I have observed all the rules of academic integrity while taking this exam.

______________________________
signature
Question #1 (16 pts) CIRCLE CORRECT ANSWERS

Consider the hypothetical elements X, Y and Z with the following electron-dot formulas:

(a) The covalent molecule formed between X and Z should have the formula:
   (1 pt)
   (i) XZ
   (ii) XZ₂
   (iii) XZ₃
   (iv) XZ₅
   (v) X₂Z
   (vi) X₃Z
   (vii) None of the above

(b) Y should form an ion of the type:
   (1 pt)
   (i) [Y]⁺
   (ii) [Y]²⁺
   (iii) [Y]³⁺
   (iv) [Y]⁻
   (v) [Y]²⁻
   (vi) [Y]³⁻
   (vii) None of the above

(c) The potassium salt of Y should be:
   (1 pt)
   (i) KY
   (ii) KY₂
   (iii) KY₃
   (iv) K₂Y
   (v) K₃Y
   (vi) None of the above

(d) The calcium salt of X should be:
   (1 pt)
   (i) CaX
   (ii) CaX₂
   (iii) CaX₃
   (iv) Ca₂X
   (v) Ca₃X
   (vi) None of the above
Question #1 (Cont'd)

(e) If X, Y and Z are on the same horizontal row of the periodic table, I would expect that the most electronegative element would be:
   (2 pts)
   (i) X
   (ii) Y
   (iii) Z
   (iv) The sentence above is incorrect: X, Y and Z cannot possibly be on the same horizontal row of the periodic table.

(f) If X, Y and Z are on the same vertical column of the periodic table, I would expect that the most electronegative element would be:
   (2 pts)
   (i) X
   (ii) Y
   (iii) Z
   (iv) The sentence above is incorrect: X, Y and Z cannot possibly be on the same vertical column of the periodic table.

(g) The bond between X and Z in part (a) (of this question) is:
   (2 pts)
   (i) Ionic
   (ii) Non-polar covalent
   (iii) Polar covalent, with X(δ+) and Z(δ-)
   (iv) Polar covalent, with X(δ-) and Z(δ+)
   (v) None of the above

(h) The bond between K and Y in part (c) is:
   (2 pts)
   (i) Ionic
   (ii) Non-polar covalent
   (iii) Polar covalent, with K(δ+) and Y(δ-)
   (iv) Polar covalent, with K(δ-) and Y(δ+)
   (v) None of the above
**Question #2** (14 pts)

What are the **oxidation states** of

(a) phosphorus in $P_4S_{10}$

(b) nitrogen in $NH_4Cl$

(c) iodine in $[IF_4]^{-}$

(d) xenon in $[XeF_5]^{+}$

(e) phosphorus in potassium phosphate

(f) nitrogen in nitric acid

(g) sulfur in the sulfate ion

**Question #3** (8 pts) (**circle correct answers**)

What are the values of:

(a) The O–O–O angle of ozone ($O_3$)?  60° / 90° / 109° / 120° / 180°

(b) The H–O–O angle in hydrogen peroxide (HOOH)?  60° / 90° / 109° / 120° / 180°

(c) The H–N–C angle in the molecule HNCO?  60° / 90° / 109° / 120° / 180°

(d) The N–C–O angle in the molecule HNCO?  60° / 90° / 109° / 120° / 180°
Question #4 (15 pts) Given the following geometries:

(a) What are the expected geometries of the following molecules or ions? (Fill in the blanks below with P, Q, R, etc., or "none of the above")

<table>
<thead>
<tr>
<th>BrF₃</th>
<th>XeF₄</th>
<th>[BF₄]⁻</th>
<th>[IF₆]⁺</th>
<th>XeF₆</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(b) What are the hybridizations of the central atoms of these molecules or ions? (Fill in the blanks below with sp, sp², sp³, sp³d, sp³d² or sp³d³).

<table>
<thead>
<tr>
<th>BrF₃</th>
<th>XeF₄</th>
<th>[BF₄]⁻</th>
<th>[IF₆]⁺</th>
<th>XeF₆</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Question # 5  (15 pts)

Given the following organic molecule:

(CIRCLE CORRECT ANSWERS or FILL IN THE BLANKS)

What is the H – C₁ – H angle?  
\[ 90° / 109° / 120° / 180° \]

What is the C₁ – C₂ – O angle?  
\[ 90° / 109° / 120° / 180° \]

What is the C₂ – C₃ – N angle?  
\[ 90° / 109° / 120° / 180° \]

What orbital is H using for the C₁ – H bond?  
\[ s / p / sp / sp^2 / sp^3 \]

What orbital is C₁ using for the C₁ – H bond?  
\[ s / p / sp / sp^2 / sp^3 \]

What orbital is C₂ using for the C₂ – C₃ bond?  
\[ s / p / sp / sp^2 / sp^3 \]

What orbital is C₃ using for the C₂ – C₃ bond?  
\[ s / p / sp / sp^2 / sp^3 \]

What orbital is C₂ using for the C₂ = O σ bond?  
\[ s / p / sp / sp^2 / sp^3 \]

What orbital is C₂ using for the C₂ = O π bond?  
\[ s / p / sp / sp^2 / sp^3 \]

How many σ and π bonds are there in the molecule below?  
Ans: _____ σ and _____ π
**Question #6**  (12 pts)

Given the following molecular orbital diagram for diatomic molecules:

![Molecular Orbital Diagram](image)

Predict the **bond order** and the **number of unpaired electrons** for the following molecules or ions:

<table>
<thead>
<tr>
<th></th>
<th>Bond order</th>
<th>Number of unpaired electrons</th>
</tr>
</thead>
<tbody>
<tr>
<td>CN</td>
<td></td>
<td></td>
</tr>
<tr>
<td>[NO]⁻</td>
<td></td>
<td></td>
</tr>
<tr>
<td>[F₂]⁺</td>
<td></td>
<td></td>
</tr>
<tr>
<td>[BC]²⁺</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Question #7  (12 pts)

Using the bond energy table below, calculate ΔH (the enthalpy change) for the following reaction:

$$4 \text{CH}_2\text{NH} + 7 \text{O}_2 \rightarrow 4 \text{CO}_2 + 6 \text{H}_2\text{O} + 2 \text{N}_2$$

<table>
<thead>
<tr>
<th>Bond Strengths</th>
<th>(in kJ/Mole)</th>
</tr>
</thead>
<tbody>
<tr>
<td>C – H</td>
<td>413</td>
</tr>
<tr>
<td>C – N</td>
<td>293</td>
</tr>
<tr>
<td>C = N</td>
<td>615</td>
</tr>
<tr>
<td>C ≡ N</td>
<td>891</td>
</tr>
<tr>
<td>O – O</td>
<td>146</td>
</tr>
<tr>
<td>O = O</td>
<td>495</td>
</tr>
<tr>
<td>O – H</td>
<td>463</td>
</tr>
<tr>
<td>N – H</td>
<td>391</td>
</tr>
<tr>
<td>C – O</td>
<td>358</td>
</tr>
<tr>
<td>C = O</td>
<td>799</td>
</tr>
<tr>
<td>C ≡ O</td>
<td>1072</td>
</tr>
<tr>
<td>N – N</td>
<td>163</td>
</tr>
<tr>
<td>N = N</td>
<td>418</td>
</tr>
<tr>
<td>N ≡ N</td>
<td>941</td>
</tr>
</tbody>
</table>

Connectivity of atoms in CH₂NH is

```
H
C   N   H
H
```
**Question #8**  (12 pts)

Four of the following molecules do **not** have a permanent dipole moment. Identify them.

IF  SeF$_2$  BI$_3$  TeF$_4$  BrF$_5$

O$_3$  KrF$_2$  IF$_3$  SnF$_4$  AsF$_5$

Answers:  [ ]  [ ]  [ ]  [ ]
Bonus Question (9 pts) Circle correct answers

(a) MRI stands for:

(i) magnetically-reversed ionization
(ii) microwave resonance interferometry
(iii) magnetic resonance imaging
(iv) microwave radiationless illumination
(v) magnesium rubidium iodate
(vi) none of the above

(b) The thermite reaction \((\text{Fe}_2\text{O}_3 + 2\text{Al} \rightarrow \text{Al}_2\text{O}_3 + 2\text{Fe})\) is:

(i) highly endothermic
(ii) slightly endothermic
(iii) highly exothermic
(iv) slightly exothermic
(v) none of the above

(c) A freshly-cut surface of sodium metal tarnishes quickly in air because:

(i) it reacts with water vapor in air to form sodium hydroxide
(ii) it reacts with oxygen in air to form sodium oxide
(iii) it reacts with nitrogen in air to form sodium nitride
(iv) it reacts with carbon dioxide in air to form sodium carbonate
(v) it reacts with nitrogen oxides in air to form sodium nitrate
(vi) none of the above

(d) Yttrium oxide, \(\text{Y}_2\text{O}_3\), is:

(i) an inert gas
(ii) a highly reactive gas
(iii) a volatile, inflammable liquid
(iv) a thick, viscous liquid
(v) a solid

(e) Sulfur is:

(i) a red-brown gas
(ii) a yellow powder
(iii) a silvery metal
(iv) a blue crystalline solid
(v) a colorless liquid

(f) The molecule shown at right is used as:

(i) an artificial sweetener
(ii) a food coloring agent
(iii) a flavor enhancer
(iv) an explosive
(v) a gasoline additive
(vi) an antacid