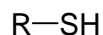


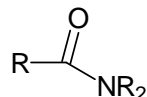
MARK ONE ANSWER FOR EACH QUESTION ON BOTH THE EXAM AND YOUR SCANTRON!

1. Which of the following best describes the functional group shown below:



- A. sulfide      B. thiol      C. mercaptenyl      D. sulfanol      E. sulfone

2. Which of the following best describes the functional group shown below:

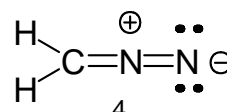
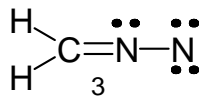
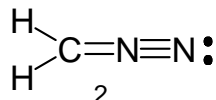
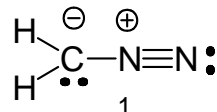


- A. tertiary amide      B. tertiary amine      C. 2° amide      D. ester      E. nitrile

3. What best describes a node?

- A. the area with the highest electron density in the molecule  
 B. the place where the atomic nucleus is located  
 C. an area with zero electron density  
 D. the region where valence electrons can be found  
 E. a region in which two orbitals overlap

4. Consider the Lewis dot structures for diazomethane, below. This as an overall uncharged molecule. Select one option:

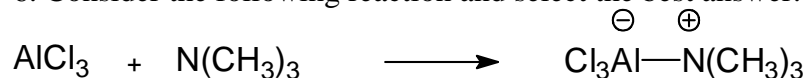


- A. Only structure 1 is correct      B. Only structure 2 is correct  
 C. Only structure 3 is correct      D. Only structure 4 is correct  
 E. Structures 1 and 4 are both correct

5. What description best fits the ozone ( $\text{O}_3$ ) molecule?

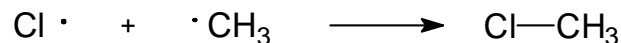
- A. The molecule is angled, with lone pairs on all oxygens  
 B. The molecule has two double bonds  
 C. The molecule is linear (not angled), with one double bond  
 D. The molecule is linear, with one triple bond  
 E. The molecule has two single bonds

6. Consider the following reaction and select the best answer:



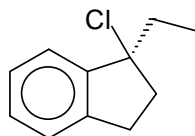
- A. Aluminum chloride is a Bronstead acid  
 B. Aluminum chloride is a Lewis base  
 C. Aluminum chloride is a Lewis acid  
 D. Aluminum chloride is both a Lewis and a Bronsted base  
 E. This is not an acid-base reaction at all

7. Consider the following reaction, in which a chlorine radical and a methyl radical each provide one electron to form a bond. Select the best answer:



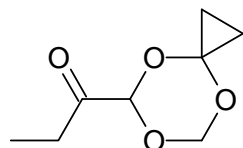
- A. The chlorine radical is a Bronstead acid in this reaction
- B. The chlorine radical is a Bronstead base in this reaction
- C. The chlorine radical is a Lewis (but not Bronstead) acid in this reaction
- D. The chlorine radical is a Lewis (but not Bronstead) base in this reaction
- E. This is not an acid-base reaction at all

8. What is the proper molecular formula for the compound below?



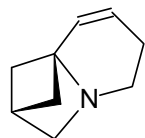
- A.  $\text{C}_5\text{H}_{15}\text{Cl}$
- B.  $\text{C}_{11}\text{H}_{15}\text{Cl}$
- C.  $\text{C}_{11}\text{H}_{13}\text{Cl}$
- D.  $\text{C}_{10}\text{H}_{14}\text{Cl}$
- E. none of these

9. What is the proper molecular formula for the compound below?



- A.  $\text{C}_7\text{H}_{12}\text{O}_4$
- B.  $\text{C}_8\text{H}_{11}\text{O}_4$
- C.  $\text{C}_8\text{H}_9\text{O}_4$
- D.  $\text{O}_4\text{H}_{12}\text{C}_8$
- E. none of these

10. What is the proper molecular formula for the compound below?

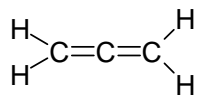


- A.  $\text{C}_9\text{H}_{12}\text{N}$
- B.  $\text{C}_9\text{H}_{13}\text{N}$
- C.  $\text{C}_9\text{NH}_{13}$
- D.  $\text{C}_9\text{H}_8\text{N}$
- E. none of these

11. Molecular orbital (MO) theory can readily explain why  $\text{H}_2$  is stable while  $\text{He}_2$  is unstable. Select the most appropriate explanation, based on MO theory:

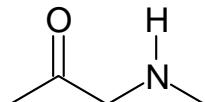
- A.  $\text{He}_2$  is unstable because just as many electrons end up in an anti-bonding molecular orbital as in a bonding molecular orbital.
- B.  $\text{He}_2$  is unstable because it violates the octet rule
- C.  $\text{He}_2$  is unstable because noble gases cannot form compounds
- D.  $\text{He}_2$  is unstable because the He atoms are too large to approach each other for bonding
- E.  $\text{He}_2$  is unstable because the wave functions of the s orbitals of the two helium atoms have different signs and cannot overlap.

12. Consider the allene molecule below and select the best description of this molecule:



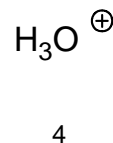
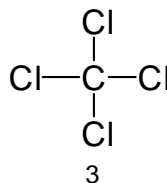
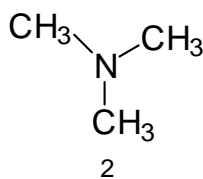
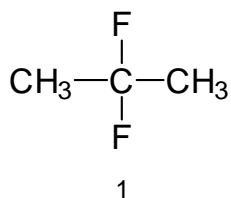
- A. The central carbon is  $sp^2$  hybridized
- B. The molecule is twisted propeller-like so that the four hydrogens are not in the same plane
- C. This molecule has a lone pair, not shown here
- D. The central carbon of this molecule violates the octet rule
- E. The two carbons at either end are  $sp$  hybridized.

13. Consider the compound below and select among the following statements:



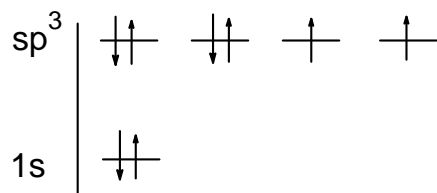
- A. This compound is a secondary amide
- B. The oxygen in this molecule is  $sp^2$  hybridized
- C. This molecule has two lone pairs
- D. The nitrogen in this molecule is  $sp^2$  hybridized
- E. This molecule contains three carbons

14. Consider the molecules below and select one option:



- A. All of them have permanent dipole moments
- B. Only 1 has a permanent dipole moment
- C. Only 2 has a permanent dipole moment
- D. Only 3 has a permanent dipole moment
- E. Three of them have permanent dipole moments

15. Consider the atomic orbital energy diagram below and select the most appropriate statement:

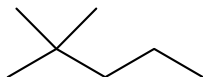


- A. This represents the ground state of oxygen
- B. This represents  $sp^3$  hybridized nitrogen
- C. This represents  $sp^3$  hybridized oxygen
- D. This represents oxygen isotope 17.
- E. The diagram omits the 2s orbital and is therefore invalid

16. What was Heisenberg's main contribution to science?

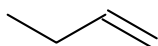
- A. He stated that the number of protons must be equivalent to the number of electrons
- B. He stated that atomic orbitals are filled lowest-to-highest energy
- C. He stated that orbitals, which have wave functions of opposite sign cannot overlap
- D. He stated that electrons can only reside in discrete energy levels, so-called orbitals
- E. None of the above

17. Select the best suited name for the compound below:



- A. 1,1,1-trimethylbutane
- B. 1-2-dimethylpentane
- C. 1,1-dimethylpentane
- D. 2,2-dimethylpentane
- E. dimethylpentane

18. Select the appropriate name for the compound below:



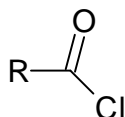
- A. butene
- B. 1-butan-ene
- C. 2-butene
- D. butane-1
- E. 1-butene

19. Which of the following violate the octet rule?

- 1. ozone (O<sub>3</sub>), 2. carbon dioxide 3. boron trifluoride 4. atmospheric oxygen (O<sub>2</sub>)

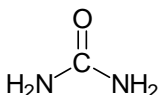
- A. All of them
- B. Ozone and boron trifluoride
- C. Boron trifluoride and O<sub>2</sub>
- D. Ozone only
- E. None of them

20. Which of the following best describes the functional group shown below:



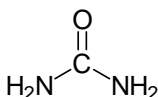
- A. aldehyde
- B. alkyl chloride
- C. chloroform
- D. acid halide
- E. ketone

21. State the hybridization of carbon in urea:



- A. sp<sup>3</sup> hybridized
- B. sp<sup>2</sup> hybridized,
- C. sp hybridized,
- D. not hybridized
- E. this concept does not apply here

22. State the hybridization of oxygen in urea:



- A. sp<sup>3</sup> hybridized
- B. sp<sup>2</sup> hybridized,
- C. sp hybridized,
- D. not hybridized
- E. this concept does not apply to oxygen

23. One of the following statements about bond-line structures is **INCORRECT**. Select the **INCORRECT** one!

- A. Bond-line structures may contain wedges to depict the shapes of molecules
- B. "Bond-line structure" means exactly the same as "Kekule formula"
- C. Bond-line structures may omit lone pairs
- D. Selected carbons may be shown explicitly (but don't have to be)
- E. Hydrogens attached to heteroatoms must be shown explicitly

24. What is the overall formal charge of the  $\text{NH}_2$  molecule? (it abides by the octet rule)

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

25. What is the overall formal charge of the  $\text{BH}_4$  molecule? (it abides by the octet rule)

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

Key:

1B

2A

3C

4E

5A

6C

7E

8C

9E

10B

11A

12B

13B

14E

15C

16E

17D

18E

19C

20D

21B

22B

23B

24B

25B