國立臺灣科技大學

114學年度碩士班招生

試題

系所組別：0600化學工程系碩士班

科　　目：化工熱力學與動力學

<<506002>>

國立臺灣科技大學 參考服務章

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(總分為 100 分；所有試題務必於答案卷內頁依序作答)

1. (10%) Please answer/define the following items briefly (1 point for each item)

(1%) (a) Ideal solution

(1%) (b) Raoult's law

(1%) (c) Henry's law

(1%) (d) Chemical potential

(1%) (e) Fugacity

(1%) (f) For an ideal gas, what is the value of $(C_p - C_v)$

(1%) (g) The phase rule

(1%) (h) The inequality of Clausius (Just show the equation)

(1%) (i) Joule-Thompson Coefficient

(1%) (j) What is the thermodynamic efficiency of the reversible Carnot cycle if the high and low temperatures of the isothermal steps are T_h and T_c, respectively?

2. (20%) Nitrogen gas leaves a compressor at 2.0 MPa and 120°C and is collected in two different cylinders, each of volume 0.3 m^3. In each case the cylinder is to be filled to a pressure of 2.0 MPa. Cylinder 1 is initially evacuated, and cylinder 2 contains nitrogen at 1 MPa and 20°C. Please find the final temperature of nitrogen in each of the cylinders, assuming nitrogen to be an ideal gas with $C_p^* = 29.3$ J/mol K. In each case assume the gas does not exchange heat with cylinder walls.

3. (20%) Figure 1 illustrates a binary fluid power generation cycle, where electricity is generated from geothermal energy, and isobutane is used as the working fluid. The isobutane flows through four units in sequence: a compressor, a high-temperature heat exchanger, a turbine, and a low-temperature heat exchanger. It is known that isobutane is vaporized and superheated at constant pressure to 227°C and 80 bar in the high-temperature heat exchanger, while it is isobarically condensed to a saturated liquid at 67°C in the low-temperature heat exchanger. Assume that the compressor and turbine operate adiabatically and isentropically. The P-H diagram (SI Units) for isobutane is shown in Figure 2.

(10%) (a) Please calculate the heat or work for the four units of the cycle.

(10%) (b) What is the efficiency the proposed cycle?

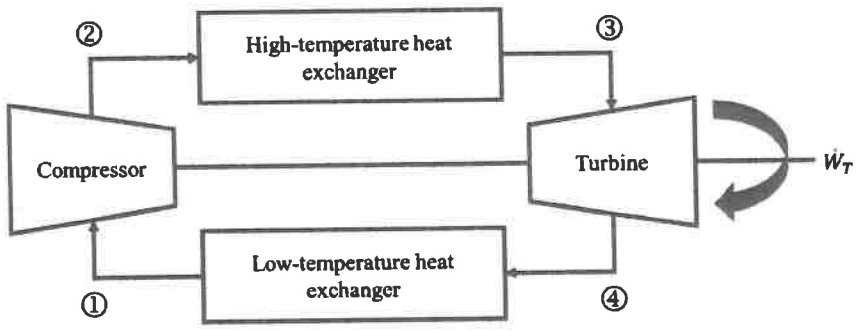

Figure 1. The power generation cycle.

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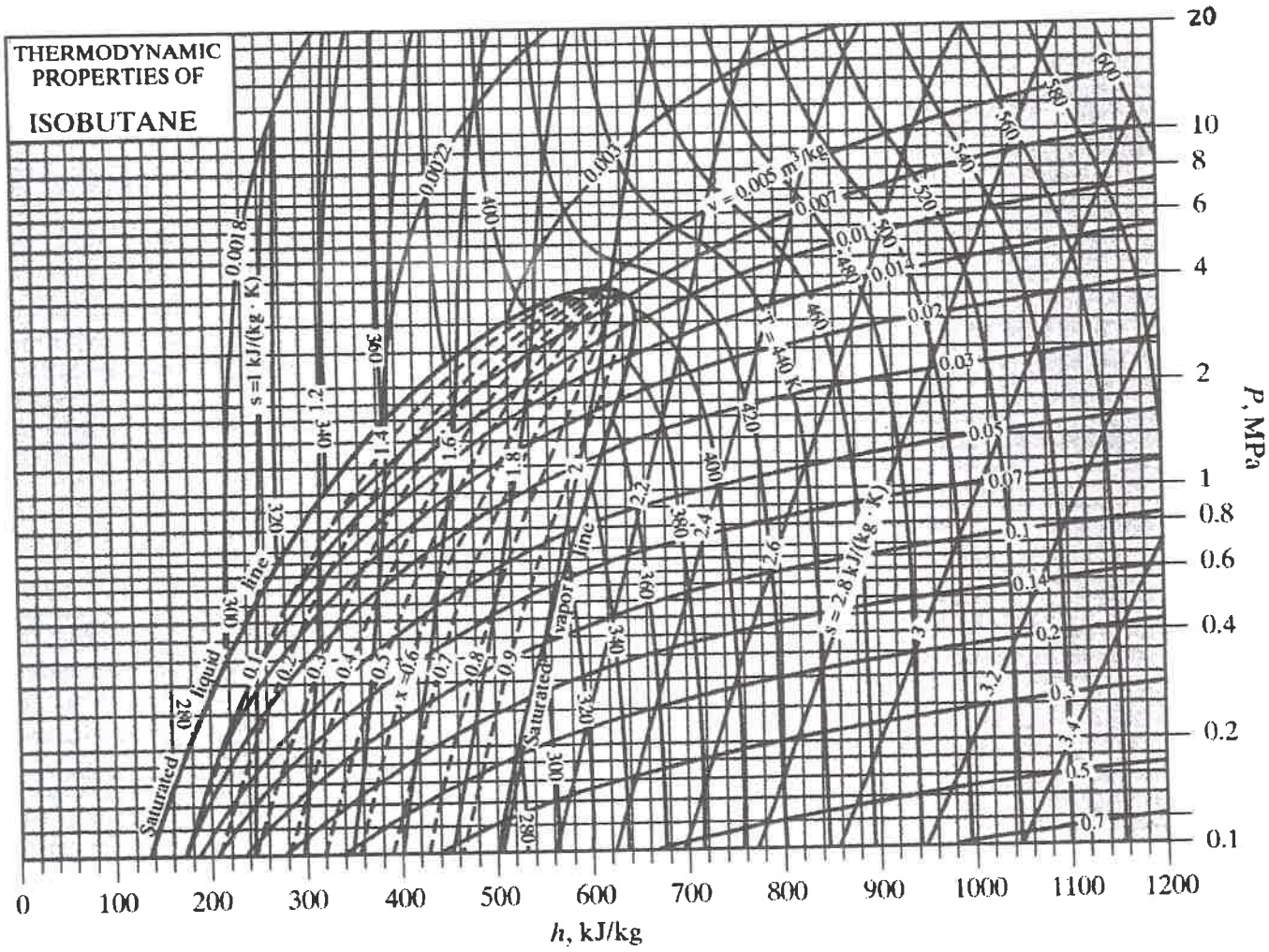

Figure 2. The P-H diagram for isobutane.

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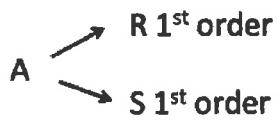
4. **(20%)**

(1) (10%) Substance A in a liquid reacts to produce R and S as follows:



A feed ($C_{A_0} = 1, C_{R_0} = C_{S_0} = 0$) enters in two mixed flow reactors in series ($\tau_1 = 2min; \tau_2 = 5min$). Knowing the composition in the first reactor ($C_{A1} = 0.40, C_{R1} = 0.40\ and\ C_{S1} = 0.2$), **find the composition leaving the second reactor.**

(2) (10%) The **desired** liquid phase reaction:

$$A + B \rightarrow R + T \quad \frac{dC_R}{dt} = \frac{dC_T}{dt} = k_1 C_A^{1.5} C_B^{0.30}$$

is accompanied by the **undesired** side reaction

$$A + B \rightarrow S + U \quad \frac{dC_S}{dt} = \frac{dC_U}{dt} = k_2 C_A^{0.50} C_B^{1.8}$$

What types of reactors would you use to carry above reactions minimize the concentration of undesired products?

5. **(15%)** The first-order irreversible exothermic liquid-phase reaction

$$A \rightarrow B$$

is to be carried out in a jacketed CSTR. Species A and an inert I are fed to the reactor in equilmolar amounts. The molar feed rate of A is 80 mol/min.

(a) (3%) What is **the reactor temperature** for a feed temperature of 450 K?

(b) (3%) "**Roughly" plot** the reactor temperature as a function of the feed temperature.

(c) (3%) To what **inlet temperature** must the fluid be preheated for the reactor to operate at a high conversion? What are **the corresponding temperature and conversion** of the fluid in the CSTR at this inlet temperature?

(d) (3%) Suppose that the fluid is now heated 5°C above the temperature in part (c) and then cooled 20°C, where it remains. What will be **the conversion**?

(e) (3%) What is **the inlet extinction temperature** for this reaction system?

Data:

Heat capacity of the inert: 30 cal/g mol· °C

Heat capacity of A and B: 20 cal/g mol· °C

UA=8,000 cal/ min· °C

Ambient temperature, $T_a = 300K$

$\tau = 100min$

$\Delta H_{R_x} = -7500 \frac{cal}{min}$

k=6.6×10^{-3} min^{-1} at 350 K

E=40,000 cal/mol· K

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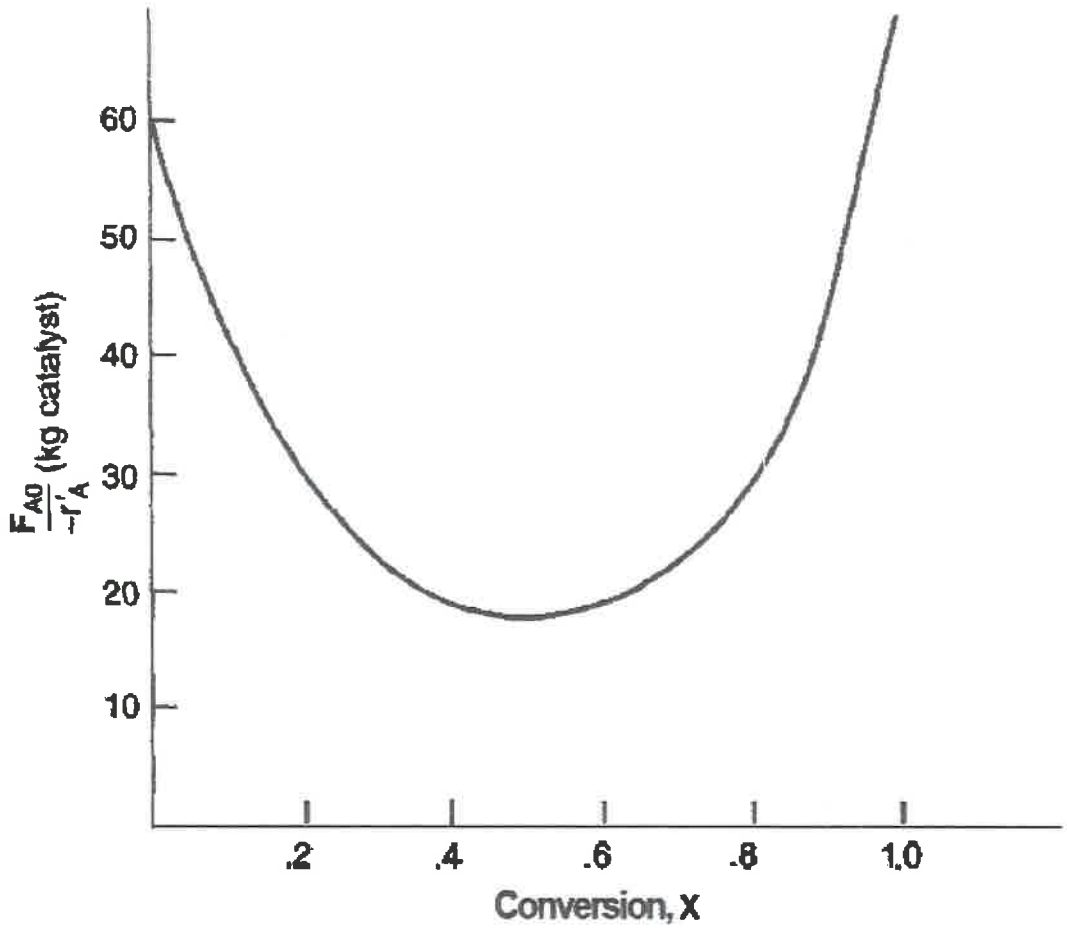
6. **(15%)** The curve shown in the following figure is typical of an exothermic reaction carried out adiabatically. **Please draw and calculate amounts of catalyst from the figure below.**



(a) (3%) Assuming that you have a CSTR and a PBR containing equal weights of catalyst, **how should they be arranged for an isothermal reaction and for adiabatic reaction?** In each case use the, smallest amount of catalyst weight and still achieve 80% conversion.
(b) (3%) What is the catalyst weight necessary to achieve 80% conversion in a well-mixed reactor (e.g., CSTR) with catalyst particles?
(c) (3%) What "CSTR" weight is necessary to achieve 40% conversion?
(d) (3%) What "PBR" weight is necessary to achieve 80% conversion?
(e) (3%) What "PBR" weight is necessary to achieve 40% conversion?

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