Problem 2: \((8 + 8 + 8 = 24\) points)

**Oppgave 2, a**

Henry’s law: \(q = Kc\) represents a straight line – can be plotted directly

Freundlich isotherm: \(q = Kc^n\) can be transformed to: \(\ln q = \ln K + n \ln c\) hence straight line

Langmuir isotherm: \(q = q_0c/(K + c)\) can be inverted: \((1/q) = (K/q_0)(1/c) + (1/q_0)\)

Where \((K/q_0) = \) angular coefficient and \((1/q_0) = \) interception with the y-axis

**Oppgave 2 b)**

Checking quickly or plotting as above suggested shows that neither Henry’s Law nor Freundlich can be used. We therefore try the Langmuir isotherm:

Data: given:

<table>
<thead>
<tr>
<th>(c) ((g/cm^3))</th>
<th>0.0040</th>
<th>0.0087</th>
<th>0.019</th>
<th>0.027</th>
<th>0.094</th>
<th>0.195</th>
</tr>
</thead>
<tbody>
<tr>
<td>(q) ((solute/) ((g) alumina)</td>
<td>0.026</td>
<td>0.053</td>
<td>0.075</td>
<td>0.082</td>
<td>0.123</td>
<td>0.129</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>(1/c) ((cm^3/g))</th>
<th>250</th>
<th>114.9</th>
<th>52.6</th>
<th>37</th>
<th>10.6</th>
<th>5.1</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1/q)(g alumina/ solute)</td>
<td>38.5</td>
<td>18.9</td>
<td>13.3</td>
<td>12.2</td>
<td>8.1</td>
<td>7.6</td>
</tr>
</tbody>
</table>

The data above can be plotted, and will show a nearly straight line. The answer below are approximate, as the data will not fall exactly on a straight line, but close enough.

**Interception with the axis:** \((1/q_0) = 7 \rightarrow q_0 = 0.143\)

**Angular coefficient:** \((K/q_0) = (18.9 - 8.1)/(114.9 - 10.6) = 0.10355 \rightarrow K = 0.0148\)

Hence the equation for the Langmuir isotherm is: \(q = 0.143c/(0.0148 + c)\)

This answer may vary slightly depending on the accuracy you are using in your plot.

**(Note 1: It is NOT sufficient to answer “I will plot the data \(q = f\) \((c)\) and compare the curves. It is stated in the problem determine / “bestem” the equation which means like given above. There is a very good example in the textbook (example 12.1-2 how this is done, this was also lectured.)**

**(Note 2: If the curve is plotted according to Freundlich (logarithmic plot), and the candidate argues that the data shows a linear plot and determines the constants from this, it is rewarded as well.)**
Oppgave 2 c)
See the textbook 12.3A, 12.3B and 12.3C. Note the figures and explanations of total bed and usable bed. Figure 12.3.1 illustrates there is a certain height of a transfer zone. So a transfer zone does not only “start” at the break point – but from break point we can find the height of a transfer zone.

Oppgave 4 DIFFUSJON – DIALYSE 6 + 5 + 5 + 5 + 5 = 26 poeng

a) See the textbook chapter 13.2 Note the value of $K'$- this will influence how you draw the concentration profiles for the system – negative $K'$ means higher concentration at surface.

b) See the textbook chapter 13.2A

c) Individual resistances:

$$\frac{1}{k_{c1}} = 2.4 \times 10^4 \text{s/m}, \quad \frac{1}{k_{c2}} = 4.5 \times 10^4 \text{s/m}, \quad \frac{1}{P_M} = \frac{L}{(DAB \cdot K')} = 5 \times 10^5 \text{s/m}$$

Total resistance: Adding the individual resistances = $57.25 \times 10^4 \text{s/m}$

Membrane will then be $(5/5.725) \times 100\% = 87.3\%$

d) $N_A = 0.384 \times 10^{-7} \text{ kmol A/(s m2)}$ by inserting known and calculated values in given equation

Calculating membrane area: $0.02 \text{ (kmolA/h)} / (0.384 \times 10^{-7} \times 3600 \text{ kmolA/h m}^2) = 144.7 \text{ m}^2$

e) $K_{c1} \to \infty$, then $1/kc1$ can be neglected, and the total resistance will be reduced. The thickness of the membrane is also reduced, $L = 1 \mu m = 10^{-6} \text{ m}$ (NB: Important conversion!)

Total resistance: $\frac{1}{k_{c2}} + \frac{1}{P_M} = 7.83 \times 10^4 \text{ s/m}$

And the new flux will be: $N_A = (2.5 - 0.3) \times 10^{-2} / 7.83 \times 10^4 = 2.81 \times 10^{-7} \text{ kmol A / (s m2)}$

Small variations in the answers are accepted, as long as the set up is correct.

Note: 1 hour = 3600 s (NOT 60 s as some candidates have used.)