SAMPLE CONTENT

Precise

CHEMISTRY

Vol. II

BASED ON NEW PAPER PATTERN

Std. XII Science

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Target Publications® Pvt. Ltd.

Written as per the latest textbook prescribed by the Maharashtra State Bureau of Textbook Production and Curriculum Research, Pune.

Precise

CHEMISTRY (Vol. II)

Std. XII Sci.

Salient Features

- Written as per Latest Board Paper Pattern
- Subtopic-wise segregation for powerful concept building
- Complete coverage of Textual Exercise Questions and Intext Questions
- Includes selective and relevant Board questions from March 2013 to July 2022
- Includes selective questions from NCERT textbook for practice
- 'Quick Review' of the chapter facilitates quick revision
- Marks provided to the Questions as per relevant weightage wherever deemed necessary
- 'Reading Between the Lines' to elucidate concept
- Video/pdf links provided via QR codes for boosting conceptual retention
- Includes Board Question Paper of March 2023 (Solution in pdf format through QR code)

Printed at: **Print to Print,** Mumbai

Balbharati Registration No.: 2018MH0022

TEID: 2521

P.O. No. 8400

PREFACE

Precise Chemistry Vol. II, Std. XII Sci. is intended for every Maharashtra State Board aspirant of Std. XII, Science. The scope, sequence, and level of the book are designed to match the new textbook issued by the Maharashtra State board.

We understand that Board Examinations can be daunting and the stress of cracking the examination can often leave students struggling to make sense of the curriculum. Selective and relevant questions of Board Examination from March 2013 to July 2022 are provided so that students would get an idea about the types of questions that are asked in Board Examinations.

With the examination in focus, the ***Precise Series*** has been specifically designed to make preparation easier, by providing a methodical and organized perspective of the curriculum, thus greatly improving the chances of scoring well.

Chemistry is a science that has the potential to unlock the understanding of the natural world by allowing us to appreciate the changes that characterize matter interactions.

In order to make sure that students fully grasp the nub of the subject, it is important to present such concepts meaningfully and in an easy to read format.

In this vein, the Precise Chemistry book has been crafted to provide an **exam-centric approach** to the curriculum, while **retaining the essence** of the subject. Each chapter is thus structured to provide a **conceptual foundation**, in addition to offering **ample practice** for acing the board examination. **Chemical formulae, bonding structures** and **chemical equations** form the basic building blocks of Chemistry and students are advised to memorise them perfectly.

To quote the Nobel Prize winner, Marie Curie, *"**Nothing in life is to be feared. It is only to be understood.**"* Knowing the simple and basic organic reactions covered in each chapter serves as a foundation for understanding the synthesis of more complex molecules. Students should take advantage of compilation of various **organic reactions** provided in the book to ascertain their command on solving organic reaction-based problems.

A holistic preparation is the key to mastering any subject and conquering the board examination.

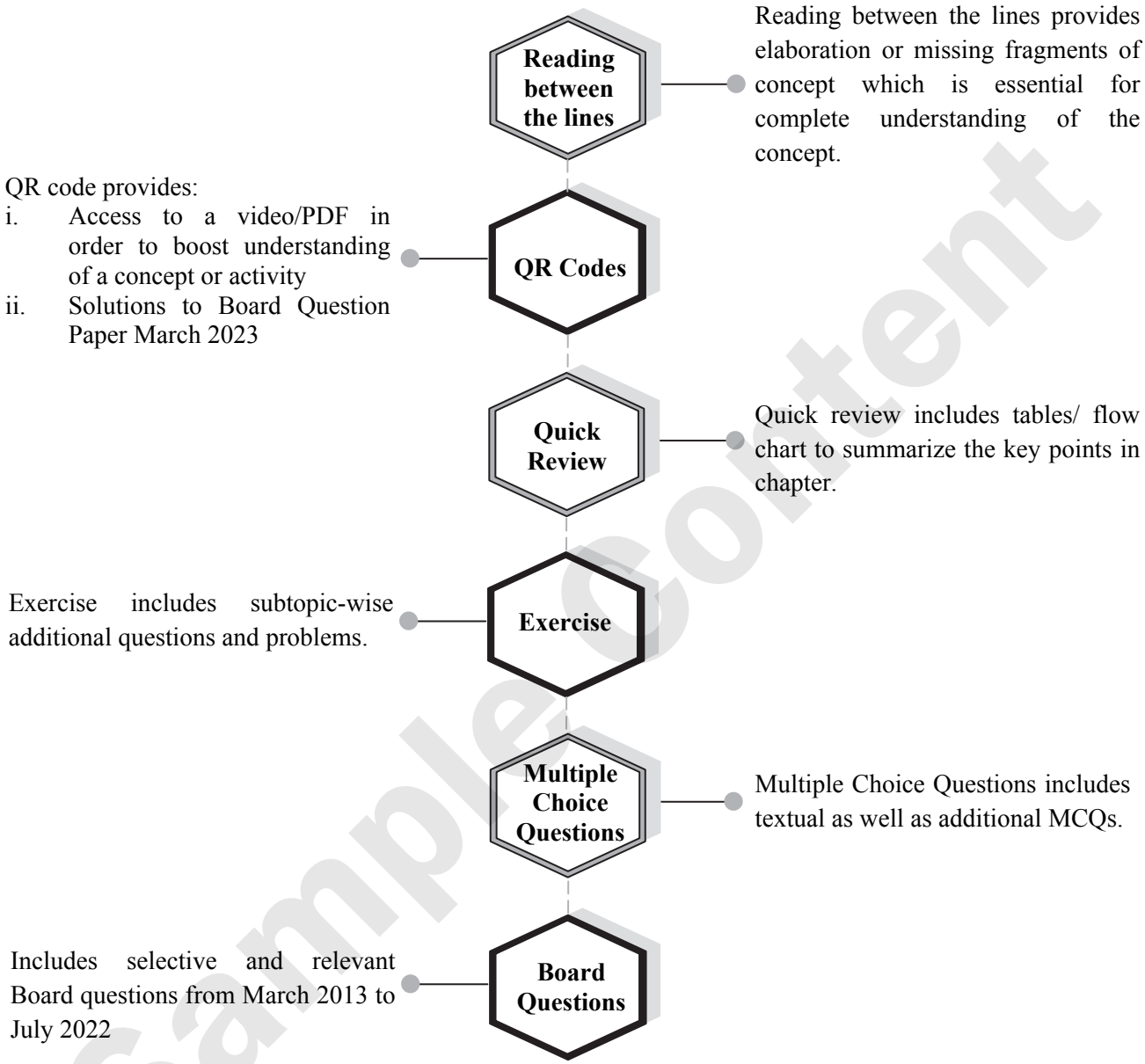
Our **Precise Chemistry Vol. II, Std. XII Sci.** adheres to our vision and achieves several goals: **building concepts, recapitulation and self-study** —all while facilitating effective preparation of the chapter.

Publisher

Edition: Fifth

The journey to create a complete book is strewn with triumphs, failures and near misses. If you think we've nearly missed something or want to applaud us for our triumphs, we'd love to hear from you.
Please write to us on: mail@targetpublications.org

KEY FEATURES



PAPER PATTERN

- There will be one single paper of 70 Marks in Chemistry.
- Duration of the paper will be 3 hours.

Section A: **(18 Marks)**

This section will contain Multiple Choice Questions and Very Short Answer(VSA) type of questions.
There will be 10 MCQs and 8 VSA type of questions, each carrying **One** mark.
Students will have to attempt all the questions.

Section B: **(16 Marks)**

This section will contain 12 Short Answer (SA-I) type of questions, each carrying **Two** marks.
Students will have to attempt any 8 questions.

Section C: **(24 Marks)**

This section will contain 12 Short Answer (SA-II) type of questions, each carrying **Three** marks.
Students will have to attempt any 8 questions.

Section D: **(12 Marks)**

This section will contain 5 Long Answer (LA) type of questions, each carrying **Four** marks.
Students will have to attempt any 3 questions.

Distribution of Marks According to the Type of Questions

Type of Questions		
MCQ	1 Mark each	10 Marks
VSA	1 Mark each	8 Marks
SA - I	2 Marks each	16 Marks
SA - II	3 Marks each	24 Marks
LA	4 Marks each	12 Marks

CONTENTS

[Reference: Maharashtra State Board of Secondary and Higher Secondary Education, Pune - 04**]**

Note:
1. * mark represents Textual question.
2. # mark represents Intext question.
3. + mark represents Textual examples.
4. 🔔 symbol represents textual questions that need external reference for an answer.
5. Chapters 1 to 9 are a part of Precise Chemistry Vol. I, Std. XII Sci.

Scan the adjacent QR Code to know more about our ***"Model Question Papers with solutions"*** book for Std. XII (Sci.) and Gear up yourself to score more in the XII Board Examination.

Scan the adjacent QR Code to know more about our ***"Board Questions with Solutions"*** book for Std. XII (Sci.) and Learn about the types of questions that are asked in the XII Board Examination.

16 Green Chemistry and Nanochemistry

Contents and Concepts

16.1 Introduction

Q.1. Can you recall? *(Textbook page no. 340)*

i. What do you mean by environment? **[1 Mark]**

Ans: The physical, chemical and biological factors which influence an organism collectively are called as environment.

ii. Which are the factors affecting the environment? **[2 Marks]**

Ans:

a. The factors affecting the environment are natural and artificial factors.
b. Natural factors such as earthquakes, volcanoes, droughts, etc., can adversely affect the environment.
c. Also, artificial or man-made factors like environmental pollution caused due to population explosion, fast industrialization, and indiscriminate use of natural resources, deforestation and unplanned urbanization can harm the environment.
d. Biotic and abiotic factors are related to each other in an ecosystem, and if any of the factors is changed or removed, it can affect the entire ecosystem.

Reading between the lines

i. Biotic factors include producers, consumers and decomposers.
ii. Abiotic factors are non-living components i.e. water, sunlight, temperature, oxygen, soil, pH, etc.
iii. Changes in biotic and abiotic factors can have drastic effects on the environment. For example, if plants (producers) in an ecosystem do not receive adequate sunlight, they eventually will die, thereby disturbing the entire food chain. Due to lack of availability of food even the consumers will die. This ultimately creates an imbalance in the environment as consumers rely on producers for their food.

iii. What is pollution? Which are the types of pollution? **[2 Marks]**

Ans:

a. *Unnecessary and unacceptable changes in the environment due to natural events or human activities is known as **pollution**.*

OR

*Direct or indirect changes in physical, chemical and biological properties of air, water and soil that are harmful to humans and other living beings is called as **pollution**.*

b. There are three main types of pollution: Air pollution, water pollution and soil pollution.

iv. Why it occurs? **[3 Marks]**

Ans: Following are the components and causes of different types of pollution:

	Air pollution	Water pollution	Soil pollution
Components	Gases: CO_2, CO, Hydrocarbons, sulfur, NO_x, hydrogen sulphides, etc. Solid: dust, ash, carbon, lead, asbestos, etc.	Oil and derivatives; carbonic compounds; heavy metals like mercury, lead, cadmium, etc., silt and sediments; pathogens.	Organic chemicals, pesticides, radioactive materials, oils and tar.
Causes	Emissions released from chemical industries, automobiles, burning of garbage, burning of fuels like coal, petroleum, etc.	Releases of industrial wastes, domestic waste, sewage, chemicals discharged from industries, into water bodies. Pesticides used in agriculture also reach water bodies.	Emissions released from chemical industries; mining, biomedical wastes; Excessive uses of pesticides and fertilizers; Dumping of domestic wastes, etc.

***Q.2. Define green chemistry.** **[1 Mark] [Mar 22; July 22]**

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

Q.3. What is green chemistry? Explain its importance. **[3 Marks]**

Ans:

i. Green Chemistry is an approach to chemistry that aims to maximize efficiency and minimize hazardous effects on human health and environment.

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

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

iv. Due to increase in human population and the industrial revolution, energy crisis and environmental pollution are highlighted major global problems in the 21st century. To reduce the impact of energy crisis, pollution and to save natural resources, we need to implement 12 principles of green chemistry enunciated by Paul Anastas wherever possible.

16.2 Sustainable development

***Q.4. Define 'sustainable development'.** **[1 Mark]**

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

Q.5. How can we achieve sustainable development? **[1 Mark]**

Ans: We can achieve sustainable development by adapting the twelve principles of green chemistry.

16.3 Principles of green chemistry

Q.6. List the 12 principles of green chemistry. **[2 Marks]**

Ans: The 12 principles of green chemistry are as follows:

i. Prevention of waste or by products
ii. Atom economy
iii. Less hazardous chemical synthesis
iv. Designing safer chemicals
v. Use of safer solvent and auxiliaries
vi. Design for energy efficiency
vii. Use of renewable feed stocks
viii. Reduce derivatives (Minimization of steps)
ix. Use of catalysis
x. Design for degradation
xi. Real-time analysis pollution prevention
xii. Safer chemistry for accident prevention

Q.7. With the help of suitable examples explain in detail all the 12 principles of Green Chemistry.

Ans: The sustainable development can be achieved by adapting following 12 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 a chemical synthesis, waste product should be zero or minimum.

It also aims to use the waste product of one system as the raw material for other system.

For example:

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

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

ii. Atom economy:

a. ***Atom economy*** *is a measure of the amount 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 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

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

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

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

iii. 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 formation of hazardous waste from chemical processes.

Illustration:

Earlier Dichlorodiphenyltrichloroethane (DDT) was used as insecticide and which 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 insecticide. One of the γ-isomer (gamma) of BHC is called gammexane or lindane.

iv. 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 toxic environment. Safer chemicals must be designed in order to prevent the workers from exposure to toxicity.

For example:

Adipic acid is widely used in polymer industry. Benzene is the starting material for the synthesis of adipic acid but benzene is carcinogenic and benzene being volatile organic compound (VOC) pollutes air.

In green technology developed by Drath and Frost, adipic acid is enzymatically synthesised from glucose.

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

Illustration:

a. The main aim behind 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.

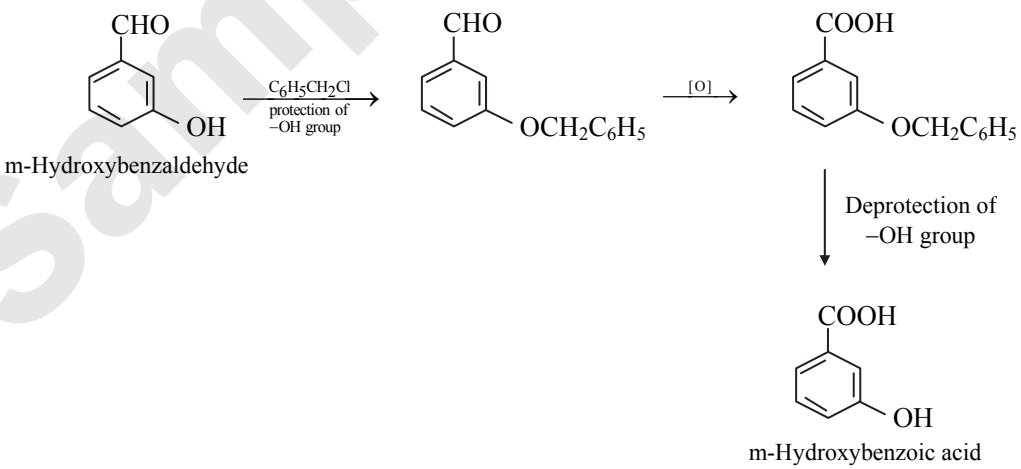
c. Water is a safe benign solvent while dichloromethane is hazardous.

d. 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.

vi. Design for energy efficiency: According to this principle of green chemistry, chemical synthesis should be designed to minimize the use of energy by carrying out reactions at room temperature and pressure.
This can be achieved by use of proper catalyst, microorganisms for organic synthesis, renewable materials, etc.
Illustration:
The biocatalyst can work at the ambient condition. Similarly, in chemical synthesis, refluxing conditions require less energy, improving the technology of heating system, use microwave heating, etc.

vii. Use of renewable feedstocks: The perspective of this principle of green chemistry is largely toward petrochemicals. Use chemicals which are made from renewable (plant based) sources rather than other non-renewable sources for such as crude oil.
Illustration:
a. Overexploitation of non-renewable feedstocks will deplete the resources and future generation will be deprived and also puts burden on the environment.
b. On the other hand, use of renewable resources such as agricultural or biological product ensures the sharing of resources by future generation.
c. This practice generally does not put much burden on environment. The products and waste are generally biodegradable.

viii. Reduce derivatives (Minimization of steps): In organic synthesis protecting or blocking groups are commonly used.
According to this principle of green chemistry, unnecessary derivatization, for example, installation / removal of 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, protection of some functional groups is required. Again, the deprotection of functional group is required at the end.
For example: Synthesis of m-hydroxybenzoic acid from m-hydroxybenzaldehyde.
b. In such cases, 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 selective group.



m-Hydroxybenzaldehyde

m-Hydroxybenzoic acid

ix. Use of catalysis: Catalysis is the process of increasing the rate of a chemical reaction by adding a substance known as a catalyst, which is not consumed in the catalyzed reaction and can continue to act repeatedly. Thus, the use of catalyst in the chemical reaction speeds up its rate and also helps to increase selectivity, minimize waste and reduce reaction times and energy demands.
For example, 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.

x. Design for degradation: According to this principle of green chemistry, chemicals are designed in such way that they degraded and can be discarded easily. It is ensured that both chemicals and their degradation products are not toxic, bioaccumulative or environmentally persistent.

Illustration:

The aim of this principle is that the waste product should degrade automatically to clean the environment.

Thus, the biodegradable polymers and pesticides are always preferred.

To make separation easier for the consumer, an international plastic recycle mark is printed on larger items.

xi. Real-time analysis pollution prevention: This principle of green chemistry focuses on developing analytical methods which allow real-time, in process monitoring and control prior to the formation of hazardous substances.

Illustration:

Analytical methodologies should be developed or modified, so that continuous monitoring of the manufacturing and processing units is possible. This is very much important for the chemical industries and nuclear reactors.

xii. Safer chemistry for accident prevention: According to this principle of green chemistry, we need to develop chemical processes that are safer and minimize the risk of accidents.

Illustration:

The substances to be used in a chemical reaction should be selected in such a way that they can minimize the occurrence of chemical accidents, explosions, fire and emission.

For example, if the chemical process works with the gaseous substances, then the possibility of accidents including explosion is relatively higher compared to the system working with nonvolatile liquid and solid substances.

***Q.8. Explain any three principles of green chemistry.** **[3 Marks]**

Ans: *Refer Q.7.(Any three principles of green chemistry)*

***Q.9. Explain atom economy with suitable example.** **[3 Marks]**

Ans: *Refer Q.7.(ii)*

***Q.10. Write the formula to calculate % atom economy.** **[1 Mark]**

Ans: *Refer Q.7.(ii).(Formula)*

***Q.11. Name the γ-isomer of BHC.** **[1 Mark]**

Ans: Gammexane or Lindane

***Q.12. How will you illustrate the use of safer solvent and auxiliaries?** **[3 Marks]**

Ans: *Refer Q.7.(v)*

***Q.13. How will you illustrate the principle, minimization of steps?** **[3 Marks]**

Ans: *Refer Q.7.(viii)*

***Q.14. Define catalyst. Give two examples.** **[2 Marks]**

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

e.g. 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 catalyst is used to convert inedible oils into solid fat for the production of margarine.

#Q.15. Complete the chart. *(Textbook page no. 342)* **[½ Mark Each]**

	Reaction	Name of catalyst used
i.	Hydrogenation of oil (Hardening)	---
ii.	Haber's process of manufacture of ammonia	---
iii.	Manufacture of HDPE polymer	---
iv.	Manufacture of H_2SO_4 by contact process	---
v.	Fischer-Tropsch process (Synthesis of gasoline)	---

Ans:

	Reaction	Name of catalyst used
i.	Hydrogenation of oil (Hardening)	Nickel
ii.	Haber's process of manufacture of ammonia	Mo/Fe
iii.	Manufacture of HDPE polymer	Ziegler-Natta catalyst
iv.	Manufacture of H_2SO_4 by contact process	Platinised asbestos
v.	Fischer-Tropsch process (Synthesis of gasoline)	Co-Th alloy

Note: Chart to sort plastic materials in daily life: *(Textbook page no. 343)*

	Symbol	Used In	Status	Is recycled to make
Number 1: *PETE or PET (Polyethylene terephthalate)*	 PETE	microwavable food trays; salad dressing, soft drink, water and beer bottles	Hard to clean; absorbs bacteria and flavours; avoid reusing	carpet, furniture, new containers, polar fleece
Number 2: *HDPE (high density polyethylene)*	 HDPE	household cleaner and shampoo bottles	Transmits no known chemicals into food	Detergent bottles, fencing, floor tiles, pens
Number 3: *V or PVC (vinyl)*	 V	cooking oil bottles, clear food packaging, mouthwash bottles	Is believed to contain phthalates that interfere with hormonal development; avoid	Cables, mud flaps, panelling, roadway gutters
Number 4: *LDPE (Low density polyethylene)*	 LDPE	bread and shopping bags, carpet, clothing, furniture	Transmits no known chemicals into food	envelopes, floor tiles, lumber, trash-can liners
Number 5: *PP (Polypropylene)*	 PP	ketchup bottles, medicine, and syrup bottle, drinking straws	Transmits no known chemicals into food	Battery, cables, brooms, ice scrapers, rakes
Number 6: *PS (Polystyrene)*	 PS	disposable cups and plates, egg cartons, take-out containers	Is believed to leach styrene, a possible human carcinogen into food; avoid	Foam packaging, insulation, light switch plates, rulers
Number 7: *Other (Miscellaneous)*	 Other	3- and 5- gallon water-jugs, nylon, some food containers	Contains bisphenol A, which has been linked to heart disease and obesity; avoid	Custom-made products

16.4 The role of green chemistry

***Q.16. Explain the role of green chemistry.** **[3 Marks]**

Ans: 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 green house effect (Global warming).

16.5 Introduction to nanochemistry

***Q.17. Define the following terms:** **[1 Mark Each]**

i. Nanoscience **ii. Nanotechnology [July 22]**
iii. Nanomaterial **iv. Nanochemistry [July 22]**

Ans:

i. 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.*

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

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

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

[Note: *Students can refer Figure 16.1-Macro-materials to atoms and Figure 16.2-Scale of nanomaterials from Textbook page no. 345 to compare sizes of different natural and man-made materials.****]***

Q.18. Write a note on 'nanometer scale'. **[2 Marks]**

Ans: Nanometer scale:

i. Conventionally, the nanometer scale is defined as 1-100 nm.
ii. One nanometer is one billionth of a meter. (that is, 1 nm = 10^{-9} m).
iii. The materials we see around us are bulk materials that possess macroscopic physical properties. Grain of sand that is micron-sized material also possesses same bulk properties.
iv. However, the material synthesized at nanoscale (1 nm-100 nm) possesses unique optical, structural, thermal, catalytic, magnetic and electrical properties. These properties change as a function of size and are very different from their bulk materials.

***Q.19. 1 nm = _____ m** **[1 Mark]**

Ans: 10^{-9}

Q.20. Explain the term nanomaterial. **[2 Marks]**

Ans: Nanomaterial:

i. *The* ***nanomaterial*** *is a material having structural components with at least one dimension in the nanometer scale, that is, 1-100 nm.*
ii. Nanomaterials are larger than single atoms but smaller than bacteria and cells.
iii. Nanomaterials may be nanoparticles, nanowires and nanotubes according to dimensions.
iv. Nanostructured materials may be large organic molecules, inorganic cluster compounds and metallic or semiconductor particles.

#Q.21. What are zero, one and two dimensional nanoscale system? *(Textbook page no. 346)* **[3 Marks]**

Ans:

i. Zero-Dimensional Nanostructures:
A zero dimensional structure is one in which all three dimensions are in the nanoscale.
That is, all three dimensions < 100 nm
e.g. Nanoparticles, quantum dots, nanoshells, nanorings, microcapsules

ii. One-Dimensional Nanostructures:
A one dimensional nanostructure is one in which two dimensions are in the nanoscale.
That is, two dimensions < 100 nm
e.g. Nanowires, nanofibres, nanotubes and nanorods

iii. Two-Dimensional Nanostructures:
A two-dimensional nanostructure is one in which one dimension is in the nanoscale.
That is, one dimension < 100 nm
e.g. Thin films, layers and coatings

***Q.22. Which nanomaterial is used in sunscreen lotion? Write its use. [2 Marks]**

Ans: 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.

16.6 Characteristic features of nanoparticles

Q.23. Enlist the characteristic features of nanoparticles and write significance of each. [3 Marks]

Ans: Nanoparticles possess unique properties due to their nanoscale size which ranges between 1 nm-100 nm.
Following are the characteristic features of nanoparticles:

i. Colour:
It is an optical property that is different at nanoscale.
e.g. Elemental gold has shining yellow colour. However, if only 100 gold atoms are arranged in a cube, its colour would be much more red.

ii. Surface area:
High surface-to-volume ratio is a very important characteristic of nanoparticles. If a bulk material is sub divided into a group of individual nanoparticles, the total volume remains the same, but the collective surface area is largely increased. With large surface area for the same volume, these small particles react much faster because more surface area provides more number of reaction sites, leading to more chemical reactivity.

iii. Catalytic activity:
a. Due to increase in surface area with decrease in particle size, nanomaterial-based catalysts show increased catalytic activity.
b. Usually they are heterogeneous catalysts that means catalysts are in solid form and the reactions occur on the surface of the catalyst.
c. Nanoparticle catalysts can be easily separated and can be recycled.
e.g. Pd, Pt metal nanoparticles used in hydrogenation reactions.
TiO_2, ZnO are used in photocatalysis.
Gold in bulk form is unreactive, but gold nanoparticles are found to be very good catalyst for various organic reactions.

iv. Thermal properties - Melting point:
The melting point of nanomaterial changes drastically and depends on size.
e.g. Sodium clusters (Na_n) of 1000 atoms appeared to melt at 288 K while cluster of 10,000 atoms melted at 303 K and bulk sodium melts at 371K.

v. Mechanical properties - Mechanical strength:
Nanosized copper and palladium clusters with diameter in the size range of 5-7 nm can have hardness up to 500% greater than bulk metal.

vi. Electrical conductivity:
Electrical conductivity is observed to change at nanoscale.
e.g. Carbon nanotube can act as a conductor or semiconductor in behaviour.

16.7 Synthesis of nanomaterials

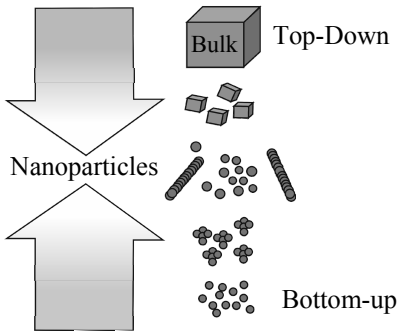
Q.24. Explain the two approaches that are followed for the synthesis of nanomaterials. Draw a suitable schematic illustration representing the two approaches. [3 Marks]

Ans: Following are the two approaches to the synthesis of nanomaterials:

i. Bottom-up approach: In this approach, molecular components arrange themselves into more complex assemblies atom by atom, molecule by molecule and cluster by cluster from the bottom.
e.g. Synthesis of nanoparticles by colloidal dispersion.

ii. Top-down approach: In this approach, nanomaterials are synthesized from bulk material by breaking the material in stepwise manner.

The bulk solids are dis-assembled into finer pieces until they are constituted of only few atoms.



Schematic illustration of the preparation of nanoparticles

***Q.25. i. What do you mean by sol and gel? [2 Marks]**

ii. Describe the sol-gel method of preparation of nanoparticles. [4 Marks]

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

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

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

ii. Sol-gel process:

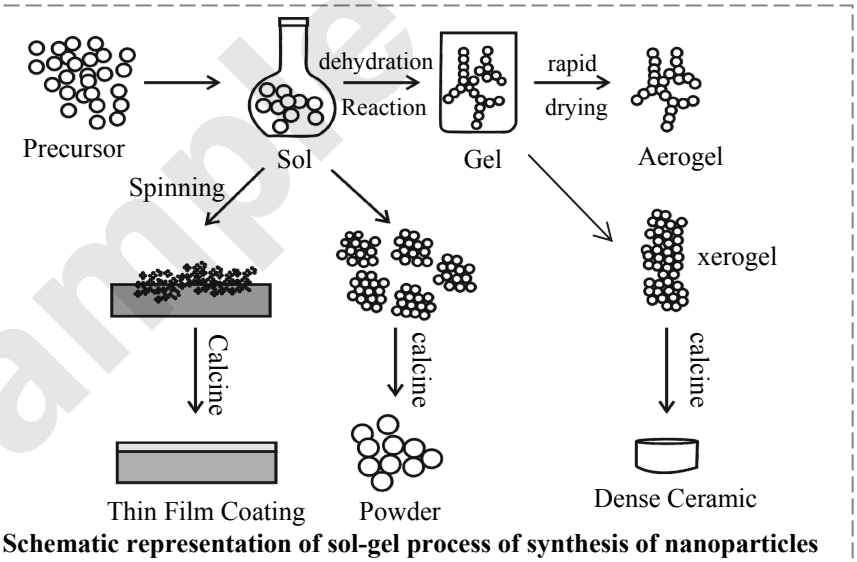
a. Sol-gel process is an example of wet chemical synthesis of nanomaterials.

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 sol-gel process of synthesis of nanoparticles

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

$$\underset{\text{(Metal alkoxide)}}{MOR} + H_2O \rightarrow MOH + ROH \quad \text{(Hydrolysis)}$$

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

1. Formation of 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.

Q.26. Mention the techniques and instruments used for analysis or characterization of nanomaterials.

[2 Marks]

Ans: The nanomaterials synthesized using variety of processes are analyzed by different analytical tools or techniques. Following are the techniques and instruments used for analysis or characterization of nanomaterials:

	Name of technique	Instrument used
i.	UV-visible spectroscopy	UV-visible spectrophotometer
ii.	X-ray diffraction (XRD)	X-ray diffractometer
iii.	Scanning Electron Microscopy (SEM)	Scanning Electron Microscope
iv.	Transmission Emission Microscopy (TEM)	Transmission Emission Microscope
v.	Fourier Transform Infrared Spectroscopy (FTIR)	Fourier Transform Infrared Spectrophotometer

[Note:** Students can refer Textbook page no.348-349 to see the photographs of the above mentioned instruments.**]

Q.27. Write the information obtained about nanomaterials with the help of following techniques.

[1 Mark Each]

i. UV-visible spectroscopy
ii. X-ray diffraction (XRD)
iii. Scanning Electron Microscopy (SEM)
iv. Transmission Emission Microscopy (TEM)
v. Fourier Transform Infrared Spectroscopy (FTIR)

Ans:

i. UV-visible spectroscopy:
Information obtained: Preliminary confirmation of formation of nanoparticles

ii. X-ray diffraction (XRD):
Information obtained: Particle size, crystal structure, geometry

iii. Scanning Electron Microscopy (SEM):
Information obtained: Structure of surface of material i.e. morphology

iv. Transmission Emission Microscopy (TEM):
Information obtained: Particle size

v. Fourier Transform Infrared Spectroscopy (FTIR):
Information obtained: Absorption of functional groups and binding nature

***Q.28. Ridhima wants to detect structure of surface of materials. Name the technique she has to use.**

[1 Mark]

Ans: Scanning Electron Microscopy

16.8 History of nanotechnology

Q.29. Nanomaterials have been produced and used by humans for hundreds of years. Explain the statement with suitable examples. **[3 Marks]**

Ans: Nanomaterials have been produced and used by humans for hundreds of years. However, the understanding of certain materials as nanostructured materials is relatively recent. Due to the development of sophisticated instruments, it has been possible to reveal the information at nanoscale.

e.g.
i. Beautiful ruby red colour of some ancient glass paintings is due to gold and silver nanoparticles trapped in the glass matrix.
ii. The decorative glaze or metallic film known as lustre found on some medieval pottery is due to certain spherical metallic nanoparticles.
iii. Carbon black is a nanostructured material that is used in tyres of car to increase the life of tyre. (Discovery in 1900). Carbon nanotubes are made up of graphite sheets with nanosized diameter. They have highest strength.
iv. Fumed silica, a component of silicon rubber, coatings, sealants and adhesives is also a nanostructured material.

***Q.30. Which nanomaterial is used for tyres of car to increase the life of tyres? [1 Mark]**

Ans: Carbon black

***Q.31. Give the full form (long form) of the names for the following instruments: [½ Mark Each]**

i. XRD ii. TEM iii. STM

iv. FTIR v. SEM

Ans:

i. X-ray diffractometer
ii. Transmission Electron Microscope
iii. Scanning Tunneling Microscope
iv. Fourier Transform Infrared Spectrophotometer
v. Scanning Electron Microscope

Q.32. Name the scientist who discovered scanning tunneling microscope (STM) in 1980. [1 Mark]

Ans: Gerd Binnig and Heinrich Rohrer

16.9 Applications of nanomaterials

Q.33. Explain in detail the applications of nanotechnology/nanomaterials in various discipline. [3 Marks]

Ans: Nanochemistry has contributed to number of innovative products in various disciplines because of their unique physical, chemical, optical, structural, catalytic properties, etc.

Following are the few applications:

i. Nanoparticles can contribute to stronger, lighter, cleaner and smarter surfaces and systems. They are used in the manufacturing of scratchproof eyeglasses, transport, sunscreen, crack resistant paints and so on.
ii. Used in electronic devices. **e.g.** Magnetoresistive Random Access Memory (MRAM).
iii. 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 highly effective antibacterial agent which kills *E. coli* from water.
iv. Self-cleaning materials:
    a. Lotus is an example of self-cleaning. The lotus plant (*Nelumbo nucifera*) although grows in muddy water, its leaves always appear clean.
    b. The plants' leaves are super-hydrophobic.
    c. Nanostructures on lotus leaves repel water which carries dirt as it rolls off. Lotus effect is the basis of self-cleaning windows.

***Q.34. How nanotechnology plays an important role in water purification techniques? [2 Marks]**

Ans: *Refer Q.33. (iii)*

***Q.35. Which flower is an example of self-cleaning? [1 Mark]**

Ans: Lotus is an example of self-cleaning.

16.10 Nanoparticles and nanotechnology

Q.36. Mention the advantages of nanoparticles and nanotechnology. [2 Marks]

Ans: Advantages of nanoparticles and nanotechnology:

i. Revolution in electronics and computing.
ii. Energy sector:
    a. Nanotechnology will make solar power more economical.
    b. Energy storage devices will become more efficient.
iii. Medical field:
    a. Manufacturing of smart drugs, helps cure faster and without side effects.
    b. Curing of life threatening diseases like cancer and diabetes.

Q.37. What are the disadvantages of nanoparticles and nanotechnology? **[3 Marks]**

Ans: Disadvantages of nanoparticles and nanotechnology:

Despite the possibilities and the advancements that the nanotechnology offers to the world, there also exist certain potential risks involved with it.

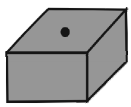
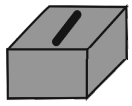
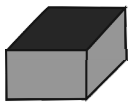
i. Nanotechnology has raised the standard of living but at the same time, it has increased the pollution which includes air pollution. The pollution caused by nanotechnology is known as nano pollution. This kind of pollution is very dangerous for living organisms.

ii. Nanoparticles can cause lung damage. Inhaled particulated matter may get deposited throughout the human respiratory tract and then in the lungs.

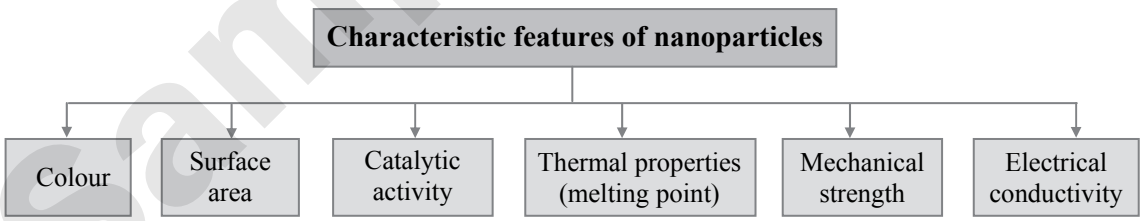
iii. The characteristics of nanoparticles that are relevant for health effects are size, chemical composition and shape.

Quick Review

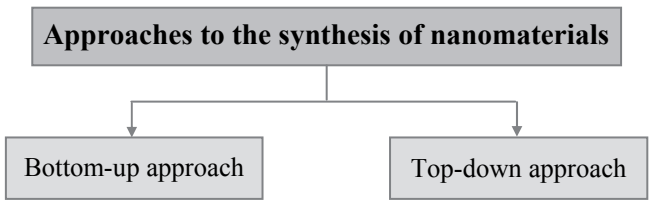
➢ **Types of nanomaterials according to dimensions:**

Nanomaterial Dimension	Nanomaterial Type	Example
All three dimensions < 100 nm	Nanoparticles, Quantum dots, nanoshells, nanorings, microcapsules	
Two dimensions < 100 nm	Nanotubes, fibres, nanowires	
One dimension < 100 nm	Thin films, layers and coatings	

➢ **Characteristic features of nanoparticles:**



➢ **Synthesis of nanomaterials:**



➢ **Techniques used for analysis or characterization of nanomaterials:**

Name of technique	Information obtained
UV-visible spectroscopy	Preliminary confirmation of formation of nanoparticles
X-ray diffraction (XRD)	Particle size, crystal structure, geometry
Scanning Electron Microscopy (SEM)	Structure of surface of material i.e. morphology
Transmission Emission Microscopy (TEM)	Particle size
Fourier Transform Infrared Spectroscopy (FTIR)	Absorption of functional groups and binding nature

Exercise

16.1 Introduction

1. Define the term: Green chemistry. **[1 Mark]**
Ans: *Refer Q.2.*

16.3 Principles of green chemistry

2. Write the 12 principles of green chemistry. **[2 Marks]**
Ans: *Refer Q.6.*

3. Explain the following principle of green chemistry: **[2 Marks]**
'Prevention of waste or by products'
Ans: *Refer Q.7. (i)*

4. Define atom economy. **[1 Mark]**
Ans: *Refer Q.7. (ii-a)*

5. How will you illustrate the principle, Safer chemistry for accident prevention? **[2 Marks]**
Ans: *Refer Q.7. (xii)*

16.4 The role of green chemistry

6. Explain the role of Green chemistry (Any four). **[2 Marks]**
Ans: *Refer Q.16.*

16.5 Introduction to nanochemistry

7. Define the term: Nanoscience. **[1 Mark]**
Ans: *Refer Q.17. (i)*

8. Give two examples of zero dimensional nanostructures. **[1 Mark]**
Ans: *Refer Q.21. (i)*

16.6 Characteristic features of nanoparticles

9. Describe any three characteristic features of nanoparticles. **[3 Marks]**
Ans: *Refer Q.23.*

10. Write a note on catalytic activity of nanoparticles. **[2 Marks]**
Ans: *Refer Q.23. (iii)*

16.7 Synthesis of nanomaterials

11. Explain bottom-up approach in the synthesis of nanomaterials. **[3 Marks]**
Ans: *Refer Q.24. (i)*

12. Explain top-down approach in the synthesis of nanomaterials. **[3 Marks]**
Ans: *Refer Q.24. (ii)*

13. Explain in detail the wet chemical synthesis of nanomaterials. **[4 Marks]**
Ans: *Refer Q.25.*

14. What information are obtained about nanomaterials using XRD and FTIR? **[2 Marks]**
Ans: *Refer Q.27.*

16.9 Applications of nanomaterials

15. Explain any two applications of nanotechnology. **[2 Marks]**
Ans: *Refer Q.33.*

16.10 Nanoparticles and nanotechnology

16. Write any two advantages of nanotechnology. **[1 Mark]**
Ans: *Refer Q.36.*

17. Write two disadvantages of nanotechnology. **[2 Marks] [Mar 22]**
Ans: *Refer Q.37.*

Multiple Choice Questions

[1 Mark Each]

*1. The concept of green chemistry was coined by _____.
(A) Born Haber (B) Nario Taniguchi
(C) Richard Feynman (D) Paul T. Anastas

*2. The development that meets the needs of present without compromising the ability of future generations to meet their own need is known as _____.
(A) continuous development
(B) sustainable development
(C) true development
(D) irrational development

3. ZWT in green chemistry stands for: **[July 22]**
(A) zero waiting time
(B) zero waste technology
(C) zubl water technology
(D) zhen wu tang

*4. Which of the following is γ-isomer of BHC?
(A) DDT (B) Lindane
(C) Chloroform (D) Chlorobenzene

5. The size of nanomaterials ranges between _____.
(A) 100 nm to 1000 nm
(B) 0.01 nm to 100 nm
(C) 1 nm to 10 nm
(D) 1 nm to 100 nm

*6. The prefix 'nano' comes from _____.
(A) French word meaning billion
(B) Greek word meaning dwarf
(C) Spanish word meaning particle
(D) Latin word meaning invisible

7. Which of the following property of nanomaterials play significant role in providing more number of reaction sites?
(A) Electrical conductivity
(B) Thermal property
(C) High surface area to volume ratio
(D) Colour

8. Which of the following step is NOT involved in sol-gel process?
(A) Hydrolysis
(B) Hydrogenation
(C) Polycondensation
(D) Thermal decomposition

*9. Which of the following information is given by FTIR technique?
(A) Absorption of functional groups
(B) Particle size
(C) Confirmation of formation of nanoparticles
(D) Crystal structure

10. Ruby red colour of some ancient glass paintings is due to _____ and _____ nanoparticles trapped in glass matrix.
(A) gold, titanium (B) gold, silver
(C) silver, zinc (D) gold, zinc

11. Carbon nanotubes are made up of _____ sheets with nano-sized diameter.
(A) silver (B) silicon
(C) graphite (D) fumed silica

12. The term '_____' was defined by Tokyo Science University Professor, Nario Taniguchi in 1974.
(A) Green Chemistry
(B) Catalyst
(C) Nanotechnology
(D) Nanochemistry

13. The name of metal nanoparticle which acts as highly effective bacterial disinfectant in water purification process is _____. **[Mar 22]**
(A) carbon black (B) silver
(C) gold (D) copper

Answers to Multiple Choice Questions

1.	(D)	2.	(B)	3.	(B)	4.	(B)
5.	(D)	6.	(B)	7.	(C)	8.	(B)
9.	(A)	10.	(B)	11.	(C)	12.	(C)
13.	(B)						

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