Problem 16-07 Gas adsorption on solids – Differential (isosteric) adsorption enthalpy

Adsorption of the gaseous pentane on a solid adsorbent was studied at several temperatures, always at the same adsorbed amount. At the temperature of 45.6 °C and equilibrium pressure of 39 Pa was found that 2.64 g of the gaseous hydrocarbon was adsorbed on 11 g of the solid adsorbent. At the temperature of 86 °C the same surface occupancy was achieved at equilibrium pressure of 0.16 kPa. Calculate

(a) differential adsorption enthalpy at this surface occupancy,

(b) equilibrium pressure corresponding to this surface occupancy at the temperature of 118°C

[$Q_{dif}(a) = -33.256$ kJ mol^{-1}, $p = 398$ Pa]

Solution:

$t_1 = 45.6$°C $\quad t_2 = 86$°C $\quad t_3 = 118$°C

$p_1 = 39$ Pa $\quad p_2 = 0.16$ kPa $\quad p_3 = ?$

$m_s = 11$ g

$m_{pentane} = 2.6$ g $\quad a_1 = a_2 = a_3 = 2.64/11 = 0.24\ g_{pentane}/g_s$

Adsorption isostere: $\left(\frac{\partial \ln p}{\partial T}\right)_a = -\frac{Q_{dif}(a)}{\boldsymbol{R}T^2}$

$$Q_{dif}(a) = \frac{\boldsymbol{R}\cdot\ln\frac{p_2}{p_1}}{\frac{1}{T_2}-\frac{1}{T_1}} = \frac{8.314\cdot\ln\frac{0.16\cdot10^3}{39}}{\frac{1}{(86+273.15)}-\frac{1}{(45.6+273.15)}} = -33256\ \text{J mol}^{-1}$$

$$\ln\frac{p_3}{p_1} = \frac{Q_{dif}(a)}{R}\left(\frac{1}{T_3}-\frac{1}{T_1}\right) = \frac{-33256}{8.314}\left(\frac{1}{(118+273.15)}-\frac{1}{(45.6+273.15)}\right) = 2.322764$$

$$p_3 = p_1\cdot e^{2.322764} = 39\cdot10.20384 = 397.95\ \text{Pa}$$