Chemistry 360

Practice Midterm Examination 2

Actual midterm: Friday 6 November, 2009

Please show all your work. Page 4 of this midterm has useful quantities and relations. **<u>CIRCLE YOUR FINAL ANSWER!</u>** Check to make sure your signs, units, and order of magnitude appear physically meaningful.

1. State at least three things the Gibbs Free Energy tells us about the chemical properties of a system. (*6pts*)

2. $MgCl_2$ is a common salt used to melt ice. For a 0.100 M solution of $MgCl_2$ in water,

(a) Calculate the ionic strength.

(b) Calculate the average activity coefficient. How does this compare to the experimental value, 0.535? The Debye-Huckel constant for water is 1.177.

(c) Using your calculated $\gamma_{+/-}$ from above, calculate the RT ln a, the change in the chemical potential from standard conditions.

(d) Calculate the ΔT for melting. K_f is 1.860 K kg mol^{-1}. 3pts

3. (a) Write the cell reactions and electrode half-reactions for the following cell:

$Pt(s)\ Br_2(l)\ |\ HBraq)\ ||\ HCl(aq)\ |\ Cl_2(g)\ |\ Pt$

(b) Write the Nernst equations for this cell, expressing the activities in symbolic form (concentrations, pressure, etc). Assume ideal behavior.

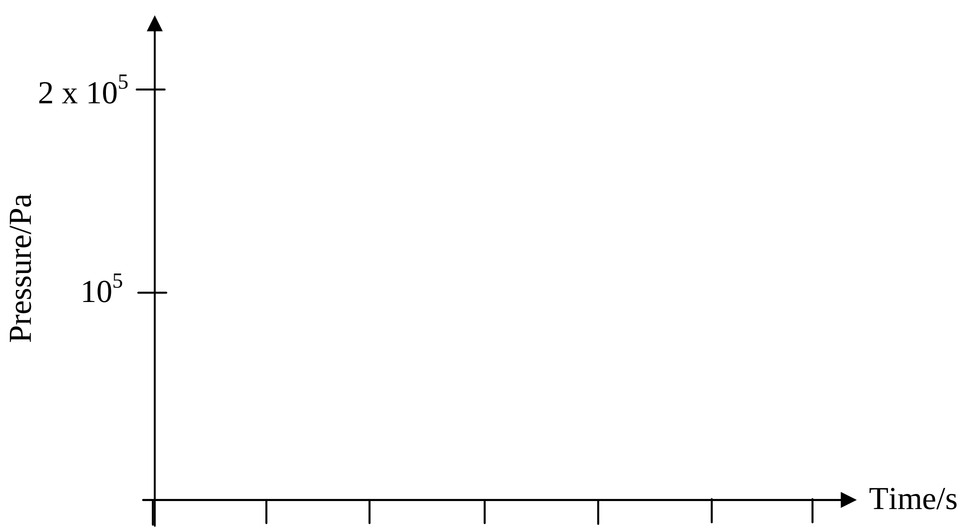
(c) Use the standard potentials for the electrodes to calculate the standard potential of the cell.

4. C_4H_8 (g) decomposes to 2 C_2H_4 (g) at T = 438 C with a rate constant of $2.48 \times 10^{-4}\ s^{-1}$.

(a) Based on the rate constant, what is the order of the reation?

(b) What is the half-life, assuming $p_o = 1.000 \times 10^5$ for C_4H_8?

(c) Calculate the pressure of both C_4H_8 and C_2H_4 at t = 0, 1000, 3000, and 6000 s, and plot on the graph below.



5. A rate constant is 1.78×10^{-4} L $mol^{-1}s^{-1}$ at $14.0^{o}C$ and 1.38×10^{-3} at $41.0^{o}C$. Calculate both the pre-exponential factor (A) and the activation energy (E_a) for the reaction.

Useful Stuff

R = molar gas constant = 8.31 J mol^{-1} K^{-1}
N_{Av} = Avogadro constant = 6.02 x 10^{23} mol^{-1}
m^o = 1m = 1 mole (kg solvent)$^{-1}$
pV = nRT

π = 3.14
p^o = 100,000 Pa = 1 bar
$C_{v,m}$ (IG) = 3/2 R; $C_{p,m}$(IG) = 5/2 R
T/K = T/C + 273.15

THERMODYNAMICS

dU = dq + dw = TdS – PdV
dG = dH - d(TS) = Vdp -SdT*
dH = dU + d(pV) = TdS + VdP
dS = dq_{rev}/T

Equilibrium $\Delta_{rxn}G = \Delta_{rxn}G^o + RT \ln Q \Rightarrow 0 = \Delta_{rxn}G^o + RT \ln K_{eq}$

$$\ln\left(\frac{K_{eq}^{T_2}}{K_{eq}^{T_1}}\right) = \frac{\Delta_{rxn}H}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)$$

phase diagrams: $\frac{dp}{dT} = \frac{\Delta_{trans}S}{\Delta_{trans}\overline{V}} = \frac{\Delta_{trans}H}{T\Delta_{trans}\overline{V}}$; $\ln\frac{p'}{p} = \frac{\Delta_{vap}H}{R}\left(\frac{1}{T} - \frac{1}{T'}\right)$

$\mu = \mu^o + RT\ln a$

$\Delta_{rxn}G = \Delta_{rxn}G^o + RT \ln Q$

a for solute = [B] if ideal, or = γ[B] if non-ideal

Colligative Properties

$\Delta T_b = K_b m$
$\Delta T_f = K_f m$
$\Pi = RT[B]$

Ionic Solutions

$$I = \frac{1}{2}\sum_i c_i z_i^2$$

$$\ln \gamma_{+/-} = \frac{-\alpha_{DH}|z_+ z_-| I^{1/2}}{1 + I^{1/2}}$$

Electrochemical cells: oxidation on LHS, reduction on RHS

$-nFE = \Delta_{rxn}G$; F = 96,485 coul mol^{-1} ; $E = E^o - ({}^{RT}/_{nF})\ln Q$

KINETICS

Arrhenius Equation: $k = Ae^{-E_a/RT}$

Integrated rate law 1^o $[A] = [A]_o e^{-kt}$ simple 2^o $\frac{1}{[A]} = \frac{1}{[A]_o} + kt$

SS approx $d[I]/dt \approx 0$

From CT, 2^o rate constants
$k = P\, N_{Av}\, \sigma_{AB} (8RT/\pi\mu_{AB})^{1/2}$ $\mu_{AB} = M_A M_B/(M_A + M_B)$; $\sigma_{AB} = \pi(r_A + r_B)$

$k_d = 8RT/3\eta$