23.1

$$M_H = \sqrt{\frac{\mathscr{D} k C_B}{k_{Al}^2}} = \sqrt{\frac{10^{-6}(10)(10^2)}{1^2}} = 3.16\times10^{-2} \qquad \therefore E = 1$$

$$-r_A'''' = \frac{p_A}{\frac{1}{k_{Ag}a} + \frac{H_A}{k_{Al}a.E} + \frac{H_A}{kC_Bf_l}} = \frac{10^2}{\frac{1}{0.1} + \underbrace{\frac{10^5}{10^2(1)}}_{50\%} + \underbrace{\frac{10^5}{10(10^2)0.1}}_{50\%}} = 0.05 \frac{\text{mol}}{\text{hr}\cdot\text{m}^3\text{reac.}}$$

(a) Reaction rate = 0.05 mol / hr. m^3 reactor ← a)

(b) Resistance: 50% liquid film, 50% main body
Reaction zone: main body of liquid
Behavior in liquid film: physical transport } ← b)

23.3

$$M_H = \sqrt{\frac{\mathscr{D} k C_B}{k_{Al}}} = \sqrt{\frac{10^{-6}(10)(10^2)}{1}} = 3.16\times10^{-2} \qquad \therefore E = 1$$

$$-r_A'''' = \frac{p_A}{\frac{1}{k_{Ag}a} + \frac{H_A}{k_{Al}a\,E} + \frac{H_A}{kC_Bf_l}} = \frac{10^2}{\underbrace{\frac{1}{0.1}}_{33\%} + \underbrace{\frac{10^3}{10^2(1)}}_{33\%} + \underbrace{\frac{10^3}{10(10^2)(10^{-1})}}_{33\%}} = 3.33$$

(a) Reaction rate = 3.33 $\frac{\text{mol}}{\text{hr}\cdot\text{m}^3\text{ reactor}}$ ← a)

(b) Resistance: 1/3 in gas film, 1/3 in liquid film, 1/3 in main body
Location of reaction zone: main body of liquid
Behavior in liquid film: physical transport } ← b)

23.5

$$M_H = \sqrt{\frac{\mathscr{D} k C_B}{k_{Al}}} = \sqrt{\frac{10^{-6}(10^{-2})10^2}{1}} = 10^{-3} \quad \cdots \quad \therefore E = 1$$

$$-r_A''' = \frac{p_A}{\frac{1}{k_{Ag}a} + \frac{H_A}{k_{Al}a.E} + \frac{H_A}{kC_Bf_l}} = \frac{10^2}{\underbrace{\frac{1}{0.1}}_{50\%} + \frac{H_A}{10^2(1)} + \underbrace{\frac{H_A}{10^{-2}(10^2)0.1}}_{50\%}} = 5$$

(a) Reaction rate = 5 mol/hr. m^3 reactor ← a)

(b) Resistance: 50% in gas film, 50% in main body
Reaction zone: main body of liquid
Behavior of liquid film: physical transport } ← b)

23.7 Make one change in Example 1

$$c_B = 100 \Longrightarrow c_B = 1$$

First evaluate M_H and E_i and from this find E

$$M_H = \sqrt{\frac{\mathcal{D} k c_B}{k_{Al}}} = \sqrt{\frac{10^{-6}(10^6)1}{1}} = 1$$

$$E_i = 1 + \frac{1(1)10^5}{2(5\times10^3} = 1 + 50 = 51$$

Since $E_i > 5 M_H$ Fig 4 shows that we have a pseudo-1st order reaction in the film and

$$E = M_H = 1$$

Now to the rate expression

$$-r_A'''' = \frac{p_A}{\frac{1}{k_{Ag}a} + \frac{H_A}{k_{Al}aE} + \frac{H_A}{kC_B^2 f_l}} = \frac{3\times10^5}{\frac{1}{0.01} + \frac{10^5}{20(1)} + \frac{10^5}{10^6(1^2)0.98}}$$

$$= \frac{5\times10^3}{100 + 5000 + 0.1} = \frac{5000}{5001} \cong 1 \text{ mol/hr}\cdot\text{m}^3 \text{ of reactor}$$

resistance is in the liquid film.

(a) Main resistance is in liquid film

(b) Reaction zone is in the liquid film

(c) I can't tell

(d) The rate is 1 mol/hr·m³ reactor

23.9 (a) Find $-r_A''''$ with reaction

$$M_H = \sqrt{\frac{\mathscr{D} k C_B}{k_{Al}}} = \infty \quad \cdots \text{ because } k = \infty$$

$$E_i = 1 + \frac{\mathscr{D}_B C_B H_A}{\mathscr{D}_A p_{Ai}} = 1 + 0.64\,\frac{250(10^{-4})}{0.02\ 10^{-3}} = 1 + 800 = 801$$

assume that all the resistance is in the gas phase. We'll see if this is true

$\therefore E = 801$

Next evaluate the rate equation

$$-r_A'''' = \frac{p_A}{\frac{1}{k_{Ag}a} + \frac{H_A}{k_{Al}aE} + \frac{H_A}{kC_B f_l}} = \frac{p_A}{\frac{1}{60} + \frac{10^{-4}}{0.03(801)} + 0} = \frac{0.02}{16.7\times10^{-3} + 4\times10^{-6}}$$

99.97% of the resistance. this verifies our assumption

$-r_A'''' = k_{Ag} a\, p_A = 60(0.02) = 1.2\ \text{mol/m}^3\cdot\text{s}$
Gas film controls

(b) Straight absorption

$$-r_A'''' = \frac{1}{\frac{1}{k_{Ag}a} + \frac{H_A}{k_{Al}a}}(p_A - 0) = \frac{p_A}{\frac{1}{60} + \frac{10^{-4}}{0.03}} = \frac{p_A}{16.67\times10^{-3} + 3.3\times10^{-3}}$$

83% in gas phase

$$= 50\,p_A = 50(0.02) = 1\ \text{mol/m}^3\cdot\text{s}$$

$\therefore$ the rate is raised by 20% by adding MEA