

Hyperconjugation Chemistry Questions with Solutions

Q1: Hyperconjugation involves the delocalisation of _____

- a) σ bond orbital
- b) π bond orbital
- c) Both σ and π bond orbital
- d) None of the mentioned

Answer: a) σ bond orbital

Explanation: The delocalisation of the σ -bond orbital is involved in hyperconjugation. It is the stabilising interaction that occurs when electrons in a σ -bond (typically C-H or C-C) engage with a nearby vacant or partially full p-orbital or a π -orbital to produce an extended molecular orbital that increases the system's stability.

Q2: Larger the number of hyperconjugation structures, the stability of free radicals will _____

- a) Decrease
- b) Increase
- c) Remains same
- d) None of the mentioned

Answer: b) Increase

Explanation: Free radical stability will increase as the number of hyperconjugation structures increases.

Q3: On increasing the number of α -hydrogens, the number of hyperconjugation structures will _____.

- a) Increase
- b) Decrease
- c) Remains same
- d) None of the mentioned

Answer: a) Increase

Explanation: As the number of α -hydrogens increases, so does the number of hyperconjugation structures. The quantity of α -hydrogens has a direct relationship with hyperconjugation. The hydrogen atom linked to a functional group's carbon is referred to as α -hydrogen.

Q4: The compound that can be most readily sulphonated is _____

- a) Benzene
- b) Nitrobenzene
- c) Toluene

d) Chlorobenzene

Answer: c) Toluene

Explanation: Toluene is the compound that can be sulphonated the most easily. Toluene is a colourless, water-insoluble liquid with the scent of paint thinners. It comprises a methyl group with a benzene ring.

Q5: When the contributing structure contains the same number of two-electron bonds as the normal lewis formula, it will be _____.

- a) Heterovalent hyperconjugation
- b) Sacrificial hyperconjugation
- c) Isovalent hyperconjugation
- d) All of the mentioned

Answer: c) Isovalent hyperconjugation

Explanation: Isovalent hyperconjugation occurs when the contributing structure has the same number of two-electron bonds as the usual Lewis formula.

Q6: Ethene is devoid of any alpha hydrogen so hyperconjugation is not possible.

- a) True
- b) False

Answer: a) True

Explanation: Because ethene lacks alpha hydrogen, hyperconjugation is forbidden because the presence of alpha hydrogen is required for hyperconjugation.

Q7: Why is Resonance more stable than Hyperconjugation?

Answer:

Both hyperconjugation and resonance allow a molecule to stabilise by delocalising electrons; however, hyperconjugation needs delocalisation of sigma bond electrons as well as pi bond electrons, whereas resonance only produces sigma bond electron delocalisation.

Resonance facilitates delocalisation, which lowers a molecule's total energy as the electrons occupy a larger volume, making resonance molecules more stable than those that do not. These are referred to as stabilised resonance compounds.

Hyperconjugation is a stabilising process that occurs when electrons in a σ -bond (typically C-H or C-C) engage with a p-orbital or a π -orbital neighbouring unoccupied or partially filled to produce an extended molecular orbital that enhances system stability.

Q8: Write a brief note on hyperconjugation with example of propene.

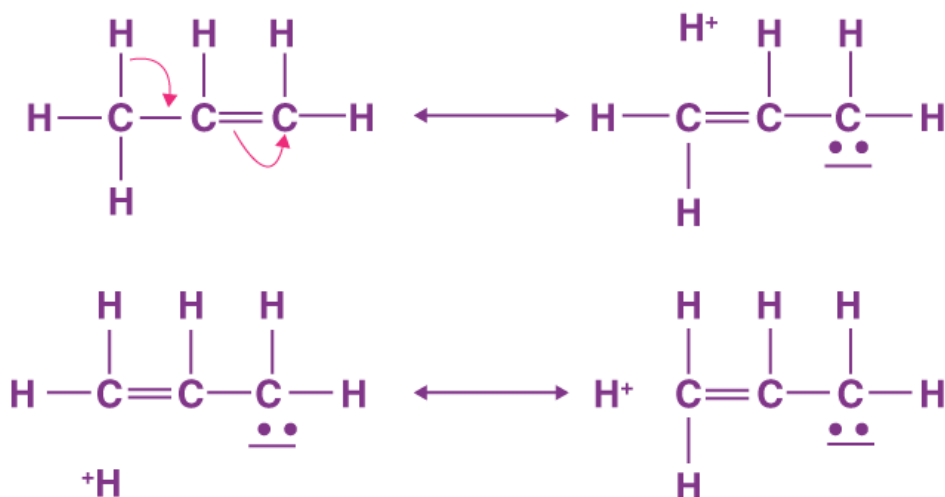
Answer:

The interaction of electrons in a σ -bond with a nearby vacant or partially filled non-bonding p-orbital, antibonding σ or π orbital, or filled π -orbital to generate an extended molecular orbital that boosts the system's stability is known as hyper-conjugation.

Hyper conjugation occurs in propene because the sp^3 sigma bond orbital and the vacant p-orbital of an adjacent c-atom partially overlap.

One of the $-CH_3$ group's C-atom C-H bonds can be found in the plane of the pi-bond orbital, resulting in partial overlapping.

Propene's hyperconjugation structures are shown below:



It's also worth noting that Hyperconjugation is also known as no-bond resonance. Although resonance requires electron delocalisation, it is the electrons that are delocalised in hyper conjugation.

Q9: Explain Electromeric effect.

Answer:

The electromeric effect is a transient effect that occurs when an attacking reagent comes into contact with a multi-bonded organic molecule (a double or triple bond). On the demand of an attacking reagent,

a shared pair of π -electrons is completely transferred to one of the atoms connected by numerous bonds in this effect. When the attacking reagent is withdrawn from the reaction's domain, the effect disappears.

There are two types of electromeric effects.

1. Positive Electromeric Effect (+E effect):

The transfer of π -electrons from many bonds to the atom with which the reagent is bonded is known as the positive electromeric effect.



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2. Negative Electromeric Effect (-E effect):

The transfer of π -electrons from multiple bonds to the atom with which the reagent does not attach is known as the negative electromeric effect.



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Q10: Why Ethers do not show the Hyperconjugation effect?

Answer:

Compounds with hydrogen linked to the neighbouring carbon of the sp^2 carbon do not show hyperconjugation. Those species with the most H will have the most hyperconjugation.

Q11: Mention the applications of Hyperconjugation.

Answer:

- Alkene stability: hyperconjugation explains why some alkenes are more stable than others.

- The number of alpha hydrogens in an alkene is directly proportional to the number of resonant structures and vice versa.
- The number of resonant structures and the number of alpha hydrogens are directly proportional to the stability of alkyl carbocations.
- The size of the carbon-carbon double bond in an alkene increases as the number of resonant structures increases.
- CH_3 is +R group, ortho-para directing group used for electrophilic aromatic substitution due to hyperconjugation.
- Hyperconjugation can be used to explain the stability of free radicals.

Q12: What is Reverse hyperconjugation?

Answer:

A system in which an electron interaction is directed from the pi bond to the sigma bond rather than from sigma to pi bond is known as reverse hyperconjugation or negative hyperconjugation. In other words, electrons shift from the pi bond to the sigma bond.

Q13: In which species Hyperconjugation effect is possible?

Answer:

Carbocations, free radicals, and alkenes can all undergo hyperconjugation. Nathan and Baker were the first to observe this phenomenon in 1935.

Q14: Hyperconjugation involves the delocalisation of what species?

Answer:

The delocalisation of carbon-hydrogen bond electrons in an alkyl group directly connected to an unsaturated molecule or an atom with an unshared P orbital is known as hyperconjugation. The electrons in the alkyl group's carbon-hydrogen bond partially conjugate with the connected unsaturated molecule.

Q15: What is the difference between Isovalent and Sacrificial Hyperconjugation?

Answer:

The interaction of σ -bonds with a pi network is known as hyperconjugation. We can explore two major types of hyperconjugation: isovalent and sacrificial hyperconjugation.

Isovalent and sacrificial hyperconjugation vary in that isovalent hyperconjugation happens in free radicals and carbocations where the canonical form has no charge separation but the primary form has.

In the meantime, sacrificial hyperconjugation refers to a condition in which the canonical form has no bond resonance but the primary form has no charge distribution.

Practise Questions on Hyperconjugation

Q1: Number of hyperconjugation structures in isopropyl radical is _____

- a) 3
- b) 6
- c) 9
- d) 12

Answer: b) 6

Explanation: In the isopropyl radical, there are six hyperconjugation structures. C_3H_7 is the chemical formula for isopropyl.

Q2: Which of the following is a consequence of the Baker-Nathan effect?

- a) It is helpful in explaining the directive influence of alkyl groups in aromatic alkyl benzene
- b) It is helpful in explaining the relative stability of alkenes
- c) It is helpful in explaining the relative stabilities of alkyl carbocations
- d) All of the mentioned

Answer: d) All of the mentioned

Explanation: In aromatic alkyl benzene, the Baker-Nathan effect is useful in explaining the directive influence of alkyl groups. It's helpful in explaining alkene relative stability and alkyl carbocation relative stability.

Q3: Explain hyperconjugation effect. How does hyperconjugation effect explain the stability of alkenes?

Answer:

The amount of no-bond resonance structures that can be built for distinct classes of carbonium ions may explain their relative stability. The bonding electrons from a nearby C-H bond are shifted to the electron-deficient carbon to produce such structures. The positive charge that was originally on carbon is dispersed to hydrogen in this method.

Hyperconjugation or No-Bond Resonance is the process of releasing electrons by assuming no-bond character in the nearby C-H bond. The more hyperconjugation there is, the more stable the molecule will be.

Q4: Is hyperconjugation possible in a triple bond?

Answer:

Hyperconjugation does not usually happen with alkynes, although it can. Only if there are other multiple bonds conjugated to the triple bond. But-1-en-3-yne, for example, is conjugated, whereas 1-butyne is not.

Q5: What is the Conjugation effect?

Answer:

The conjugation effect occurs when molecular orbitals are conjugated to new, more delocalised and lower-energy molecular orbitals. In this new extended system, electrons are free to move around.

