Table 2–6 (*continued*)

B. With Maximum Boiling Point		
Component, %	*Boiling Point of Pure Component, °C*	*Maximum Boiling Point, °C*
31.3 Acetic acid	118.1	162
68.7 Triethylamine	89.4	
77 Formic acid	101	107.1
23 Water	100	
42 Phenol	181.5	186.2
58 Aniline	184.4	

QUESTIONS AND PROBLEMS

2–1. The "observed" melting point of some impure camphor is 170.0°C. The thermometer is immersed in the melting point bath (See Figure 2–3) to the 120° mark. A second thermometer shows that the average temperature of the exposed stem is 120°C. What is the corrected melting point of the impure camphor? The melting point of pure camphor is 178.9°C. What is the molality of the impurity? The impurity is known to be naphthalene. Calculate the percentage by weight of naphthalene in the impure camphor. *Ans.* 170.4°C, 0.224 m, 2.78% w/w

2–2. Plot the stem correction as a function of observed reading for a thermometer which is always immersed to the − 10° mark, assuming that the average temperature of the exposed stem is 30°C.

2–3. Calculate the expected freezing point of an aqueous solution containing 10 g of glycerol in 50 g of water. *Ans.* − 4.0°C

2–4. A 7.50-g sample of a paraffin hydrocarbon was dissolved in 50.0 g of benzene. The freezing point of the solution was 0.0°C. Identify the hydrocarbon. *Ans.* $C_{10}H_{22}$

2–5. If you were to choose a solvent for the determination of molecular weight by the freezing point depression, which solvent (from those in Table 2–3) would you select for maximum accuracy? Why?

2–6. Describe the composition of the system containing an intimate mixture of 2 moles of naphthalene and 2 moles of camphor as it is heated from 0° to 200°C.

2–7. A 1.00-g sample of a polymer with the general formula $(CH_2)_n$ dissolved in 7.5 g of benzene depressed the freezing point of benzene by 0.50°. What is the value of n? *Ans.* 98

2–8. Draw the temperature–composition curve for mixtures of cinnamic acid (m.p. 136.8°C) and benzoic acid (m.p. 121.5°C). The melting point of the eutectic mixture containing 57 mole % benzoic acid is 82°C. There are no solid solutions. Predict the shape of the cooling curve (temperature vs. time) for:
(a) Pure benzoic acid.
(b) A mixture containing 20% cinnamic acid.
(c) A mixture containing 20% benzoic acid.
(d) The eutectic mixture.

2–9. The vapor pressure of ether is 442 torr at 20°C, 647 torr at 30°C, 760 torr at 34.6°C. What is its heat of vaporization? If the pressures are expressed in atmospheres, the value of R is 1.987 cal mole^{-1} deg^{-1}. *Ans.* 7000 cal/mole

2–10. The heat of vaporization of water at its normal boiling point is 9718 cal mole^{-1}. What is its vapor pressure at 75°C? *Ans.* 299 torr

2–11. What is the vapor pressure of a benzene-toluene solution at 30°C? State the answer in the form of an equation involving mole fraction of benzene, and the two vapor pressures of the pure compounds—118 torr for benzene and 36 torr for toluene, both at 30°C. Assume Raoult's law is valid for this system.

2–12. From the data in Problem 2–11, calculate the mole fraction of benzene in the vapor which is in equilibrium with an equi-molar solution of benzene and toluene at 30°C. *Ans.* 0.765

2–13. The vapor pressure of *n*-octane at 100°C is 351 torr, while that of *iso*-octane is 777 torr. If a fuel contains 90 mole % *iso*-octane and 10 mole % *n*-octane what is its vapor pressure at 100°C? What is the composition of the vapor in equilibrium with the liquid at 100°C? What additional information is needed in order to compute the boiling point of this fuel? *Ans.* 734 torr, $Y_{iso} = 0.952$

2–14. The vapor pressures of some paraffins are given in Table 2–1.

(a) What is the vapor pressure of a 1:1:1 (by moles) mixture of *n*-pentane, *n*-heptane, and *n*-octane at 30°C? *Ans.* 229 torr

(b) What is the vapor pressure of a 1:1:1 (by weight) mixture of *n*-pentane, *n*-heptane, and *n*-octane at 30°C? *Ans.* 282 torr

(c) What mixture of *n*-pentane and *n*-heptane boils at 90°C under atmospheric pressure? *Ans.* 5.9 mole % pentane

(d) *n*-Heptane boils at 98°C. What would be the composition of a mixture of *n*-pentane and *n*-octane which boils at the same temperature? How could you distinguish between these two liquids (heptane and the pentane–octane mixture) which have the same boiling point by distillation alone?

(e) What is the composition of a mixture of *n*-hexane and *n*-heptane which boils at 80°C? *Ans.* $X_{hex} = 0.535$

(f) What is the composition of the vapor over a mixture of *n*-hexane and *n*-heptane (mole fraction = 0.5) at 100°? *Ans.* $Y_{hex} = 0.70$

(g) Does the composition of the vapor calculated in (f) depend on temperature?

2–15. A liquid mixture of 3 moles of *A* and 2 moles of *B* boils freely at 100°C when atmospheric pressure is 760 torr. Calculate the vapor pressure of pure *A* if the vapor pressure of pure *B* is 400 torr (all at 100°C). *Ans.* 1000 torr

2–16. Calculate the total pressure of the system and the mole fraction of *A* in the vapor of a mixture of *A* and *B* ($X_A = 0.3$) at a temperature where the vapor pressure of pure *A* is 700 torr and that of pure *B* is 300 torr. *Ans.* 420 torr, 0.5

2–17. Why should the reflux ratio be increased when the number of plates in the column is increased?

2–18. Why is the effective number of plates in a bubble-cap column less than the actual number?

2–19. How would you expect *H* to vary with the reflux ratio?

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