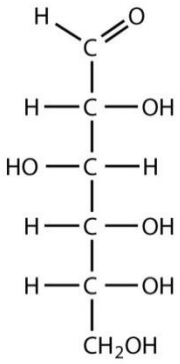
Name (Last, First): _____SAMPLE_____ ID Number: _____SAMPLE_____

Sample Questions for the Individual Round Exam

1. Glucose is the most basic sugar involved in human metabolism. Its structure is provided below:



a. The overall reaction of glucose metabolism is given below.

$$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$$

i. Provide average oxidation numbers of the following atoms in particular molecules.

Carbon in Glucose ($C_6H_{12}O_6$) _____
Oxygen in O_2 _____
Oxygen in CO_2 _____
Carbon in CO_2 _____

ii. Of the two reactants, which one is the reducing agent and which one is oxidizing agent? Clearly indicate which reactant corresponds to each.

(This question continues on the next page.)

iii. According to the American Heart Association, the maximum amount of added sugars the average person should digest in one day is 37.5 g. Assuming all of this sugar is in the form of glucose, how many electrons are transferred from the reducing agent to the oxidizing agent? Show all work to support your answer.

b. The first step of glucose metabolism is the phosphorylation (adding a phosphate group to a molecule) of glucose. In this reaction, glucose is reacted with adenosine triphosphate (a molecule that has 3 phosphate groups) to produce glucose – 6 – phosphate (glucose with 1 phosphate group replacing one of the –OH groups).

i. The net balanced equation for glucose phosphorylation is provided below. Given that ΔG for this reaction at 25 °C is 13.8 kJ/mol, determine K_c of the forward direction.

$$\text{Glucose} + \text{ATP} \rightleftarrows \text{ADP} + \text{Glucose} - 6 - \text{phosphate}$$

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ii. The ΔG value (given in the previous part) was determined at pH 7.0 and 25 °C. Given the following heats of formation, how many moles of glucose-6-phosphate are produced at 30 °C, if you start with 1 mole of glucose and 1 mole of ATP?

ΔH_f (Glucose) = -1268 kJ/mol
ΔH_f (ADP) = -2000 kJ/mol
ΔH_f (ATP) = -2982 kJ/mol
ΔH_f (Glucose-6-phosphate) = -780 kJ/mol

2. A salt is an ionic compound formed when a metal cation replaces the hydrogen atom of an acid.

a. Certain metals can be identified by a flame test in which the metal ions emit a specific color when they are heated. These colors are the result of excited electrons transitioning back to their stable ground state and releasing that energy in the form of light of a specific wavelength when these ions are heated. A chart of the flame test colors for specific metals is listed below. Which metal emits light of the highest energy? Justify your answer.

Metal	**Flame Color**
Sodium	Yellow
Calcium	Orange
Lithium	Red
Copper	Green
Lead	Blue

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b. The Electromagnetic radiation, like the light you see in a flame test, is composed of photons. Calculate the wavelength of a photon with energy of 2.098×10^{-19} J in nanometers. Then identify the color of the photon using the chart provided below.

Color	**Wavelength(nm)**
Red	700-635
Orange	635-590
Yellow	590-560
Green	560-520
Cyan	520-490
Blue	490-450
Purple	450-400

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c. By a process known as selective precipitation, ions in solution can be separated based on their solubility. An aqueous solution of lithium chloride (LiCl) is slowly added to another aqueous solution of 1.30×10^{-4} M barium ions, 9.80×10^{-2} M lead (II) ions, and 7.90×10^{-5} M copper (I) ions at $25\ ^{\circ}C$. Determine the order in which the three chloride salts will precipitate. The K_{sp} of these salts are provided below.

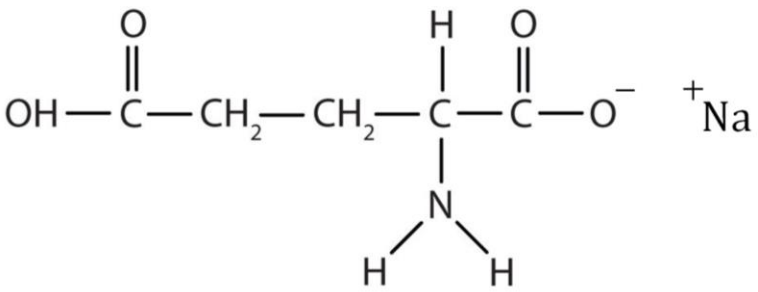
Salt	**K_{sp}**
Copper Chloride	1.70×10^{-7}
Barium Chloride	2.60×10^{-9}
Lead Chloride	1.20×10^{-5}

d. If the salt that precipitated out first in part c was dissolved in pure water, would the solution be acidic or basic? Explain your answer.

3. 5 out of 5 doctors recommend that humans should not consume Uranium, but rather recommend eating healthier foods such as apples or Broccoli. One substance with health effects that are much more controversial is monosodium glutamate, or as it is more commonly known, MSG. MSG is commonly used by people to add a savory flavor to foods, but people have gone as far call it a "silent killer".

a. Below is the structure of MSG. How many atoms are sp^3 hybridized? sp^2? sp?

Write your answer here: _____



b. What is the VSEPR predicted geometry around the nitrogen atom of the amine group ($-NH_2$)? How does the Carbon-Nitrogen-Hydrogen bond angle of the amine group compare to the Hydrogen-Carbon-Hydrogen bond angle of Methane (CH_4)? How do the electron domain geometries of the groups compare?

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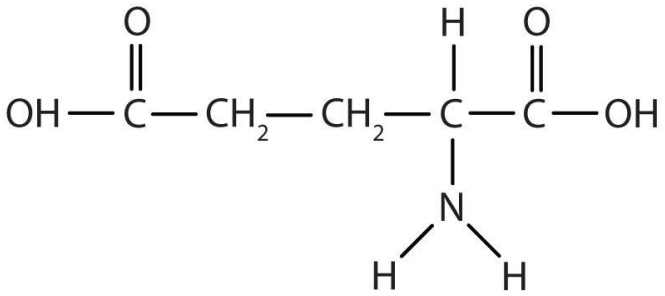
c. The reason MSG is an effective flavor enhancer is that it mimics the amino acid Glutamic Acid, and binds to similar receptors. Glutamic Acid is released from the breakdown of meat. The structure is shown below. Under physiological conditions, the carboxylic acid group on the right deprotonates. Why is MSG able to effectively activate glutamate receptors? Explain below.



d. Name the general reaction type by which glutamate is converted into monosodium glutamate.

e. If equimolar amounts of MSG and glutamate were placed into separate glasses each containing equal amounts of water, which solution would have the higher boiling point?