CM 4710, Biochemical Processes Homework #4
SOLUTIONS
Chapter 6

Problem 1

(6.1) a. μ_{max}

$$\mu_{net} = \frac{1}{x}\frac{dx}{dt}, \text{ when } \mu \text{ is constant} \Rightarrow \ln x - \ln x_0 = \mu t$$

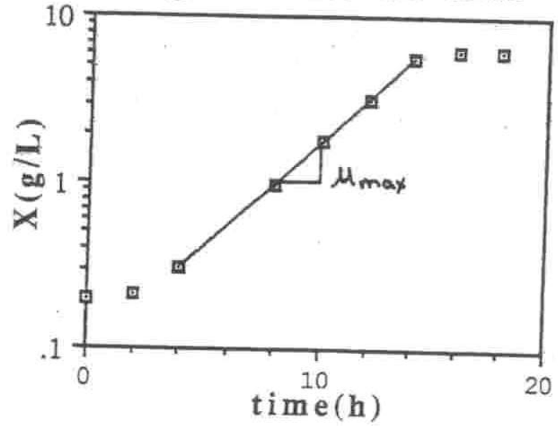
plot log x vs. t

The greatest slope occurs in linear region.

$$\mu_{max} = \frac{\ln 3.2 - \ln 0.98}{(12-8)\ hr}$$

$$\mu_{max} = 0.296\ hr^{-1}$$

log biomass vs. time



b. $Y_{X/S}^{App}$

$$Y_{X/S}^{App} = \frac{-\Delta X}{\Delta S} = \frac{-(6.2-0.2)\ g\ cells/L}{(0-9.23)\ g\ substrate/L} = 0.65\ \frac{g\ cells}{g\ substrate}$$

c. t_d

$$\ln\left(\frac{X}{X_0}\right) = \mu t, \quad t_d \text{ occurs when } X = 2X_0$$

$$\ln 2 = \mu t_d, \quad t_d = \frac{\ln 2}{\mu}, \quad t_d = 2.34\ hr$$

d. K_s

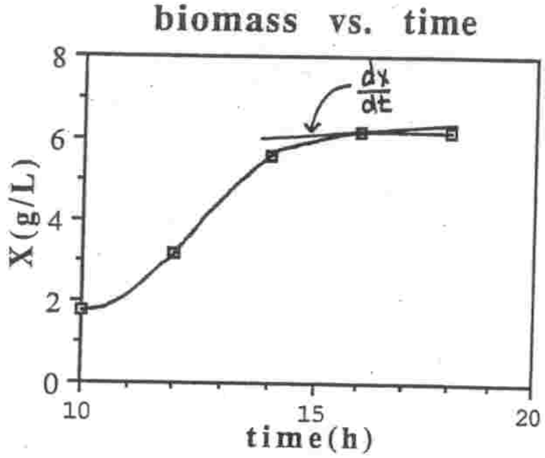
$$\mu = \frac{\mu_m [S]}{K_s + [S]}$$

- up until t = 4 hr have lag phase, after that Monod Kinetics can be applied
- between t = 4 hr & t = 14 hr $\mu = \mu_{max}$

Problem 1

(6.1) cont'd

- at $[S]=0$, $\mu = 0\ hr^{-1}$
- plot X vs. t, datermine $\frac{dX}{dt}$, $\mu = \frac{1}{X}\frac{dX}{dt}$



at $t = 16\ hr$

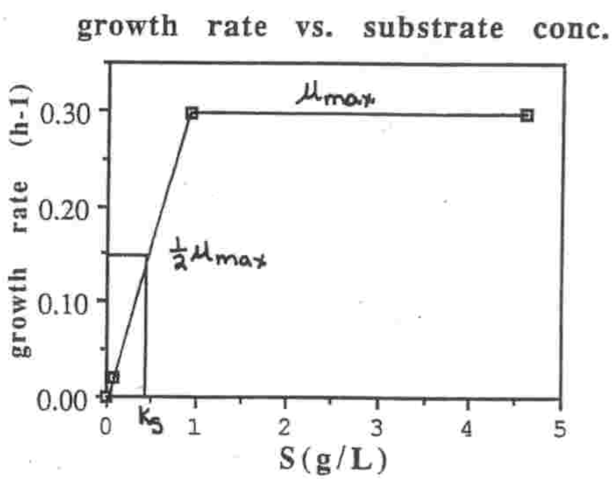
$[S] = 0.077\ g/L$

$\frac{dx}{dt} = 0.123\ \frac{g}{L \cdot hr}$

$\mu = 0.020\ hr^{-1}$

- plot μ vs. S
- $K_s = [S]$ at $\mu = \frac{1}{2}\mu_{max}$

$K_s = 0.45\ g/L$



e. at $t = 10\ hr$, $\mu_{net} \approx \mu_{max} = 0.296\ hr^{-1}$

Problem 2

6.11 $\frac{1}{Y_{ap}} = \frac{1}{Y_M} + \frac{m}{D}$ $S_0 = 500$ mg/L

$D (h^{-1})$	$\theta_H = 1/D$ (h)	$Y_{ap} = \frac{X}{(S_0 - S)}$	$1/Y_{ap}$
0.05	20.	0.33	3.03
0.11	9.1	0.44	2.27
0.24	4.2	0.55	1.82
0.39	2.6	0.59	1.69
0.52	1.92	0.61	1.64
0.70	1.43	0.64	1.56
0.82	1.22	0.65	1.54

A plot of $1/Y_{ap}$ vs $1/D$ yields: $1/Y_M = 1.5$ (intercept)

$Y_M = 0.67$ gX/gS and $m = 0.08$ (slope) gS/gX.h

a) $m = \frac{k_d}{Y_M}$, $k_d = m Y_M = (0.67)(0.08) = 0.054\ h^{-1}$

$D = \mu_N = \mu - k_d = \frac{\mu_m S}{K_S + S} - k_d$; $D + k_d = \frac{\mu_m S}{K_S + S}$

or $\frac{1}{D + k_d} = \frac{1}{\mu_m} + \frac{K_S}{\mu_m}\frac{1}{S}$

$D + k_d$	$1/(D+k_d)$	$1/S$
0.104	9.61	0.067
0.164	6.1	0.04
0.294	3.4	0.02
0.444	2.25	0.01
0.574	1.74	0.0071
0.754	1.326	0.0055
0.874	1.144	0.0042

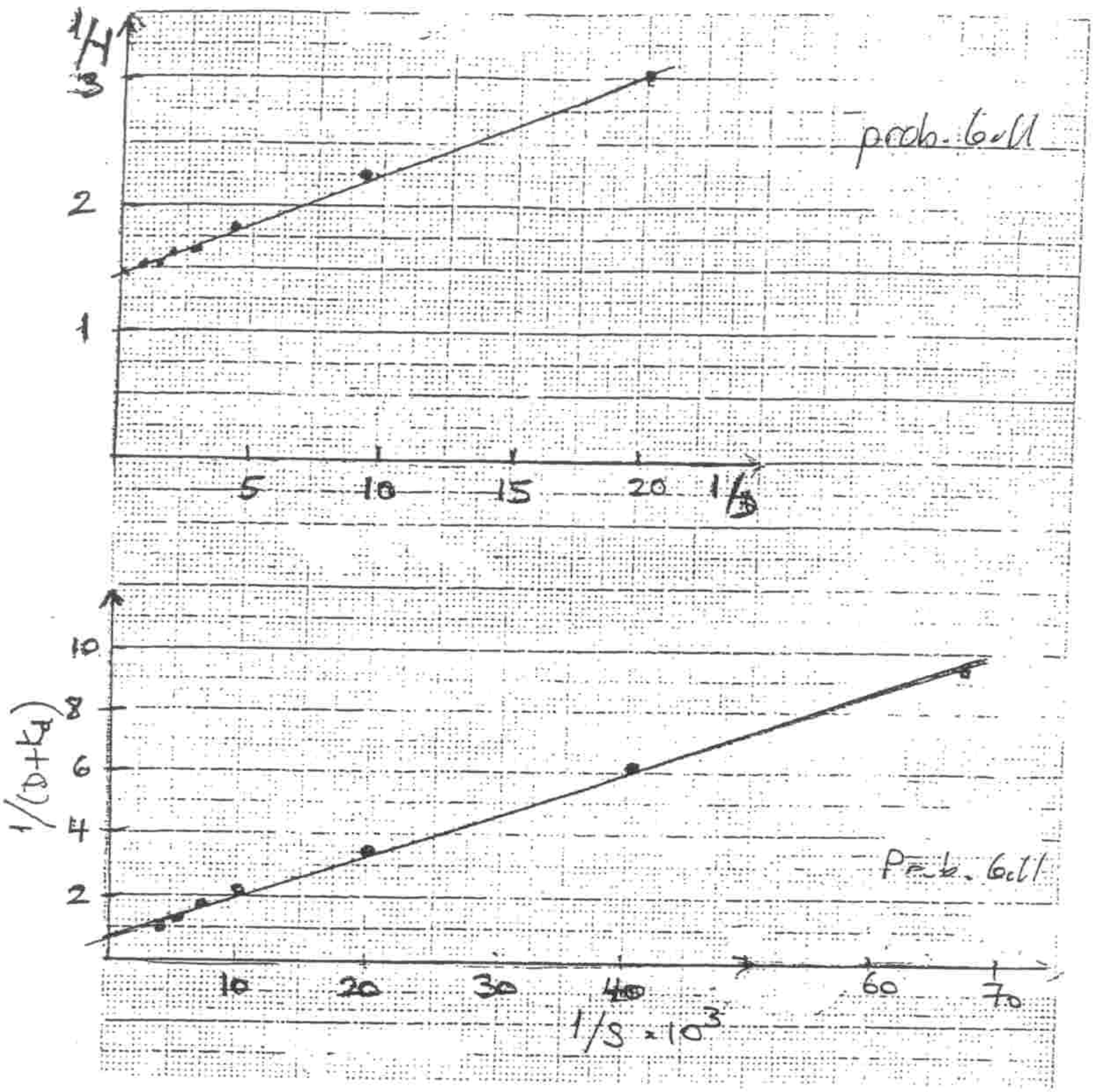
A plot of $1/(D+k_d)$ vs $1/S$ yields: $\frac{1}{\mu_m} = 0.8$ (intercept)

$\mu_m = 1.25\ h^{-1}$

$\frac{K_S}{\mu_m} = 135$ (slope)

$K_S = 1.25(135) = 169$ mg/l

Problem 2


1/H
3
2
1
5
10
15
20
prob. 6.11
10
8
6
4
2
1/(D+Kd)
10
20
30
40
60
70
1/S ×10^3
Prob. 6.11