國 立 清 華 大 學 命 題 紙

八十四學年度 化學工程研究 所 甲 組碩士班研究生入學考試

科目 化工熱力學及化學反應工程 科號 1602 共 3 頁第 1 頁 *請在試卷【答案卷】內作答

Problem 1 (20%)

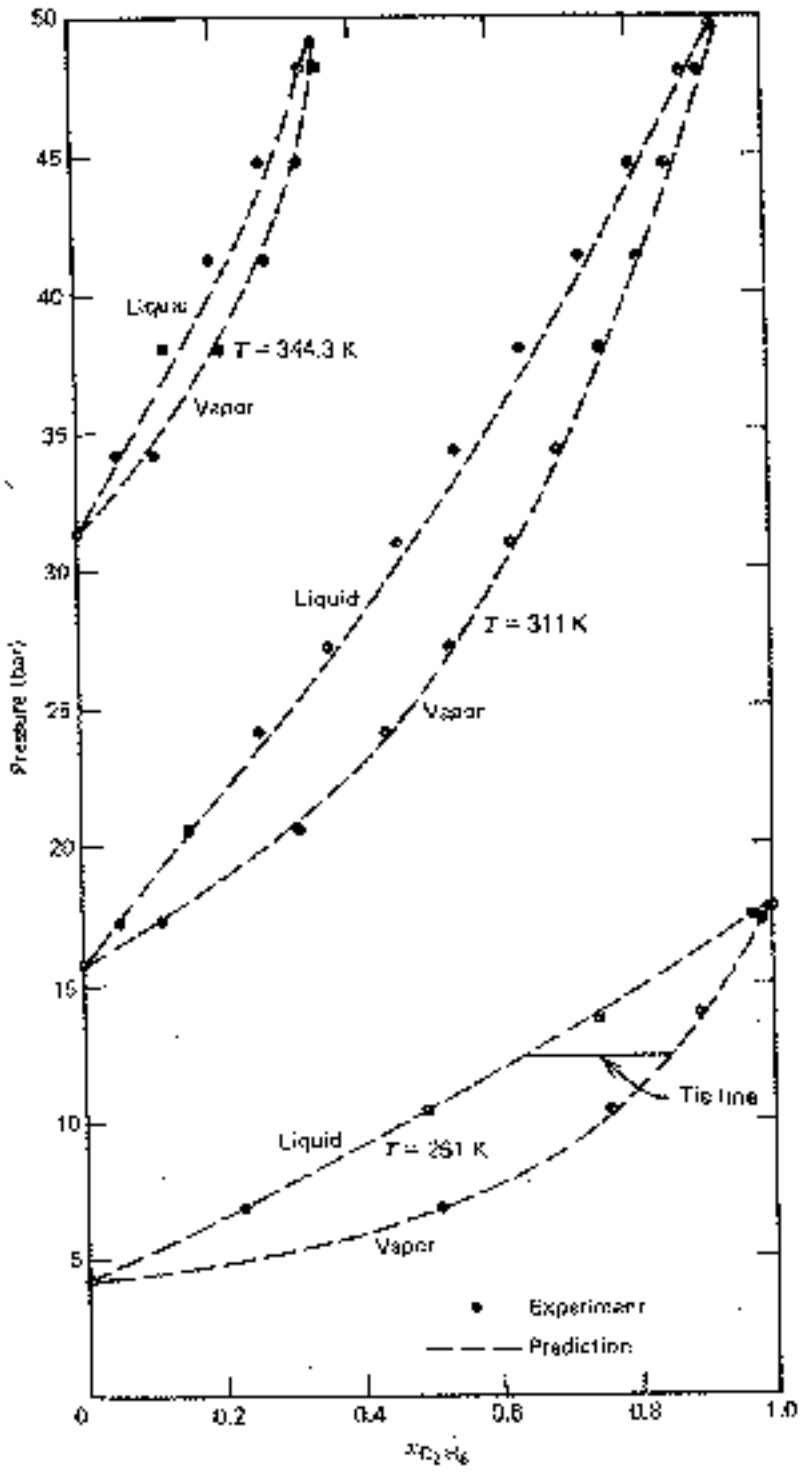
乙烷與丙烯之汽液平衡數據如附，請問：

(a) 50 mol% 乙烷與乙烯在 311K 之泡點壓力(bubble point pressure)

(b) 50 mol% 乙烷與乙烯在 311K 之露點壓力(dew point pressure)

(c) 乙烷之臨界溫度是在 344K 與 311K 之間抑或 311K 與 261K 之間

(d) 在運送液體時我們通常使用往復式泵浦(reciprocating pump)，運送氣體時我們通常使用離心式泵浦(cenfuifugal pump)，現需在 311K 運送 80mol% 之乙烷與乙烯，請問使用往兩類泵浦各自的壓力限制。



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Problem 2 (20%)

A steady stream of air at 180°C and 5 atm is available. It flows through a reversible device and leaves at 30°C and 1 atm, and the device may exchange heat with the surroundings at 30°C. If assume ideal gas behavior and constant heat capacity $\left(C_p = 6.0 \frac{\text{cal}}{\text{gmol} - \text{K}}\right)$, how much work can be obtained from each g mol of air? The gas constant, R, is 1.987 $\frac{\text{cal}}{\text{gmol}-^\circ\text{K}}$ or 0.082 $\frac{\text{atm} - \text{liter}}{\text{gmol}-^\circ\text{K}}$.

Problem 3 (20%)

Under appropriate conditions the decomposition of ethyl bromide may be explained by the following mechanism.

Initiation:

$$C_2H_5Br \xrightarrow{k_1} C_2H_5\bullet + Br\bullet \qquad E_{a,1}$$

Propagation:

$$Br\bullet + C_2H_5Br \xrightarrow{k_2} HBr + C_2H_4Br\bullet \qquad E_{a,2}$$

$$C_2H_4Br\bullet \xrightarrow{k_3} C_2H_4 + Br\bullet \qquad E_{a,3}$$

Termination:

$$Br\bullet + C_2H_4Br\bullet \xrightarrow{k_4} C_2H_4Br_2 \qquad E_{a,4}$$

(a) Derive an expression for the rate of disappearance of ethyl bromide.
(b) What is the apparent order of the reaction?
(c) What is the apparent activation energy for the reaction in terms of the activation energies of the individual steps?

Note that the amount of ethyl bromide that disappears by the initiation reaction is small compared to that which disappears via reaction 2.

Problem 4 (40%)

An olifin (B) produced by dehydrogenation of a saturated hydrocarbon (A) undergoes isomerization to produce (C).

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$$A \longrightarrow B + H_2 \rightleftharpoons C + H_2 \qquad \text{(gas phase reaction)}$$

From the following data determine

10% (a) the equilibrium constant of $A \longrightarrow B + H_2$ and $B + H_2 \rightleftharpoons C + H_2$.

10% (b) the appropriate rate constant assuming first order kinetics.

10% (c) the space time for a PFR to reach 80% conversion of (A).

10% (d) the space time for a CSTR to reach 80% conversion of (A).

Time, min	A	B	C (m · mole/ℓ)
0	100	0	0
0.2	90.5	8.5	1.0
0.4	81.9	14.6	3.5
0.6	74.1	19.3	6.6
0.8	67.0	23.0	10.0
1.0	60.7	26.0	13.3
1.5	47.2	31.8	31.0
2.0	36.8	35.9	27.3
2.5	28.7	39.7	31.6
3.0	22.3	41.9	35.8
4.0	13.5	44.8	41.7
5.0	8.2	46.9	44.9
6.0	5.0	48.1	46.9
7.0	3.0	48.6	48.4
8.0	1.8	49.3	49.1
10.0	0.7	49.7	49.6

note:

$$\frac{dy}{dt} + py = Q$$

$$y\, e^{\int p dx} = \int Q e^{\int p dx} dx + \text{const}$$