

Total number of printed pages-23

3 (Sem-6/CBCS) CHE HE 1/2/3  
2022 (Green Chemistry)

Answer the Questions from any one Option.  
(Honours Elective)

**OPTION - A**

(Green Chemistry)

Paper : CHE-HE-6016

**OPTION - B**

(Industrial Chemicals and Environment)

Paper : CHE-HE-6026

**OPTION - C**

(Inorganic Materials of Industrial Importance)

Paper : CHE-HE-6036

Full Marks : 60

Time : Three hours

The figures in the margin indicate full marks for the questions.

Contd.



**OPTION - A**

Paper : CHE-HE-6016

**( Green Chemistry )**

1. Answer **any seven** of the following questions:  $1 \times 7 = 7$

(a) The concept of green chemistry was introduced in which of the following legislations ?

- (i) Clean Water Act of 1972
- (ii) Montreal Protocol of 1989
- (iii) Pollution Prevention Act of 1990
- (iv) Superfund Act of 1980

(b) Identify the non-toxic and green solvent :

- (i) Liquefied carbon dioxide
- (ii) Benzene
- (iii) Carbon tetrachloride
- (iv) Toluene

(c) The use of solar power is an example of which of the 12 principles of green chemistry ?

- (i) Atom economy
- (ii) Design for energy efficiency
- (iii) Design benign chemicals
- (iv) Less hazardous synthesis

(d) Which of the following is not an atom economic reaction ?

- (i) Addition reaction
- (ii) Elimination reaction
- (iii) Rearrangement reaction
- (iv) Diels-Alder reaction

(e) Which of the following options given below is not related to the twelve principles of green chemistry ?

- (i) Use of catalysts
- (ii) Cleaning of waste
- (iii) Recycling
- (iv) Reduce less solvents

(f) Green chemists reduce risk by

- (i) reducing the hazard inherent in a chemical product or process
- (ii) minimizing the use of all chemicals
- (iii) inventing technologies that will clean up toxic sites
- (iv) developing recycled products

(g) Identify the wrong statement among the following :

- (i) Catalytic reagents are superior to stoichiometric reagents.
- (ii) Methane gas can be considered as renewable starting material.



- (iii) All catalysts cause lowering of the activation energy.
- (iv) Microwave heating is a greener technology in chemical synthesis.
- (h) Wittig reaction is an atom economic reaction. (State whether this statement is true or false)
- (i) Turnover frequency of catalyst A is more than that of catalyst B. State which catalyst is more active.
- (j) What do you mean by LD<sub>50</sub> while measuring toxicity of a chemical?

2. Answer **any four** of the following questions :  $2 \times 4 = 8$

- (a) What is the relationship between risk and hazard?
- (b) Give an example of a reaction with 100% atom economy.
- (c) Catalytic reagents are superior to stoichiometric reagents. Explain.
- (d) What is sonication? Which effect is responsible for supplying energy in sonication?
- (e) Why is water considered as universal solvent in organic synthesis?

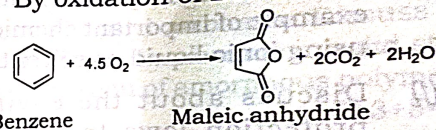
- (f) "Metathesis reaction is a green chemical process." Elaborate this statement using principles of green chemistry.
- (g) What is supercritical CO<sub>2</sub>? What are its advantages?
- (h) Write two applications of 'tellurium' in organic synthesis.

3. Answer **any three** of the following questions :  $5 \times 3 = 15$

- (a) Maleic anhydride may be synthesized by the following two routes :

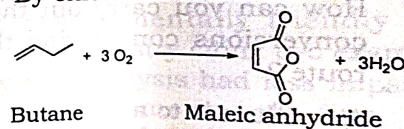
Route I

(i) By oxidation of Benzene



Route II

(ii) By oxidation of Butane



Calculate the % of atom economy of both the reactions. What are the advantages if Route II was offered as a green chemistry alternative for the production of maleic anhydride?



(b) Explain with example how the replacement of tributyltin hydride with tetrathiafulvalene (TTF) as radical initiator would reduce the production of hazardous materials in some free radical reactions.

(c) Explain the statement 'Design for Degradation'. Write the importance of asymmetric synthesis illustrating the thalidomide babies' case.  $3+2=5$

(d) Give different techniques of minimizing hazardous wastes.

(e) What are the characteristics of ionic liquids? Classify them. Give any one example of important chemical reaction using ionic liquid as solvent.  $2+2+1=5$

(f) Discuss about the environmental protection laws to promote green chemistry.

(g) How can you carry out the following conversions considering the greener route?

(i) Glucose to adipic acid

(ii) Corn to polylactic acid

(h) What is the role of solvent in a chemical reaction? How is the role fulfilled in solvent-free reaction?  $3+2=5$

4. Answer **any three** of the following questions:  $10 \times 3 = 30$

(a) Discuss and compare the mechanisms of energy transfer using high pressure, steam, microwaves and ultrasound. Discuss the role and limitations of solvents for carrying out a chemical reaction using these energy sources.

(b) What do you mean by sustainable development? Discuss how green chemistry works toward sustainability. What are the obstacles in the pursuit of the goals of green chemistry?

(c) What are green reagents? Mention some uses of dimethyl carbonate. Discuss the use of diphenyl carbonate in solid state polymerization of amorphous polymers.  $2+3+5=10$

(d) Discuss the role catalysts have played in the development of a more economic and environmentally friendly bulk chemical industry citing two examples. Why has catalysis had less impact on the development of fine and pharmaceutical products? Differentiate between homogenous and heterogenous catalysis. Elaborate the advantage of use of heterogenous catalyst to meet the requirement of green chemistry.  $3+2+3+2=10$



(e) Discuss briefly the problems associated with the synthesis of adipic acid and BHT. Give the alternate green method of synthesis of adipic acid. Justify how this method is green.  $5+5=10$

(f) What is clayan? How is it prepared? Give two examples of application of clayan in organic synthesis. Which principle(s) of green chemistry is/are involved in application of clayan?  $1+2+5+2=10$

(g) Give the principle of inherent safer design (ISD). How does it work for designing the green processes in industries? Write a brief account of development of analytical techniques to prevent generation of hazardous substances.  $3+3+4=10$

(h) What are phase transfer catalysts? Describe their types, advantages and application in synthesis of nitriles from alkyl and aryl halides.  $2+2+3+3=10$

### OPTION - B

Paper : CHE-HE-6026

### (Industrial Chemicals and Environment)

1. Answer **any seven** questions:  $1 \times 7 = 7$

(a) Which of the following is a flammable gas?

- (i)  $O_2$
- (ii)  $N_2$
- (iii)  $H_2$
- (iv) Ar

(b) Which of the following metals is used in semiconductor industry?

- (i) K
- (ii) Ba
- (iii) Mg
- (iv) Ga

(c) Which of the following gases is responsible for turning 'Taj Mahal' yellow?

- (i)  $Cl_2$
- (ii)  $SO_2$
- (iii)  $CO_2$
- (iv) CO



(d) Which of the following formulas represents bleaching powder ?

- (i)  $\text{CaOCl}$
- (ii)  $\text{CaOCl}_2$
- (iii)  $\text{Ca}(\text{OCl})_2$
- (iv)  $\text{CaCl}_2$

(e) Which of the following coagulants is used for sewage treatment ?

- (i) Lime
- (ii) Alum
- (iii)  $\text{FeCl}_3$
- (iv) Ferric sulfate

(f) Which of the following techniques is used in water purification ?

- (i) Turgor pressure
- (ii) Osmosis
- (iii) Reverse osmosis
- (iv) Cytolysis

(g) The most notorious greenhouse gas in the atmosphere is \_\_\_\_\_.

(Fill in the blank)

(h) Which radioactive metal is used as a renewable fuel in nuclear fission ?

(i) Which of the following industrial processes is used to manufacture sulphuric acid ?

- (i) Ostwald process
- (ii) Contact process
- (iii) Wacker process
- (iv) Haber process

(j) Which of the following pairs of metals can cause water pollution ?

- (i)  $\text{Na}^+$  and  $\text{Ba}^{2+}$
- (ii)  $\text{K}^+$  and  $\text{Mg}^{2+}$
- (iii)  $\text{Na}^+$  and  $\text{Al}^{3+}$
- (iv)  $\text{Pb}^{2+}$  and  $\text{Hg}^{2+}$

2. Answer **any four** questions :  $2 \times 4 = 8$

(a) Mention one industrial use each of helium and acetylene.

(b) In the commercial production of concentrated sulphuric acid, oleum is first prepared followed by its hydrolysis to obtain sulphuric acid. Why is  $\text{SO}_3$  not directly reacted with water to obtain sulphuric acid ?



(c) Match the following two columns :

**Column I**

- (i) Sodium thiosulphate
- (ii) Carbon monoxide
- (iii) Potassium dichromate
- (iv)  $\text{NO}_x$

**Column II**

- (a) Automobile exhaust
- (b) Chemical oxygen demand
- (c) Photography
- (d) Shortness of breath

(d) Name **any four** major air pollutants.

(e) What do you mean by greenhouse effect ?

(f) What is the reason of common salt being iodized for the purpose of human consumption ?

(g) Why are industrial fertilizers considered as major contributors to eutrophication of fresh water body ?

(h) Give the chemical reaction(s) leading to the formation of acid rain. What is the chemical effect of acid rain on eggshells ?

3. Answer **any three** questions :  $5 \times 3 = 15$

(a) Write briefly about the hazards in handling the following chemicals :

(i)  $\text{H}_2$  gas

(ii) Concentrated  $\text{H}_2\text{SO}_4$

$$2\frac{1}{2} \times 2 = 5$$

(b) Discuss briefly about the nitrogen cycle.

(c) How would you broadly divide the major regions of the atmosphere ? State their respective altitudes and temperature ranges.

(d) Discuss briefly about the pollution caused by  $\text{NO}_x$ .

(e) Write briefly about the impact of water pollution on aquatic ecosystem.

(f) Write a brief note about nuclear pollution.

(g) How is  $\text{KMnO}_4$  manufactured industrially ? Give two applications of  $\text{KMnO}_4$ .  $3+2=5$

(h) What is a biocatalyst ? How are biocatalysts important in chemical industry ?  $2+3=5$

4. Answer **any three** questions :  $10 \times 3 = 30$

(a) (i) Describe the method for the commercial production of chlorine gas.

(ii) Explain why chlorine gas is dried over concentrated  $\text{H}_2\text{SO}_4$  and not over  $\text{NaOH}$ .



(iii) Explain why  $F_2$  is a colorless gas while  $Cl_2$  is a light yellow gas.

6+2+2=10

(b) (i) What is photochemical smog? Discuss the mechanism of its formation. 1+5=6

(ii) What are the harmful effects of photochemical smog and what measures can be taken to reduce its formation? 4

(c) (i) Discuss the major techniques of measuring water pollution. 7

(ii) While the 'Ganga River' is a holy river in India, it is also one of the most polluted rivers. What are the sources of pollution of 'Ganga River'? 3

(d) (i) What is ozone layer? Discuss the mechanism by which the concentration of ozone is maintained at the normal level in the stratosphere. 5

(ii) Discuss how chlorofluorocarbons (CFCs) contribute to the depletion of ozone layer. 5

(e) (i) "Carbon dioxide, a non-pollutant, is perhaps the single most important environmental question facing at the moment." Discuss the statement in the context of greenhouse effect. 8

(ii) Suggest two measures to cut down the concentration of carbon dioxide in the atmosphere. 2

(f) What is industrial waste? Discuss the methods of industrial waste management. 1+9=10

(g) (i) What is nuclear fission? Take uranium as an example and discuss the process of nuclear fission that can generate a huge amount of energy. 7

(ii) Write briefly about the disposal of nuclear waste. 3

(h) Discuss about the important water quality parameters for waste water, industrial water and domestic water.



**OPTION - C**

Paper : CHE-HE-6036

**(Inorganic Materials of Industrial Importance)**

1. Choose the correct option : **(any seven)**

(a) The role of cerium oxide ( $\text{CeO}_2$ ) present in Crookes glass is to

- (i) give colour to the glass
- (ii) strengthen the glass
- (iii) cut-off ultraviolet rays
- (iv) make it transparent

(b) Glass reacts with mineral acids

- (i) Hydrochloric acid
- (ii) Hydrofluoric acid
- (iii) Nitric acid
- (iv) Sulphuric acid

(c) An example of yellow pigment is

- (i)  $\text{PbCrO}_4$
- (ii)  $\text{K}_2\text{CrO}_4$
- (iii)  $\text{PbCO}_3$
- (iv)  $\text{K}_2\text{CO}_3$

(d) Bronze is an alloy which contains

- (i) Cu and Al
- (ii) Cu and Zn
- (iii) Cu and Fe
- (iv) Cu and Sn

(e) Which among the following is not a nitrogenous fertilizer?

- (i) Ammonium sulphate
- (ii) Calcium cyanamide
- (iii) Superphosphate of lime
- (iv) Urea

(f) Lead azide  $\text{Pb}(\text{N}_3)_2$  is an example of

- (i) inorganic polymer
- (ii) chemical explosive
- (iii) alloy
- (iv) ceramics

(g) Which of the following compounds is responsible for quick setting of cement?

- (i)  $\text{MgO}$
- (ii)  $\text{SiO}_2$
- (iii)  $\text{Fe}_2\text{O}_3$
- (iv)  $\text{Al}_2\text{O}_3$



(h) Which of the following is a non-ferrous alloy?

(i) Carbon steel

(ii) Brass

(iii) Cast iron

(iv) Nickel steel

(i) In a galvanic cell, which one of the following statements is not correct?

(i) Anode is negatively charged.

(ii) Cathode is positively charged.

(iii) Reduction takes place at anode.

(iv) Reduction takes place at cathode.

(j) In lead storage battery

(i)  $PbO_2$  is reduced to  $PbSO_4$  at the cathode

(ii)  $Pb$  is oxidised to lead sulphate ( $PbSO_4$ ) at the anode

(iii) Both electrodes are placed in dil.  $HNO_3$  solution

(iv)  $SO_2$  gas is evolved

2. Answer the following questions: (any four)  $2 \times 4 = 8$

(a) What advantage do the fuel cells have over primary and secondary batteries?

(b) Write the cell reactions of lead storage battery when it is discharged. How does the density of electrolyte change when battery is discharged?

(c) What is lithopone? Write the constituents from which it is prepared.

(d) What is the full form of PETN? Give one method of preparation of PETN.

(e) What are fertilizers? Name two fertilizers containing nitrogen and phosphorus.

(f) What is the role of gypsum during setting of cement?

(g) What is fullerene? Write two uses of fullerene.

(h) Give the general composition of glass.



3. Answer the following questions : **(any three)**

5×3=15

(a) Write the chemical composition of sodalime glass, lead glass and borosilicate glass.

(b) What are ceramics ? What do you mean by glazing of ceramics ?

(c) Write the chemical composition of Portland cement. Write the chemical reactions involved during the manufacture of cement.

(d) What is the chemical name of RDX ? Write the differences between RDX and PETN. What is a C-4 bomb ?

(e) Give the composition, properties and uses of gunmetal alloys.

(f) What are paints ? Write various constituents of paints. Give the properties of paints.

(g) What are fuel cells ? Write the working principle and reactions taking place at electrodes for a fuel cell.

(h) Make distinction between homogeneous and heterogeneous catalyses. Give examples. What do you mean by deactivation of catalyst ?

4. Answer the following : **(any three)**

(a) What are silicones ? How are silicones classified ? Discuss the methods of preparation and uses of silicones.

(b) With a flow sheet diagram, discuss various steps involved in manufacture of urea. Also discuss the conditions to get good yield.

(c) How is steel manufactured from cast iron ? Write the reactions involved. What do you mean by nitriding of steel ?

(d) What are lead storage batteries ? Write the reactions involved at cathode and at anode. Also write the chemistry of recharging of lead storage batteries.



(e) Define glass. What are the composition of amber coloured bottle glass? Write the reactions that take place in furnace when batch material consists of silica ( $\text{SiO}_2$ ), limestone ( $\text{CaCO}_3$ ) and soda ash. What do you mean by annealing of glass?  $2+2+4+2=10$

(f) (i) What do you mean by rocket propellants? Give two examples. How are rocket propellants classified? What is the most common rocket fuel?  $2+2+3+1=8$

(ii) How are explosives classified? 2

(g) (i) What do you mean by nitrogen fixation?

(ii) Write the names of pigments which are used to prepare blue, yellow and green paints.  $7+3=10$

(iii) What are extenders? Give two examples of extenders.  $3+3+4=10$

(h) Write short notes on :

$$5+5=10$$

(i) Desulfurisation of steel

(ii) Dephosphorisation of steel