Exercise Problem 1

An aqueous solution of acetic acid is produced at 100 mol/min and contains 1.8 mole% acetic acid. We need to purify acetic acid so that only 0.2% of acetic acid is left in the aqueous solution. We decided to use liquid-liquid extraction (countercurrent mode), using 100% pure 1-butanol as a solvent, available at 80 mol/min. 1-butanol/water can be considered immiscible. Calculate the number of stages required by the graphical method. Calculate the concentration of acetic acid in 1-butanol in the extract at the exit.

$$k_D = 1.6$$

$$y = \frac{R}{E}x + \left(y_{N+1} - \frac{R}{E}x_N\right)$$

R = 100

E = 80

$$\frac{R}{E} = \frac{100}{80} = 1.25$$

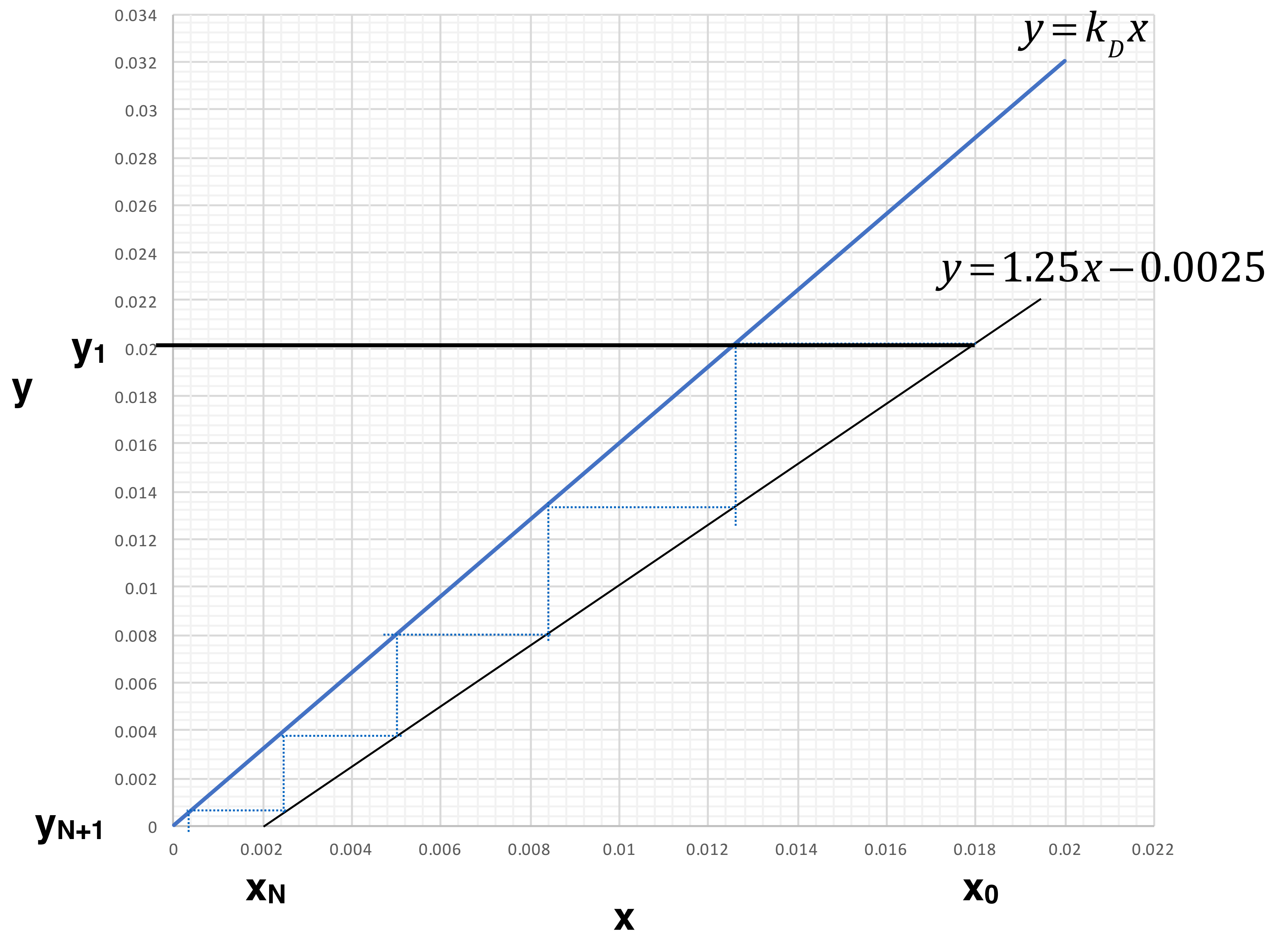
$$x_N = 0.002 \qquad y_{N+1} = 0$$

$$x_0 = 0.018$$

$$N = 5$$

$$y_1 = 0.02$$

The concentration of acetic acid in 1-butanol in the extract at the exit = 2%



Exercise problem 2: Minimum solvent flow rate

An aqueous solution of acetic acid is produced at 100 mol/min and contains 1.8 mole% acetic acid. We need to purify acetic acid so that only 0.2% of acetic acid is left in the aqueous solution. We decided to use liquid-liquid extraction (countercurrent mode), using 100% pure 1-butanol as a solvent. 1-butanol/water can be considered immiscible.

Calculate the minimum possible flow rate of 1-butanol.

$$y_{j+1} = \frac{R}{E}x_j + \left(y_{N+1} - \frac{R}{E}x_N \right)$$

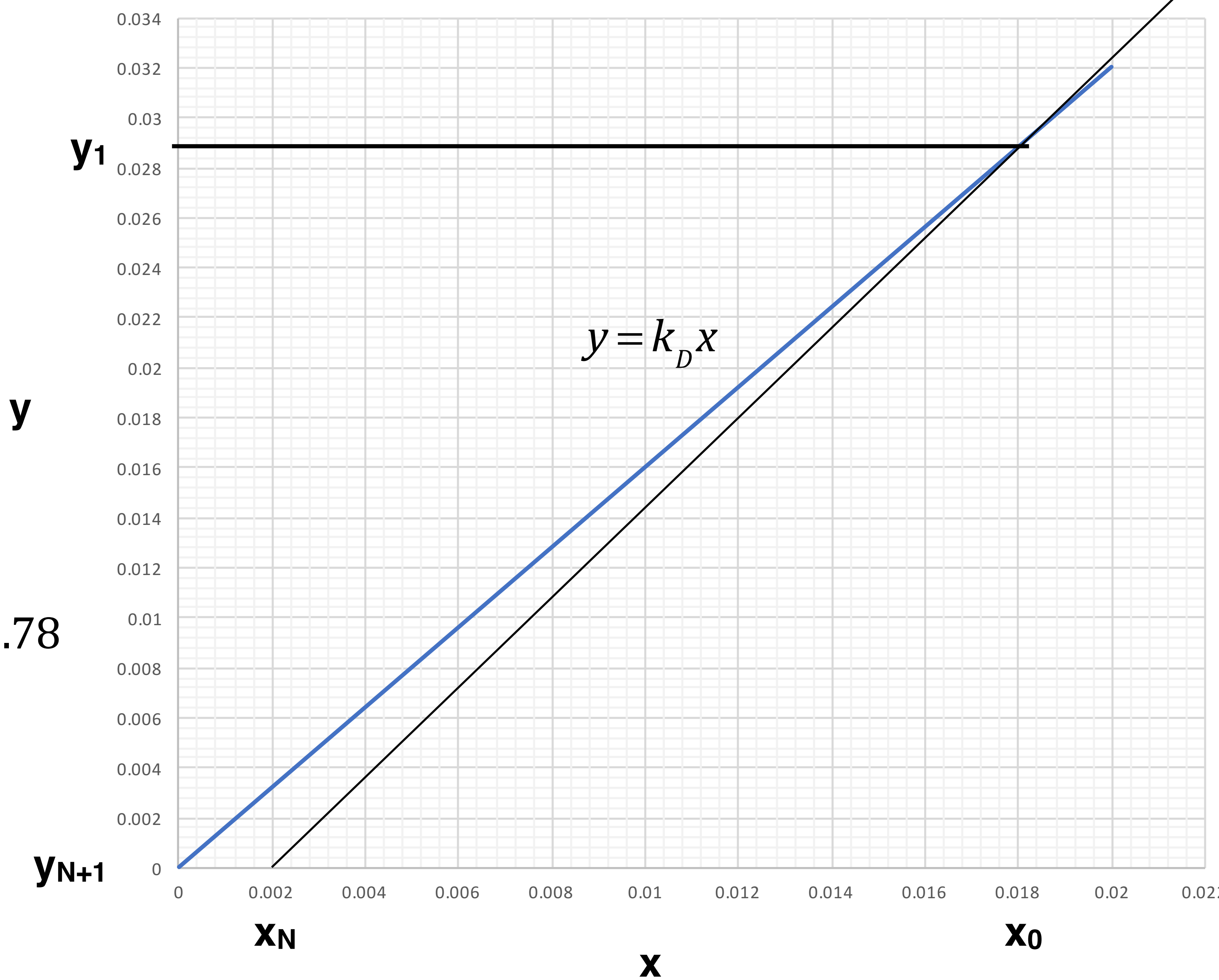
$$k_D = 1.6$$

$$y = \frac{R}{E}x + (y_{N+1} - \frac{R}{E}x_N)$$

$$y_1 = 0.0284$$

$$\left(\frac{R}{E}\right)_{\max} = slope = \frac{(0.0284 - 0)}{(0.018 - 0.002)} = 1.78$$

$$E_{\min} = \frac{100}{1.78} = 56.2$$



Exercise problem 3

An aqueous solution of acetic acid is produced at 100 mol/min and contains 1.8 mole% acetic acid. We need to purify acetic acid so that only 0.2% of acetic acid is left in the aqueous solution. We decided to use liquid-liquid extraction (**cross-flow mode**), using **100% pure 1-butanol** as a solvent, available at **100 mol/min**. 1-butanol/water can be considered immiscible.

Calculate the number of stages required by the graphical method.
What is the total solvent flow rate that is needed?

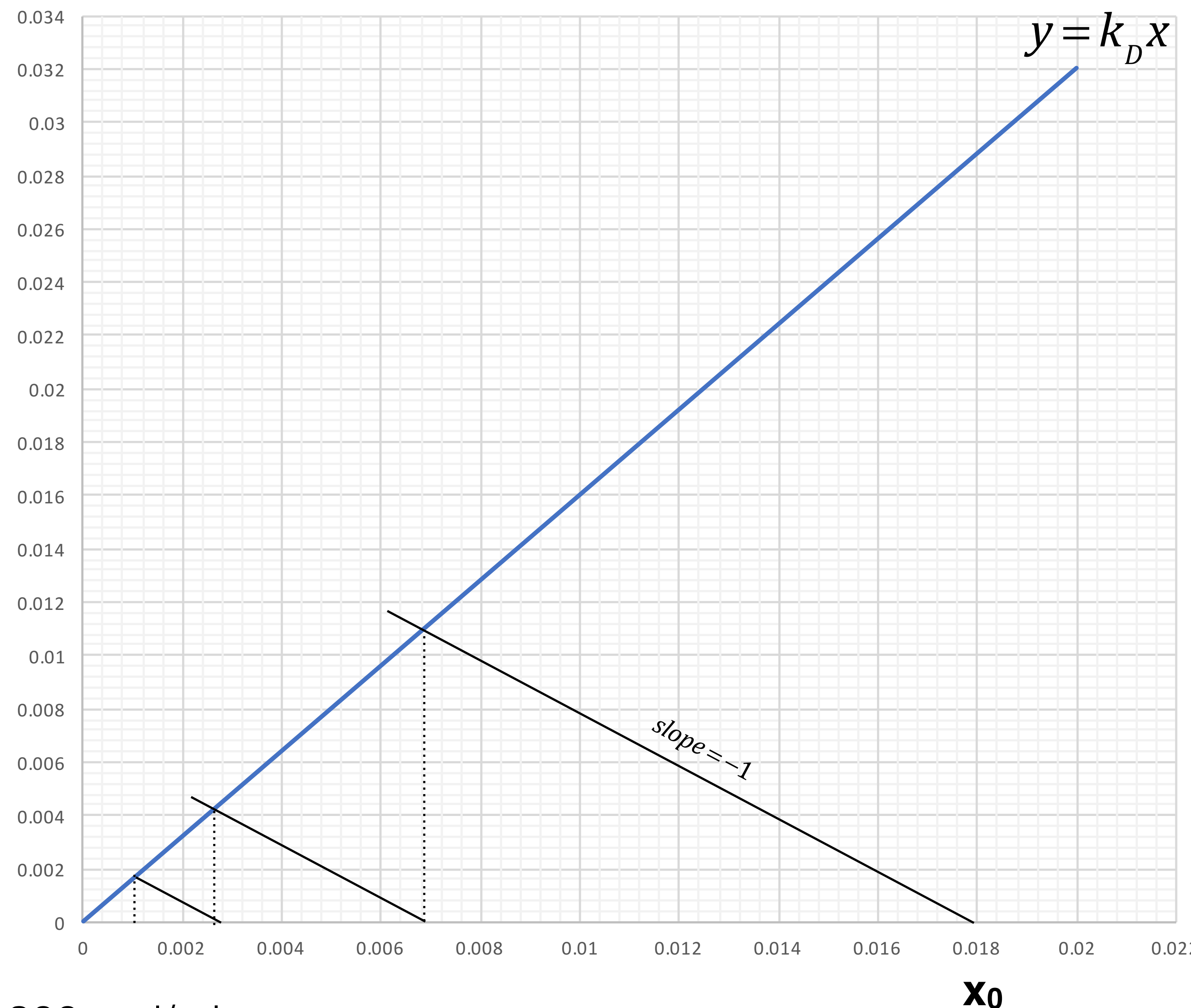
$$k_D = 1.6$$

$$\frac{R}{E_j} = \frac{100}{100} = 1$$

$$y_j = -\frac{R}{E_j} x_j + \left(\frac{R}{E_j} x_{j-1} + y_{j,in} \right)$$

$$y_{j,in} = 0$$

$$N = 3$$



Total solvent flow rate needed = 3*100 = 300 mol/min