Carbon and its Compounds

CHAPTER 4

EXAM DRILL

ANSWERS

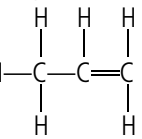
1. Because (i) it acts as catalyst and (ii) it removes water which is necessary to proceed the reaction in forward direction.

2. Pentene

3(i) Valency of an element is a measure of its combining power with other atoms when it forms chemical compounds or molecules.

3(ii) In an organic compound, minimum four carbon atoms should be present in order to form branching.

3(iii)



: 7 single bonds.

3(iv) Ethene.

4(i) *P*, *Q* and *R* are classified as hydrocarbons because these compounds are made up of carbon and hydrogen only.

4(ii) *R* is an alkyne.

4(iii) (a)

4(iv) (b)

5. (a)

6. (b) : It has a single branched chain in the carbon chain of pentane.

OR

(a) : The double/triple covalent bonds break to which other atoms attach.

7. (c) : When acetic acid and water are mixed, a clear and homogeneous solution was formed.

8. (a)

OR

(c) : Because most of the carbon compounds are covalent.

9. (b) : A lattice of graphite appears as hexagonal rings, which are arranged in layers.

10. (a) : The common salt is added to soap due to which all the soap precipitates out from the solution.

11. (a)

12. (d) : In test tube *Z*, sodium carbonate reacts with ethanoic acid and liberates CO_2 gas, which can extinguish the burning splinter.

OR

(b) : In both cases homogeneous mixture is formed.

13. (b)

14. (c) : Less reactivity of saturated hydrocarbons is due to presence of single bonds between carbon atoms. Paraffins (alkanes) may have straight chain or branched chain isomers which have different parent names.

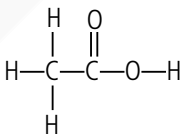
15. (a) Unsaturated compounds contain double or triple bonds between the two C-atoms and show addition reactions.

e.g., $\underset{\text{Ethene}}{CH_2=CH_2} + \underset{\text{Bromine}}{Br_2} \longrightarrow \underset{\text{1, 2 dibromoethane}}{CH_2(Br)-CH_2(Br)}$

While saturated compounds contain carbon-carbon (C–C) and carbon-hydrogen (C–H) single bonds which are quite unreactive and inert so undergo substitution reactions.

e.g., $\underset{\text{Methane}}{CH_4} + Cl_2 \xrightarrow{\text{Sunlight}} \underset{\text{Chloromethane}}{CH_3Cl} + HCl$

(b) The structure of ethanoic acid is



There are 6 single bonds and 1 double bond in it.

OR

(a) – COOH is the functional group in a carboxylic acid.

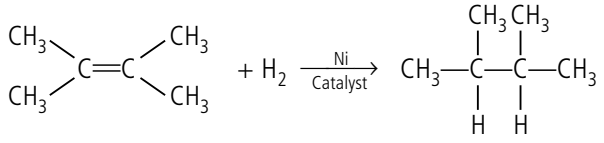
(b) Ethanoic acid is made from fermentation of ethanol with the help of bacteria.

(c) 100% pure ethanoic acid is called glacial acetic acid.

16. (i) $CH_3COOH + NaOH \longrightarrow \underset{\text{Sodium ethanoate}}{CH_3COONa} + H_2O$

(ii) $C_2H_5OH + 2[O] \xrightarrow{KMnO_4} \underset{\text{Ethanoic acid}}{CH_3COOH} + H_2O$

(iii)



2, 3-dimethyl butane

17. (a) Covalent bonds between carbon atoms in each layer and van der Waals' forces between the layers of carbon atoms.

(b) Graphite is soft. The layers of carbon atoms can slide over each other because of the weak van der Waals' forces between them.

(c) Chemically graphite is carbon which combines with oxygen to form carbon dioxide.

18. (a) CH_3COOH is ethanoic acid. It has carboxylic acid ($-\overset{\overset{O}{\|}}{C}-OH$) as a functional group.

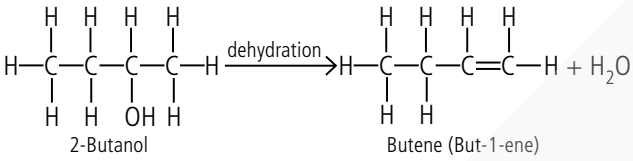
(b) The following tests show the presence of ethanoic acid :

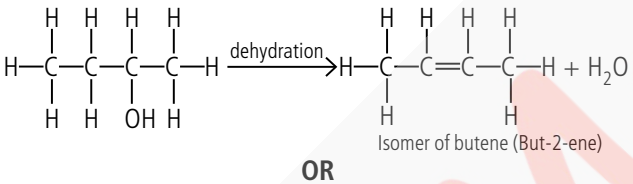
Sodium bicarbonate test – To a small amount of organic compound add a pinch of solid sodium bicarbonate. Evolution of carbon dioxide gas with brisk effervescence shows the presence of ethanoic acid (carboxylic acid).

(c) $CH_3COOH + Na_2CO_3 \longrightarrow \underset{\text{Sodium ethanoate}}{2CH_3COONa} + CO_2\uparrow + H_2O$

The gas evolved can be easily identified by passing it through freshly prepared lime water, if it turns lime water milky then carbon dioxide is present.

19. The two alkenes are but-1-ene and but-2-ene.

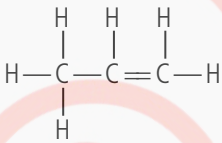


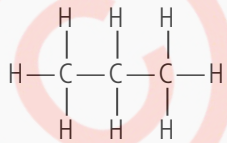


OR

(a) $X + H_2 \longrightarrow \underset{(C_3H_8)}{Y}$

As Y is an alkane, X should be an alkene which on hydrogenation gives alkane.

So, X is C_3H_6 ; 

and Y is C_3H_8 ; 

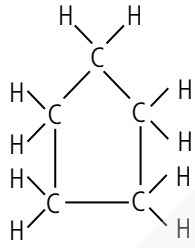
(b) (i) As X is showing substitution, it should be an alkane.

$\underset{(X)}{CH_3-CH_3} + Br_2 \xrightarrow{\text{UV light}} CH_3CH_2Br + HBr$

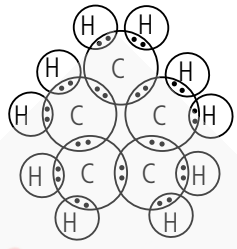
(ii) As Y is showing addition of 1 mole of Br_2, it should be an alkene.

$\underset{(Y)}{CH_2=CH_2} + Br_2 \longrightarrow \underset{Br}{\overset{|}{CH_2}}-\underset{Br}{\overset{|}{CH_2}}$

20. The general formula of cycloalkanes is C_nH_{2n}. On putting $n = 5$ in this general formula, the formula of cyclopentane is obtained *i.e.*, C_5H_{10}. Cyclopentane has 5 carbon atoms in the form of a pentagonal ring which are connected by single bonds. The structural formula and electron-dot structure of cyclopentane are given as :



Structural formula of cyclopentane, C_5H_{10}



Electron-dot structure of cyclopentane, C_5H_{10}

21. (a) Dehydration :

$\underset{\text{Ethanol}}{CH_3CH_2OH} \xrightarrow{\text{Conc. } H_2SO_4,\ 443\ K} \underset{\text{Ethene}}{CH_2=CH_2} + H_2O$

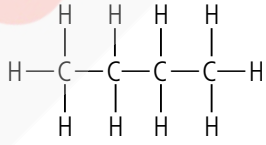
(b) Oxidation :

$\underset{\text{1-Propanol}}{CH_3CH_2CH_2OH} + 2[O] \xrightarrow[\text{(ii) Dil. } H_2SO_4]{\text{(i) Alk. } KMnO_4/KOH,\ \text{Heat}} \underset{\text{Propanoic acid}}{CH_3CH_2COOH} + H_2O$

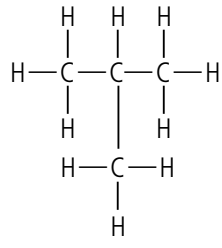
22. Two or more organic compounds having the same molecular formula but different structures, are called structural isomers and the phenomenon is known as structural isomerism.

There is no possible isomers for propane as it contains three carbon atoms and it is not possible to have different arrangements of these carbon atoms.

The structures of possible isomers of butane (C_4H_{10}) are :



n-Butane
(I)



2-Methylpropane
(II)

23. Since, compound Z on combustion forms two moles of CO_2 and three moles of H_2O, therefore, compound Z must contain two carbon atoms and six hydrogen atoms. Thus, compound Z must be C_2H_6 (ethane).

$\underset{\substack{\text{Ethane}\\(Z)}}{C_2H_6} + \underset{\text{Oxygen}}{7/2O_2} \xrightarrow{\text{Heat}} \underset{\text{Carbon dioxide}}{2CO_2} + \underset{\text{Water}}{3H_2O}$

Since, compound (Z) is obtained by addition of 1 mole of H_2 in presence of Ni to compound (Y), therefore (Y) must be ethene.

$\underset{\substack{(Y)\\\text{Ethene}}}{CH_2=CH_2} + H_2 \xrightarrow{\text{Ni, Heat}} \underset{\substack{(Z)\\\text{Ethane}}}{CH_3-CH_3}$

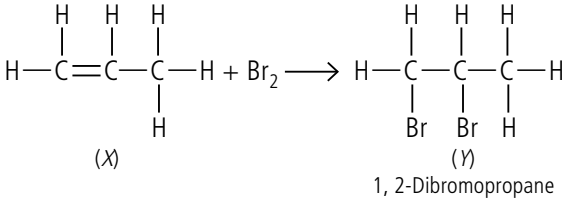
Since, compound (Y) is formed by heating compound (X) with conc. H_2SO_4, therefore, compound (X) must be ethanol.

$$\underset{(X)\ \text{Ethanol}}{CH_3CH_2OH} \xrightarrow[\text{(Dehydration)}]{\text{Conc. } H_2SO_4,\ 443\ K} \underset{(Y)\ \text{Ethene}}{CH_2 = CH_2} + H_2O$$

OR

(a) One mole of X (C_3H_6) react with one mole of Br_2, thus, X contains one double bond.

∴ Structure of X: H—C(H)=C(H)—C(H)(H)—H (Propene)



(*X*) (*Y*)

1, 2-Dibromopropane

(b) 2, 4, 6-Trimethyl-2, 5-heptadiene

24. (i) With Na_2CO_3 :

$$\underset{\text{Ethanoic acid}}{2CH_3COOH} + \underset{\text{Sodium carbonate}}{Na_2CO_3} \longrightarrow \underset{\text{Sodium ethanoate}}{2CH_3COONa} + \underset{\text{Carbon dioxide}}{CO_2} + \underset{\text{Water}}{H_2O}$$

(ii) With sodium hydrogen carbonate :

$$\underset{\text{Ethanoic acid}}{CH_3COOH} + \underset{\text{Sodium bicarbonate}}{NaHCO_3} \longrightarrow \underset{\text{Sodium ethanoate}}{CH_3COONa} + \underset{\text{Carbon dioxide}}{CO_2} + \underset{\text{Water}}{H_2O}$$

(iii) With NaOH :

$$\underset{\text{Ethanoic acid}}{CH_3COOH} + \underset{\text{Sodium hydroxide}}{NaOH} \longrightarrow \underset{\text{Sodium ethanoate}}{CH_3COONa} + \underset{\text{Water}}{H_2O}$$

25. (a) (i) **Combustion of alcohol :** Ethanol is a highly inflammable liquid. It catches fire easily and starts burning. Ethanol burns readily in air to form carbon dioxide and water vapour with the evolution of heat and light.

$$\underset{\text{Ethanol}}{C_2H_5OH} + \underset{\text{Oxygen}}{3O_2} \xrightarrow{\text{Combustion}} \underset{\text{Carbon dioxide}}{2CO_2} + \underset{\text{Water vapour}}{3H_2O} + \text{Heat} + \text{Light}$$

(ii) **Dehydration of alcohol :** When ethanol is heated with excess of concentrated sulphuric acid at 170°C (443 K), it gets dehydrated to form ethene. In this reaction, concentrated sulphuric acid acts as a dehydrating agent (which removes water molecule form ethanol molecule).

$$\underset{\text{Ethanol}}{CH_3CH_2OH} \xrightarrow[\text{(Dehydration)}]{\text{Conc. } H_2SO_4,\ 170°C} \underset{\text{Ethene}}{CH_2 = CH_2} + H_2O$$

(b) Ethanol which has been made unfit for drinking purposes by adding poisonous substances like methanol, pyridine, copper sulphate, etc., is called denatured alcohol.

To supply cheaper alcohol to industries and to refrain from drinking, alcohol is denatured by adding poisonous substances.

26. (a) Palmitic acid ($C_{15}H_{31}COOH$), stearic acid ($C_{17}H_{35}COOH$) and oleic acid ($C_{17}H_{33}COOH$).

(b) The Ca^{2+} and Mg^{2+} ions present in hard water react with soap to form dirty white precipitate. This white precipitate is called scum.

$$\underset{\substack{\text{Sodium stearate}\\\text{(Soap)}}}{2C_{17}H_{35}COONa} + \underset{\substack{\text{Calcium ion}\\\text{(from hard water)}}}{Ca^{2+}} \longrightarrow \underset{\substack{\text{Calcium stearate}\\\text{(Scum)}}}{(C_{17}H_{35}COO)_2Ca} + 2Na^+$$

$$\underset{\text{Sodium stearate}}{2C_{17}H_{35}COONa} + \underset{\substack{\text{Magnesium ion}\\\text{(from hard water)}}}{Mg^{2+}} \longrightarrow \underset{\substack{\text{Magnesium stearate}\\\text{(Scum)}}}{(C_{17}H_{35}COO)_2Mg} + 2Na^+$$

(c) (i) $\underbrace{CH_3(CH_2)_{15}CH_2}_{\text{Hydrophobic part}}\underbrace{—C(=O)—O^-Na^+}_{\text{Hydrophilic part}}$

(ii) $\underbrace{CH_3(CH_2)_{14}CH_2}_{\text{Hydrophobic part}}\underbrace{—N^+(CH_3)_3Br^-}_{\text{Hydrophilic part}}$

OR

(a) Carbon dioxide, $:\underline{O} = C = \underline{O}:$

(b) Methane, H—C(H)(H)—H

(c) Ammonium chloride, $\left[H—\underset{H}{\overset{H}{N}}—H\right]^+ Cl^-$

(d) $\underset{\text{Ethanol}}{CH_3CH_2—OH}$ or $\underset{\text{Ethanoic acid}}{CH_3COOH}$

Unsaturated compounds burn with a sooty flame. For example, ethene, ethyne, etc.

27. (a) **Homologous series :** A family of organic compounds having the same functional group, similar chemical properties and the successive members of which differ by a CH_2 group or 14 mass units.

Characteristics :

(i) All the members of homologous series have similar chemical properties.

(ii) Any two consecutive members differ in their molecular formula by a $–CH_2$ group.

(b) Water containing calcium hydrogen carbonate is hard water. Detergents are preferred over soaps for cleaning clothes in hard water because calcium salts of detergents are soluble in water while calcium salts of soaps are insoluble. Therefore, if washing is done with soap, lot of soap will be wasted.

(c) Soaps cannot be used in acidic medium for washing purposes because in acidic medium soaps are converted into free fatty acids which are insoluble in water. As a result, they stick to the surface of the fabric and the cleaning ability of soaps is blocked. However, detergents can be used in acidic medium. The reason being that in acidic medium, detergents are converted into free sulphonic acids which are also soluble

in water. As a result, the cleaning ability of detergents is not blocked.

28. Detergents are generally ammonium or sulphonate salts of long chain carboxylic acids. *e.g.*, sodium *n*-dodecyl benzene sulphonate which has cleaning property in water.

Merits of using detergents :

(i) Detergents are very strong cleansing agents.

(ii) They can form lather well even in hard water as they do not form insoluble calcium or magnesium salts.

Demerits of using detergents :

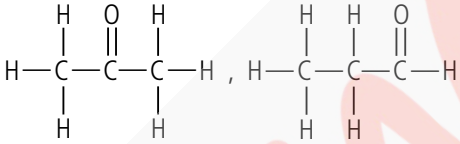
(i) As detergents are ammonium or sulphonate salts of long chain carboxylic acids which are very bulky molecules, are not easily degraded by bacteria and hence, they are non-biodegradable and cause water pollution.

(ii) They are highly basic in nature and cause damage to skin. Synthetic detergents can be used even in hard water because they do not react with Ca^{2+} and Mg^{2+} ions present in hard water. They do not form curdy white precipitates (scum) of calcium and magnesium salts of fatty acids.

OR

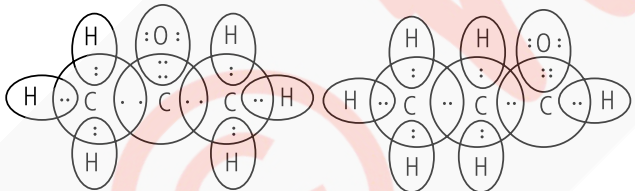
(a) Isomers are those compounds which have the same molecular formula but different structural formula *i.e.*, show different properties.

(b) Two possible isomers of the compound, C_3H_6O are :



Propanone Propanal

(c) The electron dot structures of propanone and propanal are :



Propanone Propanal

29. A hydrocarbon in which the carbon atoms are joined by a double bond or a triple bond is called an unsaturated hydrocarbon. Ethene being an unsaturated hydrocarbon undergoes addition reactions. On the basis of addition reactions, the following two tests can be used to distinguish ethene from ethane.

(i) **Baeyer's test or $KMnO_4$ test :** When ethene is passed through cold aqueous alkaline $KMnO_4$ solution, the purple colour of $KMnO_4$ is discharged and a brown precipitate of manganese dioxide (MnO_2) is formed.

$$2KMnO_4 + 3\underset{\text{Ethene}}{CH_2{=}CH_2} + 4H_2O \xrightarrow{\text{Cold}} 2KOH + \underset{\text{Ethylene glycol}}{3HOCH_2{-}CH_2OH} + \underset{\text{Brown ppt.}}{2MnO_2}$$

(ii) **Br_2-CCl_4 test :** When ethene is passed through a solution of Br_2 in CCl_4, the orange colour of Br_2 is discharged.

$$\underset{\substack{\text{Bromine}\\\text{(Orange)}}}{Br_2} + \underset{\text{Ethene}}{CH_2{=}CH_2} \xrightarrow{CCl_4} \underset{\substack{\text{1, 2-Dibromoethane}\\\text{(Colourless)}}}{BrCH_2{-}CH_2Br}$$

30. (a) **Hydrogenation reaction :** The addition of hydrogen to unsaturated hydrocarbon to obtain a saturated hydrocarbon is called hydrogenation. For example,

$$\underset{\text{Ethene}}{CH_2{=}CH_2} + H_2 \xrightarrow{\text{Nickel, 473 K}} \underset{\text{Ethane}}{CH_3{-}CH_3}$$

(b) **Oxidation reaction :** Addition of oxygen to any substance is called oxidation and the substances which are capable of adding oxygen to other substances are called oxidising agent.

$$CH_3CH_2OH + \underset{\substack{\text{From}\\\text{oxidising}\\\text{agent}}}{2[O]} \xrightarrow{KMnO_4/KOH,\ \text{Heat}} CH_3{-}\overset{\overset{O}{\|}}{C}{-}OH + H_2O$$

(c) **Substitution reaction :** Reactions which involve the direct replacement (displacement or substitution) of an atom or a group of atoms in an organic molecule by another atom or group of atoms without any change in the rest of the molecule are called substitution reactions.

$$\underset{\text{Methane}}{CH_4} + \underset{\text{Chlorine}}{Cl_2} \xrightarrow{\text{Sunlight}} \underset{\substack{\text{Chloromethane}\\\text{(Substitution}\\\text{product)}}}{CH_3Cl} + \underset{\substack{\text{Hydrogen}\\\text{chloride}}}{HCl}$$

(d) **Saponification reaction :** When hydrolysis of an ester is carried out with a base such as sodium hydroxide, sodium salt of the original acid and the original alcohol are formed. Since sodium salts of higher fatty acids are called soaps, therefore, alkaline hydrolysis of an ester to give the salt of the corresponding carboxylic acid and the alcohol is called saponification. It is reverse of esterification.

$$\underset{\text{Ethyl ethanoate}}{CH_3{-}\overset{\overset{O}{\|}}{C}{-}OCH_2CH_3} + \underset{\substack{\text{Sodium}\\\text{hydroxide}}}{NaOH} \xrightarrow{\text{Heat}} \underset{\text{Sodium ethanoate}}{CH_3{-}\overset{\overset{O}{\|}}{C}{-}ONa} + \underset{\text{Ethanol}}{CH_3CH_2OH}$$

(e) **Combustion reaction :** Combustion means heating a substance strongly in presence of excess of oxygen or air. During combustion, all the allotropic forms of carbon (diamond, graphite, fullerene, coal, etc.) are oxidised to form carbon dioxide and water with release of a large amount of heat and light.

$$\underset{\text{Methane}}{CH_4} + \underset{\text{Oxygen}}{2O_2} \longrightarrow \underset{\text{Carbon dioxide}}{CO_2} + \underset{\text{Water}}{H_2O} + \text{heat} + \text{light}$$

OR

Since, compound *A*, on oxidation with alkaline potassium permanganate gives ethanoic acid (acetic acid) which turns blue litmus red, therefore, compound *A* is ethanol and *B* is ethanoic acid.

$$\underset{\substack{(A)\\ \text{Ethanol}}}{CH_3CH_2OH} + 2[O] \xrightarrow[\text{or } K_2Cr_2O_7 / H_2SO_4, \text{ Heat}]{KMnO_4 / KOH, \text{ Heat}} \underset{\substack{(B)\\ \text{Ethanoic acid}}}{CH_3COOH} + H_2O$$

Ethanol is a constituent of wine and beer and is also used as a fuel.

Since, *B* is an acid which on heating with *A* in presence of a few drops of conc. H_2SO_4 gives a sweet smelling compound *C*, therefore, *C* must be an ester.

$$\underset{\substack{(A)\\ \text{Ethanol}}}{CH_3CH_2OH} + \underset{\substack{(B)\\ \text{Ethanoic acid}}}{CH_3COOH} \xrightarrow[\text{Warm}]{\text{Conc. } H_2SO_4} \underset{\substack{(C)\\ \text{Ethyl ethanoate}}}{CH_3COOCH_2CH_3} + \underset{\text{Water}}{H_2O}$$

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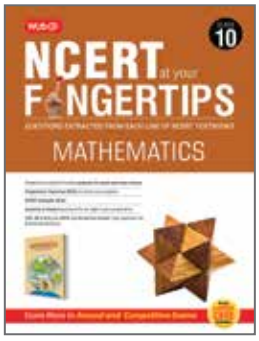

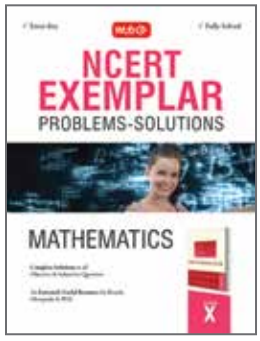

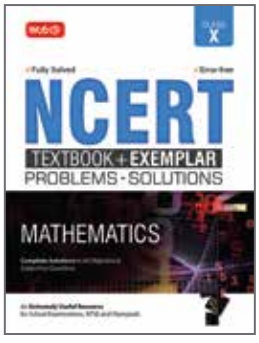

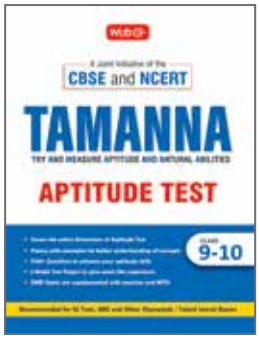

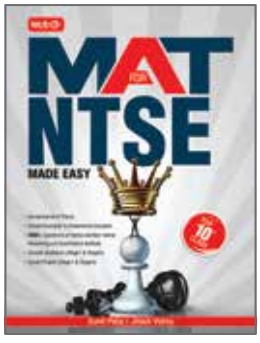

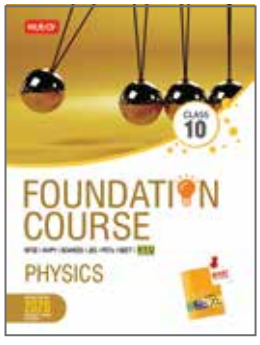

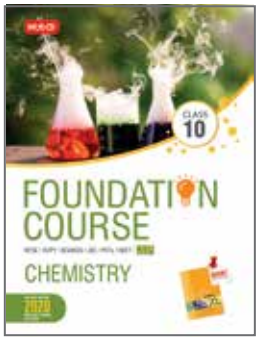

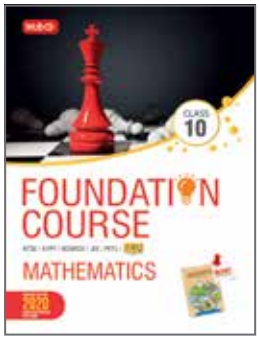

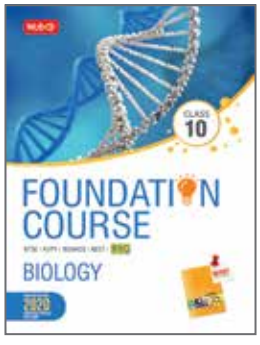

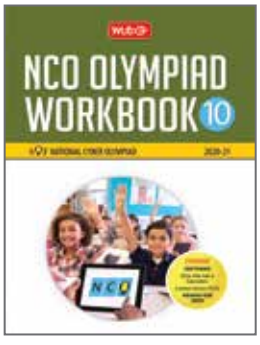

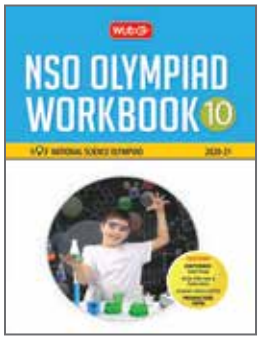

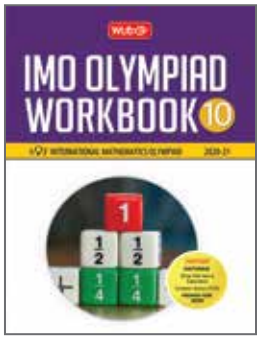

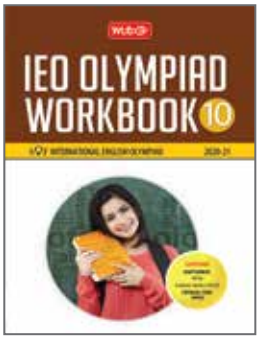

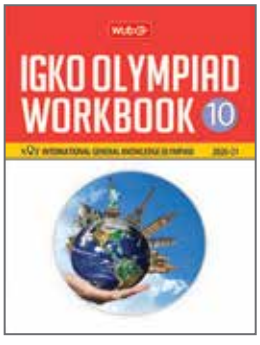

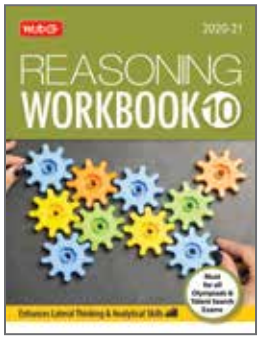

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