題號： 84　　　　國立臺灣大學 106 學年度碩士班招生考試試題
科目：大氣化學
節次： 4

Constants or equations that you might need	
PV= nRT for all gases discussed in this test	1 atm = 760 Torr = 101300 Pa = 1013 hPa
R (gas constant) = 8.314 J mol^{-1} K^{-1}, 0.082 L atm mol^{-1} K^{-1}	The radius of the Earth : 6400 km
k (Boltzmann constant) = 1.381 x 10^{-23} J K^{-1}	1 ppmv = 1 x 10^{-6} mol/mol=1 x 10^{-6} atm/atm
N_{av} = 6.02 x 10^{23} molecule mol^{-1}	1 ppbv = 1 x 10^{-9} mol/mol=1 x 10^{-9} atm/atm
Pa = Nm^{-2}	1 pptv = 1 x 10^{-12} mol/mol=1 x 10^{-12} atm/atm

1. Atmospheric ozone plays different roles based on the location as shown in Figure 1-1. However, the formation of ozone at stratosphere and troposphere is very different.

a) (12 pts) The ozone formation over the stratosphere is based on the Chapman mechanism. Please describe **in detail** the major four reactions of Chapman mechanism.

b) (20 pts) Figure 1-2 shows the temporal profile for several given parameters related to the formation of the ozone hole. With all information provided in Figure 1-2, please describe **in detail where, when** and **how** the ozone hole is formed. All required conditions and the chemical reactions for the formation of the ozone hole should be described.

c) (10 pts) The sources of tropospheric ozone can be contributed via transferring from the stratosphere and chemical reactions happening in the troposphere. For transport part, it can be estimated using a two-box model as shown in Figure 1-3. The residence time of air in the stratosphere is $\tau_S = 1/k_{ST}$ = 1.3 years. **Please use the two-box model as shown in Figure 1-3 to estimate the residence time ($1/k_{TS}$) of air in the troposphere** (hints: mass balance equations for two boxes for air mass).

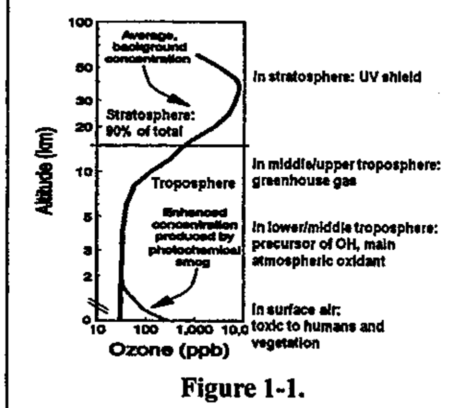

Figure 1-1.

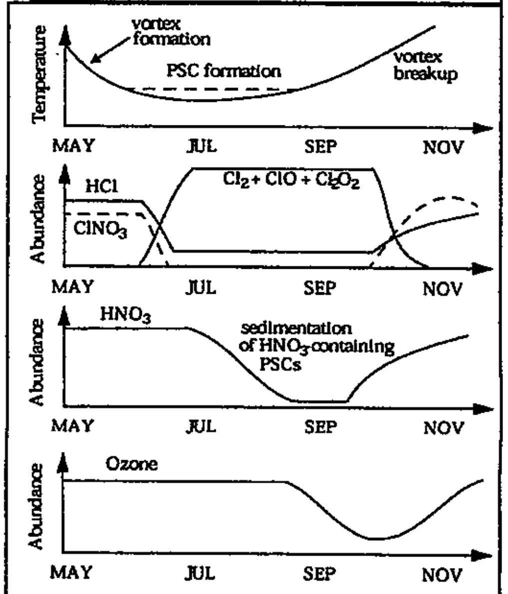

Figure 1-2.

2. Ozone and PM2.5 are major two air pollutants globally and are reported every hour as shown in Figure 2-1. EPA-Taiwan provides the emission data at the website for the whole Taiwan. The total emission is 1.2×10^{8} Kg/yr for SO_2 and 4.3×10^{8} Kg/yr for NOx (assuming as NO_2 for this exam) over the Taiwan island (此為台灣總排放量)(Atomic weight: S(32g/mole), N (14g/mole), O (16g/mole), H (1g/mole)).

(a) (12 pts) Figure 2-2 shows the cycling of HO_x and O_3 production in a polluted atmosphere. Please describe **in detail** how the ozone is formed in the troposphere.

(b) (6 pts) Using Taipei center as a site, please plot how the ozone concentration will change with time from 0:00 to 23:00 in a summer day and explain what causes the trend you draw.

(c) (8 pts) Please provide at least two major compositions of PM2.5 and how they become or enter the PM2.5.

(d) Consider only local emission. We assume that all of the emitted NOx and SO_2 are precipitated back over Taiwan as HNO_3 (1 mole of NOx forms 1 mole of HNO_3) and H_2SO_4 (1 mole of SO_2 forms 1 mole of H_2SO_4), respectively. The area of Taiwan is 36200 km^2 and the mean precipitation rate is 7 mm day^{-1} (based on CWB data). Assume that HNO_3 and H_2SO_4 are the only impurities in the rainwater,

(i) (4 pts) please calculate the total amount of rain over the whole Taiwan per day (in a unit of liter day^{-1}).

(ii) (6 pts) please calculate the concentration of HNO_3 and H_2SO_4 in the rain respectively (in a unit of M, 體積莫爾濃度).

(iii) (4 pts) please calculate the resulting rainwater pH (assuming equilibrium with H_2SO_4 and HNO_3, H_2SO_4 and HNO_3 are strong acids and dissociate completely).

(iv) (6 pts) In general, the pH of rain over Southern Taiwan is higher than Northern Taiwan. Please explain the possible reasons by considering only local emission.

(e) (12 pts) Please describe at least two impacts of ozone, PM2.5 and acid rain on the environment and ecosystem, respectively.

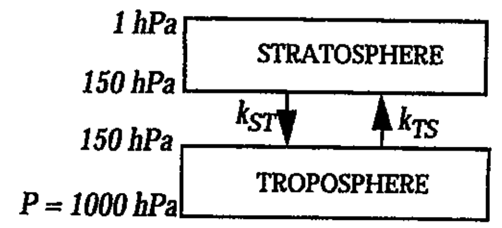

Figure 1-3. Two-box model for stratosphere-troposphere exchange

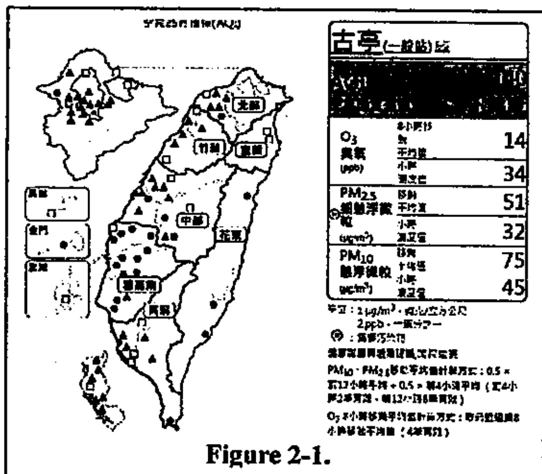

Figure 2-1.

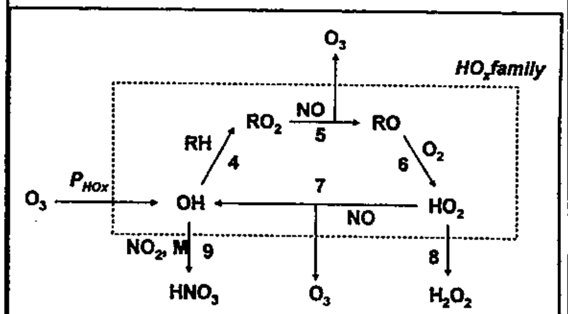

Figure 2-2.

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