

Exercise problem: calculate breakthrough time

An adsorption process is designed to remove traces of xylene (0.1 mole/m³) from nitrogen gas using a 1.2 meter long silica column bed at 1.0 atm and 0°C. Nitrogen does not absorb at all. Calculate the breakthrough time using following data:

$$\rho_{adsorbent} = 2100 \text{ kg_adsorbent/m}^3$$

$$\varepsilon_e = 0.43$$

$$q = 0.2 * c$$

q is in mole_solute/kg_adsorbent

c is in mole_solute/m³

$$\varepsilon_p = 0.48$$

$$K_d = 1.0$$

$$A_c = 0.1 \text{ m}^2$$

$$V_{inter} = \frac{Q}{\varepsilon_e A_c}$$

$$Q = 0.008 \text{ m}^3/\text{minute}$$

$$u_s = \frac{V_{inter}}{1 + \left(\frac{1-\varepsilon_e}{\varepsilon_e}\right) * (K_d \varepsilon_p) + \left(\frac{1-\varepsilon_e}{\varepsilon_e}\right) * (1-\varepsilon_p) * \rho \left(\frac{\Delta q}{\Delta c}\right)}$$

Unit of q
mol solute/kg adsorbent

Unit of c
mol solute/m³

$$Breakthrough \ time = t_{saturation} - t_{in} = \frac{L}{u_s}$$