

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 $1s$ orbital is spherically symmetrical.
 - An atomic orbital may contain zero, one, or two electrons.
 - A $2s$ orbital and a $2p$ orbital are equal in energy.
 - A $2p_x$ orbital and a $2p_y$ orbital are equal in energy.
 - A $2p$ 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?
- Ionization potential decreases going across a row left to right.
 - Ionization potential increases going down a group.
 - Electron affinity increases going across a row left to right.
 - Electron affinity increases going down a group.
 - 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?
- 2
 - 3
 - 6
 - 9
 - 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?
- $n = 1, l = 0, m_l = 0, s = +\frac{1}{2}$
 - $n = 1, l = 1, m_l = 0, s = +\frac{1}{2}$
 - $n = 2, l = 1, m_l = 1, s = +\frac{1}{2}$
 - $n = 2, l = 1, m_l = -1, s = -\frac{1}{2}$
 - $n = 3, l = 0, m_l = 0, s = -\frac{1}{2}$

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 $5d$ subshell?
- $n = 5; l = 2, m_l = -3, s = \frac{1}{2}$
 - $n = 5; l = 2, m_l = -2, s = \frac{1}{2}$
 - $n = 5; l = 4, m_l = -2, s = -\frac{1}{2}$
 - $n = 5; l = 2, m_l = -2, s = 1$
 - $n = 5; l = 1, m_l = 0, s = -\frac{1}{2}$

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
- the Pauli principle
 - the aufbau principle
 - the Heisenberg uncertainty principle
 - Hund's rule
 - 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 *5d* orbital contain?
- 1
 - 2
 - 3
 - 4
 - 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 *2s* orbital?
- There are zero nodes in a *2s* orbital.
 - A *2s* orbital has one spherical node.
 - A *2s* orbital has one nodal plane.
 - A *2s* orbital has one spherical node and one nodal plane.
 - A *2s* orbital has two spherical nodes.

ANS: B DIF: Medium REF: 1.2

OBJ: Derive nodes based on quantum numbers

MSC: Analyzing

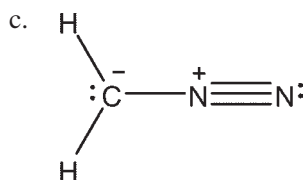
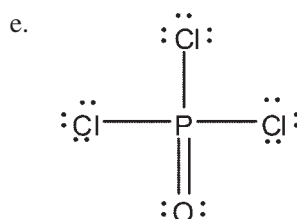
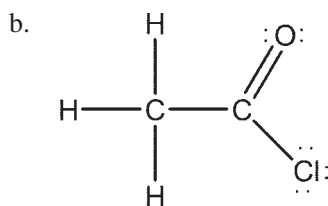
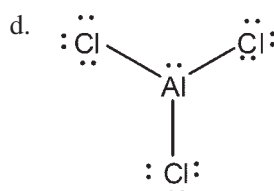
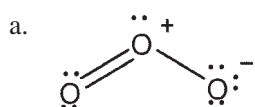
9. Which of the following statements accurately describes the node(s) in a *2p* orbital?
- There are zero nodes in a *2p* orbital.
 - A *2p* orbital has one spherical node.
 - A *2p* orbital has one nodal plane.
 - A *2p* orbital has one spherical node and one nodal plane.
 - A *2p* orbital has two spherical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

ANS: C DIF: Medium REF: 1.2

OBJ: Derive nodes based on quantum numbers

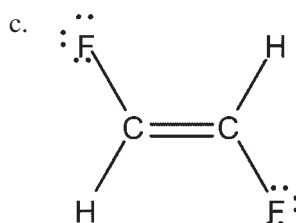
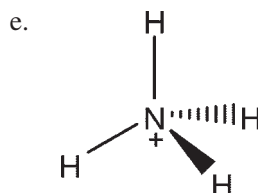
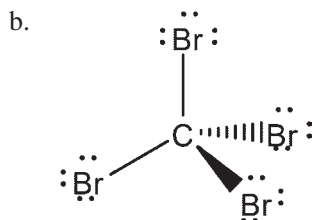
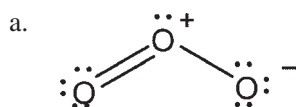
MSC: Analyzing

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



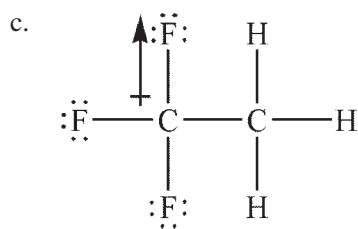
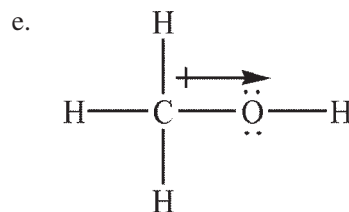
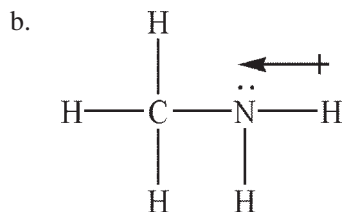
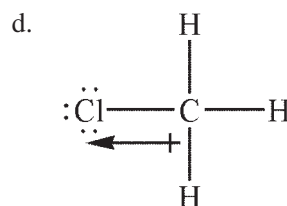
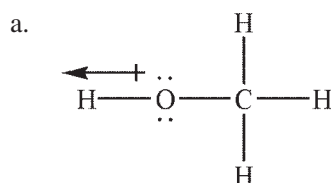
ANS: D DIF: Medium REF: 1.3
OBJ: Apply rules for Lewis structures MSC: Analyzing

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



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?

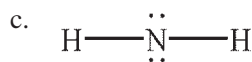
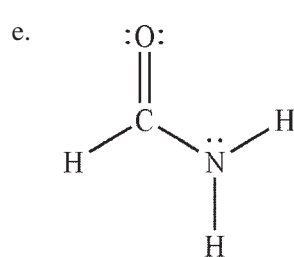
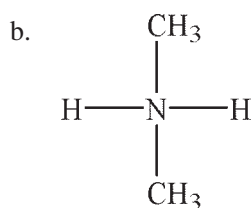
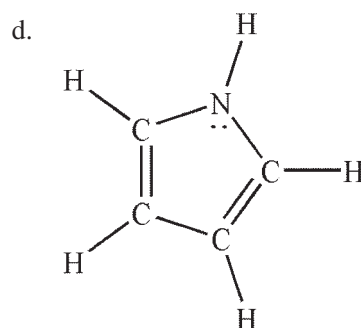
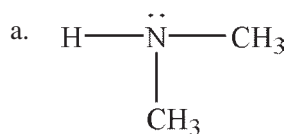


ANS: A DIF: Easy REF: 1.3

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+?



ANS: B

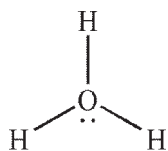
DIF: Easy

REF: 1.3

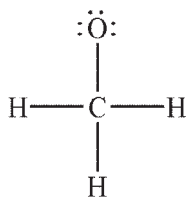
OBJ: Calculate formal charge

MSC: Applying

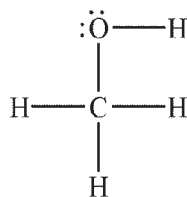
14. What is the formal charge on the oxygen atom in each of the following Lewis structures?



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

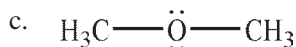
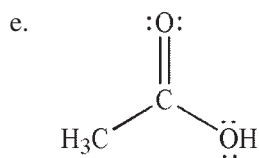
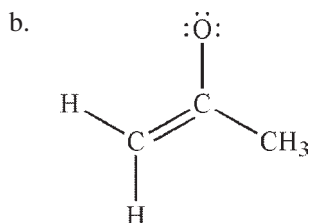
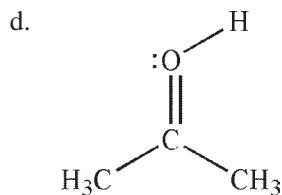
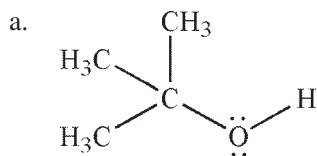
DIF: Easy

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?



ANS: D

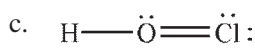
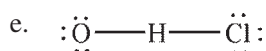
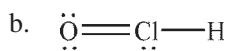
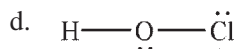
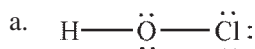
DIF: Easy

REF: 1.3

OBJ: Calculate formal charge

MSC: Applying

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



ANS: A

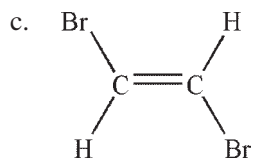
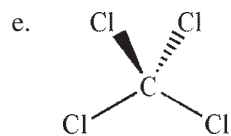
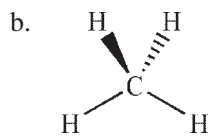
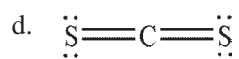
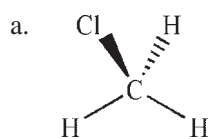
DIF: Medium

REF: 1.3

OBJ: Apply rules for Lewis structures

MSC: Analyzing

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

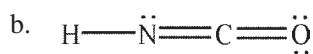
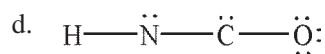


ANS: A DIF: Medium REF: 1.3

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?



e. Both c and d

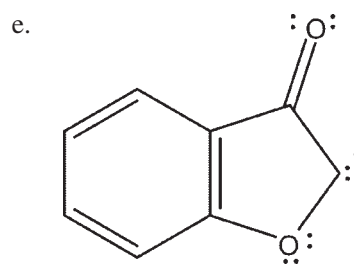
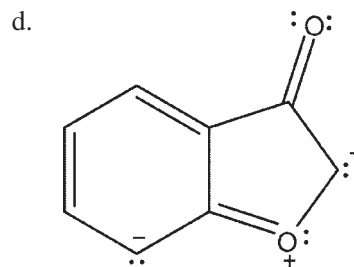
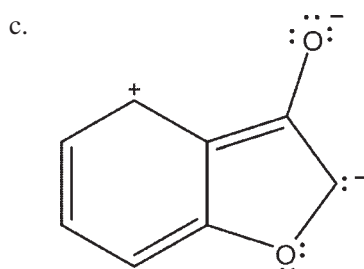
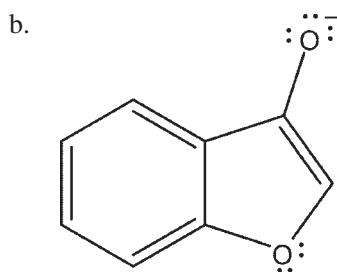
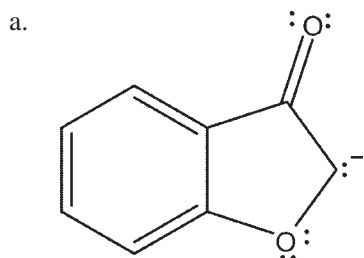


ANS: C DIF: Medium REF: 1.3

MSC: Applying

OBJ: Calculate formal charge

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



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?



e. Both a and b

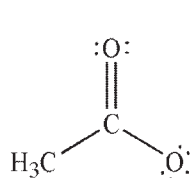
ANS: A DIF: Easy

REF: 1.4

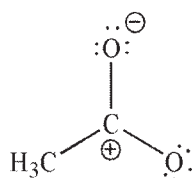
OBJ: Identify resonance structures

MSC: Remembering

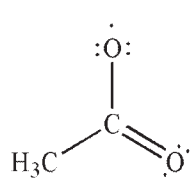
21. Which two of the following structures are *equivalent* resonance contributors?



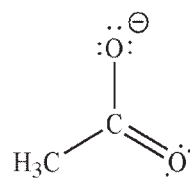
Structure A



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

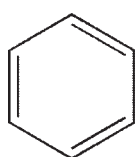
REF: 1.4

OBJ: Identify resonance structures

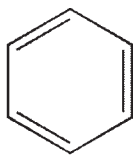
MSC: Analyzing

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

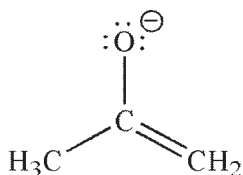
a.



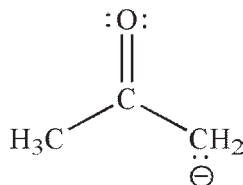
and



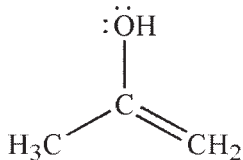
b.



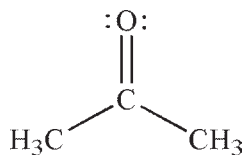
and



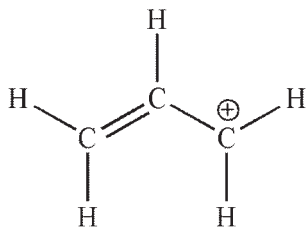
c.



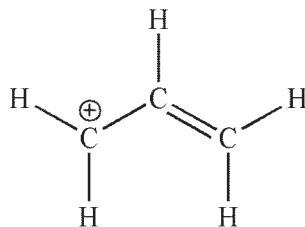
and



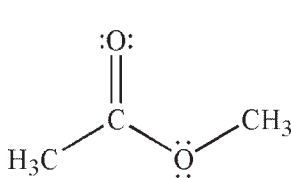
d.



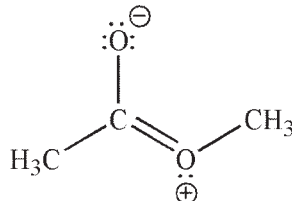
and



e.



and



ANS: C

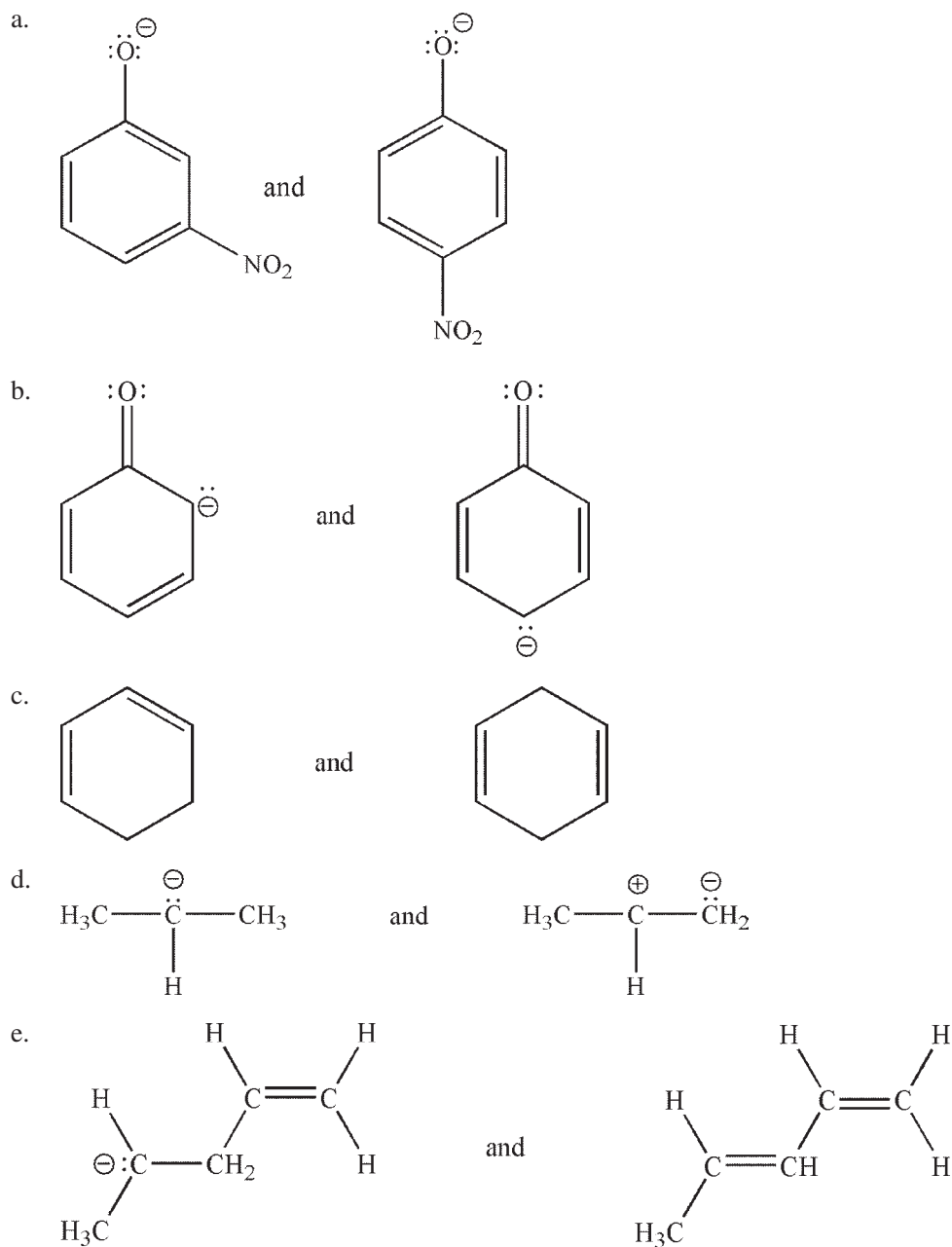
DIF: Medium

REF: 1.4

OBJ: Identify resonance structures

MSC: Analyzing

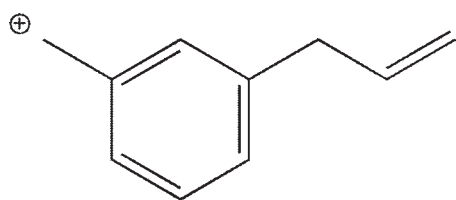
23. Which of the following pairs are related as resonance structures? All nonzero formal charges are shown.



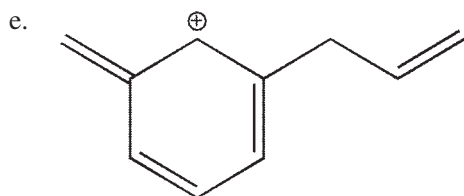
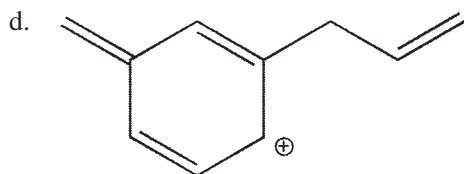
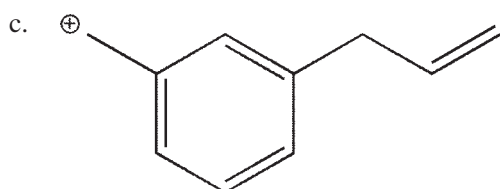
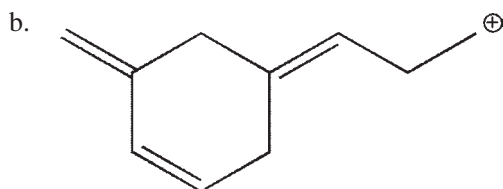
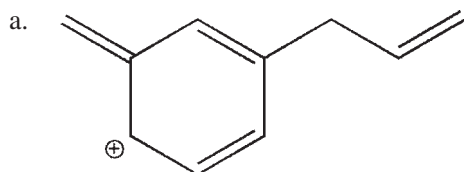
ANS: B DIF: Medium
OBJ: Identify resonance structures

REF: 1.4
MSC: Analyzing

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



Structure A



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

d. 3

b. 1

e. 4

c. 2

ANS: A

DIF: Easy

REF: 1.5

OBJ: Construct molecular orbital diagrams

MSC: Applying

26. How many molecular orbitals are generated from combining one $2p$ orbital on carbon and one $2p$ orbital on oxygen?
- 0
 - 1
 - 2
 - 3
 - 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 $2p$ orbital on nitrogen and one $2p$ orbital on carbon?
- 0
 - 1
 - 2
 - 3
 - 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?
- 2
 - 4
 - 8
 - 16
 - It cannot be determined from the information given.

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

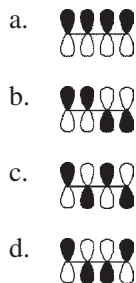
MSC: Applying

29. Which of the following statements about the molecular orbital diagram for H_2^- is *false*?
- There are two atomic orbitals that mix to produce molecular orbitals.
 - There is one bonding molecular orbital.
 - There is one antibonding molecular orbital.
 - All bonding orbitals are occupied.
 - 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 $2p$ orbitals.)

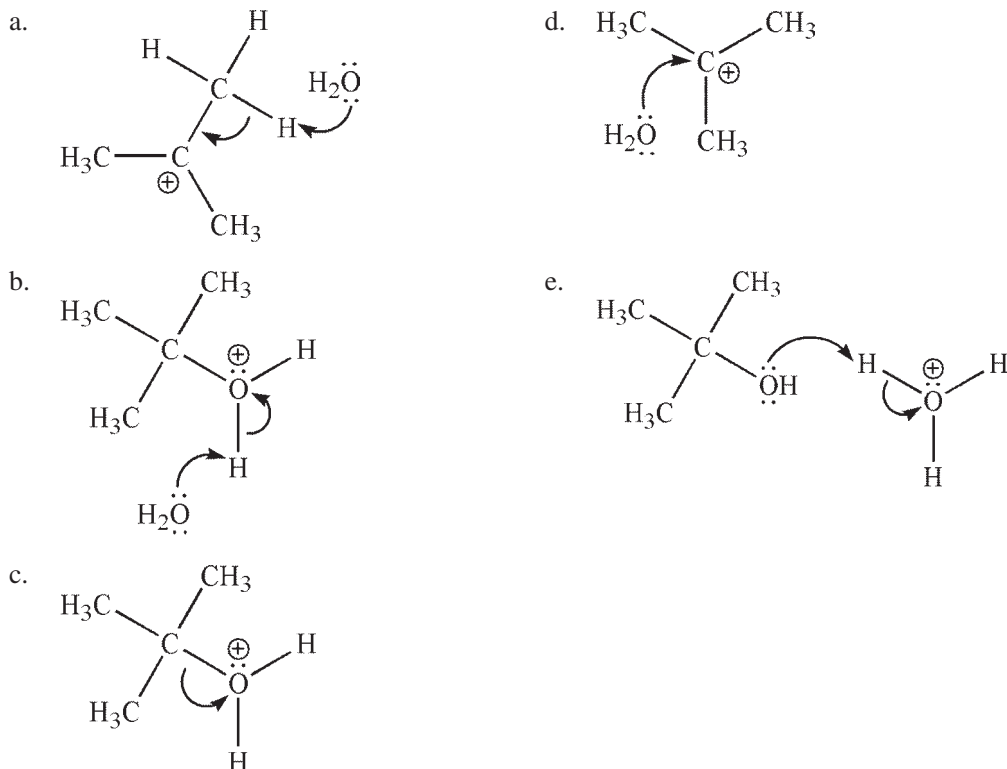


- e. All four orbitals shown are equal in energy.

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?



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?
- H atom 1s with H⁺ cation 1s
 - He atom 1s with He atom 1s
 - He atom 1s with H atom 1s
 - H⁺ cation 1s with He⁺ cation 1s
 - H⁺ cation 1s with He atom 1s

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?
- Lewis acids are also called nucleophiles.
 - A Lewis base always accepts a proton from a Lewis acid.
 - The interaction between a Lewis acid and a Lewis base leads to a covalent bond.
 - A Lewis base accepts an electron pair from a Lewis acid.
 - 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

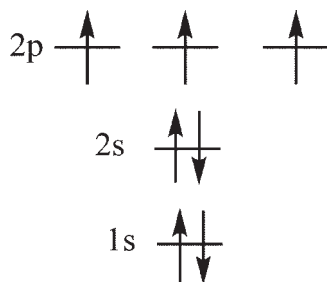
DIF: Medium REF: 1.2

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

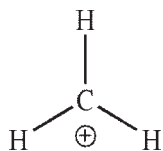
REF: 1.2

OBJ: Write electron configurations

MSC: Applying

9. Draw a Lewis structure for methyl cation, ${}^+\text{CH}_3$.

ANS:



DIF: Easy

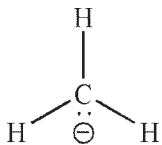
REF: 1.3

OBJ: Draw Lewis structures

MSC: Creating

10. Draw a Lewis structure for methyl anion, ${}^{-}\text{CH}_3$.

ANS:



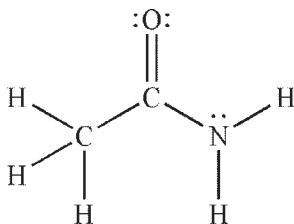
DIF: Easy
MSC: Creating

REF: 1.3

OBJ: Draw Lewis structures

11. Draw a Lewis structure for acetamide, CH_3CONH_2 .

ANS:



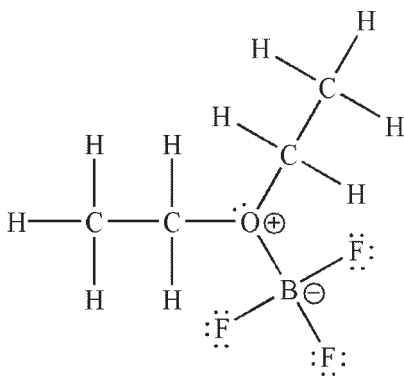
DIF: Medium
MSC: Creating

REF: 1.3

OBJ: Draw Lewis structures

12. A molecule called boron trifluoride etherate has the formula $\text{BF}_3\text{O}(\text{CH}_2\text{CH}_3)_2$. Draw a Lewis structure for this molecule, including all nonzero formal charges and lone pairs of electrons.

ANS:

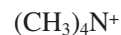


DIF: Difficult
MSC: Creating

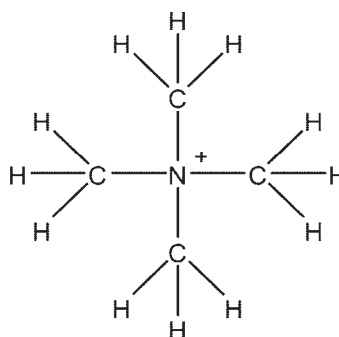
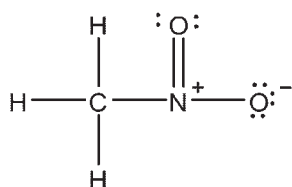
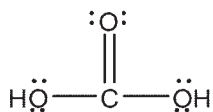
REF: 1.3

OBJ: Draw Lewis structures

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.



ANS:

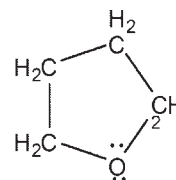
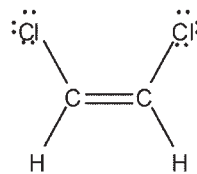
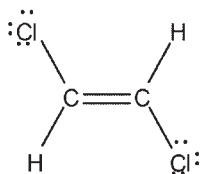
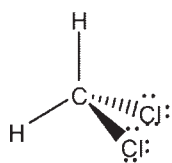


DIF: Medium
MSC: Creating

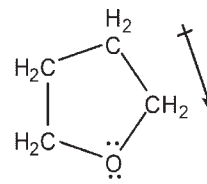
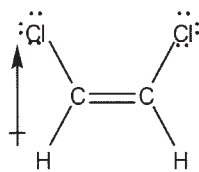
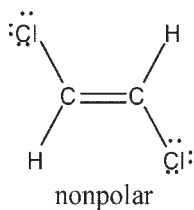
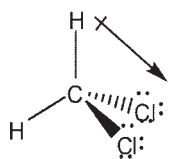
REF: 1.3

OBJ: Draw Lewis structures

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



ANS:



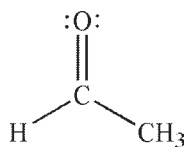
DIF: Medium

REF: 1.3

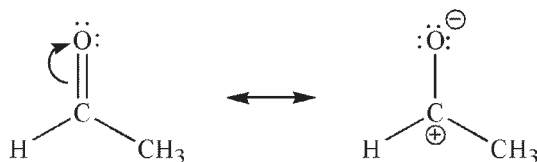
OBJ: Determine polarity based on 3D structures and bond dipoles

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:

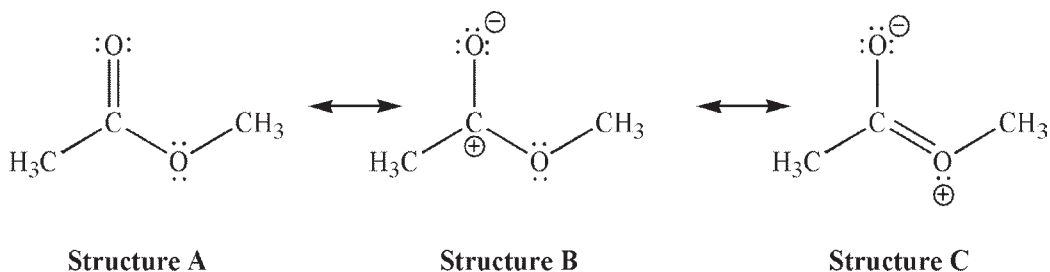


DIF: Medium
MSC: Creating

REF: 1.4

OBJ: Draw resonance forms

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



ANS:

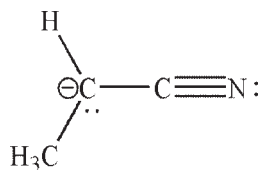
Structure **B** is the least important contributor. In structures **A** and **C** all atoms have octets of electrons and both **A** and **C** have the same number of bonds; in **B**, carbon lacks an octet and the structure has fewer bonds than the other two contributors.

DIF: Medium
MSC: Evaluating

REF: 1.4

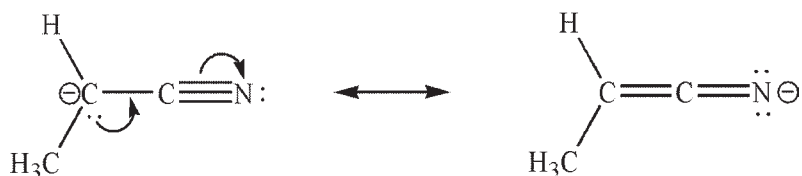
OBJ: Analyze resonance forms

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.

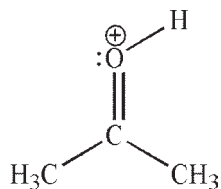


DIF: Medium
MSC: Creating

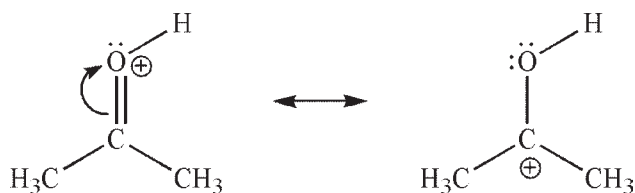
REF: 1.4

OBJ: Draw resonance forms

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
MSC: Evaluating

REF: 1.4

OBJ: Draw resonance forms