＊＊＊＊監試與應試考生請注意：

(a)可以攜帶計算機與直尺等繪圖工具作答。

(b)第四題需要手繪 3 成分相圖(可以用鉛筆)。本題評分並不要求答案精確，即使沒用直尺畫圖，只要解法正確（但必須於圖上標示清楚）亦可以給分。

1. At steady state the temperature profiles in a laminated system appear thus: Which material has the higher thermal conductivity? Explain why?　(10 points)
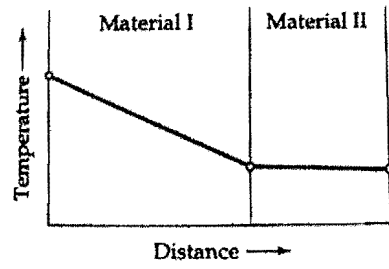
2. The depth in the soil of the earth at which freezing temperatures penetrate is often of importance in agriculture and construction. On a certain fall day, the temperature in the earth is constant at 15.6 °C to a depth of several meters. A cold wave suddenly reduces the air temperature from 15.6 to -17.8 °C. The convective coefficient above the soil is 11.36 W/m^2 • K. The soil properties can be assumed as $\alpha = 4.65 * 10^{-7}$ m^2/s and $k = 0.865$ W/m•K.　(30 points)

(a) What is the surface temperature after 5 hours ?

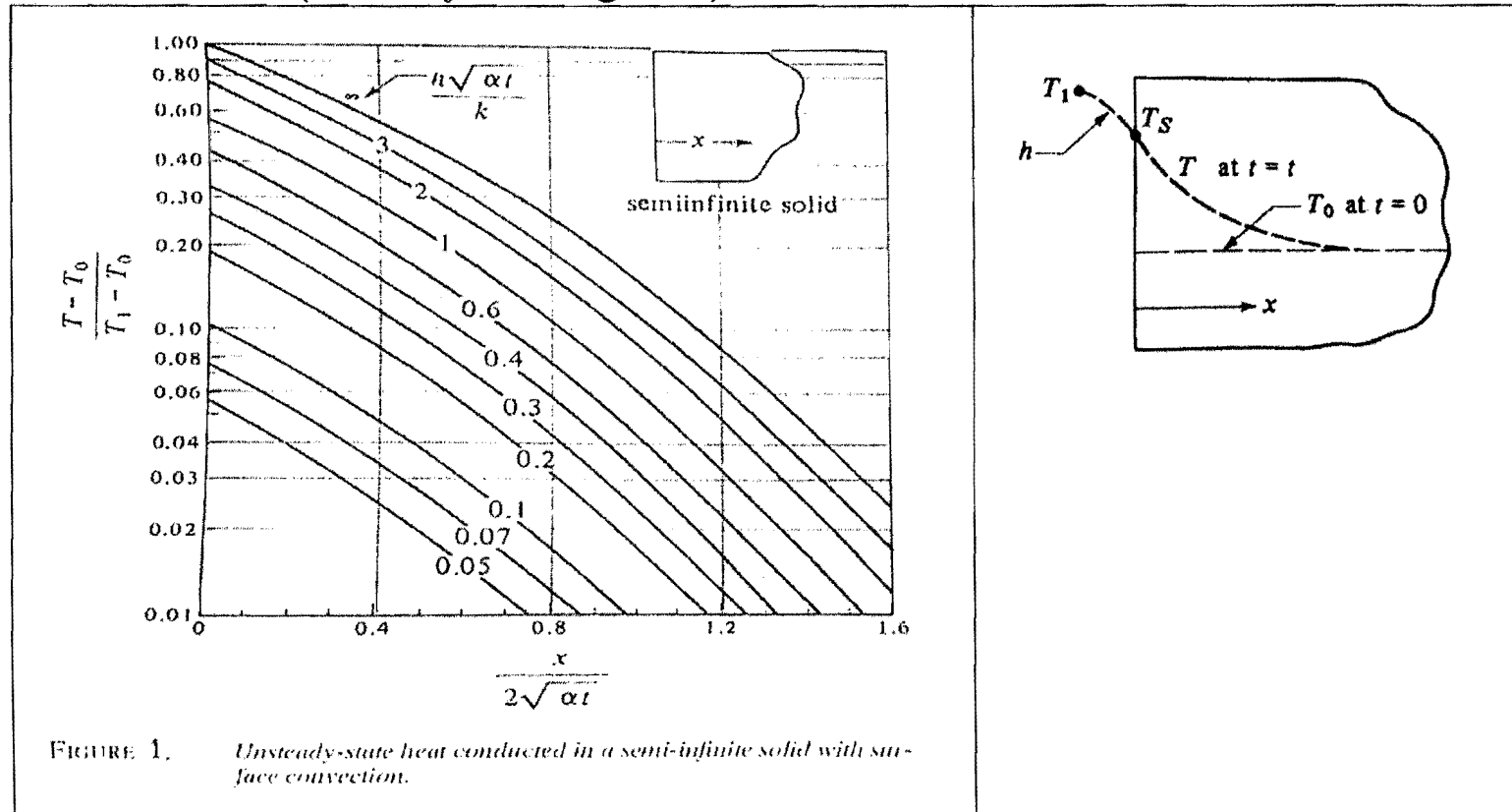(b) To what depth in the soil will the freezing temperature of 0 °C penetrate in 5 hours ?　(*Hint: refer to* Figure 1)

FIGURE 1.　*Unsteady-state heat conducted in a semi-infinite solid with surface convection.*

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背面尚有試題

3. (a) Derive the following equation for a laminar Newtonian flow in a circular pipe:

$$v_{x\,av} = \frac{(p_0 - p_L)R^2}{8\mu L} = \frac{(p_0 - p_L)D^2}{32\mu L}$$

(*Hint: make a shell momentum balance inside a pipe*) (20 points)

(b) A small capillary with an inside diameter of 2.22×10^{-3} m and a length 0.317 m is being used to continuously measure the flow rate of a liquid having a density of 875 kg/m^3 and μ(viscosity) = 1.13×10^{-3} Pa·s. The pressure-drop reading across the capillary during flow is 0.0655 m water (density 996 kg/m^3). What is the flow rate in m^3/s if end-effect corrections are neglected? (10 points)
(Given: Pa = N/m^2, N = kg·m/s^2, g = 9.8 m/s^2)

4. A single-stage extraction is performed in which 400 kg of a solution containing 35 wt % acetic acid in water is contacted with 400 kg of pure isopropyl ether.
   (a) Calculate the amounts and compositions of the extract and raffinate layers.
   (b) What percent of the acetic acid is removed? (30 points)
   (*Hint: use the following equilibrium data*)

A.3-24   **Acetic Acid–Water–Isopropyl Ether System, Liquid–Liquid Equilibria at 293 K or 20°C**

Water Layer (wt %)			Isopropyl Ether Layer (wt %)		
Acetic Acid	Water	Isopropyl Ether	Acetic Acid	Water	Isopropyl Ether
0	98.8	1.2	0	0.6	99.4
0.69	98.1	1.2	0.18	0.5	99.3
1.41	97.1	1.5	0.37	0.7	98.9
2.89	95.5	1.6	0.79	0.8	98.4
6.42	91.7	1.9	1.93	1.0	97.1
13.30	84.4	2.3	4.82	1.9	93.3
25.50	71.1	3.4	11.40	3.9	84.7
36.70	58.9	4.4	21.60	6.9	71.5
44.30	45.1	10.6	31.10	10.8	58.1
46.40	37.1	16.5	36.20	15.1	48.7

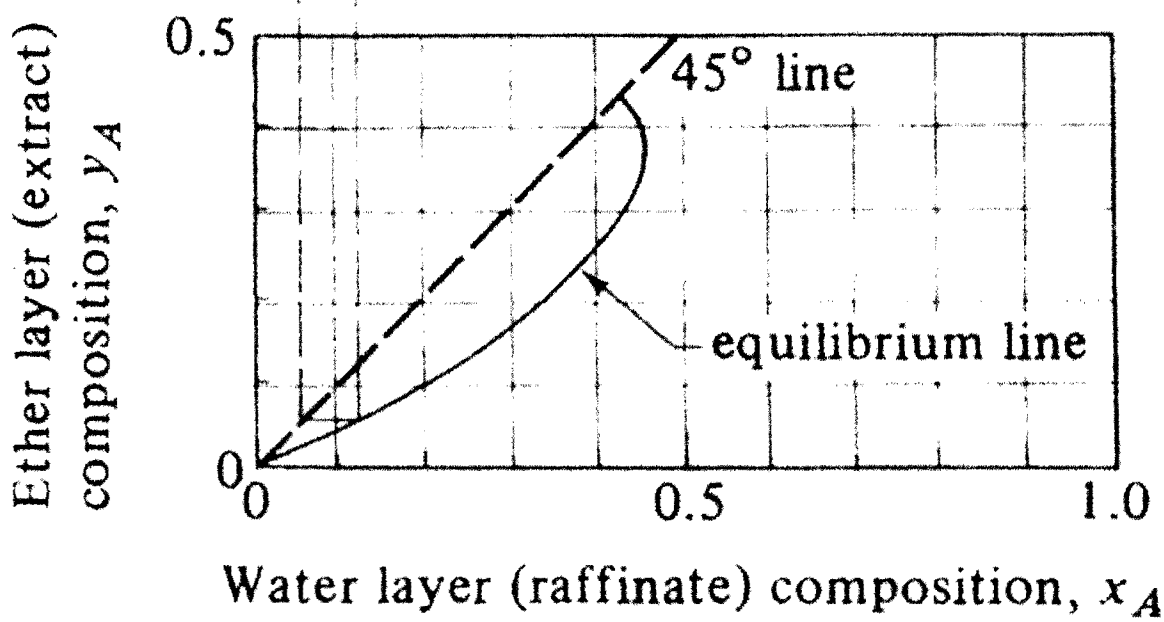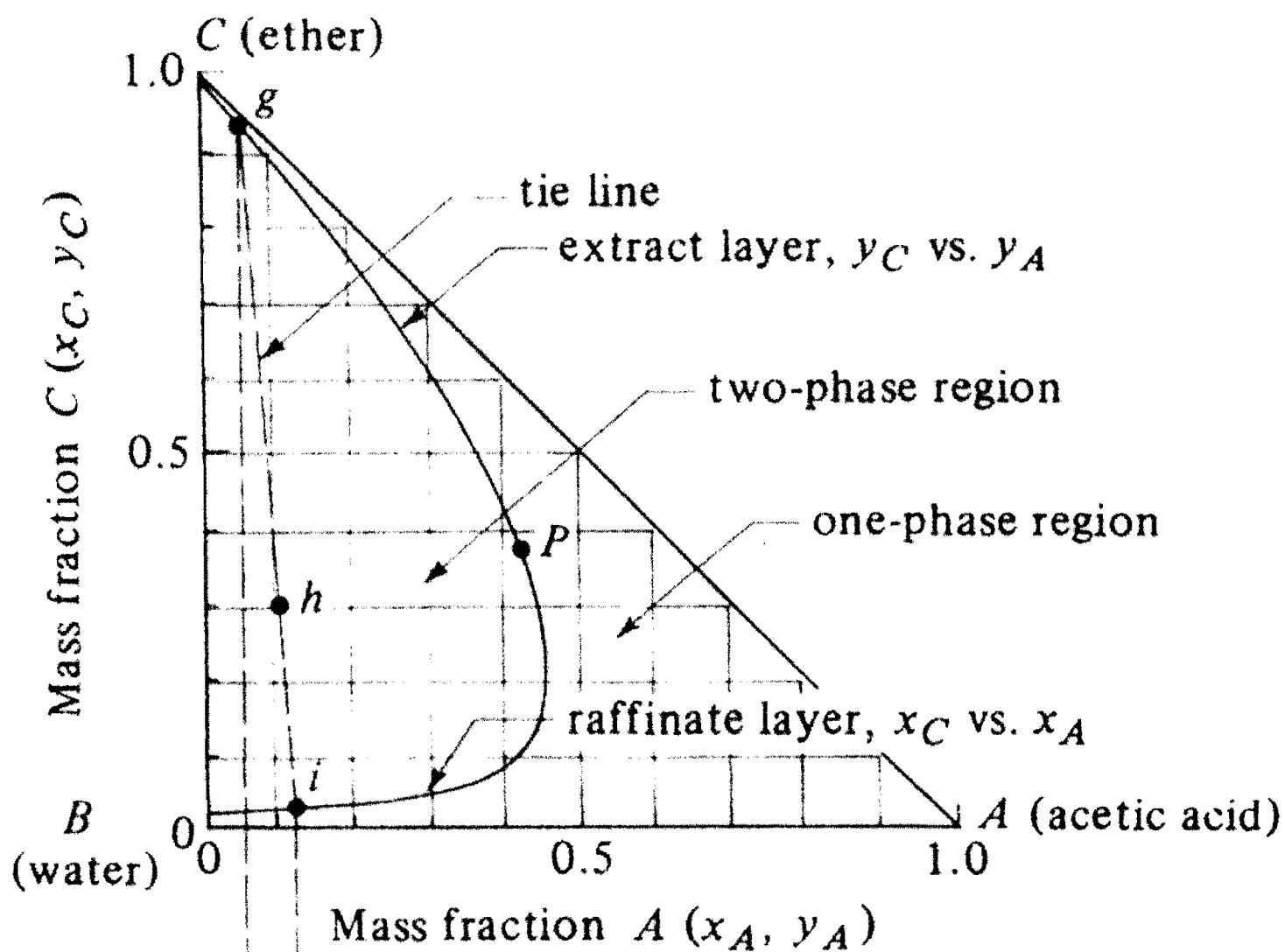*Source: Trans. A.I.Ch.E., 36, 601, 628 (1940). With permission.*

FIGURE 12.5-3.　Acetic acid (A)–water (B)–isopropyl ether (C) liquid–liquid phase diagram at 293 K (20°C).

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