Practice AP Questions

Name:

Your instructor will give you one, two, or all three of these questions. You should spend 20 minutes on question 1 and 20 minutes combined on questions 2 and 3. Please write your name on this page only. Note also there is a periodic table and a formula sheet attached on the subsequent pages. Please answer each question in the lined space provided.

<table>
<thead>
<tr>
<th>Problem 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Problem 2</td>
</tr>
<tr>
<td>Problem 3</td>
</tr>
</tbody>
</table>
1. Ammonium carbamate, $\text{NH}_4\text{CO}_2\text{NH}_2$, reversibly decomposes into $\text{CO}_2$ and $\text{NH}_3$ as shown by the balanced equation below:

$$\text{NH}_4\text{CO}_2\text{NH}_2(s) \rightleftharpoons 2\text{NH}_3(g) + \text{CO}_2(g) \quad K_p = ?$$

A student places 0.50 g of solid $\text{NH}_4\text{CO}_2\text{NH}_2$ in a previously evacuated, rigid 0.750 L container that is held at a constant temperature of 298 K. The student monitors the total pressure in the container as a function of time and obtains the graph shown below:

(a) Based on the information in the graph and the reaction above, determine:

i. The final partial pressure of $\text{NH}_3$ (g) in the 0.750 L container.

ii. The value of $K_p$ for the decomposition of $\text{NH}_4\text{CO}_2\text{NH}_2$.

iii. The mass of solid $\text{NH}_4\text{CO}_2\text{NH}_2$ (molar mass 78.09 g/mol) that decomposed.

The student is asked to perform the experiment a second time with one of the following changes to the experimental conditions:

- Perform the experiment at a higher temperature of 325 K.
- Perform the experiment with 1.00 g of solid $\text{NH}_4\text{CO}_2\text{NH}_2$.
- Perform the experiment in a 1.00 L container.
- Perform the experiment in a 0.500 L container.

(b) Which of the changes to the experimental conditions listed above will result in a greater mass of $\text{NH}_4\text{CO}_2\text{NH}_2$ decomposing than was calculated in part (a) iii? Justify your answer.
Although it has not been directly observed, NH$_2$COOH has been proposed as an important intermediate in the decomposition of ammonium carbamate.

(c) In the box below, complete the Lewis electron dot diagram for NH$_2$COOH by drawing in the electron pairs.

(d) Based upon the Lewis diagram drawn above what is the approximate O-C-O bond angle in NH$_2$COOH?

NH$_2$COOH is predicted to be a highly soluble Bronsted-Lowry acid when placed in water.

(e) Using principles of intermolecular forces, explain why NH$_2$COOH would be very soluble in water.

(f) Circle the atom in the diagram above that will be released when NH$_2$COOH, acts as an acid in aqueous solution.
2O₃(g) → 3O₂(g)  \( \Delta H^\circ = -286 \text{ kJ/mol}_{\text{rxn}} \)

2. Ozone, O₃, reacts to form O₂ as shown by the equation above.

(a) If 4.0 moles of O₃ completely react to form O₂, calculate the magnitude of heat energy that is released or absorbed.

The rate law for the reaction is known to be:

\[ \text{rate} = k[O_3] \]

(b) The half life of the reaction is 31 minutes at 25°C. Determine the rate constant for the reaction. Please include units in your answer.

(c) A student places a 0.00400 M sample of O₃ in a previously evacuated reaction vessel. The student then monitors the production of O₂ as the reaction above proceeds at a constant temperature of 25°C. Calculate the concentration of O₂ produced 45 minutes after the reaction has started.

(d) The O-O bond length in O₂ is 121 picometers. Circle which of the following best describes the bond lengths of the O-O bonds in O₃.

- All bonds in O₃ are **longer** than those in O₂
- All bonds in O₃ are **shorter** than those in O₂
- One bond in O₃ has the **same length** as the bond in O₂. The other bond is **longer** than that in O₂.
- One bond in O₃ is **shorter** than the bond in O₂. The other bond is **longer** than that in O₂.

Justify your answer in terms of principles of molecular structure.
3. Answer the following questions about the elements nitrogen, fluorine, and the ions they form.

<table>
<thead>
<tr>
<th>Atom</th>
<th>First Ionization Energy (kJ mol⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>1681</td>
</tr>
<tr>
<td>N</td>
<td>1402</td>
</tr>
</tbody>
</table>

(a) Using principles of atomic structure explain why the first ionization energy of atomic fluorine is greater than that of atomic nitrogen.

The common anions of atomic nitrogen and atomic fluorine (the nitride and fluoride anions) that are found in ionic compounds are isoelectronic to one another.

(b) Pick one element above, write the formula of the most common ion it would form, and write the complete electron configuration of that ion.
(c) Which of the two ions would have the greatest size? Justify your answer using principles of atomic structure.