

1. Two cylinders A and B, each with a volume of  $0.01 \text{ m}^3$ , are connected and are immersed in a water bath so that their contents are always at  $300 \text{ K}$ . Initially, cylinder A contains an ideal gas at a pressure of  $5 \text{ bar}$  and the other is evacuated. A valve is opened and the pressures are allowed to equalize. For this change please calculate:

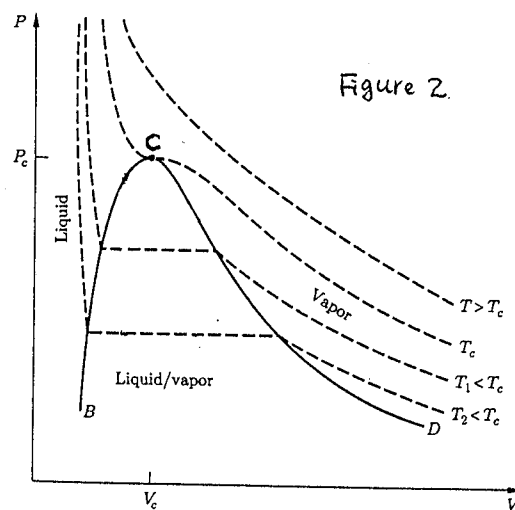
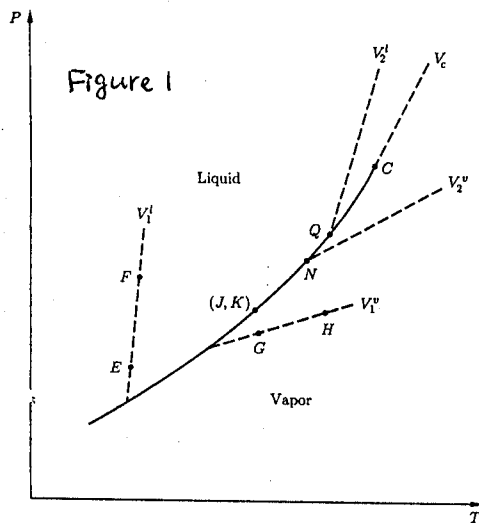
- (a) the total heat exchange between the bath and the cylinders resulting from this change; (4%)
- (b) the heat exchange between cylinder A and the bath. (7%)

2. Which two figures are often used to describe the PVT behavior of a pure substance? (4%) and Why? (3%)

如果有封閉的試管，裡面盛裝了不同高度的液體，如下列三種狀況所述：

- (i) 液面接近試管頂部，
- (ii) 所裝液體量少，液面低，
- (iii) 所裝液體量使得液面在試管的中央位置。

當試管予以加熱，則請由 Figure 1 中分別列出上述三種狀況可能之完整途徑(請用圖中之英文符號標示行經之途徑)。(9%) 再者，請由 Figure 2 清楚地畫出與上述答案對等的途徑。(6%) [Note] You are suggested to draw the pathways as clearly as possible! 並請將 Figure 2 與答案有關的部份畫在答案卷上，再將答案直接畫在上面。



3. [a] What is the definition of a Mollier diagram? Show that the isobars on a Mollier diagram must have the same slope for a given temperature. (5%)

[b] Express  $dH$  and  $dS$  in terms of  $P$ ,  $T$ ,  $V$  and  $C_p$ . (Note:  $P$ ,  $T$  and  $V$  can be in differential forms) (14%)

4. Consideration is being given to the use of a steady-flow expander (or gas turbine) powered by a stream of hot compressed gases. It is required that the gases should discharge from the turbine at atmospheric pressure and 80 °F. It is also required that the turbine produce 1,250 hp for a flow rate of 50 lbmol/min of gas. Estimate the initial temperature and pressure required for the gas stream. For the purpose of an estimate, assume that the turbine will operate isentropically and that the gases are ideal with  $C_p$  constant at 10.5 Btu/(lbmol °F). [1 hp = 42.4 Btu/min; ideal gas constant  $R = 1.987$  Btu/(lbmol °R)] (16%)

5. The enthalpy of a binary liquid system of species 1 and 2 at fixed  $T$  and  $P$  is represented by the equation

$$H = 200x_1 + 300x_2 + x_1x_2(20x_1 + 10x_2)$$

where  $H$  is in  $J mol^{-1}$ . (1) Write the expression for the excess enthalpy of this binary liquid system ( $H^E$ ) as a function of  $x_1$  and  $x_2$ . (2) Derive the expressions for the partial properties  $\bar{H}_1^E$  and  $\bar{H}_2^E$  as functions of  $x_1$ , and determine their values in a mixture containing 25 mol% of species 1 at the given conditions.

(20%)

6. Show that

$$M^E = M^R - \sum_i x_i M_i^R \quad \text{and} \quad \bar{M}_i^E = \bar{M}_i^R - M_i^R$$

where  $M^E$  and  $M^R$  denote the excess property and residual property, respectively,  $M_i^R$  is the residual property for pure species  $i$ ,  $\bar{M}_i^E$  and  $\bar{M}_i^R$  are the partial molar properties, and  $x_i$  is the mole fraction.

(12%)