SOLUTION EXAM 2015 M-B Hägg

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

Oppgave 2, a

Henry's law: $q = K \cdot c$ represents a straight line – can be plotted directly

Freundlich isotherm: $q = K \cdot c^n$ can be transformed to: $\ln q = \ln K + n \ln c$ hence straight line

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

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:

c (g/cm3)	0.0040	0.0087	0.019	0.027	0.094	0.195
q (solute/ (g alumina)	0.026	0.053	0.075	0.082	0.123	0.129

1/ c (cm3/g)	250	114.9	52.6	37	10.6	5.1
1/q(g alumina/ solute)	38.5	18.9	13.3	12.2	8.1	7.6

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: $(1/q_0) = 7$ → $\underline{q_0 = 0.143}$

Angular coefficient: $(K/q_0) = (18.9 – 8.1)/(114.9 – 10.6) = 0.10355$ → $\underline{K = 0.0148}$

Hence the equation for the Langmuir isotherm is: : **$\underline{q = 0.143c/(0.0148 + c)}$**

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

(Note1: It is NOT sufficient to answer "I will plot the data q = f (c) and <u>compare</u> the curves. It is stated in the problem <u>determine / "bestem" the equation</u> 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:

$1/k_{c1}$ = **$2,4 \times 10^4$ s/m**, $1/k_{c2}$ = **$4,5 \times 10^4$ s/m**, $1/P_M$ = L/(DAB K') = **5×10^5 s/m**

Total resistance: Adding the individual resistances = **$57,25 \times 10^4$ s/m**

Membrane will then be (5/5,725)100% = **87,3%**

d) $N_A = 0,384 \times 10^{-7}$ kmol A/(s m2) by inserting known and calculated values in given equation

Calculating membrane area: 0,02 (kmolA/h)/($0,384 \times 10^{-7} \times 3600$ kmolA/h m^2) = **144,7 m^2**

e) $K_{c1} \rightarrow \infty$, then 1/kc1 can be neglected, and the total resistance will be reduced. The thickness of the membrane is also reduced, L = 1 µm = 10^{-6} m (NB: Important conversion!)
Total resistance: $1/k_{c2} + 1/P_M = 7,83 \times 10^4$ s/m
And the new flux will be: $N_A = (2,5 – 0,3) \times 10^{-2} / 7,83 \times 10^4$ = **$2,81 \times 10^{-7}$ 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.)