1. 4 points All parts of this question pertain to the reaction drawn below.

\[
\text{O} \quad \text{Na} + \quad \text{Br}\quad \rightarrow \quad \text{O} \quad \text{Na} + \quad \text{Br}
\]

Briefly (using only the space provided and writing legibly) describe how the phase transfer catalyst works and why it is critical to the success of the reaction. You may use diagrams and/or reaction equations for part of your answer. It is OK to abbreviate the benzene ring as Ph.

Suppose that 2.02 g of sodium benzoate (MW=144) and 1.72 g of 1-bromobutane (MW=137, d=1.27 g/mL) were used in the reaction and that 1.77 g of butyl benzoate (MW=178, d=1.00 g/mL) was obtained. Determine the limiting reagent (a), and calculate the theoretical yield (b) and experimental percent yield (c). Show work with units and circle or box or underline the final answer for the three items requested in the previous sentence.

2. 2 point What is the biggest safety concern with using diethyl ether in the Chem 21 lab?

3. 1 point What is wrong with the following statement concerning the experiment in which the components of an analgesic tablet were separated by column chromatography? “The low yield of caffeine in the column chromatography is due to its significant solubility in water.”
4. 4 points The reaction below forms a pair of enantiomers. The product mixture is recrystallized using a mixed-solvent recrystallization during which it is dissolved in a minimum amount of warm ethanol, water is added until the solution just turns cloudy, and then ethanol is added until it just clears up. The solution is then allowed to cool as per the usual recrystallization protocol.

\[
\text{Ph-CH(OH)-C} + \text{Br}_2 \rightarrow \text{Ph-CH(OH)-C-Br}_2
\]

a. Why is it important to use warm, as opposed to room temperature, solvents for the recrystallization?

b. What would be a suitable solvent for washing the crystals during the filtration? Why?

c. Should the crystals be stored until the next lab period in a covered or uncovered container? Why?

d. The melting point of the enantiomeric pair mixture is lower than that of either enantiomer. Why?

5. 2 points The relationship between solubility and temperature for a given compound in three different solvents (A, B, and C) is shown in the graph below. Based solely on this information, which solvent would be the best choice for recrystallizing the compound? Briefly justify your choice.
6. 3 points Suppose that the E2 reaction below was done using two different bases, potassium tert-butoxide and sodium methoxide, and that the resulting product mixture was analyzed by gas chromatography with the results shown below the reaction.

\[
\begin{align*}
\text{Br} \quad \text{Base, } \Delta & \quad \Rightarrow \quad \text{bp 96°C} \quad + \quad \text{bp 85°C}
\end{align*}
\]

Unfortunately, the person who did the GC analysis forgot to mark each GC graph with the base used. Label each GC graph above with the base that was used and briefly justify your choices.

Sketch a graph of the GC that might be obtained if the reaction was done using potassium tert-butoxide that had been left for some time with its lid off. Briefly explain why you drew what you did.

7. 3.3 points Provide the name for each of the following pieces of equipment. If you can’t remember the name then describe or name the lab procedure that for which it’s used. Drawings are not to relative scale.
8. 1.6 point A mixture containing substances X and Y was separated into four fractions using column chromatography. Thin-layer chromatography was used to analyze the four fractions as well as pure samples of X and Y with the results shown below.

a. Which fraction(s) should be used to isolate pure Y? __________

b. Which fraction(s) should be used to isolate pure X? __________

![Graph showing fractions X, Y, 1, 2, 3, 4]

9. 2.1 points The following graphs of temperature vs. volume collected were obtained during a fractional and a simple distillation of hexane and octane. Label each graph with the name of the type of distillation. On the fractional distillation graph indicate and label the areas where pure hexane and pure octane are being collected.

![Fractional distillation graph]

![Simple distillation graph]

10. 2 points Suppose that a mixture of aspirin and caffeine (structures below) is dissolved in diethyl ether, the resulting solution is poured into a vessel suitable for an extraction, and aqueous KOH is added. Assuming that enough KOH is added to react with anything that’s going to react with it, draw the structures of the species present in each layer. The density of diethyl ether, CH₃CH₂OCH₂CH₃, is less than the density of water.

![Aspirin structure]  ![Caffeine structure]  [pKₐ 3.5]

The upper layer:  The lower layer: