Chem 454-Light, Dark and Glycogen Problems 4-15pts
SHOW ALL WORK-Due Thursday NAME__________________.

1. Calculate the energy efficiency of cyclic and non-cyclic photosynthesis using 680nm light under standard conditions. Consider NADPH to have the equivalent "cost" of 2.5 ATP. What would the efficiency be with 500 nm light?

Non cyclic:

E= hc/λ, for 680nm 1 mole (Einstein) = -42 kcal/mol
8 photons yields (see pg 556) 2 NADPH and 3 ATP ~ (2.5 *2) +3ATP =8 ATP "equivalents" * -7.3 kcal/mol= 58.4 kcal/mol to synthesize. 8 mol photons * -42 kcal/mol= - 336 kcal. And 58.4/336 * 100% = **17% efficiency**

E= hc/λ, for 500nm 1 mole (Einstein) = -57.2 kcal/mol * 8 = -457.6 kcal so 58.4/457.6 * 100% = **12.8 % efficiency**

Cyclic:

4 photons yields (see pg 557) 2 ATP
for 680nm, 4 * -42 kcal/mol= -168 kcal/mol
2* (7.3)/-168 * 100%= **8.7% efficiency**.

4 photons yields (see pg 557) 2 ATP
for 500 nm, 4 * -57.2 kcal/mol= -229 kcal/mol
2* (7.3)/-229 * 100%= **6.4% efficiency**

So even though the book says cyclic is "somewhat more productive" it is not unless you assume it is "free" to produce NADPH!

Under actual cell physiological conditions, the ΔG' for ATP hydrolysis is about -12 kcal/mol. What would the efficiencies be under real conditions?

8 ATP "equivalents" * -12 kcal/mol= 96 kcal/mol to synthesize
And 96/336 * 100% = **29% efficiency**

96/457.6 * 100% = **21 % efficiency**

Cyclic:

4 photons yields (see pg 557) 2 ATP
for 680nm, 4 * -42 kcal/mol= -168 kcal/mol
2* (12)/-168 * 100%= **14.2% efficiency**.

4 photons yields (see pg 557) 2 ATP
for 500 nm, 4 * -57.2 kcal/mol= -229 kcal/mol
2* (12)/-229 * 100%= **10.5% efficiency**

2. What is the <u>minimum</u> pH gradient necessary to synthesize ATP in the chloroplast? Assume 4 H+/ATP, $\Delta\Psi$=0 mV, T= 25 C and the "real" physiological conditions for ATP synthesis above in #1.

$\Delta G = 2.3\ RT\ (pH_{thylakoid} - pH_{stroma}) + \sout{F\Delta\Psi}_{(out\ relative\ to\ in)}$

$\Delta G = -12 = 2.3 * 0.00199 * 298\ (x)$

$-12 / 1.36 = x = 8.8 = \Delta pH$ for 1 H+. So 8.8/4 = <u>2.2 =minimum ΔpH for 4 H+/ATP under cellular conditions(-12 kcal/mol)</u>

3. Although animals <u>cannot</u> show a net synthesis of glucose from acetyl CoA, if a rat is fed 14C acetate some label will appear in glycogen extracted from the muscle. Explain and diagram the metabolic pathways involved.

Acetate→acetyl CoA→ **TCA** → *Oxaloacetate (labeled in all carbons)→

PEP→→→Glucose-6-phosphate←→ Glucose-1-Phosphate→UDP-Glucose→glycogen