CHE 31	Self-Evaluation Exam for Mid-Term	**Date: 8.08.2010**

Name (Surname, Given)	Section	Score

Instructions:
(1) Read the problem carefully and intelligently.
(2) Answer all questions pertaining to the problem.
(3) Write all answers on the space provided.
(4) Inputs with erasures are not considered so make sure you check them before finalizing your answers.

Problem 1.

The reaction A ===> B is carried out in a laboratory reactor. According to published article the concentration of A should vary with time as follows:

$$C_A = C_{A0} \exp(-kt)$$

where C_{A0} is the initial concentration of A in the reactor and k is a constant. The following data are taken for $C_A(t)$:

t(min)	**0.5**	**1.0**	**1.5**	**2.0**	**3.**	**5.0**	**10.0**
C_A(lb-mole/ft^3)	**1.02**	**0.84**	**0.69**	**0.56**	**0.38**	**0.17**	**0.02**

a) Determine the values and units of C_{A0} and k.
b) Convert the formula with the calculated constants in (a) to an expression for the molarity of A in the reaction mixture in terms of t in seconds.
c) Calculate the molarity at t = 200 s

Summary of Calculations

Part (a)

Linearized form of C(t):____

If the standard form of a linear equation is $y = mx + b$, give the equivalence of y, x, m, and b in the linearized equation for C(t):

y = _________________ x = _________________ m = _________________ b = _________________

Complete the following table:

x								S_X =
y								S_Y =
xx								S_{XX} =
xy								S_{XY} =

Values of m and b: m = ___________________ b = ___________________

Values and units of C_{A0} and k: C_{A0} = ___________________ k = ___________________

Part (b)

Numerical relationship between C_A and C_A' and t and t' :

C_A = _______________ C_A' t = _______________ t'

Problem 1. (continued)

Write the transformed equation $C_A'(t')$: ____

Part (c)

Value of C_A' at $t' = 200$ s: C_A' (mol/L): ______________

Problem 2

A mixture of methane and air is capable of being ignited only if the mole percent of methane is between 5% and 15%. A mixture containing 9.0% methane in air is flowing at a rate of 700 kg/h is to be diluted with pure air to reduce the methane concentration to the lower flammability limit. Calculate the required flow rate of air in mol/h and the percent by mass of oxygen in the diluted mixture. (Note: Air may be taken to consist of 21% O_2 and 79% N_2 and to have a molecular weight of 29.0)

Hint: Apply the conservation principle to CH_4 and air before and after dilution.

Summary of Calculations

Average MW of original CH_4-air mixture: MW = ______________________ g/mol

Total molar flowrate of original mixture: n_1 = ______________________ kmol/h

Molar flowrate of CH_4 in original mixture: $(n_{CH4})_1$ = ______________________ kmol/h

Molar flowrate of air in original mixture: $(n_{air})_1$ = ______________________ kmol/h

Molar flowrate of CH_4 in diluted mixture: $(n_{CH4})_2$ = ______________________ kmol/h

Molar flowrate of air in diluted mixture: $(n_{air})_2$ = ______________________ kmol/h

Molar flowrate of pure air: n_{air} = ______________________ mol/h

Mass flowrate of diluted mixture: n_2 = ______________________ kg/h

Mass percent of O_2 in diluted mixture: $\%O_2$ = ______________________%

Problem 3

Estimate the specific volume (in m^3/kg) of water vapor at P_{abs} = 11 MPa and T = 580^0C using the following methods:

a) assuming ideal gas behaviour
b) using the generalized equation of state
c) using the van der Waals equation of state
d) using the steam table

Summary of Calculations

Part (a). Ideal Gas Behaviour

Absolute Pressure: __________ kPa Absolute Temperature: __________ K

MW of Water: ____________kg/kmol Value of R: __________________ $(kPa)(m^3)/(kmol)(K)$

Specific Volume of Water: ______________ m^3/kg

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Problem 3. (continued)

Part (b). Generalized Equation of State

P_C for Water: ______________ kPa T_C for Water: ______________ K

P_r: ______________ T_r: ______________ z-value: ______________

Specific Volume of Water: ________________ m^3/kg

Part (c). van der Waals Equation

van der Waals constants for water: a = ________________ kPa $(m^3/kmol)^2$

b = ________________ $m^3/kmol$

Write the cubic form of the van der Waals equation: ____

Write the specific forms of f(V) and f' (V) for the given condition (assume a basis of 1 kmol):

f(V) = ____

f' (V) = ____

Solve for the volume using the Newton-Raphson method with initial guess value for volume based on ideal gas equation and number of steps equal to 7. Summarize the results using the table below:

Step	V_k (m^3)	f(V)	f' (V)	V_{k+1} (m^3)	Error
0					
1					
3					
5					
6					

Specific Volume of Water: ________________ m^3/kg

Problem 3. (continued)

Part (d). Using the Steam Table

Determine the values of the specific volume (in m^3/kg) of water at the specified conditions:

	P = 10.0 MPa	P = 11.0 MPa	P = 12.5 MPa
T = 550^{0}C			
T = 580^{0}C			
T = 600^{0}C			

Problem 4

Pure chlorobenzene is contained in a flask attached to an open-end mercury manometer. When the flask contents are at 58.3^{0}C, the height of the mercury in the arm of the manometer connected to the flask is 747 mm and that in the arm open to the atmosphere is 52 mm. At 110^{0}C, the mercury level is 577 mm in the arm connected to the flask and 222 mm in the other arm. Atmospheric pressure is 755 mm Hg

a) Estimate the vapor pressure of chlorobenzene using the Clausius-Clapeyron equation.
b) Air saturated with chlorobenzene at 130^{0}C and 101.3 kPa is cooled to 58.3^{0}C at constant pressure. Estimate the percentage of the chlorobenzene that condenses.

Summary of Calculations

Part (a):

Vapor pressure of chlorobenzene at T = 58.3^{0}C p^*_1 = __________ mm Hg

Vapor pressure of chlorobenzene at T = 110^{0}C p^*_2 = __________ mm Hg

Value of ($\Delta Hv/R$) for chlorobenzene   ($\Delta Hv/R$) = ____________

Value of B for chlorobenzene   B = __________________

Write the specific form of the Clausius-Clapeyron equation for chlorobenzene:

____

Vapor pressure of chlorobenzene at T = 130^{0}C p^*_3 = __________ mm Hg

Part (b): (Assume a basis of 100 mol of mixture)

Mole fraction of chlorobenzene in mixture before condensation: y_0 = ______________

Mole fraction of chlorobenzene in mixture after condensation: y_1 = ______________

Moles of air in the vapor phase: n_{air} = ____________ mol

Total moles of vapor phase after condensation: $(n_V)_T$ = ___________ mol

Moles of chlorobenzene that condenses n_C = ____________ mol

% Condensation   %C = ___________ %