

Organic Chemistry, 8e (Wade)

Chapter 1 Introduction and Review

1) While you were up late one night studying organic chemistry, you happened to see the last 5 minutes of an infomercial on TV. The spokesperson claimed that their brand of automobile tires were superior to all other brands on the market because they were made by using only natural rubber, isolated from the resin of rubber trees. How could a chemist test her claims that no petroleum products went into the manufacture of her brand of tires?

Answer: Compounds synthesized from petroleum products have a lower content of ^{14}C . Plant-derived compounds are recently synthesized from CO_2 in the air and have a higher ^{14}C content.

Diff: 2

Section: 1.1

2) The atomic number of boron is 5. The correct electronic configuration of boron is:

- A) $1s^2 2s^3$
- B) $1s^2 2p^3$
- C) $1s^2 2s^2 2p^1$
- D) $2s^2 2p^3$
- E) $1s^2 2s^2 3s^1$

Answer: C

Diff: 1

Section: 1.2

3) How many distinct p orbitals exist in the second electron shell, where $n = 2$?

- A) 2
- B) 3
- C) 4
- D) 5
- E) 6

Answer: B

Diff: 1

Section: 1.2

4) The _____ tells us that each orbital can hold a maximum of 2 electrons.

- A) aufbau principle
- B) Pauli exclusion principle
- C) Hund's rule principle
- D) LeChatelier principle
- E) uncertainty principle

Answer: B

Diff: 1

Section: 1.2

5) A node is a region of high electron density between the two atoms in a covalent bond.

Answer: FALSE

Diff: 1

Section: 1.2

6) When filling two or more orbitals of the same energy with electrons, the electrons will go into different orbitals rather than pair up in the same orbital.

Answer: TRUE

Diff: 1

Section: 1.2

7) Atoms with the same number of protons but different numbers of neutrons are called _____.

Answer: isotopes

Diff: 1

Section: 1.2

8) The electron density of _____ orbitals has spherical symmetry.

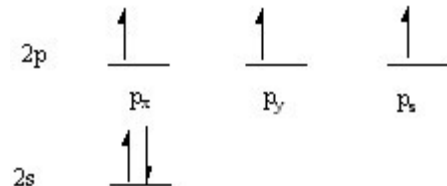
Answer: s

Diff: 1

Section: 1.2

9) Draw the line energy orbital diagram for the outer shell of an uncharge nitrogen atom and describe the location and number of unshared electrons.

Answer:



There are three unshared electrons in Shell 2 and they are located in the three degenerate atomic p orbitals.

Diff: 1

Section: 1.2

10) An oxygen atom has _____ valence electrons.

Answer: 6

Diff: 1

Section: 1.2

11) Which element in the second row of the periodic table has six valence electrons and a valence of two?

Answer: oxygen

Diff: 1

Section: 1.2

12) Orbitals which are equal in energy are referred to as _____.

- A) degenerate
- B) polar
- C) nodes
- D) filled
- E) nonpolar

Answer: A

Diff: 2

Section: 1.2

13) In a carbon atom, the 2s and 2p orbitals are equal in energy.

Answer: FALSE

Diff: 2

Section: 1.2

14) The element with the electronic configuration $1s^2 2s^2 2p^6 3s^1$ is _____.

Answer: sodium

Diff: 2

Section: 1.2

15) Provide the electron configuration of phosphorus.

Answer: $1s^2 2s^2 2p^6 3s^2 3p^3$

Diff: 2

Section: 1.2

16) Draw the shape of a 2p orbital.

Answer:

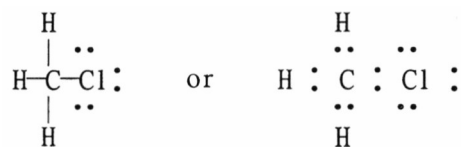


Diff: 2

Section: 1.2

17) Draw a correct Lewis structure for chloromethane, CH_3Cl .

Answer:

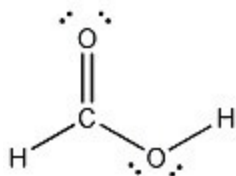


Diff: 1

Section: 1.4

18) Provide a Lewis structure for a molecule with molecular formula CH_2O_2 .

Answer:

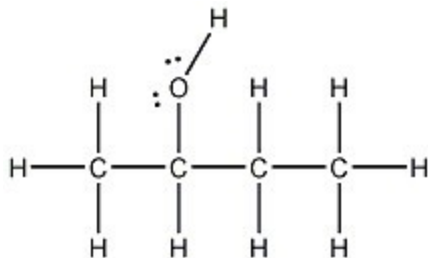


Diff: 2

Section: 1.4

19) Draw the Lewis structure for 2-butanol, $\text{CH}_3\text{CH}(\text{OH})\text{CH}_2\text{CH}_3$.

Answer:

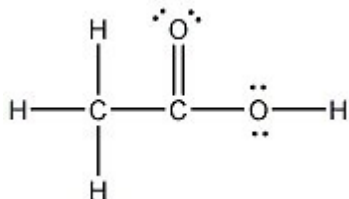


Diff: 2

Section: 1.4

20) Draw the Lewis structure of acetic acid, $\text{CH}_3\text{CO}_2\text{H}$.

Answer:

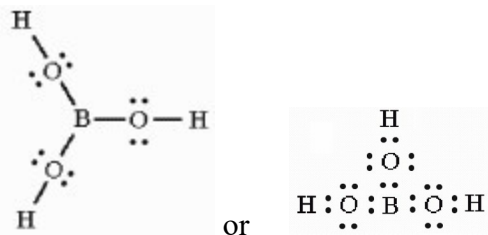


Diff: 2

Section: 1.4

21) Draw a correct Lewis structure for boric acid, $\text{B}(\text{OH})_3$.

Answer:

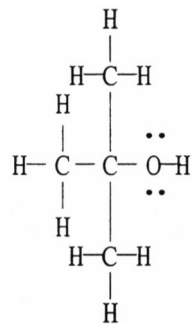


Diff: 2

Section: 1.4

22) Draw a correct Lewis structure for *tert*-butyl alcohol, $(\text{CH}_3)_3\text{COH}$.

Answer:

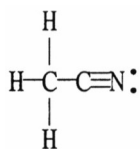


Diff: 2

Section: 1.4

23) Draw a correct Lewis structure for acetonitrile, CH_3CN .

Answer:

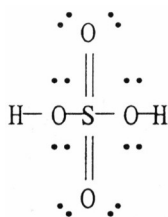


Diff: 2

Section: 1.4

24) Draw a proper Lewis structure for H_2SO_4 .

Answer:

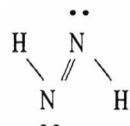


Diff: 2

Section: 1.4

25) Write a Lewis structure for a compound with the molecular formula H_2N_2 .

Answer:



Diff: 2

Section: 1.4

26) A carbon-hydrogen bond in ethane (CH_3CH_3) is best described a _____.

- A) highly polar
- B) essentially nonpolar
- C) ionic
- D) a multiple bond
- E) resonance stabilized

Answer: B

Diff: 1

Section: 1.6

27) The electronegativity of elements on the periodic table increases going _____ a column and to the _____ in each row.

- A) up, right
- B) up, left
- C) down, right
- D) down, left

Answer: A

Diff: 1

Section: 1.6

28) Within a given row of the periodic table, electronegativity typically increases left to right across the row.

Answer: TRUE

Diff: 1

Section: 1.6

29) Which of the following molecules contains a polar covalent bond?

- A) H_2
- B) F_2
- C) CH_3Cl
- D) NaCl
- E) He

Answer: C

Diff: 1

Section: 1.6

30) Covalent bonds may be polar or nonpolar. What property of the atoms forming a given bond determines this?

Answer: Electronegativity

Diff: 2

Section: 1.6

31) The compound methylamine, CH_3NH_2 , contains a C-N bond. In this bond, which of the following best describes the charge on the carbon atom?

- A) +1
- B) slightly positive
- C) uncharged
- D) slightly negative
- E) -1

Answer: B

Diff: 3

Section: 1.6

32) The formal charge on oxygen in dimethyl ether, CH_3OCH_3 , is _____.

- A) +2
- B) +1
- C) 0
- D) -1
- E) -2

Answer: C

Diff: 1

Section: 1.7

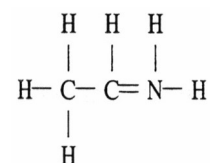
33) For most compounds in which a nitrogen atom bears no formal charge, the valence of this nitrogen atom is _____.

Answer: 3

Diff: 1

Section: 1.7

34) The formal charge on nitrogen in the compound below is _____.



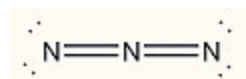
- A) +2
- B) +1
- C) 0
- D) -1
- E) -2

Answer: B

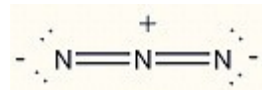
Diff: 2

Section: 1.7

35) Assign the correct formal charge to each nitrogen atom in the following Lewis structure.



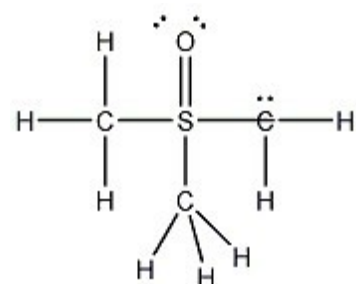
Answer:



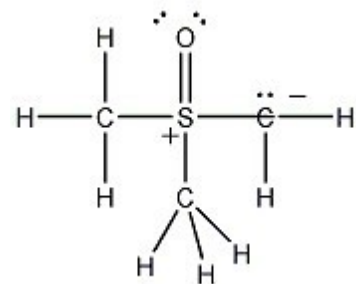
Diff: 2

Section: 1.7

36) Add the appropriate formal charge to each atom in the molecule below. It is not necessary to indicate formal charges when zero.



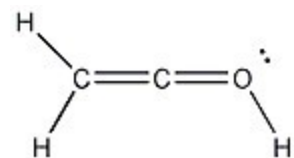
Answer:



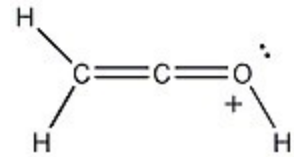
Diff: 2

Section: 1.7

37) Add the appropriate formal charge to each atom in the molecule below. It is not necessary to indicate formal charges when zero.



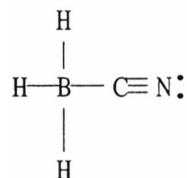
Answer:



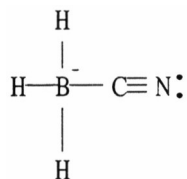
Diff: 2

Section: 1.7

38) One or more of the atoms in the structure shown should have nonzero formal charges. Redraw the structure and indicate any such charges.



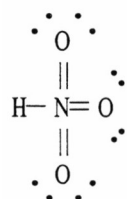
Answer:



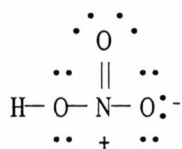
Diff: 2

Section: 1.7

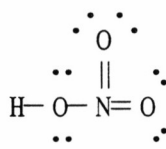
39) Which of the following are correct Lewis structures, including formal charges, for nitric acid, HNO_3 ?



A



B



C

A) A only

B) B only

C) C only

D) both B and C

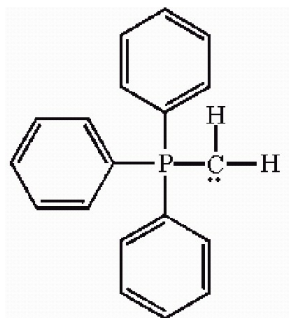
E) A, B, and C

Answer: B

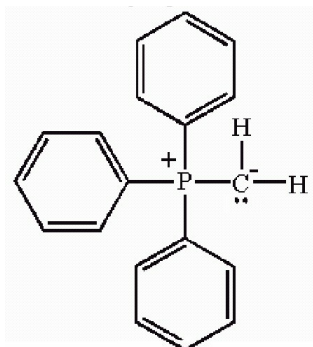
Diff: 3

Section: 1.7

40) One or more of the atoms in the structure shown should have nonzero formal charges. Redraw the structure and indicate any such charges.



Answer:



Diff: 3

Section: 1.7

41) In the compound sodium methoxide (NaOCH_3), there is _____ bonding.

- A) ionic
- B) polar covalent
- C) nonpolar covalent
- D) a mixture of ionic and covalent
- E) resonance stabilized

Answer: D

Diff: 1

Section: 1.8

42) Which of the following compounds are covalent compounds?

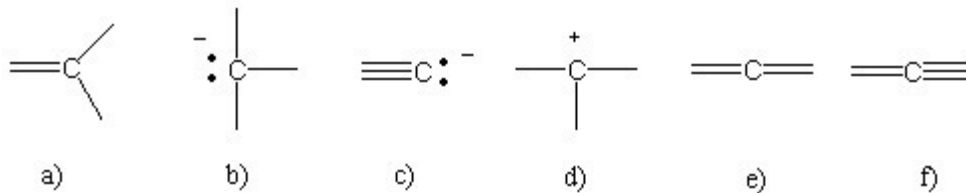
- A) KCl
- B) CF_4
- C) NH_3
- D) both A and B
- E) both B and C

Answer: E

Diff: 2

Section: 1.8

43) Which of the following bonding patterns of carbon is not allowed in the formation of an organic



compound?

Answer: f

Diff: 2

Section: 1.8

44) When a negatively charged species is most appropriately depicted as a hybrid of several resonance forms, the negative charge present is considered to be rapidly moving between the resonance forms bearing the formal negative charge.

Answer: FALSE

Diff: 1

Section: 1.9

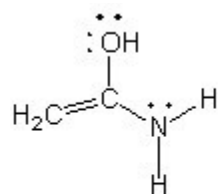
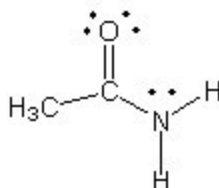
45) When a molecule can best be represented as a series of resonance forms, each of these forms always contributes to the same degree in the hybrid.

Answer: FALSE

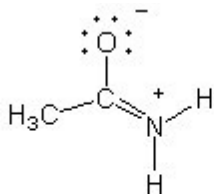
Diff: 1

Section: 1.9

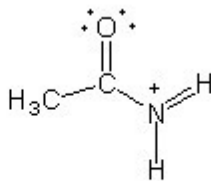
46) Which of the following structures (a-d) is another resonance structure of the following organic molecule?



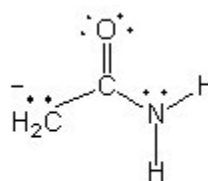
a)



b)



c)



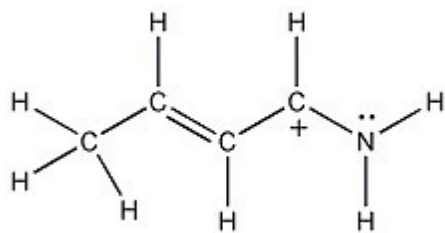
d)

Answer: b

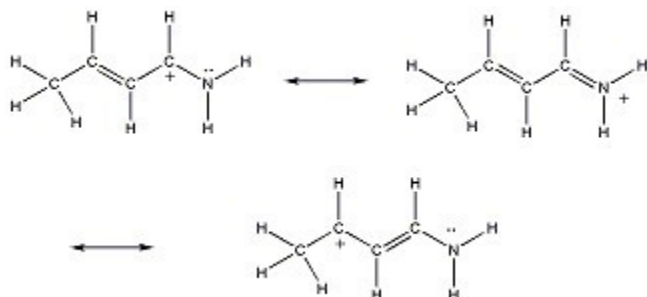
Diff: 2

Section: 1.9

47) One resonance structure of a cation is shown. Provide the other reasonable resonance structures.



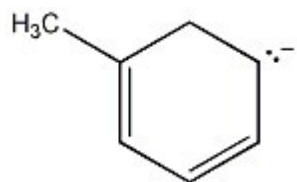
Answer:



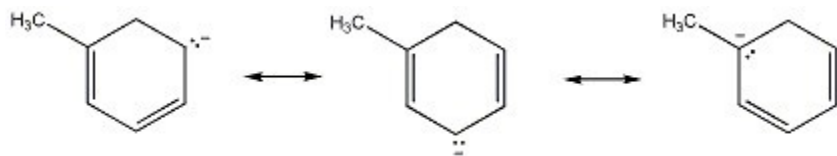
Diff: 2

Section: 1.9

48) Draw the important resonance forms of:



Answer:

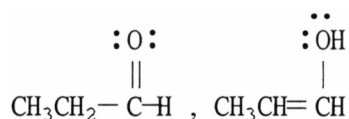


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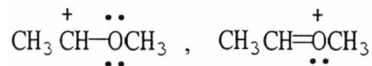
Section: 1.9

49) Which of the following choices represent(s) a pair of resonance forms?

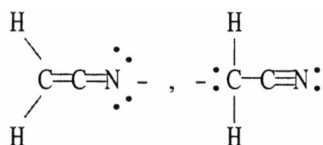
A)



B)



C)



D) both A and C

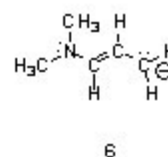
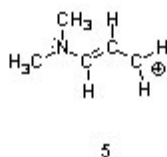
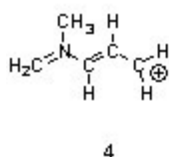
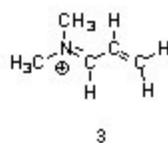
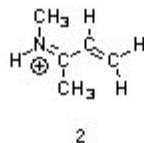
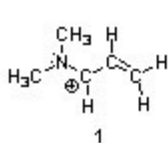
E) both B and C

Answer: E

Diff: 3

Section: 1.9

50) Structures _____, shown below, are resonance structures, and structure _____ is the major contributor to the overall resonance hybrid.



A) 2 & 4; 2

B) 1, 3 & 5; 3

C) 4 & 6; 6

D) 1, 3 & 5; 1

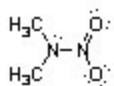
E) 1, 3, 4 & 5; 3

Answer: B

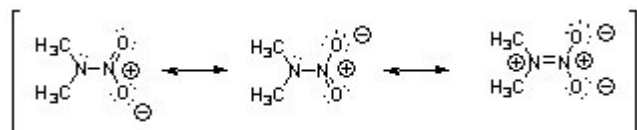
Diff: 3

Section: 1.9

51) Nitroamines are common functional groups found in energetic materials, such as RDX and HMX. For the structure below, draw two other significant resonance structures, include any formal charges, and indicate the hybridization on each nitrogen and oxygen.



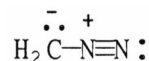
Answer: All nitrogen and oxygen atoms are sp^2 hybridized.



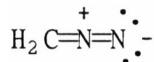
Diff: 3

Section: 1.9

52) Draw the other important resonance form of:



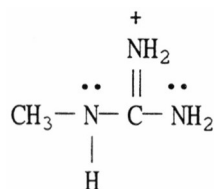
Answer:



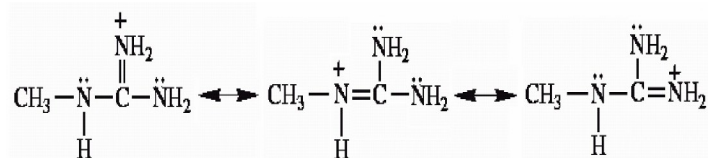
Diff: 3

Section: 1.9

53) Draw the important resonance forms for the structure shown below.



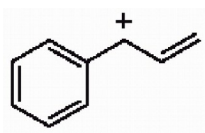
Answer:



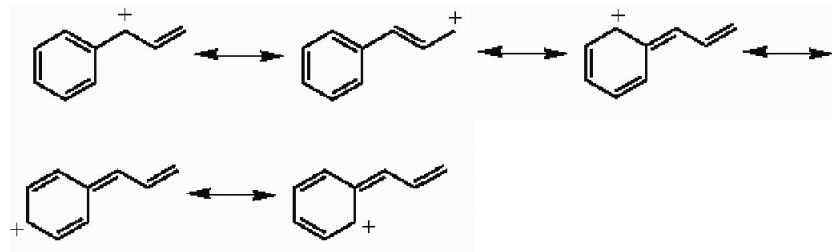
Diff: 3

Section: 1.9

54) Draw the important resonance forms for the structure shown below.



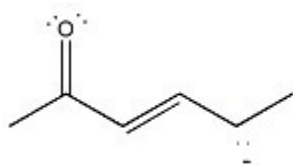
Answer:



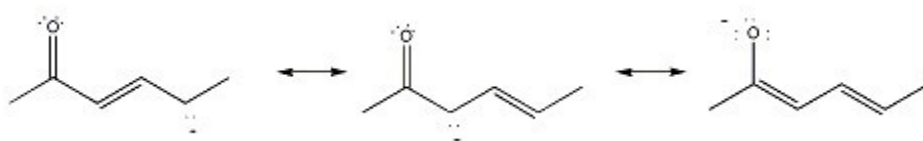
Diff: 3

Section: 1.9

55) Draw the important resonance forms for the structure shown below.



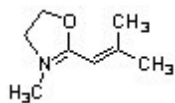
Answer:



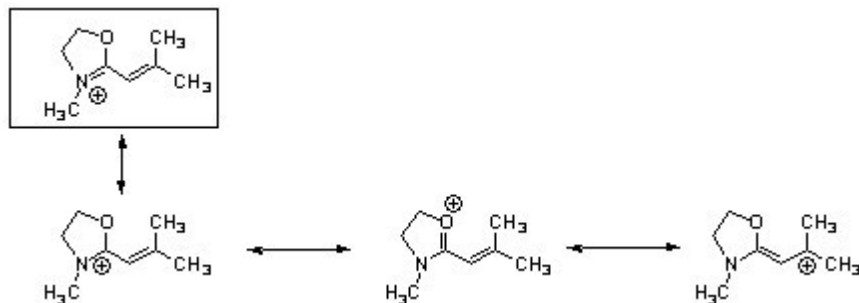
Diff: 3

Section: 1.9

56) Draw 3 significant resonance structures for the compound shown below. Place a box around the major contributor. Fill in any missing formal charges.



Answer:

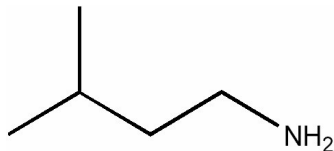


Diff: 3

Section: 1.9

57) Draw a line-angle formula for $(\text{CH}_3)_2\text{CHCH}_2\text{CH}_2\text{NH}_2$.

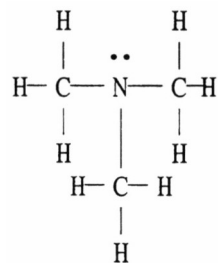
Answer:



Diff: 1

Section: 1.10

58) The Lewis structure of trimethylamine is shown below. Draw the condensed structural formula which corresponds to this Lewis structure.

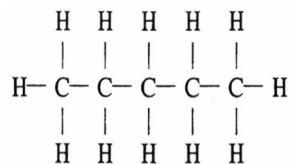


Answer: $(\text{CH}_3)_3\text{N}$

Diff: 1

Section: 1.10

59) The Lewis structure of pentane is shown below. Draw the condensed structural formula which corresponds to this Lewis structure.



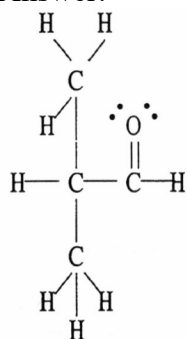
Answer: $\text{CH}_3(\text{CH}_2)_3\text{CH}_3$

Diff: 1

Section: 1.10

60) Draw the complete Lewis structure for the compound whose condensed formula is $(\text{CH}_3)_2\text{CHCHO}$.

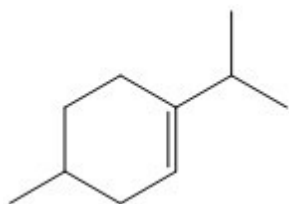
Answer:



Diff: 1

Section: 1.10

61) How many carbon atoms are present in the molecule shown?



A) 6

B) 8

C) 10

D) 11

E) 12

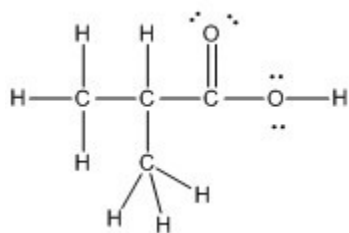
Answer: C

Diff: 1

Section: 1.10

62) Draw a complete Lewis structure, including lone pairs, for $(\text{CH}_3)_2\text{CHCO}_2\text{H}$.

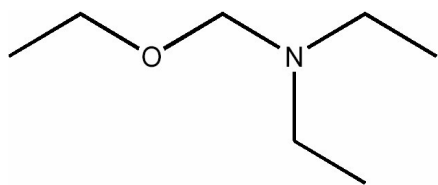
Answer:



Diff: 2

Section: 1.10

63) Which of the following condensed formulas represents the same compound as the line-angle structure shown?



- A) $\text{CH}_3\text{CH}_2\text{CH}_2\text{OCH}_2\text{CH}_2\text{CH}_2\text{N}(\text{CH}_2\text{CH}_2\text{CH}_3)_2$
- B) $\text{CH}_3\text{CH}_2\text{CH}_2\text{OCH}_2\text{N}(\text{CH}_2\text{CH}_3)_2$
- C) $\text{CH}_3\text{CH}_2\text{OCH}_2\text{N}(\text{CH}_2\text{CH}_3)_2$
- D) $\text{CH}_3\text{CH}_2\text{OCH}_2\text{N}(\text{CH}_2\text{CH}_2\text{CH}_3)_2$
- E) $\text{CH}_3\text{ON}(\text{CH}_3)_2$

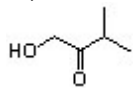
Answer: C

Diff: 2

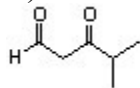
Section: 1.10

64) Indicate the line-angle structure that corresponds to the condensed structure, $\text{HOCH}_2\text{C}(\text{O})\text{CH}(\text{CH}_3)_2$.

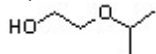
A)



B)



C)



D)



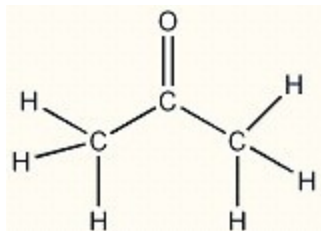
Answer: A

Diff: 2

Section: 1.10

65) A condensed structure for acetone is CH_3COCH_3 . Provide the structural formula for acetone.

Answer:

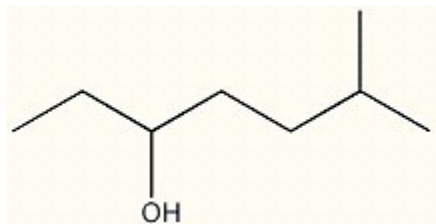


Diff: 2

Section: 1.10

66) Provide the line-angle formula for the alcohol $\text{CH}_3\text{CH}_2\text{CH}(\text{OH})\text{CH}_2\text{CH}_2\text{CH}(\text{CH}_3)_2$.

Answer:

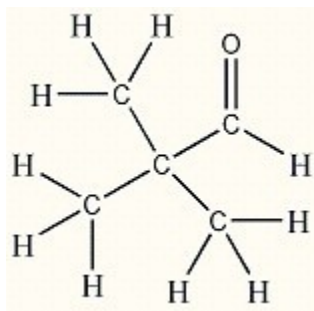


Diff: 2

Section: 1.10

67) Provide the structural formula for an aldehyde whose condensed structure is $(\text{CH}_3)_3\text{CCHO}$.

Answer:

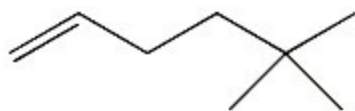


Diff: 2

Section: 1.10

68) Provide the line-angle formula (skeletal structure) for $\text{CH}_2=\text{CHCH}_2\text{CH}_2\text{C}(\text{CH}_3)_3$.

Answer:

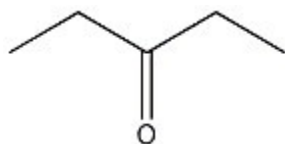


Diff: 2

Section: 1.10

69) Provide the line-angle formula (skeletal structure) for $(\text{CH}_3\text{CH}_2)_2\text{C}=\text{O}$.

Answer:

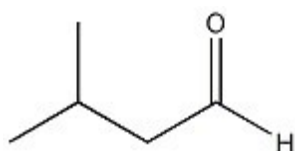


Diff: 2

Section: 1.10

70) Provide the line-angle formula (skeletal structure) for $(\text{CH}_3)_2\text{CHCH}_2\text{CHO}$.

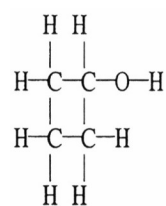
Answer:



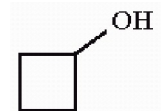
Diff: 2

Section: 1.10

71) Draw an acceptable line-angle formula for cyclobutanol (shown below).



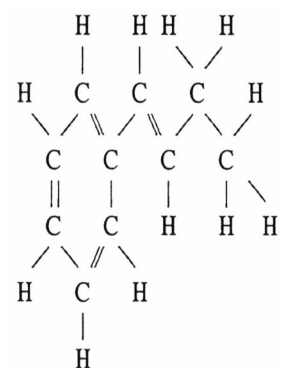
Answer:



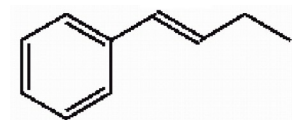
Diff: 2

Section: 1.10

72) Draw an acceptable line-angle formula for the compound shown below.



Answer:

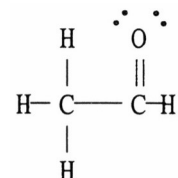


Diff: 2

Section: 1.10

73) Draw a correct Lewis structure for acetaldehyde, CH_3CHO .

Answer:

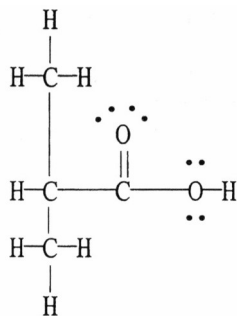


Diff: 2

Section: 1.10

74) Draw a correct Lewis structure for $(\text{CH}_3)_2\text{CHCOOH}$.

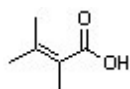
Answer:



Diff: 2

Section: 1.10

75) Which of the following condensed formulas correctly represents the line-angle structure shown below?



A) $\text{CH}(\text{CH}_3)_2\text{CH}(\text{CH}_3)\text{CO}_2\text{H}$

B) $\text{C}_2(\text{CH}_3)_3\text{CO}_2\text{H}$

C) $(\text{CH}_3)_2\text{CC}(\text{CH}_3)\text{CO}_2\text{H}$

D) $\text{C}(\text{CH}_3)_2\text{C}(\text{CH}_3)\text{CH}_2\text{CO}_2\text{H}$

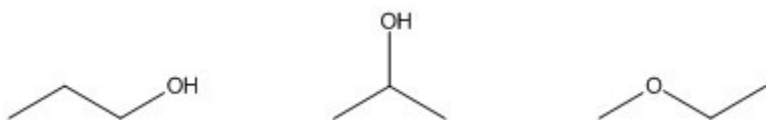
Answer: C

Diff: 2

Section: 1.10

76) Draw the line-angle formula for three compounds with molecular formula $\text{C}_3\text{H}_8\text{O}$.

Answer:

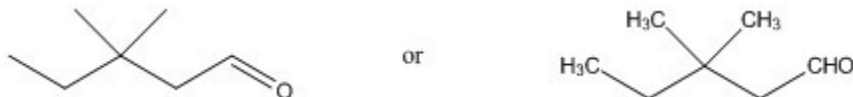


Diff: 2

Section: 1.10

77) Provide the line-angle formula for $\text{CH}_3\text{CH}_2\text{C}(\text{CH}_3)_2\text{CH}_2\text{CHO}$

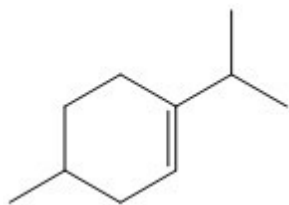
Answer:



Diff: 2

Section: 1.10

78) How many hydrogen atoms are present in the molecule shown?



Answer: 18

Diff: 2

Section: 1.10

79) Draw condensed structures for the four compounds with formula C_3H_9N .

Answer: $CH_3CH_2CH_2NH_2$

$CH_3CH_2NHCH_3$

$(CH_3)_2CHNH_2$

$(CH_3)_3N$

Diff: 3

Section: 1.10

80) Compute the empirical and molecular formulas for the compound of molecular weight 180 g/mol which is shown to contain 40.0% C and 6.7% H by elemental analysis.

Answer: The empirical formula is CH_2O and the molecular formula is $C_6H_{12}O_6$.

Diff: 2

Section: 1.11

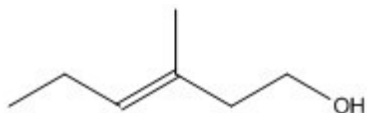
81) Compute the empirical and molecular formulas for the compound of molecular weight 86 g/mol which is shown to contain 55.8% C and 7.0% H by elemental analysis.

Answer: The empirical formula is C_2H_3O and the molecular formula is $C_4H_6O_2$.

Diff: 2

Section: 1.11

82) What is the molecular formula for the molecule shown?



Answer: $C_7H_{14}O$

Diff: 2

Section: 1.11

83) A sample of compound X is subjected to elemental analysis and the following percentages by weight are found: 39.97% C, 6.73% H, and 53.30% O. The molecular weight of X is 90. What is the empirical formula of X?

- A) C_6HO_8
- B) $\text{C}_2\text{H}_4\text{O}_2$
- C) $\text{C}_4\text{H}_{10}\text{O}_2$
- D) $\text{C}_3\text{H}_6\text{O}_3$
- E) CH_2O

Answer: E

Diff: 3

Section: 1.11

84) Calculate the empirical and molecular formulas of the compound with molecular weight 122 and an elemental analysis of 59.01% C, 4.97% H, 13.12% O, and 22.90% N.

Answer: Empirical and molecular formulas are the same: $\text{C}_6\text{H}_6\text{N}_2\text{O}$.

Diff: 3

Section: 1.11

85) Calculate the molecular formula for the organic compound whose quantitative elemental analysis showed 48.6% carbon and 8.1% hydrogen by weight.

- A) CH_2O
- B) $\text{C}_2\text{H}_4\text{O}_2$
- C) C_2H_6
- D) $\text{C}_3\text{H}_6\text{O}$
- E) $\text{C}_3\text{H}_6\text{O}_2$

Answer: E

Diff: 3

Section: 1.11

86) The pH of a 150 mL aqueous solution of 2.13×10^{-3} M HCl is _____.

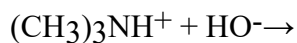
- A) -3.000
- B) 3.000
- C) 2.672
- D) 2.130
- E) none of the above

Answer: C

Diff: 2

Section: 1.12

87) Provide the products of the following acid-base reaction.



Answer: $(\text{CH}_3)_3\text{N} + \text{H}_2\text{O}$

Diff: 2

Section: 1.12

88) Calculate the pH of a 250 mL aqueous solution which contains 0.70 g of HCl.

Answer: 1.11

Diff: 2

Section: 1.12

89) A 0.1 M aqueous solution of an acid HA has a pH of 4.0. What is the pK_a of HA?

Answer: 7

Diff: 3

Section: 1.12

90) Calculate the pH of a 100 mL aqueous solution containing 1.80 g of KOH (MW = 56.11 g/mol).

Answer: 13.506

Diff: 3

Section: 1.12

91) What is the pK_a and general acid strength of formic acid if its conjugate base form has a pK_b of 10.23?

A) 3.77 - fairly strong weak acid

B) 5.99 - moderately strong weak acid

C) 14.00 - not an acid but rather a strong base

D) 3.23 - fairly strong weak acid

E) cannot be determined from the information given

Answer: A

Diff: 1

Section: 1.13

92) Provide the structure of the conjugate acid of ethanamine ($\text{CH}_3\text{CH}_2\text{NH}_2$)

Answer:



Diff: 1

Section: 1.13

93) The conjugate acid of ammonia, NH_3 , is _____.

- A) NH_2^-
- B) NH_2OH
- C) NH_4^+
- D) none of the above

Answer: C

Diff: 2

Section: 1.13

94) The K_a of formic acid is 1.7×10^{-4} . The $\text{p}K_a$ of formic acid is _____.

- A) 1.70
- B) 4.00
- C) -2.36
- D) 3.77
- E) 10.38

Answer: D

Diff: 2

Section: 1.13

95) When methanol (CH_3OH) acts as a base, its conjugate acid is _____.

- A) $-\text{CH}_2\text{OH}$
- B) CH_3O^-
- C) CH_4OH
- D) CH_3OH_2^+
- E) CH_4O^+

Answer: D

Diff: 2

Section: 1.13

96) Which of the following pairs of bases lists the stronger base first?

- A) $\text{I}^- > \text{Cl}^-$
- B) $\text{H}_2\text{O} > \text{HO}^-$
- C) $\text{HO}^- > \text{H}_2\text{N}^-$
- D) $\text{CH}_3\text{COO}^- > \text{HO}^-$
- E) $\text{H}_2\text{N}^- > \text{CH}_3\text{COO}^-$

Answer: E

Diff: 2

Section: 1.13

97) According to the following pKa values listed for a set of acids, which would lead to the strongest conjugate base?

- A) -2
- B) 1
- C) 7
- D) 25
- E) 50

Answer: E

Diff: 2

Section: 1.13

98) Strong bases usually contain positively charged atoms of high electronegativity and no resonance stabilization.

Answer: FALSE

Diff: 2

Section: 1.13

99) Rank the following compounds in order of increasing acidity: CH_3OH , HCl , NH_3 , and CH_4 .

Answer: $\text{CH}_4 < \text{NH}_3 < \text{CH}_3\text{OH} < \text{HCl}$

Diff: 2

Section: 1.13

100) Rank the following compounds in order of increasing basicity: CH_3O^- , H_2N^- , H_2O , and NH_3 .

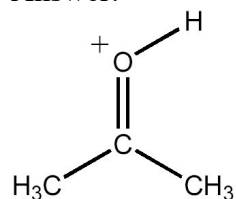
Answer: $\text{H}_2\text{O} < \text{NH}_3 < \text{CH}_3\text{O}^- < \text{H}_2\text{N}^-$

Diff: 2

Section: 1.13

101) Draw the structure of the conjugate acid of acetone (CH_3COCH_3).

Answer:



Diff: 2

Section: 1.13

102) Methanol has a pKa of 15.5. Calculate its Ka.

Answer: 3.2×10^{-16}

Diff: 2

Section: 1.13

103) Write a completed equation for the acid-base pair shown below.



Diff: 2

Section: 1.13

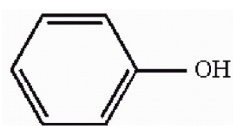
104) Write a completed equation for the acid-base pair shown below.



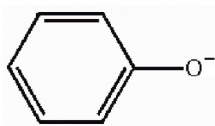
Diff: 2

Section: 1.13

105) The compound phenol is shown below. Provide the structure of the conjugate base of phenol.



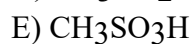
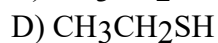
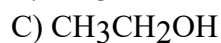
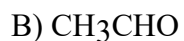
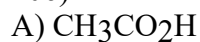
Answer:



Diff: 2

Section: 1.13

106) Which of the following acids has the most stable conjugate base?

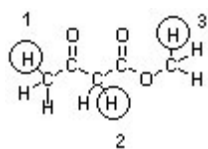


Answer: E

Diff: 2

Section: 1.13

107) Which sequence correctly ranks the indicated protons in order of increasing acidity?



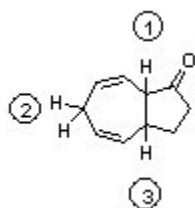
- A) $1 < 2 < 3$
- B) $2 < 3 < 1$
- C) $3 < 1 < 2$
- D) $2 < 1 < 3$
- E) $1 < 3 < 2$

Answer: C

Diff: 3

Section: 1.13

108) Which sequence correctly ranks the following protons in order of increasing acidity?



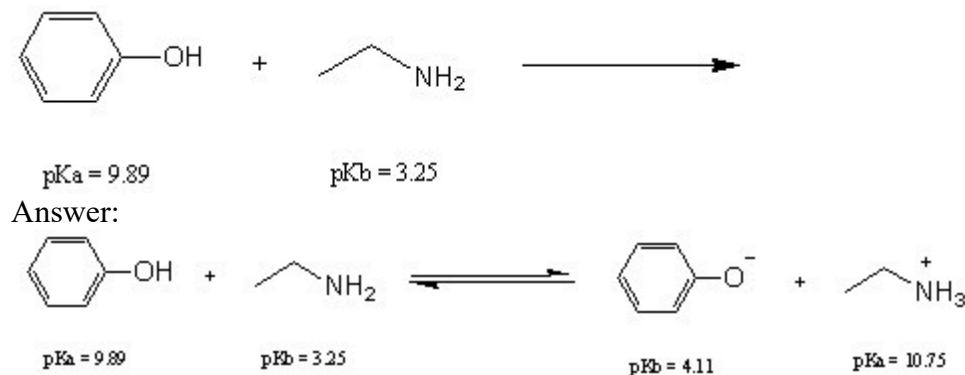
- A) $1 < 2 < 3$
- B) $2 < 3 < 1$
- C) $3 < 1 < 2$
- D) $3 < 2 < 1$
- E) $2 < 1 < 3$

Answer: D

Diff: 3

Section: 1.13

109) Complete the following chemical reaction and predict whether the equilibrium will favor the reactants or products:



The stronger acid and the stronger base are both on the left side of the reaction (reactants); therefore, the equilibrium concentration should favor the products or right side of this equation.

Diff: 3

Section: 1.13

110) Which is more acidic, HF or HI? Explain.

Answer: HI is more acidic. As a conjugate base I⁻ is more stable than F⁻. The large size of the I⁻ ion allows the extra negative charge to be spread out in a large volume of space.

Diff: 3

Section: 1.13

111) Which is more acidic, methanesulfonic acid (CH₃SO₃H) or propanoic acid (CH₃CH₂CO₂H)? Explain.

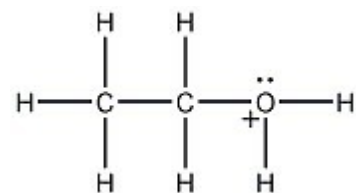
Answer: Methanesulfonic acid is considerably more acidic. The methanesulfonate ion is much more stable than the propanoate ion. Both of these conjugate bases are stabilized by resonance delocalization of the negative charge, but this delocalization is more extensive in the sulfonate.

Diff: 3

Section: 1.13

112) Provide the Lewis structure of the conjugate acid of ethanol (CH₃CH₂OH).

Answer:



Diff: 3

Section: 1.13

113) Consider the set of compounds, NH_3 , HF , and H_2O . Rank these compounds in order of increasing acidity and discuss your rationale.

Answer: $\text{NH}_3 < \text{H}_2\text{O} < \text{HF}$

When determining relative acidity, it is often useful to look at the relative basicity of the conjugate bases. The stronger the acid, the weaker (more stable, less reactive) the conjugate base. In this case, one would look at the relative basicity of F^- , OH^- , and NH_2^- . The relative strengths of these species can be gauged based on the electronegativity of the charged atom in each. Since fluorine is the most electronegative, F^- is the most stable, least reactive base in the group. This means that its conjugate acid, HF , is the strongest.

Diff: 3

Section: 1.13

114) Methanesulfonic acid, $\text{CH}_3\text{SO}_3\text{H}$, has a pK_a of -7 while ethanol, $\text{CH}_3\text{CH}_2\text{OH}$, has a pK_a of 15.9. Which is the stronger acid and what accounts for this large difference in relative acidity?

Answer: Methanesulfonic acid is the stronger acid. The lower the pK_a , the stronger the acid. A lower pK_a is associated with a larger K_a which signifies greater dissociation. The large relative difference in acidity in this case can be most easily seen by gauging the relative basicities of the conjugate bases. The weaker the base, the stronger the corresponding conjugate acid. Methanesulfonate, CH_3SO_3^- , is considerably stabilized by resonance delocalization which is not found in ethoxide, $\text{CH}_3\text{CH}_2\text{O}^-$. This effect greatly reduces the basicity of methanesulfonate relative to ethoxide.

Diff: 3

Section: 1.13

115) Would you predict trifluoromethanesulfonic acid, $\text{CF}_3\text{SO}_3\text{H}$, to be a stronger or weaker acid than methanesulfonic acid, $\text{CH}_3\text{SO}_3\text{H}$? Explain your reasoning.

Answer: Trifluoromethanesulfonic acid is a stronger acid. Compare the strengths of the conjugate bases and remember that the weaker the base, the stronger the conjugate acid. Both bases are stabilized by resonance, but in the case of the trifluoro derivative, the presence of the highly electronegative fluorine atoms serves to delocalize the negative charge to an even greater extent. This additional delocalization makes trifluoromethanesulfonate a weaker base.

Diff: 3

Section: 1.13

116) Consider the species CH_3O^- , NH_2^- , and CH_3COO^- . Rank these ions in order of increasing basicity, and explain your rationale.

Answer: $\text{CH}_3\text{COO}^- < \text{CH}_3\text{O}^- < \text{NH}_2^-$

The first factor to consider is the nature of the atom which bears the negative charge. The more electronegative the atom that bears the negative charge, the more stable the anion. Stable anions are less reactive and are hence weaker bases. Since O is more electronegative than N, the NH_2^- is the strongest base in the set. In the remaining two species, the negative charge is on the O, but in the case of CH_3COO^- , the negative charge is also delocalized by resonance.

Diff: 3

Section: 1.13

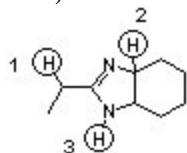
117) Stabilization of a charged species usually results when this species can be more accurately depicted as a hybrid of several resonance forms. Why is this the case?

Answer: Stabilization results from delocalization of charge.

Diff: 3

Section: 1.13

118) Which sequence ranks the indicated protons in order of increasing acidity?



A) 1<2<3

B) 2<1<3

C) 1<3<2

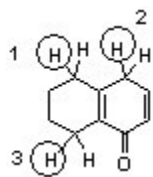
D) 3<2<1

Answer: A

Diff: 3

Section: 1.13

119) Which sequence correctly ranks the following protons in order of increasing pK_a value?



A) 3<1<2

B) 2<1<3

C) 3<2<1

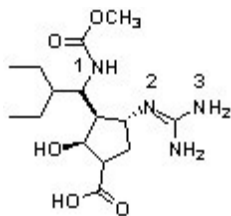
D) 1<3<2

Answer: B

Diff: 3

Section: 1.13

120) Peramivir, shown below, has shown to be effective against the influenza B virus (*J. Med. Chem.* **2010**, 6421). Which sequence ranks the following nitrogen atoms in order of increasing basicity?



- A) 2<3<1
- B) 3<1<2
- C) 1<3<2
- D) 1<2<3

Answer: A

Diff: 3

Section: 1.13

121) The hydroxide ion (HO⁻) cannot function well as which of the following?

- A) a Bronsted-Lowry base
- B) a Lewis base
- C) a nucleophile
- D) an electron-pair acceptor
- E) a proton acceptor

Answer: D

Diff: 1

Section: 1.14

122) Which of the following terms comes closest to describing an electrophile?

- A) anion
- B) Lewis base
- C) Lewis acid
- D) nucleophile
- E) nonpolar

Answer: C

Diff: 2

Section: 1.14

123) According to the Lewis definition, which of the following may act as acids?

- A) NH₃
- B) HCl
- C) AlCl₃
- D) A & B
- E) A, B, & C

Answer: E

Diff: 2

Section: 1.14

124) Use the curved arrow formalism to show the movement of electron pairs in the following reaction.



Answer:



Diff: 2

Section: 1.14

125) In the reaction below, label each reactant as a nucleophile or an electrophile.



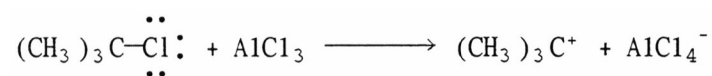
Answer: BH₃, electrophile

CH₃SCH₃, nucleophile

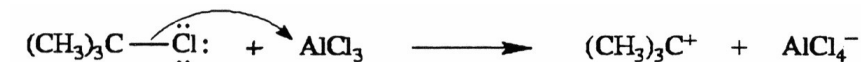
Diff: 2

Section: 1.14

126) Use the curved arrow formalism to indicate the movement of electron pairs in the following reaction.



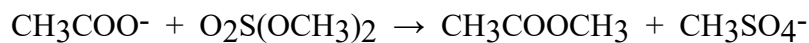
Answer:



Diff: 2

Section: 1.14

127) In the reaction below, label each reactant as a nucleophile or an electrophile.



Answer: CH₃COO⁻, nucleophile

O₂S(OCH₃)₂, electrophile

Diff: 3

Section: 1.14