Green Chemistry and Nanochemistry

EXERCISE [PAGES 351 - 352]

Exercise | Q 1.1 | Page 351

Choose the most correct option.

The development that meets the needs of the present without compromising the ability of future generations to meet their own need is known as _____.

1. Continuous development
2. **Sustainable development**
3. True development
4. Irrational development

Solution: The development that meets the needs of the present without compromising the ability of future generations to meet their own need is known as **Sustainable development.**

Exercise | Q 1.2 | Page 351

Choose the most correct option.

Which of the following is Ɣ-isomer of BHC?

1. DDT
2. **lindane**
3. Chloroform
4. Chlorobenzene

Solution: lindane

Exercise | Q 1.3 | Page 351

Choose the most correct option.

The prefix 'nano' comes from _____.

1. A French word meaning billion
2. **Greek word meaning dwarf**
3. A Spanish word meaning particle
4. Latin word meaning invisible

Solution: The prefix 'nano' comes from the **Greek word meaning dwarf**.

Exercise | Q 1.4 | Page 351

Choose the most correct option.

Which of the following information is given by the FTIR technique?

1. **Absorption of functional groups**
2. Particle size
3. Confirmation of formation of nanoparticles
4. Crystal structure

Solution: Absorption of functional groups

Exercise | Q 1.5 | Page 351

Choose the most correct option.

The concept of green chemistry was coined by _____.

1. Born Haber
2. Nario Taniguchi
3. Richard Feynman
4. **Paul T. Anastas**

Solution: The concept of green chemistry was coined by **Paul T. Anastas** .

Exercise | Q 2.1 | Page 351

Answer the following

Write the formula to calculate the % atom economy.

Solution:

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

Exercise | Q 2.2 | Page 351

Answer the following

Name the ϒ-isomer of BHC.

Solution: Gammexane or Lindane

Exercise | Q 2.3 | Page 352

Answer the following

Ridhima wants to detect the structure of the surface of materials. Name the technique she has to use.

Solution: Scanning Electron Microscopy

Exercise | Q 2.4 | Page 352

Answer the following

Which nanomaterial is used for tyres of the car to increase the life of tyres?

Solution: Carbon black

Exercise | Q 2.5 | Page 352

Answer the following

Name the scientist who discovered a scanning tunneling microscope (STM) in 1980.

Solution: Gerd Binnig and Heinrich Rohrer

Exercise | Q 2.6 | Page 352

Answer the following

1 nm = _____m ?

Solution: 1 nm = 10^{-9}m

Exercise | Q 3.1 | Page 352

Answer the following

Define: Green chemistry

Solution: Green chemistry is the use of chemistry for pollution prevention by an environmentally conscious design of chemical products and processes that reduce or eliminate the use or generation of hazardous substances.

Exercise | Q 3.1 | Page 352

Answer the following

Define: sustainable development

Solution:

Sustainable development is the development that meets the needs of the present, without compromising the ability of future generations to meet their own need.

Exercise | Q 3.2 | Page 352

Answer the following

Explain the role of green chemistry.

Solution:

The green chemistry approach recognizes that the Earth does have a natural capacity for dealing with much of the waste and pollution that society generates. It is only when that capacity is exceeded that we become unsustainable.

Following is the role of Green Chemistry:

i. To promote innovative chemical technologies that reduce or eliminate the use or generation of hazardous substances in the design, manufacture, and use of chemical products.

ii. The green chemistry helps to reduce capital expenditure, to prevent pollution.

iii. Green chemistry incorporates pollution prevention practices in the manufacture of chemicals and promotes pollution prevention and industrial ecology.

iv. Green chemistry is a new way of looking at chemicals and their manufacturing process to minimize any negative environmental effects.

v. Green chemistry helps to protect the presence of ozone in the stratosphere essential for the survival of life on the earth.

vi. Green chemistry is useful to control the greenhouse effect (Global warming).

Exercise | Q 3.3 | Page 352

Answer the following

Give the full form (long form) of the name for following instrument.

XRD

Solution: X-ray diffractometer

Exercise | Q 3.3 | Page 352

Answer the following

Give the full form (long form) of the name for the following instrument.

TEM

Solution: Transmission Electron Microscope

Exercise | Q 3.3 | Page 352

Answer the following

Give the full form (long form) of the name for the following instrument.

STM

Solution: Scanning Tunneling Microscope

Exercise | Q 3.3 | Page 352

Answer the following

Give the full form (long form) of the name for the following instrument.

FTIR

Solution: Fourier Transform Infrared Spectrophotometer

Exercise | Q 3.3 | Page 352

Answer the following

Give the full form (long form) of the name for the following instrument.

SEM

Solution: Scanning Electron Microscope

Exercise | Q 3.4 | Page 352

Answer the following

Define the following term :

Nanoscience

Solution: Nanoscience:

Nanoscience is the study of phenomena and manipulation of materials at atomic, molecular, and macromolecular scales where properties differ significantly from those at a larger scale.

Exercise | Q 3.4 | Page 352

Answer the following

Define the following term: Nanotechnology

Solution:

Nanotechnology:

Nanotechnology is the design, characterization, production, and application of structures, devices, and systems by controlling shape and size at nanometer scale.

Exercise | Q 3.4 | Page 352

Answer the following

Define the following term: Nanomaterial

Solution:

Nanomaterial:

The nanomaterial is a material having structural components with at least one dimension in the nanometer scale, that is, 1-100 nm.

Exercise | Q 3.4 | Page 352

Answer the following

Define the following term: Nanochemistry

Solution:

Nanochemistry:

Nanochemistry is the combination of chemistry and nanoscience which deals with designing and synthesis of materials of nanoscale with different sizes and shape, structure and composition, and their organization into functional architectures.

Exercise | Q 3.5 | Page 352

Answer the following

How nanotechnology plays an important role in water purification techniques?

Solution:

Nanotechnology plays an important role in water purification techniques.

a. Water contains waterborne pathogens like viruses, bacteria.

b. Cost-effective filter materials coated with silver nanoparticles (AgNps) is an alternative technology and can be used in water purification.

c. Silver nanoparticles act as a highly effective antibacterial agent that kills E. coli from water.

Exercise | Q 3.6 | Page 352

Answer the following

Which nanomaterial is used in sunscreen lotion? Write its use.

Solution:

Sunscreen lotions contain nanoparticles of zinc oxide (ZnO) and titanium dioxide (TiO_2).

These chemicals protect the skin against harmful UV (ultraviolet) rays by absorbing or reflecting the light. Hence, sunscreen lotions prevent the skin from damage.

Exercise | Q 3.7 | Page 352

Answer the following

How will you illustrate the use of a safer solvent and auxiliaries?

Solution:

Use of safer solvent and auxiliaries:

This principle of green chemistry involves the use of a safer solvent and minimizing the total amount of solvents and auxiliary substances used for any given step of the reaction. This is because solvents and auxiliary substances make up a large percentage of the total waste created.

Illustration:

a. The main aim of this principle is to use green solvents. For example, water or supercritical CO_2 in place of volatile halogenated organic solvents (such as CH_2Cl_2, $CHCl_3$, CCl_4) for chemical synthesis and other purposes.

b. Solvents as chemicals that dissolve solutes and form solutions facilitate many reactions.

c. Water is a safe benign solvent while dichloromethane is hazardous.

d. The use of toxic solvent affects millions of workers every year and has implications for consumers and the environment as well. Many solvents are used in high volumes and many are volatile organic compounds. Their use creates large amounts of waste, air pollution, and other health impacts.

e. Finding safer, more efficient alternatives or removing solvents altogether is one of the best ways to improve a process or product.

Exercise | Q 3.8 | Page 352

Answer the following

Define catalyst.

Solution:

A catalyst is a substance that increases the rate of a chemical reaction without being consumed in the process.

Exercise | Q 3.8 | Page 352

Answer the following

Give two examples of catalysts.

Solution:

i. In the contact process of industrial production of sulfuric acid; sulphur dioxide and oxygen from the air react reversibly over a solid catalyst of platinised asbestos.

ii. Hydrogenation with nickel as a catalyst is used to convert inedible oils into solid fat for the production of margarine.

Exercise | Q 4.1 | Page 352

Answer the following

Explain any three principles of green chemistry.

Solution:

Following the Principles of Green Chemistry:

i. Prevention of waste or by-products: According to this principle of green chemistry, priority is given for the prevention of waste rather than cleaning up and treating waste after it has been generated.

Illustration: To develop zero-waste technology (ZWT). As per ZWT, in chemical synthesis, the waste product should be zero or minimum. It also aims to use the waste product of one system as the raw material for other systems.

For example:

a. The bottom ash of the thermal power station can be used as a raw material for the cement and brick industry.

b. The effluent coming out from the cleansing of machinery parts may be used as coolant water in the thermal power station.

ii. Less hazardous chemical synthesis:

According to this principle of green chemistry, designed chemical reactions and synthesis routes should be as safe as possible to avoid the formation of hazardous waste from chemical processes.

Illustration:

Earlier Dichlorodiphenyltrichloroethane (DDT) was used as an insecticide and was effective in controlling diseases like typhoid and malaria-carrying mosquitoes. It was realized that DDT is harmful to living things. Nowadays, benzene hexachloride (BHC) is

used as an insecticide. One of the γ-isomer (gamma) of BHC is called gammexane or lindane.

iii. Designing safer chemicals: This principle of green chemistry aims at developing products that are less toxic or which require less toxic raw materials. Illustration: In chemical industries workers are exposed to a toxic environment. Safer chemicals must be designed in order to prevent workers from exposure to toxicity.

For example:

Adipic acid is widely used in the polymer industry. Benzene is the starting material for the synthesis of adipic acid but benzene is carcinogenic and benzene being a volatile organic compound (VOC) pollutes the air. In green technology developed by Drath and Frost, adipic acid is enzymatically synthesised from glucose.

Exercise | Q 4.2 | Page 352

Answer the following

Explain the atom economy with a suitable example.

Solution:

Atom economy:

a. Atom economy is a measure of the number of atoms from the starting materials that are present in the useful products at the end of the chemical process.

b. Good atom economy means most of the atoms of the reactants are incorporated in the desired products and only small amounts of unwanted by-products are formed and hence lesser problems of waste disposal.

Illustration: The concept of the atom economy gives the measure of the unwanted product produced in a particular reaction.

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

For example: Conversion of Butan-1-ol to 1-bromobutane

$$CH_3CH_2CH_2CH_2OH + NaBr + H_2SO_4 \longrightarrow CH_3CH_2CH_2CH_2Br + NaHSO_4 + H_2O$$

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

$$= \frac{137u}{275u} \times 100 = 49.81\%$$

Exercise | Q 4.3 | Page 352

Answer the following

How will you illustrate the principle, minimization of steps?

Solution:

Reduce derivatives (Minimization of steps):

In organic synthesis protecting or blocking groups is commonly used. According to this principle of green chemistry, unnecessary derivatization, for example, installation/removal of the use of protecting groups should be minimized or avoided if possible, because such steps require additional reagents and can generate waste.

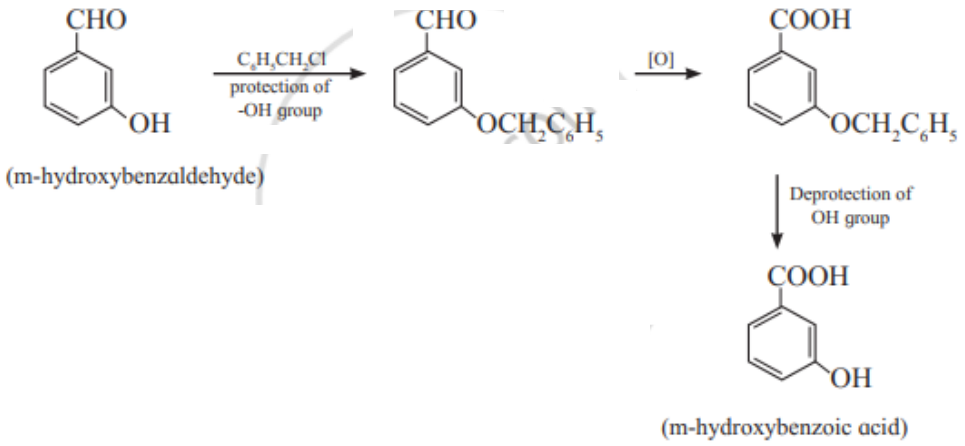
Illustration:

a. In organic synthesis, the protection of some functional groups is required. Again, the deprotection of the functional group is required at the end.

For example: Synthesis of m-hydroxybenzoic acid from mhydroxybenzaldehyde.

b. In such cases, the atom economy is also less.

c. The green chemistry principle aims to develop the methodology where unnecessary steps should be avoided. This can be done if possible, by using practicable biocatalytic reactions, which very often need no protection of the selective group.



(m-hydroxybenzaldehyde)

(m-hydroxybenzoic acid)

Exercise | Q 4.4 | Page 352

Answer the following

What do you mean by sol and gel?

Solution:

Sol-gel method (Wet chemical synthesis of nanomaterials):

i. Sol: Sols are dispersions of colloidal particles in a liquid.

ii. Gel: A gel is an interconnected rigid network with pores of sub-micrometer dimensions and polymeric chains whose average length is greater than a micrometer.

Exercise | Q 4.4 | Page 352

Answer the following

Describe the sol-gel method of preparation for nanoparticles.

Solution:

Sol-gel process:

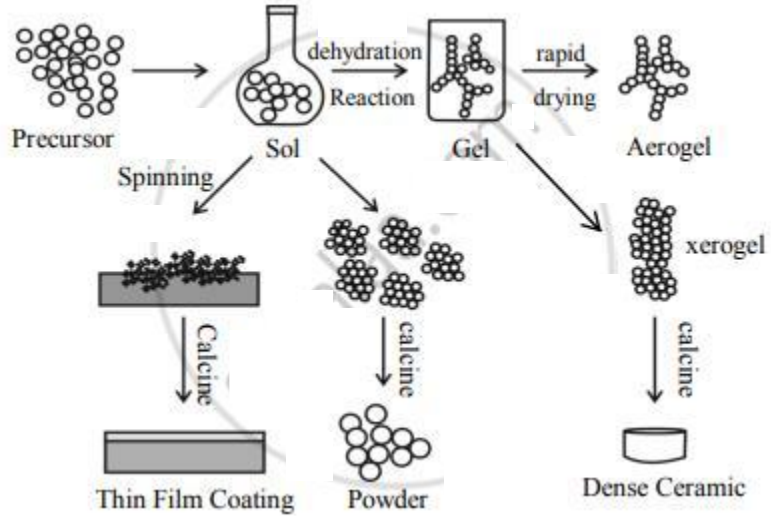
a. The sol-gel process is an example of wet chemical synthesis of nanomaterials.

b. This technique is based on inorganic polymerization reactions.

c. It is generally carried out at room temperature and includes four steps: Hydrolysis, polycondensation, drying, and thermal decomposition.

d. This method is widely employed to prepare oxide materials.

e. Schematic representation:



Schematic representation of the sol-gel process of synthesis of nanoparticles

f. The reactions and steps involved in the sol-gel process can be described as follows:

$$\underset{\text{(Metal alkoxide)}}{\text{MOR}} + \text{H}_2\text{O} \longrightarrow \text{MOH} + \text{ROH}\ \text{(Hydrolysis)}$$

$$\text{MOH} + \text{ROM} \longrightarrow \text{M}-\text{O}-\text{M} + \text{ROH}\ \text{(Condensation)}$$

1. Formation of the different stable solution of the alkoxide or solvated metal precursor.

2. Gelation resulting from the formation of an oxide or alcohol bridged network (gel) by a polycondensation reaction.

3. Aging of the gel means during that period gel transforms into a solid mass.

4. Drying of the gel: In this step, water and other volatile liquids are removed from the gel network.

5. Dehydration: The material is heated at temperatures up to 800°C.

Exercise | Q 4.5 | Page 352

Answer the following

Which flower is an example of self-cleaning?

Solution:

Lotus is an example of self-cleaning.