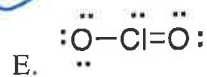
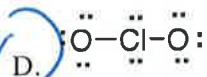
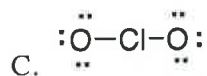
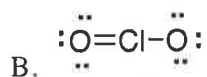
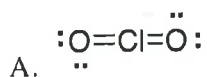


1. Which of the following is the correct Lewis structure for  $\text{ClO}_2^-$ ?



2. Write resonance structures for  $\text{NO}_2^-$  and  $\text{NO}_3^-$ . Based on these structures one can conclude that:

A. Both ions have the same bond length

B.  $\text{NO}_2^-$  has longer bonds than  $\text{NO}_3^-$

C.  $\text{NO}_2^-$  has shorter bonds than  $\text{NO}_3^-$

3. Which statement below is true about the effect of resonance on the structure of ozone,  $\text{O}_3$ ?

A. Ozone contains two oxygen-oxygen bonds of different length

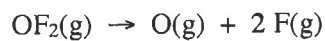
B. Ozone contains two oxygen-oxygen bonds of equal length

C. The central oxygen atom in ozone has a formal charge of +2

D. Both statements b and c are true

E. Both statements a and c are true

4. The standard enthalpy of the below reaction is 368 kJ. Calculate the average O-F bond energy in kJ/mol.



A. 736 kJ/mol

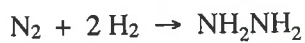
B. 536 kJ/mol

C. 184 kJ/mol

D. 242 kJ/mol

E. 368 kJ/mol

5. Calculate the enthalpy of the reaction below using the following bond energies:  
( $\text{N}\equiv\text{N}$  941 kJ/mol;  $\text{H}-\text{H}$  435 kJ/mol;  $\text{H}-\text{N}$  389 kJ/mol;  $\text{N}-\text{N}$  159 kJ/mol)



- A. 96 kJ  
B. 828 kJ  
C. -828 kJ  
D. -96 kJ  
E. 715 kJ
6. The bond angles in  $\text{AsCl}_4^+$  are \_\_\_\_\_.
- A. exactly  $90^\circ$   
B. slightly less than  $90^\circ$   
 C. exactly  $109.5^\circ$   
D. slightly less than  $109.5^\circ$   
E. exactly  $120^\circ$
7. What term below best describes the molecular bond geometry of  $\text{ClF}_4^+$ ?
- A. linear  
B. bent  
 C. tetrahedral  
D. square planar  
E. see-saw
8. Which bond angle below would best describe the C-C-C bond angle in acetone,  $\text{CH}_3\text{COCH}_3$ ?
- A. Exactly  $109.5^\circ$   
B. Exactly  $120^\circ$   
 C. Slightly less than  $120^\circ$   
D. Slightly greater than  $120^\circ$   
E. Slightly greater than  $109.5^\circ$

9. Which of the following molecules is polar?

- A. CO<sub>2</sub>
- B. BF<sub>3</sub>
- C. SO<sub>2</sub>
- D. CO<sub>2</sub> and SO<sub>2</sub>
- E. CO<sub>2</sub>, BF<sub>3</sub>, and SO<sub>2</sub>

10. In the following oxidation reaction the shape of the reactant is \_\_\_ and the shape of the product is \_\_\_.



- A. linear, linear
- B. bent, bent
- C. linear, bent
- D. bent, linear
- E. square planar, T-shaped

11. Which molecule contains a central atom best described using sp hybrid orbitals?

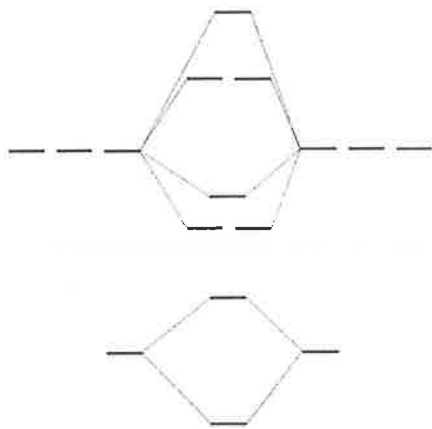
- A. CO<sub>3</sub><sup>2-</sup>
- B. BF<sub>3</sub>
- C. H<sub>2</sub>O
- D. CO<sub>2</sub>
- E. NO<sub>2</sub>

12. Consider the Lewis structure of CH<sub>3</sub>CCCH<sub>3</sub>. How many σ and π bonds the molecule contain?

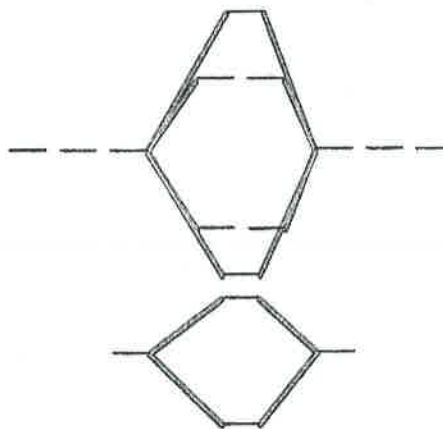
- A. 9 σ, 2 π
- B. 8 σ, 2 π
- C. 9 σ, 1 π
- D. 8 σ, 3 π
- E. 10 σ, 1 π

13. Use these diagrams below as needed for the next three questions:

**B<sub>2</sub>, C<sub>2</sub>, N<sub>2</sub>, and their ions:**



**O<sub>2</sub>, F<sub>2</sub>, Ne<sub>2</sub>, and their ions:**



What is the bond order and magnetic property of the peroxide anion?

- A. 1, diamagnetic
- B. 1.5, diamagnetic
- C. 0.5, diamagnetic
- D. 1.5 paramagnetic
- E. 1, paramagnetic

14. An important property of molecules is the energy difference between the highest energy molecular orbital occupied with electrons (HOMO) and the lowest energy molecular orbital unoccupied with electrons (LUMO). Identify the HOMO of O<sub>2</sub>.

- A.  $\pi_{2p}$
- B.  $\sigma_{2p}$
- C.  $\sigma^*_{2p}$
- D.  $\pi^*_{2p}$
- E.  $\pi^*_{2s}$

15. Which molecule below has the longest bond length?

- A. B<sub>2</sub>
- B. F<sub>2</sub>
- C. C<sub>2</sub>
- D. O<sub>2</sub>
- E. N<sub>2</sub>

16. A balloon is filled with air and has a volume of 3.25 L at 30.0°C. The balloon is then placed in a freezer at -10.0°C. What is the volume of the balloon at this temperature? 04001

A. 3.74 L  
B. 2.82 L  
C. 2.56 L  
D. 2.30 L  
E. 2.02 L

17. The Goodyear blimp contains  $5.12 \times 10^3$  kiloliters of helium at 25.0°C and 1.00 atm. What is the mass, in kg, of helium in the blimp?

A. 652 kg  
B.  $1.03 \times 10^3$  kg  
C. 837 kg  
D. 10.3 kg  
E. 0.837 kg

18. What is the density in g/L of  $\text{BrF}_3$  at 425 torr and 77.0°C?

A. 2.66 g/L  
B. 2.24 g/L  
C. 1.92 g/L  
D. 1.72 g/L  
E. 1.33 g/L

19. Octane burns according to the below reaction. The cylinders in an automobile engine have a total volume of 494 mL. If the cylinders are filled with air that is 21.0%  $\text{O}_2$  by volume at 50.0°C and 1.00 atm, what mass (g) of octane must be injected to react fully with all the oxygen?



A. 0.171 g  
B. 0.203 g  
C. 0.0724 g  
D. 0.0358 g  
E. 0.0427 g

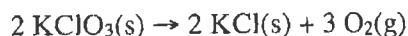
20. 1.00 g of a pure gaseous compound that has the general formula of  $\text{SF}_x$ , where  $x$  is unknown, is added to a container with a volume of 269 mL. If the pressure inside the container is measured to be 745 mm Hg at  $75^\circ\text{C}$ , what is the molecular formula of the compound, assuming ideal gas behavior?

- A. SF
- B.  $\text{SF}_2$
- C.  $\text{SF}_3$
- D.  $\text{SF}_4$
- E.  $\text{SF}_6$

21. A gas mixture at STP is comprised of 50.0%  $\text{O}_2$ , 25.0%  $\text{N}_2$  and 25.0%  $\text{Cl}_2$  by mass. What is the partial pressure (atm) of  $\text{N}_2$  in the mixture? Hint: You will need to calculate the mol fraction of  $\text{N}_2$  in the mixture.

- A. 0.0751 atm
- B. 0.126 atm
- C. 0.251 atm
- D. 0.318 atm
- E. 0.426 atm

22. The gaseous product generated by the below reaction is collected over water at  $27.0^\circ\text{C}$ . If 2.00 L quantity of gas is collected with a total pressure of 1.00 atm, how much mass of  $\text{KClO}_3$  was consumed in the reaction? Take into consideration that the collected gas would also include water vapor since the vapor pressure of  $\text{H}_2\text{O}$  at  $27.0^\circ\text{C}$  is 26.0 torr. Assume ideal gas behavior.



- A. 6.12 g
- B. 5.54 g
- C. 6.41 g
- D. 5.78 g
- E. 6.89 g

23. What is the root-mean velocity ( $v_{\text{rms}}$ ) of a sample of oxygen ( $\text{O}_2$ ) at  $25^\circ$ ?

- A. 482 m/s
- B. 1.51 m/s
- C. 0.439 m/s
- D. 15.2 m/s
- E. 47.9 m/s

24. Which of the following gases of  $\text{N}_2\text{O}$ ,  $\text{C}_2\text{H}_2$ , and  $\text{NO}$  diffuse more slowly than  $\text{O}_2$  under identical experimental conditions?
- A.  $\text{N}_2\text{O}$  only  
B.  $\text{C}_2\text{H}_2$  only  
C.  $\text{NO}$  only  
D.  $\text{NO}$  and  $\text{C}_2\text{H}_2$   
E.  $\text{N}_2\text{O}$  and  $\text{C}_2\text{H}_2$
25. When the pressure of a gas is increased from 5.0 to 1000 atm at constant temperature, its volume changes from 3.0 L to 20.5 mL, though the volume would have become 15.0 mL had the gas behaved ideally. What is most likely the largest cause of deviation from ideal behavior?
- A. The average molecular speed has decreased.  
B. The volume of the gas molecules is now a significant fraction of the volume of the container.  
C. The molecules experience higher net attraction to each other at the higher pressure.  
D. The collision of the molecules with the walls of the container are no longer elastic.  
E. The molecules have decomposed to form more molecules.
26. Which of the following can form intermolecular hydrogen bonds in its pure liquid?
- 1)  $\text{HOCH}_2\text{CH}_2\text{OH}$     2)  $\text{CH}_3\text{CH}_2\text{CH}_2\text{NH}_2$     3)  $\text{CHF}_3$
- A. 1 only  
B. 2 only  
C. 3 only  
D. 1 and 2  
E. 1, 2, and 3
27. Which of the following compounds has the greatest total intermolecular forces and most likely the greatest boiling point?
- A.  $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_3$   
B.  $\text{CH}_3\text{CH}_2\text{COH}$   
C.  $\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$   
D.  $\text{CH}_3\text{COCH}_3$   
E. All the above compounds likely have similar boiling points
28. Which of the following compounds most likely has the greatest enthalpy of vaporization?
- A.  $\text{CH}_4$   
B.  $\text{SiH}_4$   
C.  $\text{GeH}_4$   
D.  $\text{SnH}_4$   
E.  $\text{BH}_3$