ChE 344
Fall 2014
Final Exam

Wednesday, December 17, 2014
4 p.m. – 6 p.m.

Open Book, Closed Web and Closed Notes

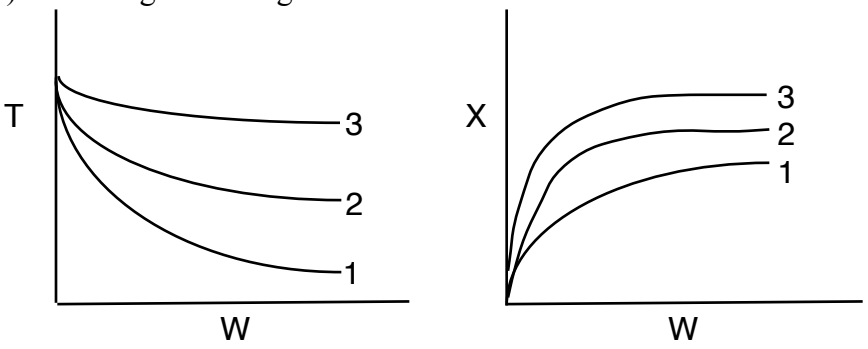
Name_____

Honor Code: *I have neither given nor received unauthorized aid on this examination, nor have I concealed any violations of the Honor Code.*

_____
(Sign at the end of exam period)

Point Totals	
1)	____/ 5 pts
2)	____/ 5 pts
3)	____/ 15 pts
4)	____/ 20 pts
5)	____/ 25 pts
6)	____/ 25 pts
7)	____/ 35 pts
Total	____/130 pts

(5 pts) 1) The conversion and temperature are shown below as a function of catalyst weight for three sets (1, 2, 3) of cooling or heating rates



Circle the correct answer.

A) One of the curves could correspond to an exothermic irreversible reaction with too high of a cooling rate.

True False Insufficient information to tell

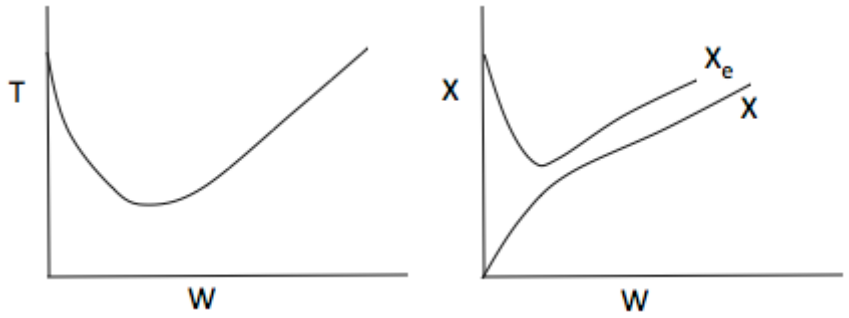
B) One of the curves could correspond to an endothermic reversible reaction with too high of a heating rate.

True False Insufficient information to tell

C) The reaction could be second order exothermic and carried out adiabatically.

True False Insufficient information to tell

(5 pts) 2) Consider the following profiles for the reaction $A \rightleftarrows B$



Which of the following statements are true? Circle all that apply.

A) The above reaction could be adiabatic.
B) The above reaction could be exothermic with constant cooling temperature.
C) The above reaction could be endothermic with constant heating temperature.
D) The above reaction could be second order.
E) The above reaction could be first order.

(15 pts) 3) The enzymatic reaction

$$S + E \rightarrow P + E$$

follows Michaelis-Menten kinetics. The reaction is carried out in a batch reactor where the initial substrate concentration is 0.1 mol/dm^3. When the substrate concentration is 0.02 mol/dm^3 the reaction rate is one half the maximum rate. If 20 minutes are necessary to reach one half the maximum rate, what is V_{max}?

(20 pts) 4) Study Problem

P10-6$_B$ The formation of propanol on a catalytic surface is believed to proceed by the following mechanism

$$O_2 + 2S \rightleftharpoons 2O \cdot S$$

$$C_3H_6 + O \cdot S \rightarrow C_3H_5OH \cdot S$$

$$C_3H_5OH \cdot S \rightleftharpoons C_3H_5OH + S$$

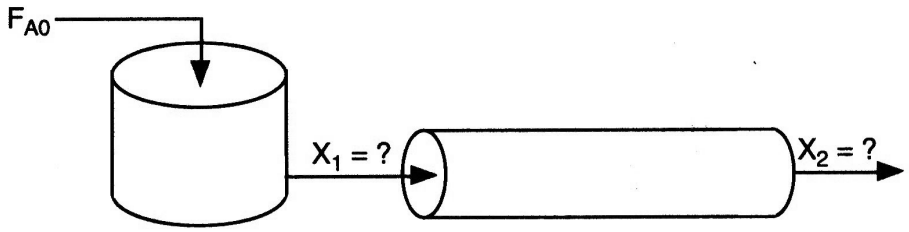
At low concentrations of oxygen, the initial rate is half order in O_2 and first order in propylene. Suggest a rate-limiting step and derive a rate law.

(25 pts) 5) Study Problem P5-20$_B$, Modified California Registration Exam Problem

The elementary gas phase reaction

$$A \rightarrow B$$

takes place isobarically and isothermally in a PFR where 63.2% conversion is achieved. The feed is Pure A. It is proposed to put a CSTR of equal volume upstream of the PFR, i.e.,



Based on the entering molar flow rate to A to the first reactor, what will be the intermediate from the CSTR, X_1 and exit conversions from the PFR based on feed to first reactor? The entering flow rates and all other variables remain the same as that for the single PFR.

X_1 = _____

X_2 = _____

(25 pts) 6) Study Problem from California Professional Engineers Exam

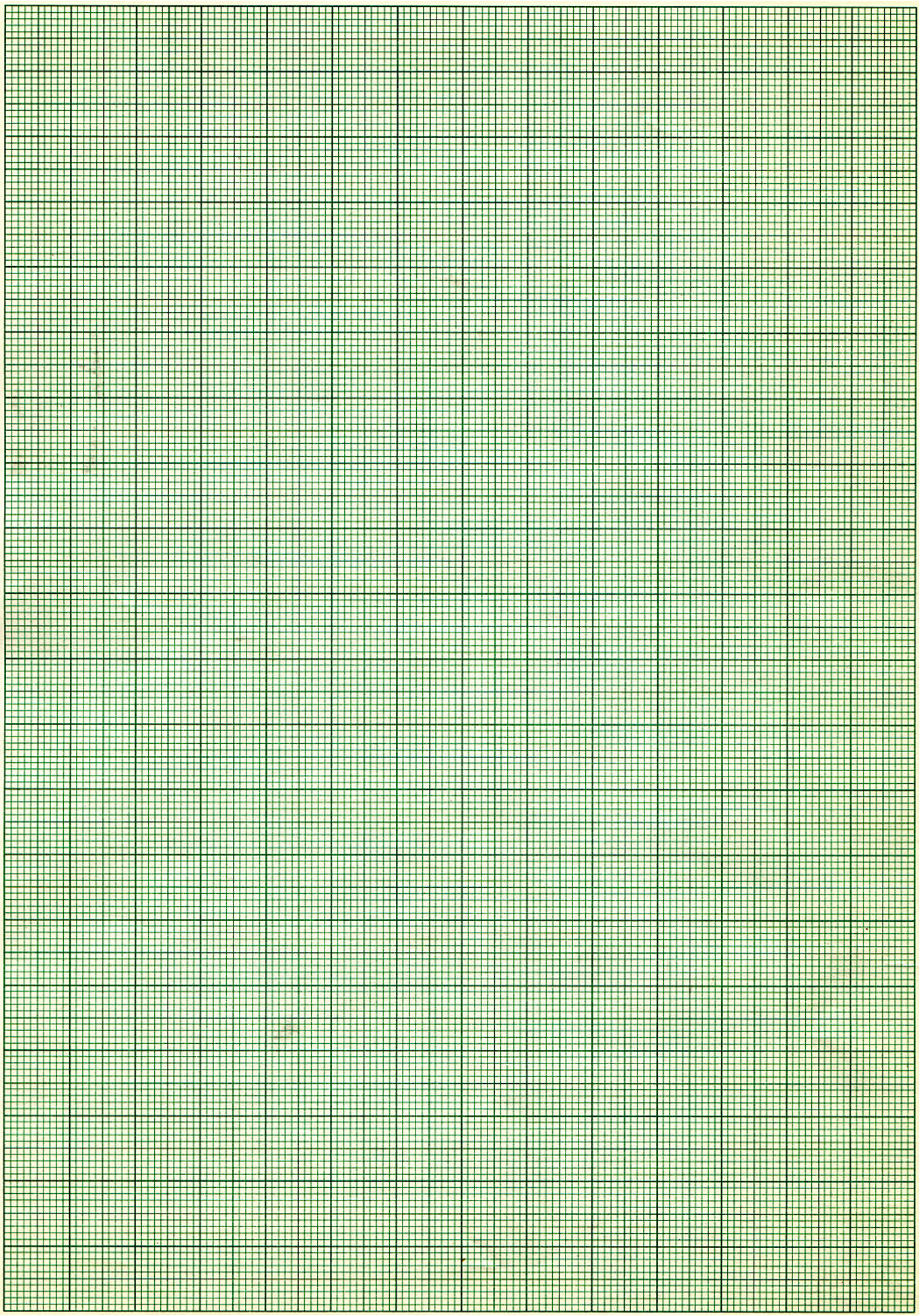
P7-8$_A$ In order to study the photochemical decay of aqueous bromine in bright sunlight, a small quantity of liquid bromine was dissolved in water contained in a glass battery jar and placed in direct sunlight. The following data were obtained at 25°C:

Time (min)	10	20	30	40	50	60
ppm Br_2	2.45	1.74	1.23	0.88	0.62	0.44

(10 pts) **(a)** Determine whether the reaction rate is zero or first order in bromine using any technique you choose (e.g., trial and error, plotting) and calculate the reaction rate constant in units of your choice.

(15pts) **(b)** Assuming identical exposure conditions, calculate the required hourly rate of injection of bromine (in pounds per hour) into a sunlit body of water, 25,000 gal in volume, in order to maintain a sterilizing level of bromine of 1.0 ppm. [If you are unable to determine the rate constant in part (a) assume it is equal to 1.0 in appropriate units.]

(*Note*: ppm = parts of bromine per million parts of brominated water by weight. In dilute aqueous solutions, 1 ppm ≡ 1 milligram per liter).



(35 pts) 7)

P13-7$_B$ The following reactions are taking place in a 2,000 dm^3 liquid phase batch reactor under a pressure of 400 psig

$$A + 2B \xrightarrow{k_{1A}} C \qquad \Delta H_{Rx1B} = -5{,}000 \text{ cal/mol} \qquad -r_{1A} = k_{1A}C_AC_B^2$$

$$3C + 2A \xrightarrow{k_{2A}} D \qquad \Delta H_{Rx2C} = +10{,}000 \text{ cal/mol} \qquad -r_{2A} = k_{2A}C_AC_C$$

$$B + 3C \xrightarrow{k_{3C}} E \qquad \Delta H_{Rx3B} = -50{,}000 \text{ cal/mol} \qquad -r_{3C} = k_{3C}C_BC_C$$

The initial temperature is 450 K and the initial concentrations of A, B and C are 1.0, 0.5 and 0.2 mol/dm^3 respectively. The coolant flow rate was at its maximum value so that $T_{a1} = T_{a2} = T_a = 400$ K so that the product the exchange area and overall heat transfer coefficient, UA, is $UA = 100$ cal/s•K.

(a) If $Q_r > Q_g$ at time $t = 0$, and there is no failure of the heat exchange system, is there any possibility that reactor will run away? Explain

_____

_____

_____

(b) What is Q_r at $t = 0$? $Q_r =$ _____

(c) What is Q_g at $t = 0$? $Q_g =$ _____

(d) What is the initial rate of increase in temperature, (i.e., dT/dt) at $t = 0$?

$\frac{dT}{dt} =$ _____

(e) Suppose that the ambient temperature T_a is lowered from 400 K to 350 K, what is the initial rate of reactor temperature change?

$\frac{dT}{dt} =$ _____

Additional Information:

As a first approximation, assume all heats of reaction are constant (i.e., $\Delta C_{P_{ij}} \cong 0$) Specific reaction rates at 450 K are

$k_{1A} = 1 \times 10^{-3}$ (dm^3/mol)^2/s $\quad C_{P_A} = 10$ cal/mol/K $\quad C_{P_D} = 80$ cal/mol/K

$k_{2A} = \frac{1}{3} \times 10^{-3}$ (dm^3/mol)^2/s $\quad C_{P_B} = 10$ cal/mol/K $\quad C_{P_E} = 50$ cal/mol/K

$k_{3C} = 0.6 \times 10^{-3}$ (dm^3/mol)^2/s $\quad C_{P_C} = 50$ cal/mol/K

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