ENV 235 – Second Term Examination 1999-2000

February 1, 2000

Please do not open until instructed to begin!

Instructions: The exam is composed of 6 questions worth a total of 100 points. Take note that some of the questions have multiple parts, so it would be wise to budget your time according to the value of the question to avoid spending too much time on a particular part. *Please read the questions carefully* and write your answers in **ink**. If you have questions about the exam please go quietly to Jeremy. Once you are finished, leave as quietly as possible so that others may continue without interruption. Thanks for your cooperation.

Reminder: The essays are due on Friday, February 4, at 5:00 pm. They can be handed in at my office (Lash-Miller 239) at 5:00 pm. Five points will be taken off for every day that an essay is late. Weekends will count as one day.

NAME:____

1. Explain the following terms and discuss **briefly** why each is relevant to environmental chemistry. (21 points total)

   (a) Reservoir gas (3 points):

   (b) IR active mode (3 points):

   (c) Latent heat (3 points):

   (d) pKa (3 points):

   (e) Catalytic converter (3 points):

(f) Activation barrier (3 points):

(g) Cation exchange (3 points):

2. For each stage in the life cycle of a Nitrogen atom, provide a plausible account of the chemistry involved. Give **mechanisms** for reactions where appropriate. (21 points total)

   (a) Initially, at 8:00 A.M. one morning our Nitrogen atom is found in the lower atmosphere above Los Angeles, California in its most common form in the atmosphere. What percent of dry, unpolluted air is composed of this species? Why is this the case? (3 points)

   (b) The species containing the Nitrogen atom drifts near a car just as the car is started for the morning commute. The heat from the engine transforms the initial chemical species. (3 points)

(c) The new molecule containing our Nitrogen encounters a peroxyl radical and the molecule is converted into an orange-brown molecule.(3 points)

(d) The orange-brown molecule is struck by visible light and breaks apart in oxygen-rich air.(3 points)

(e) The molecule now containing the Nitrogen atom suddenly encounters ozone, an oxidizing bully.(3 points)

(f) The resulting Nitrogen-containing species happens upon its illustrious colleague, known as the great "vacuum cleaner" of the troposphere.(3 points)

(g) The product from the previous step drifts into the clouds, and comes down to earth.(3 points)

3. Give a chemical reason for the dominant chemical reactive pathways for each of the steps given below in the breakdown of a hydrocarbon $R - CH_2 - CH_3$ on a sunny day, where R is electron withdrawing.(15 points total: 3 points each part)

   (a) $R - CH_2 - CH_2 \cdot + O_2 \longrightarrow R - CH_2 - CH_2 - O - O \cdot$

   (b) $R - CH_2 - CH_2 - O - O \cdot + NO \longrightarrow R - CH_2 - CH_2 - O \cdot + NO_2$

   (c) $R - CH_2 - CH_2 - O \cdot \longrightarrow HCOH + R - CH_2 \cdot$

   (d) What happens to the $R - CH_2 \cdot$?

   (e) What happens to the formaldehyde?

4. (a) Explain from a molecular perspective how greenhouse gases trap heat in the atmosphere.(5 points)

   (b) Why are CFCs potent greenhouse gases? (5 points)

   (c) Would you expect CF_2Cl_2 or CHF_2Cl to be a more potent greenhouse gas. Justify your answer.(5 points)

5. Consider the set of equilibrium reactions involved in the production of ground level O_3:

$$NO_2 + O_2 \overset{h\nu}{\rightleftharpoons} NO + O_3$$

(a) Explain in mechanistic terms how the presence of hydrocarbons in the atmosphere leads to high levels of ground level ozone on warm, sunny days. (10 points)

(b) NO is known to catalytically destroy O_3. Write a mechanism for this process and explain why this process has little effect on reducing the concentration of *ground* level O_3. (5 points)

6. Discuss three effects of acid rain on the environment in chemical terms (where appropriate). (13 points)