Acid, Alcohol and catalytic amount of concentrated sulfuric acid were placed in a flask equipped with reflux condenser and drying tube. The reaction mixture was heated to reflux in sand bath that was preheated to 90°C. After 90 minutes the reaction mixture was cooled to room temperature and the condenser was removed. 20 ml of saturated NaHCO₃ solution was added and then the reaction mixture was heated for additional 20 minutes at 80°C. The residue was diluted with 20 ml CH₂Cl₂ and the aqueous layer was separated. The organic layer was dried over Na₂SO₄ and the solvent was evaporated to give pure ester.

a. Complete the chemical equation.

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  \[ \text{Benzenedicarboxylic acid} + \text{CH}_3\text{OH} \xrightarrow{\text{H}_2\text{SO}_4} \text{ester} \]
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b. Calculate how many moles of methyl alcohol were used.

c. What did the drying tube contain and why?

__________________________________________________________________

d. What was the temperature inside the reaction flask? _____________

e. Why was NaHCO₃ added? _______________________________________

f. What was observed when the NaHCO₃ solution was added? ________________
g. Why was the reaction mixture heated again? _____________________________

h. What did the aqueous layer contain? Draw chemical formula.

2. Answer the following questions using the provided vapor–liquid phase diagram (for liquids A and B).

   a. (4 pt.) Mark the area where only vapor exists with the letter V.
   b. (4 pt.) The boiling point of pure solution of A is _______.
   c. (5 pt.) When a solution containing 1:1 ratio of A and B is boiling, the vapor contains ______ mole fraction of A.
   d. (6 pt.) You have a mixture containing 0.8 mole fraction of B. How many evaporation-condensation cycles are required to obtain a solution containing 0.65 mole fraction of A? ______ Show your work on the graph.
3. A student was trying to identify an unknown solid compound. He measured the melting point and then dissolved 20 mg of the unknown in acetone. He used the solution to carry out Jones test and got a negative result. Then he tested the solution with 2,4-DNP and he observed an orange precipitate. The student concluded that the unknown is a ketone. To his surprise, he got zero for his lab report.

a. What is Jones reagent?

b. What was wrong? Provide a short explanation.

4. Complete the arrow pushing and missing charges (if needed) for this step in the reaction between acetaldehyde and 2,4 DNP:
5.
I. Which of the following solvents will not form two layers when mixed with water?
   a. Ethyl acetate
   b. 1-octanol
   c. hexane
   d. 2-methyl-2 propanol

II. The following scheme describes a medieval chemical apparatus.

   ![Image of medieval chemical apparatus]

   This apparatus is equivalent to:
   a. fractionating column
   b. GC column
   c. Separatory funnel
   d. Hot filtration

III. Which of the following materials can be used for making IR windows?
   a. polished glass
   b. calcium fluoride
   c. polyethylene
   d. condensed silica gel

IV. Which of the following solvents has the lowest polarity?
   a. MTBE
   b. Ethyl acetate
   c. CO₂
   d. Diethyl ether
7. (16 pt.)
   a. The structure of MTBE is:

   b. The product that is formed when \( \text{CH}_3\text{CCH}_2\text{OH} \) is reacted with Lucas reagent is:

   c. Draw the chemical structure that corresponds to the yellow precipitate which is indicative of positive iodoform reaction.

   d. Circle the molecule that have the lowest R_f value on silica gel.