Plant Physiology Fall 2007 Exam
(50 points)

Name:

Question 1.
Picture yourself ten years from now as a respected scientist giving a talk to members of Congress in Washington DC about why our government should allocate more resources to basic research for using plants in our daily diets to cure diseases such as cancer and Alzheimer's. You show them a slide demonstrating how all of these chemicals can be linked to the conversion of the sun's energy into chemical energy in the chloroplast. (a) Draw a chloroplast in the space below and label the thylakoid membrane, stroma and where you would find PSII, PSI complexes and the enzyme, Rubisco. (5 points)

(b) Draw a flow chart of the Calvin cycle showing the three main stages. Include the stage where Rubisco operates and how many molecules of ATP and NADPH are utilized during the carboxylation of a single CO_2 molecule. (5 points)

2. You are working in Dr. Tuohtraws lab over the summer and you are asked to make an enzyme assay buffer solution for *in vitro* Rubisco activity. The recipe includes bicarbonate, a Tris buffer and a pH of 8.0. What ion is missing and explain why it is necessary for this ion to be present in the enzyme activity analysis. Describe how Rubisco is activated. (5 points)

3. A large emphasis is being placed on growing plants that can utilize the sun's energy efficiently to build organic substrates that can be converted into ethanol. Explain why it would or would not be a good idea to knock out one of the genes that regulate photorespiration in the C_3 plant that is being targeted for increased biomass yields. Use an analogy with C_4 plants to substantiate your answer (10 points)

4. You are asked to review an article that is submitted to the prestigious plant science journal, Plant, Cell and Environment. The authors submit the following set of Figures and Table demonstrating the effect of drought on biochemical limitations on the Calvin cycle. They describe the results in the following manner. Provide a valuable critique of the results section of the article pointing out why the authors' work should be rejected from this highly prestigious plant science journal (15 points).

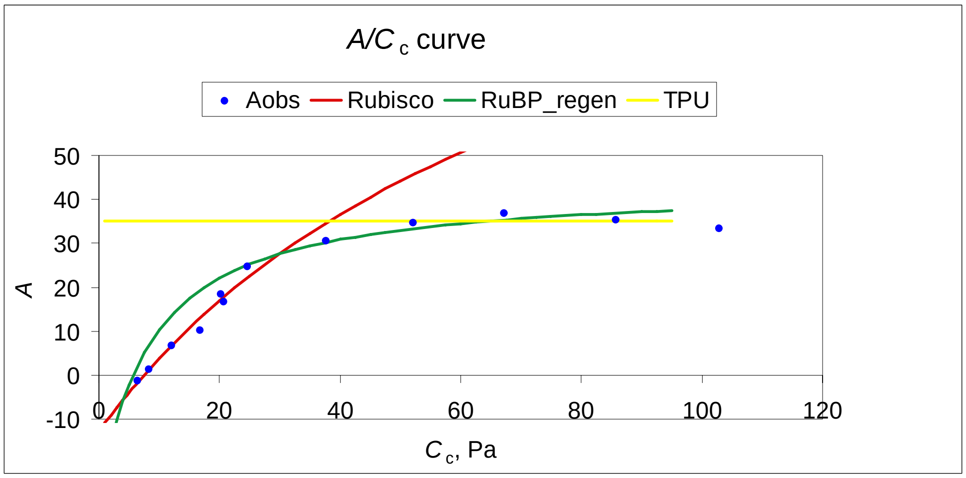

Figure 1. CO_2 response curve for a plant growing under drought conditions (no water for a week)

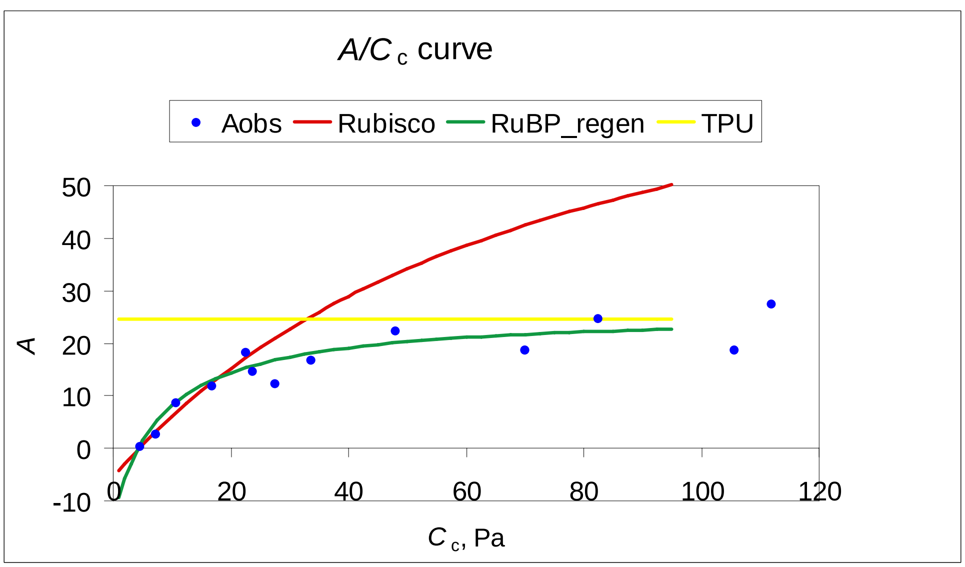

Figure 2. CO_2 response curve for a plant growing under well-watered conditions (water every second day)

Table 1. Biochemical parameters estimated from model.

Biochemical Variable	Drought	Well-watered
Vcmax	7.8 µmol m^{-2} s^{-1}	78 µmol m^{-2} s^{-1}
J	9.1 µmol m^{-2} s^{-1}	91 µmol m^{-2} s^{-1}
TPU	0.73 µmol m^{-2} s^{-1}	7.3 µmol m^{-2} s^{-1}
gm	0.042 µmol m^{-2} s^{-1}	0.42 µmol m^{-2} s^{-1}
Rd	0.158 µmol m^{-2} s^{-1}	1.58 µmol m^{-2} s^{-1}
Ko (Kpa)	17.89 KPa	17.89 KPa
Kc (Pa)	35.32 Pa	35.32 Pa
Γ*	4.05 Pa	4.05 Pa
C (chloroplast CO_2)	23.7 Pa	23.7 Pa
O (chloroplast O_2)	21 KPa	21 KPa

Results

Our CO_2 response curves show that the plant experiencing drought had a lower carboxylation efficiency (Vcmax), electron transport rate used to regenerate RuBP (J) and a lower triose phosphate utilization (TPU) than the high water plant (Figures 1 and 2, Table 1). The mesophyll conductance (gm) was much lower in the drought plant which explains why the chloroplast CO_2 concentrations could be the same under the two water treatments. Dark respiration was lower in the plant experiencing drought which correlates with the lower carboxylation efficiency under drought conditions. This makes sense. When using equations 1 and 2 to calculate the amount of oxygenation to carboxylation, we find that the plant experiencing drought has a higher rate of photorespiration relative to the well-watered plants. This makes sense given that the Vcmax was lower in the plant experiencing drought.

ϕ (small letter Phi) $= Vo/Vc = (Vomax/Ko)*(Kc/Vcmax)O/C = (1/Sc/o)(O/C)$
(equation 1)

Where Vcmax, Vomax, Kc and Ko are maximal rates and Michaelis-Menten constants of carboxylation and oxygenation respectively.

Sc/o is the relative specificity of rubisco and C and O are the chloroplastic CO_2 an O_2 partial pressures.

Sc/o is the relative specificity of rubisco and C and O are the chloroplastic CO_2 an O_2 partial pressures.

When Rd= 0, A=0 when ϕ=2 (ie. Oxygenation = 2X carboxylation and the amount of CO_2 released during oxygenation equals what is consumed during photosynthesis) The chloroplast CO_2 partial pressure at which this occurs has been named gamma star (Γ*).

ϕ (small letter Phi) = $2\Gamma^*/C$ **(equation 2)**

Write your critique below.

Question 5.

A. What is meant by the term quantum yield (Φ, capital Phi) (2 points)?

B. What is the typical quantum yield of O_2 in C_3 and C_4 plants? (2 points)

C. What is the typically quantum yield of CO_2 in C_3 and C_4 plants? Why is it lower than the quantum yield for O_2? (2 points)

D. In theory, how many photons are needed to make 2 molecules of NADPH? (2 points)

E. Approximately how many molecules of ATP can be made when the number of photons in (D) results in the formation of 2 NADPH? (2 points)