Subjective Matter : For Self Study

● Introduction futureexplosion.com

➢ The branch of chemistry used to prevent pollution by designing the environmentally conscious chemical products and process which reduce or eliminates the use or generation of hazardous substances is green chemistry.
➢ Energy crisis, pollution and maintenance of harmful resources is performed by using 12 principles of Paul Anastas.
➢ The sustainable development of green chemistry is achieved by these 12 principles to meet the needs of future generation.

● Principles of Green chemistry

1) Prevention of waste or By products

➢ Priority is given to prevent the formation of waste and not to clean the waste.
➢ The aim of green chemistry is to minimize the waste product up to zero by using eco-friendly reactans and chemical process.
➢ To decrease the generation of waste at zero level is called zero waste technology (ZWT)
➢ If some waste is formed in industries used to produce another eco-friendly products such as ash from thermal power station is used in brick industries.

2) Atom economy

➢ In industrial process maximum atoms of reactants should be converted in expected products and minimum by products should be formed to minimize the waste.

% atom economy

$$= \frac{\text{Formula weight of the desired product}}{\text{Sum of formula weight of all the reactants used in the reaction}} \times 100$$

Example : Conversion of Butan-1-ol to 1-bromobutane

$$CH_3–CH_2–CH_2–CH_2–OH + H_2SO_4 \longrightarrow CH_3–CH_2–CH_2–CH_2–Br + NaHSO_4 + H_2O$$

Solution : % Atom Economy

$$= \frac{\text{Mass of atoms in 1 – bromobutane}}{\text{Mass of all atoms in reactants}} \times 100$$

% Atom Economy

$$= \frac{\text{Mass of } (4C+9H+1Br) \text{ atoms}}{\text{Mass of } (4C+12H+5O+1Br+1Na+1S) \text{ atoms}} \times 100$$

$$= \frac{137\,u}{275\,u} \times 100$$

$$= 49.81\ \%$$

3) Less hazardous chemical synthesis

➢ Green chemistry should design the chemical reactions and synthesize routes which are most safe and decrease or completely avoid the formation hazardous products.
➢ DDT is harmful insecticide and now-a-day it is replaced by BHC.

4) Designing of safer chemicals

➢ To decrease the pollution and to save the nature, we have to prepare safe chemicals and they are to be used at the place of old toxic compounds.

Example : In old days adipic acid was prepared from benzene which is toxic but now-a-day it is synthesized from non-toxic compound glucose which can maintain the health of workers in industries.

5) Use of safer solvet and auxilaries

➢ The green chemistry should use the safer solvents and auxilaries in chemical process to decrease the pollution.
➢ Use of toxic solvent in industries can pollute, air, soil, water etc. hence safer solvent like water is to be used.

6) Design for energy efficiency

➢ Most of the reactions are accelerated by heat but the use of energy can be decreased by using catalyst or by microorganism.
➢ Now-a-day most of chemical reactions are catalysed by micro organisms.

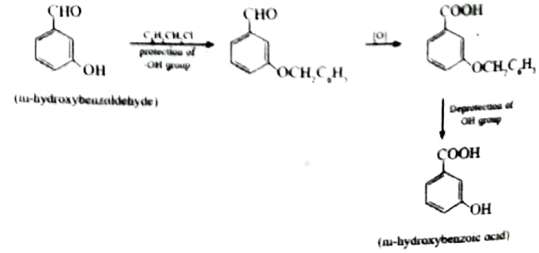
7) Use of renewable feedstocks

➢ Green chemistry should use the raw material which is renewable.
➢ The use of non-renewable materials like petroleum can affect the human civilisation future.
➢ The product waste should be biodegradable.

8) Reduce derivatives

➢ Commonly we have to used chemical process which can convert reactants in products in minimum steps.
➢ The chemical process should not affect the unwanted functional groups.
➢ The process involving change in unwanted functional groups have low atom economy.

Example : In the conversion of m-hydroxybenzoic acid –OH group is protected to decrease the steps in reactions.



9) Use of catalyst

- Use of catalysts can increase the rate of chemical reactions.
- Catalyst increase the selectivity of reaction minimise waste and reduce reaction time and energy by decreasing the activational energy.

10) Design for degradation

- Green chemistry should design the chemical reaction to form easily biodegradable waste to clean the environment.

11) Real time analysis pollution prevention

- The analytical methods should be modified so that they should be continuously monitored during nomenclature. It is important in chemical industries and nuclear reactors.

12) Safer chemistry for accident prevention

- The green chemistry should develop the chemical process which are accident free.
- They should not have explosion, chemical accidents like linkage of hazardous gases and liquids, fire etc.

● **Role of green chemistry**

- The Earth should have capacity to deal the problems of waste and pollution.
- To promote the innovative technology to decrease or eliminate the formation of hazardous waste.
- To reduce the capital expenditure to prevent pollution.
- It helps to protect the ozone layer from depletion.
- To control green house effect.

● **Introduction to Nano chemistry**

- **Nano science :** The study of phenomenon of manipulation of materials at atomic, molecular and macro molecular scale where they have different properties in their larger scale.
- **Nano technology :** The designing, characterization, production and application of structures, device and system by controlling shape and size at nanometer scale i.e. 10^{-9} m is called nano technology.
- Nanometer scale is defined as 1-100 nm.
- One nanometer is one billion of a meter i.e. 1 nm = 10^{-9} m.
- The normal material around us are bulk materials have macroscopic properties.
- The material synthesized at nanoscale i.e. 1-100 nm have unique, optical, structural, thermal, catalytic, magnetic and electrical properties.
- The change in properties is possible only due to change in size.
- Nanomaterial is larger than atoms but smaller than bacteria and cells.
- Nanomaterials may be nano particles, nanotubes according to this dimensions.
- Zero dimensional structures have all three dimensions in nanoscale. e.g. quantum dots, nanoshells, nanoring and microcapsules.
- One dimentional nano structures have two dimensions in nanoscale. e.g. nanowires, nanorods, nanotubes.
- Two dimentional nanostructures have only one dimention in nanoscale. e.g. thin films, layers, coating.
- **Nanochemistry :** The branch of chemistry which deals the preparation of properties of nanomaterials is called nanochemistry.

● **Characteristics of nano particles**

- The properties of nanoparticles are differ from their normal particles.

i) Colour :

- It is the optical property of material.
- Normal gold is shining yellow in colour but gold in nano size is red in colour.

ii) Surface area

- High surface to volume ratio is a very important characterisitcs of nano particles.
- Nano particles have very high suface area for the same volume.
- As surface area increases, chemical reactivity of material also increases.

iii) Catalyst activity

- Nano particle acts as catalyst due to large surface area.
- They acts as heterogenous catalyst in which reactions are possible at the surface of solid catalyst.
- Nano particle catalysts are easily separated and recycled. e.g. Pd, pt, metal nano particles.
- TiO_2, ZnO are used in photocatalysis, nano gold in different organic reactions.

iv) Thermal properties : (Melting point)

- As size of nano particles decreases, melting point also decreases.
- Melting point of bulk sodium 371 K where as sodium melted at 303 K.

v) Mechanical properties

- Nano size particles more harder than normal.
- Cu and Pd in nanosize (5-7 nm) are 500% more harder than regular size.

vi) Electrical conductivity

- Electrical properties get changed in nano size.
- Carbon nanotubes can acts as conductor and semiconductor.

● **Synthesis of nano materials**

i) Top down and bottom up process

- In top down approach, nanoparticles are prepared by breaking the bulk material into fine pieces until they are constitued of only few atoms.
- In bottom approach, very smaller molecular components arrange themselves into more complex assemblies atoms by atom, molecule by molecule and cluster by cluster from bottom.

ii) Wet chemical synthesis of nanoparticles (Sol gel process)

- Sols are dispersion of collidal particles in a liquid.
- Colloids are solid particles with diameters of 1-100 nm.
- Sol gel process is based on inorganic polymerization reactions.
- It includes four steps i.e. hydrolysis, polycondensation, drying and thermal decomposition.
- The reactions in sol gel process are

$$MOR + H_2O \longrightarrow MOH + R\text{–}OH$$

(hydrolysis)
Metal alkoxide

$$MOH + ROM \longrightarrow M\text{-}O\text{-}M + R\text{–}OH$$

(condensation)

- **Analysis or characterization of nano materials**

- The nano material prepared are analysed by following analytical tools.

- **History of nano technology**

- Nano materials are present in nature from antiquity.
- Example : Beautiful ruby red coloured glass paintings. Decorative glaze or metallic film in medieval pottery. Coating of carbon black on tyres of cars which increase the life of tyres, fumed, silicon, silicon rubber, etc.

- **Application of nano materials**

i) In the manufacturing of scratchproof, eyeglasses, transport, sunscreen, crack resistant paints, etc.
ii) In electrical devices like Magnetoresistive Random Acess Memory (MRAM).
iii) In purification of water.
iv) In self cleaning material.

- **Advantages of nano particles and nano technology**

i) It is widely used in electronics and computers.
ii) **Energy sector :** It is used in solar power to made micro economic and energy storage devices.
iii) **Medical field :** Used in manufacturing of drugs, helps in fast care of cancer and diabetes.
iv) The nano particles can cause long damage as they are through respiratory system.

Name of technique	Instrument used	Information
1. U.V. visible spectroscopy	U.V. visible spectrophotometer	Preliminary confirmation formation of nanoparticles.
2. X-ray Diffraction (XRD)	X-ray diffractometer	Particle size, crystal structure, geometry
3. Scanning electron microscopy	Scanning electron microscope (SEM)	Structure of surface of material that is morphology.
4. Transmission electron microscopy	Transmission electron microscope (TEM)	Particle size
5. FTIR Fourier transform infrared spectroscopy	Fourier transform infrared spectrometer	Absorption of functional groups. binding nature.