① 12/6/21

Class ⇒ B.Sc.(Hons.) Part II
Subject ⇒ Chemistry
Paper ⇒ III A Physical Chemistry
Topic ⇒ Zeolite, Promoters, Catalytic poisoning

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Zeolite

Zeolites are microporous, aluminosilicate minerals commonly used as commercial adsorbents and catalyst.

Zeolites have a porous structure that can accommodate a wide variety of cations, such as Na^+, K^+, Ca^{2+}, Mg^{2+}. These positive ions are rather loosely held and can readily be exchanged for others in a contact solution.

Some common mineral zeolites are analcime, chabazite, clinoptilolite etc.

The mineral formula of a zeolite,

$$Na_2Al_2Si_3O_{10} \cdot 2H_2O$$

(Natrolite)

These cations exchanged zeolites possess different acidity and catalyse several acid catalysis.

Zeolites are the aluminosilicate members of the family of microporous solids known as molecular sieves and mainly consist of Silicon, Aluminium, oxygen and have the general formula:-

$M_xAl_xSi_{1-x}O_2 \cdot YH_2O$ Where M=Metal ion or H^+, x = value between 0 and 1.

Zeolites are widely used as ion-exchange beds in domestic and commercial water purification and softening.

Zeolites are widely used as catalyst and sorbents. Their well-defined pore structure and adjustable acidity make them highly active in a large variety of reactions.

Promoters

A substance which, though itself not a catalyst, promotes the activity of a catalyst is called promoter.

Examples of Promoters

Molybdenum (Mo) or Aluminium oxide (Al_2O_3) promotes the activity of iron catalyst in the Haber synthesis for the manufacture of ammonia.

$$N_2 + 3H_2 \underset{+Mo}{\overset{Fe}{\rightleftharpoons}} 2NH_3$$

Ammonia

In some reactions, mixtures of catalysts are used to obtain the maximum catalytic efficiency

e.g. In the synthesis of Methanol (CH_3OH) from carbon monoxide and hydrogen, a mixture of zinc and chromium oxide is used as catalyst.

$$CO + 2H_2 \xrightarrow[Cr_2O_3]{ZnO} CH_3OH$$

Methanol.

Explanation of Promoter action

It is assumed that the following changes take place on adding the promoter to the catalyst.

(1) change in lattice spacing ⇒ The lattice spacing is increased thus enhancing the space between

the Catalyst particles. The bond between the molecule of the reactants (say H_2) are weakened and cleaved. This makes the reaction go faster.

(2). Increase of Peaks and cracks (or active sites) ⇒ The presence of the promoter increases the peaks and cracks on the Catalyst surface. This increases the Concentration of the reactant molecules and hence the rate of reaction.

* ⇒ The phenomenon of Promoter is a Common feature of heterogeneous Catalysis.

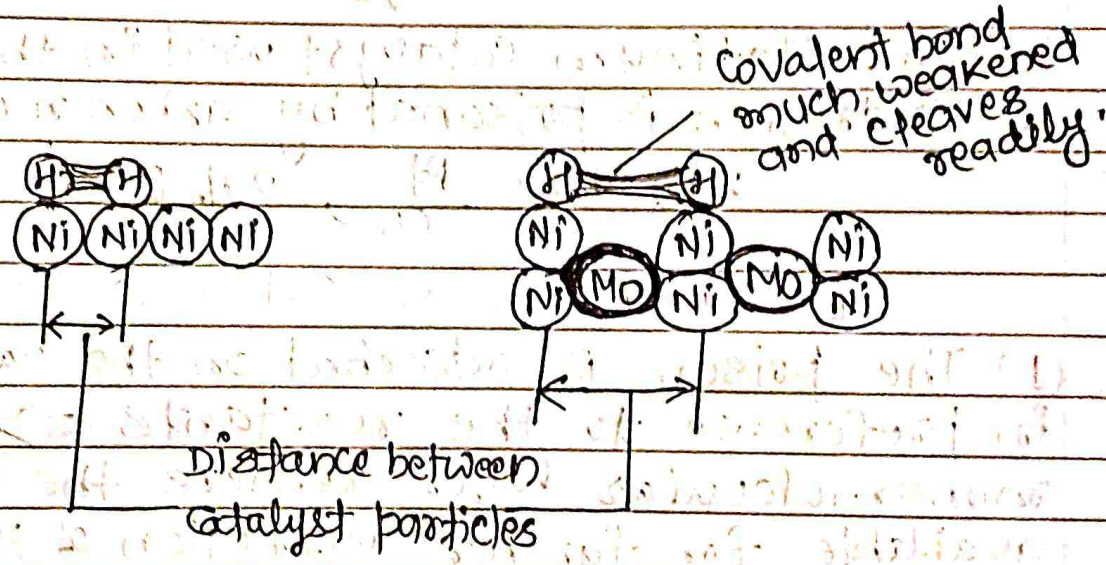


Fig:- Increase of crystal lattice spacing of catalyst makes the reaction go faster.

Catalytic Poisoning
OR
Inhibitors

Heterogeneous Catalyst is rendered ineffective by the presence of small amounts of impurities in the reactants.

A Substance which destroys the activity of the Catalyst to accelerate a reaction is

Called Poison and the process is called Catalytic poisoning or Inhibitors.

Examples of Catalytic poisoning ⟹

(1) The Platinum Catalyst used for the oxidation of sulphur dioxide (Contact process) is poisoned by Arsenic oxide (As_2O_3)

$$SO_2 + O_2 \xrightarrow[As_2O_3]{Pt} 2SO_3$$

(2) The Iron Catalyst used for the Synthesis of NH_3 (Haber Process) is poisoned by H_2S

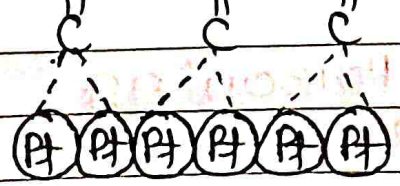
$$N_2 + 3H_2 \xrightarrow[H_2S]{Fe} 2NH_3$$

(3) The Platinum Catalyst used in the oxidation of Hydrogen is poisoned by Carbon monoxide.

$$2H_2 + O_2 \xrightarrow[CO]{Pt} 2H_2O$$

Explanation of Catalytic poisoning

(1) The poison is adsorbed on the catalyst surface in preference to the reactants ⟹ Even a monomolecular layer renders the surface un-available for further adsorption of the reactants. The poisoning by As_2O_3 or CO appears to be of this kind.



(2) The Catalyst may combine chemically with the impurity ⟹ The poisoning of iron catalyst by H_2S ~~falls~~.

$$Fe + H_2S \longrightarrow FeS + H_2$$

—x—