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ASSIGNMENT-2

AMOGH GARG - 2020UCD2123

(1) (a) What is meant by homogeneous and heterogeneous as applied to catalysts?

- When reactants, products and catalyst are in same phase, it is known as homogeneous catalysis.
- When reactants and catalysts are not in same phase, it is known as heterogeneous catalysis. (b) Diff. b/w phase and physical st
- The state of matter is the form taken by matter at a given temperature and pressure. Whereas, a phase of matter is uniform wht its physical and chemical properties. Matter undergoes phase transitions to change from one phase to another.

(2) (a) Explain the difference between the words adsorbed and absorbed.

- Adsorption: The process of accumulation of particles on the surface of a substance rather than in bulk of solid/liquid is called Adsorption.
- Absorption: The process of accumulation of molecular species in the bulk of a substance (solid/liquid) is called absorption.

(b) Explain why silver and tungsten aren't good catalyst, but platinum and nickel are in terms of strength of adsorption of gases to their surfaces.

- Silver is not a very good catalyst because it is not very good at adsorbing things on its surface i.e it does not form strong enough bonds with the reactants.
- On the other hand tungsten is not a good catalyst because it adsorbs things too strongly i.e the bond formed btw reactant and catalyst is very strong and ∴ the product is unable to detach from catalyst.
- Whereas Platinum and Nickel form bonds of perfect strength so as to catalyze the reaction.

(3) (a) $CH_2=CH_2 + H_2 \xrightarrow{Ni} CH_3CH_3$

Draw a series of labelled diagrams to show the mechanism for this reaction. Showing clearly the role of adsorption.

Let us assume $CH_2=CH_2$ to be A and H_2 to be B. Also let's assume CH_3CH_3 to be P.

I. A B Ni

II. Ni A B

A and B are adsorbed on Ni.

III. Ni P → A and B react on surface of Ni to form product P.

IV. Ni P → Product P detaches from surface of Ni.

(b) $SO_2 + \frac{1}{2}O_2 \xrightarrow{V_2O_5} SO_3$ · Write eqn to show mechanism of this reaction.

a) Oxidation of SO_2 into SO_3 by V^{5+}

$2SO_2 + 4V^{5+} + 2O^{2-} \longrightarrow 2SO_3 + 4V^{4+}$

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(b) Oxidation of V^{4+} back into V^{5+} by dioxygen. (catalyst regeneration)

$4V^{4+} + O_2 \rightarrow 4V^{5+} + 2O^{2-}$

i. Vanadium is obtained in its original form and SO_2 is converted into SO_3.

(4) (a) Catalytic converters use metal such as platinum, palladium and rhodium deposited in thin layers on ceramic honeycomb. Explain the reason for this.

Catalytic converters use metals such as platinum, palladium and rhodium deposited in thin layers on ceramic honeycomb in order to increase the surface area so that more reactants are adsorbed on it and so the reaction proceeds even faster.

(b) Write an equation to show how a catalytic converter might remove CO and NO from exhaust gas.

To describe the process we will assume that the metal surface consists of active sites, denoted as "*". The catalytic reaction cycle begins with adsorption of CO and O_2 on surface of platinum, whereby the oxygen molecule dissociates into two O atoms.

$O_2 + 2* \rightleftharpoons 2O*$ (Adsorbed on catalyst)

$CO + * \rightleftharpoons CO*$ (" " ")

$CO* + O* \rightleftharpoons CO_2 + 2*$

CO_2 being stable and relatively unreactive

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interacts only weakly with platinum surface and desorbs almost instantly.

- Similarly NO gets converted to NO_2.

(c) Why is it essential not to use leaded petrol with a catalytic converter?

It is essential not to use leaded petrol with a catalytic converter because lead deactivates the catalytic activity of converter thereby causing pollution (because conversion of CO into CO_2 becomes difficult without catalytic activity)

(5) (a) Explain importance of ozone in high atmosphere

Ozone present in high atmosphere acts as a shield which prevents the harmful UV rays from Sun to reach the surface of Earth.

(b) State the nature of the ozone – destroying free radicals, and write equations to help you to explain how these radicals destroy ozone.

- Ozone can decompose spontaneously, and also under influence of light, but a Cl atom accelerates the reaction tremendously. As it leaves the reaction cycle unaltered, the Cl atom is a catalyst.

- $Cl + O_3 \longrightarrow ClO_3$
  $ClO_3 \longrightarrow ClO + O_2$
  $ClO + O \longrightarrow Cl + O_2$
  } Homogeneous catalysis

  Overall, $O_3 + O \longrightarrow 2O_2$

- Chlorine reaches at such high altitudes

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in the form of chloro fluoro carbons (CFC) which are released from aerosol sprays, refrigerators etc.

(b) $S_2O_8^{2-} + 2I^- \longrightarrow 2SO_4^{2-} + I_2$

(a) What type of catalysis is this?
It is ~~heterogeneous~~ Homogeneous catalysis.

(b) Why is reaction so slow in absence of catalyst?
Catalyst provides an alternative pathway for the reaction to occur in which energy barrier is less while in absence of catalyst activation energy increases and reaction becomes slower.

(c) Use equations to help you explain what happens in presence of iron (II) ions.

- If a small amount of Fe^{2+} ions are added to the reaction mixture, they will reduce the peroxidisulfate ions to sulfate ions and will be oxidized to Fe^{3+} ions in the process.

$2Fe^{2+} + S_2O_8^{2-}(aq) \longrightarrow 2Fe^{3+}(aq) + 2SO_4^{2-}(aq)$

- The Fe^{+3} produced will oxidize iodide ions to iodine and will be reduced back to Fe^{+2} ions in the process.

$2Fe^{+3}(aq) + 2I^-(aq) \longrightarrow 2Fe^{+2}(aq) + I_2(aq)$

- The Fe^{+2} ions produced can reduce more peroxodisulfate ions and so the catalyzed reaction can continue.

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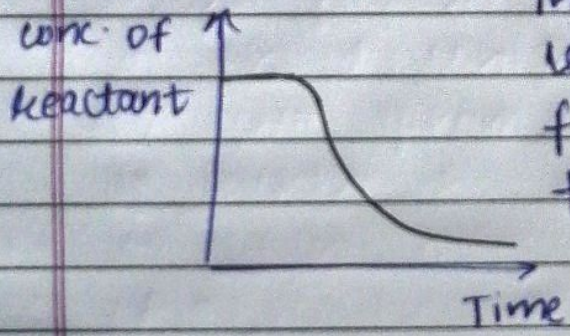
(7) $2MnO_4^- + 6H^+ + 5 \begin{matrix} COOH \\ | \\ COOH \end{matrix} \longrightarrow 2Mn^{2+} + 10CO_2 + 8H_2O$

(a) Using this reaction as an example, explain what is meant by autocatalysis?

- In autocatalysis, the reaction is catalyzed by one of its products.
- The above reaction is catalyzed by Mn(II) ions Mn(II) ions are formed as products and ∴ More and more catalyst is produced as the reaction proceeds and so the reaction speeds up.

(b) Sketch graph of the conc. of manganate (VII) ions against time.



The reaction is initially slow but becomes faster and faster as more product is formed and finally stops when reactants are used up.

(c) You can get similar curves in cases which don't involve autocatalysis. Suggest one another situation where you might get a similar curve.

Eg.) If the reaction involved a solid reacting with a liquid, there must be some sort of coating on surface of solid which liquid has to penetrate so that Rxn. can happen. In this case we would get curve similar to that drawn above.