YORK UNIVERSITY **NAME:** ______________________________

F2013 SC/CHEM 2011.03 **STUDENT NO.** ________________________

Final Exam **December 18, 2013** **21 questions** **180 minutes** **100 marks**

No documentation is allowed. Calculators are allowed.
The exam has **4 parts**. Parts 1, 2, and 3 correspond to tests 1, 2, and 3, and each count for 20%, or 0%, whichever is to your advantage. Part 4 is worth 40%. The last page has formulas and constants.

Part 1

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Part 2

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Part 3

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Part 4

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Constants and Formulas

$$
\begin{aligned}
R &= 8.31451\,J\,K^{-1}\,mol^{-1} \quad ; \quad k_B = 1.38066\times10^{-23}\,J\,K^{-1} \\
1\,bar &= 10^5\,Pa \quad ; \quad 1\,atm = 101325\,Pa \\
1\,L &= 1\,dm^3 = 10^{-3}\,m^3 \quad ; \quad 0^\circ C = 273.15\,K
\end{aligned}
$$

$$
\begin{aligned}
P &= \frac{nRT}{V-nb} - \frac{n^2 a}{V^2} \\
w &= -\int P_{ext}\,dV \quad ; \quad w = \int F\,dx \\
w &= -nRT\ln(V_2/V_1) \qquad \text{(reversible process, constant T)} \\
P_1V_1^\gamma &= P_2V_2^\gamma \quad \text{where} \quad \gamma = C_{P,m}/C_{V,m} \qquad \text{(reversible process, q = 0)} \\
C_P &= dq_P/dT = \left(\frac{\partial H}{\partial T}\right)_P \quad ; \quad C_V = dq_V/dT = \left(\frac{\partial U}{\partial T}\right)_V \\
C_{P,m} - C_{V,m} &= R \qquad \text{(for I.G.)} \quad ; \quad C_P = C_V + TV\beta^2/\kappa \\
\beta &= \frac{1}{V}\left(\frac{\partial V}{\partial T}\right)_P \quad ; \quad \kappa = \frac{-1}{V}\left(\frac{\partial V}{\partial P}\right)_T \quad ; \quad \left(\frac{\partial H}{\partial P}\right)_T = V(1-T\beta) \\
\Delta H_R^\circ &= \sum_p^{products} \Delta H_f^\circ(p) - \sum_r^{reactants} \Delta H_f^\circ(r) \\
dS &= \frac{dq_{rev}}{T} \quad ; \quad dS \geq \frac{dq}{T} \quad ; \quad S = k_B \ln W \quad ; \quad \epsilon = 1 - T_{cold}/T_{hot} \\
\Delta S &= nC_{P,m}\ln(T_f/T_i) - nR\ln(P_f/P_i) \qquad \text{(I.G.)} \\
\Delta S &= C_P\ln(T_f/T_i) - V\beta(P_f - P_i) \qquad \text{(solids and liquids)} \\
\Delta S_{tr} &= \frac{\Delta H_{tr}}{T_{tr}} \quad ; \quad K = e^{-\Delta G_R^\circ/RT} \\
K_P &= \frac{\text{product of partial pressures of products}}{\text{product of partial pressures of reactants}} \\
\ln K(T_2) &= \ln K(T_1) - \frac{\Delta H_R^\circ}{R}(1/T_2 - 1/T_1) \\
\frac{\Delta G(T_2)}{T_2} &= \frac{\Delta G(T_1)}{T_1} + \Delta H(T_1)\left(\frac{1}{T_2} - \frac{1}{T_1}\right) \\
\Delta U &= q + w \quad ; \quad H = U + PV \quad ; \quad G = H - TS \quad ; \quad A = U - TS \\
\Delta H &= \Delta U + \Delta(PV) \quad ; \quad \Delta H_P = n\int_{T_1}^{T_2} C_{P,m}\,dT \\
\mu &= \left(\frac{\partial G}{\partial n}\right)_{T,P} \quad ; \quad dG = \sum_i \mu_i\,dn_i \quad ; \quad \mu_i = \mu_i^\circ + RT\ln x_i \\
\Delta S_{mixing} &= -nR\sum_i x_i \ln x_i \quad ; \quad \Delta G_{mixing} = nRT\sum_i x_i\ln x_i \quad \text{for I.G.}
\end{aligned}
$$