Nano structured materials-synthesis, properties, self assembly and applications

by Prof. A.K. Ganguli, Chemistry Department,
IIT Delhi, New Delhi.

MODULE 4 (LECTURE 1, 2 & 3): PHOTOCATALYSIS

Problem:

1. Define the following terms: a)catalysis b) catalysts
2. What is the role of catalyst in a reaction
3. What are the different types of catalysts and catalytic reactions.
4. What are the applications of catalysts
5. What are the general requirements for a good catalyst.
6. Define photochemical recations.
7. What do you understand by quantum yield.
8. Define a) metal b) semiconductor c) insulator
9. What is photocatalysis and how does a photocatalyst works
10. Differentiate between photosynthesis and artificial photosynthesis
11. ΔG^0 for water splitting reaction……
12. What are the controlling factors which decides to design an efficient photocatalyst.
13. Why do we need semiconductor material to act as photocatalyst.
14. Define the following a) valence band b) conduction band c) band gap c) Fermi level
15. What are the basic steps involved during a photocatalytic reaction
16. How the recombination of electron-hole pair can be prevented in a photocatalytic reaction.
17. How the electron – hole pair take part in a photocatalytic reaction.
18. What is the minimum energy required to initiate water splitting reaction.
19. What are the two important class of photocatalyst. Give examples
20. What is a co-catalyst.
21. What are the different process of hydrogen generation
22. What do you understand by photo electrolysis of water
23. What are the challenges in photodecomposition of water.
24. Why TiO_2 is considered as one of the best photocatalyst material.
25. How the generation of hydrogen and oxygen is monitored during a photocatalytic water splitting reaction.
26. What are the advantages of semiconductor nanoparticles as photocatalyst compared to bulk.
27. How band gap varies with size of particle
28. What is the role of potential of valence and conduction band in deciding the efficiency of a photocatalyst.
29. What are the applications of photocatalyst.
30. What sources are used to initiate the photocatalytic reactions

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Solution :

1. Catalysis - *Catalysis*is the increase in the rate of a chemical reaction due to the participation of a substance called a catalyst
   Catalyst - A substance, usually used in small amounts relative to the reactants, that modifies and increases the rate of a reaction without being consumed in the reaction.
2. Lowers the activation energy of the reaction
3. Types of catalyst and catalytic reaction
   Based on physical state – solid, liquid, gas
   Based on substance from which made – inorganic and organic
   Based on the catalyst work – homogenous and heterogenous
   Based on catalyst action – acid-base catalyst, enzymatic, photocatalyst, electrocatalyst
4. Industrial application- petroleum, energy sector
   Environmental application – pollution control
5. Activity, selectivity, stability, reusability.
6. Initiated by absorption of light
7. Number of specific primary products formed by absorption of each photon.
8. Metals: The conductivity of metals is based on the free electrons (so-called Fermi gas) due to the metal bonding.
   Insulators possess no free charge carriers and thus are non-conductive
   Semiconductors are solids whose conductivity lies between the conductivity of conductors and insulators.
9. *Photocatalysis* is using light as a catalyst to increase the rate of a photoreaction. photocatalyst is the substance which can modify the rate of chemical reaction using light irradiation. Irradiation of photocatalyst with light energy greater than the band gap of the material generates electron-hole pairs which leads to the photocatalytic reactions.
10. Photosynthesis is carried out by green plants whereas photocatalytic water splitting is an artificial photosynthesis.
11. 237 KJ/mol
12. Band gap, carrier transport, crystallinity, surface area, chemical stability
13. Metals has no band gap, only reduction or oxidation is possible, whereas insulators pposses large band gap and require high energy.
14. *Valence band* is the highest range of electron energies in which electrons are normally present at absolute zero temperature.
    Conduction band is the range of electron energies enough to free an electron from binding with its atom to move freely within the atomic lattice of the material as a 'delocalized electron'
    Fermi level is the total chemical potential for electrons.

Band gap generally refers to the energy difference (in electron volts) between the top of the valence band and the bottom of the conduction band

15. Photon absorption and generation of electron hole
    Charge separation and migration to surface active sites
    Construction of surface reactive sites for hydrogen and oxygen evolution.
16. Use of co-catalyst.
17. Electron –hole pair leads to the formation free radicals which results in the oxidation-reduction reaction in a photocatalytic reactions.
18. 1.23 eV
19. UV and visible light based photocatalyst.
20. Either of a pair of cooperative catalysts that improve each others catalytic activity .
21. Thermochemical routes, electrolytic generation of hydrogen, photolytic reaction, chemical reformation of naphtha.
22. Generation of electron in the presence of light and application of potential between the electrodes leading to decomposition of water to hydrogen.
23. Band edges of the electrode must overlap with the acceptor and donor sites
24. Stability, corrosion resistive
25. GC-MS
26. High surface area
27. Band gap is inversely proportional to size of particle.
28. Decides the efficiency of the material.
29. Degradation of organic pollutants, water splitting reaction
30. Visible- xenon, tungsten
    UV- mercury