$\alpha = 1741.5 * \frac{2*1.38*10^5}{0.001*50} = 1.044 * 10^{10}$, *[m*kg⁻¹]*

$R_F = 75.651 * \frac{1.38*10^5}{0.001} = 9.613 * 10^{10}$, *[M⁻¹]*

Remark: It is surprising to notice that the filter resistance RF more than doubles when switching from 69 to 138 kPa. In fact, it should remain constant, provided it is the same material that has been used for both experiments. In a normal situation (as suggested by the linearized equation), the intercept of the regression should be divided by two when the pressure is doubled. A possible explanation for this strange behavior could be that the filter itself is of a compressible nature, which would make the flow of liquid more difficult at higher pressure.

2. Is the cake of a compressible nature?
   It can be seen that the value of α does not change significantly from 69 to 138 kPa. The calculated value for the cake compressibility n is ca. 0.22, which effectively corresponds to a fairly incompressible cake.

Exercise 2.4: Lysis kinetics in a bead mill

Schütte & Kula (1990)(1) have lysed Bacillus cereus cells in a bead mill and measured the activity of the released L-Leucine dehydrogenase (LDH) in the liquid phase as a function of treatment duration. The results are given in the table below:

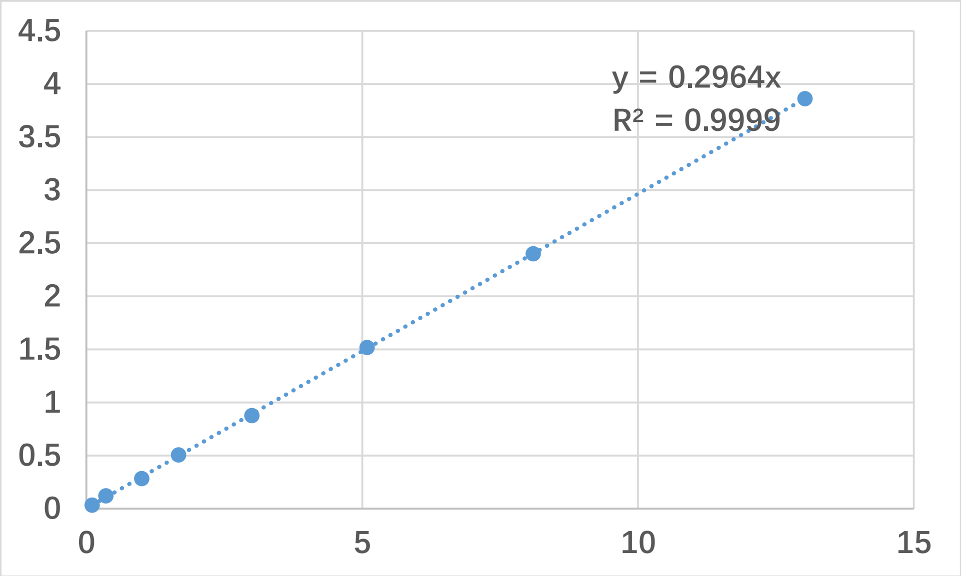
t [min]	0.10	0.35	1.00	1.67	3.00	5.09	8.10	13.03
LDH [U/mL]	1.15	4.15	9.08	14.7	21.62	28.97	33.73	36.32

(1) Schütte H., Kula M.-R. (1990): Pilot- and process-scale techniques for cell disruption. Biotechnology and Applied Biochemistry 12, 599-620

1. Assuming lysis kinetics is first order, determine the value of the kinetic constant.
   ln (R m/(Rm-R)) = k·t.
   The problem with that kind of linearization is that one needs to give an estimate for the maximal value of the measured variable, Rm, (here the enzyme activity concentration) to be able to do the regression. This is a bit strange since R m is one of the model parameters. In the present case, Rm = 37.1 [U/ml] gave the best linearity (R^2=0.9999).

t [min]	*0.1*	*0.35*	*1*	*1.67*	*3*	*5.09*	*8.1*	*13.03*
LDH [U/mL]	*1.15*	*4.15*	*9.08*	*14.7*	*21.62*	*28.97*	*33.73*	*36.32*
ln (R m/(Rm -R))	*0.031487885*	*0.11863*	*0.2807*	*0.50456*	*0.87407*	*1.51806*	*2.3987*	*3.86208*

Make a plot of ln(R m/(Rm-R)) = f(t):



k=0.2964 min^{-1}

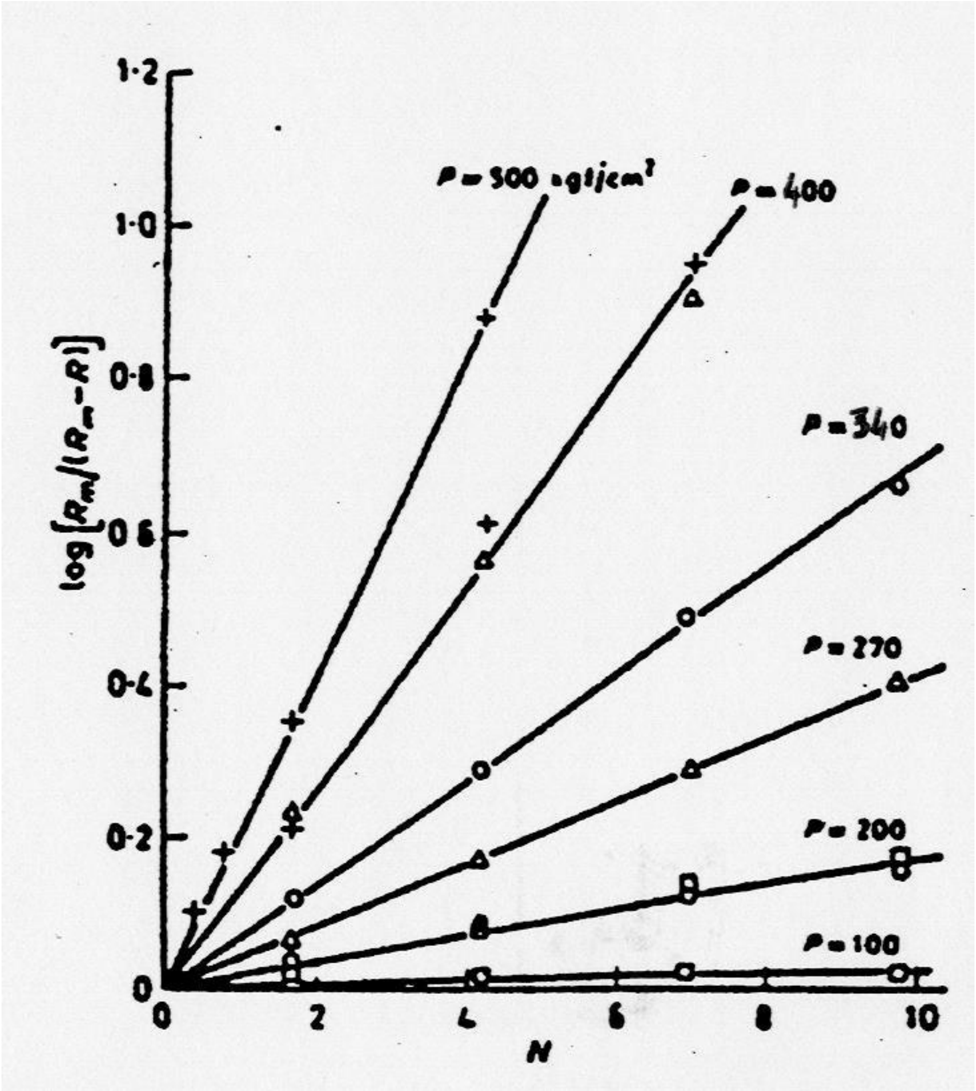
2. What is the main complication with linearizations of the form ln (R m/(Rm-R)) = k·t ?

   The problem with that kind of linearization is that one needs to give an estimate for the maximal value of the measured variable, Rm, (here the enzyme activity concentration) to be able to do the regression.

   If a non-linear regression is performed, this problem can be avoided since both parameters can be optimized simultaneously. The result is Rm = 36.83 [U/ml] and k = 0.289 [min-1].

Exercise 2.5: Cell lysis in a high pressure homogenizer

Cell lysis of a yeast suspension was achieved using a high pressure homogenizer at different pressures. The results are given in the graph below under the linear form corresponding to the Hetherington equation.



1. How many passages N would you need to reach 90% lysis at each pressure? (take N as a continuous variable)

2. What minimal pressure would you need to achieve 75% lysis after three passages?

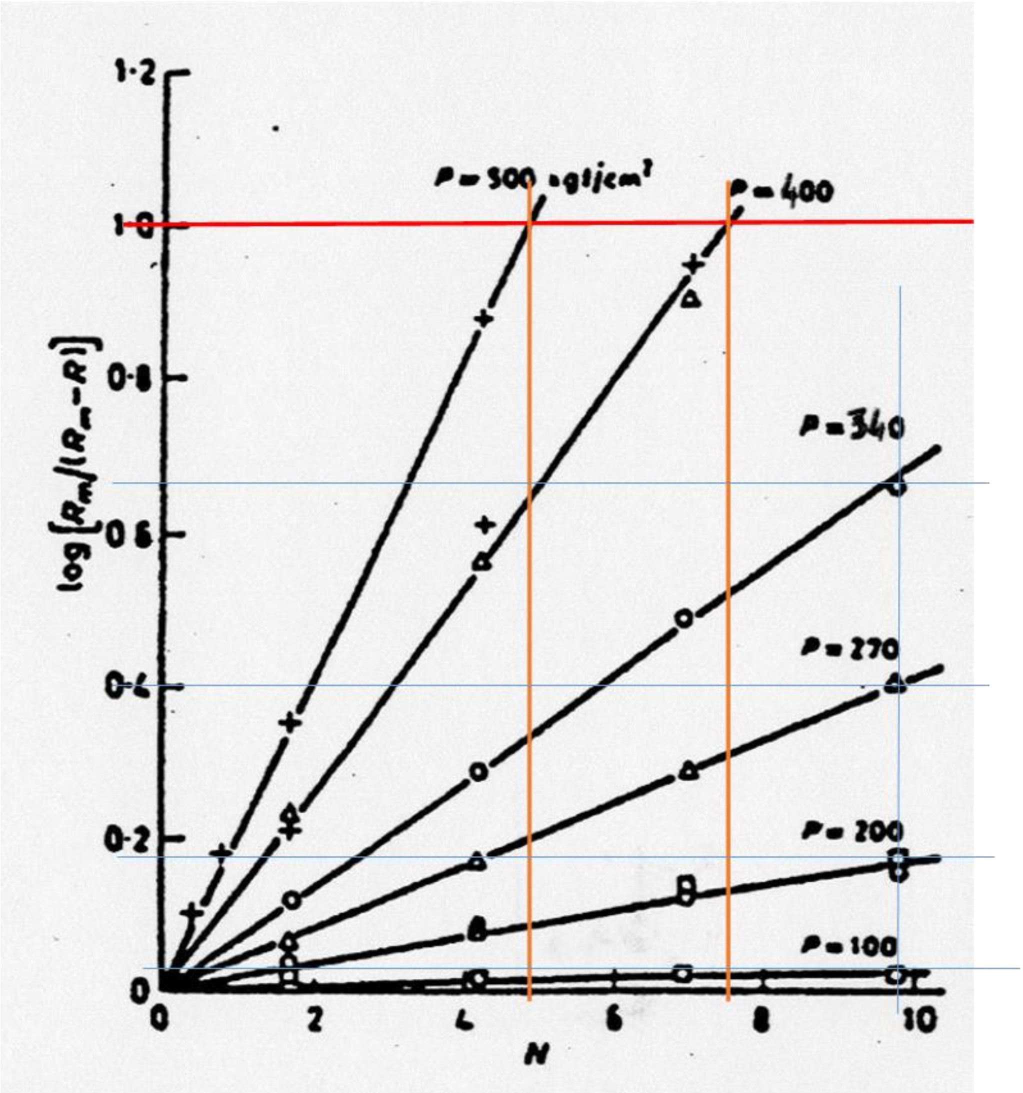
Reminder: 1 kg/cm2 = 0.981 bar

1. As already stated, this problem is based on Hetherington's equation:

$$\log\left(\frac{R_m}{R_m - R}\right) = K * N * P^n$$

A lysis rate of 90% means that R is equal to 0.9 Rm, which in turn implies that R m/(Rm – R) is equal to 10 and that log[R m/(Rm – R)] is equal to 1.0.

Hence one just needs to draw a horizontal line at log[R m/(Rm – R)] = 1 on the above graph and read the values of N corresponding to the different pressures.

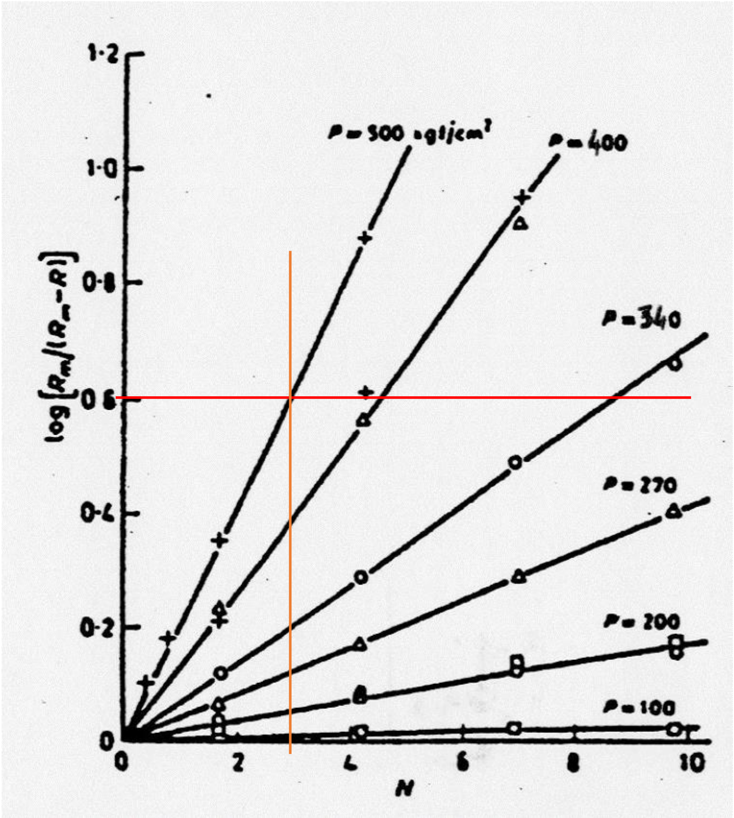


One then finds:

P [kg/cm2]	500	400	340	270	200	100
P [Pa]	490.5	392.4	333.54	264.87	196.2	98.1
N [y=1]	4.8	7.4				
y [N=9.75]			0.65	0.4	0.17	0.017
K*P^n	0.208333333	0.13513514	0.066667	0.041026	0.017435897	0.001744
N, when y=1			15	24.375	57.35294118	573.5294

For the first two pressures, we can get N directly from the figure, but for the last four pressures, it is hard to get it directly, so I select the final plot of each line to calculate the N.

2. With 75% lysis, log[R m/(Rm – R)] is equal to 0.602. To answer the question graphically we can draw a vertical line at N=3 and a horizontal line at log[R m/(Rm – R)] = 0.602.



We then see that the required pressure lies pretty close to 500 kg/cm2 or 491 bar.
*To obtain a more precise answer we need to know the values of K and n in the Hetherington equation. This can be obtained by plotting the log of the K *P^n values in the table above as a function of logP. log (K*P^n)=log(K)+n*log(P), This is done below:*

logP	*2.6906390 12*	*2.593729*	*2.52314 8*	*2.42303 3*	*2.2926990 03*	*1.99166 9*
*log (K*P^n)*	*- 0.6812412 37*	*- 0.869231 7*	*- 1.17609*	*- 1.38694*	*- 1.7585556 9*	*- 2.75856*
logK	*-8.665*					
n	*2.9872*					
K	*2.16272E-09*					

l

*The slope of the straight line is equal to the exponent n = 2.9872. The intercept, -8.665, is equal to log(K). As a consequence, K = 2.16272*10^{-09} [$Pa^{-298721}$] (note that the units for K depend strongly on the value for n).*
We now have a full description of our system and we can solve for p when log[R m/(Rm – R)] = 0.602 and N = 3.

$$\log\left(\frac{R_m}{R_m - R}\right) = 0.602 = KNP^n = 2.16272 * 10^{-9} * 3 * P^{2.9872}$$

Solving for P, one finds: P = 465 [Pa], which is very close to the graphically found solution.