TEST BANK

Organic Chemistry: Principles and Mechanisms

Second 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

We first conducted a focus group with the brightest minds in educational testing to create a new model for assessment. A good assessment tool needs to do several things: (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 based on the assessment outcomes in terms of what they know, what they don't know, and the depth of their knowledge. Accurate assessments of student mastery allow instructors to focus on areas where students need the most help in learning.

HOW DOES IT WORK?

For each chapter, the learning objectives that students could be expected to master by reading the text are listed. The questions are identified as remembering, understanding, applying, analyzing, evaluating, and creating. This classification is patterned after Bloom's taxonomy of educational objectives. Bloom listed six levels of learning: knowledge (information), comprehension, application, analysis, synthesis, and evaluation. Questions are also posed at three difficulty levels: easy, medium, and difficult. 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 (classified according to Bloom's taxonomy):

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 engage 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 topics discussed in the text.

Each question is linked to links to a specific learning objective and is written in clear, concise, and grammatically correct language appropriate for the learning objective and difficulty level being assessed. Every effort is made to eliminate bias (e.g. race, gender, cultural, ethnic, regional, handicap, age) to focus on the material and to assure validity and reliability.

KEY TO THE QUESTION META-DATA

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 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 (described above) that the question is designed to test.

Test Bank files are available in Word, PDF, and ExamView® Assesment Suite formats.

Finally, we would like to thank Suazette Mooring of Georgia State University and Joshua Osbourn of West Virginia University, whose careful review improved the accuracy and usefulness of this product.

Chapter 1: Atomic and Molecular Structure

LEARNING OBJECTIVES

Determine the number of valence and/or core electrons for an atom or ion.

Interpret the electron configuration and formal charge for an atom or ion.

Identify forces that are involved in chemical bonding.

Analyze an energy versus internuclear distance diagram to understand the properties of a chemical bond.

Predict the properties of a covalent bond based on known periodic trends, and vice versa.

Assess the validity of a Lewis structure.

Apply knowledge of chemical structure to determine the formal charge of an unknown species.

Compare a series of structures to determine if they are resonance structures.

Determine the molecular formula of an organic compound from a structural drawing or condensed formula.

Master the structural drawing of organic molecules—specifically, Lewis structures and line structures.

Assimilate your knowledge of molecular structure to identify and/or draw organic functional groups.

Identify the key structural features of amino acids, saccharides, and nucleotides.

Deduce and draw the resonance structures that contribute to the resonance hybrid, and vice versa.

Elaborate how an electrostatic potential map correlates to molecular structure and properties.

Predict the ionic or covalent nature of an organic structure from physical property data.

Indicate bond dipoles and lone pairs on an organic structure, and predict how these structural features impact chemical reactivity.

Apply the concept of resonance to predict the outcome of a chemical reaction.

Depict electron delocalization via resonance using appropriate arrow notation.

Recognize and name functional groups within a complex molecule.

Draw a structure of a given molecular formula that contains a specific functional group.

MULTIPLE CHOICE

1. Which orbital does NOT house core electrons for a bromine atom?
   a. $1s$
   b. $4p$
   c. $3p$
   d. $2s$
   e. $3s$

   ANS: B DIF: Easy REF: 1.3
   OBJ: Determine the number of valence and/or core electrons for an atom or ion.
   MSC: Remembering

2. An atom of which element would have an electron configuration of $1s^22s^22p^63s^23p^1$?
   a. Al
   b. Ne
   c. B
   d. Si
   e. Na

   ANS: A DIF: Easy REF: 1.3
   OBJ: Interpret the electron configuration and formal charge for an atom or ion.
   MSC: Understanding

3. Which electron configuration is correct for a carbon atom with a formal charge of -1?
   a. $1s^22s^22p^63s^1$
   b. $1s^22s^22p^3$
   c. $1s^22s^22p^5$
   d. $1s^22s^22p^63s^23p^5$
   e. $1s^22s^22p^4$

   ANS: B DIF: Easy REF: 1.3 | 1.9
   OBJ: Interpret the electron configuration and formal charge for an atom or ion.
   MSC: Understanding

4. Which electron configuration is correct for the carbon of a carbocation?
   a. $1s^22s^22p^1$
   b. $1s^22s^22p^3$
   c. $1s^22s^22p^5$
   d. $1s^22s^22p^63s^23p^5$
   e. $1s^22s^22p^4$

   ANS: A DIF: Easy REF: 1.3 | 1.9
   OBJ: Interpret the electron configuration and formal charge for an atom or ion.
   MSC: Understanding

5. Which electron configuration is correct for a Ca^{2+} ion?
   a. $1s^22s^22p^63s^23p^1$
   b. $1s^22s^22p^63s^23p^64s^2$
   c. $1s^22s^22p^63s^23p^6$
   d. $1s^22s^22p^63s^23p^64s^24p^6$
   e. $1s^22s^22p^63s^2$

   ANS: C DIF: Easy REF: 1.3 | 1.9
   OBJ: Interpret the electron configuration and formal charge for an atom or ion.
   MSC: Applying

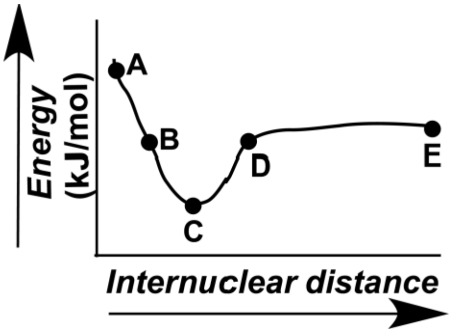
6. How many valence electrons are assigned to oxygen when determining formal charge in the ionic compound sodium methoxide, $NaOCH_3$?
   a. 4
   b. 5
   c. 6
   d. 7
   e. 8

   ANS: D DIF: Easy REF: 1.3 | 1.9
   OBJ: Determine the number of valence and/or core electrons for an atom or ion.
   MSC: Analyzing

7. Which of the following is an example of an electrostatic attractive force between particles at the atomic level?
   a. Neutrons attract protons.
   b. Protons repel protons.
   c. Core electrons attract valence electrons.
   d. Protons attract electrons.
   e. Electrons attract neutrons.

ANS: D DIF: Moderate REF: 1.4
OBJ: Identify forces that are involved in chemical bonding. MSC: Remembering

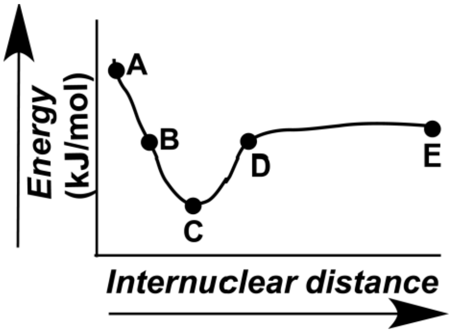
8. Which point on the following diagram represents two atoms functioning independently?



a. A
b. B
c. C
d. D
e. E

ANS: E DIF: Moderate REF: 1.4
OBJ: Analyze an energy versus internuclear distance diagram to understand the properties of a chemical bond. MSC: Analyzing

9. Which point on the following diagram can be extrapolated to identify the length and strength of a chemical bond?



a. A
b. B
c. C
d. D
e. E

ANS: C DIF: Difficult REF: 1.4
OBJ: Analyze an energy versus internuclear distance diagram to understand the properties of a chemical bond. MSC: Analyzing

10. A C—O single bond is 143 pm in length, whereas an O—O single bond is 148 pm in length. Which bond is weaker and why?
a. The C—O bond is weaker because O is more electronegative than C.
b. The C—O bond is weaker because each O atom is electronegative and pulls the shared electrons toward itself.
c. The O—O bond is weaker because oxygen has *d* orbitals to engage in bonding.
d. The C—O bond is weaker because C is more electronegative than O.
e. The O—O bond is weaker because both oxygens are equally electronegative and pull the shared electrons toward themselves.

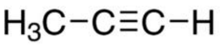
ANS: E DIF: Moderate REF: 1.4
OBJ: Predict the properties of a covalent bond based on known periodic trends, and vice versa.
MSC: Evaluating

11. How many total valence electrons are used in the structure of ammonium chloride, NH_4Cl?
a. 13
b. 14
c. 15
d. 16
e. 28

ANS: D DIF: Easy REF: 1.5

OBJ: Determine the number of valence and/or core electrons for an atom or ion.
MSC: Analyzing

12. Which of the following Lewis structures violates the octet rule and is therefore incorrect?



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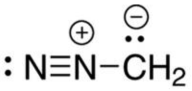

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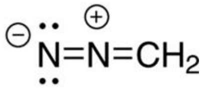

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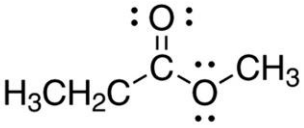

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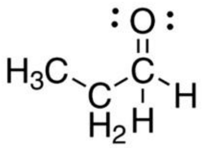
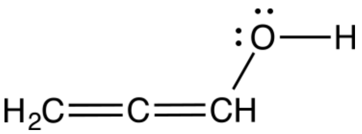


V

a. Structure I
b. Structure II
c. Structure III
d. Structure IV
e. Structure V

ANS: E DIF: Moderate REF: 1.5
OBJ: Assess the validity of a Lewis structure. MSC: Analyzing

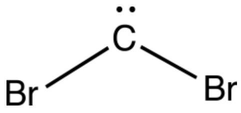
13. Evaluate the following Lewis structure and determine its legitimacy.



a. The structure is legitimate.
b. The structure is not legitimate, because the oxygen does not have an octet.
c. The structure is not legitimate, because the formal charges are not shown.
d. The structure is not legitimate, because the middle carbon lacks an octet.
e. The structure is not legitimate, because the leftmost carbon is missing a lone pair.

ANS: A DIF: Moderate REF: 1.5 | 1.6
OBJ: Assess the validity of a Lewis structure. MSC: Evaluating

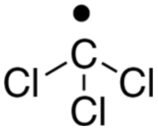
14. Consider the interesting structure below, called a dibromocarbene. The carbon of the dibromocarbene has one lone electron pair and two separate covalent bonds to individual bromine atoms. What is the formal charge on the carbon atom of the dibromocarbene?



a. +2
b. +1
c. 0
d. –1
e. –2

ANS: C DIF: Easy REF: 1.9
OBJ: Apply knowledge of chemical structure to determine the formal charge of an unknown species.
MSC: Understanding

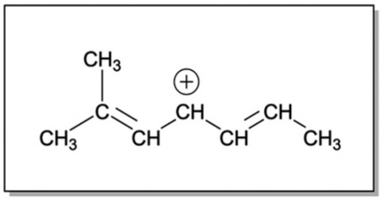
15. Consider the interesting structure below, called a free radical. The carbon of this free radical has one unpaired electron and three separate covalent bonds to individual chlorine atoms. What is the formal charge on the carbon atom?

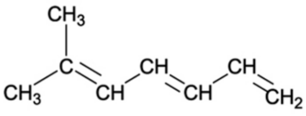


a. +2
b. +1
c. 0
d. –1
e. –2

ANS: C DIF: Moderate REF: 1.9
OBJ: Apply knowledge of chemical structure to determine the formal charge of an unknown species.
MSC: Applying

16. Which of the following is a resonance structure of the given molecule?





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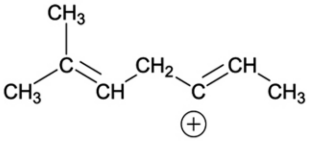

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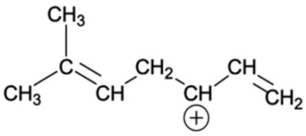

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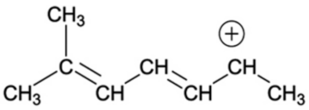

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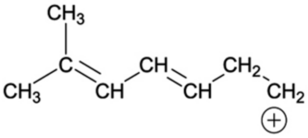
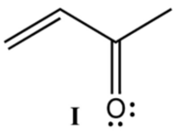


V

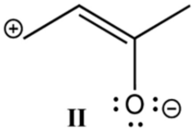
a. I
b. II
c. III
d. IV
e. V

ANS: D DIF: Moderate REF: 1.10
OBJ: Compare a series of structures to determine if they are resonance structures.
MSC: Analyzing

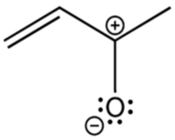
17. Which individual structures below could be contributing resonance structures to the given hybrid structure?



I



II



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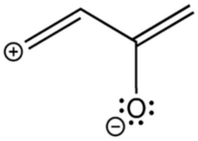

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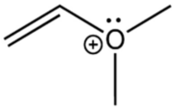
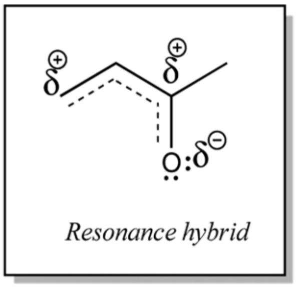


V



Resonance hybrid

a. All are contributing structures.
b. All but V are contributing structures.
c. I, II, and III are contributing structures.
d. I, III, and IV are contributing structures.
e. Only I and III are contributing structures.

ANS: C DIF: Moderate REF: 1.10
OBJ: Deduce and draw the resonance structures that contribute to the resonance hybrid, and vice versa.

MSC: Evaluating

18. When two Lewis structures are related as resonance forms, which of the following are true?

I. When compared, the resonance forms have the same atoms connected in the same order.
II. Either individual Lewis structure can be used as an accurate representation of valence electron distribution.
III. Electrons in single bonds may be delocalized in the resonance forms.
IV. Electrons in a multiple bond may be delocalized in the resonance forms.
V. A lone pair of electrons on an atom adjacent to a multiple bond can be delocalized in the resonance forms.

a. All are true.
b. Only I, II, IV, and V are true.
c. Only I, III, IV, and V are true.
d. Only I, IV, and V are true.
e. Only I and IV are true.

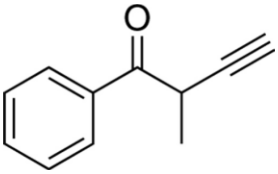
ANS: D DIF: Difficult REF: 1.10 | 1.11
OBJ: Compare a series of structures to determine if they are resonance structures.
MSC: Evaluating

19. Which of following does NOT suggest that another resonance structure exists?

a. a lone pair of electrons adjacent to a multiple bond
b. an incomplete octet on an atom adjacent to a multiple bond
c. a lone pair of electrons on an atom adjacent to an atom with an incomplete octet
d. a ring containing an atom with an incomplete octet
e. a ring of alternating single and double bonds

ANS: D DIF: Easy REF: 1.11
OBJ: Depict electron delocalization via resonance using appropriate arrow notation.
MSC: Remembering

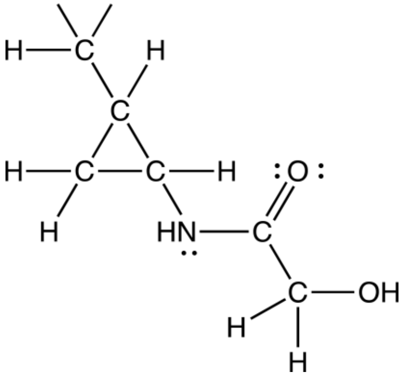
20. How many hydrogen atoms are in the following molecule?



a. 7
b. 8
c. 9
d. 10
e. 11

ANS: D DIF: Easy REF: 1.12
OBJ: Master the structural drawing of organic molecules—specifically, Lewis structures and line structures. MSC: Understanding

21. What is the molecular formula of this compound?

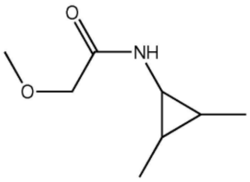


a. $C_6H_{12}NO_2$
b. $C_5H_{12}NO_2$
c. $C_5H_{11}NO_2$
d. $C_6H_{11}NO_2$
e. $C_6H_{13}NO_2$

ANS: D DIF: Easy REF: 1.12

OBJ: Determine the molecular formula of an organic compound from a structural drawing or condensed formula. MSC: Understanding

22. Which line structure is correct for Molecule Z?



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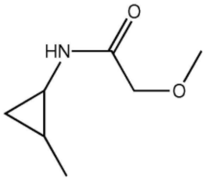

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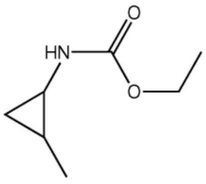

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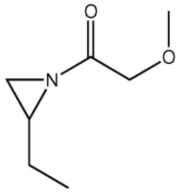

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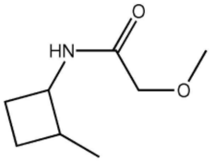
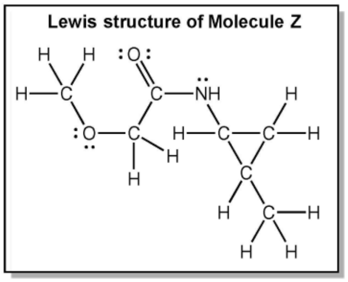


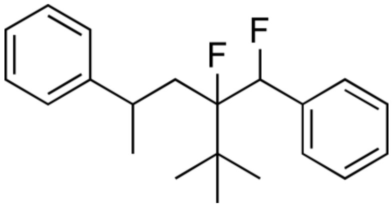
V



a. I
b. II
c. III
d. IV
e. V

ANS: B DIF: Moderate REF: 1.12
OBJ: Master the structural drawing of organic molecules—specifically, Lewis structures and line structures. MSC: Understanding

23. In sum, how many total hydrogen atoms are directly connected to the benzene rings found in the following molecule?



a. 8
b. 9
c. 10
d. 11
e. 12

ANS: C DIF: Moderate REF: 1.12
OBJ: Assimilate your knowledge of molecular structure to identify and/or draw organic functional groups. MSC: Understanding

24. Which condensed formula contains an aldehyde functional group?

a. CH_3COCH_3
b. $CH_3CO_2CH_2CH_3$
c. $CH_3CH_2CH_2COOH$
d. CH_3CH_2OH
e. CH_3CHO

ANS: E DIF: Moderate REF: 1.12 | 1.13
OBJ: Assimilate your knowledge of molecular structure to identify and/or draw organic functional groups. MSC: Applying

25. Which condensed formula contains a carboxylic acid?

a. CH_3COCH_3
b. $CH_3CO_2CH_2CH_3$
c. $CH_3CH_2CH_2COOH$
d. CH_3CH_2OH
e. CH_3CHO

ANS: C DIF: Moderate REF: 1.12 | 1.13
OBJ: Assimilate your knowledge of molecular structure to identify and/or draw organic functional groups. MSC:

Applying

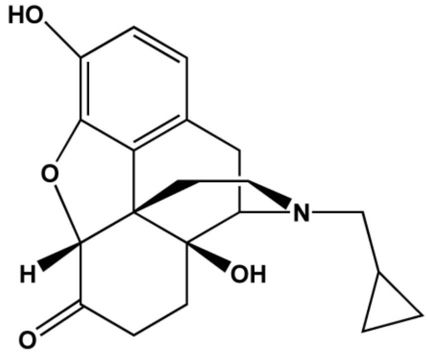
26. Which condensed formula contains a ketone?
    a. CH_3COCH_3
    b. $CH_3CO_2CH_2CH_3$
    c. $CH_3CH_2CH_2COOH$
    d. CH_3CH_2OH
    e. CH_3CHO

ANS: A DIF: Moderate REF: 1.12 | 1.13
OBJ: Assimilate your knowledge of molecular structure to identify and/or draw organic functional groups. MSC: Applying

27. Which condensed formula contains an ester?
    a. $(CH_3CH_2)_2O$
    b. $CH_3CO_2CH_2CH_3$
    c. $CH_3CH_2CH_2COOH$
    d. CH_3CH_2OH
    e. CH_3CHO

ANS: B DIF: Moderate REF: 1.12 | 1.13
OBJ: Assimilate your knowledge of molecular structure to identify and/or draw organic functional groups. MSC: Applying

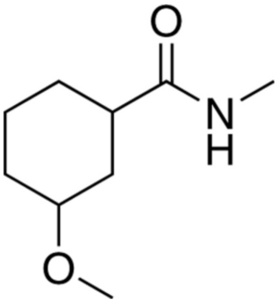
28. Naltrexone is an FDA-approved treatment for alcoholism that targets the mu opioid receptor. Name four functional groups that are present in naltrexone.



    a. amine, phenol, aldehyde, ether
    b. amine, phenol, amide, alcohol
    c. amine, phenol, ketone, alcohol
    d. ether, ketone, amide, alcohol
    e. ketone, phenol, alcohol, ester

ANS: C DIF: Moderate REF: 1.13
OBJ: Assimilate your knowledge of molecular structure to identify and/or draw organic functional groups. MSC: Applying

29. Which functional group is present in the following molecule?



    a. amine
    b. alcohol
    c. ketone
    d. ester
    e. ether

ANS: E DIF: Moderate REF: 1.13
OBJ: Recognize and name functional groups within a complex molecule.
MSC: Analyzing

30. Which of the following α–amino acids possesses two hydrogen atoms adjacent to the carboxylic acid?

a. serine
b. phenylalanine
c. glycine
d. tryptophan
e. lysine

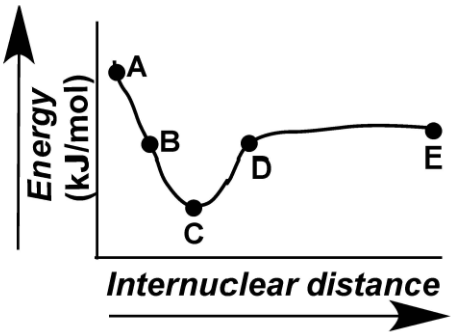
ANS: C DIF: Easy REF: 1.14
OBJ: Identify the key structural features of amino acids, saccharides, and nucleotides.
MSC: Remembering

31. For which of the following α–amino acids can resonance forms be drawn for its side chain?
a. alanine
b. methionine
c. glycine
d. proline
e. histidine

ANS: E DIF: Moderate REF: 1.14
OBJ: Identify the key structural features of amino acids, saccharides, and nucleotides.
MSC: Remembering

SHORT ANSWER

1. The evolution of a chemical bond can be tracked by plotting energy versus internuclear distance, as shown in the figure here. Describe what is occurring at the atomic level for points A–E on the graph.



ANS:
POINT A. Point of highest energy, because the two positive nuclei are pushed close together. Like charges repel.
POINT B. The positively charged nuclei are farther apart; thus, this data point occurs at lower energy than Point A.
POINT C. Point of lowest energy; this is the optimum internuclear distance to form a chemical bond.
POINT D. Nuclei are farther apart and weakly bonded to one another.
POINT E. Nuclei are functioning independently, and the internuclear distance is too great for a chemical bond to form.

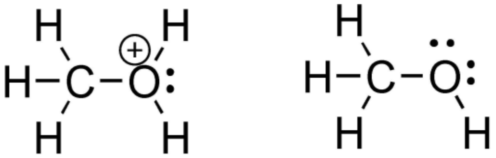
DIF: Moderate REF: 1.4
OBJ: Analyze an energy versus internuclear distance diagram to understand the properties of a chemical bond. MSC: Understanding

2. Which would you expect to be a stronger bond: C–Si or C–C? Explain your response.

ANS:
A C–Si single bond is weaker and longer than a C–C single bond. Because silicon is larger and is polarizable (since it is in period 3), its electrons do not have as great an attraction to the nucleus, and the bond between Si and C is thus longer.

DIF: Difficult REF: 1.4
OBJ: Predict the properties of a covalent bond based on known periodic trends, and vice versa.
MSC: Analyzing

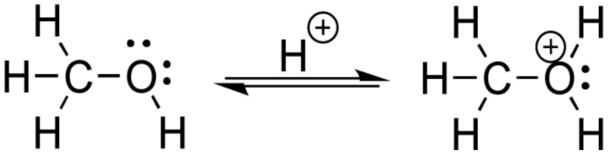
3. Oxygen is an important heteroatom found in many organic molecules. Consider methanol and its protonated derivative, shown below. How does an oxygen with a positive charge, called an oxonium species, influence the magnitude of the partial positive charge on the carbon atom? Which oxygen–carbon bond do you think is more difficult to break? Explain.



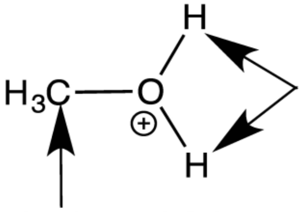
ANS:
The C–O bond in the oxonium species would have the greatest bond dipole. Consequently, this bond would be weaker and easier to break than the C–O bond of methanol.

DIF: Difficult REF: 1.4 | 1.5 | 1.9
OBJ: Predict the properties of a covalent bond based on known periodic trends, and vice versa.
MSC: Evaluating

4. Using a chemical reaction to convert an alcohol to an oxonium species is a highly valued tool in every organic chemist’s arsenal (see the following figure). Although this reaction was not covered in the current chapter, it will be discussed in due course. Reconsider your response to the preceding question. Can you identify the two different atoms of the oxonium species to which a negatively charged species might be most attracted? Explain. Hint: It is not the oxygen with the positive charge.



ANS:
Oxygen is an electronegative atom that is relatively unstable owning a positive charge; thus, it wants to engage in a process that will make it more stable.

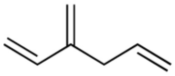


Either H would be attracted to a negatively charged species. In the process, O would get its electrons back.

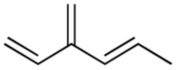
A positively charged O is very selfish and would pull electrons in the C–O bond toward itself. This would make the C have a large partial positive charge.

DIF: Difficult REF: 1.4 | 1.5 | 1.9
OBJ: Predict the properties of a covalent bond based on known periodic trends, and vice versa.
MSC: Evaluating

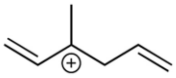
5. Compare Structure A with Structures B, C, and D. Is Structure B, C, or D a resonance structure of A? Justify your response. For any structures that are resonance forms, use curved arrows to show how the resonance forms are interconverted.



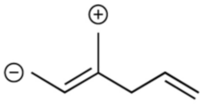
A



B

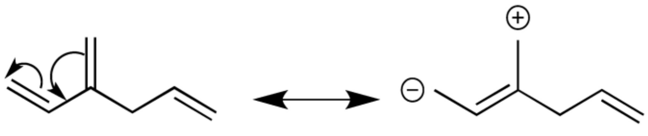


C



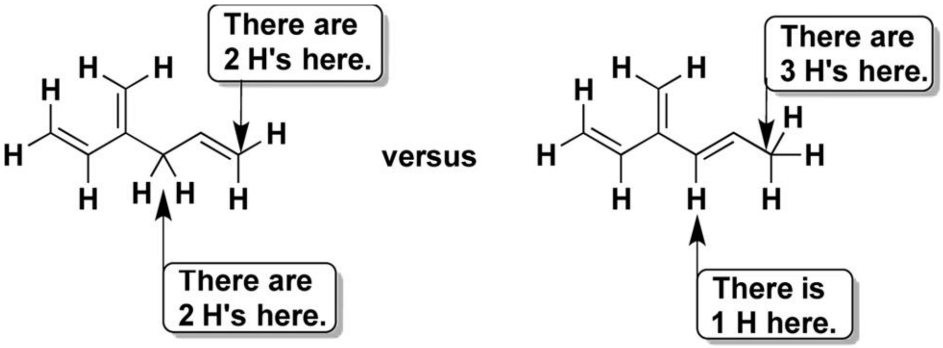
D

ANS:
Structure D is a resonance structure of Structure A.



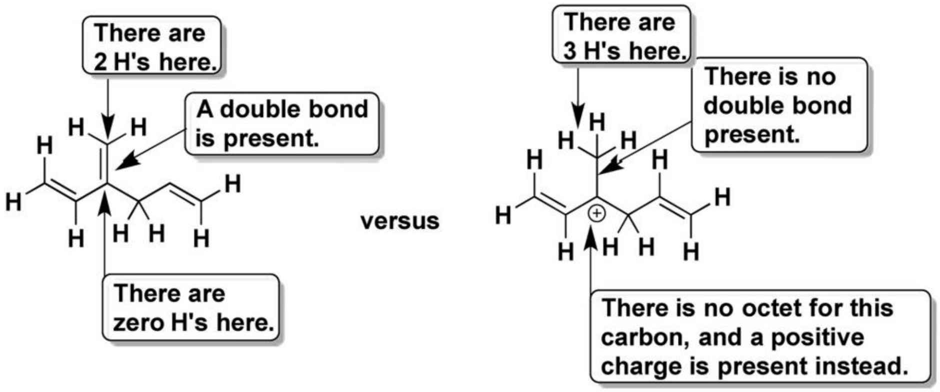
A **D**

Structure B is not a resonance structure of Structure A, because a C–H single bond changes position.



Structure A **Structure B**

Structure C is not a resonance structure of Structure A, because a double bond from Structure A is replaced with a C–H bond and a positive charge. Furthermore, the molecular formulas of A and C are different.



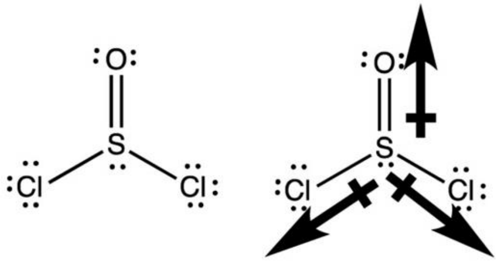
Structure A **Structure C**

DIF: Moderate REF: 1.4 | 1.5 | 1.9 | 1.10
OBJ: Compare a series of structures to determine if they are resonance structures.
MSC: Evaluating

6. Draw a Lewis structure of thionyl chloride ($SOCl_2$), showing all lone pairs. Show each bond dipole using a dipole arrow.

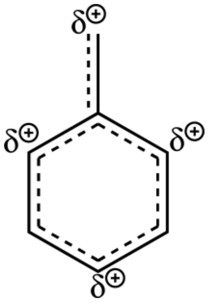
ANS:

$SOCl_2$
Electron count
S = group 6 x 1= 6 valence e–
O = group 6 x 1 = 6 valence e–
Cl= group 7 x 2 = 14 valence e–
----
26 total valence electrons

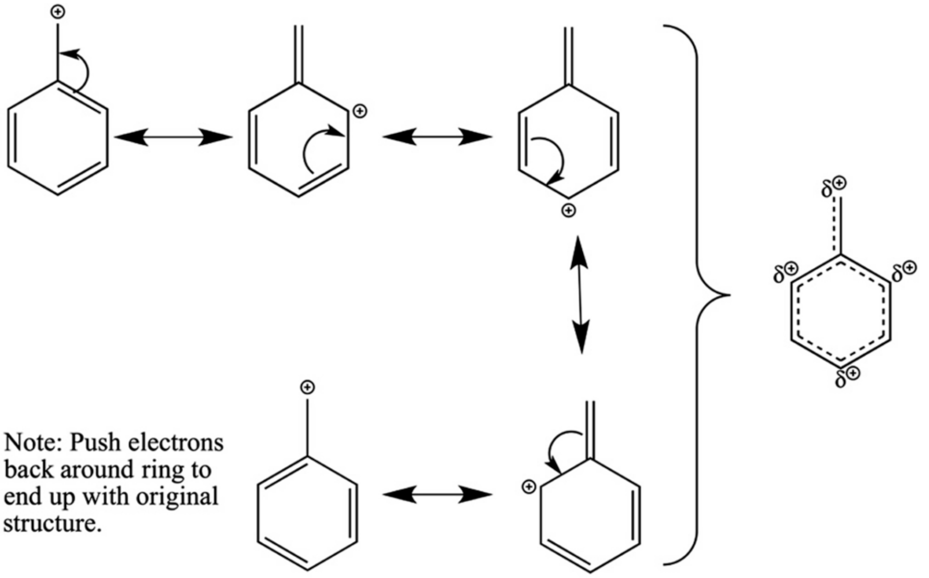


DIF: Moderate REF: 1.5 | 1.9
OBJ: Assimilate your knowledge of molecular structure to identify and/or draw organic functional groups. MSC: Creating

7. Using line structures, draw the individual resonance contributors from the resonance hybrid structure given here.



ANS:



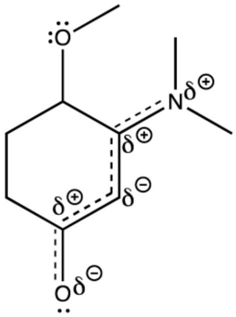
Note: Push electrons back around ring to end up with original structure.

NOTICE THAT POSITIVE CHARGES ARE ON THE SPECIFIC ATOMS WHERE THE PARTIAL CHARGES WERE LOCATED IN THE HYBRID.

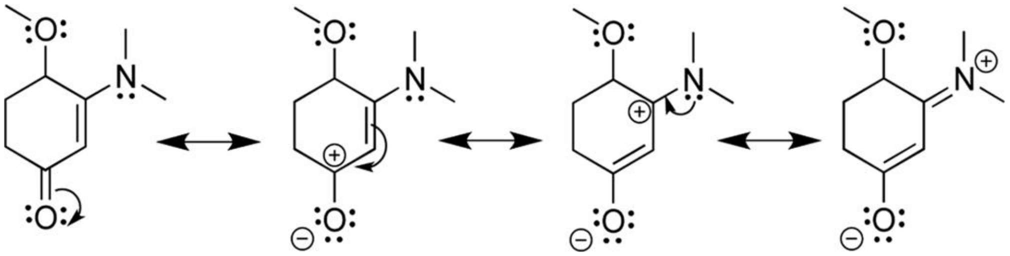
DIF: Difficult REF: 1.5 | 1.9 | 1.10 | 1.12

OBJ: Deduce and draw the resonance structures that contribute to the resonance hybrid, and vice versa. MSC: Creating

8. Using line structures, deduce individual resonance contributors from the resonance hybrid structure given here.



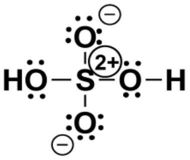
ANS:



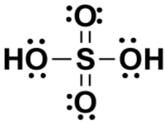
DIF: Difficult REF: 1.5 | 1.9 | 1.10 | 1.12

OBJ: Deduce and draw the resonance structures that contribute to the resonance hybrid, and vice versa. MSC: Creating

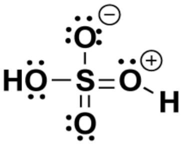
9. Are the following Lewis structures for sulfuric acid related as resonance structures? Explain.



Structure I



Structure II



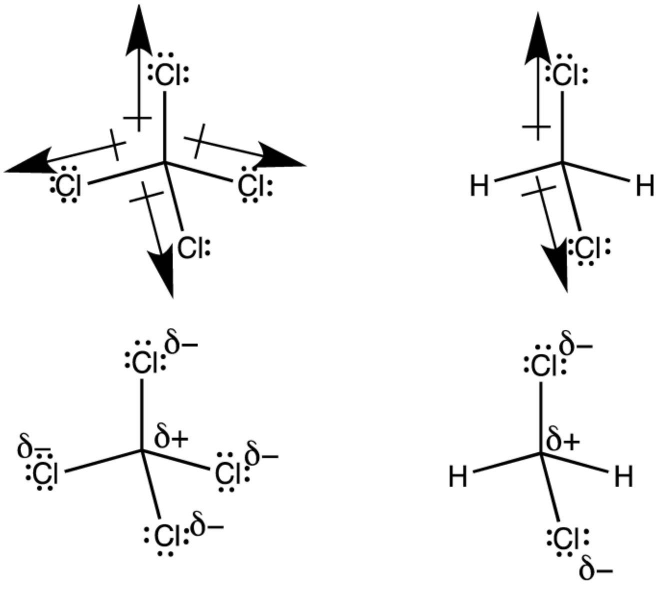
Structure III

ANS:
Yes, they are all resonance structures. The structures differ in the position of lone pairs and π bonds. Atoms are in the same position and no sigma bonds have been broken. The structures have different potential energies due to structural and electrostatic differences.

DIF: Moderate REF: 1.5 | 1.9 | 1.10
OBJ: Compare a series of structures to determine if they are resonance structures.
MSC: Analyzing

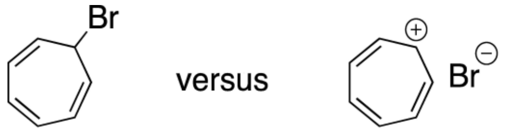
10. Consider two solvents that are commonly used for organic chemistry reactions: CH_2Cl_2 and CCl_4. It is interesting that studies have shown that one of these solvents is polar and one is nonpolar. Draw valid Lewis structures for these two molecules. Show bond dipoles and both partial charges
(use ä+ and ä–). How would the electrostatic potential maps for the two molecules be similar? How would they be different?

ANS:
Although CCl_4 has individual bond dipoles, the vector sum of the bond dipoles is zero. This means that CCl_4 is a nonpolar molecule. CH_2Cl_2 has two bond dipoles that do not cancel; thus, CH_2Cl_2 is a polar molecule. The electrostatic potential map of CH_2Cl_2 would show that the electron density in each of the C–Cl bonds is shifted toward the Cl atom.



DIF: Moderate REF: 1.7
OBJ: Elaborate how an electrostatic potential map correlates to molecular structure and properties.
MSC: Analyzing

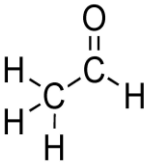
11. A compound with a molecular formula of C_7H_7Br has a melting point of 203°C. The compound is soluble in water but not in diethyl ether. Based on your knowledge of organic structure, is the compound most stable in its ionic or covalent form? Justify your answer.

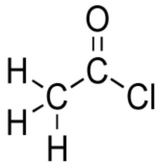


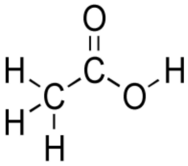
ANS:
The high melting point of +200 degrees and the water solubility of the seven-carbon molecule suggest that the compound is ionic. Additionally, because the compound is insoluble in ether, a charged hydrocarbon salt is most likely the most stable structure.

DIF: Difficult REF: 1.7 | 1.8
OBJ: Predict the ionic or covalent nature of an organic structure from physical property data.
MSC: Evaluating

12. A carbonyl, the C=O unit, is a component of many important functional groups. Consider the Lewis structures below. Convert the Lewis structures to line structures, showing all lone pairs. Rank the structures for increasing partial positive charge. Predict which carbonyl carbon should have greatest partial positive charge, assuming that the chlorine lone pairs do not engage in resonance. Explain your answer.

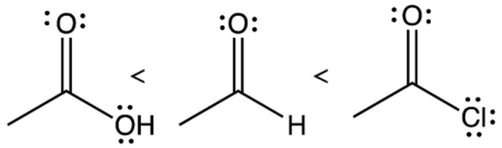






ANS:
The point of difference in the three structures is the substitution on the carbon of the carbonyl.
Any property that influences electron distribution will influence the magnitude of the positive charge. Effects are either electron withdrawing (e.g., an electronegative atom) or electron donating (e.g., compare the Pauling electronegativity values and resonance potential of each atom). The carbonyl carbon of the acyl chloride has the greatest partial positive charge. There are three lone pairs on Cl and two on the O of the OH. Because one of the oxygen lone pairs can be delocalized through resonance, electron density is added to the C=O, and the partial positive charge of the carbonyl carbon is reduced. Given that Cl does not typically engage in resonance, then the electron withdrawing nature of the electronegative Cl predominates.

INCREASING d^+ CHARGE ON C of C=O



Note: Hydrogen atoms bonded to carbon atoms
are not typically drawn on line structures.
The aldehyde H is shown here for emphasis.

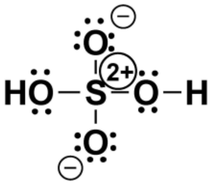
DIF: Difficult REF: 1.7 | 1.10
OBJ: Indicate bond dipoles and lone pairs on an organic structure, and predict how these structural features impact chemical reactivity. MSC: Evaluating

13. (a) Sulfuric acid, H_2SO_4, is an important strong oxo acid in organic chemistry. Propose Lewis structures for sulfuric acid, showing all lone pairs and formal charges, using the following guidelines:

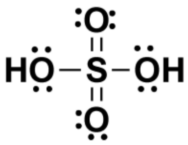
> In Structure I, one atom has a +2 formal charge. Two other atoms each possess a charge of −1. All atoms in Structure II are completely neutral. In Structure III, one atom has a +1 charge and another a −1 charge.

(b) Which Lewis structure is most stable? Why?

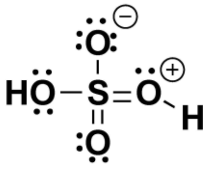
ANS:
The neutral structure is most stable. The number of covalent bonds is maximized, and charges are minimized (e.g., there are no individual formal charges on atoms).



Structure I



Structure II

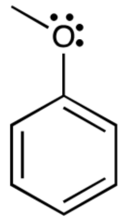


Structure III

DIF: Easy REF: 1.9 | 1.10
OBJ: Master the structural drawing of organic molecules—specifically, Lewis structures and line structures. MSC:

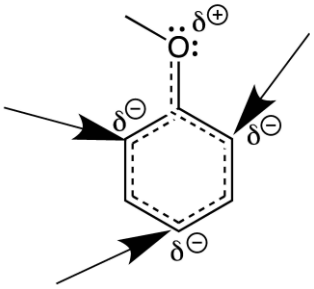
Analyzing | Creating

14. To which carbon atoms in anisole would a positively charged species, called “E^+,” bond? Explain your answer using the concept of resonance. Hint: Refer to your response from question 16 for further insight.



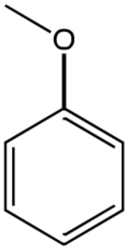
anisole

ANS:
Opposites attract. It is reasonable to predict that any positively charged species would be attracted to the carbon atoms with a partial negative charge. These partially negative carbon atoms are highlighted with an arrow in the resonance hybrid.



DIF: Moderate REF: 1.9 | 1.10
OBJ: Apply the concept of resonance to predict the outcome of a chemical reaction.
MSC: Analyzing | Evaluating

15. Draw all possible resonance forms for anisole using appropriate arrow notation. Which resonance structure is most stable? Which is least stable? Draw the resonance hybrid for anisole, indicating all partial charges.



ANS:
The neutral structure is most stable. The two structures with the partial negative charge closest to the oxygen are equal in energy. These structures are also more stable than the structure with the charges farther apart; thus, they contribute a greater degree to the hybrid.