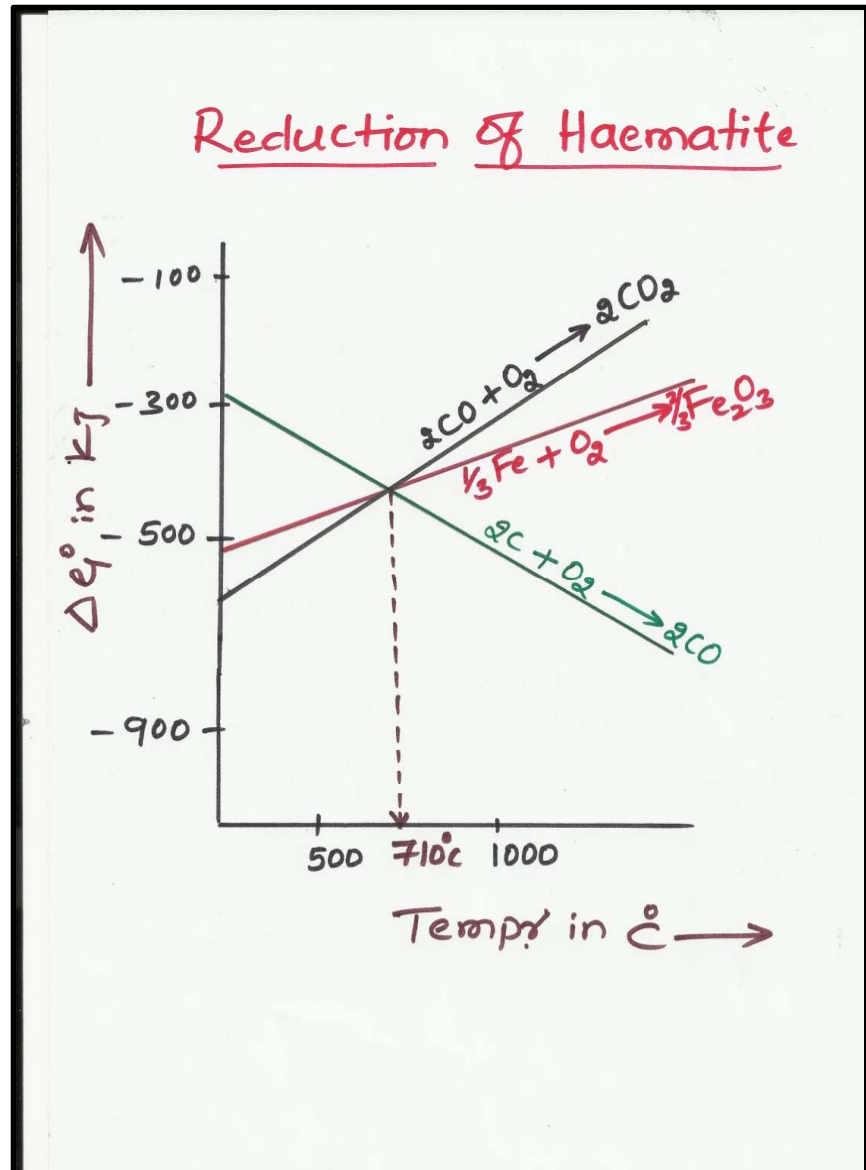


**Q.7 With the help of Ellingham diagram, explain why carbon monoxide acts as reducing agent in the production of cast iron from Haematite. (2Mark)**

- Below 710°C, std.change in free energy for the formation of Fe<sub>2</sub>O<sub>3</sub> is more than that of formation of CO<sub>2</sub> from “CO”. There fore “CO” is better reducing agent for Fe<sub>2</sub>O<sub>3</sub> below 710°C.



- Above  $710^{\circ}\text{C}$ , the std .change in free energy value for the formation of  $\text{Fe}_2\text{O}_3$  is more than that of CO formation from Carbon(Coke)
- Hence above  $710^{\circ}\text{C}$ , coke (carbon ) is better reducing agent for  $\text{Fe}_2\text{O}_3$ .



**Q 8. Explain the chemical reactions that occur during the extraction of iron from haematite ore by smelting in a blast furnace (3 Marks)**

OR

- Q.9 Explain the chemical reactions that occur during the extraction of cast iron At i) Zone of combustion ii) zone of reduction iii) zone of slag formation of blast furnace.**

OR

**(3 Marks)**

**Q.10 Draw a neat labelled diagram of blast furnace used in the extraction of cast iron. Give the chemical reactions that take place in the different zones of the furnace. [April-2007]**

**(3Marks)**



# Metallurgy of Iron(Fe)

## Important Minerals of Iron

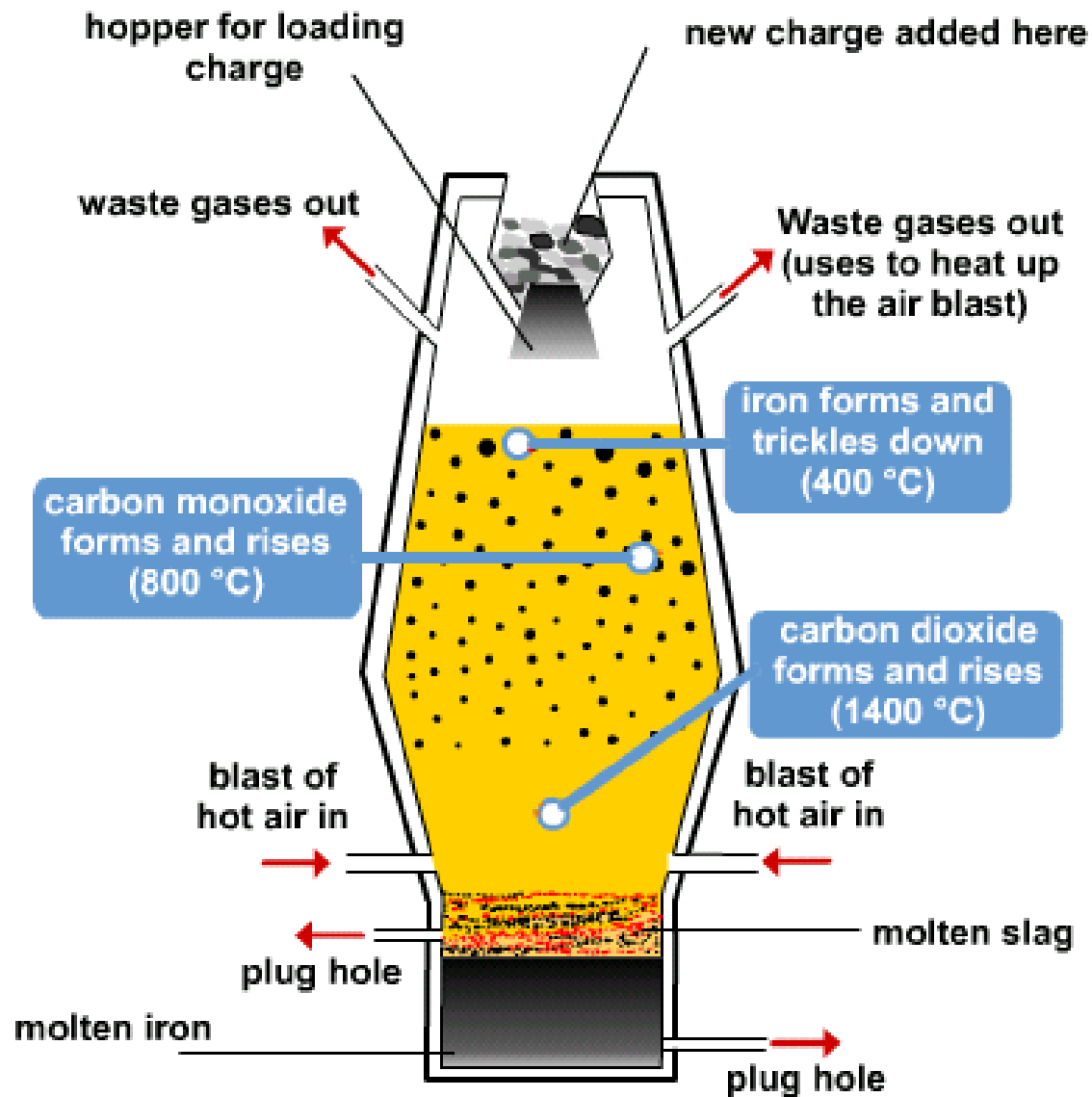
- Haematite - $\text{Fe}_2\text{O}_3$
- Magnetite-  $\text{Fe}_3\text{O}_4$
- Limonite - $2\text{Fe}_2\text{O}_3 \cdot 3\text{H}_2\text{O}$
- Siderite - $\text{FeCO}_3$
- Iron Pyrites-  $\text{FeS}_2$

# Metallurgy of Iron(Fe)

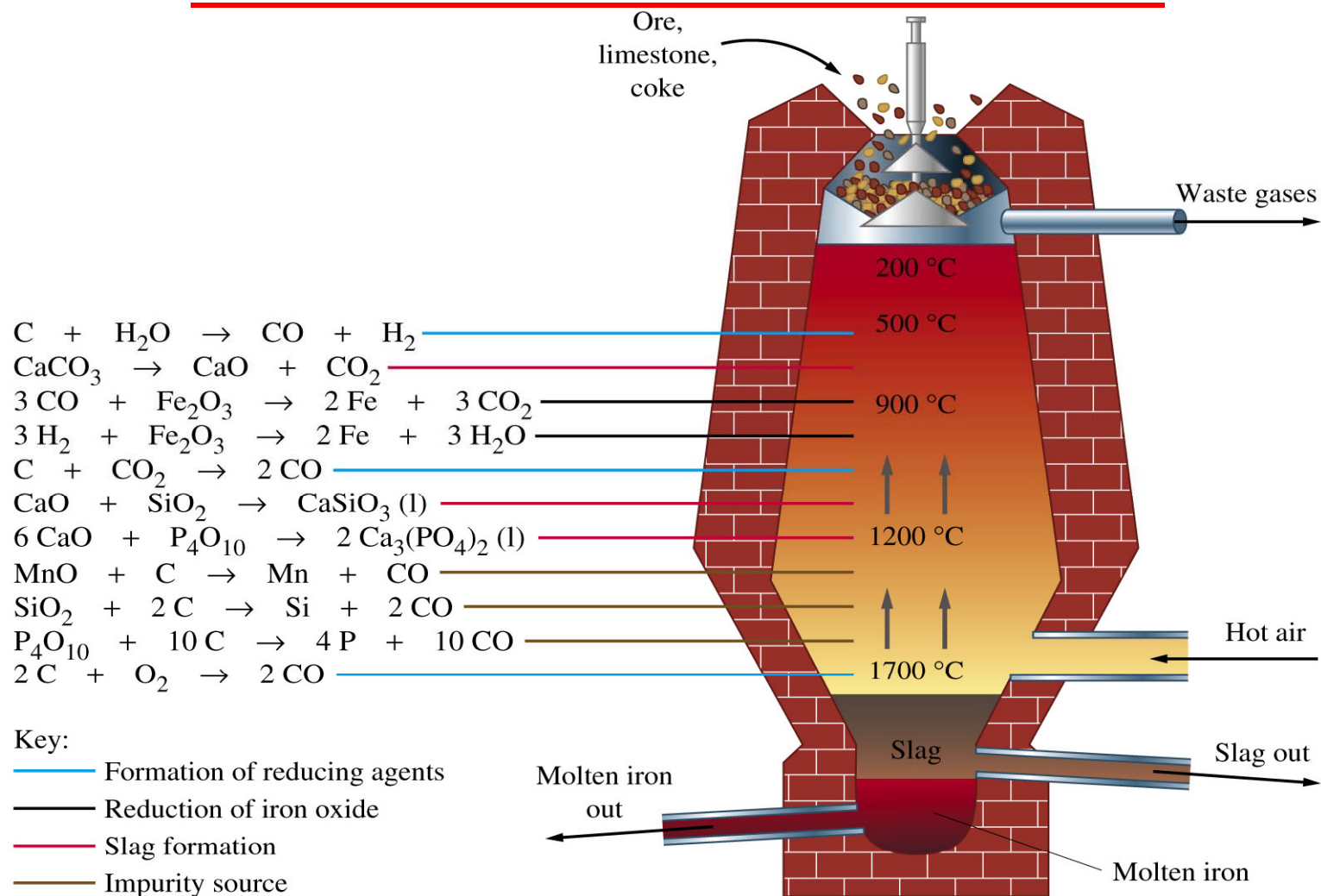
## I. Concentration of Haematite

- Haematite ore is concentrated by washing with a current of water
- The concentrated ore is subjected to “calcination”
- Volatile impurities are removed.
- If there is any traces  $\text{FeO}$ , it is oxidised to  $\text{Fe}_2\text{O}_3$ .
- The ore become porous.

# Blast furnace-Smelting



# BLAST FURNACE



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A mixture of *haematite Ore +lime stone+ Coke* (8:1:4) is introduced in to a tall cylindrical blast furnace by means of *cup & double cone* at the top of the furnace.

The *widest portion* of the furnace is called as "*Boshes*"

Hot air is blasted into the furnace just below the boshes using "*tuyers*"

*I. Zone of combustion (1500°C)*



Due to this *exothermic reaction*, the temperature raises to **1500°C** at the *combustion zone*.

- As the  $\text{CO}_2$  raises up the furnace, coke combines with  $\text{CO}_2$  to form CO
- $\text{CO}_2(g) + \text{C}(s) \longrightarrow 2\text{CO}(g) - 163\text{kJ}$
- This reaction is endothermic. Therefore the temperature decreases gradually from bottom ( $1500^\circ\text{C}$ ) towards the top ( $400^\circ\text{C}$ )

## II. Zone of reduction (below 710<sup>0</sup>C OR at 600<sup>0</sup>C )

- At about 600<sup>0</sup>C, Fe<sub>2</sub>O<sub>3</sub> is reduced by “CO” to give spongy iron
- $\text{Fe}_2\text{O}_3 + 3\text{CO} \longrightarrow 2\text{Fe} + 3\text{CO}_2$
- Spongy iron collects at the bottom of the furnace called pig iron or “cast iron”

## III. Zone of slag formation: (at 900<sup>0</sup>C)



(flux)      (gangue)                      (slag)

**Q.12** *What is the function of lime stone & coke in the smelting of haematite ? (1Mark)*

- Lime stone( $\text{CaCO}_3$ ) decomposes to  $\text{CaO}$  which acts as “flux”



(flux) (gangue) (slag)

- Coke produces “CO” which acts as reducing agent  $\text{Fe}_2\text{O}_3 + 3\text{CO} \longrightarrow 2\text{Fe} + 3\text{CO}_2$



**Q.13 Write the reaction that occurs in the zone of combustion in the blast furnace -july 2009**

**(1Mark)**

- **Coke burns with air to produce carbon dioxide**



**Due to this exothermic reaction, the temperature raises to 1500°C at the combustion zone.**

# **Industrially Important Compounds**

**-4hrs X 1.5=6marks**

## ***I. Manufacture of NaOH-Nelson's process***

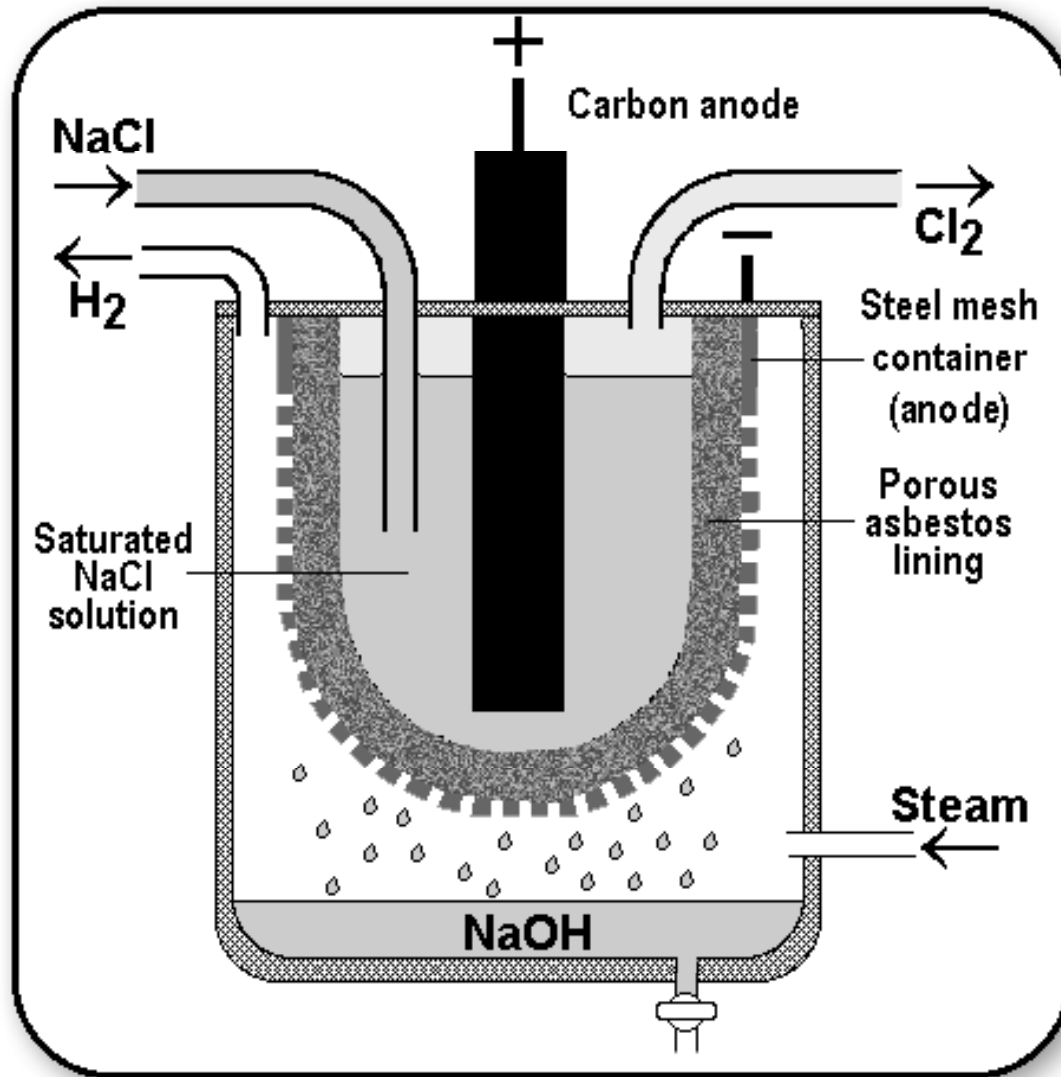
***Q.14 .With a neat labelled diagram explain the manufacture of caustic soda using Nelson cell (July-07 &2011)***

### **Principle:**



- A solution of sodium chloride in water contains **Na<sup>+</sup>, Cl<sup>-</sup>, H<sup>+</sup> and OH<sup>-</sup>**
- During electrolysis, only **H<sup>+</sup> ion reduced** to H<sub>2</sub> at cathode .Similarly only **Cl<sup>-</sup> is oxidized** to Cl<sub>2</sub> at anode
- **The solution become richer in Na<sup>+</sup> & OH<sup>-</sup> ions**

# Nelson's cell



# Nelson's cell

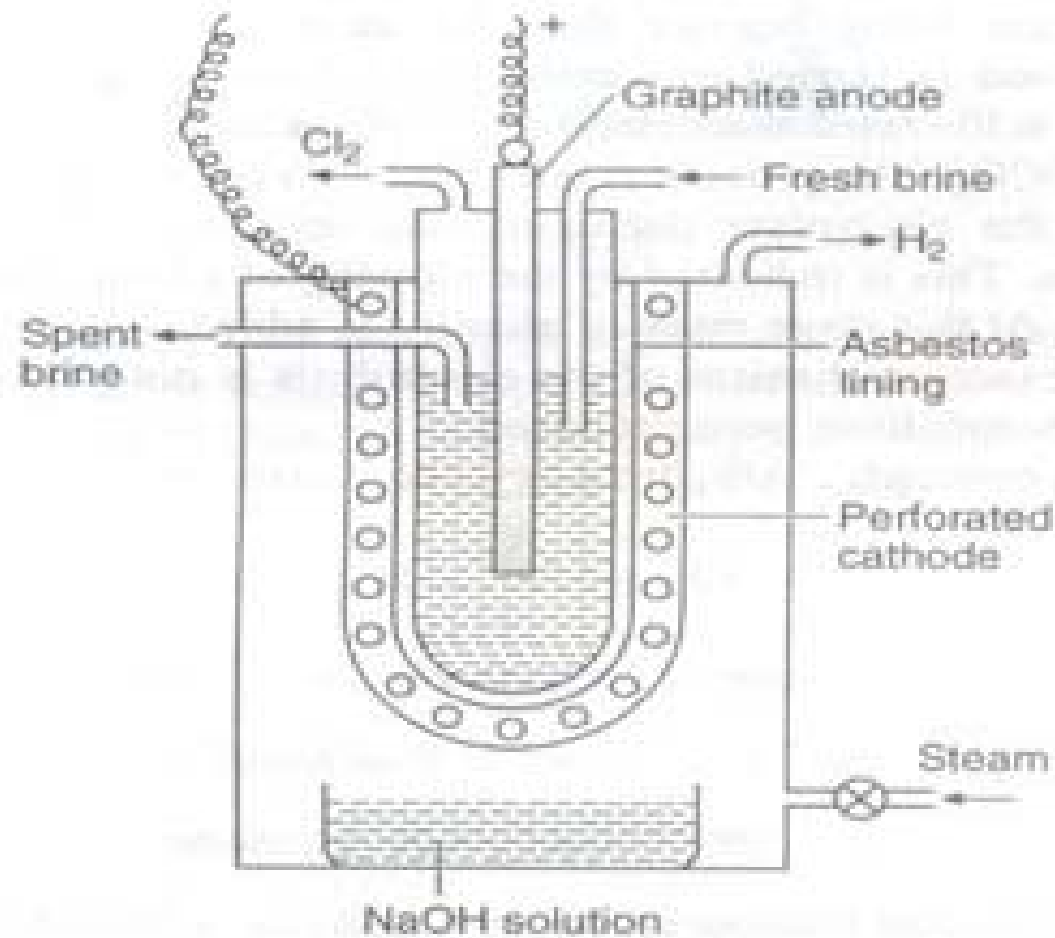


Fig. 12.19 Nelson cell

## ***Process:***

- Nelson cell consists of a rectangular steel tank. A perforated **U-tube** is suspended in the tank. It is made to act as **Cathode**.
- The steel U-tube is lined inside with **asbestos** which act as **diaphragm**
- A saturated solution of NaCl in water (**Brine**) is taken in the cell.
- A **graphite rod** dipped in the solution is made to act as **Anode**

## During electrolysis:



- The solution becomes richer in NaOH. It collects in the catch basin at the bottom
- The steam is circulated ,to keep the electrolyte warm & to keep the pores clean and clear

**Purification:** The 98% pure NaOH is further purified by dissolving in alcohol

**Q15. Name the gas liberated at anode during the manufacture of caustic soda using Nelson cell**

**(july-09) 1mark**

- **chlorine ( $\text{Cl}_2$ ) gas is evolved anode**



## Uses of NaOH:

- Manufacture of soap, paper etc...
- In Baeyer's process
- Refining of petroleum & vegetable oil
- In the form of sodalime (NaOH + CaO) used as decarboxylating agent
- In mercerizing cotton in textile industry
- in volumetric analysis

## Manufacture of ammonia- *By Haber's process*

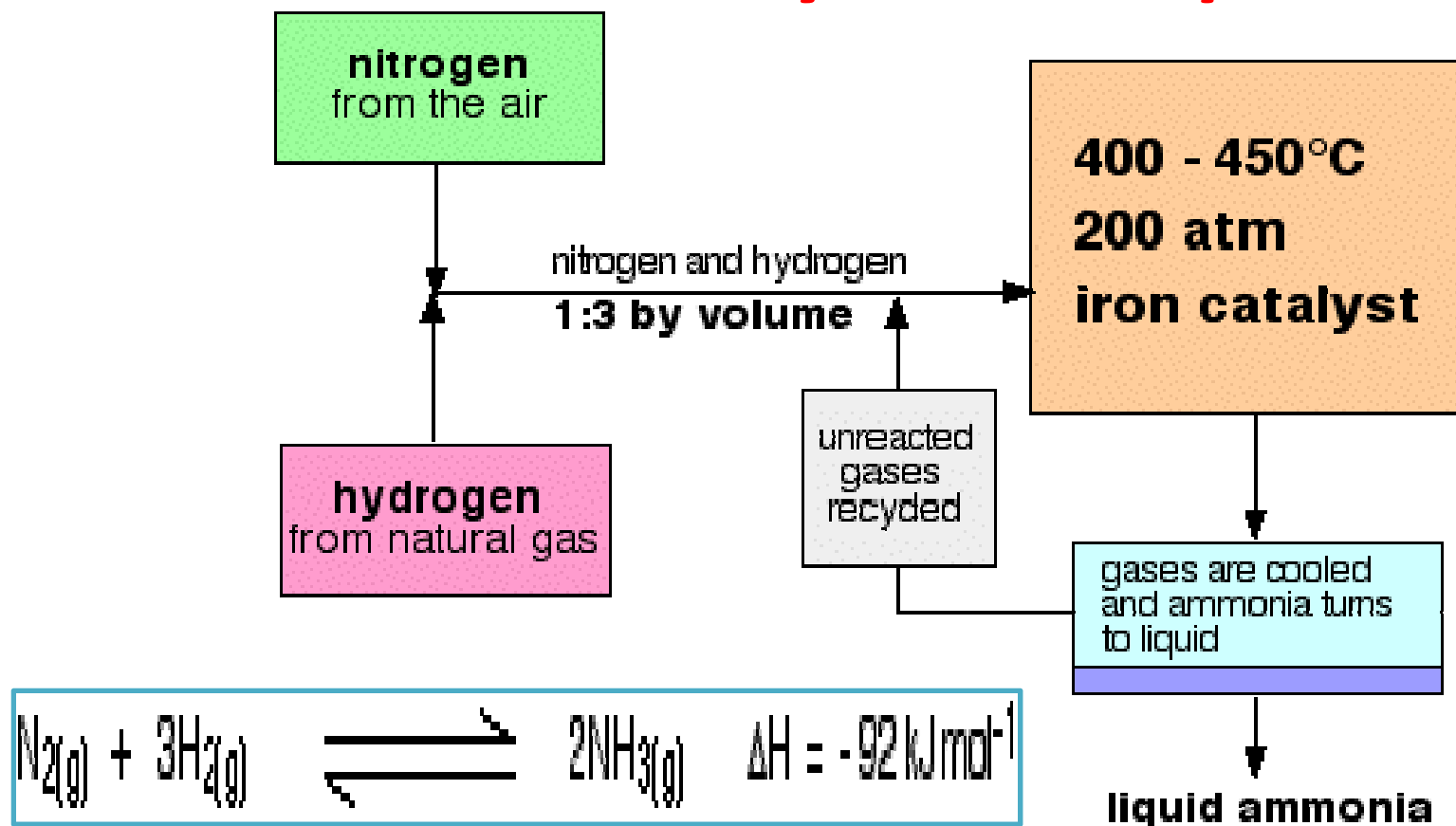
*Q.How is ammonia manufactured by Haber's process?*

- Haber's process involves the direct combination of  $N_2$  &  $H_2$



- According to *Le Chatelier's principle*, The following favorable conditions give better yield of ammonia;  
i) Finely divided "Fe" catalyst  
ii) a promoter like Mo or  $K_2O$  or  $Al_2O_3$ .  
iii) a moderate temperature of 773K (500°C)  
iv) A high pressure of 200atm

# Manufacture of ammonia- By Haber's process

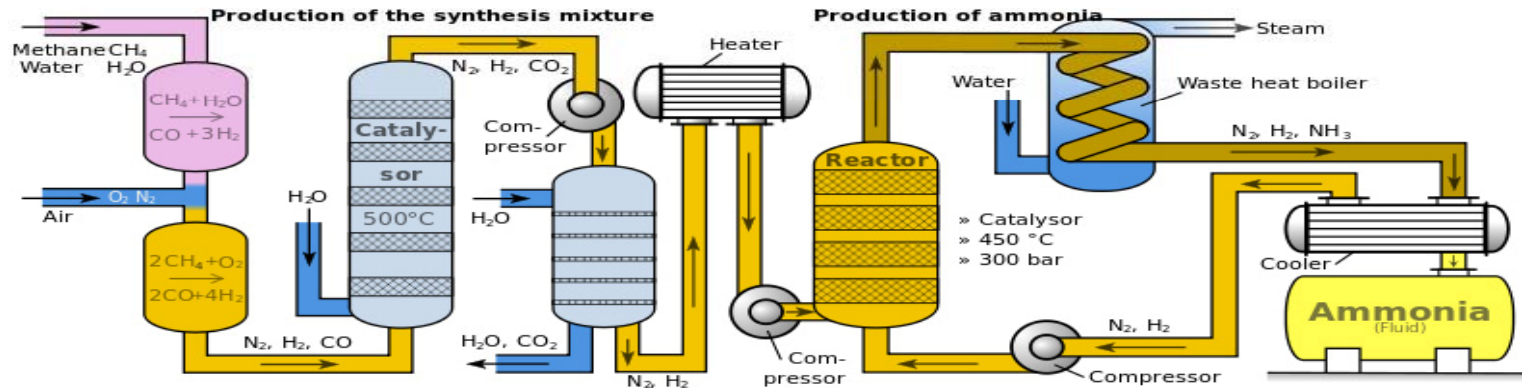


# Fritz Haber



- It is thought that two in five people owe their existence to the discoveries made by one brilliant chemist. However despite his incredible discovery many people still call Fritz Haber a *murderer.*
- It has been suggested that without this process, Germany would not have fought the war, or would have had to surrender years earlier

# Manufacture of ammonia- By Haber's process



# Process:

Step-I; Compression; A mixture of  $N_2$  &  $H_2$  in the ratio of 1:3 by volume is compressed to a pressure of 200 atm

Step-II: Conversion; \*The compressed gaseous mixture is passed over heated "Fe-catalyst" in presence of "Mo" as promoter

\*The catalytic converter is maintained at 450-500°C

\*Only about 15-20% of the mixture is converted in to



### Step-III: Cooling

- The gaseous mixture is passed through **cooling pipes**. Only  $\text{NH}_3$  liquefies

### Step-IV: Recycling

- The unreacted gases are collected & recycled
- $\text{NH}_3$  gas is dried over **CaO** to get liquor ammonia

## Uses of NH<sub>3</sub>:

- In the manufacture of fertilisers like urea, ammonia sulphate etc...
- *As refrigerant* –due to its high heat of vapourisation
- In the manufacture of HNO<sub>3</sub> by Ostwald's process
- As a non-aqueous solvent
- In the manufacture of Na<sub>2</sub>CO<sub>3</sub> by Solvay's process



## Manufacture of $H_2SO_4$ -by Contact process

Q16. How is  $H_2SO_4$  is manufactured by Contact process? 4mark

- $SO_{2(g)} + O_{2(g)} \rightleftharpoons 2SO_{3(g)} + 188\text{kJ}$
- According to Le Chatelier's principle, the following favorable conditions are maintained;
- i) Catalyst like  $V_2O_5$  or Platinized asbestos or  $Fe_2O_3$ .
- ii) Temperature = 723K or 500°C
- iii) Pressure ; 2 to 3 atm



# Manufacture of $\text{H}_2\text{SO}_4$

## -by Contact process

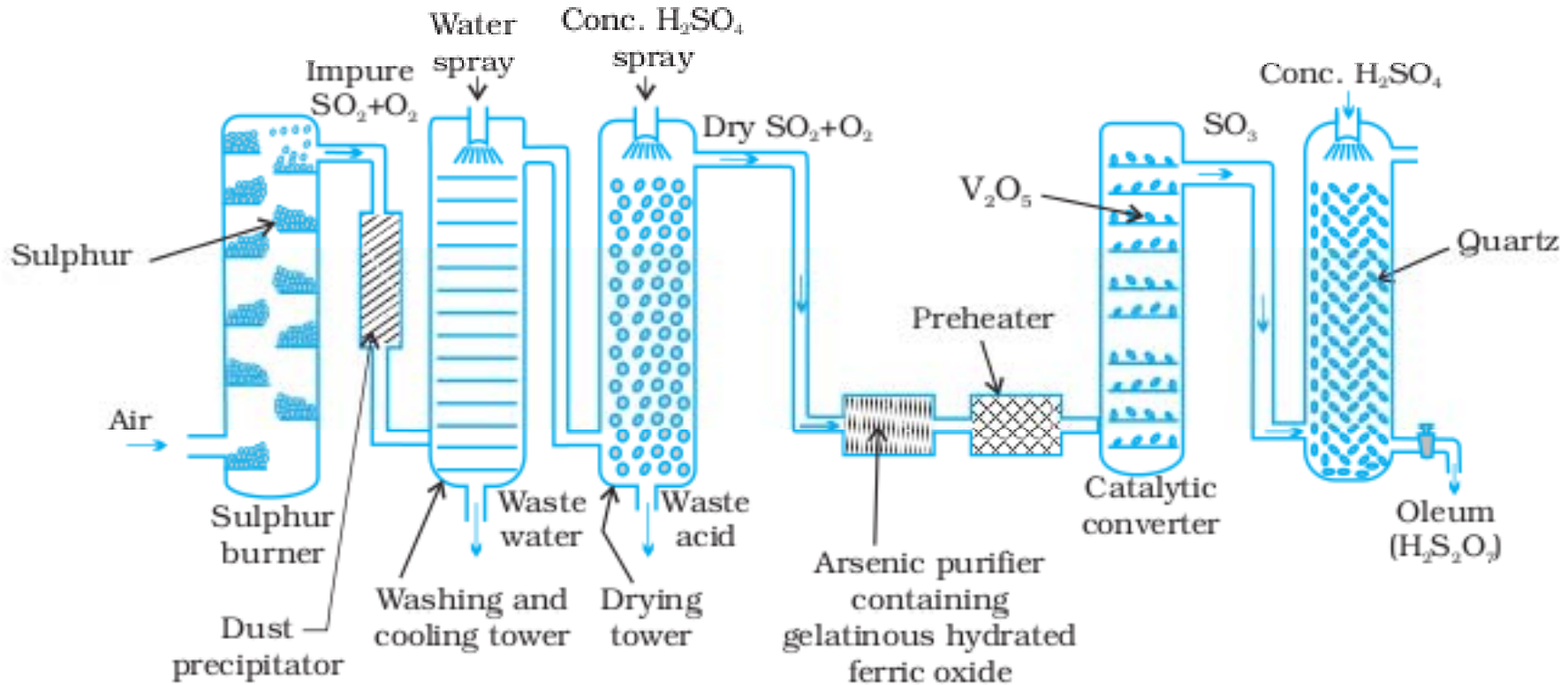
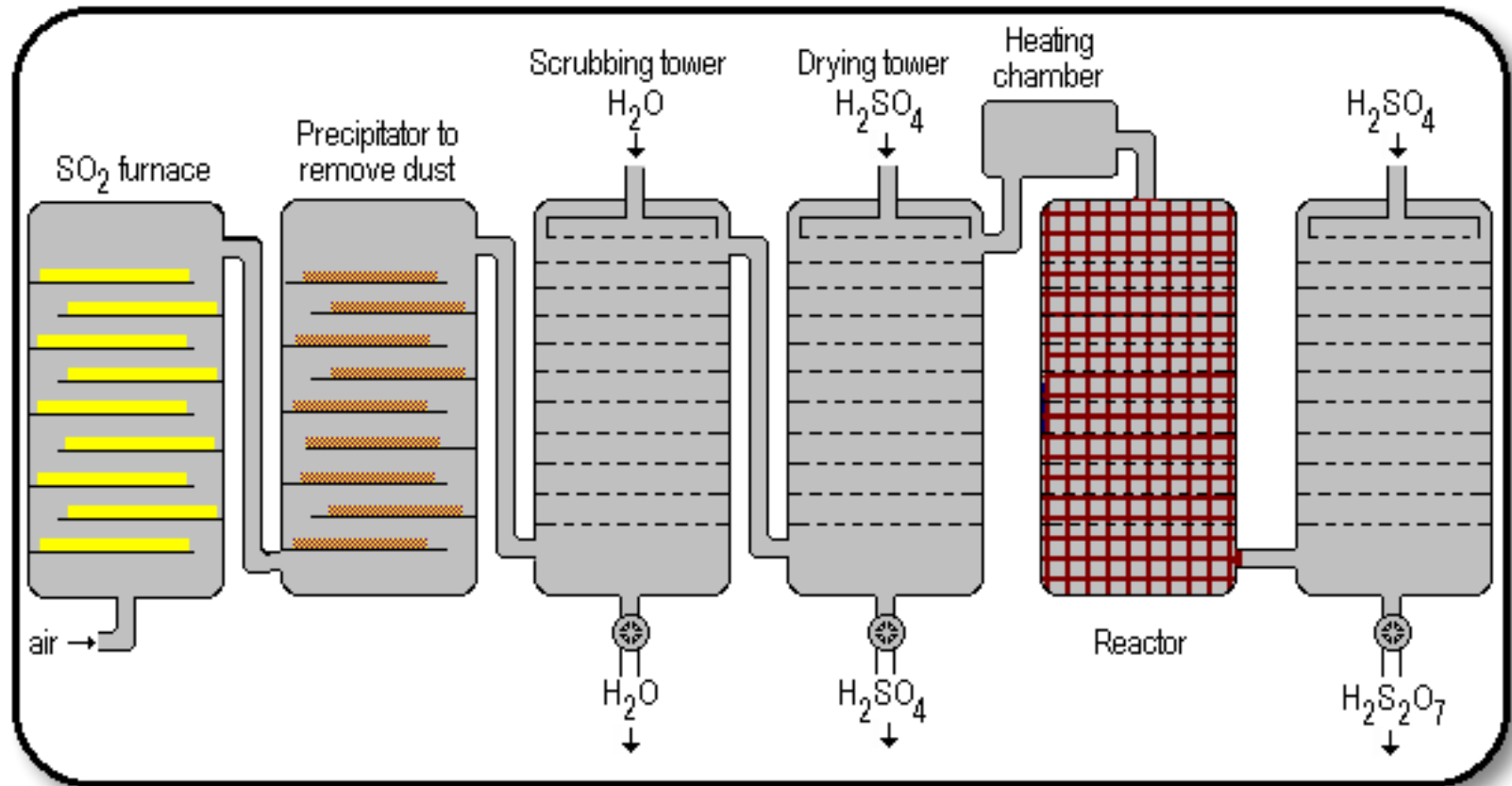


Fig. 7.7: Flow diagram for the manufacture of sulphuric acid

# Manufacture of $\text{H}_2\text{SO}_4$

## -by Contact process



## Process;

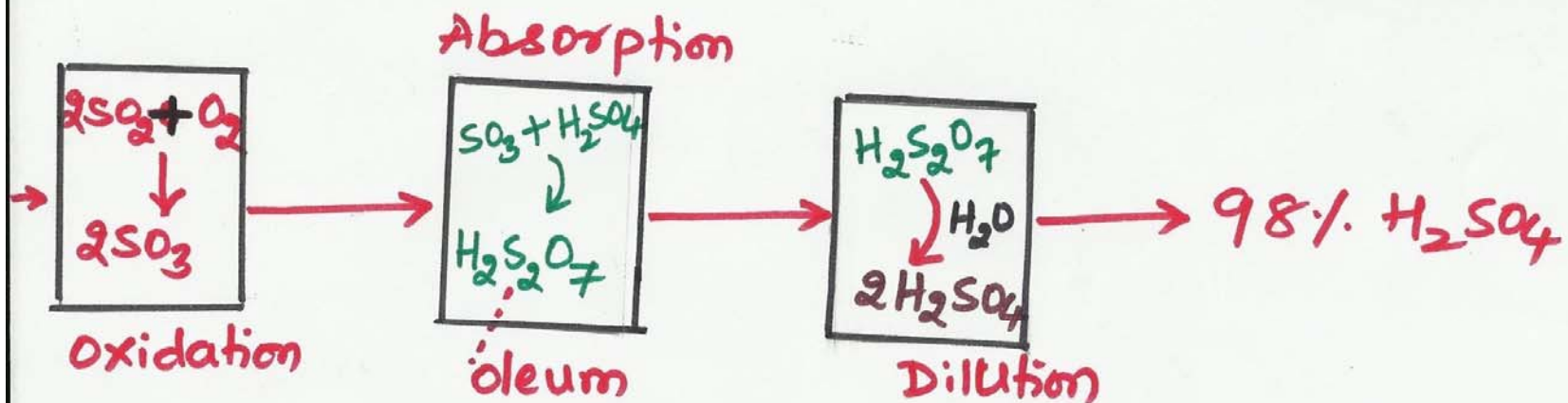
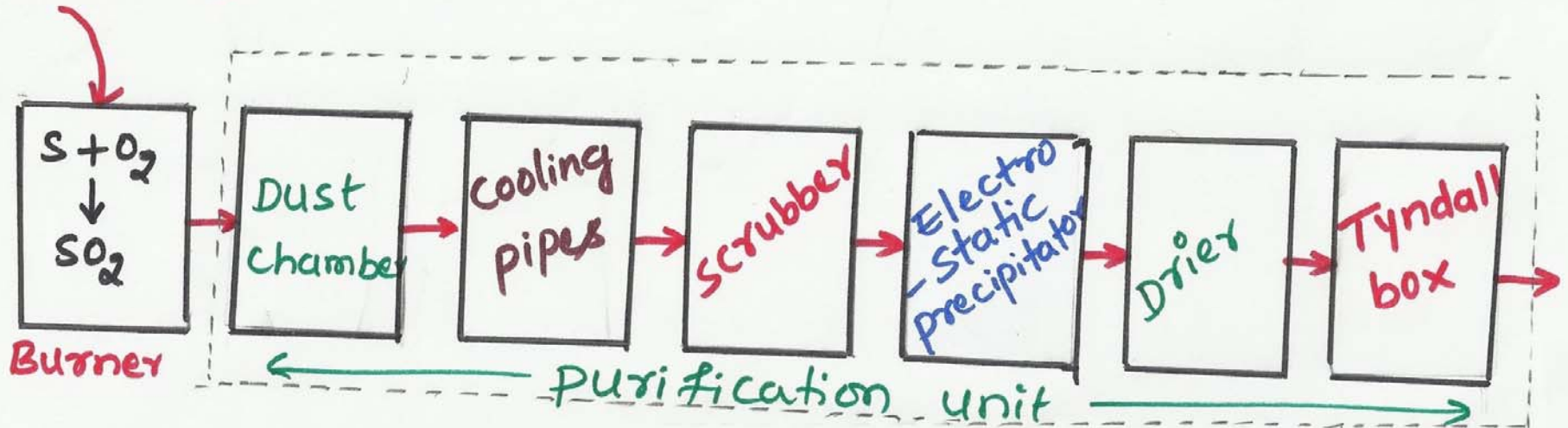
### Step-I: Production of SO<sub>2</sub>.

- SO<sub>2</sub> is produced either by *burning elemental sulphur* or *iron pyrites (4FeS<sub>2(s)</sub>)* in excess of air.



# Manufacture of $H_2SO_4$ - By Contact process

$S$  or  $FeS_2$



## **Step-II; Purification of Gases**

Mixture of  $\text{SO}_2$  &  $\text{O}_2$  is purified by passing through a series of Chambers;

- **1)Dust chamber:** Steam is passed. **Steam condenses** on the **dust particles** which settle at the bottom
- **2)Cooler:** The hot gases are cooled by passing through **cooling pipes**
- **3)Scrubber:** Water is sprayed from the top of the tower. **Water soluble impurities** are removed.

**4) Cottrell precipitator:** Electrically charged colloidal particles are removed

- **5) Drier:** The gaseous mixture is **dried** by spraying  $\text{Con.H}_2\text{SO}_4$ .
- **6) Arsenic purifier:**  $\text{As}_2\text{O}_3$  impurity is removed by using  $\text{Fe(OH)}_3$  ppt.
- **7) Tyndall box:** Pure & dry gas is passed through a “**Tyndall box**” to detect the presence of **colloidal impurities**

## Step-III; Oxidation of $SO_2$ to $SO_3$ :

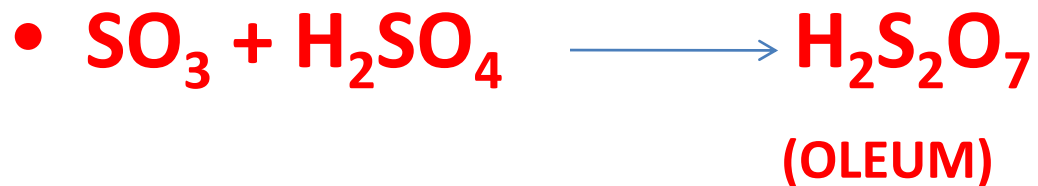
- The gaseous mixture is *pre-heated to  $300^{\circ}C$*  & passed in to the converter.
- The converter is packed with " $V_2O_5$ " or " $Pt$ " catalyst & maintained at  $500^{\circ}C$ .
- $2SO_{2(g)} + O_{2(g)} \xrightarrow{\text{"V}_2\text{O}_5" \text{ or "Pt"}} 2SO_{3(g)} + 188\text{kJ}$





## Step-IV; Absorption

- SO<sub>3</sub> gas is absorbed by using Con.H<sub>2</sub>SO<sub>4</sub> (98%) in the absorption tower to get **OLEUM** or Fuming sulphuric acid.



- **Oleum** is carefully diluted with calculated amount of water to obtain 98% H<sub>2</sub>SO<sub>4</sub>.



**Q17. Name the catalyst used in the Contact process (july-06) 1mark**

- VANADIUM PENTAOXIDE ( $V_2O_5$ )



# Use of $\text{H}_2\text{SO}_4$ .

- In the manufacture of fertilizers
- Refining of petroleum
- Manufacture of dyes , drugs. Etc...
- Manufacture of explosives like TNT,RDX, picric acid etc..
- In storage batteries
- As drying agent
- As sulphonating agent
- In laboratory as volumetric reagent

## Manufacture of $K_2Cr_2O_7$ - From Chromite ore

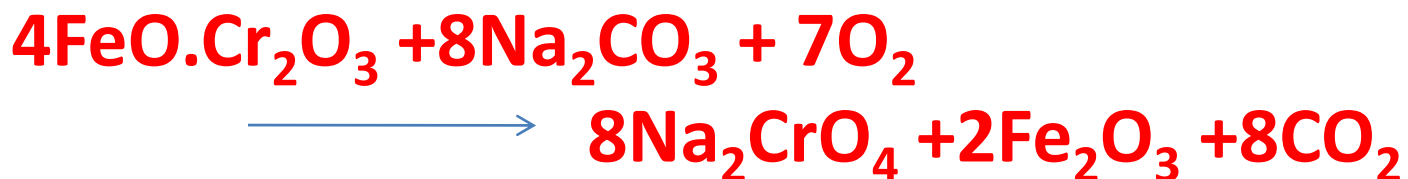
Q 18. How is pure  $K_2Cr_2O_7$  manufactured from chromite ore? (March-08)

### Step-I: Concentration of Chromite ore ;

- Chromite ore ( $FeO \cdot Cr_2O_3$  or  $FeCr_2O_4$ ) is concentrated by Gravity separation method.

### Step-II: Roasting of concentrated ore'

- The concentrated ore is roasted with  $Na_2CO_3$  in a reverberatory furnace in presence of excess of air to obtain Sodium chromate ( $Na_2CrO_4$ )



### Step-III: Conversion of $\text{Na}_2\text{CrO}_4$ to $\text{Na}_2\text{Cr}_2\text{O}_7$

- $\text{Na}_2\text{CrO}_4$  is treated with calculated amount of conc.  $\text{H}_2\text{SO}_4$  to get sodium dichromate ( $\text{Na}_2\text{Cr}_2\text{O}_7$ )



- The less soluble  $\text{Na}_2\text{SO}_4$  crystals are removed by filtration.

## Step-IV: Conversion of $\text{Na}_2\text{Cr}_2\text{O}_7$ to $\text{K}_2\text{Cr}_2\text{O}_7$

- Hot & concentrated solution of  $\text{Na}_2\text{Cr}_2\text{O}_7$  is treated with calculated amount of KCl
- $\text{Na}_2\text{Cr}_2\text{O}_7 + \text{KCl} \longrightarrow \text{K}_2\text{Cr}_2\text{O}_7 + 2\text{NaCl}$
- (Sod.dichromate) (pot.dichromate)
- The solution is concentrated, less soluble  $\text{K}_2\text{Cr}_2\text{O}_7$  separates out. The crystals are removed by filtration.

# Uses of $K_2Cr_2O_7$

- **As an oxidising agent**
- **As primary standard in volumetric analysis**
- **Used to clean glass apparatus in the form of Chromic acid**
- **Used in Chromyl test**
- **In Chrome tanning of leather**
- **As mordant in dyeing industry**

## Chemical properties of H<sub>2</sub>SO<sub>4</sub>

### Dehydration property:

- *Q19. How does Conc. H<sub>2</sub>SO<sub>4</sub> react with oxalic acid crystals? Give equation. [April-2007] 2mark*



### Oxidation property:

Con. H<sub>2</sub>SO<sub>4</sub> is good oxidising agent due to the following reaction,



Eg; a) KBr to Br<sub>2</sub>

b) KI to I<sub>2</sub>

c) H<sub>2</sub>S to S

d) C to CO<sub>2</sub>

e) S to SO<sub>2</sub> etc ....



**Q 20.  $H_2S$  cannot be dried with con.  $H_2SO_4$ .**

**Give reason**

**[july2007]**

- **Conc.  $H_2SO_4$  oxidizes  $H_2S$  to S**
- **$H_2S + \text{Con}H_2SO_4 \longrightarrow SO_2 + 2H_2O + S$**

**Q. What happens when con.  $H_2SO_4$  reacts with  $PCl_5$ ?**  
**( March-11) 2mark**

- **$H_2SO_4 + PCl_5 \longrightarrow SO_3H-Cl + POCl_3 + HCl$**   
chlorosulphonic acid
- **$H_2SO_4 + 2PCl_5 \longrightarrow SO_2Cl_2 + 2POCl_3 + 2HCl$**   
(excess) sulphuryl chloride

## Chemical properties of $K_2Cr_2O_7$

**Q 21. What is the action of KOH on  $K_2Cr_2O_7$ ? (July-10)**

**1mark**



• **Note: at pH=4**



**Q. Illustrate the oxidation property of potassium dichromate with an example.**

**In acid medium  $K_2Cr_2O_7$  is good oxidizing agent due to the following reaction**

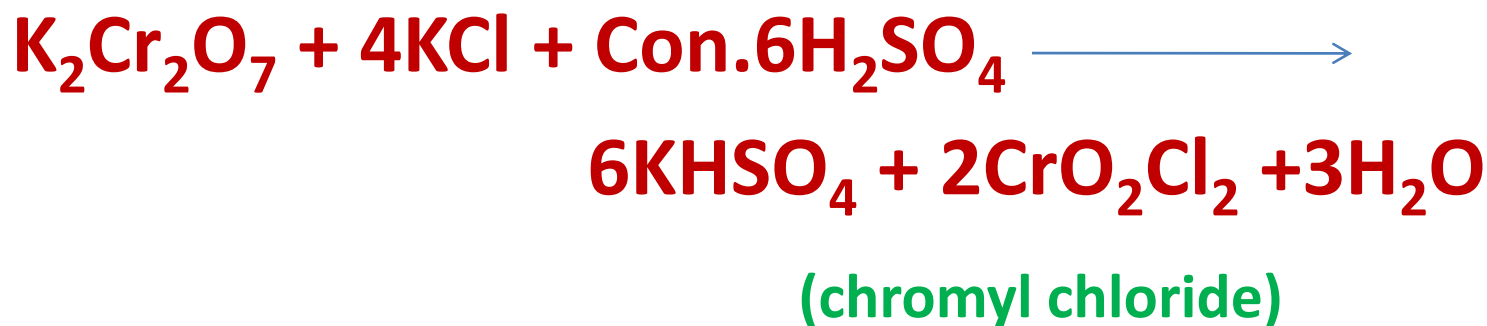


**It oxidizes a)  $FeSO_4$  to  $Fe_2(SO_4)_3$ . b)  $KI$  to  $I_2$  ;  
c)  $H_2S$  to  $S$  etc...**

**Q 22. Explain Chromyl chloride reaction ( june-2011)**

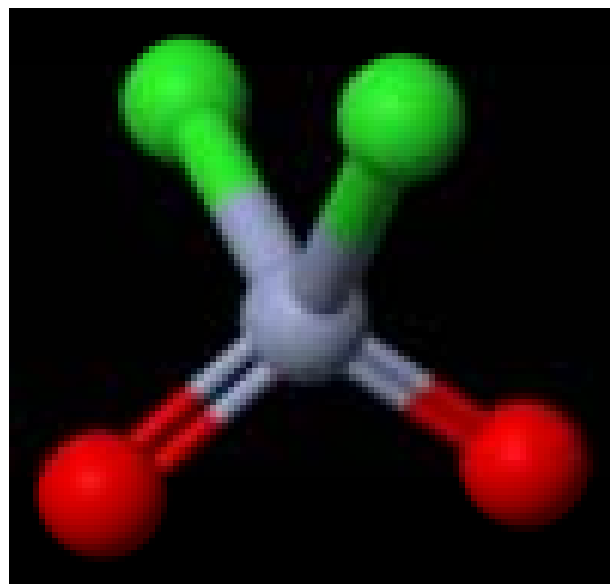
**2 mark**

When a mixture of potassium dichromate crystals and a water soluble chloride is heated with Con.sulphuric acid, red vapours of chromyl chloride is evolved



**Q. Write the molecular formula of Chromyl chloride.** (June-11) 1mark

- **Chromyl chloride**  
 **$2\text{CrO}_2\text{Cl}_2$**



# d-Block elements

# Periodic Table of the Elements

## Valence

<http://chemistry.about.com>

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About Chemistry

1A		Valence										3A 4A 5A 6A 7A					8A			
1																			2	
H																			He	
Hydrogen																			Helium	
2A		Maximum Valence										3A 4A 5A 6A 7A					8A			
3	4																			
Li	Be																			
Lithium	Beryllium																			
11	12																			
Na	Mg																			
Sodium	Magnesium																			
3B		4B	5B	6B	7B	8B		1B	2B	3A 4A 5A 6A 7A					8A					
19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36			
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr			
Potassium	Calcium	Scandium	Titanium	Vanadium	Chromium	Manganese	Iron	Cobalt	Nickel	Copper	Zinc	Gallium	Germanium	Arsenic	Selenium	Bromine	Krypton			
37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54			
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe			
Rubidium	Strontium	Yttrium	Zirconium	Niobium	Molybdenum	Technetium	Ruthenium	Rhodium	Palladium	Silver	Cadmium	Indium	Tin	Antimony	Tellurium	Iodine	Xenon			
55	56	57-71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86			
Cs	Ba	Lanthanides	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn			
Cesium	Barium	Lanthanides	Hafnium	Tantalum	Tungsten	Rhenium	Osmium	Iridium	Platinum	Gold	Mercury	Thallium	Lead	Bismuth	Polonium	Astatine	Radon			
87	88	89-103	104	105	106	107	108	109	110	111	112	113	114							
Fr	Ra	Actinides	Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg	Cn	Uut	Uuq							
Francium	Radium	Actinides	Rutherfordium	Dubnium	Seaborgium	Bohrium	Hassium	Mtnerium	Darmstadtium	Roentgenium	Copernicium	Ununtrium	Ununquadium							

Lanthanides

57	58	59	60	61	62	63	64	65	66	67	68	69	70	71
La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
Lanthanum	Cerium	Praseodymium	Neodymium	Promethium	Samarium	Europium	Gadolinium	Terbium	Dysprosium	Holmium	Erbium	Thulium	Ytterbium	Lutetium

Actinides

89	90	91	92	93	94	95	96	97	98	99	100	101	102	103
Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr
Actinium	Thorium	Protactinium	Uranium	Neptunium	Plutonium	Americium	Curium	Berkelium	Californium	Einsteinium	Fermium	Mendelevium	Nobelium	Lawrencium

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	I	II											III	IV	V	VI	VII	VIII/ O	
I	H																		He
II	Li	Be											B	C	N	O	F	Ne	
III	Na	Mg											Al	Si	P	S	Cl	Ar	
IV	K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr	
V	Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe	
VI	Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn	
VII	Fr	Ra	Ac	Unq	Unp	Unh	Uns	Uno	Une	Uun									

d - block

p - block

s- block

***Q23. Mention two reasons for the formation of co-ordination compounds by transition metals***

**(2m)**

**a) Presence of vacant d-orbitals**

**b) High charge /size ratio i.e high polarization power**



**Q 24. Why are transition elements & their compounds good catalyst? Explain (2m)**

a) They exhibit variable oxidation states

b) Presence of vacant d-orbitals using which unstable intermediate compounds can be formed which decompose giving products

c) In their finely divided form they can produce large surface area for adsorption

**Q 25. Which among  $\text{Cu}^+$  &  $\text{Cu}^{2+}$  salts is coloured? (1m)**

- $\text{Cu}^{2+}$  is paramagnetic & coloured, because it has unpaired electron

E.C of  $\text{Cu}^{2+}$  :  $[\text{Ar}]3\text{d}^9 4\text{s}^0$  - one unpaired electron

E.C of  $\text{Cu}^+$  :  $[\text{Ar}]3\text{d}^{10} 4\text{s}^0$  - No unpaired electron



Crystal of  $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$



Anhydrous  $\text{CuSO}_4$  powder

Q 26. Among  $\text{Sc}^{3+}$  ( $Z=21$ ) &  $\text{Cr}^{3+}$  ( $Z=24$ ), which is coloured. Why? (2m)

- E.C of  $\text{Sc}^{3+}$  is  $[\text{Ar}]3d^0$

In  $\text{Sc}^{3+}$ , there are no unpaired electron.

Therefore it is colourless

- E.C of  $\text{Cr}^{3+}$  is  $[\text{Ar}]3d^3 4s^0$

There are three unpaired electrons in 3d-orbitals. Hence it should be paramagnetic & coloured

Q 27. Write the electronic configuration of 3d series of elements. Hence explain; i) Why  $\text{Cu}^+$  ion and  $\text{Sc}^{3+}$  ion are colourless ii)  $\text{Zn}^{2+}$  ions are diamagnetic

a) E.C of 3d series of elements  $[\text{Ar}]3\text{d}^{(1-10)}4\text{s}^{(1-2)}$

i) E.C of  $\text{Cu}^{2+}$  :  $[\text{Ar}]3\text{d}^9 4\text{s}^0$

E.C of  $\text{Sc}^{3+}$  :  $[\text{Ar}]3\text{d}^0 4\text{s}^0$

There are no unpaired electrons in both of them. Therefore they are colorless & diamagnetic.

ii) E.C of  $\text{Zn}^{2+}$  :  $[\text{Ar}]3\text{d}^{10} 4\text{s}^0$

$\text{Zn}^{2+}$  also has no unpaired electron. It is also diamagnetic and colorless

**Q 28. Write the electronic configuration of 3d series of elements. Hence explain; i) Why  $\text{Cu}^+$  ion and  $\text{Sc}^{3+}$  ion are colourless ii)  $\text{Zn}^{2+}$  ions are diamagnetic**

a) E.C of 3d series of elements  
 $[\text{Ar}]3d^{(1-10)}4s^{(1-2)}$

i) E.C of  $\text{Cu}^+$  :  $[\text{Ar}]3d^{10} 4s^0$

E.C of  $\text{Sc}^{3+}$  :  $[\text{Ar}]3d^0 4s^0$

There are no unpaired electrons in both of them. Therefore they are colorless & diamagnetic.

ii) E.C of  $\text{Zn}^{2+}$  :  $[\text{Ar}]3d^{10} 4s^0$

$\text{Zn}^{2+}$  also has no unpaired electron. It is also diamagnetic and colorless



**Q 29. Name the transition metal in 3d series which shows maximum oxidation state (1m)**

- **Manganese(Mn) shows maximum oxidation state of +7**
- **Potassium permanganate solution**



## Q 30. Why $\text{Fe}^{3+}$ ion is more stable than $\text{Fe}^{2+}$ ion?

- Presence of half filled d-orbitals

OR

- Smaller the size higher the stability

OR

- Higher the oxidation state, more is the stability

THANK YOU

***WISH YOU GOOD LUCK***