TEST BANK

Organic Chemistry

FIFTH EDITION

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PREFACE

When was the last time you were pleased with the consistency and quality of the assessment supplements that come with introductory texts? If you are like most professors, you probably find that these assessment packages do not always meet your needs. To address this issue, Norton has collaborated with Valerie Shute (Florida State University) and Diego Zapata-Rivera (Educational Testing Services) to develop a methodology for delivering high-quality, valid, and reliable assessment supplements through our test banks and extensive suite of support materials.

WHY A NEW APPROACH?

In evaluating the test banks that accompany introductory texts, we found four substantive problem areas associated with the questions:

1. Test questions were misclassified in terms of type and difficulty.
2. The prevalence of low-level and factual questions misrepresented the goals of the course.
3. Topics were unevenly distributed: Trivial topics were tested via multiple items, while important concepts were not tested at all.
4. Links to course topics were too general, thus preventing diagnostic use of the item information.

STUDENT COMPETENCIES AND EVIDENCE-CENTERED DESIGN

In December 2007, we conducted a focus group with the brightest minds in educational testing to create a new model for assessment. A good assessment tool needs to (a) define what students need to know and the level of knowledge and skills expected, (b) include test items that assess the material to be learned at the appropriate level, and (c) enable instructors to accurately judge students' mastery of the material—what they know, what they don't know, and to what degree—based on the assessment outcomes. Accurate assessments of student mastery allow instructors to focus on areas where students need the most help.

HOW DOES IT WORK?

The test bank authors listed the learning objectives from each chapter that they believed are the most important for students to learn. The author then developed questions designed to test students' knowledge of a particular learning objective. By asking students questions that vary in both type and level of difficulty, instructors can gather different types of evidence, which will allow them to more effectively assess how well students understand specific concepts.

Six Question Types:

1. Remembering questions—test declarative knowledge, including textbook definitions and relationships between two or more pieces of information. Can students recall or remember the information in the same form it was learned?
2. Understanding questions—pose problems in a context different from the one in which the material was learned, requiring students to draw from their declarative and/or procedural understanding of important concepts. Can students explain ideas or concepts?
3. Applying questions—ask students to draw from their prior experience and use critical-thinking skills to take part in qualitative reasoning about the real world. Can students use learned information in another task or situation?

4. Analyzing questions—test students' ability to break down information and see how different elements relate to each other and to the whole. Can students distinguish among the different parts?
5. Evaluating questions—ask students to assess information as a whole and frame their own argument. Can students justify a stand or decision?
6. Creating questions—pose questions or objectives that prompt students to put elements they have learned together into a coherent whole to generate new ideas. Can students create a new product or point of view based on data?

Three Difficulty Levels:

1. Easy questions—require a basic understanding of the concepts, definitions, and examples.
2. Medium questions—direct students to use critical thinking skills, to demonstrate an understanding of core concepts independent of specific textbook examples, and to connect concepts across chapters.
3. Difficult questions—ask students to synthesize textbook concepts with their own experience, making analytical inferences about biological topics and more.

Each question measures and explicitly links to a specific competency and is written with clear, concise, and grammatically correct language that suits the difficulty level of the specific competency being assessed. To ensure the validity of the questions, no extraneous, ambiguous, or confusing material is included, and no slang expressions are used. In developing the questions, every effort has been made to eliminate bias (e.g., race, gender, cultural, ethnic, regional, handicap, age) to require specific knowledge of material studied, not of general knowledge or experience. This ensures accessibility and validity.

KEY TO THE QUESTION METADATA

Each question in the Test Bank is tagged with five pieces of information designed to help instructors create the most ideal mix of questions for their quiz or exam. These tags are:

ANS: This is the correct answer for each question. Or, in the case of some short answer questions, a possible correct answer to the given question.

DIF: This is the difficulty assigned to the problem. Problems have been classified as Easy, Medium, or Difficult.

REF: This is the section in the textbook from which a question is drawn.

OBJ: This is the learning objective that the question is designed to test.

MSC: This is the knowledge type (see above) the question is designed to test.

Chapter 1: Atoms and Molecules; Orbitals and Bonding

LEARNING OBJECTIVES

Understand properties of atomic orbitals
Multiple Choice: 1
Short Answer: 6, 24

Evaluate trends in IP, EA in periodic table
Multiple Choice: 2

Determine atomic orbital structure
Multiple Choice: 3

Apply rules for quantum numbers
Multiple Choice: 4, 5
Short Answer: 7

Understand the rules for quantum mechanics
Multiple Choice: 6
Short Answer: 1, 2, 5

Apply rules and properties for atomic orbitals
Short Answer: 3

Construct electronic configuration using rules for quantum mechanics
Short Answer: 8

Derive nodes based on quantum numbers
Multiple Choice: 7–9

Apply rules for Lewis structures
Multiple Choice: 10, 16

Determine polarity based on 3D structure, bond dipoles
Multiple Choice: 11
Short Answer: 14

Determine a dipole moment from a structure
Multiple Choice: 12, 17

Calculate formal charge
Multiple Choice: 13–15, 18

Analyze resonance forms for stability
Multiple Choice: 19

Identify resonance structures
Multiple Choice: 20–24

Construct molecular orbital diagrams
Multiple Choice: 25
Short Answer: 21–23

Apply rules for molecular orbital construction
Multiple Choice: 26–30, 32

Identify types of bond cleavage
Multiple Choice: 31
Short Answer: 26

Understand Lewis acids and bases
Multiple Choice: 33
Short Answer: 28–31

Apply rules and properties for atomic orbitals
Short Answer: 3

Draw Lewis structures
Short Answer: 9–13

Draw resonance forms
Short Answer: 15, 17, 18, 20

Analyze resonance forms
Short Answer 16, 19

Apply thermodynamics of bond formation
Short Answer: 25, 27

MULTIPLE CHOICE

1. Which of the following statements about atomic orbitals is *false*?
   a. A 1*s* orbital is spherically symmetrical.
   b. An atomic orbital may contain zero, one, or two electrons.
   c. A 2*s* orbital and a 2*p* orbital are equal in energy.
   d. A $2p_x$ orbital and a $2p_y$ orbital are equal in energy.
   e. A 2*p* orbital is not spherically symmetrical.

   ANS: C DIF: Easy REF: 1.1
   OBJ: Understand properties of atomic orbitals MSC: Remembering

2. Which of the following statements is true?
   a. Ionization potential decreases going across a row left to right.
   b. Ionization potential increases going down a group.
   c. Electron affinity increases going across a row left to right.
   d. Electron affinity increases going down a group.
   e. Atoms with high ionization potentials have correspondingly high electron affinities.

   ANS: C DIF: Easy REF: 1.2
   OBJ: Evaluate trends in IP, EA in periodic table MSC: Remembering

3. What is the total number of occupied *p* orbitals in a neutral phosphorus atom?
   a. 2
   b. 3
   c. 6
   d. 9
   e. 12

   ANS: C DIF: Easy REF: 1.2
   OBJ: Determine atomic orbital structure MSC: Analyzing

4. Which one of the following sets of quantum numbers is impossible?
   a. $n = 1, l = 0, m_l = 0, s = +½$
   b. $n = 1, l = 1, m_l = 0, s = +½$
   c. $n = 2, l = 1, m_l = 1, s = +½$
   d. $n = 2, l = 1, m_l = -1, s = -½$
   e. $n = 3, l = 0, m_l = 0, s = -½$

   ANS: B DIF: Easy REF: 1.2
   OBJ: Apply rules for quantum numbers MSC: Applying

5. Which of these sets of quantum numbers would define an electron in the 5*d* subshell?
   a. $n = 5; l = 2, m_l = -3, s = ½$
   b. $n = 5; l = 2, m_l = -2, s = ½$
   c. $n = 5; l = 4, m_l = -2, s = -½$
   d. $n = 5; l = 2, m_l = -2, s = 1$
   e. $n = 5; l = 1, m_l = 0, s = -½$

   ANS: B DIF: Easy REF: 1.2
   OBJ: Apply rules for quantum numbers MSC: Applying

6. The rule or principle that states that the electronic state with the greatest number of unpaired spins will have the lowest energy is called
   a. the Pauli principle
   b. the aufbau principle
   c. the Heisenberg uncertainty principle
   d. Hund's rule
   e. the octet rule

   ANS: D DIF: Easy REF: 1.2
   OBJ: Understand the rules for quantum mechanics MSC: Remembering

7. *d*-orbitals have two nodal planes. How many *spherical* nodes will a 5*d* orbital contain?
   a. 1
   b. 2
   c. 3
   d. 4
   e. 5

   ANS: B DIF: Difficult REF: 1.2
   OBJ: Derive nodes based on quantum numbers MSC: Analyzing

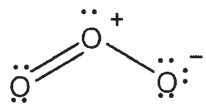
8. Which of the following statements accurately describes the node(s) in a 2*s* orbital?
   a. There are zero nodes in a 2*s* orbital.
   b. A 2*s* orbital has one spherical node.
   c. A 2*s* orbital has one nodal plane.
   d. A 2*s* orbital has one spherical node and one nodal plane.
   e. A 2*s* orbital has two spherical nodes.

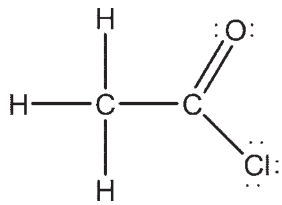
   ANS: B DIF: Medium REF: 1.2
   OBJ: Derive nodes based on quantum numbers MSC: Analyzing

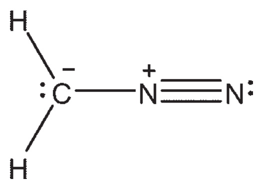
9. Which of the following statements accurately describes the node(s) in a 2*p* orbital?
   a. There are zero nodes in a 2*p* orbital.
   b. A 2*p* orbital has one spherical node.
   c. A 2*p* orbital has one nodal plane.
   d. A 2*p* orbital has one spherical node and one nodal plane.
   e. A 2*p* orbital has two spherical nodes.

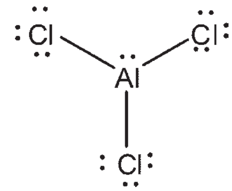
   ANS: C DIF: Medium REF: 1.2
   OBJ: Derive nodes based on quantum numbers MSC: Analyzing

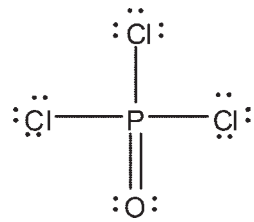
10. Which of the Lewis structures shown below is *incorrect*?

a. 

b. 

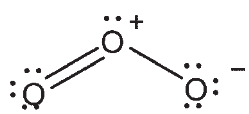
c. 

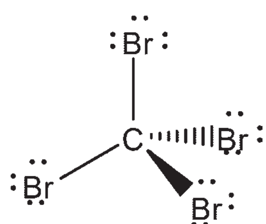
d. 

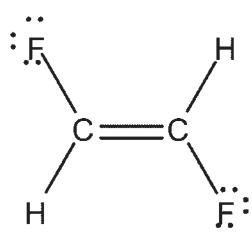
e. 

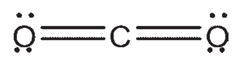
ANS: D DIF: Medium REF: 1.3
OBJ: Apply rules for Lewis structures MSC: Analyzing

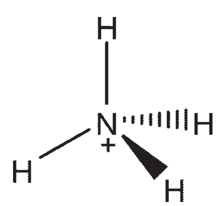
11. Indicate which of the species shown are expected to have a net dipole moment.

a. 

b. 

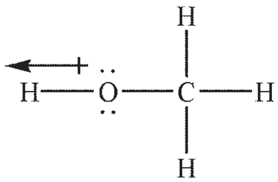
c. 

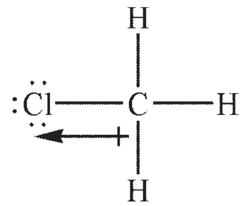
d. 

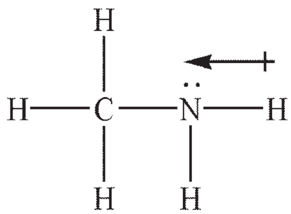
e. 

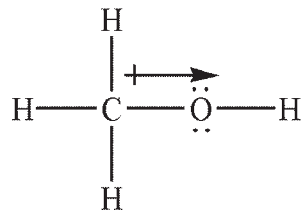
ANS: A DIF: Difficult REF: 1.3
OBJ: Determine polarity based on 3D structure, bond dipoles MSC: Analyzing

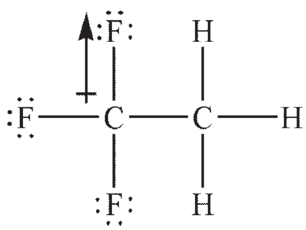
12. Which of the following Lewis structures shows an *incorrectly* drawn bond dipole?

a. 

d. 

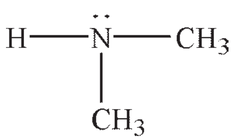
b. 

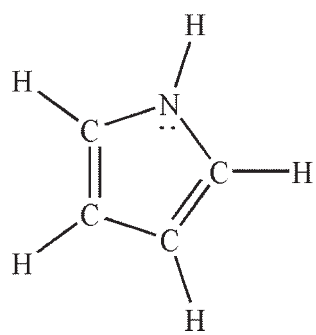
e. 

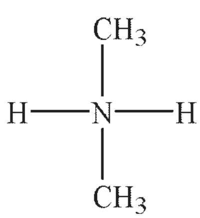
c. 

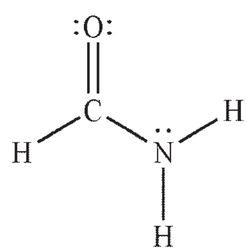
ANS: A DIF: Easy REF: 1.3
OBJ: Determine a dipole moment from a structure MSC: Analyzing

13. In which of the following Lewis structures does the nitrogen atom have a formal charge of 1+?

a. 

d. 

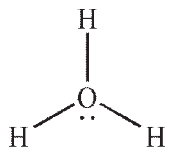
b. 

e. 

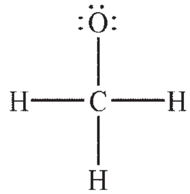
c. 

ANS: B DIF: Easy REF: 1.3 OBJ: Calculate formal charge
MSC: Applying

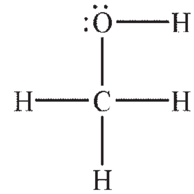
14. What is the formal charge on the oxygen atom in each of the following Lewis structures?



Structure A



Structure B

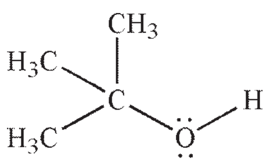


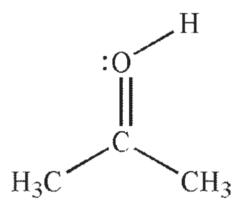
Structure C

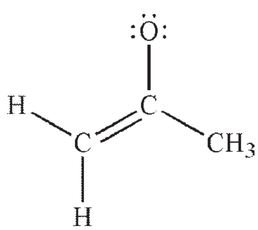
a. **A**: 0, **B**: 1–, **C**: 1+
b. **A**: 1+, **B**: 1–, **C**: 0
c. **A**: 1–, **B**: 1+, **C**: 0
d. **A**: 1–, **B**: 1–, **C**: 1–
e. **A**: 1+, **B**: 1+, **C**: 1–

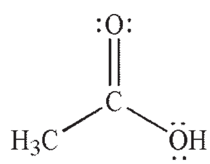
ANS: B DIF: Easy REF: 1.3 OBJ: Calculate formal charge
MSC: Applying

15. Which of the following Lewis structures contains an oxygen atom with a 1+ formal charge?

a. 

d. 

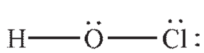
b. 

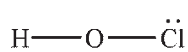
e. 

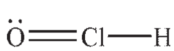
c. 

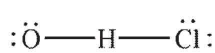
ANS: D DIF: Easy REF: 1.3 OBJ: Calculate formal charge
MSC: Applying

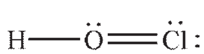
16. Which of the following structures is the best Lewis structure for hypochlorous acid, HOCl?

a. 

d. 

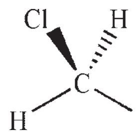
b. 

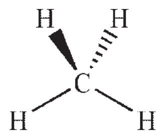
e. 

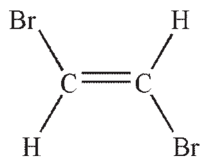
c. 

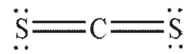
ANS: A DIF: Medium REF: 1.3
OBJ: Apply rules for Lewis structures MSC: Analyzing

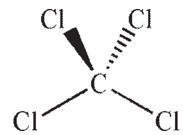
17. Which of the following molecules has a net dipole moment?

a. 

b. 

c. 

d. 

e. 

ANS: A DIF: Medium REF: 1.3
OBJ: Determine a dipole moment from a structure MSC: Applying

18. In which of the following structures does the carbon atom have a formal charge that is *not* zero?

a. 

b. 

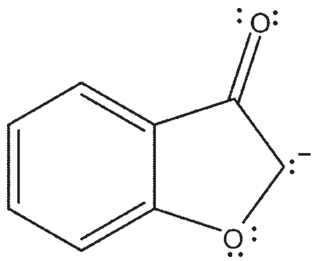
c. 

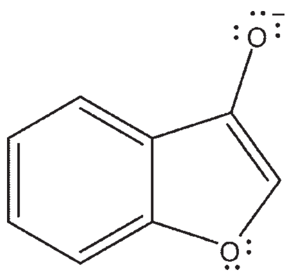
d. 

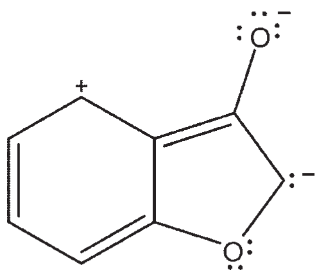
e. Both c and d

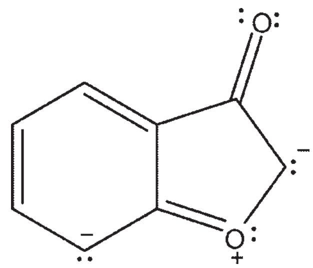
ANS: C DIF: Medium REF: 1.3 OBJ: Calculate formal charge
MSC: Applying

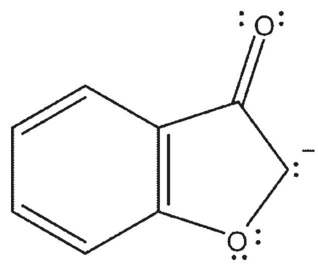
19. Which of the following resonance forms would be expected to be the most important contributor for the anionic species?

a. 

b. 

c. 

d. 

e. 

ANS: B DIF: Medium REF: 1.4
OBJ: Analyze resonance forms for stability MSC: Analyzing

20. Which of the following arrow conventions is used to show the relationship of two chemical species as resonance structures?

a. 

b.

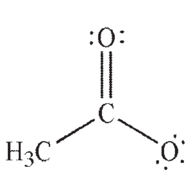
c. 

d. 

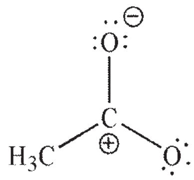
e. Both a and b

ANS: A DIF: Easy REF: 1.4
OBJ: Identify resonance structures MSC: Remembering

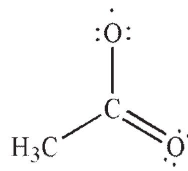
21. Which two of the following structures are *equivalent* resonance contributors?



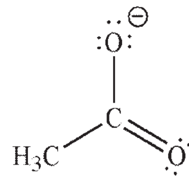
Structure A



Structure B



Structure C



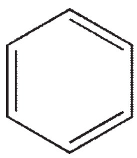
Structure D

a. **A** and **B**
b. **A** and **C**
c. **B** and **C**
d. **A** and **D**
e. All the structures are equivalent.

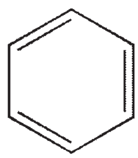
ANS: B DIF: Easy REF: 1.4
OBJ: Identify resonance structures MSC: Analyzing

22. Which of the following pairs are *not* related as resonance structures?

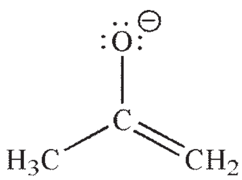
a.



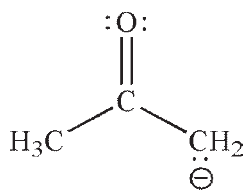
and



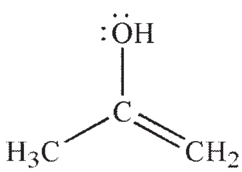
b.



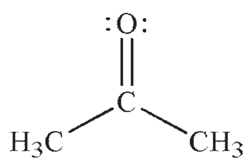
and



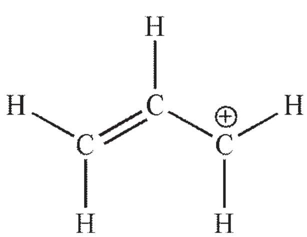
c.



and



d.



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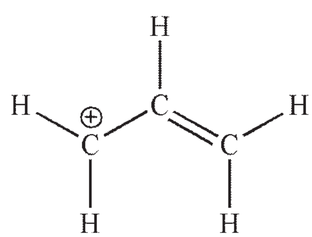
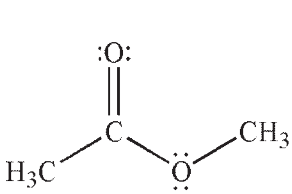
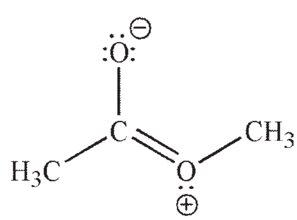


e.

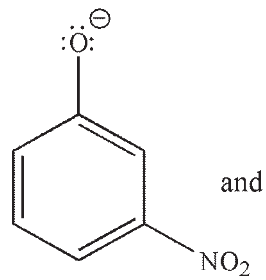
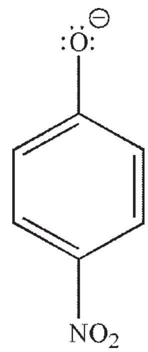


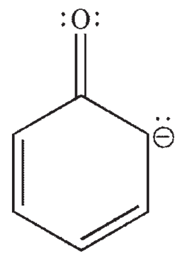
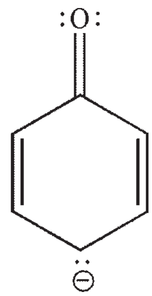
and

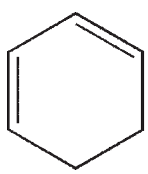
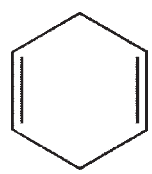


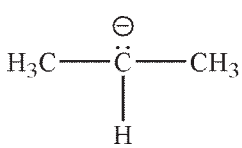
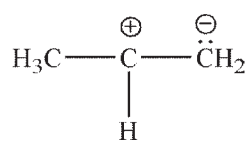
ANS: C DIF: Medium REF: 1.4
OBJ: Identify resonance structures MSC: Analyzing

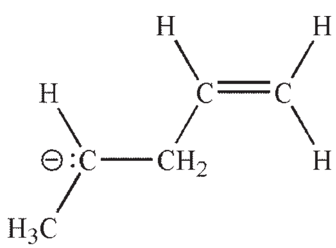
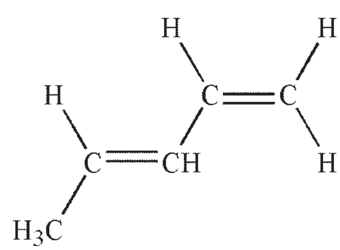
23. Which of the following pairs are related as resonance structures? All nonzero formal charges are shown.

a.  and 

b.  and 

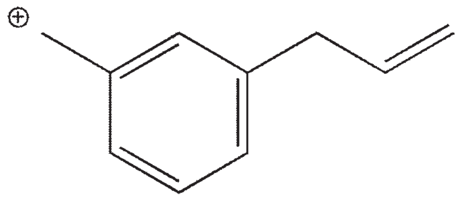
c.  and 

d.  and 

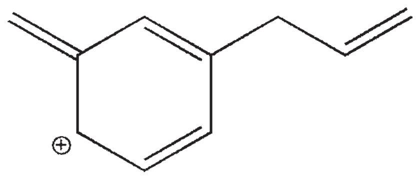
e.  and 

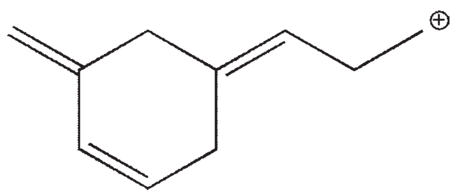
ANS: B DIF: Medium REF: 1.4
OBJ: Identify resonance structures MSC: Analyzing

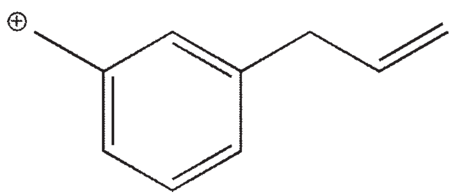
24. Which of the structures shown is *not* related to Structure **A** as a resonance contributor?

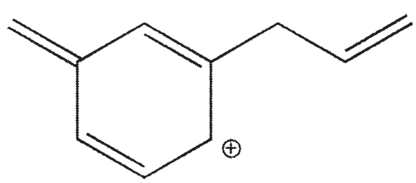


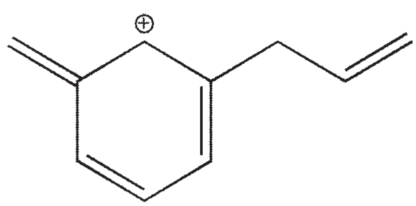
Structure A

a. 

b. 

c. 

d. 

e. 

ANS: B DIF: Medium REF: 1.4
OBJ: Identify resonance structures MSC: Analyzing

25. In the orbital interaction diagram for ground state H_2, how many electrons occupy the antibonding molecular orbital?

a. 0
b. 1
c. 2
d. 3
e. 4

ANS: A DIF: Easy REF: 1.5
OBJ: Construct molecular orbital diagrams MSC: Applying

26. How many molecular orbitals are generated from combining one 2*p* orbital on carbon and one 2*p* orbital on oxygen?
   a. 0
   b. 1
   c. 2
   d. 3
   e. 4

   ANS: C DIF: Easy REF: 1.5
   OBJ: Apply rules for molecular orbital construction MSC: Applying

27. How many antibonding molecular orbitals are generated from combining one 2*p* orbital on nitrogen and one 2*p* orbital on carbon?
   a. 0
   b. 1
   c. 2
   d. 3
   e. 4

   ANS: B DIF: Easy REF: 1.5
   OBJ: Apply rules for molecular orbital construction MSC: Applying

28. A certain orbital interaction diagram has four bonding molecular orbitals and four antibonding molecular orbitals. How many atomic orbitals were mixed to create all these orbitals?
   a. 2
   b. 4
   c. 8
   d. 16
   e. It cannot be determined from the information given.

   ANS: C DIF: Easy REF: 1.5
   OBJ: Apply rules for molecular orbital construction MSC: Applying

29. Which of the following statements about the molecular orbital diagram for H_2^- is *false*?
   a. There are two atomic orbitals that mix to produce molecular orbitals.
   b. There is one bonding molecular orbital.
   c. There is one antibonding molecular orbital.
   d. All bonding orbitals are occupied.
   e. All antibonding orbitals are unoccupied.

   ANS: E DIF: Medium REF: 1.5
   OBJ: Apply rules for molecular orbital construction MSC: Applying

30. Which of the following molecular orbitals is the highest in energy? (All were generated by the mixing of four 2*p* orbitals.)

   a. 

   b. 

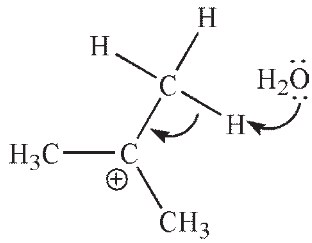
   c. 

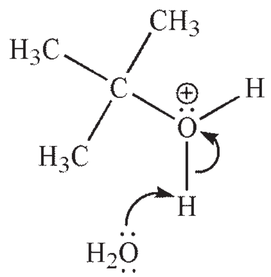
   d. 

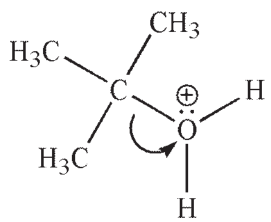
   e. All four orbitals shown are equal in energy.

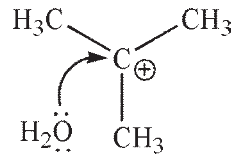
   ANS: C DIF: Difficult REF: 1.5
   OBJ: Apply rules for molecular orbital construction MSC: Applying

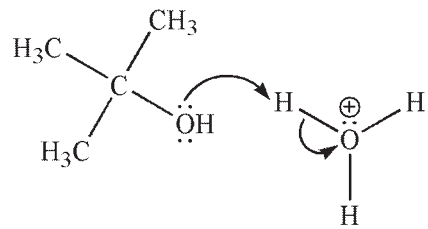
31. Each of the chemical events shown represents a mechanistic step in a reaction you will learn this semester. Which of the following pictures represents the heterolytic cleavage of a carbon–oxygen bond?

a.


b.


c.


d.


e.


ANS: C DIF: Medium REF: 1.6
OBJ: Identify types of bond cleavage MSC: Analyzing

32. Which of these orbital interactions would be expected to form a covalent bond with the highest BDE?

a. H atom 1*s* with H^+ cation 1*s*
b. He atom 1*s* with He atom 1*s*
c. He atom 1*s* with H atom 1*s*
d. H^+ cation 1*s* with He^+ cation 1*s*
e. H^+ cation 1*s* with He atom 1*s*

ANS: E DIF: Difficult REF: 1.6
OBJ: Apply rules for molecular orbital construction MSC: Applying

33. Which of the following statements is true about Lewis acids and bases?

a. Lewis acids are also called nucleophiles.
b. A Lewis base always accepts a proton from a Lewis acid.
c. The interaction between a Lewis acid and a Lewis base leads to a covalent bond.
d. A Lewis base accepts an electron pair from a Lewis acid.
e. Homolytic bond cleavage leads to the formation of a Lewis acid/base pair.

ANS: C DIF: Easy REF: 1.7
OBJ: Understand Lewis acids and bases MSC: Remembering

SHORT ANSWER

1. State the Heisenberg uncertainty principle.

   ANS:
   It is not possible to determine simultaneously both the position and momentum of an electron.

   DIF: Easy REF: 1.1 OBJ: Understand the rules for quantum mechanics
   MSC: Remembering

2. Explain what is meant by the term *quantized* as it applies to the energy of an electron.

   ANS:
   A property such as the energy of an electron is quantized when it is restricted to certain values.

   DIF: Medium REF: 1.1 OBJ: Understand the rules for quantum mechanics
   MSC: Remembering

3. What is the relationship between the principal quantum number n and the number of nodes in an orbital?

   ANS:
   The number of nodes in an orbital is one less than the principal quantum number n.

   DIF: Easy REF: 1.2 OBJ: Apply rules and properties for atomic orbitals
   MSC: Applying

4. Write the lowest-energy electron configuration for a neutral, ground-state oxygen atom.

   ANS:
   $1s^2 2s^2 2p_x^2 2p_y^1 2p_z^1$

   DIF: Easy REF: 1.2 OBJ: Write electron configurations
   MSC: Creating

5. A student wrote the following electron configuration for a ground state, neutral nitrogen atom: $1s^2 2s^2 2p_x^2 2p_y^1$. Explain why the configuration does not describe the lowest energy state of a ground-state nitrogen atom and provide the lowest-energy electron configuration for nitrogen.

   ANS:
   Nitrogen has seven electrons ($Z = 7$). The student violated Hund's rule by pairing two electrons in the same p orbital instead of placing an unpaired electron in each of the three available p orbitals, as Hund's rule states that for a given electron configuration, the state with the greatest number of parallel spins has the lowest energy. The lowest-energy electron configuration is $1s^2 2s^2 2p_x^1 2p_y^1 2p_z^1$.

   DIF: Medium REF: 1.2 OBJ: Understand the rules for quantum mechanics
   MSC: Applying

6. Define the term *node* as it applies to an orbital.

ANS:
A node is a region of space at which the electron density is zero.

DIF: Medium REF: 1.2 OBJ: Understand properties of atomic orbitals
MSC: Remembering

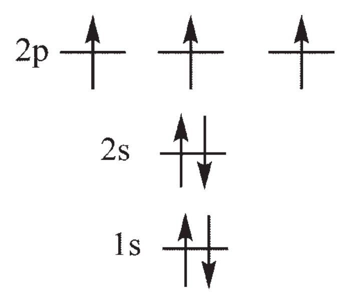
7. How many values can m_l have for quantum number $l = 5$?

ANS:
11

DIF: Medium REF: 1.2 OBJ: Apply rules for quantum numbers
MSC: Applying

8. Applying the aufbau principle and Hund's rule, construct the electronic configuration of the element nitrogen.

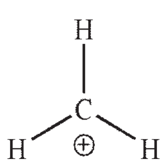
ANS:



DIF: Easy REF: 1.2 OBJ: Write electron configurations
MSC: Applying

9. Draw a Lewis structure for methyl cation, $^{+}CH_3$.

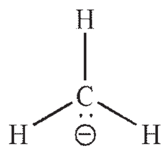
ANS:



DIF: Easy REF: 1.3 OBJ: Draw Lewis structures
MSC: Creating

10. Draw a Lewis structure for methyl anion, $^{-}CH_3$.

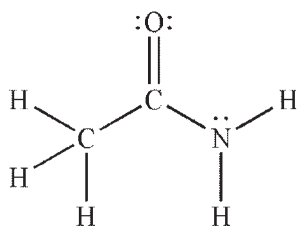
ANS:



DIF: Easy REF: 1.3 OBJ: Draw Lewis structures
MSC: Creating

11. Draw a Lewis structure for acetamide, CH_3CONH_2.

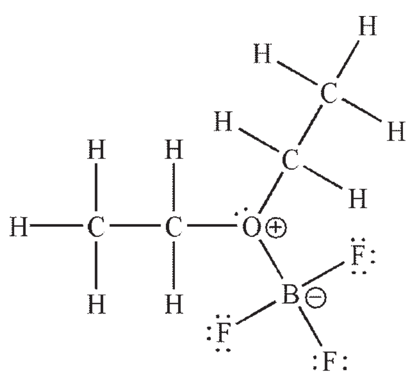
ANS:



DIF: Medium REF: 1.3 OBJ: Draw Lewis structures
MSC: Creating

12. A molecule called boron trifluoride etherate has the formula $BF_3O(CH_2CH_3)_2$. Draw a Lewis structure for this molecule, including all nonzero formal charges and lone pairs of electrons.

ANS:

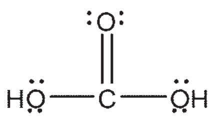
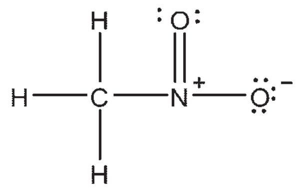
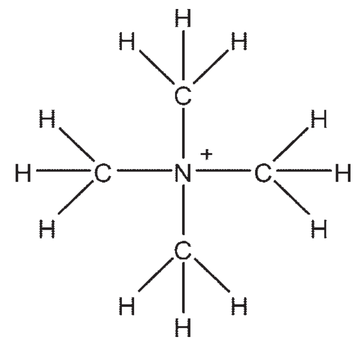


DIF: Difficult REF: 1.3 OBJ: Draw Lewis structures
MSC: Creating

13. Draw Lewis structures for the following compounds. Show all nonbonding electrons and indicate the formal charge on any atom that has a nonzero charge.

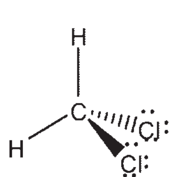
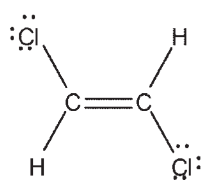
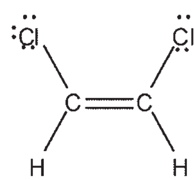
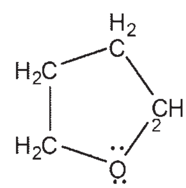
H_2CO_3 $\qquad$ CH_3NO_2 $\qquad$ $(CH_3)_4N^+$

ANS:

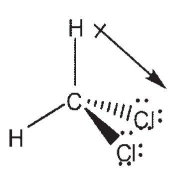
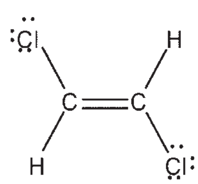




DIF: Medium REF: 1.3 OBJ: Draw Lewis structures
MSC: Creating

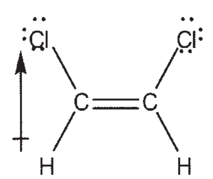
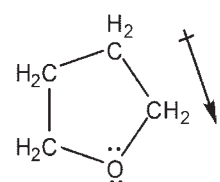
14. For each molecule shown, indicate whether the molecule is polar by drawing a dipole arrow (+⟶) pointing towards the negative end of the molecule.

ANS:

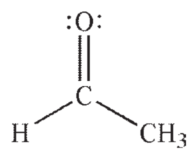



nonpolar

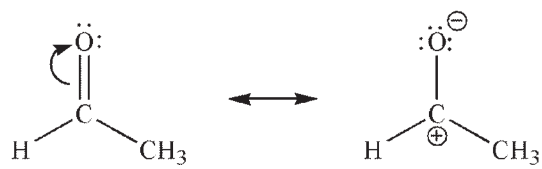



DIF: Medium REF: 1.3
OBJ: Determine polarity based on 3D structures and bond dipoles
MSC: Analyzing

15. Using the Lewis structure of acetaldehyde shown, draw an additional reasonable resonance contributor. Show the conversion of the original structure to your new structure using curved arrow formalism. Include all lone pairs of electrons and nonzero formal charges in the new structure.

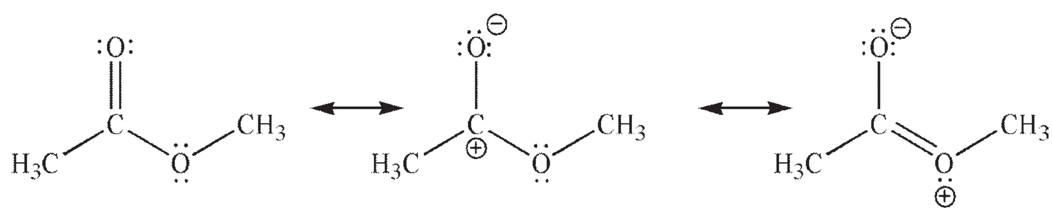


ANS:



DIF: Medium REF: 1.4 OBJ: Draw resonance forms
MSC: Creating

16. Which of the following resonance structures is the least important contributor to the resonance hybrid, and why?

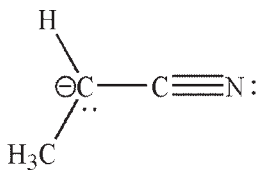


Structure A **Structure B** **Structure C**

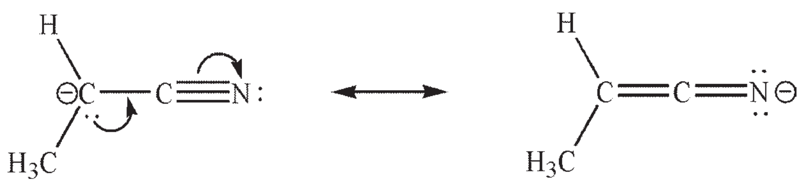
ANS:
Structure **B** is the least important contributor. In structures **A** and **C** all atoms have octets of electrons and both **A** and **C** have the same number of bonds; in **B**, carbon lacks an octet and the structure has fewer bonds than the other two contributors.

DIF: Medium REF: 1.4 OBJ: Analyze resonance forms
MSC: Evaluating

17. The Lewis structure of the anion shown has an additional resonance structure that is a more important representation for this anion. Draw the better resonance contributor, using curved arrow formalism to show how the new structure is obtained from the original structure.

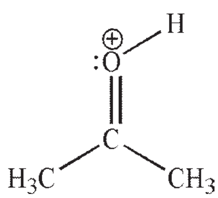


ANS:
The better resonance contributor places the negative charge on the more electronegative atom, nitrogen.

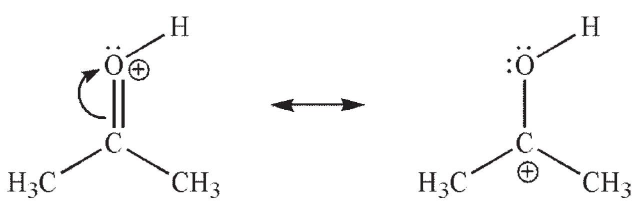


DIF: Medium REF: 1.4 OBJ: Draw resonance forms
MSC: Creating

18. The Lewis structure shown has an additional resonance contributor. Draw this contributor and determine which structure is a better contributor to the resonance hybrid. Provide a brief explanation for your choice.



ANS:

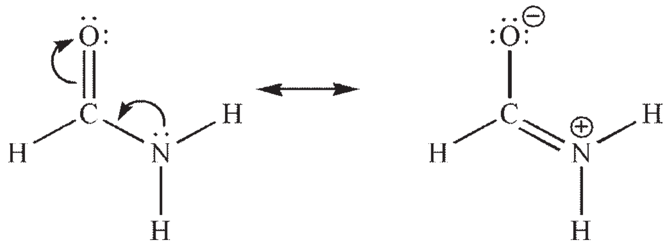


The original structure is the better contributor to the resonance hybrid, as it has more bonds and all atoms have octets of electrons.

DIF: Medium REF: 1.4 OBJ: Draw resonance forms
MSC: Evaluating

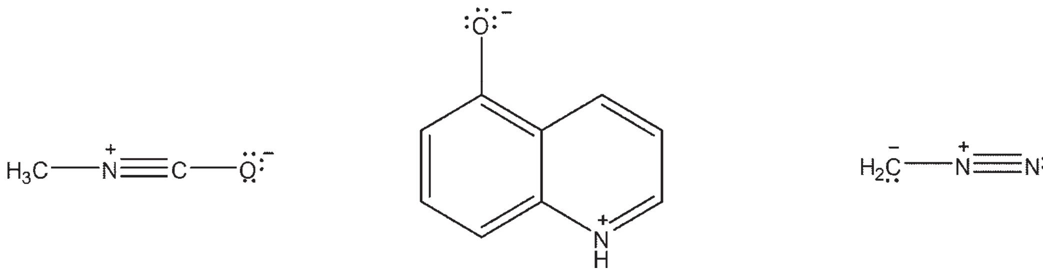
19. The carbon–nitrogen bond in formamide, $HCONH_2$, has been shown to have a bond length that is in between a typical C—N single bond and a typical C—N double bond. Provide an explanation to account for this observation, using relevant structures as support.

ANS:
Formamide has another resonance contributor that has a carbon–nitrogen double bond. The C—N bond in the resonance hybrid is thus intermediate in length between a C—N single bond and a C—N double bond.

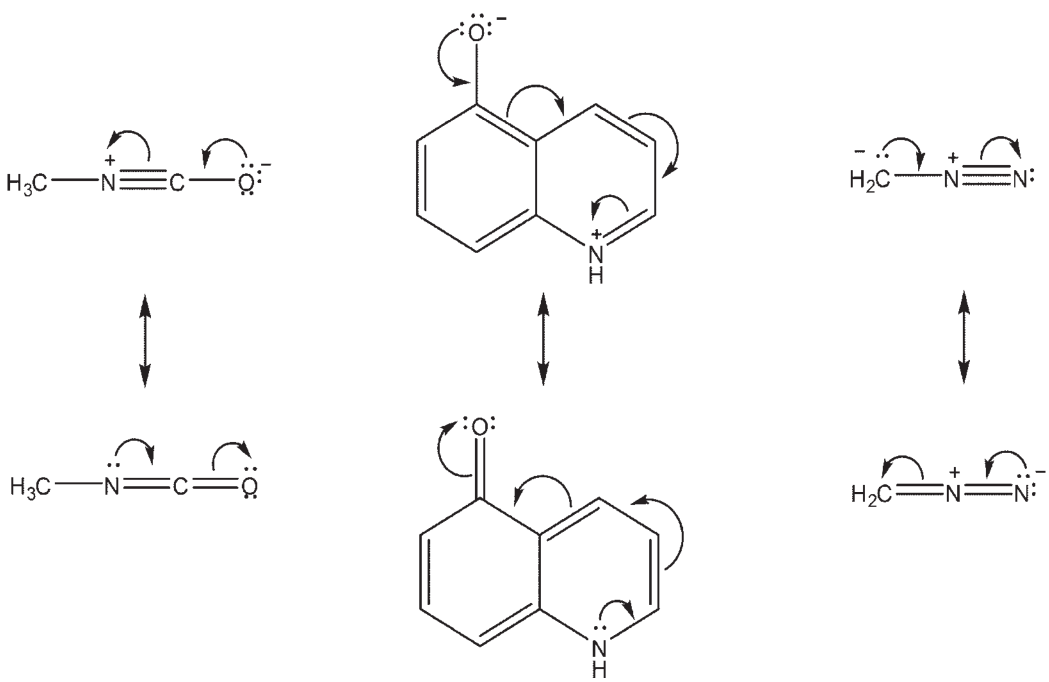


DIF: Difficult REF: 1.4 OBJ: Analyze resonance forms
MSC: Creating

20. Draw a resonance form for each of the following species that would be expected to be a better contributor. Use curved arrows to show the “movement” of electrons and double-headed arrows between the resonance structures.

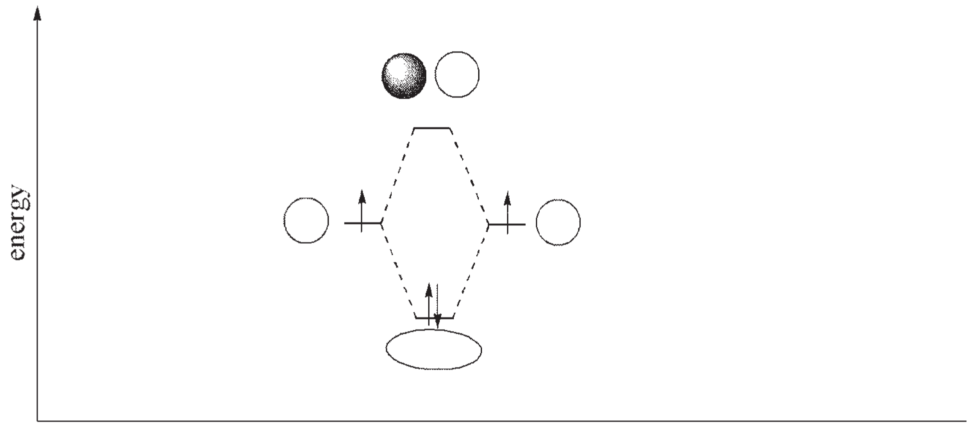


ANS:

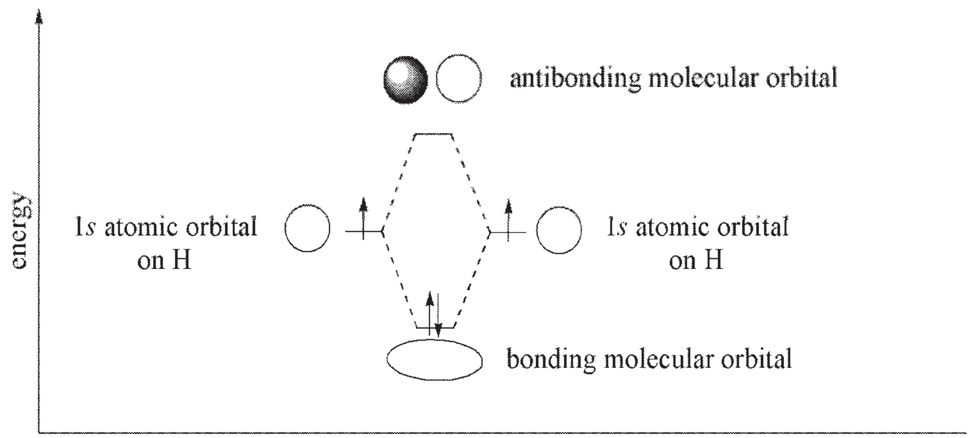


DIF: Difficult REF: 1.4 OBJ: Draw resonance forms
MSC: Creating

21. In the orbital interaction diagram for H_2 shown here, label the atomic orbitals, the bonding molecular orbital, and the antibonding molecular orbital.



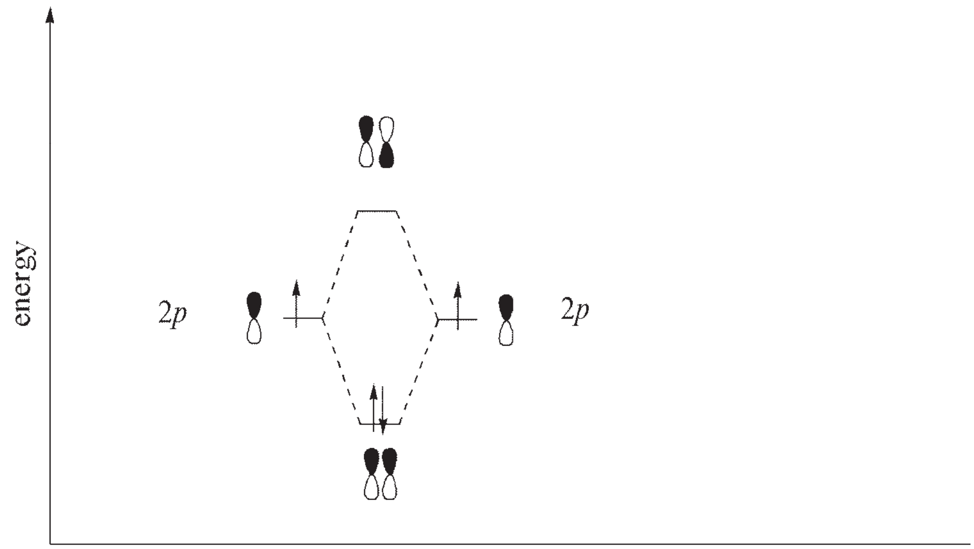
ANS:



DIF: Easy REF: 1.5 OBJ: Construct molecular orbitals diagrams
MSC: Remembering

22. Draw an orbital interaction diagram for a pair of 2*p* orbitals interacting in a side-by-side manner. Draw the atomic orbitals and the bonding and antibonding molecular orbitals and indicate the relative energy levels of all orbitals.

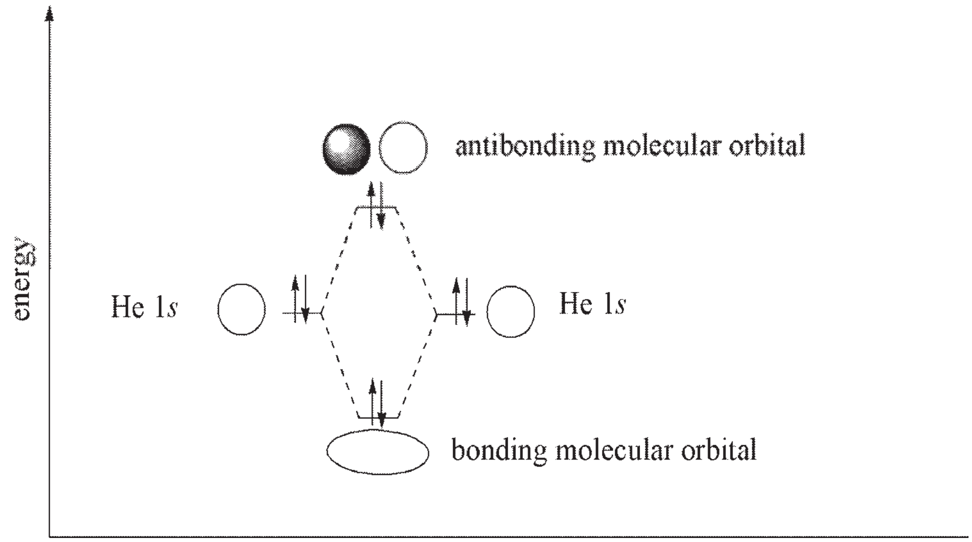
ANS:



DIF: Medium REF: 1.5 OBJ: Construct molecular orbitals diagrams
MSC: Creating

23. Use an orbital interaction diagram to provide an explanation for the fact that diatomic helium, He_2, does not exist.

ANS:

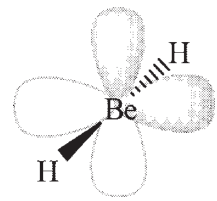


Each helium atom brings two valence electrons to the system for a total of four electrons. When these four electrons are placed in the molecular orbital diagram for He_2 according to Hund's rule, the Pauli exclusion principle, and the aufbau principle, two electrons occupy the bonding MO and two occupy the antibonding MO. Although the two electrons in the bonding MO are stabilizing, this stabilization is offset by the destabilization caused by the two electrons in the antibonding MO.

We can also reach this conclusion by calculating bond order: (electrons in bonding orbitals – electrons in antibonding orbitals)/2. For He_2, bond order = (2 – 2)/2 = 0.

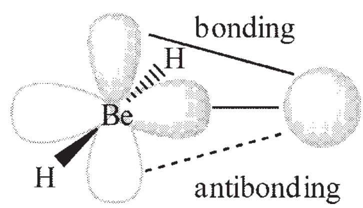
DIF: Medium REF: 1.5 OBJ: Construct molecular orbitals diagrams
MSC: Creating

24. Beryllium hydride (BeH_2) is a linear molecule with two perpendicular *p*-orbitals on the beryllium atom:



An *s*-orbital approaching BeH_2 will only be able to interact with one of the two *p*-orbitals; explain why.

ANS:
Since the two *p*-orbitals are perpendicular to each other, an *s*-orbital that interacts with one of the *p*-orbitals will be orthogonal to the second orbital:



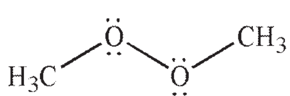
DIF: Difficult REF: 1.5 OBJ: Understand properties of atomic orbitals
MSC: Analyzing

25. Is forming a bond between an oxygen atom and a hydrogen atom endothermic or exothermic? Briefly explain your answer.

ANS:
The system described by the oxygen–hydrogen bond is more stable than the separated oxygen and hydrogen atoms. Thus, energy is released to the environment as the atoms form a bond, and the process is exothermic.

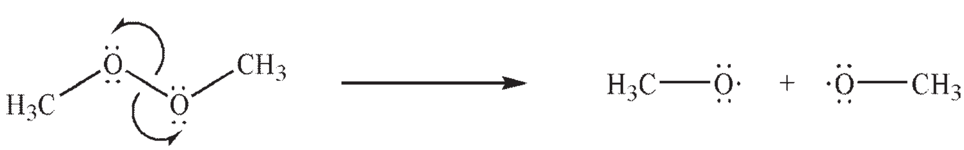
DIF: Medium REF: 1.6 OBJ: Apply thermodynamics of bond formation
MSC: Evaluating

26. Using curved arrow formalism, show the homolytic cleavage of the O—O bond in dimethyl peroxide. Draw the products of the reaction, including all lone pairs and unpaired electrons.



dimethyl peroxide

ANS:



DIF: Medium REF: 1.6 OBJ: Identify types of bond cleavage
MSC: Creating

27. Use the bond dissociation energies given to estimate the enthalpy change, $\Delta H°$, of the following reaction.

$CH_3OH + HBr \rightarrow CH_3Br + H_2O$

Bond dissociation energies (kcal/mol): C-O, 92; H-Br, 88; O-H, 119; C-Br, 72.

ANS:
−11 kcal/mol

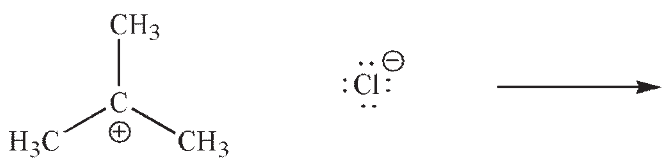
DIF: Difficult REF: 1.6 OBJ: Apply thermodynamics of bond formation
MSC: Applying

28. Define the term *Lewis base*.

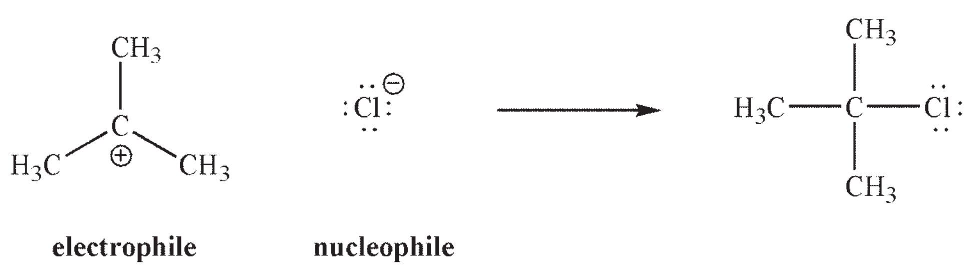
ANS:
A Lewis base is a chemical species that donates an electron pair to another chemical species in order to form a covalent bond.

DIF: Easy REF: 1.7 OBJ: Understand Lewis acids and bases
MSC: Remembering

29. Identify the nucleophile and the electrophile in the following reaction and draw the product of the reaction.

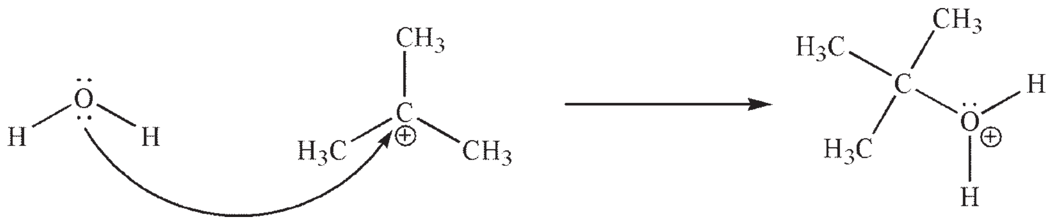


ANS:

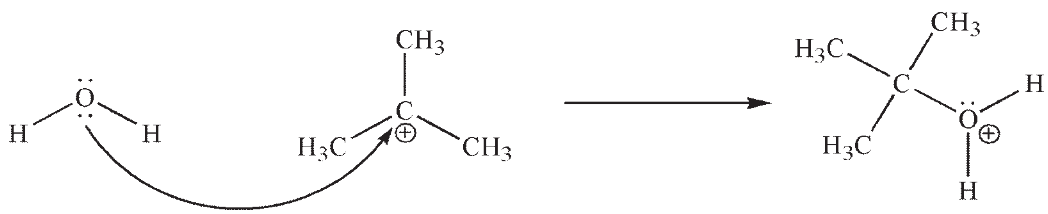


DIF: Easy REF: 1.7 OBJ: Understand Lewis acids and bases
MSC: Analyzing

30. The reaction shown here is an example of one you will learn later in the course. Identify the Lewis acid and the Lewis base in the reaction.



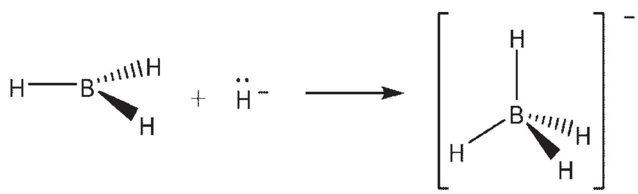
ANS:



Lewis base **Lewis acid**

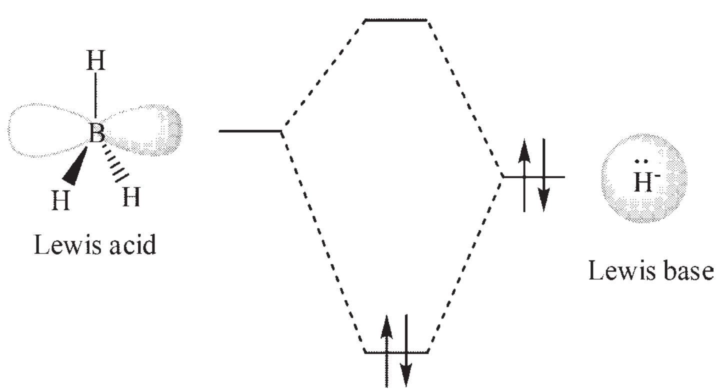
DIF: Easy REF: 1.7 OBJ: Understand Lewis acids and bases
MSC: Analyzing

31. Draw a molecular orbital diagram showing the formation of a sigma-bond between the vacant 2p orbital on boron in BH_3 and the filled 1s orbital of the hydride anion to form the borohydride anion:



Identify which species is acting as a Lewis acid and which is acting as a Lewis base in the reaction.

ANS:



DIF: Medium REF: 1.7 OBJ: Understand Lewis acids and bases
MSC: Creating