Problem 1: Oxidative Phosphorylation (20 points)

a) (10 points) Name and explain two regulators of oxidative phosphorylation. Use three sentences maximum for your explanation of each regulator (6 sentences total maximum).

b) (10 points) Starting with 1 molecule of glucose, track the metabolic processes that occur and tabulate how much ATP can theoretically be generated through these processes.

Problem 2: ATP Synthase (30 points)

a) (7.5 points) Explain how the mechanical movement of the c ring of ATP synthase is generated in a maximum of 7 sentences.

b) (7.5 points) Explain in a maximum of 5 sentences how the mechanical movement you described in part (a) generates asymmetry in the αβ ring. How does the asymmetry of the catalytic β subunits lead to ATP synthesis?

c) Uncoupling proteins are proton channels found in the inner mitochondrial membrane.
   i. (5 points) What effects do uncoupling proteins have on the electron transport chain? On ATP synthesis? (Use 2 sentences maximum to explain.)
   ii. (5 points) What happens to the energy from the proton electrochemical gradient when uncoupling proteins are present? (Use 2 sentences maximum to explain.)
   iii. (5 points) Dinitrophenol can also shuttle H⁺ across the inner mitochondrial membrane. Explain why this molecules was used as a weight loss supplement and why it is very dangerous. (Use 4 sentences maximum to explain.)

Problem 3: Calvin Cycle and Its Intermediates (20 points)

a) (10 points) List the products of the Calvin cycle if you start with Ribulose 5-phosphate and add one CO₂ molecule. Continue adding CO₂ until glucose can be made and Ribulose 5-phosphate regenerated, listing the products of each step after each equivalent of CO₂ is added.

b) (10 points) How many equivalents of CO₂ are needed to generate glucose and regenerate Ribulose 5-phosphate? How much ATP and NADPH molecules are used? How many Ribulose 5-phosphates are used and regenerated?
Problem 4: Photosynthesis (30 points)

a) (6 points) Provide insight on the advantage of producing ATP and NADPH in the stromal space in a maximum of 2 sentences.

b) (5 points) Describe the effect on photosynthesis if the CF$_1$ (of the CF$_1$-CF$_0$ ATP synthase complex) subunit were oriented such that it faced the Thylakoid space in a maximum of 3 sentences.

c) During the photosynthesis, electrons are excited and transferred within the electron transfer chain on the thylakoid. Please identify and briefly describe your reasoning for the following:

i. (5 points) At the very beginning moment of the photon excitation event, what are the primary origin sources of the electrons in the electron flow of photosynthesis? If the origin source loses the electrons, how can new electrons be supplemented and where do they come from? Use a maximum of 5 sentences in your explanation.

ii. (5 points) Suppose you give a transient pulse of light to the plant and then shut off the light. This pulse is just enough to excite the electrons to go through one entire electron transfer flow. After shutting off the light, where is the final destination of the electrons in the transfer flow? Use a maximum of 3 sentences in your explanation.

d) (9 points) In the photophosphorylation process, suppose the current NADPH/NADP$^+$ ratio is very high (nearly saturated). Please briefly explain your reasoning for each question.

i. (3 points) Does any new NADPH come out? (2 sentence maximum)

ii. (3 points) Do any new O$_2$ molecules get generated? (2 sentence maximum)

iii. (3 points) Can any ATP be synthesized? (2 sentence maximum)