Homework 6 solutions:

1.
First compute moles of glucose consumed: 26 g glucose* (1 mol glucose/180 g glucose) = 0.14444 mol glucose consumed with a standard deviation of .2g * (1 mol glucose/180 g glucose) = .0011mole glucose

Now we note that the molecular weight of the yeast = 144 g = (6*12 + 10*1 + 1* 14 + 3*16) g

0.1444 mol glucose *(0.48 mol dry cell/mol glucose) *(144g dry cell/mol dry cell) = 9.95328 g dry cells produced with a standard deviation of .0011*(0.48 mol dry cell/mol glucose) *(144g dry cell/mol dry cell) =.0768 g dry cells.

Use yield coefficient to determine the amount of heat released into the fermenter.

9.95328g dry cells *(1 kcal heat/0.42 g dry cells) = 23.6983 cal heat with a standard deviation of .0768 g * (1 kcal heat/0.42 g dry cells) =.182857 cal heat

Now determine the rise in temperature this leads to:

(23.6983 kcal heat/ 15 L broth)*(1 degree C * L broth/ 1 kcal heat) = 1.58 degree Celsius with a standard deviation of (.0768 kcal heat/ 15 L broth)*(1 degree C * L broth/ 1 kcal heat) = .005067 degrees Celsius

total answer: 1.58 +/- .005067degrees Celsius
Since half of the heat is released into the environment the final answer is 1.58/2 +/- .005067/2 which gives us .79 +/-.0025 degrees celsius

2. **Energy Balances.** MMD text chapter 4, problem 4.

39 g glucose/can * mol glucose/180 g * 36 mol ATP/mole glucose = 7.8 mol ATP/can.

7.8 mol ATP/can * 30 g cell mass dw/mol ATP * g total/0.3 g dw = 780 g cells/can ~ 0.8 kg tissue/can.

3. **Bioenergetics.**
Delta G = RT*ln(C1/C2) + ZF$\Delta\Psi$

34.5 nM on outside of cell
Efficiency = 59%
It takes 7.3 kcal/mol to convert ADP -> ATP
So 0.59=DeltaG/(7.3 kcal/mol) so DeltaG=4.307 kcal/mol

So 4.307 kcal/per mol is available to overcome and unfavorable transfer of solute across the membrane (must be unfavorable if cell has to actively transport it across memberane)

$F = 9.65x10^{-4}$ C/mole
Z = -1
Assume T = 37 C = 310 K
R = 0.001986 kcal / (mol K) =1.986cal/(mol)

DeltaG = +4.301 kcal/mole = RT*ln(C1/35.5 nM) +zF((-35 mV) – (+75 mV))

Therefore
4.301 – (zF((-35 mV) – (+75 mV))) = RT*ln(C1/35.5 nM)
[4.301 – (zF((-35 mV) – (+75 mV)))]/ RT = ln(C1/35.5 nM)
e ^ [4.301 – (zF((-35 mV) – (+75 mV)))]/ RT} =C1/35.5 nM
35.5nM * e ^ [4.301 – (zF((-35 mV) – (+75 mV)))]/RT} =C1

C1=1.2 *10^12 M

4.
Bioenergetics
Inlet pressure = 7 mmHg
Inlet diameter = 6.0 mm
Outlet pressure = 82 mmHg
Outlet diameter = 4.5 mm

a) Vdot is same for the inlet and outlet, and we know that Vdot = V*A where V is linear velocity, A is cross sectional area. Thus,

For the inlet:
$(3.2 \text{ L/min})*(1000 \text{ cm}^3 /\text{L})*(1 / (\pi*(.3)^2 \text{ cm}^2))*(1 \text{ min}/60 \text{ sec}) = 188.628$ cm/sec.
Two significant figures: 190 cm/sec

For the outlet:
$(3.2 \text{ L/min})*(1000 \text{ cm}^3 /\text{L})*(1 / (\pi*(.225)^2 \text{ cm}^2))*(1 \text{ min}/60 \text{ sec}) = 335.338$ cm/sec.
Two significant figures: 340 cm/sec

b) Work is the only energy involved; kinetic and potential energies are negligible. We consider the equilibrium state, where d(Energy)/dt = 0, so work w=0.

The work being done is F*v, where the force in this case is pressure, and velocity is the volumetric flow rate. Total w = w(done by pump) + w(flow).

So w(pump) = w(flow) = (3.2 L/min)(7 mmHg - 82mmHg)

Unit conversion:

(3.2 L/min)*(7 mmHg - 82mmHg)*(1 min/60 sec)*(1 m^3/1000L)*(10^5 Pa/750.061 mmHg)*
* (1 W/ (1m^3 Pa/sec)) = 0.5333 W, or 0.53 watts to two sig. figures.

c) We know that Watt = Amp * Volt. So we can solve:

.53 W * 5days * 24 hours/day = 63.6 W hr
63.6 / .38 = 167.368 W hr

(167.368 W hr) / (6 V) * (1 A / (W/V)) * (1000 mA / A) = 27894 mA hr
With two significant figures, this works out to 28000 mA hr.

d) For this problem we use the solution in part c that has not been adjusted to account for significant figures.

So from before we know that 27894 mA hr leads to 120 hours (5 days) of operation
27894*.007 = 195 mA hr

Note that there is no error introduced from converting current capacity to operation time, so we can easily find the error in time.

(195 mA hr) * (1 A / 1000 mA) * (1 W / (V mA)) * (6V / (.53 W) * (1 day / 24 hours) = .035 days

Note that this is the same as: 5 days * .007= .035 days

Now we use the Z test. To test with 99.9999% confidence, we use a Z-value of 4.67.

(5 ± x) / .035 = 4.67
So x = 5 - 0.16345 = 4.83655 days * (24 hours / day) = 116.07 hr.

When converting to 2 significant figures, we do not round up. Rather, we need to this **down** to 2 significant figures since we want to have a certainty of at least 99.9999%. Thus, the final answer is 110 hr.

5.
Binding. MMD text chapter 5, problem 1.
(a) P-L1 will be more prevalent because the protein binds it preferentially over L2.
(b) Because binding is dynamic, a given protein molecule will bind different L1's and L2's.
(c) This is akin to competitive inhibition. L2 still binds, so adding more will "distract" the protein from binding L1. Therefore, it will decrease, not increase the amount of P-L1 present.

6.
Binding
S4 binds to the first enzyme's binding site, which is enzyme inhibition. Thus S1 cannot bind with as much of the enzyme, which slows down the whole chain of reaction. Concentrations of S2, S3, S4 will drop. This is therefore an example of negative feedback.