For Each Example, Specify Whether The Two Structures Are Resonance Contributors To The Same Resonance

For Each Example, Specify Whether The Two Structures Are Resonance Contributors To The Same Resonance

Resonance is a fundamental concept in chemistry that describes the delocalization of electrons within a molecule. When drawing Lewis structures, multiple valid configurations—called resonance structures—can often be depicted for a single molecule or ion. These structures are not real, separate entities but rather different representations of the same electronic arrangement. Understanding whether two structures are resonance contributors to the same resonance involves analyzing their electronic similarities and differences, particularly focusing on the movement of electrons, formal charges, and overall molecular geometry. This article provides a comprehensive guide to evaluating resonance structures across various examples, helping students and chemists alike to distinguish when two structures are part of the same resonance hybrid.

Understanding Resonance and Resonance Contributors

What Is Resonance?

Resonance occurs when a molecule cannot be adequately described by a single Lewis structure. Instead, multiple valid structures are used to represent the molecule's true electronic distribution, which is a hybrid of these contributors. The actual structure is a resonance hybrid, often more stable and lower in energy than any individual contributor.

Resonance Contributors Defined

Resonance contributors are the different Lewis structures that collectively describe the delocalized electrons in a molecule. For structures to be considered resonance contributors to the same resonance:

- They must have the same arrangement of atoms (connectivity).
- They only differ in the placement of electrons, not in the positions of nuclei.
- The movement involves electrons, such as lone pairs and π bonds, without

breaking or forming new bonds that alter the overall connectivity.

Criteria for Resonance Structures to Be the Same Resonance

To determine if two structures are resonance contributors to the same resonance:

1. Same skeletal structure: Atoms are connected in the same way.
2. Same number of electrons: The total number of valence electrons remains constant.
3. Electron movement only: The differences are solely in the position of electrons, typically through the shifting of π bonds or lone pairs.
4. No net change in formal charges: While formal charges may shift, the net charge of the molecule remains the same, and the overall charge distribution is consistent.

Examining Examples of Resonance Structures

To clarify the concept, let's analyze specific examples, evaluating whether the given pairs are resonance contributors to the same resonance.

Example 1: Benzene (C_6H_6)

Structure A: Alternating double bonds between carbons (the Kekulé structure).

Structure B: Same as Structure A but with double bonds shifted to adjacent bonds, resulting in a different pattern of double bonds.

Analysis

- Same skeletal structure: Yes, the carbon framework is identical.
- Electron movement: The shift involves π electrons moving from one bond to the next, with the positions of double bonds changing.
- Formal charges: No change; both structures are neutral.
- Connectivity: No atoms are added or removed; only π electrons are delocalized.

Conclusion

Structures A and B are resonance contributors to the same resonance hybrid because they differ only in the position of the π bonds, with the same atomic connectivity, electrons, and overall charge.

Example 2: Nitrate Ion (NO_3^-)

Structure A: Nitrogen double-bonded to one oxygen, with two single-bonded oxygens bearing negative charges.

Structure B: The double bond shifted to a different oxygen atom, with the negative charge on a different oxygen.

Analysis

- Same skeletal structure: Yes, nitrogen is bonded to three oxygens.
- Electron movement: The π electrons from the N–O double bond are delocalized, shifting the double bond among the oxygens.
- Formal charges: The distribution of negative charges shifts but the total charge remains the same.
- Connectivity: No bonds are broken or formed; only electron pairs move.

Conclusion

Structures A and B are resonance contributors to the same resonance because they differ only in the placement of the π electrons (double bonds) and negative charges on oxygens, with the atomic framework unchanged.

Example 3: Nitro Group ($–NO_2$)

Structure A: N is double-bonded to one oxygen and single-bonded to another oxygen bearing a negative charge.

Structure B: The double bond is shifted to the other oxygen, with the negative charge on the first oxygen.

Analysis

- Same skeletal structure: Yes.
- Electron movement: The π electrons are delocalized between the two oxygens, similar to the nitrate ion.
- Formal charges: The negative charge shifts between oxygens.
- Connectivity: The bonding pattern remains the same.

Conclusion
These two structures are resonance contributors to the same resonance hybrid, as they differ only by the delocalization of electrons over the oxygen atoms.

Example 4: Carboxylic Acid (CH_3COOH)

Structure A: Carbonyl group with a double-bonded oxygen and a hydroxyl group.

Structure B: The lone pair on the hydroxyl oxygen forms a double bond with carbon, pushing the electrons onto the oxygen, resulting in a negatively charged oxygen.

Analysis
- Same skeletal structure: Yes, the carbon chain remains intact.
- Electron movement: Electrons from the lone pair on the hydroxyl oxygen delocalize into the carbon, forming a C=O double bond and giving the hydroxyl oxygen a negative charge.
- Formal charges: The distribution of charges changes, but the overall molecular charge remains neutral.
- Connectivity: The atom connectivity does not change.

Conclusion
Structures A and B are resonance contributors to the same resonance hybrid because they only differ in the distribution of electrons, not in the connectivity.

Example 5: Positively Charged Molecule (Carbocation)

Structure A: A primary carbocation with a positive charge on a specific carbon.

Structure B: The positive charge shifts to an adjacent carbon through electron movement.

Analysis
- Same skeletal structure: Yes, the carbon skeleton is unchanged.
- Electron movement: The shift involves the movement of a pair of electrons to stabilize the positive charge.
- Formal charges: The positive charge moves but the overall charge remains +1.

- Connectivity: No bonds are broken or formed; only electrons shift.

Conclusion
These are resonance structures contributing to a common resonance hybrid because they only differ in the position of the positive charge, with the skeletal structure unchanged.

Common Mistakes and Clarifications

Misinterpreting Electron Movement
A common mistake is assuming that any change in structure implies different resonance contributors. Remember, only electrons move—atoms do not shift positions in resonance structures.

Breaking or Forming Bonds
Resonance involves delocalization of electrons without breaking covalent bonds or changing the molecular skeleton. If bonds are broken or new bonds formed that alter the connectivity, the structures are not resonance contributors to the same resonance.

Formal Charges
While formal charges can shift between atoms, the total charge of the molecule must remain the same across structures. Structures that differ in total charge are not resonance contributors to each other.

Summary and Key Takeaways

- Resonance structures are different electron arrangements of the same molecule that differ only in the positions of electrons, not atoms.
- Two structures are resonance contributors to the same resonance if:
- They have the same atomic connectivity.
- They differ only in the placement of electrons (π bonds, lone pairs).
- The overall charge remains unchanged.
- Resonance hybrids are the real molecules, representing a weighted average of all contributors.
- Analyzing whether two structures are resonance contributors involves

carefully examining electron movement, formal charges, and skeletal structure.

Final Thoughts

Understanding whether two Lewis structures are resonance contributors to the same resonance is crucial for grasping molecular stability, reactivity, and electronic properties. Practice analyzing various structures, paying close attention to electron delocalization, formal charges, and connectivity. Recognizing the subtle differences between resonance contributors enhances your ability to predict and explain chemical behavior effectively.

Frequently Asked Questions

In a molecule with a benzene ring and a nitro group, are the resonance structures with the nitro group as an electron-withdrawing substituent considered resonance contributors to the same resonance as the aromatic ring?

Yes, they are resonance contributors to the same overall structure, as the electron delocalization occurs within the aromatic system and extends to the substituent, reflecting the resonance stabilization of the entire molecule.

Are the resonance structures showing the lone pair on the oxygen of a carbonyl group localized or resonance contributors to the same structure?

They are resonance contributors to the same structure, as the lone pair can delocalize into the pi system, creating different valid resonance forms that collectively stabilize the molecule.

In an allylic carbocation, is the resonance structure with the positive charge on one carbon a resonance contributor to the structure where the positive charge is shifted to an adjacent carbon?

Yes, these are resonance contributors of the same structure, illustrating the delocalization of the positive charge across adjacent carbons.

Are the resonance structures with a double bond between carbons and a positive charge on an oxygen atom considered to be the same resonance contributor in a molecule with conjugated systems?

No, they are different resonance contributors because they differ in the placement of the double bonds and charges; they represent different valid electron arrangements but contribute to the overall resonance hybrid.

Does the resonance structure with a lone pair on nitrogen forming a double bond with carbon and a positive charge on nitrogen contribute to the same resonance as the structure with a lone pair on nitrogen and no double bond?

Yes, both structures are resonance contributors of the same molecule, depicting different ways electrons can be delocalized involving nitrogen.

In a conjugated diene, are the resonance structures with the double bonds in different positions considered to be the same or different resonance contributors?

They are different resonance contributors that collectively describe the delocalization of electrons across the conjugated system.

Are the resonance structures with a lone pair on a nitrogen atom delocalized into a neighboring pi system considered to be the same resonance contributor?

No, they are different resonance contributors, as the lone pair may or may not be involved in delocalization depending on the structure, but both contribute to the overall resonance hybrid.

In a molecule with a conjugated carbonyl and a double bond, are the resonance structures with the positive charge localized on oxygen versus on the

alpha carbon considered to be the same resonance contributor?

No, these are different resonance contributors because the positive charge is located on different atoms, representing alternative electron arrangements within the conjugated system.

Are the resonance structures with a pi bond shifted between two different pairs of carbons considered to be the same or different resonance contributors?

They are different resonance contributors, as they show alternative placements of the double bonds, reflecting electron delocalization within the molecule.

In a molecule with conjugated pi systems, does shifting electrons to form different Kekulé structures qualify as the same or different resonance contributors?

They are different resonance contributors, representing various valid electron arrangements that contribute to the overall stability of the molecule.

Additional Resources

For Each Example, Specify Whether The Two Structures Are Resonance Contributors To The Same Resonance

Understanding resonance in chemistry is fundamental for grasping how molecules behave, stabilize, and react. When discussing for each example, specify whether the two structures are resonance contributors to the same resonance, we delve into a crucial aspect of molecular structure analysis. Resonance contributors are different Lewis structures that depict the delocalization of electrons within a molecule. Recognizing whether two structures are part of the same resonance system allows chemists to better understand molecular stability, reactivity, and electronic distribution. This guide provides a detailed exploration of how to identify resonance contributors, with step-by-step examples and analysis to clarify this important concept.

What Is Resonance and Why Does It Matter?

Resonance describes the phenomenon where a molecule cannot be accurately represented by a single Lewis structure. Instead, it is better depicted as a hybrid of multiple contributing structures. These resonance structures differ mainly in the placement of electrons, such as lone pairs and π bonds, but not in the positions of atoms.

Why is resonance important?

- It explains molecular stability: The more resonance contributors a molecule has, generally, the more stabilized it is.
- It clarifies reactivity: Electron delocalization can influence how molecules interact with other species.
- It aids in understanding properties: Such as bond lengths, partial charges, and overall electronic distribution.

Defining Resonance Contributors

Resonance contributors are individual Lewis structures that differ only in the distribution of electrons, not in the positions of nuclei. These structures:

- Must obey the rules of Lewis structures.
- Have the same placement of atoms.
- Differ in the arrangement of electron pairs, such as double bonds, lone pairs, and charges.
- Are connected through arrows indicating electron delocalization.

Key point: Different resonance structures that are valid Lewis structures and differ only in electron placement are resonance contributors to the same resonance.

How to Determine if Two Structures Are Resonance Contributors to the Same Resonance

To assess whether two structures are resonance contributors to the same resonance, follow these steps:

1. Check the atom connectivity: The positions of atoms must be the same.
2. Compare the placement of electrons: They should differ only in the distribution of electrons, not in atom positions.
3. Verify the rules of Lewis structures: Both must obey the octet rule (or duet for hydrogen), and charges should be consistent.
4. Use resonance arrows: They should be connected via a resonance arrow (↔) indicating electron delocalization.
5. Assess if the structures can be interconverted by moving electrons: Only electrons (bonds or lone pairs) should be moved, not atoms.

Examples: Applying the Concept

Let's now analyze some specific examples to clarify whether two structures are resonance contributors to the same resonance.

Example 1: Benzene (C_6H_6)

Structure A:

- Alternating single and double bonds around the ring.

Structure B:

- The double bonds are shifted: the position of the double bonds has moved to adjacent bonds.

Analysis:

- The atoms are identical in both structures.
- The double bonds are in different positions; lone pairs are unchanged.
- Both structures obey the octet rule.
- They are related by moving π electrons around the ring.

Conclusion:

These two structures are resonance contributors to the same resonance, representing the delocalized π-electron system of benzene.

Example 2: Nitrate Ion (NO_3^-)

Structure A:

- The nitrogen is double-bonded to one oxygen; other oxygens are single-bonded with negative charges.

Structure B:

- The double bond shifts to a different oxygen atom, but the overall charge distribution remains similar.

Analysis:

- The atom connectivity remains the same.
- Only the position of the double bond and negative charges change.
- Both structures obey octet rules.
- The structures differ only in the placement of electrons.

Conclusion:

These are resonance contributors to the same resonance, illustrating delocalization of the negative charge over the oxygens.

Example 3: Nitro Group (NO_2)

Structure A:

- N is double-bonded to one oxygen, single-bonded to another oxygen with a negative charge.

Structure B:

- The double bond shifts to the other oxygen.

Analysis:

- Same atom connectivity.
- Electrons (double bonds and charges) are moved.
- Both obey octet rules.

Conclusion:

These are resonance contributors to the same resonance, showing electron delocalization within the nitro group.

Example 4: An Incorrect Pair—Different Atom Connectivity

Suppose you compare:

- Structure A: N double-bonded to one oxygen, with a negative charge on another oxygen.
- Structure B: N bonded to two oxygens with single bonds, and both oxygens carry negative charges.

Analysis:

- The atom connectivity differs: in one, nitrogen is double-bonded; in the other, it is not.
- The positions of atoms are different.

Conclusion:

These are not resonance contributors because they involve different connectivity, thus representing different molecules or different resonance systems.

Common Pitfalls and How to Avoid Them

- Moving atoms, not electrons: Resonance involves only electrons; moving nuclei invalidates the structure as a resonance contributor.
- Violating octet rule: Structures that break the octet rule are invalid resonance contributors.
- Incorrect charge assignment: Charges must be consistent with electron movement.
- Misinterpreting tautomerism: Tautomers involve different connectivity, not just electron delocalization; they are not resonance structures.

Summary Table: Key Points for Identifying Resonance Contributors

Criterion	Resonance Contributors?	Explanation
Atom connectivity	Yes	Same atoms in the same positions
Electron placement	Different	Only electrons (bonds, lone pairs) are rearranged
Atom positions	Same	Nuclei do not move
Obedience to Lewis rules	Yes	Octet/full shell rules are maintained
Charge distribution	Varies	Charges shift with electron movement but overall charge remains consistent

---

Final Thoughts: The Significance of Recognizing Resonance Structures

Distinguishing whether two structures are resonance contributors to the same resonance is foundational for understanding molecular stability and reactivity. Recognizing these structures helps in predicting reactive sites, understanding bond lengths, and explaining properties like UV-Vis absorption or acidity.

Practice Tip: When analyzing a molecule, always look for the possibility of electron movement without altering atom positions. Use resonance arrows to visualize electron delocalization and confirm whether the structures are connected through legitimate electron shifts.

In conclusion, for each example, specify whether the two structures are resonance contributors to the same resonance by carefully examining atom positions, electron placements, and obeying Lewis structure rules. Mastery of this skill enhances your ability to analyze complex molecules and appreciate the elegant delocalization phenomena that underpin much of organic and inorganic chemistry.

For Each Example Specify Whether The Two Structures Are Resonance Contributors To The Same Resonance

For Each Example Specify Whether The Two Structures Are Resonance Contributors To The Same Resonance

Related Articles

- Is The Following Passage Pro Or Con Appeasement?Then All Has Been Said, One Fact Remains Dominant And
- Joseph Is Having A Difficult Time Comparing Two Characters In A Novel For A Language Arts Assignment.
- Help I Need To Do A Signature AssignmentTo Do Wellyou Need To Apply The Same Close Reading Skills You

Back to Home