**Practice MT3 – 2:** Take exam like at the real exam!

1. Which statement is true about the polarity of HCN, which has a structure of H–C≡N: ?
   (Hint: The electronegativities of H, C, and N are 2.1, 2.5, and 3.0, respectively.)
   
   a. The carbon-nitrogen bond in HCN is a polar-covalent bond
   b. Both bonds in HCN are nonpolar covalent bonds
   c. The total molecular dipole moment in HCN points towards the H atom.
   d. Statements a and c are correct
   e. Statements b and c are correct

2. Why does the most proper Lewis structure of BeCl₂ contain two single Be-Cl bonds instead of two double Be=Cl bonds?
   
   a. The formal charges of the atoms would be maximized, rather than minimized as required by the formal charge rule, if BeCl₂ contained two double bonds
   b. Neither Be nor Cl could satisfy the octet rule if BeCl₂ contained two double bonds
   c. Be would be surrounded by more than eight electrons if BeCl₂ had two double bonds
   d. The Cl atoms would be surrounded by more than eight electrons each if BeCl₂ contained two double bonds
   e. The formal charges could not sum to zero if BeCl₂ contained two double bonds

3. Which molecule in each pair has the shortest bond length?

   I. O₂ vs. N₂  
   II. H₂O or H₂S  
   III. NO⁺ or NO⁻

   a. I. N₂  II. H₂O  III. NO⁺
   b. I. N₂  II. H₂O  III. NO⁻
   c. I. O₂  II. H₂O  III. NO⁺
   d. I. O₂  II. H₂S  III. NO⁻
   e. I. N₂  II. H₂S  III. NO⁻

4. Which statement(s) about the effect of resonance and the nitrate ion is/are true?
   
   a. Nitrate has three different, yet equivalent resonance structures
   b. All bonds in NO₃⁻ are equal in length
   c. Only two of the bonds in NO₃⁻ are equal in bond length
   d. Both statements a and b are true
   e. Both statements a and c are true
5. Which Lewis structure below best represents N₂O.

a. N=O=N
b. N≡N=O
c. N≡N-O
d. N=O-N
e. N-N≡O

6. How many total σ and π bonds are there in N₂O?

a. 1 σ and 1 π bond
b. 2 σ and 1 π bond
c. 1 σ and 2 π bond
d. 2 σ and 2 π bonds
e. 2 σ and 3 π bonds

7. Choose the member in each pair with the shortest bond length. Explain your choice.

a. The carbon-oxygen bond in CO or the carbon-oxygen bond in CH₂O

b. The carbon-hydrogen bond in CH₄ or the boron-hydrogen bond in BH₃

c. The oxygen-oxygen bond in O₂ or the oxygen-oxygen bond in O₂²⁻ (Hint: you can consider either their Lewis structures or molecular orbital diagrams to answer this question)

8. Consider sulfur dioxide.

a. Draw all of its possible Lewis structure(s).

b. Select and explain the most proper statement about the bonds in nitrite: (Circle one)

   i. The bonds in the molecule are equal in bond length
   ii. The bonds in the molecule differ in bond length

Explanation:
9. Which molecule has the greatest bond order?
   
   a. C$_2$\(^{2+}\)
   b. C$_2$\(^{2-}\)
   c. O$_2$
   d. O$_2$\(^{2-}\)
   e. F$_2$

10. Which ranking of by order of increasing bond length is correct for O$_2$, C$_2$, and N$_2$?
    
   a. O$_2$ < N$_2$ < C$_2$
   b. C$_2$ < N$_2$ < O$_2$
   c. N$_2$ < O$_2$ < C$_2$
   d. N$_2$ < C$_2$ < O$_2$
   e. C$_2$ < O$_2$ < N$_2$

11. Which molecule/ion would has the shortest oxygen-oxygen bond length?
    
   a. O$_2$\(^{-}\)
   b. O$_2$
   c. O$_2$\(^{+}\)
   d. O$_2$\(^{2-}\)
   e. More information is needed

12. The valence orbitals in bromine interact with the same pattern as fluorine. What is the proper valence MO configuration of bromine?
    
   a. $\sigma_{2s}^2\sigma^*_{2s}^2\sigma_{2p}^2\pi_{2p}^4\pi^*_{2p}^4$
   b. $\sigma_{4s}^2\sigma^*_{4s}^2\sigma_{4p}^2\pi_{4p}^4\pi^*_{4p}^4$
   c. $\sigma_{4s}^2\sigma^*_{4s}^2\pi_{4p}^4\pi^*_{4p}^4$
   d. $\sigma_{4s}^2\sigma^*_{4s}^2\sigma_{4p}^2\sigma^*_{4p}^2\pi_{4p}^4\pi^*_{4p}^2$
   e. None of the above
    
   (Exam continues with #23).
23. Use the following bond energies to calculate $\Delta H^\circ$ for the given reaction.
\[(H - C = 414; \ C - C = 347; \ C = C = 619; \ H - H = 435)\]

\[
\begin{align*}
\text{H} & \quad \text{H} & \quad \text{H} \\
\text{H} & \quad \text{C} & \quad \text{C} & \quad \text{H} \\
\text{H} & \quad \text{C} & \quad \text{H} & \quad \text{H}
\end{align*}
\]

H - C = C - H + H - H $\rightarrow$ H - C - C - H

$\Delta H^\circ$ can be calculated using the bond energies provided.

A. -55
B. -102
C. -72
D. -121
E. -92

24. The bond angles in IF$_2^+$ are _____.

A. exactly 90°
B. slightly less than 90°
C. exactly 109.5°
D. slightly less than 109.5°
E. exactly 120°

25. Write resonance structures for NO$_2^-$. Based on these structures one can conclude that the bond order of the N - O bond is

A. $\frac{1}{2}$
B. 1
C. 1 $\frac{1}{2}$
D. 1 $\frac{1}{2}$
E. 1 $\frac{3}{4}$

26. In the following oxidation reaction the shape of the reactant is ___ and the shape of the product is ___.

\[\text{SF}_4 \quad \longrightarrow \quad \text{SF}_4^{2+} + 2 \text{e}^-\]

A. tetrahedral, square pyramid
B. tetrahedral, see-saw
C. see-saw, tetrahedral
D. T-shaped, square planar
E. square planar, T-shaped
27. What types of hybrid orbitals are involved in bonding of \( \text{SO}_4^{2-} \)?
   A. \( \text{sp}^3 \)
   B. \( \text{sp}^2 \)
   C. \( \text{sp} \)
   D. \( \text{dsp}^3 \)
   E. \( \text{d}^2\text{sp}^3 \)

28. Draw the Lewis formula for \( \text{NH}_2^- \). What term describes the shape of this species?
   A. linear
   B. bent
   C. tetrahedral
   D. square planar
   E. see-saw

29. Which of the following is an acceptable Lewis structure for \( \text{H}_2\text{CNH} \)?

   ![Lewis structures](image.png)
   A. 
   B. 
   C. 
   D. 
   E.
30. Consider the following molecules and select those that are polar.

1) ClF       2) ClF₃       3) ClF₅

A. 1 and 2  
B. 2 and 3  
C. 1 and 3  
D. 1, 2 and 3  
E. only 3

31. The oxalate ion, C₂O₄²⁻ has a single bond between the carbon atoms and each carbon atom is bonded to two oxygen atoms. Write a resonance form conforming to the Lewis octet rule and determine the number of double bonds in this species.

A. one  
B. two  
C. three  
D. zero

32. Which of the following has bond angles of approximately 120°?

1) ClF₃       2) BF₃       3) ClO₃⁻       4) SF₄       5) GeCl₄

A. 1 and 4  
B. 2 and 3  
C. 2 only  
D. 4 only  
E. 5 only

33. Which of the following molecules is nonlinear?

A. SO₂  
B. CO₂  
C. HCN  
D. C₂H₂  
E. HCl
34. What is the density (g/L) of carbon dioxide at 30.3°C and 744 mm Hg?

A. 1.85  
B. 1.73  
C. 1.61  
D. 1.42  
E. 1.28

35. A gas occupies 250. mL at 700. torr and 300. K. What volume (mL) will the gas occupy at 350. torr and 450 K?

A. 750.  
B. 83.3  
C. 375  
D. 500.  
E. 950.

36. Imagine two flasks of identical volume. One contains 2 grams of H₂ at 200 K and the other contains 2 grams of He at 800 K. Which of the following properties are the same for the two flasks?

I. pressure  
II. average KE  
III. density  
IV. number of molecules  
V. average velocity

A. I  
B. III & IV  
C. III  
D. IV  
E. III & V

37. Consider three one-liter flasks labeled A, B, and C filled with the gases NO, NO₂, and N₂O, respectively, each at STP. Which flask contains 1.0 mole of gas?

A. flask A  
B. flask B  
C. flask C  
D. none  
E. all are the same
38. What volume (L) of O\textsubscript{2} at STP is required to burn 1.3 g of acetylene at STP?

\[ 2 \text{C}_2\text{H}_2(\text{g}) + 5 \text{O}_2(\text{g}) \rightarrow 4 \text{CO}_2(\text{g}) + 2 \text{H}_2\text{O}(\text{g}) \]

A. 2.1  
B. 2.8  
C. 1.8  
D. 3.2  
E. 2.5

39. A 1.14 g sample of impure aluminum carbide reacts with water to give 452 mL of CH\textsubscript{4} at 20.0 °C and 745 mm Hg. What is the % Al\textsubscript{4}C\textsubscript{3}?

\[ \text{Al}_4\text{C}_3(\text{s}) + \text{H}_2\text{O}(\text{l}) \rightarrow 3 \text{CH}_4(\text{g}) + 4 \text{Al(OH)}_3(\text{s}) \]

A. 74.2  
B. 80.2  
C. 77.6  
D. 82.4  
E. 72.1

40. Which of the following statements about kinetic energy (K.E.) is true?

A. All objects moving with the same velocity have the same K.E.  
B. As the velocity of a body increases, its K.E. decreases.  
C. The K.E. of a body will quadruple if its velocity doubles.  
D. The K.E. of a body is independent of its mass.  
E. None of the these are true.

41. A mixture contains 1.20 g helium, 4.00 g neon and 6.50 g argon. What is the partial pressure (mm Hg) of argon in the mixture at STP?

A. 242  
B. 345  
C. 187  
D. 425  
E. 122
42. The rms speed of an O$_2$ molecule is 425 m/s at 0.00°C. What is the rms speed at 100.0°C?

A. 425  
B. 497  
C. 515  
D. 535  
E. 581

43. Which of the following can form intermolecular hydrogen bonds in the pure liquid?

1) \( \text{H-C-C-C-O-H} \)  
2) \( \text{H-C-C-O-C-H} \)  
3) \( \text{H-C-C-C-H} \)

A. 1 only  
B. 2 only  
C. 3 only  
D. 1 and 2  
E. 1 and 3

44. Which one of the following DECREASES as the strength of the attractive intermolecular forces INCREASES?

A. The heat of vaporization.  
B. The normal boiling temperature.  
C. The extent of deviations from the ideal gas law.  
D. The sublimation temperature of a solid.  
E. The vapor pressure of a liquid.