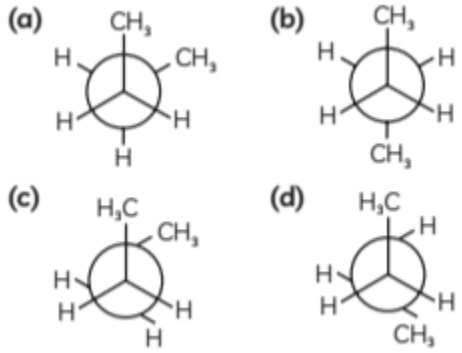
Hydrocarbons

Case Study Based Questions

Read the following passages and answer the questions that follow:

1. Conformational isomerism is a type of stereoisomerism in chemistry in which isomers can be interconverted simply by rotating them around formally single bonds. While any two atomic configurations in a molecule that differ by rotation about single bonds are called distinct conformations, conformations that correspond to local minima on the potential energy surface are called conformational isomers or conformers. When hydrogen atoms are connected to two carbon regions as close to one other as possible, the conformation is called eclipsed. To further explain, the closest proximity of two substituents X and Y on adjacent atoms A and B indicates that the torsion angle X-A-B - Y is 0° Another type of conformation is called a staggered conformation, which occurs when hydrogen atoms connected to two carbons are spaced as far apart as feasible. These conformations can be found in any open chain single chemical bond connecting two sp3 hybridized atoms and have low conformational energy. For some compounds, such as n-butane, there are specialised kinds of staggered conformations called gauche and anti.

(A) In the following, the most stable conformation of n-butane is:



(B) With respect to conformers of ethane, which of the following is true?

(a) Bond length remains the same but the bond angle changes.

(b) Both length and bond angle changes.

(c) Bond angle and bond length remains the same.

(d) Bond angle remains the same and the bond length changes.

(C) Increasing order of stability of the three conformers of ethane is:

(a) eclipsed > gauche > staggered

(b) eclipsed < gauche < staggered

(c) gauche > staggered > eclipsed

(d) eclipsed > staggered > gauche

(D) Increasing order of stability of the three conformers of ethylene glycol is:

(a) eclipsed > gauche > staggered

(b) eclipsed < gauche < staggered

(c) gauche > staggered > eclipsed

(d) eclipsed < staggered > gauche

(E) The magnitude of torsional strain depends upon the:

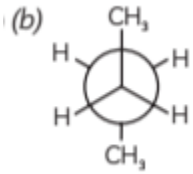
(a) dihedral angle

(b) staggered conformer

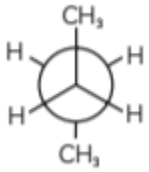
(c) eclipsed conformer

(d) none of the above

Ans. (A)



Explanation: The anti-conformation is the most stable conformer of n-butane. The bulky methyl groups are spaced as widely apart as possible, reducing steric repulsions to a minimum and hence, increasing the stability.



(B) (c) Bond angle and bond length remains the same.

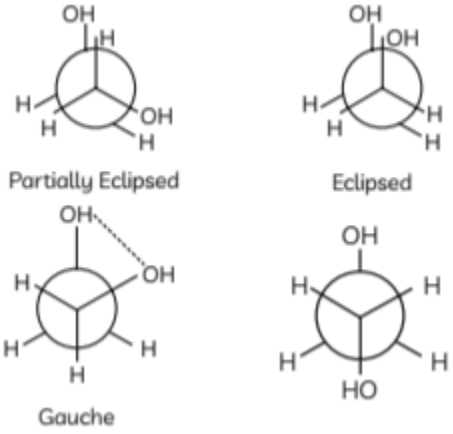
Explanation: Conformers are isomers that exist as a result of rotation around single bonds without any bond cleavage. An infinite number of conformations are possible in ethane. The two important forms are the staggered conformation, which is the most stable, and the eclipsed conformation of ethane that have the same bond angle and bond length but have different energy, stability, and dihedral angles.

(C) (b) eclipsed < gauche < staggered

Explanation: The eclipsed conformer is the least stable because the hydrogen and bonding electron pairs on adjacent carbon are close to one another. This causes maximum repulsion and hence the least stability of the conformer. In staggered form, because the hydrogen and bonding electron pairs on adjacent carbon are far apart at anti-position to one another. Thus, gaining the minimum repulsion and maximum stability. The gauche form lies
in between these two conformers. So, the order of stability is: eclipsed < gauche < staggered.

(D) (c) gauche > staggered > eclipsed

Explanation: In ethylene glycol, the gauche conformer is most stable due to the presence of H-bonding between the -OH groups of two carbons.



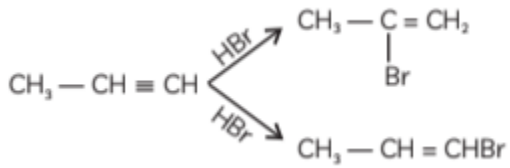
(E) (a) dihedral angle

Explanation: The magnitude of torsional strain depends upon the angle of rotation about C-C bond. This angle is known as dihedral angle or torsional angle.

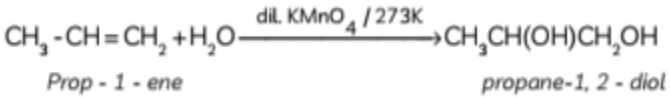
2. Alkenes are made up of a lot of weakly held pi bonds. They display additional reactions due to the presence of such bonds. Electrophiles (Electron-seeking species) are added to the double-bonded molecules in this reaction, resulting in the production of a new product. It also has the ability to undertake free radical substitution reactions under certain conditions. Ozonolysis and oxidation reactions are also vividly displayed. HX (HBr, HBr, HI) and alkenes undergo two types of addition reactions: Markovnikov and Anti-Markovnikov. The Markovnikov reaction occurs when HX is added to an alkene or alkyne, with H-bonding to the double bond's less substituted carbon atom and X bonding to the other double- bonded carbon atom via an ionic mechanism. When HBr (not HCL, HI) is

introduced to an alkene or alkyne, Br attaches to the less substituted double-bonded carbon, whereas H links to the other carbon atom, resulting in the anti-Markovnikov reaction. This is where the Markovnikov and Anti-Markovnikov.

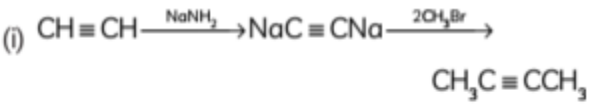
(A) What would be the major product in the given figure, if the following reaction obeys Markovnikov rule?

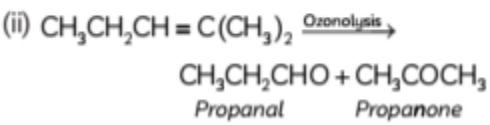


(B) Prop-1-ene can be converted into propane-1,2-diol by the reaction with dilute potassium permanganate.



(C)

(i) 

(ii) 

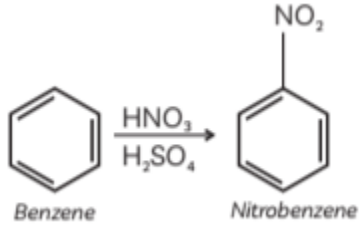
3. The molecular formula of benzene is determined by elemental analysis. As a result, benzene is a highly unsaturated compound. It took several years to assign its structure due to its unique properties and unusual stability. Benzene was discovered to be a stable molecule that forms a triozonide, indicating the presence of three double bonds. A compound 'A' contains a meta-directing group. This compound is produced when benzene is heated with a mixture of concentrated nitric acid and concentrated sulphuric acid.

(A) Identify the compound 'A'.

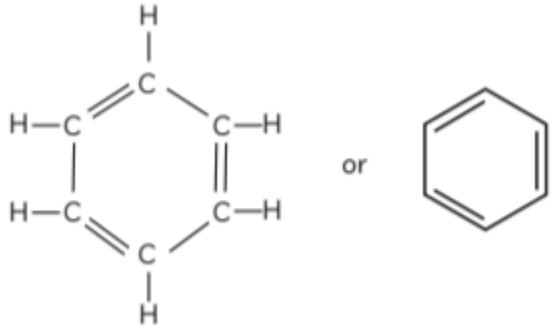
(B) What are meta-directing groups?

(C) Comment on the structure of benzene.

Ans. (A) Compound 'A' is nitrobenzene



(B) Meta directors are also referred to as deactivators. Meta directors are substituents in an electrophilic aromatic substitution that aids in the electrophilic attack of the Meta substituent. For example- nitro groups, sulphonic groups, and carbonyl compounds.
(C) The molecular formula of benzene is C6H6 as determined by elemental analysis. As a result, benzene is a highly unsaturated compound. Benzene was discovered to be a stable molecule that forms a triozonide, indicating the presence of three double bonds. Benzene was also discovered to produce only one monosubstituted derivative, indicating that all six carbon and six hydrogen atoms in benzene are identical.



4. Benzene has six electrons which are delocalised and can freely move around the six carbon nuclei. The nuclei of the carbon atoms attract the delocalised electron cloud more strongly than the electron cloud localised between two carbon atoms. As a result, the appearance of delocalised electrons in benzene increases its stability.
According to X-ray diffraction data, benzene is a planar molecule. According to the data, all six (C-C) bond lengths are of the same order (139 pm), which is intermediate between (C-C) single bond (154 pm) and C = C double bond (133 pm). This behaviour can be explained on the basis of delocalisation of p-electrons.

(A) Benzene ha..... electrons...

(a) 0
(b) 6
(c) 3
(a) 1

(B) What is the hybridisation of carbon atoms in the benzene ring?

(a) sp3

(b) sp2

(c) sp

(d) dsp3

(C) Which of the following compounds is formed when benzene reacts with hydrogen gas in presence of Nickel?

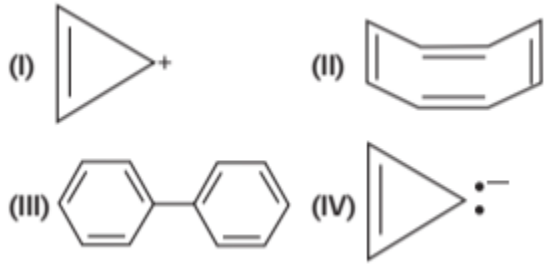
(a) Hexyne

(b) Hexene

(c) Cyclohexane

(d) Cyclopentane

(D) Four structures are given in options (i) to (iv). The correct option which represents the aromatic structures is



Options:

(a) (1) and (11)

(b) (1) and (III)

(c) (II) and (III)

(d) (II) and (IV)

(E) Benzene reacts with anhydrous aluminium chloride in the dark and cold atmosphere to form.....

(a) chlorobenzene

(b) toluene

(c) hexachlorobenzene

(d) acetylene

Ans. (A) (b) 6

Explanation: Benzene has 6 pi electrons. Six pi electrons in benzene are delocalized in six p-orbitals that overlap across each plane of the ring. Because of the loosely held pi

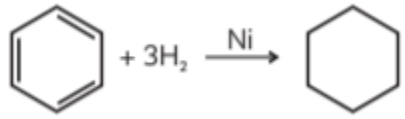
electrons, the benzene ring becomes electron-rich, allowing it to react with electrophiles. Because benzene adheres to Huckel's rule, it is exceptionally stable. As a result, reactions that preserve the aromatic ring are preferred.

(B) (b) sp2

Explanation: Carbon atoms in the benzene ring have a trigonal planar geometry around them, and thus the hybridization is sp^2.

(C) (c) Cyclohexane

Explanation: Hydrogenation of benzene produces cyclohexane under vigorous conditions, i.e., at high temperature and pressure in the presence of a nickel catalyst.



(D) (b) (1) and (III)

Explanation: For a compound to be aromatic it should follow Huckel Rule. That is

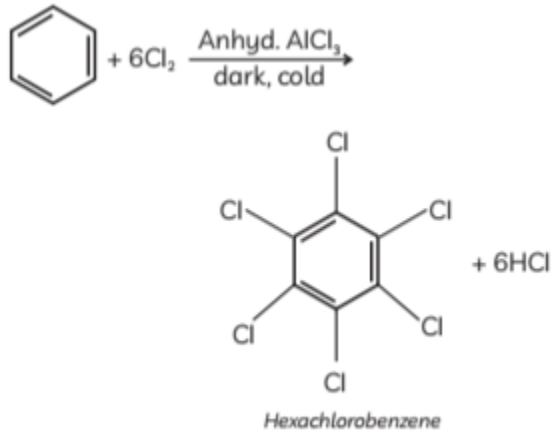
(1) It should have (4n+2) π electrons.

(2) It should be planar.

(3) л-electronrs must be delocalised. These conditions are fulfilled by (1) and (III) only hence these two are aromatic.

(E) (c) hexachlorobenzene

Explanation: If an excessive amount of electrophilic reagent is used, a further substitution reaction may occur in which other hydrogen atoms of the benzene rings are successively replaced by the electrophile.



Hexachlorobenzene