Multiple Choice (3 points each)
Bubble in the correct answer on the scantron form.

1) How many of the following electron configurations are correct?
   - Fr – [Xe] 7s¹
   - Cu – [Ar] 4s¹3d¹⁰
   - F – 1s²2s²2p⁶
   - Cd – [Kr] 5s²3d¹⁰
   - If does not exist

   a) 0 – None are correct  b) 1  c) 2  d) 3  e) 4 – All are correct

2) In the ground state of fluorine, which of these orbitals will NOT contain an electron?
   - I.  
   - II.  
   - III.  
   - IV.  

   a) I and II  b) III  c) II and III  d) IV  e) III and IV

3) Rank the following elements in order of increasing number of unpaired electrons
   - Cr  
   - Mg  
   - N  
   - Se  
   - Br

   a) Cr < Mg < N < Se < Br  b) Cr < N < Se < Br < Mg  
   c) Mg < Cr < Se < Br < N  d) Mg < Br < Se < N < Cr  
   e) N < Br < Se < Mg < Cr

4) How many of the following bonds are polar, but not ionic?
   - Ionic  
   - polar  
   - polar  
   - non-polar  
   - non-polar

   a) 0 – none of them  b) 1  c) 2  d) 3  e) 4
5) Which of the elements should have the highest 1st ionization energy?
   a) Cr  b) Sr  c) As  d) Se  e) Br

6) For which of the elements do you expect a large jump between the 3rd and the fourth ionization energy?
   a) Na  b) Br  c) O  d) N  e) Al

7) Which of the following statements about Bohr's model of the atom is false?
   a) An electron in the n = 5 energy level is in the excited state. True
   b) The wavelength of light emitted if the electron drops from n = 5 to n = 3 will be longer than the wavelength of light emitted when the electron falls from n = 4 to n = 2. True
   c) It takes less energy to ionize the electron from n = 5 state than from the ground state. True
   d) The Bohr model works only for one electron atoms. True
   e) None of the above

8) Which of the following molecules has the most number of lone pairs in the Lewis Structure (not just the central atom)?
   a) NH₃
   b) I₃⁻
   c) NBr₃
   d) NO₃⁻
   e) PCl₅

9) How many of the molecules in the previous question exhibit tetrahedral electron geometry?
   a) 0 – none of them  b) 1  c) 2  d) 3  e) 4

   NH₃
   NBr₃
Use the following picture of the electromagnetic spectrum to answer the following 2 questions.

10) From lowest energy to highest energy, which of the following correctly orders the different categories of electromagnetic radiation?

a) visible light, infrared, X rays, ultraviolet, gamma rays, radio
b) infrared, visible light, ultraviolet, X rays, gamma rays, radio
c) radio, infrared, visible light, ultraviolet, X rays, gamma rays
d) gamma rays, X rays, visible light, ultraviolet, infrared, radio
e) radio, X rays, visible light, ultraviolet, infrared, gamma rays

11) When an electron moves from the n=2 → n=1, the energy is released as a ultraviolet radiation. Which of the following lines best describes the transition that would absorb an infrared ray?

a) A, n = 1 → n = 4
b) B, n = 4 → n = 1

Circle C, n = 3 → n = 4

d) D, n = 4 → n = 3
e) E, n = 3 → n = 1

K must move up
n=4 an energy level
n=3 A or C
n=2
n=1
12) How many of the following molecules exhibit a bent shape?

- sulfur difluoride
- water
- hydrogen cyanide
- ozone, O₃
- carbon dioxide

a) 0 – none of them  b) 1  c) 2  d) 3  e) 4

13) How many of the following molecules are polar?

- ClF₅  ✓
- CCl₄  ✓
- CO  ✓
- NF₃  ✓
- XeCl₂, Xe – Cl: no

a) 0 – none of them  b) 1  c) 2  d) 3  e) 4

14) How many of the following exhibit d²sp³ hybridization?

- XeCl₂
- PCl₃
- NF₃
- PO₄³⁻
- NCl₅

a) 0 – none of them  b) 1  c) 2  d) 3  e) 4

15) Which of the following has the highest boiling point?

a) CH₃OH  b) CH₃OCH₃  c) CaCl₂  d) CH₃CH₂CH₃  e) CH₄

- H-bonding  - polar  - electrostatic  - LD  - LD

The following two questions use the isoelectronic series.

16) Which atom has the largest radius?

a) Ca²⁺  b) K⁺  c) Ar  d) Cl⁻  e) S²⁻

17) Which atom has the highest ionization energy?

a) Ca²⁺  b) K⁺  c) Ar  d) Cl⁻  e) S²⁻
Complete the Lewis structure for the following organic molecule and use the completed Lewis structure to answer the next 3 questions.

18) How many pi bonds are in the completed structure?
   a) 0 – no pi bonds  
   b) 2  
   c) 3  
   d) 6  
   e) 18  

19) What is the bond angle around the atom labeled a?
   a) 90  
   b) 120  
   c) 180  
   d) 109.5  
   e) 108  

20) What orbitals overlap to form the bond labeled b?
   a) O(sp\(^3\)) – C (sp\(^3\))  
   b) O(sp\(^3\)) – C (sp\(^3\))  
   c) O(sp\(^3\)) – C (sp\(^3\))  
   d) O(sp\(^3\)) – C (sp\(^3\))  
   e) O(sp) – C (sp\(^3\))
True-False

State whether the following questions are true or false. If the question is false, correct the underlined portion so that the statement is true. (1 pt each)

21. The P—H bond is nonpolar because P and H have similar electron affinities. \[ \text{F} \]
Correction: electronegativities

22. A pi bond cannot be rotated because the orbitals in a pi bond do not overlap head-to-head. \[ \text{T} \]
Correction: __________________________

23. A molecule with lone pairs of electrons on the central atom is always polar. \[ \text{F} \]
Correction: sometimes often \[ \text{F} - 'Xe' \text{-} 'F' \]

24. The three degenerate 2p orbitals can hold up to 6 electrons. \[ \text{T} \]
Correction: __________________________

25. A certain element has an excited state electron configuration of [Ar] 4s²4p⁴5s² so the ground state must contain 4 unpaired electrons. \[ \text{F} \]
Correction: 6

26) An element with the electron configuration [Ar] 4s²3d⁸⁴p² will be less electronegative than oxygen. \[ \text{F} \]
Correction: \[ \text{Ga} \]

27) A 4s orbital is lower in energy than a 3p orbital. \[ \text{F} \]
Correction: ____________ higher ____________

28) An atomic orbital tells the exact location of an electron in an atom. \[ \text{F} \]
Correction: ____________ approximate ____________

29) CH₂Cl₂ is non-polar. \[ \text{F} \]
Correction: __________________________

30) The pi bond in ethylene (see picture at right) is formed from the overlap of C sp² orbital with a C sp² orbital. \[ \text{F} \]
Correction: \[ \text{C} \text{ p orbital with } \text{C} \text{ p orbital} \]
Short Answer

Answer each question to the best of your ability. When appropriate, discuss concepts covered in class.

31) What is the energy released from 0.500 moles of Li\(^{+2}\) atoms if an electron is moved from the \( n = 5 \) to \( n = 1 \) energy level? (10 pts)

\[
E = \left(3^2\right)\left(-2.199 \times 10^{-18} \text{ J} \right) \left(\frac{\frac{1}{5^2}}{\frac{1}{1^2}}\right) = -1.88 \times 10^{-19} \text{ J/phot} \\
E_{/\text{mole}} = \frac{-1.88 \times 10^{-19} \text{ J/phot}}{\text{phot}} \times \frac{6.022 \times 10^{23} \text{ photons}}{1 \text{ mole}} \times 0.500 \text{ mole} \\
= 5.66 \times 10^6 \text{ J}
\]

32) a) Give the Lewis structure(s) for each molecule that best satisfies the octet rule. (10 pts)

<table>
<thead>
<tr>
<th>CO(_2)</th>
<th>CO</th>
<th>CO(_3^{2-})</th>
<th>CH(_3)OH</th>
</tr>
</thead>
<tbody>
<tr>
<td>O=(\cdots)O \quad double bond \quad \uparrow \quad \downarrow</td>
<td>C=O \quad \downarrow \quad \uparrow</td>
<td>\text{somewhere between single and double bond} \quad \text{single bond}</td>
<td></td>
</tr>
<tr>
<td></td>
<td>\quad triple bond</td>
<td>\quad \text{between single and double bond}</td>
<td></td>
</tr>
</tbody>
</table>

b) Rank the molecules from shortest bond length to longest bond length. (4 pts)

Shortest CO \(\text{CO}\) < \(\text{CO}_2\) < \(\text{CO}_3^{2-}\) < CH\(_3\)OH

Longest CO Bond Length

C) Which of these molecules has delocalized electrons? (2 pts)

\(\text{CO}_3^{2-}\) because it exhibits resonance
33) You are working in the lab when the air conditioning goes out. Your lab partner is working with four different toxic chemicals in different beakers.

\[ \text{CCl}_4 \quad \text{CH}_2\text{O} \quad \text{CHCl}_3 \quad \text{CH}_4 \]

In a short amount of time, your lab mate begins to feel faint and weak in the knees. The paramedics arrive and want to treat your lab partner's symptoms, but they first need to know what chemical to treat your lab-mate for. Using your understanding of vapor pressure, polarity, intermolecular forces, Lewis structures, and VSEPR, explain what chemical your labmate most likely inhaled first. Assume all the beakers were equidistant from your labmate. (10 pts)

Lewis structure

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

VSEPR - Tetrahedral

Trigonal Planar

Polarity - non-polar, polar, non-polar

IMF - LD dipole-dipole dipole-dipole (LD)

Boiling pt - \( \text{CH}_4 < \text{CCl}_4 < \text{CHCl}_3 \text{ or } \text{CH}_2\text{O} \)

Vapor pressure - \( \text{CH}_4 > \text{CCl}_4 > \text{CHCl}_3 \text{ or } \text{CH}_2\text{O} \)

2pts - Clarity & Elegance

Could the grader understand your answer?