1. **Indicate the Chemical Characteristics of each amino acid <u>side chain</u> by placing an "X" in each box that applies.** Note that some amino acids may possess more than one characteristic. Assume a neutral pH of 7.

	Characteristics						Hair
Amino Acid	**Nonpolar**	**Polar**	**Negatively Charged**	**Positively Charged**	**Aromatic**	**Natural Abundance (%)**	**Abundance in Hair (%)**
D						5.4	4.2
T						5.3	6.1
S						6.5	9.5
E						6.8	9.1
P						4.7	6.1
G						7.1	5.0
A						8.3	3.4
V						6.9	4.1
C						1.4	14.8
M						2.4	0.3
I						6.0	1.9
L						9.7	4.9
Y						2.9	1.4
F						3.9	1.3
K						5.9	4.3
H						2.3	2.6
Other	N/A	N/A	N/A	N/A	N/A	5.5	21.4

2. The previous table indicates the relative abundance of amino acids in all natural proteins as compared to the proteins within human hair. Based on this list, answer the following:

a. When you wake up, your hair may be messy. You might fix this problem by wetting your hair. This solution is only temporary since by the next, your hair will probably be messy again. **What type of intermolecular interaction or intramolecular bond within your hair can you modify by wetting the hair fibers? Why is this temporary?**

b. When you get a perm at a hair salon [if you have straight hair], your hair is wrapped around small cylindrical rollers. The reducing reagent β-mecaptoethanol is applied to the hair fibers. Next, the reducing reagent is washed away, and your hair fibers are exposed to the oxidizing environment of our atmosphere. When removed from the cylindrical rollers, your hair fibers permanently curl with the curvature of the rollers. **What type of intermolecular interaction or intramolecular bond within your hair can you modify by applying a reducing reagent followed by an oxidizing atmosphere to the hair fibers? Why is this permanent?**

3. Imagine that you have just started a job at the Museum of Science and Industry! You are curating an exhibit on "**Where do proteins come from?"**. Write two sentences describing each of the following terms as text that might appear on plaques to accompany your displays.

a.) Transcription

b.) DNA replication

c.) Translation

Pick one of the terms from above. **Sketch a design for a museum display case geared for the general public that illustrates this term.**

4. Protein Purification

Imagine that you have prepared a crude lysate sample from *E.coli* cells that contains a mixture of six proteins (1, 2, 3, 4, 5, and β-galactosidase). Your goal is to obtain purified β-galactosidase. Below is a table of protein characteristics:

Protein	Concentration of ammonium sulfate (AS) required for precipitation	Molecular Weight (kDa)	Isoelectric point (pI)
1	45%	38	3.7
2	80%	22	4.8
3	65%	4	5.3
4	20%	75	6.8
5	30%	55	9.50
β-galactosidase	45%	115	5.3

You begin your purification by performing an ammonium sulfate (AS) precipitation. You add the appropriate concentration of AS to your crude lysate sample and centrifuge to generate a pellet (AS-P) and supernatant (AS-S).

a) What concentration of AS will you use to precipitate β-galactosidase?

b) After addition of that concentration of AS and centrifugation, which protein(s) will be in the pellet (AS-P)?

c) Which protein(s) will be in the supernatant (AS-S)?

d) After resuspending the AS-P in column buffer, you want to remove excess AS. Describe how to remove excess AS from a protein solution.

You decide to use a cation exchange column to purify β-galactosidase away from the other proteins in your de-salted AS-P sample.

e) What charge does the resin of a cation exchange column have?

f) At what pH will you apply the de-salted AS-P proteins to the cation exchange column if you want β-galactosidase to stick to the resin?

g) At the pH indicated in (f), which proteins from the de-salted AS-P will not stick to the cation exchange column and be removed (flushed through)?

h) At what pH will you elute β-galactosidase from the cation exchange column?

i) At the pH indicated in (h), which proteins from the de-salted AS-P will remain stuck to the cation exchange column.

5. Solution Preparation

Describe how to make 100 mL of 0.13 M glucose ($C_6H_{12}O_6$) solution.

Describe how to make 50 mL of 50 mM glucose from a 0.13 M glucose stock solution.

6. **Kinetics.** Imagine that you have discovered an enzyme where enzyme-substrate complex does not dissociate:

$$E + S \xrightarrow{k_1} ES \xrightarrow{k_{cat}} E + P \qquad \text{(Mechanism 1)}$$

Derive an expression for the initial rate in terms of rate constants (k_1 and k_{cat}), $[S]_{int}$, and $[E]_{tot}$. (Hint: While this mechanism is not that of Michailis-Menten your derivation can/should follow each step with one exception... do not try to include K_m). Show your work.

$$rate = \frac{d[P]}{dt} = ?$$

Based on you derived rate equation, which data set (A, B, or C) do you expect to observe? $[E]_{tot}$ is held constant for each series. Explain your reasoning.