

## Carbocation Stability Chemistry Questions with Solutions

**Q-1:** What is the hybridisation of carbon(carrying positive charge) in a vinylic carbocation?

- a) sp
- b)  $sp^2$
- c)  $sp^3$
- d) No hybridization

**Answer: b) sp**

Explanation:

In a vinylic carbocation, positive charge is on the olefinic carbon atom.

Steric number helps in determining the hybridisation of an atom in a molecule.

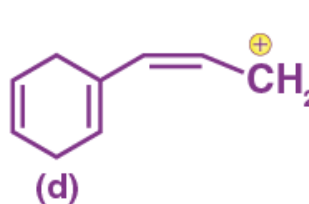
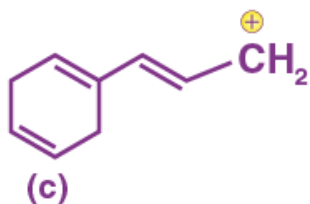
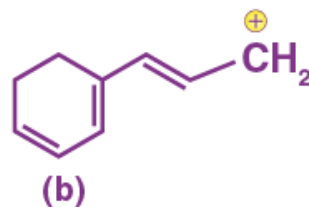
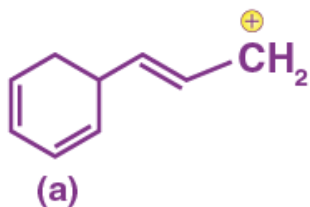
Steric number(SN) = Number of lone pairs on central atom + number of sigma bonds formed by the central atom

The central atom carbon(carrying positive charge) of a vinylic carbocation has a zero lone pair and will make 2 sigma bonds.

As a result,  $SN = 0 + 2 = 2$

According to VSEPR theory, a steric number equal to two corresponds to  $sp$  hybridization.

**Q-2:** Identify the most stable carbocation from the following:



**Answer: b)**

Explanation: The stability of carbocations increases as the number of resonances increases. The greater the number of resonating structures, the more stable the carbocation. This is due to the delocalization of the positive charge. Because of the delocalization, the electron deficiency is reduced, which increases stability.

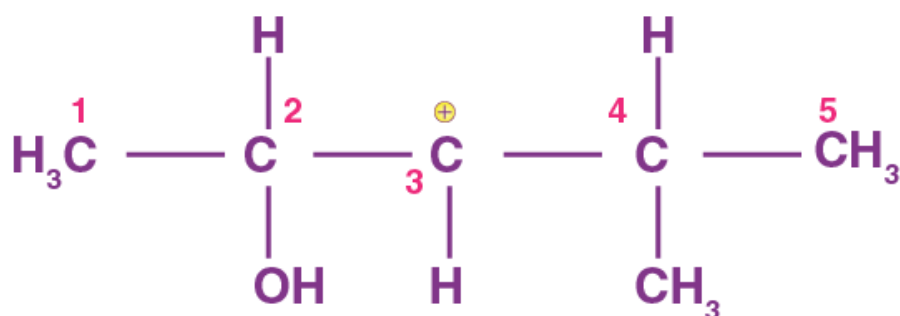
In a) there is no resonance.

In b) maximum resonance is present.

In c) and d) resonance is there but it is less than b).

Therefore, b) is the most stable carbocation.

**Q-3:** In the following cation, \_\_\_\_\_ migrates to a positively charged carbon atom.

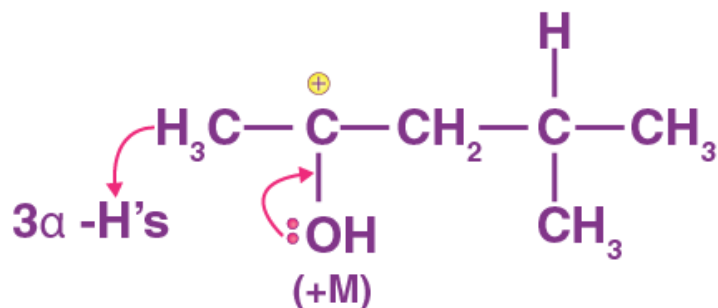


a)  $\text{CH}_3$  at C-4

- b) H at C-2
- c) CH<sub>3</sub> at C-2
- d) H at C-4

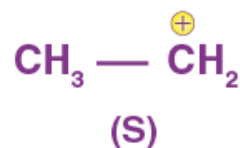
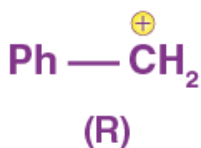
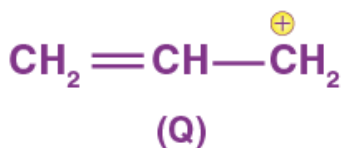
**Answer:** H at C-2

Explanation: Migration of H at C-2 results in the carbocation that is stabilised by +M effect (back bonding) as shown:



Note: Any carbocation which is stable due to the +M effect is the most stable.

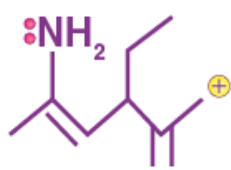
**Q-4:** Which of the following is an allylic carbocation?



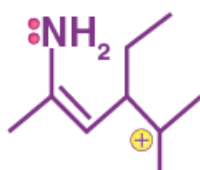
**Answer:** Q

Explanation: The presence of a carbon-carbon double bond next to a positively charged carbon is referred to as an allylic carbocation.

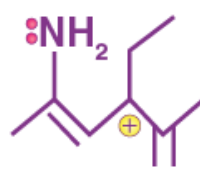
**Q-5:** Which of the following cations is the most stable?



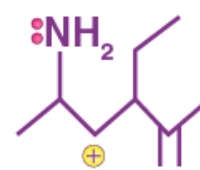
(a)



(b)



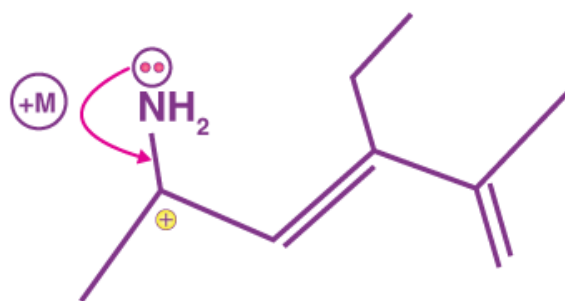
(c)



(d)

**Answer: c)**

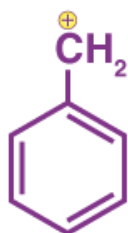
Explanation: In c), after resonance, the positive charge is stabilised by +M effect as shown, making it the most stable carbocation.



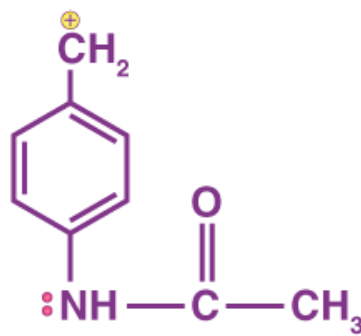
**Q-6:** The decreasing order of stability of following cation is



(P)



(Q)



(R)



(S)

- a) P>R>Q>S
- b) Q>R>S>P
- c) R>S>Q>P
- d) P>R>S>Q

**Answer: a) P>R>Q>S**

Explanation: Substituents that are capable of donating electrons to the benzene ring will stabilise the carbocation and are called electron donating groups. -OH, -NHCOCH<sub>3</sub>, OCH<sub>3</sub> are some of the such groups.

On the other hand, the substituents that withdraw electrons from the benzene ring will destabilise the carbocation and are called electron withdrawing groups. For example: NO<sub>2</sub>, CHO etc.

We can conclude that P and R will be more stable, while S will be the least stable. P is the more stable of the two. In R, the lone pair of electrons on N will cross conjugate with the adjacent -CO group, donating fewer electrons to benzene than -OH.

This makes the correct order as: P>R>Q>S

**Q-7:** What are the various factors that affect the stability of a carbocation?

**Answer:** The various factors that affect the stability of carbocation are:

- a) Aromaticity: Any positive charge which is the part of aromaticity is the most stable. For example: Tropylium cation
- b) + M effect: More electron donating groups present more is the stability. -OH, NH<sub>2</sub>, -NHCOCH<sub>3</sub> are some examples.
- c) Resonance
- d) Hyperconjugation: More alpha-hydrogens, more is the stability of the carbocation.
- e) Inductive effect: More the length of the carbon chain of a carbocation, more is the stability.

Note: Always check the stability of the carbocation in the order given above.

**Q-8:** How electronegativity affects the stability of the carbocation?

**Answer:** Electronegativity describes an atom's ability to attract electrons. The greater the electronegativity, the stronger the attraction of electrons to the atom. As a result, the electronegativity of carbon with a positive charge has a direct effect on the stability of the carbocation. As the

electronegativity of the positive charge carrying carbon atom increases, the stability of the carbocation decreases.

EN order:  $sp_c > sp^2_c > sp^3_c$

The order of the stability of carbocation will be just the reverse of it.

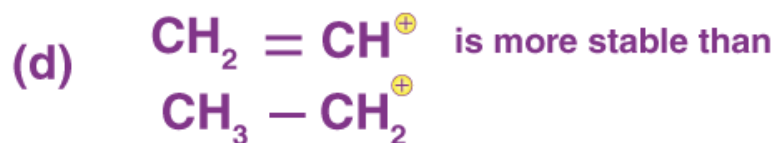
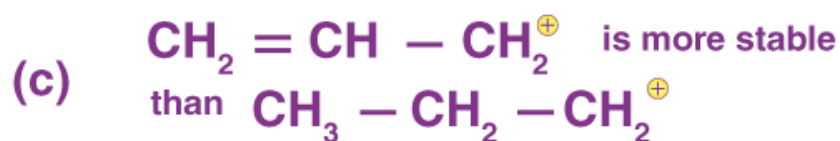
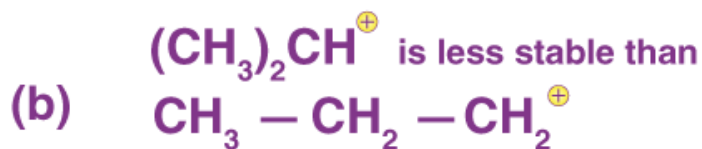
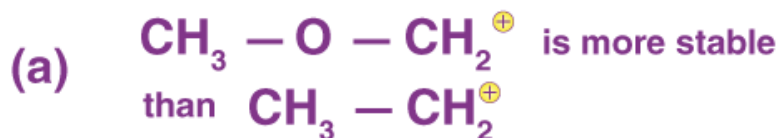
Note:  $sp$  has the highest  $s$  character and thus the highest electronegativity, whereas  $sp^3$  has the lowest  $s$  character and thus the lowest electronegativity.

**Q-9:** In  $S_N^1$  reaction, which intermediate is formed?

- a) Carbanion
- b) Carbocation
- c) Carbene
- d) Nitrene

**Answer:** b) Carbocation

**Q-10:** Which of the following are correct?



**Answer: a) and c)**

Explanation:

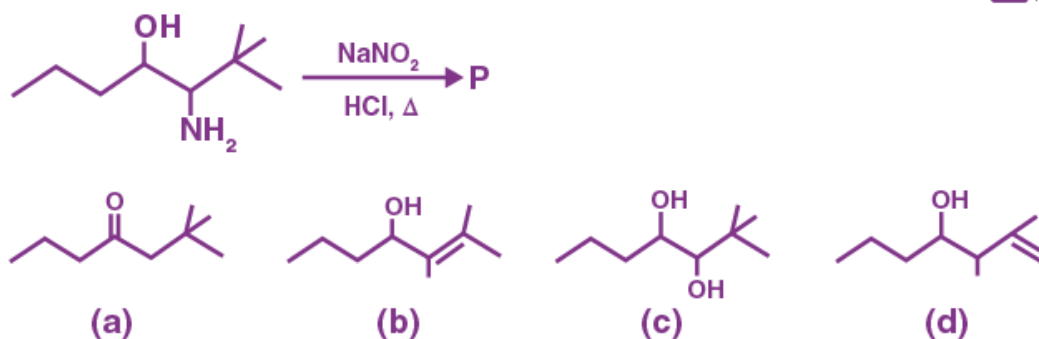
In a) former is most stable because of the lone pair donation by oxygen atom. (+ M effect)

In b) former is more stable than latter because it has more alpha-hydrogen(more hyperconjugation).

The former is resonance stabilised in c). And the latter is simply inductively stable.

In d) former has positive charge on sp carbon(more electronegativity), thus making it less stable than the latter which has positive charge on sp<sup>2</sup> carbon(less electronegativity).

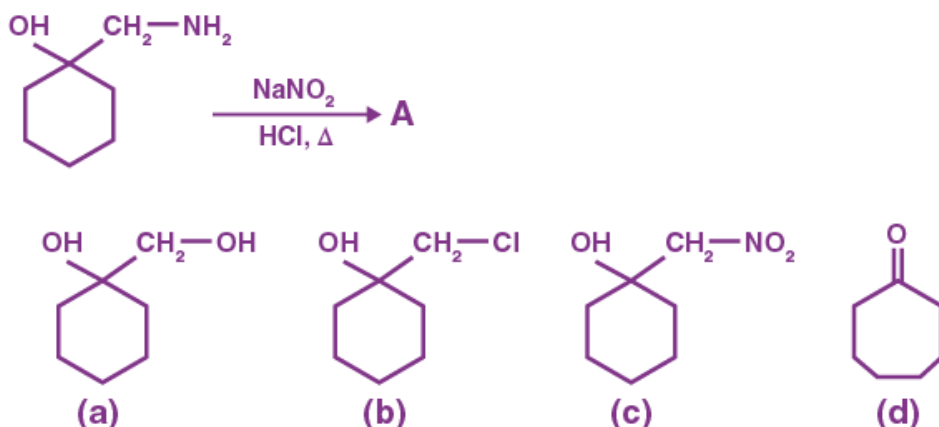
**Q-11:** Predict the major product P in the given reaction



**Answer: a)**

Explanation: In the given substrate, NH<sub>2</sub> in the presence of NaNO<sub>2</sub> and HCl produces N<sub>2</sub><sup>+</sup>Cl<sup>-</sup>, which when heated produces carbocation. The hydride shift will occur from the carbon attached to -OH, resulting in the formation of carbocation on that OH bonded carbon. Back bonding of electrons from O stabilises the carbocation and results in (a) as the product.

**Q-12:**



**Answer: d)**

**Explanation:** In the given substrate,  $\text{NH}_2$  in the presence of  $\text{NaNO}_2$  and  $\text{HCl}$  produces  $\text{N}_2^+\text{Cl}^-$ , which when heated produces carbocation. To stabilise the carbocation, ring expansion will occur, resulting in (d) as the major product.

**Q-13:** A carbocation is formed as an intermediate in

- Pinacol-Pinacolone rearrangement
- Hydration of alkene
- Acid catalysed dehydration of alcohol
- All of the above

**Answer: d)** All of the above

**Q-14:** Is carbocation a lewis acid?

**Answer:** Yes

**Explanation:** A Lewis acid is a chemical species that has an empty orbital that can accept an electron pair.

In carbocation, carbon has six electrons. It requires two electrons to complete its octet. This makes it a lewis acid.

**Q-15:** An allylic carbocation is more stable than tertiary carbocation. Why?

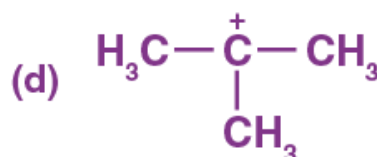
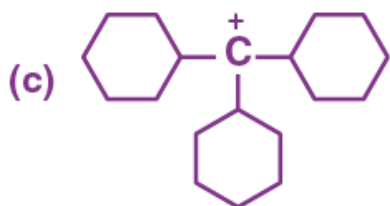
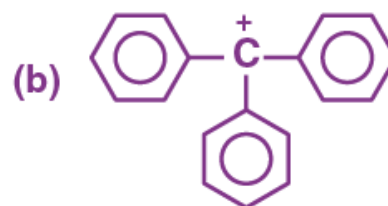


**Answer:** An allylic carbocation is resonance stabilised. On the other hand, tertiary carbocation is stabilised due to hyperconjugation.

Because the resonance effect is much stronger than hyperconjugation, the allylic carbocation is more stable than the tertiary carbocation.

## Practise Questions on Carbocation stability

**Q-1:** The carbocation with the longest half life is

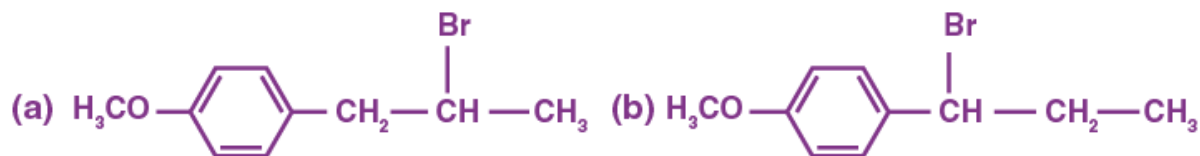
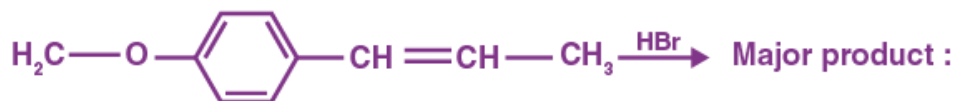


**Answer: a)**

Explanation: The half life depends on the stability of the carbocation. More is the stability of the carbocation, more is the half life.

Because of the dancing resonance, cyclopropane carbocation is exceptionally stable. As a result, the tri-cyclopropane carbocation is the most stable carbocation. Hence longest is the half life

**Q-2:** Predict the major product for the following reaction:



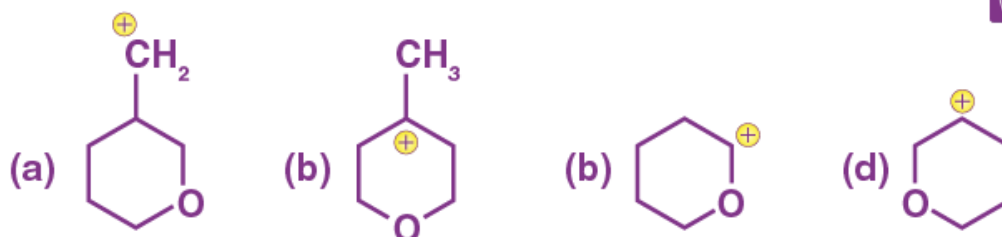
(c) Both a and b in same amount    (d) None of the above

**Answer: b)**

**Explanation:** In electrophilic addition, an electrophilic addition takes place on an unsaturated double or triple bond, causing the pi bond to break and the formation of a carbocation.

The positive charge is formed on the olefinic carbon atom attached to the phenyl ring because the resonance effect of the phenyl ring and substituent  $-\text{OCH}_3$  both stabilise that charge. As a result, the nucleophile Br will attack it next, yielding b) as the product.

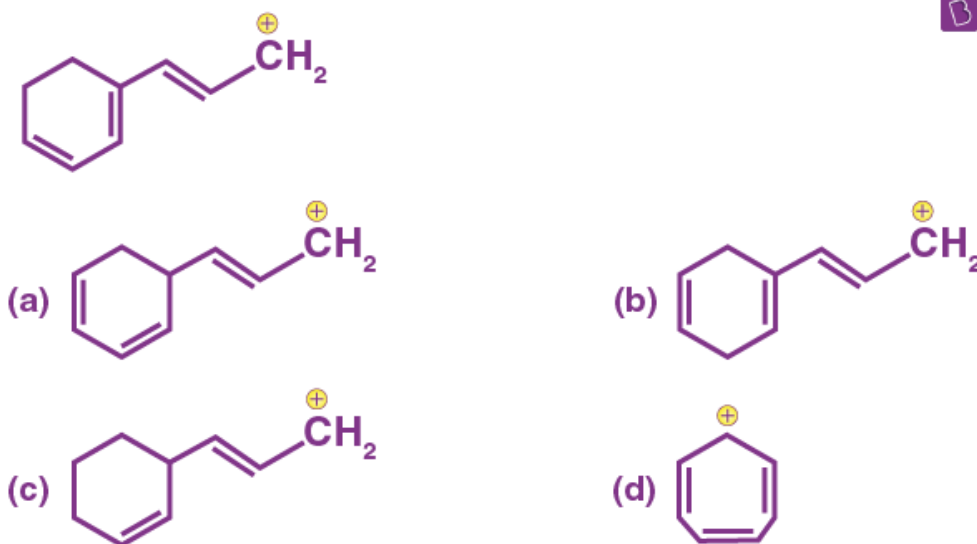
**Q-3:** Identify the most stable structure among the following:



**Answer: c)**

**Explanation:** The most stable carbocation is c) because it will be stabilised due to the lone pair donation by oxygen atom.

**Q-4:** Which of the following cations is less stable than the given below carbocation?



**Answer: a), b) and c)**

Explanation: The given carbocation is highly resonance stabilised as it has more resonance.

In a), b) and c) resonance is there but it is less than the given cation making them less stable.

d) is the most stable cation as the positive charge is the part of aromaticity imparting greater stability.

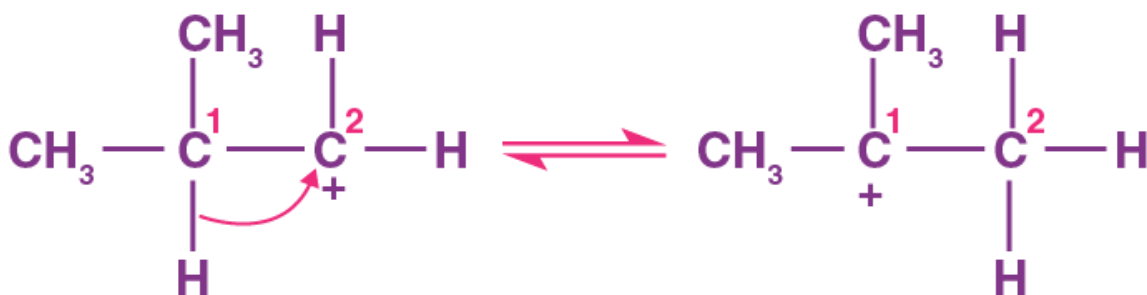
**Q-5:** How does rearrangement improve a carbocation's stability?

**Answer:** A carbocation's bonding electrons can be shifted between adjacent atoms to form a more stable carbocation. For example, if a secondary carbocation can be formed from a primary carbocation, rearrangement will be highly advantageous.

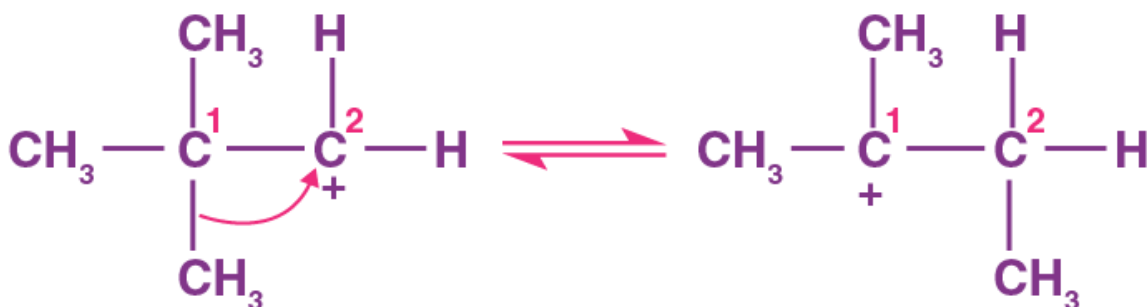
Rearrangement can be of the following types:

1. **Hydride shifting:** The hydrogen in this case is shifted from the first to the second carbon. As a result, the carbocation has shifted from primary to secondary. As a result, a more stable

structure is formed.



2. **Methyl shifting:** To form a more stable structure, the methyl group moves to the primary carbon. Because the carbocation is secondary, it is more stable than primary carbocation.



3. **Phenyl shifting:** The entire phenyl group can also be shifted to produce a more stable secondary or tertiary carbocation as opposed to a primary carbocation.