1. Draw the Lewis structure for ICl$_5$. How many of the following four statements (I-IV) is/are true regarding ICl$_5$?

I. The central atom in ICl$_5$ has one lone pair of electrons.
II. Some of the Cl–I–Cl bond angles are approximately 90°.
III. ICl$_5$ is polar.
IV. The shape of ICl$_5$ is square pyramid.

a) 0 (None are true.) b) 1 c) 2 d) 3 e) 4 (All are true.)

Use the figure below to answer the next two questions.

<table>
<thead>
<tr>
<th>Wavelength (m)</th>
<th>Infrared</th>
<th>Red</th>
<th>Orange</th>
<th>Yellow</th>
<th>Green</th>
<th>Blue</th>
<th>Violet</th>
<th>Ultraviolet</th>
</tr>
</thead>
<tbody>
<tr>
<td>$7 \times 10^{-7}$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$6 \times 10^{-7}$</td>
<td></td>
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<td></td>
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<tr>
<td>$5 \times 10^{-7}$</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>$4 \times 10^{-7}$</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

2. What color is electromagnetic radiation having a frequency of $5.0 \times 10^{14}$ sec$^{-1}$?

a) red b) orange c) yellow d) blue e) violet

3. In the emission spectrum for hydrogen, what color is the n = 6 to n = 2 electronic transition?

a) red b) orange c) yellow d) blue e) violet

4. Consider the compound butane, which has a formula of C$_4$H$_{10}$. If a sample of butane contains $2.59 \times 10^{23}$ atoms of hydrogen, what mass of butane is present?

a) 25.0 g b) 50. g c) 5.00 g d) 1.25 g e) 2.50 g

5. An unknown element E forms a covalent compound with fluorine having the formula EF$_4$. The shape of the EF$_4$ molecule is see-saw. Which of the following elements could be E?
6. Place the following atoms/ions in order of decreasing size (largest to smallest).

- F, Te\(^{-}\), I, Ne\(^{+}\)

- a) F > Te\(^{-}\) > I > Ne\(^{+}\)  
- b) F > Te\(^{-}\) > I > Ne\(^{+}\)  
- c) I > Ne\(^{+}\) > F > Te\(^{-}\)  
- d) Te\(^{-}\) > F > Ne\(^{+}\) > I  
- e) Ne\(^{+}\) > F > I > Te\(^{-}\)

7. Which of the following ground state electron configurations is associated with the atom having the largest ionization energy?

- a) \([\text{Ne}]3s^23p^2\)  
- b) \([\text{Ne}]3s^23p^3\)  
- c) \([\text{He}]2s^22p^4\)  
- d) \([\text{He}]2s^22p^3\)  
- e) \([\text{Ar}]4s^23d^{10}4p^3\)

8. The ground state electron configuration for an atom or ion has 2 electrons in the \(n=1\) orbital, 8 electrons in \(n=2\) orbitals, 18 electrons in \(n=3\) orbitals, and 12 electrons in \(n=4\) orbitals. Which of the following could be this atom or ion?

- a) Zr  
- b) Mo\(^{2+}\)  
- c) Sr\(^{2-}\)  
- d) Cd  
- e) Pd\(^{2-}\)

9. Which of the following is not accounted for in the Bohr model?

- a) Electrons follow circular orbits.  
- b) Electrons move between orbits by absorbing or emitting photons of electromagnetic radiation.  
- c) Energy is quantized.  
- d) Electrons exhibit wave properties.  
- e) For the \(n=\infty\) state, the electron has been removed from the atom.

10. Which of the following statements (a-d) is true regarding element 117 (symbolized as X)?

- a) Element 117 would form a stable compound with potassium having the formula \(\text{K}_2\text{X}\).  
- b) Element 117 has 2 unpaired electrons in the ground state.  
- c) Element 117 has one valence electron in the ground state.  
- d) Element 117 has 14 electrons in various f orbitals in the ground state.  
- e) None of the above statements (a-d) are true.

11. When \(l=5\), these are called h orbitals. How many different \(m_l\) values are possible for allowed h orbitals?

- a) 25  
- b) 21  
- c) 18  
- d) 15  
- e) 11
12. Which of the following statements is **false**?

a) When a metal reacts with a nonmetal, an ionic compound is produced.
b) Nonmetals form anions when reacted with a metal to form a compound.
c) Alkaline earth metals form stable +2 charged ions when in ionic compounds.
d) Transition metals gain electrons to form stable ions when in ionic compounds.
e) When nonmetals form compounds with each other, a covalent compound usually results.

13. The most stable ion of a certain isotope contains 15 protons and has a mass number of 33. Which of the following statements (a–d) about this ion is **true**? Note: the most stable ion is the ion that forms when this isotope is in an ionic compound.

a) The net charge of the ion is \(-3\).
b) The ion contains 10 electrons.
c) The ion contains 33 neutrons.
d) The ion is sulfur.
e) All of the above statements (a–d) are false.

14. Which of the following statements is **false**?

a) The periodic table predicts that the 8s atomic orbital will be lower in energy than the 6d atomic orbitals.
b) The quantum mechanical model assumes that the electron has wave properties.
c) The Heisenberg uncertainty principle implies that we cannot know the exact location of an electron as it moves around the nucleus.
d) DeBroglie hypothesized that all matter exhibits both particulate and wave properties.
e) The quantum mechanical model tells us that there are seven degenerate (same energy) 4f atomic orbitals.

15. Which of the following statements (a–d) about the electromagnetic spectrum is **true**? Note that wavelengths are given in units of cm.

<table>
<thead>
<tr>
<th>Radiowave</th>
<th>Microwave</th>
<th>Infrared</th>
<th>Vis.</th>
<th>UV</th>
<th>x-ray</th>
<th>γ-ray</th>
</tr>
</thead>
<tbody>
<tr>
<td>λ, cm</td>
<td>1</td>
<td>10^{-2}</td>
<td>10^{-4}</td>
<td>10^{-6}</td>
<td>10^{-8}</td>
<td></td>
</tr>
</tbody>
</table>

a) Ultraviolet (UV) radiation has a longer wavelength than visible (Vis.) radiation.
b) The frequency of microwave radiation is higher than the frequency of visible (Vis.) radiation.
c) Gamma (γ) ray radiation travels faster than radiowaves because it has a shorter wavelength.
d) A photon of x-ray radiation is more energetic than a photon of microwave radiation.
e) None of the above statements (a-d) are true.

16. Which two atomic orbitals are depicted in the figures below?

a) $d_{xy}$, $p_y$

b) $d_{x^2}$, $p_x$

c) $d_{x^2-y^2}$, $p_y$

d) $d_{xz}$, $p_y$

e) $d_{xy}$, $p_x$

17. The density of osmium (the densest metal) is 22.57 g/cm$^3$. If a 1.00 kg rectangular block of osmium has two dimensions of 4.00 cm × 4.00 cm, calculate the third dimension of the rectangular block. The volume of a rectangle is length × width × height.

a) 44.3 cm  
b) 2.77 cm  
c) 16.0 cm  
d) 1.41 cm  
e) 3.97 cm

18. A certain molecule is linear and nonpolar. Which of the following could be this molecule?

a) F–Kr–F (KrF$_2$)  
b) O–S–O (SO$_2$)  
c) O–O–O (O$_3$)

d) O–C–S (COS)  
e) F–S–F (SF$_2$)

19. Which of the following molecules has the smallest bond angle?

a) F–Kr–F (KrF$_2$)  
b) O–S–O (SO$_2$)  
c) O–O–O (O$_3$)

d) O–C–S (COS)  
e) F–S–F (SF$_2$)

20. When heated, baking soda (commonly called sodium bicarbonate) undergoes a decomposition reaction to form solid sodium carbonate, carbon dioxide gas and water vapor. How many moles of sodium carbonate are produced for every 2.0 moles of sodium bicarbonate that are decomposed? (HCO$_3^-$ is the bicarbonate ion formula.)

a) 1.0 mol sodium carbonate  
b) 1.5 mol sodium carbonate  
c) 2.0 mol sodium carbonate  
d) 2.5 mol sodium carbonate  
e) 3.0 mol sodium carbonate

21. Which of the following statements (a-c) is/are true?
CHEMISTRY 102  
HOUR EXAM I  

a) The positive charge in an atom is uniformly distributed throughout the atom.  
b) In a neutral atom, the atomic number equals the number of electrons in the atom.  
c) Most of the mass of an atom is due to the electrons.  
d) Statements b and c are both true.  
e) None of the statements (a-c) are true.  

22. Draw the Lewis structures for the following four compounds: BH$_3$, PS$_2$, BrF$_3$, and OCl$_2$. How many of these four compounds satisfy the octet rule (duet rule for H) for all elements in the compound?  
a) 0 (none)  
b) 1  
c) 2  
d) 3  
e) 4 [All satisfy the octet rule (duet rule for H)].  

23. When the following calculation is performed, how many significant figures are in the correct answer?  

\[(1.00866 - 1.00776) \times 6.022 \times 10^{23}\]  
a) 1  
b) 2  
c) 3  
d) 4  
e) 6  

Creatine is an organic compound important to the building of muscle tissue in the body. The skeletal structure of creatine is below. Complete the Lewis structure and answer the next two questions.  

24. How many of the carbon and nitrogen atoms exhibit approximately $109^\circ$?  
a) 0  
b) 1  
c) 2  
d) 3  
e) 4  

25. How many double bonds are in the completed Lewis structure?  
a) 0  
b) 1  
c) 2  
d) 3  
e) 4
26. Draw the Lewis structures for the following four diatomic ions: \( \text{C}_2^{2-} \), \( \text{N}_2^{2-} \), \( \text{O}_2^{2-} \), and \( \text{F}_2^{2+} \). How many of these four diatomic ions must have a double or triple bond in order to satisfy the octet rule?
   a) 0 (none)  
   b) 1  
   c) 2  
   d) 3  
   e) 4 (All of these ions must have a double or triple bond in order to satisfy the octet rule.)

27. Which of the following statements is true concerning atoms of bromine?
   a) \( \text{Br} \) should have a more negative electron affinity value than \( \text{Kr} \).  
   b) \( \text{Br} \) should have a smaller ionization energy than \( \text{Br}^{2-} \).  
   c) \( \text{Br} \) should have a smaller electronegativity value than \( \text{Ba} \) (element #56).  
   d) \( \text{Br} \) should have a smaller radius than \( \text{Br}^{2+} \).  
   e) \( \text{Br} \) should have a larger ionization energy than \( \text{Ne} \).  

28. Which of the following bonds to selenium should be the most pure (nonpolar) covalent bond?
   a) \( \text{Se} \) – \( \text{Ga} \)  
   b) \( \text{Se} \) – \( \text{Cl} \)  
   c) \( \text{Se} \) – \( \text{I} \)  
   d) \( \text{Se} \) – \( \text{In} \)

29. A pure substance that can be broken down into other substances by chemical change is classified as a(n):
   a) compound  
   b) element  
   c) phase  
   d) solution  
   e) mixture

30. Sarin is a nerve gas whose chemical formula has 2 atoms of oxygen for each molecule of sarin. If 50.0 g of sarin contains 11.4 g of oxygen, calculate the molar mass of sarin.
   a) 280. g/mol  
   b) 35.0 g/mol  
   c) 70. g/mol  
   d) 210. g/mol  
   e) 140. g/mol

31. How many of the following four compounds is/are named correctly?
   \[
   \text{MgCO}_3, \text{magnesium carbonate}  
   \text{P}_2\text{O}_5, \text{phosphorus oxide}  
   \text{CoClO}_2, \text{cobalt(VI) perchlorate}  
   \text{HNO}_3, \text{nitric acid}
   \]
   a) 0 (none)  
   b) 1  
   c) 2  
   d) 3  
   e) 4 (All are correctly named.)
USEFUL CONSTANTS/EQUATIONS

\[ R_H = 2.178 \times 10^{-18} \text{ J} \]
\[ h = 6.626 \times 10^{-34} \text{ J s} \]
\[ c = \frac{\lambda v}{\lambda} \]
\[ E = h \nu = \frac{\lambda \nu}{c} \text{ (de Broglie equation)} \]
\[ N = 6.022 \times 10^{23} \]
\[ 1 \text{ cm} = 1 \times 10^{-2} \text{ m; } 1 \text{ nm} = 1 \times 10^{-9} \text{ m} \]
\[ c = 2.998 \times 10^8 \text{ m/sec} \]
\[ 1 \text{ kHz} = 1000 \text{ Hz} = 1000 \text{ s} \]
\[ 1 \text{ J} = 1 \text{ kg m}^2/\text{sec}^2 \]
\[ 1 \text{ mL} = 1 \text{ cm}^3 \]

Density = mass/volume

Mass \% of A = \frac{\text{mass of } A}{\text{total mass}} \times 100

\[ \Delta E = -R_H Z^2 \left( \frac{1}{n_2^2} - \frac{1}{n_1^2} \right) \]