

Example 10.2 Adiabatic flash (Continued)

Because a computer is used, we skip preliminary bubble and dew calculations. Note that we do not tabulate all values until $0 \leq V/F \leq 1$. The first guess of 45°C is above the dew temperature. The second guess of 35°C is below the bubble temperature. The next guess happens to give a condition close to the bubble temperature, so we raise the temperature guess slightly. The column $OBJEB = (\text{Eqn. 10.19})/1000$. The compositions and enthalpies are shown below and the last row is converged. The exiting flow rates are $V = V/F(43) = 0.09(43) = 3.87$ mol/min, and $L = 43 - 3.87 = 39.13$ mol/min. About 9% (molar basis) of the inlet is flashed, and the outlet temperature is 40.2°C compared to an inlet of 70°C.

| $T^{out}(C)$ | V/F | OBJEB | x_{EtOH} | y_{EtOH} | $H^F(\text{J/mol})$ | $H^L(\text{J/mol})$ | $H^V(\text{J/mol})$ |
|--------------|-------|--------|------------|------------|---------------------|---------------------|---------------------|
| 45 | 2.98 | | | | | | |
| 35 | -9.32 | | | | | | |
| 40 | 0.001 | 3.137 | 0.50 | 0.33 | 4672 | 1481 | 39,149 |
| 41 | 0.43 | -13.30 | 0.57 | 0.40 | 4672 | 1618 | 39,539 |
| 40.2 | 0.09 | -0.22 | 0.515 | 0.349 | 4672 | 1508 | 39,225 |

Solution 2. This solution method calculates component enthalpies using the pathway of Fig. 2.6(c), the reference state of the elements at 25°C, the heats of formation of ideal gases, the generalized correlation for heat of vaporization in Eqn. 2.45, and the $Cp^{ig}(25^\circ\text{C})$ from the back flap. The results are slightly different from Solution 1, owing to the imprecision of Eqn. 2.45 and differences between the heat capacities. Process simulation software typically uses this enthalpy path and reference state.

We begin by finding the enthalpy of the feed relative to the elements at 25°C, noting that it is a liquid ideal solution. $H^F = H^L(70^\circ\text{C}) = \sum x_i(\Delta H_{f,i}^\circ + Cp^{ig}(T - T_R) - \Delta H_i^{vap}) = 0.5(-200,940 + 5.28(8.314)(70 - 25) - 35,976) + 0.5(-234,950 + 7.88(8.314)(70 - 25) - 38,595) = -252,769$ J/mol. This takes care of the first term in Eqn. 10.19. Noting that the feed is liquid, we might suspect the flash outlet to be mostly liquid. Performing a bubble-temperature calculation at 200 mmHg gives $T = 40.00^\circ\text{C}$ and $H^L(40^\circ\text{C}) = -256,901$ and with no vapor stream results in $Q = -4132$ J/mol.^a The temperature must be slightly higher to move Q toward zero. Suppose we “guessed” that the temperature is 40.23°C.^b Then the flash calculation gives $x_{EtOH} = 0.5173$, $y_{EtOH} = 0.3515$, $V/F = 0.1042$, $H^L(40.23^\circ\text{C}) = -257,502$. The formula for H^V is similar to that for H^L but omits the ΔH_i^{vap} contribution and replaces x_i with y_i , so $H^V(40.23^\circ\text{C}) = -212,088$. Following Eqn. 10.19, $Q = (1 - 0.1042)(-257,502) + 0.1042(-212,088) + 252,769 = 0.1$ J/mol. We may assume that 0.1 J/mol is sufficiently close to zero.

a. Note that the heats of vaporization must be recomputed at the new temperature.

b. Obviously, this was not our first guess. Alternatively, you could call the solver with the added constraint that $Q = 0$ while $\sum D_i = 0$ by changing T and V/F simultaneously.

10.5 EMISSIONS AND SAFETY

Hydrocarbon emission monitoring is an important aspect of environmentally conscious chemical manufacturing and processing. The United States Environmental Protection Agency (EPA) has