ECHE 260: FINAL EXAM

Units 1-7: Material and energy balances

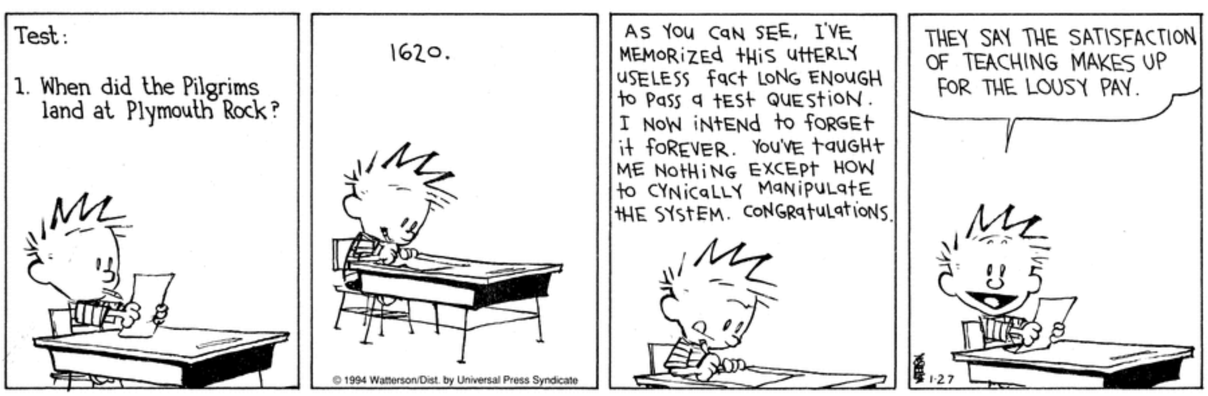
Instructor: Christine Duval (ced84@case.edu)

Due on Wednesday, December 21 at 11AM

Name: ____

Directions:

i. Write the values for all tabulated data on your solution. I should be able to calculate a numerical answer to the problem using your solution and without having to look up any additional values.
ii. Upload your PDF solution to Canvas in the Final Exam submission portal
iii. Take the course evaluation.
iv. Enjoy the winter break! ☺



Quantitative Question: SHOW ALL WORK. WRITE NEATLY.

(100 points) Acetone (C_3H_6O) can be produced by the Wacker process in which ethylene is catalytically oxidized to form acetone. The reaction is described by the chemical equation below:

$$\frac{3}{2}C_2H_4(g) + \frac{1}{2}O_2(g) \rightarrow C_3H_6O\ (g)$$

In a continuous, steady state process, pure ethylene (C_2H_4) and pure oxygen (O_2) are fed to a reactor in two separate feed streams and in a stoichiometric ratio. The oxygen stream entering the reactor is at 298K and 1 atm. The ethylene fed to the reactor first passes through a throttling valve to reduce the temperature and pressure to 1atm and 298K. The compressed ethylene (before throttling) has a volumetric flowrate of 10 L/min, P=200 atm and a temperature of 450K. The fractional conversion of the ethylene (C_2H_4) in the reactor is 0.90. The reactor is perfectly insulated and therefore adiabatic (Q=0). The reactor effluent (P=1atm) is fed to a condenser which operates at a pressure of 0.5 atm. 1 mol/min of acetone exits the condenser in the vapor stream which also contains oxygen and unreacted ethylene (C_2H_4). The liquid product stream of the process consists of pure acetone.

Using the general procedure for material and energy balances from ECHE 260, explain how to answer the questions below. A complete answer will include a fully labeled PFD, material balances, energy balances, and an explanation of how you would solve for the unknowns. You are encouraged to do a DOF analysis and write theoretical paths, but they are optional. The values of all thermodynamic tabulated data needed for the calculations should be explicitly written and sources of that data should be cited. Clearly state all assumptions and simplifications.

1. What is the volumetric flowrate of oxygen entering the reactor?
2. What is the temperature of the stream leaving the reactor?
3. How much heat must be removed from the condenser?

DO NOT solve for a numerical answer. Integrate one of the indefinite integrals to demonstrate you know how, but do not evaluate. Ex: $\int_{P_1}^{P_2} \ln(x) = (x\ln(x) + x)|_{P_1}^{P_2}$

TABLE A: Select (potentially helpful) thermodynamic data.

Species	ΔH_f^o (kJ/mol)	ΔH_c^o (kJ/mol)	Cp (kJ/mol ^{0}C)	MW (g/mol)	Tc (K)	Pc (atm)
Ethylene	52 (g)	-1410 (g)	0.040	28	300	50
Oxygen	0 (g)	--	0.030	32	150	50

Key: (g) vapor; Heat of formation at 25^{o}C and 1atm.