1.
 A) Draw the Lewis structure of chlorine nitrate.

b) Write out the chemical equations showing how chlorine nitrate is formed in the stratosphere and for the reactions that convert it back to active chlorine compounds. Include reactions that occur in polar stratospheric clouds.

1. The table below gives the reactions for the catalytic cycle for the destruction of stratospheric ozone by NO, and the Arrhenius parameters for each reaction.

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|   |   | ***A*(cm3 molecule−1 s−1)** | ***E*a(kJ mol−1)** |
|  |
| Reaction 1 | NO + O3  NO2 + O2 | 1.8 × 10−12 | 11.4 |
| Reaction 2 | NO2 + O  NO + O2 | 9.3 × 10−12 | ≈ 0 |
| Net | O + O3  O2 + O2 |   |   |
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* 1. Calculate the rate constants at 220 K for Reactions 1 and 2.
	2. Offer an explanation for why Reaction 2 has an activation energy of approximately zero.
1. Consider the net reaction in Question 2:

O + O3  O2 + O2

The standard enthalpies of formation of O and O3 are 249.2 and 142.7 kJ mol−1, respectively. Calculate the reaction enthalpy. Why does this reaction not proceed on its own, to any appreciable extent, in the stratosphere?

1. In particulate sampling, air is drawn through a filter, which collects the particulates. In one sampling, the initial weight of the filter was 3.347 g. The final filter weight was 3.762 g. If the average flow rate of air through the filter was 49 cubic feet per minute, and the sample was collected over 24 hours, what is the TSP concentration in μg/m3 for this sample?
(1 cubic foot = 0.02832 m3)
2. Write out the steps for the atmospheric oxidation of ethane.
3. Write out the steps for the atmospheric oxidation of propylene.
4. The atmospheric residence time of methane in the atmosphere is 12 years. If global methane emissions total 600 Mt (megatonnes) per year, what is the steady state concentration of methane in the atmosphere in Mt?—in ppm?

**Note:** The total mass of the atmosphere is 5.1 × 1018 kg, and the average molar mass is 29.0 g/mol.

1. A) In petroleum production, the term “solution gas” refers to gases that are dissolved in the petroleum reservoir because of the high pressure conditions underground, but become gaseous when the oil is brought to the surface. In 2007 in Alberta, 3.25 × 108 m3 of solution gas was flared (burned off) from crude oil and crude bitumen batteries.   Assuming that the solution gas was 100% methane, how many moles of CO2 are produced from this flaring? What is the increase in global concentration of CO2 in the atmosphere, in ppmv, resulting from this activity?

**Note:** The total mass of the atmosphere is 5.1 × 1018 kg, and the average molar mass is
29.0 g/mol.

b) In 2005, Alberta used 26 Mt (megatonnes) of coal to generate electricity.Assuming that 100% of the coal is converted to CO2, how many moles of CO2 are produced? What is the increase in global concentration of CO2 in the atmosphere, in ppmv, caused by this activity?

1. At the Braidwood nuclear power plant in Illinois, between 1996 and 2000,millions of litres of radioactive cooling water were leaked on the site, and groundwater is now contaminated with high levels of tritium. Tritium is a beta emitter with a half life of 12.3 years. Monitoring wells on the site have found groundwater radioactivity of up to 282,000 pCi/L. The EPA drinking water standard is 20,000 pCi/L. If the contaminated groundwater remained static and there was no decrease in tritium levels resulting from groundwater flow, how many years would it take for the radioactivity to decrease from 282,000 pCi/L to 20,000 pCi/L?

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