Do not use a calculator for this test.

\[ RT \ln(X) = (5700 \text{ J/mol}) \log(X) = (1364 \text{ cal/mol}) \log(X) \]

Also recall: \( \log 1 = 0; \log 10 = 1; \log 10^2 = 3; \log 0.01 = -2; \log 10^{-4} = -4; \) etc

(6 points)

1. The following metabolite concentrations were determined for a particular cell.

<table>
<thead>
<tr>
<th>Metabolite</th>
<th>( [M] )</th>
<th>Metabolite</th>
<th>( [M] )</th>
</tr>
</thead>
<tbody>
<tr>
<td>glucose</td>
<td>10</td>
<td>DHAP</td>
<td>0.010</td>
</tr>
<tr>
<td>Glc-6-P</td>
<td>0.10</td>
<td>G-3-P</td>
<td>0.010</td>
</tr>
<tr>
<td>Frc-6-P</td>
<td>0.010</td>
<td>1,3-BPG</td>
<td>0.0010</td>
</tr>
<tr>
<td>Frc-1,6-BP</td>
<td>0.10</td>
<td>2,3-BPG</td>
<td>10.0</td>
</tr>
<tr>
<td>3-PGA</td>
<td>0.10</td>
<td>ATP</td>
<td>1.0</td>
</tr>
<tr>
<td>2-PGA</td>
<td>0.010</td>
<td>ADP</td>
<td>0.10</td>
</tr>
<tr>
<td>PEP</td>
<td>0.010</td>
<td>( P_i )</td>
<td>1.0</td>
</tr>
<tr>
<td>pyruvate</td>
<td>0.010</td>
<td>( H^+ ) (pH = 7)</td>
<td>( 10^{-7} )</td>
</tr>
</tbody>
</table>

a) What is the \( \Delta G' \) for the chemical cleavage of Frc-1,6-BP catalyzed by the enzyme \textit{aldolase}?  
\( (\Delta G'' = +23.9 \text{ kJ/mol}) \)  
Is this a favorable reaction under these cellular conditions?
(15 points)

2. Please reproduce the catalytic mechanism found in serine proteases. There should be 6 stages total (the first is given).
3. How is specificity determined in the serine proteases?
   a. The mechanism of cleavage differs between enzyme types
   b. Each enzyme binds to a different set of amino acid side chains
   c. It depends on the specific amino acid sequence of the substrate
   d. By the orientation of the catalytic triad

4. The aspartic protease catalytic mechanism involves:
   b. aspartate rather than serine attacking the carbonyl group
   c. two aspartate side chains simultaneously attacking the carbonyl group
   d. a water molecule attacking the carbonyl group
   e. an aspartate, serine, histidine catalytic triad
   f. none of the above

   (6 points)

5. a) Zymogens are activated by what process: ______________________________

   b) Zymogen activation is thermodynamically
      ______ favorable
      ______ unfavorable
      ______ and kinetically at equilibrium

   c) Name a zymogen and its activated form:
      zymogen: ___________________________  activated form: ___________________________

6. Which of the following explains why penicillin is toxic to many microorganisms?
   b) it makes membranes excessively permeable to ions and permits K⁺ to leak out.
   c) it adheres to a component of the ribosome and prevents protein biosynthesis.
   c) it hydrolyzes a portion of the peptidoglycan cell wall & thus weakens the cell wall.
   d) it inhibits biosynthesis of folic acid (a coenzyme) & ultimately prevents DNA replication.
   e) it inhibits a transpeptidase & thus prevents peptidoglycan synthesis in the cell wall.
(4 points)
7. What is a transition state analog? How does it affect activity?

(4 points)
8. Name a class of molecular motor proteins that move:
   a) along actin filaments
   b) toward the plus-ends of microtubules

(4 points)
9. What does it mean for a protein to be a mechanochemical or chemomechanical enzyme?
   Describe in 30 words or less.

(3 points)
10. We discussed two different “high energy” molecules that serve as short-term (< 5 sec in very active tissue) energy pools in muscle. Name and draw one of these two molecules.
(24 points)

10. The following diagram represents a portion of the glycolytic pathway. Fill in the missing molecular structures of the metabolites, their names (acronym is acceptable), and enzyme names.

1. _______________

Aldolase

2. _______________

Triose phosphate isomerase

3. 

Glyceraldehyde 3-phosphate

4. _______________

5. _______________

6. _______________

7. _______________

8. _______________

9. _______________

10. _______________

11. _______________

3-Phosphoglycerate

Note: items 5, 6, 9 & 10 refer to small molecules which participate in the given reactions.
12. Fill in both sides of the net reaction for glycolysis.

\[ \text{glucose} + \text{ADP} + \text{NAD}^+ \rightarrow 2 \text{pyruvate} + \text{__________} + \text{__________} + \text{_______} \]

13. \( \Delta G^\circ' \) and \( \Delta G \) was described in lecture for every step in glycolysis. How do these two values relate to the cell?

14. Regulation of the glycolytic pathway is important. Which 3 enzymes are subject to regulation in most cells? List one inhibitor or one activator of each enzyme.

<table>
<thead>
<tr>
<th>Enzyme</th>
<th>Activator</th>
<th>or</th>
<th>Inhibitor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Which of these is typically the “commitment step?”

Explain why one of the listed activators or inhibitors “makes sense” metabolically.

15. Determine the \( \Delta G \) for the coupled reaction which generates ATP from phosphoenolpyruvate. Is this reaction favored under these conditions.

\[ \text{PEP} + \text{H}_2\text{O} \rightleftharpoons \text{pyruvate} + \text{P}_i + \text{H}^+ \quad \Delta G = -43 \text{ kJ/mol} \]

\[ \text{ATP} + \text{H}_2\text{O} \rightleftharpoons \text{ADP} + \text{P}_i + \text{H}^+ \quad \Delta G = -50 \text{ kJ/mol} \]
(4 points)

**Bonus Question:**
The following information was obtained from an octapeptide. What is the primary amino acid sequence of the peptide?

a) Amino acid analysis:
   1 Arg   1 Asp   2 Gly   1 Lys   1 Met   1 Trp   1 Tyr   1 NH₄⁺

b) One cycle of Edman degradation yielded
   the following product:

c) Elastase treatment yielded Gly and a heptapeptide.
d) Chymotrypsin treatment yielded 2 tripeptides and a dipeptide; acid hydrolysis of the dipeptide yielded Gly, Asp, and NH₄⁺.
e) CNBr treatment yielded 2 tetrapeptides.
f) Trypsin treatment yielded 2 tripeptides and a dipeptide; acid hydrolysis of the dipeptide yielded Gly and Lys. One tripeptide containing an indole ring was further cleaved to an Arg and a dipeptide by CNBr treatment.

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Sequence: _____  _____  _____  _____  _____  _____  _____  _____