Name (Last, First): _____**SAMPLE QUESTIONS**_____ ID Number: _____**SAMPLE**_____

Sample Questions for the Chemistry of Coffee Topic Test

1. During the 2013 Barista Championship, one of the contestants used a distillation apparatus to deliver a "distilled coffee" product as his specialty drink. In chemistry, distillation is traditionally used to separate compounds by boiling point.

a. This Barista first brewed coffee normally and then collected the first distillate as his flavorful product for the judges. If caffeine has a boiling point of 178°C, would the drink served to the judges contain any caffeine?

Circle your answer below and justify your response on the lines below in 3 sentences or fewer.

(Circle One): **YES** **NO**

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b. If the barista had first added sugar to the coffee before putting it through the distillation apparatus, would the judges have to wait a shorter or longer time to get their first taste of his drink? Explain your reasoning, making sure to discuss the nature of sugar as a solute.

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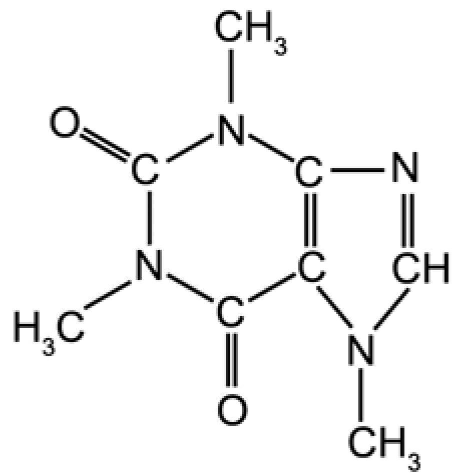
c. Given the caffeine molecule below, which type of **<u>intermolecular</u>** interactions contribute most to its high boiling point? Please circle a part of the molecule where these interactions would occur in an aqueous environment and explain your answer in 1 sentence on the lines provided below.



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2. Caffeine metabolism follows first-order kinetics. Studies have shown that the half-life of caffeine in the body of a healthy adult is 6 hours. On average, a person can only fall asleep when the amount of caffeine drops below 2.5 mg per kg of body mass.

a. There are two major varieties of coffee beans, arabica and robusta. Arabica is the better tasting, more expensive variety, and robusta is hardier and has higher caffeine content. A cup of robusta coffee contains 650 mg of caffeine. If Over-caffeinated Oscar consumes one 12 oz. cup of this coffee at 8:00 A.M., how many mg of caffeine will remain in his body at 3:30 P.M.? Show all work to support your answer.

Hint: For first-order kinetics, if $[\mathrm{A}]_t$ is the amount of substance A at a time t, and $[\mathrm{A}]_0$ is the initial amount of substance A, then the following equation applies:

$$\ln[\mathrm{A}]_t = \ln[\mathrm{A}]_0 - \mathrm{kt} \text{ , where k is a constant}$$

b. How long (in hours) after drinking the cup of robusta coffee will Oscar finally be able to fall asleep? Oscar has a mass of 85 kg. Assume the caffeine is evenly distributed in his body. Show all work to support your answer.

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c. 2 grams of caffeine is considered dangerous. If a person were to consume one cup of robusta coffee every hour, with the first cup being consumed at $t = 0$ hours, how long (in hours) will it take for the level of caffeine in the body to first exceed 2 grams? Show all work to support your answer.

d. After this point, the person continues to drink one cup per hour. Will the total amount of caffeine ever drop below 2 grams again? Justify your response below.

3. It has been said that there is a time and a place for decaffeinated coffee-- never and in the trash.

a. One method of decaffeinating coffee beans is called the Swiss Water Process. It involves soaking a batch of fresh coffee beans in very hot water to extract all the caffeine, oils, and flavorful molecules. The caffeine is selectively removed from the mixture, and the mixture is heated with another fresh batch of coffee beans. Use solubility principles to explain on the lines provided why this will result in decaffeination of the second batch of beans without a huge loss of oils and flavor molecules.

b. It would be unacceptable to just throw all of that caffeine away, so let's further investigate how we might be able to isolate/purify the caffeine into a useful form. The first step to separating the caffeine from the rest of the solution is to convert it from its protonated form to its neutral form. Should we use an acid or a base to accomplish this? Circle your response and justify it on the lines provided in 2 sentences or fewer:

(Circle One): **ACID** **BASE**

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c. Now, choose a solvent that will selectively dissolve the caffeine and allow us to separate it from the aqueous solution by forming 2 distinct layers. Circle your response and justify it on the lines provided in 3 sentences or fewer, focusing on the role of intermolecular forces.

(Circle One): **H_2O (water)** **CH3CH_2OH (ethanol)** **CH_2Cl_2 (dichloromethane)**

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d. Once we separate the two solvents from one another, we still need to figure out a way to isolate our caffeine crystals from the solvent. One method to do this is through distillation. Suppose, however, that you want to speed up the process or avoid exposing the caffeine to heat. How could you accomplish this? Hint: think about the definition of boiling or how we can manipulate the boiling point of a substance.

e. In part c we mentioned that CH_2Cl_2 might be useful in the decaffeination process. Say that Jim has a supply of methane and chlorine gases, and he wants to synthesize dichloromethane. Write a balanced overall reaction for this synthesis. Hint: Jim will need a good way to deal with formation of a strong acid.

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f. Ethyl acetate, $CH_3CO_2C_2H_5$, is another compound commonly used in decaffeination. 30 grams of ethyl acetate are combusted in excess oxygen. Assume the reaction goes to completion. If all products of the combustion are isolated, how many liters of gas are present when the product mixture is at 120 ºC and 1 atm? Assume ideal gas behavior. Show all work to support your answer.