Help: *R* = 8.314 J mol1 K1; *NA* = 6.022x1023; *h* = 6.626x1034 J sec; c=2.998x108 m/sec;

*e* = 1.602x1019 C; *R*H = 3.290x1015 sec1; *m*p/*m*e = 1836; 1 kcal = 4.184 kJ.

One Dobson Unit is equivalent to 2.687×1016 moleculecm2.

For light of wavelength 1240 nm, the photon energy is 1.00 eV.

(1a) The concentration of ozone can be monitored by its photo absorption. One measures the transmission of light through his ozone cell of 50 mm thickness to be 50% at 304 nm, estimate [O3]. (Relative accuracy requirement ±20%)

(1b) One measured the transmission of sunlight at 310 nm to be 0.37 at Solar Zenith Angle of 0 degree (the sun is straight up), estimate the transmission of sunlight at 310 nm at Solar Zenith Angle of 65 degree.

(2) One uses a LED light source at 365 nm to dissociate a gas sample of NO2 (1x1012 moleculecm3, 1 cm x 1 cm x 1 cm cell). It is known that the photodissociation yield is unity (100%) for wavelengths shorter than 400 nm. If the light flux is 2 mWcm2, estimate how long it would take to dissociate 1% of the NO2 molecules, assuming all the produced O atom would not interfere.

(3) One fluorescent dye has a fluorescence quantum yield ** = 50% and an excited-state lifetime ** = 5 ns when no quencher Q is added; ** = 20% when 1 mM of quencher Q is added, estimate ** and ** for [Q] = 4 mM.

(4) Calculate the change of entropy Si→f from the initial state *i* to the final state *f* for the following processes (the final state is in thermal equilibrium if applicable).

**(4a)** 1 gram of water, from 90 degree C to 10 degree C.

**(4b)** mixing of 1 gram of water at 90 degree C and 1 gram of water at 10 degree C.

**(4c)** mixing of 1 gram of water at 40 degree C and 1 gram of ice at 0 degree C.

**(4d)** 1 mol of ideal gas, (1 atm, 298 K) → (0.1 atm, 298 K).

**(4e)** Mixing of 1.6 mol of N2 and 0.4 mol of O2.

**(5a)** For a reaction A(*g*) → B(*g*), plot the entropy of mixing as a function of the extent of reaction *x* at 298 K and 1 atm. Note: The initial state is (1*x* mol of A and *x* mol of B without mixing); the final state is (1*x* mol of A and *x* mol of B, after mixing). You need to plot the data at *x* = 0, 0.2, 0.4, 0.5, 0.6, 0.8, 1 with appropriate units and scales.

**(5b)** For a homogeneous reaction, one has to consider the entropy of mixing. One example for A(g) → B(g), Go = 2.5 kJ/mol is shown below.

e

Replot the 3 curves for Go = 10 kJ/mol. You need to plot the data for at least 7 *x*-values (suggestion *x* = 0, 0.1, 0.2, 0.3, 0.5, 0.75, 1) with appropriate units and scales.

**(5c)** as in (5b), Replot the 3 curves but for H2O(*g*) → H2O(*l*) at 1 atm and 370 K. Ho(373K) = 40.7 kJ/mol. You may assume Ho(370K) = Ho(373K) and So(370K) = So(373K).

Note: For Quiz or Exam, grid paper (方格紙) will be provided.

**(6a)** If we consider an Air Conditioner as an ideal Carnot machine, and if the cold-end temperature is 5 degree C and the Carnot efficiency is 6.0, estimate the hot-end temperature.

**(6b)** If we consider a Refrigerator as an ideal Carnot machine, and if the cold-end temperature is 80 degree C, estimate the Carnot efficiency at a few possible hot-end temperatures (*eg* 30 degree C).

**(6c)** If we consider an ideal Carnot engine, and if the hot-end temperature is  degree C, the cold-end temperature is  degree C, estimate the Carnot efficiency of doing work.