Chem. 1A Final
Practice Test 2

All work must be shown on the exam for partial credit. Points will be taken off for incorrect or missing units. Calculators are allowed. Cell phones may not be used as calculators. On fundamental and challenge problems you must show your work in order to receive credit for the problem. If your cell phone goes off during the exam, you will have your exam removed from you.

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Fundamental Questions

Each of these fundamental chemistry questions is worth 6 points. You must show work to get credit. Little to no partial credit will be awarded. Make sure to include the correct units on your answers.

1) **6 pts** How are the local electron model and molecular theory similar? How are they different? (75 words or less)

Both the local electron model and the molecular orbital theory are based on the mixing of atomic orbitals that were determined from quantum mechanics. The local electron model results from mixing atomic orbitals that are on one atom. Molecular orbital theory mixes orbitals from all of the atoms in the molecule.

2) **6 pts** What is wavelength associated with an electron traveling at $3.0 \times 10^7 \text{ m/s}$?

$$\lambda = \frac{h}{mv} = \frac{6.626 \times 10^{-34} \text{ J} \cdot \text{s}}{(9.10939 \times 10^{-31} \text{ kg})(3.0 \times 10^{-11} \text{ m/s})} = 2.4 \times 10^{-11} \text{ m}$$

3) **6 pts** Identify if the following reactions are redox reactions or not. If they are redox reactions, specify what is oxidized and what is reduced.

- **Cu(OH)$_2$(s) + 2HNO$_3$(aq) $\rightarrow$ Cu(NO$_3$)$_2$(aq) + 2H$_2$O(l)**
  Not a redox reaction

- **Fe$_2$O$_3$(s) + 3CO(g) $\rightarrow$ 2Fe(s) + 3CO$_2$(g)**
  Redox Reaction
  Fe $+3 \rightarrow 0$ gained electrons
  Fe is reduced
  C $+2 \rightarrow +4$ lost electrons
  C is oxidized

4) **6 pts** Circle the option that best fits each of the following descriptions:

- Smallest atomic radius
  Na  Si  S  Al

- Largest ionic radius
  Na$^+$  O$^{2-}$  Mg$^{2+}$  F$^-$

- Least polar bond
  C-N  C-O  O-H

- Greatest electronegativity
  Al  C  Na  N

- Smallest first ionization energy
  K  Na  Mg
5) 6 pts  Determine if energy is absorbed or emitted when an electron transitions from the n=7 to the n=2 level of C\(^{5+}\) and the wavelength of the photon associated with the transition?

Energy is emitted

\[ |\text{Energy of the transition}| = \text{energy of photon} \]

Energy of transition

\[
\Delta E = -2.178 \times 10^{-18} \times \left( \frac{Z^2_{hf}}{n_f^2} - \frac{Z^2_{fi}}{n_i^2} \right)
\]

\[
\Delta E = -2.178 \times 10^{-18} \times \left( \frac{6^2}{2^2} - \frac{6^2}{7^2} \right) = -1.80 \times 10^{-17} \text{ J}
\]

Energy of photon

\[
E = \frac{\hbar c}{\lambda}
\]

\[
\lambda = \frac{\hbar c}{E} = \frac{(6.626 \times 10^{-34} \text{ J} \cdot \text{s})}{1.80 \times 10^{-17} \text{ J}} = 1.10 \times 10^{-8} \text{ m}
\]

6) 6 pts  Write a balanced chemical reaction for the following process. Potassium reacts with water to give potassium hydroxide and hydrogen.

\[ 2\text{K(s)} + 2\text{H}_2\text{O(l)} \rightarrow 2\text{KOH(aq)} + \text{H}_2\text{(g)} \]

7) 6 pts  How many protons, neutrons, and electrons in \(^{59}\text{Fe}\) and \(^{64}\text{Cu}^-\)?

\(^{59}\text{Fe} \quad p = 26, \ e^- = 26, \ \text{and} \ n = 33 \]

\(^{64}\text{Cu}^- \quad p = 29, \ e^- = 30, \ \text{and} \ n = 35 \]

8) 6 pts  Determine the bond angle for the numbered bonds:

1)_________120°  2)__________120°  3)__________less than 109.5°
9) 6 pts  On the following periodic table indicate the location of the metals, nonmetals, metalloids. Also label which group is the noble gases, alkaline earth metals, alkali metals, halides, and transition metals.

10) 6 pts  What wavelength of light is needed to excite an e\(^{-}\) from the ground state of a particle in a box that is 5.00\(\times\)10\(^{-7}\) m long to the n=5 state?
Calculate the energy need for an e\(^{-}\) to go from n=1 \(\rightarrow\) n=5
\[
\Delta E = \frac{\hbar^2}{8mL^2}(n_f^2 - n_i^2) = \frac{(6.626 \times 10^{-34} J \cdot s)^2}{8(9.10939 \times 10^{-31} kg)(5.00 \times 10^{-7} m)(5^2 - 1^2)}
\]
\[
\Delta E = 5.78 \times 10^{-24} J
\]
Calculate the wavelength of the photon
\[
\lambda = \frac{hc}{E} = \frac{(6.626 \times 10^{-34} J \cdot s)(2.998 \times 10^8 m/s)}{5.78 \times 10^{-24} J} = 0.0344 m
\]

11) 6 pts  If 10.0 mL of 2.5 M \(\text{SrCl}_2\) is diluted to 500. mL what is the final concentration of \(\text{Cl}^-\) ions?
\[
M_1V_1 = M_2V_2 \Rightarrow (2.5 \text{ M})(10.0 \text{ mL}) = M_2(500. \text{ mL})
\]
\[
M_2 = 0.050 \text{ M} \text{SrCl}_2 \Rightarrow \left(0.050 \text{ M} \text{SrCl}_2\right)\left(\frac{2 \text{ mol Cl}^-}{1 \text{ mol SrCl}_2}\right) = 0.10 \text{ M Cl}^-
\]
12) 6 pts  Determine the number of orbitals that can have the following designation 3f
When n=3 l cannot equal 3 therefore no orbitals can have this designation
n = 2
l = 0      m_l = 0
l = 1       m_l = -1,0,1
4 orbital

Determine the number of electrons that can have the following designation 3d_{22}

n=3 l=2 m_l = 1 value
m_s = ± ½
2 electrons

6d

n=6 l=2
m_l = -2,-1,0,1,2  m_s = ± ½
10 electrons
Challenge Problems

Each of the following short answer questions are worth the noted points. Partial credit will be given. You must show your work to get credit. Make sure to include proper units on your answer.

1) 12 pts It takes 208.4 kJ of energy to remove one mol of electrons from the atoms on the surface of rubidium metal. If rubidium metal is irradiated with 254-nm light, what is the maximum kinetic energy the released electrons can have?

Calculate energy of 254 nm light

\[
254 \text{ nm} \left( \frac{1 \text{ m}}{10^9 \text{ nm}} \right) = 2.54 \times 10^{-7} \text{ m}
\]

\[
\lambda \nu = c
\]

\[
\nu = \frac{c}{\lambda} = \frac{2.998 \times 10^8 \text{ m/s}}{2.54 \times 10^{-7} \text{ m}} = 1.18 \times 10^{-7} \text{ m/s}
\]

\[
E = h \nu = (6.626 \times 10^{-34} \text{ J} \cdot \text{s})(1.18 \times 10^{-7} \text{ m}) = 7.82 \times 10^{-19} \text{ J}
\]

This is the energy that 1 electron would have.

Calculate the energy needed to remove 1 e–.

\[
\frac{208.4 \text{ kJ/mol} \left( \frac{1 \text{ mol}}{6.022 \times 10^{23} \text{ e}^-} \right)}{6.022 \times 10^{23} \text{ e}^-} = 3.47 \times 10^{-19} \text{ J/mol}
\]

Subtract the energy needed to remove the e– from the energy provided by photon. This will give the max energy for KE.

\[
KE = 7.82 \times 10^{-19} \text{ J} - 3.47 \times 10^{-19} \text{ J} = 4.35 \times 10^{-19} \text{ J}
\]
2a) 8 pts
1) Identify the electronic structure of ICl₄⁻.
2) Identify the molecular structure of ICl₄⁻.
3) Identify the polarity of ICl₄⁻.
4) What method did you use to determine these answers?

```
Octahedral
```

2b) 8 pts
1) What is the hybridization of all of the atoms in HCN?
2) Determine the number of σ and π bonds in HCN?
3) What orbital(s) overlap to make the bond(s) between the C and the N?
4) What method did you use to determine these answers?

```
H–C≡N:
```

```
1) H = s  C = sp  N=sp
2) 2 σ bonds and 2 π bonds
3) The σ bond is formed by the overlap of the sp orbitals on the C and the N.
   The 2 π bonds are formed from the overlap of the p orbitals on the C and the N.
4) Local Electron Model
```

2c) 8 pts
1) What is the electron configuration NO⁺ (fills like N₂)?
2) What is the bond order for NO⁺?
3) Is NO⁺ diamagnetic or paramagnetic?
4) What method did you use to determine these answers?

```
1) σ₁s²σ₁s²σ₂s²σ₂s²π₂p²σ₂p²
2) b = ½ (N-N⁺) = ½(8-2) = 3
3) Diamagnetic
4) Molecular orbital theory
```

Orbitals on N
Orbitals on O
3) **16 pts**  A 20.0 L stainless steel container was charged with 2.00 atm of hydrogen gas and 3.0 atm of oxygen gas. A spark ignites the mixture, producing H₂O. What is the pressure in the tank at 25°C?

\[ 2\text{H}_2(\text{g}) + \text{O}_2(\text{g}) \rightarrow 2\text{H}_2\text{O}(\text{l}) \]

What was given

\[ V = 2.00 \text{ L} \]
\[ P_{\text{H}_2} = 2.00 \text{ atm} \]
\[ P_{\text{O}_2} = 3.00 \text{ atm} \]

This is a limiting reagent problem

Find an expression for the number of moles of H₂

\[ PV = nRT \]
\[ n_{\text{H}_2} = \frac{P_{\text{H}_2}V}{RT} = \frac{(2.00 \text{ atm})V}{RT} \]

Find an expression for the number of moles of O₂

\[ n_{\text{O}_2} = \frac{P_{\text{O}_2}V}{RT} = \frac{(3.00 \text{ atm})V}{RT} \]

Find the number of moles of O₂ needed to fully react \( \frac{(2.00 \text{ atm})V}{RT} \) moles of H₂

\[ \frac{(2.00 \text{ atm})V}{RT} \text{ mol H}_2 \left( \frac{1 \text{ mol O}_2}{2 \text{ mol H}_2} \right) = \frac{(1.00 \text{ atm})V}{RT} \text{ mol O}_2 \]

Since we have \( \frac{(3.00 \text{ atm})V}{RT} \) moles of O₂, H₂ is the limiting reagent

<table>
<thead>
<tr>
<th></th>
<th>H₂(g) (L.R)</th>
<th>O₂(g)</th>
<th>H₂O(l)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I (mol)</td>
<td>( \frac{(2.00 \text{ atm})V}{RT} )</td>
<td>( \frac{(3.00 \text{ atm})V}{RT} )</td>
<td>0</td>
</tr>
<tr>
<td>C (mol)</td>
<td>-2x</td>
<td>-x</td>
<td>+2x</td>
</tr>
<tr>
<td>E (mol)</td>
<td>0</td>
<td>( \frac{(2.00 \text{ atm})V}{RT} )</td>
<td>( \frac{(2.00 \text{ atm})V}{RT} )</td>
</tr>
</tbody>
</table>

\[ \frac{(2.00 \text{ atm})V}{RT} - 2x = 0 \]
\[ x = \frac{(1.00 \text{ atm})V}{RT} \]

The only reactant or product left that is gas is O₂

Calculate the final pressure

\[ P_{\text{tot}} = \frac{n_{\text{tot}}RT}{V} = \frac{\left( \frac{(2.00 \text{ atm})V}{RT} \right)RT}{V} = 2.00 \text{ atm} \]
4) **16 pts** A sample of a compound of Cl and O reacts with an excess of H₂ to give 0.233 g of HCl and 0.403 g of H₂O. Determine the empirical formula of the compound.

\[ \text{Cl}_x \text{O}_y + \text{H}_2 \rightarrow \text{HCl} + \text{H}_2\text{O} \]

Determine the moles of Cl (All of the Cl in \( \text{Cl}_x \text{O}_y \) goes to HCl)

\[
0.233 \, \text{g} \, \text{HCl} \left( \frac{1 \, \text{mol} \, \text{HCl}}{36.46 \, g \, \text{HCl}} \right) \left( \frac{1 \, \text{mol} \, \text{Cl}}{1 \, \text{mol} \, \text{HCl}} \right) = 0.00639 \, \text{mol} \, \text{Cl}
\]

Determine the moles of O (All of the O in \( \text{Cl}_x \text{O}_y \) goes to H₂O)

\[
0.403 \, \text{g} \, \text{H}_2\text{O} \left( \frac{1 \, \text{mol} \, \text{H}_2\text{O}}{18.02 \, g \, \text{H}_2\text{O}} \right) \left( \frac{1 \, \text{mol} \, \text{O}}{1 \, \text{mol} \, \text{H}_2\text{O}} \right) = 0.0224 \, \text{mol} \, \text{O}
\]

Divide through by smallest number (0.00881)

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<th>Substance</th>
<th>Mol with smallest number</th>
<th>Mol with whole number</th>
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<tbody>
<tr>
<td>Chlorine</td>
<td>0.00639 mol</td>
<td>0.00639 mol</td>
</tr>
<tr>
<td>Oxygen</td>
<td>0.0224 mol</td>
<td>0.0224 mol</td>
</tr>
</tbody>
</table>

\[ \text{ClO}_{1.5} \]

Turn to whole number (multiple by 2)

\[ \text{Cl}_2\text{O}_7 \]
Multiple Choice Questions

On the ParScore form, you need to fill in your answers, perm number, test version, and name. Failure to do any of these things will result in the loss of 1 point. Your perm number is placed and bubbled in under the “ID number.” Do not skip boxes or put in a hyphen; unused boxes should be left blank. Bubble in your test version (A) under the “test form.” Note: Your ParScore form will not be returned to you, therefore, for your records, you may want to mark your answers on this sheet. Each multiple-choice question is worth 5 points.

1. Which of the following is polar?
   A) XeO$_2$
   B) I$_3^–$
   C) XeF$_2$
   D) NON
   E) ICl$_4^–$

1. Which of the following statements is(are) true?
   I. An excited atom can return to its ground state by absorbing electromagnetic radiation.
   II. The energy of an atom is increased when electromagnetic radiation is emitted from it.
   III. The energy of electromagnetic radiation increases as its frequency increases.
   IV. An electron in the $n = 4$ state in the hydrogen atom can go to the $n = 2$ state by emitting electromagnetic radiation at the appropriate frequency.
   V. The frequency and wavelength of electromagnetic radiation are inversely proportional to each other.
   A) III, IV, V
   B) I, II, IV
   C) II, III, IV
   D) III, V
   E) I, II, III

3. As the bond order of a bond increases, its bond energy ______ and its bond length ______.
   A) decreases, decreases
   B) increases, decreases
   C) decreases, increases
   D) increases, increases

4. Which of the following statements is correct?
   A) More than one of these statements are correct.
   B) Free rotation may occur about a double bond.
   C) $\pi$ bonds have electron density on the internuclear axis.
   D) A triple bond is composed of two $\pi$ bonds and one $\sigma$ bond.
   E) $\sigma$ bonds result from the head-to-head overlap of atomic orbitals.
5. Using the following bond energies:

<table>
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<tr>
<th>Bond</th>
<th>Bond Energy (kJ/mol)</th>
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<tr>
<td>C=C</td>
<td>839</td>
</tr>
<tr>
<td>C-H</td>
<td>413</td>
</tr>
<tr>
<td>O=O</td>
<td>495</td>
</tr>
<tr>
<td>C=O</td>
<td>799</td>
</tr>
<tr>
<td>O-H</td>
<td>467</td>
</tr>
</tbody>
</table>

estimate the heat of combustion for 1 mol of acetylene:

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

A) –447 kJ  
B) +365 kJ  
C) –1228 kJ  
D) 1228 kJ  
E) +447 kJ  

6. Cations are ________ than/as their parent atom.
   A) the same size  
   B) larger  
   C) smaller

7. In the reaction Zn + H_2SO_4 \rightarrow ZnSO_4 + H_2, which element, if any, is oxidized?
   A) Sulfur  
   B) Oxygen  
   C) Hydrogen  
   D) Zinc  
   E) none of these

8. Consider an atom traveling at 1% of the speed of light. The de Broglie wavelength is found to be \(3.31 \times 10^{-3}\) pm. Which element is this?
   A) P  
   B) He  
   C) Ca  
   D) F  
   E) Be

9. A plot of the Maxwell distribution against speed for different molecules shows that
   A) light molecules have a very narrow range of speeds.  
   B) light molecules have a lower average speed.  
   C) heavy molecules have a higher average speed.  
   D) heavy molecules travel with speeds close to their average values.  
   E) heavy molecules have a wide range of speeds.
10. Consider the reaction between 50.0 mL of 0.200 M sodium hydroxide and 75.0 mL of 0.100 M HCl. Which of the following statements is correct?
   A) The NaOH is the limiting reactant.
   B) After the reaction, the concentration of Na\(^+\) is equal to the concentration of Cl\(^-\).
   C) After the reaction, the concentration of Na\(^+\) is still 0.200 M because Na\(^+\) is a spectator ion.
   D) After the reaction, the concentration of Na\(^+\) is greater than the concentration of OH\(^-\).
   E) None of these are correct.

11. How many of the following molecules have all of their atoms in the same plane?

   \[
   \text{H}_2\text{C} = \text{CH}_2 \quad \text{F}_2\text{O} \quad \text{H}_3\text{C} = \text{O} \quad \text{NH}_3 \quad \text{CO}_2 \quad \text{BeCl}_2 \quad \text{H}_2\text{C} = \text{C} = \text{CH}_2
   \]

   A) 5
   B) 3
   C) 6
   D) 4
   E) None of the above

12. Consider the following statements:
   1. Real gases act more like ideal gases as the temperature increases.
   2. When \( n \) and \( T \) are constant, a decrease in \( P \) results in a decrease in \( V \).
   3. At 1 atm and 273 K, every molecule in a sample of a gas has the same speed.
   4. At constant \( T \), CO\(_2\) molecules at 1 atm and H\(_2\) molecules at 5 atm have the same average kinetic energy.

   Which of these statements is true?

   A) 1 and 2
   B) 2 and 4
   C) 3 and 4
   D) 2 and 3
   E) 1 and 4

   A,A,B,E,C,C,D,D,A,E