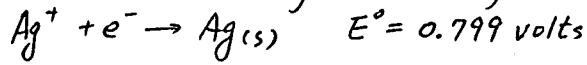


1. Given the Maxwell distribution function of molecular speeds  $f(v) = \left(\frac{m}{2\pi kT}\right)^{\frac{3}{2}} 4\pi v^2 \exp(-mv^2/2kT)$ , derive the most probable speed  $v_{mp}$ . (5%)
2. Derive the expression for the half-life of a reaction with the rate law:  $-\frac{d[A]}{dt} = k[A]^{\frac{1}{2}}$ . (5%)
3. Calculate the temperature at which 10% of the molecules in a system will be in the first excited electronic state which is 400 KJ/mol above the ground state. (5%)
4. If identical hard spheres are packed according to a body-centered cubic lattice. Calculate the fraction of volume occupied by spheres. (5%)
5. At 25°C the conductivity  $\kappa$  of the pure water is  $5.5 \times 10^{-6} \Omega^{-1} \cdot m^{-1}$ . The limiting ion mobilities of  $H^+$  and  $OH^-$  ions are  $36.25 \times 10^{-8}$  and  $20.64 \times 10^{-8} m^2 V^{-1} s^{-1}$ , respectively. Calculate the ion product constant  $K_w$  for water. (6%)
6. The rate law for  $2NO_2 \rightarrow 2NO + O_2$  reaction is  $-\frac{d[NO_2]}{dt} = k[NO_2]^2$  with  $k = 6.3 \times 10^2 \text{ mL/mol} \cdot \text{s}$  at 600K. How long will it take for 10% of  $NO_2$  (at 400mmHg initially) to decompose by this reaction? (8%)
7. (a) Show that the dissociation pressure ( $p$ ) of ammonium carbamate:
 
$$NH_2COONH_2(s) \rightleftharpoons 2NH_3(g) + CO_2(g)$$
 is related to the equilibrium Constant as  $K_p = \frac{4}{27} P^3$ . (4%)
 (b) At 25°C, the total pressure of the above reaction is 0.117 atm. Calculate  $\Delta G_f^\circ$  of ammonium carbamate. (4%)
 Given:  $\Delta \bar{G}_f^\circ(NH_3(g)) = -16.45 \text{ KJ mol}^{-1}$ ,  $\Delta \bar{G}_f^\circ(CO_2(g)) = -394.36 \text{ KJ mol}^{-1}$ .
8. Assume that benzene and toluene form ideal solutions, pure benzene boil at 80°C; at that temperature toluene has a vapor pressure of 350 torr.
 (a) Calculate the partial and total pressure of a solution at 80°C with mole fraction of benzene is 0.2? (4%)
 (b) What composition of solution would boil at 80°C under a reduced pressure of 500 torr? (4%)
9. An ideal monoatomic gas expands adiabatically from 800K, 8 atm to 1 atm final pressure. Calculate  $\Delta S$ ,  $\Delta U$  and  $q$  for the process if it is (a) reversible (b) irreversible, doing 3000J of work, (c) irreversible against zero pressure. (9%)

(背面還有題目)

10. For the cell  $Pb(s) | Pb^{2+}(0.0125M) \parallel Ag^+(0.600M) | Ag(s)$ , calculate  $E_{cell}^\circ$  and  $E_{cell}$ . Write the net cell reaction and calculate  $K_{eq}$ . Predict the spontaneous direction of reaction from the sign of  $E_{cell}$ . (9%)



11. A particle is moving in one dimension between  $x=a$  and  $x=b$ . The potential energy is such that the particle cannot be outside these limits and that the wavefunction is  $\psi = \frac{A}{x}$ .

(a) determine the normalization constant A. (5%)

(b) Calculate the expectation value of  $x$ . (5%)

12. For the following molecules :  $CHCl_3$ ,  $C_3H_6$  (cyclopropane),  $CO_2$  (linear),

(a) give the symmetry elements and the point group. (6%)

(b) which one has dipole moment? (2%)

(c) which one has pure rotational spectra? (2%)

13. Write : (a) the hybrid orbitals,

(b) the number of lone pairs in the central atom,

and (c) the shapes of the following molecules or ions.



(atomic number: Be = 4 N = 7)