# Chemistry 333
# Principles of Biochemistry
# Fall 2009
# Final Exam
# December 17, 2009

NAME: _____

1. _____/25 points
2. _____/6 points
3. _____/8 points
4. _____/11 points
5. _____/15 points
6. _____/5 points
7. _____/6 points
8. _____/10 points
9. _____/6 points
10. _____/8 points
11. _____/5 points (EXTRA CREDIT)

12. _____/100 MULTIPLE CHOICE

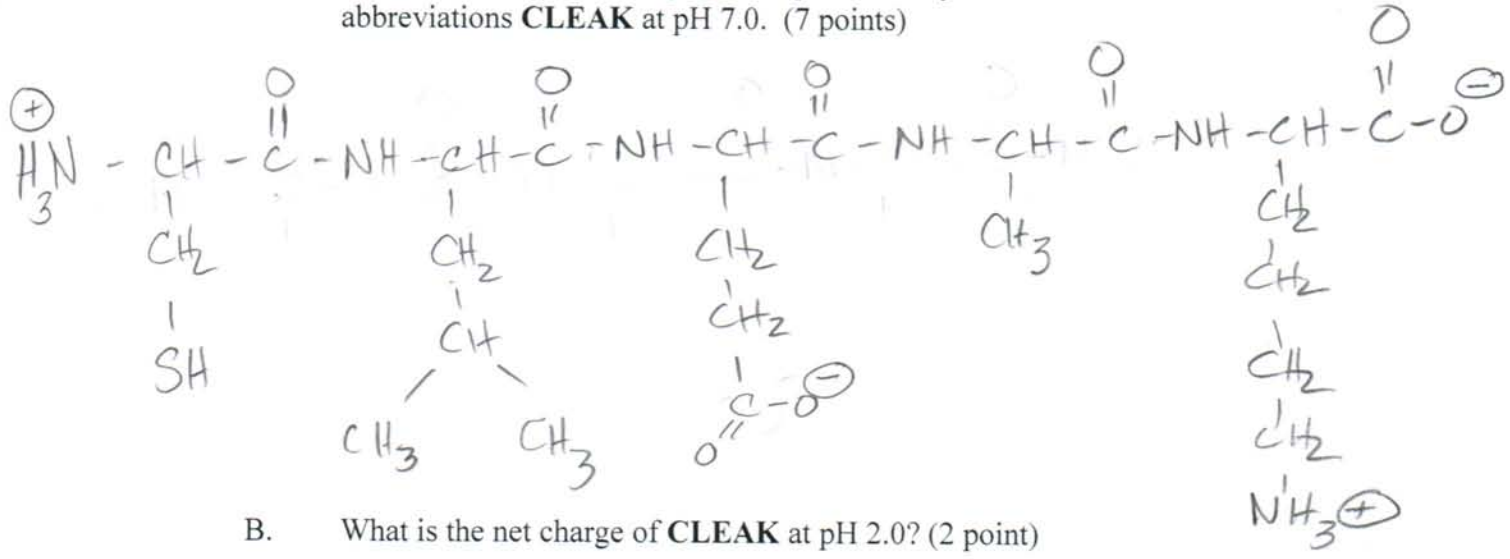
**TOTAL: _____/200 points**

**1. 25 points**

The enzyme carboxypeptidase A catalyzes the hydrolysis of the peptide **CLEAK** in 10 mM phosphate buffer at pH 7.0. The enzyme is known to obey Michaelis-Menten kinetics. Under the conditions of this experiment:

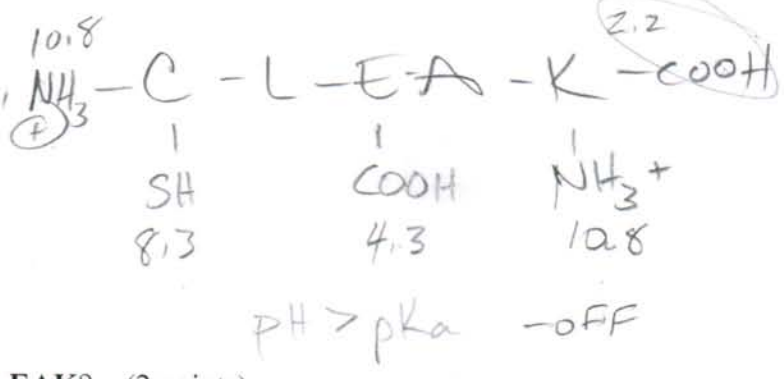
$V_{max}$ = 10 mmol/min/mg
$K_m$ (CLEAK) = 0.20 mM

A. Draw the structure of the peptide represented by the 1 letter amino acid abbreviations **CLEAK** at pH 7.0. (7 points)



B. What is the net charge of **CLEAK** at pH 2.0? (2 point)

+2




C. What is the pI of **CLEAK**? (2 points)

Fully protonated = +2

+2 $\xrightarrow{2.2}$ +1 $\xrightarrow{4.3}$ 0 $\xrightarrow{8.3}$ -1

pI average of 2 pKas on either side of the zero charged species pI = $\frac{4.3+8.3}{2}$ = 6.3

D. Suppose that the substrate concentration of **CLEAK** in this assay is **500 µM**. Calculate the expected **initial velocity**. (2 points)

$V_0 = \frac{V_{max}[S]}{K_m + [S]}$ $V_0 = \frac{(10)(0.5)}{0.2 + 0.5}$

$V_0 = 7.1$ mmol/mg/min

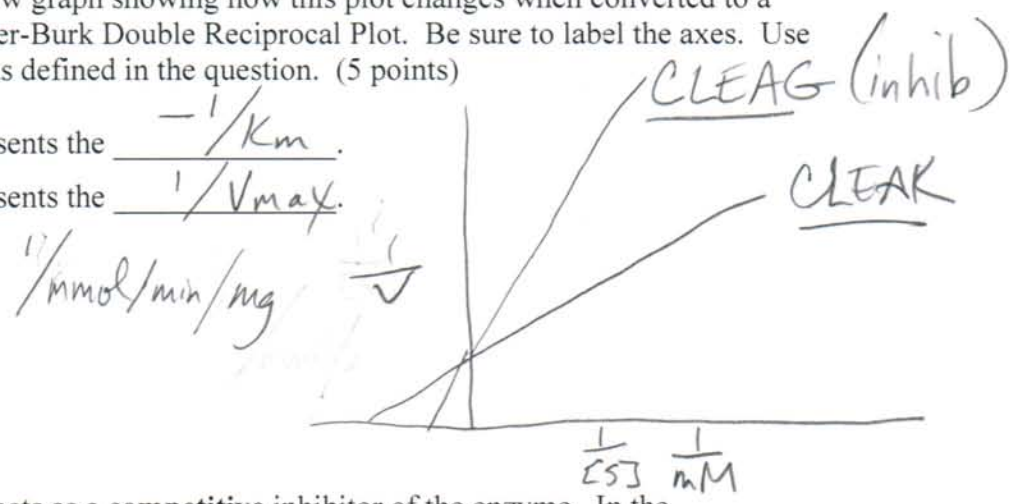
E. Suppose another substrate was tested under the same conditions at pH 7.0, **CLEAG**, and it was determined that the $K_m$ of **CLEAG** was **5 mM**. Which substrate has the **HIGHER affinity** for carboxypeptidase A? (circle one). (2 points)

**CLEAG** **CLEAK**

F. Draw a typical plot of V vs. [S] for this enzyme that follows Michaelis Menten kinetics. Label the axes and use the units as defined for Vmax and Km at the beginning of the question. (3 points)


G. Draw a new graph showing how this plot changes when converted to a Lineweaver-Burk Double Reciprocal Plot. Be sure to label the axes. Use the units as defined in the question. (5 points)

1. The X-intercept represents the $-1/K_m$.
2. The Y-intercept represents the $1/V_{max}$.

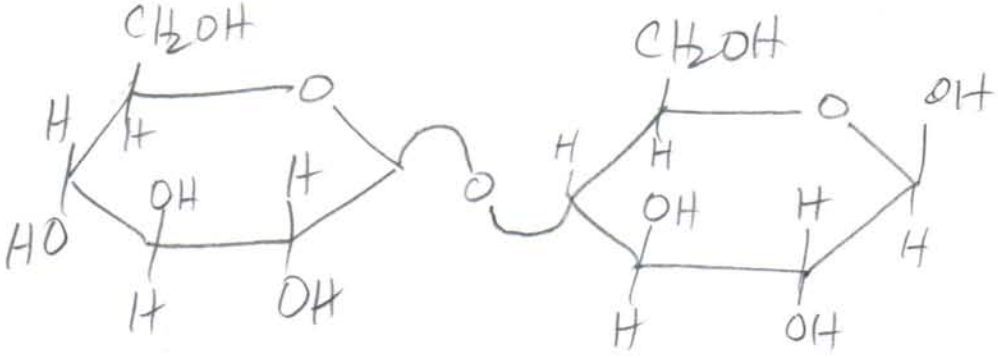



H. **CLEAG** acts as a **competitive** inhibitor of the enzyme. In the Lineweaver-Burk plot you drew above in G, draw and label a **second line** depicting how the inhibitor would cause the enzyme to act. Be sure to label both lines very clearly. (2 point)

2. Draw the Haworth projection for the following **dimers** of **glucose**: (6 points)

A. A β(1→4) linkage with both molecules of glucose in the β form.

B. Give the **common name** of the disaccharide that you drew in A and **name** the **polysaccharide** that is formed from these disaccharides?

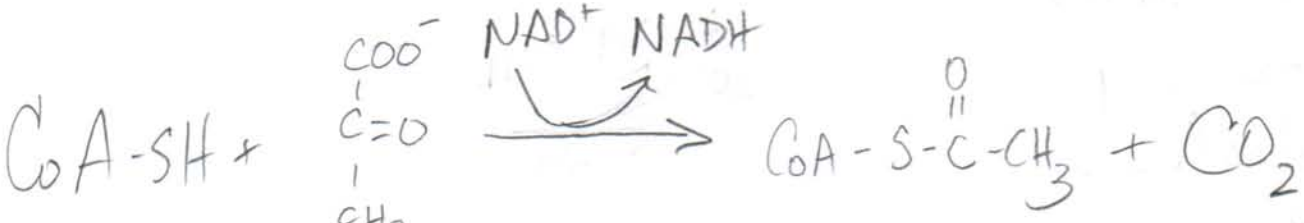


Common name = cellobiose

Polysaccharide = cellulose

**3. (8 points)**

A. Write out the major reaction performed by the **pyruvate dehydrogenase complex** in glucose metabolism. **NAME** and **DRAW** the structures of the **reactant and product**.




Pyruvate

Acetyl CoA

B. What energy rich co-factor/co-enzyme(s) does this reaction produce?

NADH

C. Is this a regulated enzyme?

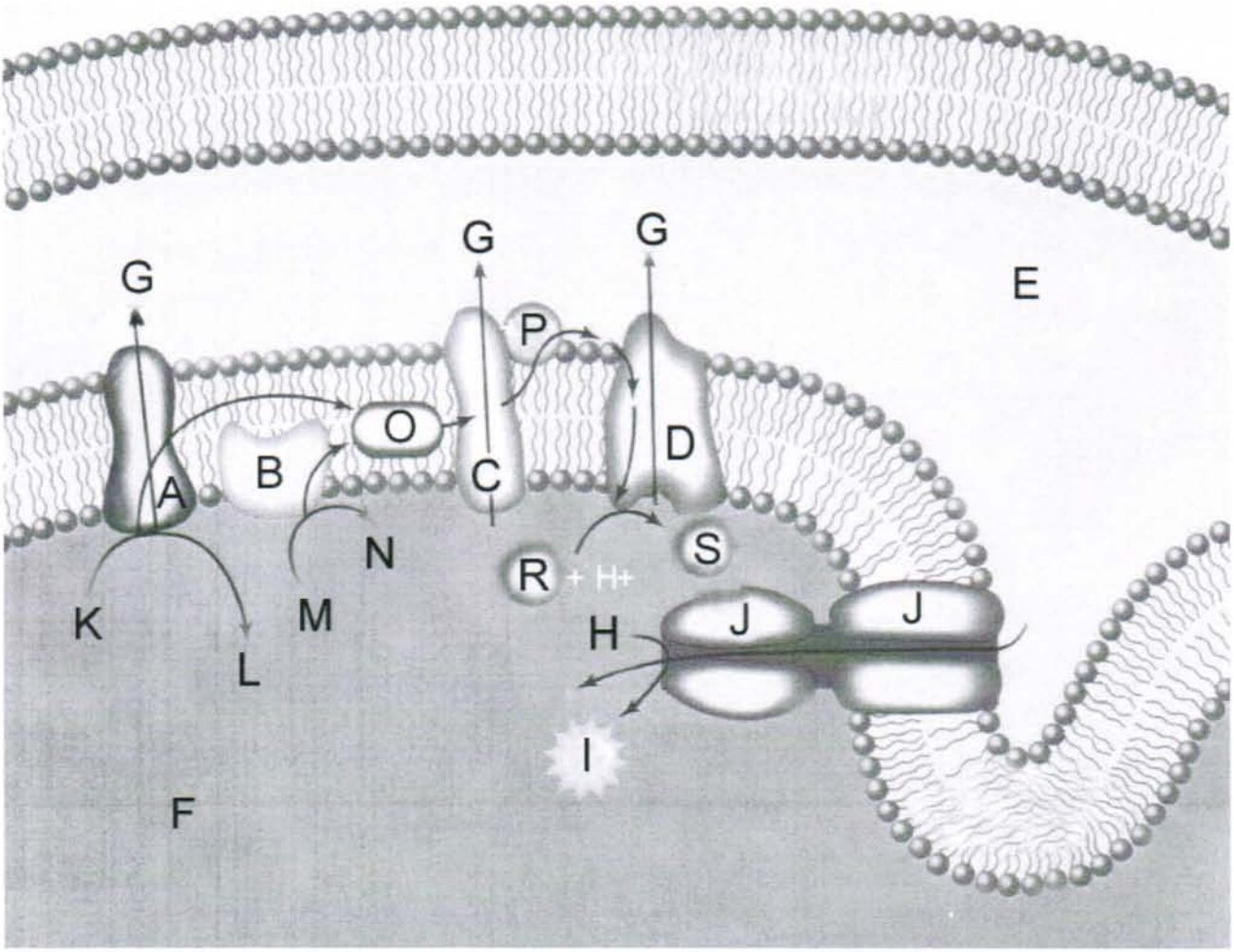
(YES) NO

4. This question relates to the **Figure** on **PAGE 9** –Use the following terms **ONLY** to answer the questions. Each term may be used more than once and some not used at all. (11 points)

| | | |
|---|---|---|
| Complex I | $FADH_2$ | Cytochrome C |
| Coenzyme Q (Q) | Oxygen | Mitochondrial matrix |
| Complex IV | Fumarate | ADP |
| ATP Synthase | Protons | Proton electrochemical gradient |
| Succinate | NADH | Complex II |
| FAD | $NAD^+$ | Complex III |
| ATP | Electrons | Oxidative Phosphorylation |
| Electron Transport | $H_2O$ | Mitochondrial intermembrane space |

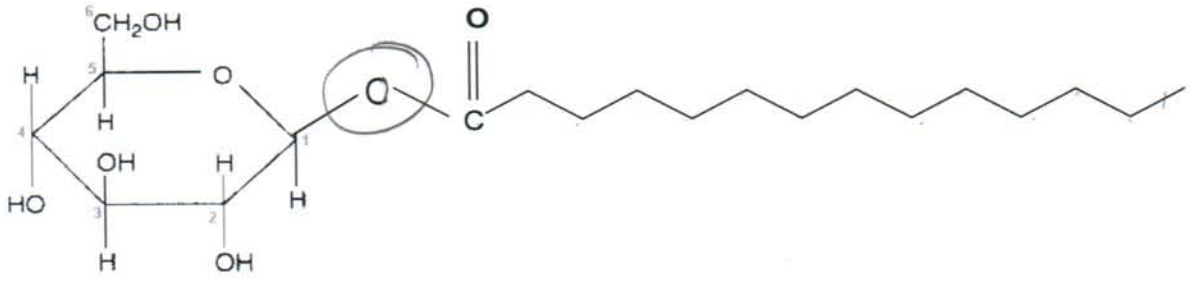
1. What **two** processes are illustrated in this diagram?
   Electron Transport & Oxidative Phosphorylation
2. What are the objects labeled **A, B, C, and D** that are embedded in the lipid bilayer?
   **A.** Complex I **B.** Complex II
   **C.** Complex III **D.** Complex IV
3. What are the subcellular compartments labeled **E and F** that are separated by the lipid bilayer membrane?
   **E.** Mitochondrial Intermembrane Space **F.** Mitochondrial Matrix
4. What is labeled by **G** that is pumped across the lipid bilayer membrane by A, C and D?
   **G.** Protons
5. What are the substances labeled H and I that are interconverted by J?
   **H.** ADP **I.** ATP
6. What is **J**, and where does J get the **energy** to make I?
   **J.** ATP Synthase **Energy Source:** Proton Electrochemical Gradient
7. What are the substances labeled **K and L** that are interconverted by **A**?
   **K.** NADH **L.** $NAD^+$
8. What are the substances labeled **M and N** that are interconverted by **B**?
   **M.** $FADH_2$ or succinate **N.** FAD or fumarate
9. What are the mobile molecules labeled **O and P**?
   **O.** Coenzyme Q **P.** Cytochrome C
10. What is the substance **R** that must be present for this entire process to proceed and what is it converted to as Substance **S**?
    **R.** Oxygen **S:** $H_2O$
11. The **arrows** connecting **A to O to C to P to D to R** represent the movement of Electrons.

**Figure For Question 4:**



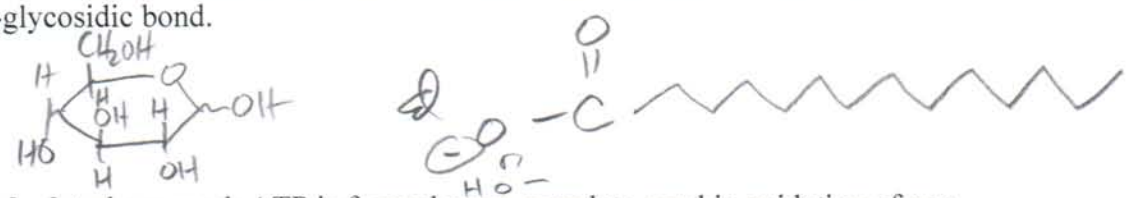
**5. A certain aerobic organism is able to metabolize the following glycolipid:**

(15 points)



A. Circle the **O-glycosidic** bond.

B. **Draw** the **2 resulting structures** that would occur upon initial **hydrolysis** of the O-glycosidic bond.



C. **Calculate** how much ATP is formed upon complete aerobic oxidation of one mole of the compound. Assume that no ATP is produced when one mole of the glycosidic bond in the above compound is hydrolyzed. Show ALL of your work!

1 mole glucose:

Glycolysis: 2 NADH → 5 ATP; 2 ATP → 2 ATP

PDH: 2 NADH → 5 ATP

TCA: 6 NADH → 15 ATP; 2 $FADH_2$ → 3 ATP; 2 ATP → 2 ATP

= 32 ATP

β-oxidation of 14:0

7 Acetyl-CoA → TCA = 70 ATP

6 NADH = 15 ATP

6 $FADH_2$ = 9 ATP

-2 ATP Act. -2 ATP

92

TOTAL = 92 + 32 = 124 ATP

D. **Calculate** how much ATP would be formed upon complete aerobic oxidation of one mole of the compound in the **presence** of an **inhibitor** of **isocitrate dehydrogenase**. Assume that no ATP is produced when one mole of the glycosidic bond in the above compound is hydrolyzed. Show ALL of your work!

Glucose

Glycolysis: 2 NADH = 5 ATP; 2 ATP = 2 ATP

PDH: 2 NADH = 5 ATP

TCA = Ø

12 ATP

14:0

7 Acetyl-CoA → TCA Ø

6 NADH = 15 ATP

6 $FADH_2$ = 9 ATP

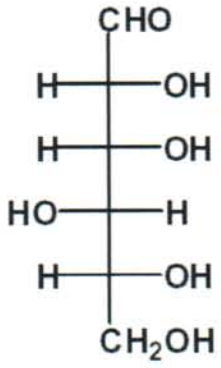
-2 ATP = -2 ATP

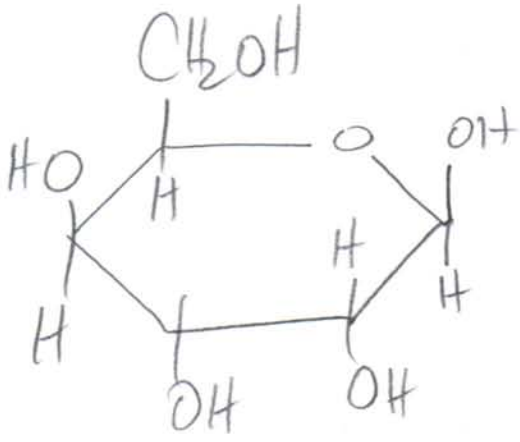
Activation

22 ATP

TOTAL: 34 ATP

6. Convert the following Fischer projection of the monosaccharide **D-gulose** to a Haworth projection with a 6-membered ring and the anomeric carbon in the β configuration. (5 points)




**D-gulose**

7. Generally how do the changes in the levels of the following energy compounds affect the activities of regulated enzymes in glycolysis, the TCA cycle and β-oxidation in a cell? (6 points)

**Use INCREASE, DECREASE or NO EFFECT**

↑ [ATP] Decrease

↓ [FAD] Decrease

↓ [NADH] Increase

8. **If you wanted to make 2L of a solution of 100 mM acetate buffer at pH 5.5, how many moles each of sodium acetate and acetic acid would you add? (10 points)**

$pH = pK_a + \log \frac{[A^-]}{[HA]}$

Acetic Acid $pK_a = 4.75$

HA = acetic acid

$A^-$ = acetate

$5.5 = 4.75 + \log \frac{[A^-]}{[HA]}$

Total moles $= (2L)\left(100 \frac{mmol}{L}\right)$

$= 200 mmol$ or 0.17 moles

$0.75 = \log \frac{[A^-]}{[HA]}$

$\frac{5.6}{1} = \frac{[A^-]}{[HA]}$

$\left(\frac{5.6}{6.6}\right)(200 mmol) = 170 mmol$ Na Acetate

$\left(\frac{1}{6.6}\right)(200 mmoles) = 30 mmol$ Acetic Acid

$0.030 mol$

9. Consider a mutant form of hemoglobin that has an **ionic interaction** between the side chains of **aspartic acid** 94 and **arginine** 146 in one subunit of hemoglobin.

Assuming all other conditions remain constant, would these changes **destabilize** or have **no effect** on this interaction and on protein structure. Why?

A. the arginine is changed to glutamate and the pH is 7.4 (2 points)

Destabilize – Changing a positively charged amino acid with a negatively charged one.

B. the arginine is changed to lysine and the pH is 7.4 (2 points)

No effect – Arg & Lys are both positively charged. Conservative mutation should not affect structure

C. the arginine is changed to isoleucine and the pH is 7.4 (2 points)

Destabilize – Changing a polar, charged amino acid with a hydrophobic amino acid

**10.** Match the concepts at the right with the aspect of protein structure at left with which they are most CLOSELY related. For example, use a "1" for Primary. ONLY ONE ANSWER PER LETTER. (8 points)

1. Primary
2. Secondary
3. Tertiary
4. Quaternary

a. 2 alpha helix

b. 2 beta sheet

c. 1 sequence of amino acids

d. 4 complex of two or more proteins

e. 3 overall shape of a monomeric protein

f. 1 dictates all other levels of protein structure

g. 3 includes arrangement of the side chains and prosthetic groups in a protein with only one subunit

h. 2 only describes the 3-dimensional structure of the peptide backbone

**11. EXTRA CREDIT (5 points) Answer here – not on scantron**

**1. Ethanol ($CH_3CH_2OH$) is the alcohol found in beverages. It is oxidized in the body to acetaldehyde by the enzyme alcohol dehydrogenase. Methanol ($CH_3OH$), also known as wood alcohol, is converted to formaldehyde by the same enzyme. Acetaldehyde is toxic, but formaldehyde is far more toxic to humans, which is why the ingestion of relatively small amounts of methanol can cause blindness or death. One treatment for mild methanol poisoning is the administration of ethanol. Why might a doctor choose this treatment? (2 points)**

A. Ethanol must act as a competitive inhibitor for the alcohol dehydrogenase and therefore slows the formation of formaldehyde.
B. Ethanol likely irreversibly binds to alcohol dehydrogenase which prevents the formation of formaldehyde.
C. The ethanol is likely an uncompetitive inhibitor and binds to a site other than the active site of the enzyme.
D. The doctor has given up on the patient and administers ethanol for sedation.
E. The ethanol converts the methanol to another compound

**2. Translate the following three letter amino acid code into the one letter amino acid code to reveal a sentence: (2 points)**

**LeuGluAlaArgAsnIleAsnGlySerCysIleGluAsnCysGluIleSerProHisAlaThr**

LEARNING SCIENCE IS PHAT

**3. What is the ONE most interesting new thing that you learned this semester? (1 point)**

Any answer OK here.