Ahmedabad University

School of Arts and Sciences

BIO 210 Intermediate Biochemistry

Mid Semester Examination 2024 (Winter Semester)

Total Marks = 50 **Time – 2 hours**

Date: 22-02-2024
No. of printed pages: 4

1. a) In the first step of glycolysis, conversion of glucose + ATP → glucose 6-phosphate +**ADP**+Pi is catalyzed. Find ΔG° for this reaction if K_{eq}'=845. T under standard conditions is 298 K. (2.5 marks)

b) Under physiological conditions, the first step of glycolysis is spontaneous: $\Delta G = -33.4$ kJ/mol. Determine the concentration of glucose 6-phosphate (G6P) under physiological conditions for a red blood cell (using ΔG^{o} from part a, the equation from part a, and information from the table below). T under physiological conditions is 310 K. (2.5 marks)

	[ATP] mM	[ADP] mM	[AMP] mM	[Pi] mM	[glucose] mM
red blood cell	2.25	0.25	0.02	1.65	5.00

2. You are studying the bioenergetics of chloroplasts in one of your garden plants. You note that under daylight conditions the pH in the chloroplast stroma is 8, whereas the pH in the thylakoid lumen is 6. The thylakoid membrane potential is +0.020 V (inside relative to outside).
a) What is the free energy change value associated with the movement of H+ down the electrochemical gradient in this system? Show calculations. (2.5 marks)
b) If $\Delta G'$ for the formation of ATP from ADP and Pi is +12kcal/mol in this system, how many H+ are required to move through the ATP Synthase complex to drive the synthesis of an ATP molecule? (2.5 marks)

3. During glycolysis, the enzyme phosphofructokinase (PFK) facilitates the conversion of fructose-6-phosphate, abbreviated as F6P, to fructose 1,6-biphosphate (FBP). This glycolytic reaction is shown below:

F6P + ATP → FBP + ADP ΔG° = -14.2 kJ/mol

a) What is/are the roles of ATP in this reaction? (1 mark)
b) Calculate the actual free energy change of this reaction for a typical yeast cell (ideal temperature for growth for yeasts is 30°C). The estimated intracellular concentrations of relevant metabolites are shown in the table below. You do not have to factor in Mg2+ concentration for this calculation. Is this reaction, given the conditions, a spontaneous or non-spontaneous reaction? (3 marks)

FBP	0.25 mM
F6P	0.014 mM
ATP	1.9 mM
ADP	0.3 mM
AMP	1.0 mM
Inorganic Phosphate	0.99 mM

c) PFK activity is regulated by the concentrations of ATP and ADP in cells. How would a lower ATP/ADP ratio affect PFK activity? (1 mark)

4. As an isotope labeling experiment, glucose molecules labeled with ^{14}C (radioactive carbon) at the carbon-1 position are fed to cells and proceed through glycolysis. Will all pyruvate molecules have this radioactive label? If the answer is no, what percentage of pyruvate molecules made by C−1 labeled glucose will have the label? Explain your answer and trace the path of the radioactive ^{14}C through the glycolytic reactions. (5 marks)

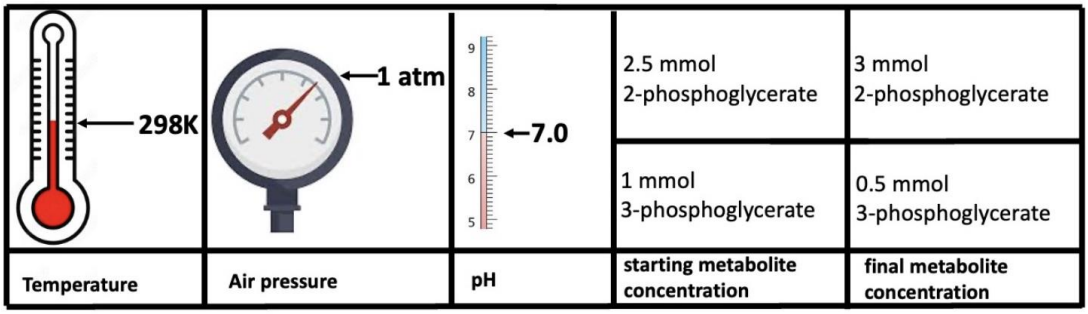
5. The first reaction of glycolysis, a thermodynamically unfavorable process, is the phosphorylation of glucose



$\Delta G^\circ = 14\ kJ/mol$

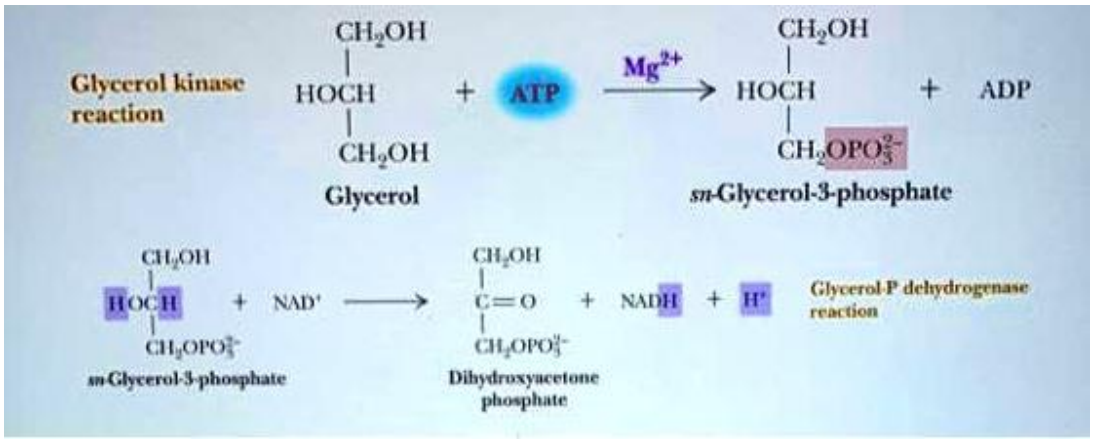
a) Calculate the Keq for this reaction and the equilibrium fraction of Glc-6-P. (2 marks)
b) In the liver, the concentrations of both Pi and Glc are maintained at 5mM each. What will be the equilibrium concentration of Glc-6-P. (2 marks)
c)Suggest 2 ways this reaction is pushed forward in the cell. (1 mark)

6. In the gluconeogenesis pathway the enzyme phosphoglycerate mutase is catalysing the conversion of 2-phosphoglycerate into 3-phosphoglycerate. Reaction participants are incubated under reaction conditions as indicated in the image below and the reaction proceeds until equilibrium is reached. The value of the gas constant is 8.315 J/molK. Determine the standard free energy change of the reaction. (5 marks)

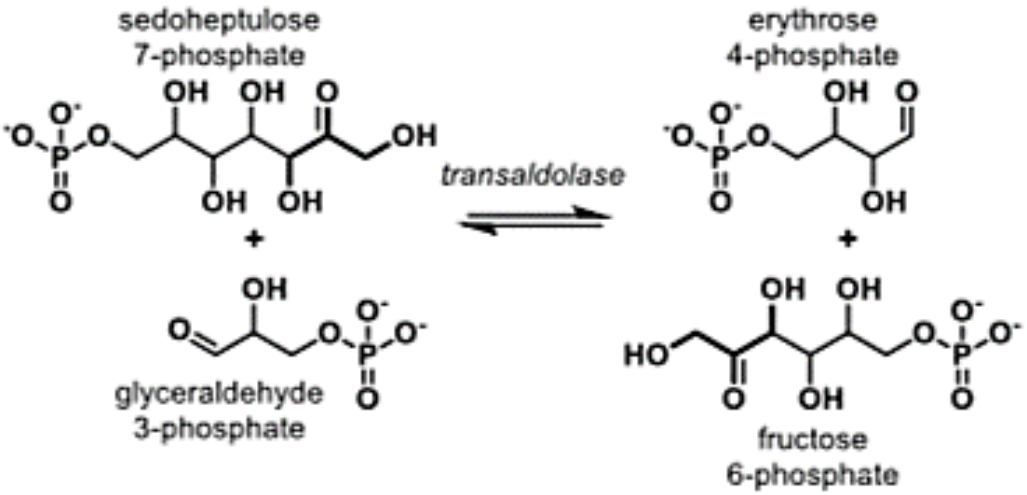


7. a) If $^{14}CO2$ were bubbled through a suspension of liver cells that was undergoing gluconeogenesis, which carbons in the glucose molecule would become radioactive? Justify your reasoning. (2.5 marks)
b) Suppose glucose is labeled with ^{14}C at C5 and fed to yeast carrying out ethanolic fermentation. In which fermentation product, and at which position would the label end up? Justify your reasoning by showing the path of the labeled atom through glycolysis and fermentation. (2.5 marks)

8. Glycerol can be used as a source of energy by some bacteria growing aerobically. The diagram shows the first two steps of glycerol catabolism. Note that the product of this pathway enters glycolysis. Glycerol cannot be used as an energy source by organisms growing anaerobically using either the lactate or the ethanol fermentation pathway. Explain why glycerol can be used aerobically and why it cannot be used anaerobically. (5 marks)



9. Transaldolase is a key enzyme in part of the pentose phosphate pathway and is related to the aldolase of glycolysis. It helps to transfer a 3-carbon fragment (in bold) from sedoheptulose 7- phosphate to glyceraldehyde 3-phosphate, generating fructose 6-phosphate and erythrose 4- phosphate.



Please answer the following questions.
a) Is this a redox reaction? How do you know? (2.5 marks)
2) Based on your knowledge of a related aldolase (for example, from glycolysis), do you think that transaldolase uses ATP as a co-substrate to make this reaction exergonic? If yes, how? If not, how does the reaction become exergonic? (2.5 marks)

10. In photosynthesis, the following processes are happening:

$$2H_2O \rightarrow O_2 + 4H^+ + 4e^-$$
$$CO_2 + 4H^+ + 4e^- \rightarrow CH_2O + H_2O$$

$$CO_2 + H_2O \rightarrow CH_2O + O_2$$

Find the total expenditure of energy required in order to produce one molecule of CH_2O from CO_2 and H2O? Standard redox potential of H_2O - O_2 pair is -0.82 V standard redox potential of CO_2 - CH_2O pair is -0.4 V. (5 marks)