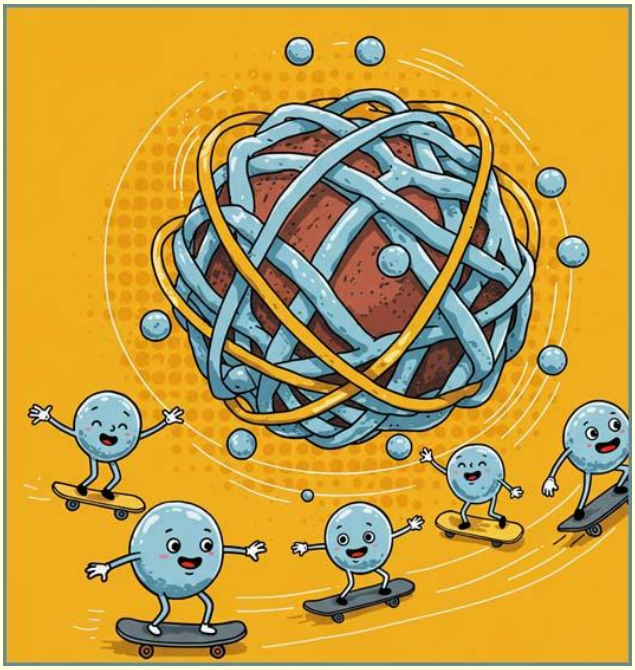
Answer all the questions below as fully as you can then check your answers

1. What is the primary reason why resonance is needed to represent the structure of certain molecules?



2. What type of electrons are typically involved in delocalisation and resonance?

3. In the context of resonance structures, what remains fixed and what is considered to be "moving" (in a theoretical sense)?

4. What is a "resonance hybrid"?

5. What does the circle inside the hexagon representing benzene signify?

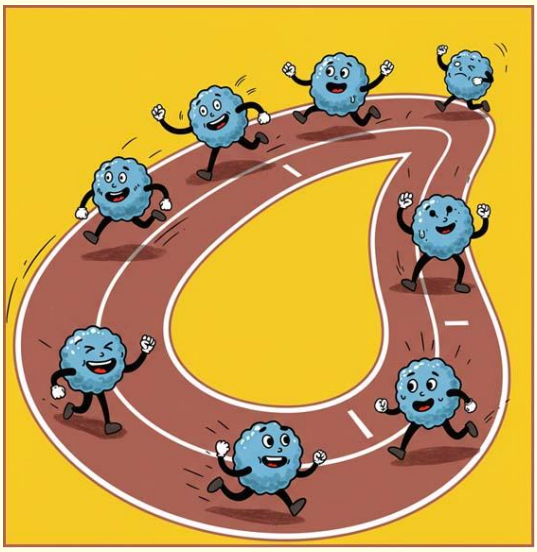
6. Explain why benzene cannot be accurately represented by a single Kekulé structure.

7. Describe the structure of the carbonate ion (CO_3^{2-}) in terms of resonance.

8. Explain why aromatic amines like aniline ($C_6H_5NH_2$) are weaker bases than aliphatic amines.

9. How does the concept of resonance contribute to the stability of molecules and ions?

10. Nitrate ions (NO_3^{2-}) has 3 resonance structures while the nitrite ion(NO_2^-) has 2 resonance structures. Using the concept of resonance, predict which of the ions would be more stable, explain your reasoning.



11. The analogy of runners on a track is used to explain delocalisation in benzene. Explain this analogy and discuss its limitations.

Answers

1. What is the primary reason why resonance is needed to represent the structure of certain molecules?

Answer: Resonance is needed when a single structure is insufficient to accurately represent the true distribution of electrons within a molecule, particularly when electrons are delocalised.

2. What type of electrons are typically involved in delocalisation and resonance?

Answer: Pi (π) electrons.

3. In the context of resonance structures, what remains fixed and what is considered to be "moving" (in a theoretical sense)?

Answer: The nuclei of the atoms remain fixed. The placement of electron pairs is what differs between resonance structures (often depicted with curved arrows as if electrons were moving, but they are actually delocalised).

4. What is a "resonance hybrid"?

Answer: A resonance hybrid is the actual structure of a molecule or ion that exhibits resonance. It is a composite or blend of all possible contributing resonance structures, representing the true electron distribution.

5. What does the circle inside the hexagon representing benzene signify?

Answer: The circle represents the delocalisation of the six pi (π) electrons over the entire benzene ring.

6. Explain why benzene cannot be accurately represented by a single Kekulé structure.

Answer: The Kekulé structures suggest alternating single and double bonds between carbon atoms. However, experimental evidence shows that all C-C bonds in benzene are of equal length, intermediate between a single and double bond. This indicates that the electrons are delocalised, which a single Kekulé structure cannot depict.

7. Describe the structure of the carbonate ion (CO_3^{2-}) in terms of resonance.

Answer: The carbonate ion has three equivalent C-O bonds. This cannot be represented by a single Lewis structure with one C=O and two C-O bonds. Instead, the carbonate ion is described as a resonance hybrid of three resonance structures, each with a double bond to a different oxygen atom. The actual structure has partial double bond character for each C-O bond.

8. Explain why aromatic amines like aniline ($C_6H_5NH_2$) are weaker bases than aliphatic amines.

Answer: In aromatic amines, the lone pair of electrons on the nitrogen atom is delocalised into the pi system of the aromatic ring. This delocalisation reduces the availability of the lone pair to form a dative covalent bond with a proton (H^+), making aromatic amines weaker bases compared to aliphatic amines where the lone pair is localised on the nitrogen atom.

9. How does the concept of resonance contribute to the stability of molecules and ions?

Answer: Delocalisation of electrons leads to greater stability. By spreading the electron density over a larger area, the electrons have lower energy, making the molecule more stable. The greater the number of contributing resonance structures, generally, the greater the stability.

10. Nitrate ions (NO_3^{2-}) has 3 resonance structures while the nitrite ion(NO_2^-) has 2 resonance structures. Using the concept of resonance, predict which of the ions would be more stable, explain your reasoning.

Answer: The nitrate ion would be more stable. It has three equivalent resonance structures, allowing for greater delocalisation of electrons compared to the nitrite ion, which only has two. Greater delocalisation leads to increased stability.

11. The analogy of runners on a track is used to explain delocalisation in benzene. Explain this analogy and discuss its limitations.

Answer: The circular track represents the benzene ring, and the runners represent the delocalized pi electrons. The fact that the runners are not confined to lanes (bonds) illustrates that the electrons are not localised between two specific atoms but are spread across the entire ring. A limitation is that electrons don't physically "run" around; they are better described as existing in a delocalised molecular orbital encompassing the entire ring.