Experiment: The Production of Esters

Problem: To study the method for making esters and to observe their properties.

Introduction: The reaction of an organic acid with an alcohol produces an ester and water. Many esters are pleasant smelling and are responsible for the fragrance of many fruits and flowers. In this activity you will prepare several esters and compare their odour with those of the starting materials. This is accomplished by pouring the reaction mixtures into cold water. The polar acids and alcohols that have not reacted will dissolve in the water while the less polar esters will float on the surface where their odours are more easily detected.

Apparatus: 400 mL beaker 4 test tubes evaporating dish heating apparatus

Procedure:

1. Heat 250 mL of water in a 400 mL beaker to boiling, then reduce the heat to maintain a gentle boil. While the water is being heated prepare and label 4 clean, dry test tubes A, B, C, D.
2. In both A and B place 10 drops of ethanol and 10 drops of acetic acid. In C place 10 drops of iso-amyl alcohol (3 –methyl-1-butanol) and 10 drops of acetic acid. In D place about 1 cm of salicylic acid and add 3 mL of methanol. Place 3 drops of sulphuric acid in B and C, and 5 drops in D. Describe the odour of each test tube.
3. Place all four test tubes in the boiling water for 5 min.
4. Half fill an evaporating dish with cold water. Pour the contents of test tube A into the cold water and describe the odour and its strength Then clean out the evaporating dish.
5. Repeat step #4 with each of the remaining test tubes.

Questions:

1. Write equations using structural formulas and stating names for all reactants and products in the test tubes labeled B, C, and D. (Note that sulphuric acid is used as a catalyst and need not appear in the reaction.)
2. In what way do the odours from A and B differ? Why would they differ?
3. On the basis of this experiment suggest a likely commercial use for two of the esters you made.

Extra Questions

1. What is the percentage composition by mass of a) ammonia b) glucose $C_6H_{12}O_6$?

2. Given $CH_3CH_2CH_2CH_3 + Br_2 \rightarrow CH_3CHBrCH_2CH_3 + HBr$

a)If one mole of butane reacts with one mole of bromine to produce 0.65 moles of 2-bromobutane what is the theoretical yield of 2-bromobutane in grams and the percentage yield of 2-bromobutane?

b)If one mole of butane reacts with 0.5 moles of bromine to produce 0.2 moles of 2-bromobutane what is the theoretical yield of 2-bromobutane in grams and the percentage yield of 2-bromobutane?

3. Adrenaline is 56.8% C, 6.5% H, 28.4% O and 8.28% N by mass. Find the empirical formula.

4. A chemist new to the behaviour of chlorine with hydrocarbons tried to make dichloromethane (CH_2Cl_2) by mixing 0.25 moles of chloromethane (CH3Cl) and 0.25 moles of chlorine (Cl_2) expecting the following reaction:

$$CH_3Cl + Cl_2 \rightarrow CH_2Cl_2 + HCl$$

Inevitably some chloroform ($CHCl_3$) and carbon tetrachloride (CCl_4) formed along with CH_2Cl_2. Also some CH_3Cl remained unchanged. When the mixture of products was separated a yield of 12.8g of dichloromethane was obtained. Calculate the percentage yield of dichloromethane. (Ans =60.4%)

5. It was found that 500 mL of an unknown gas had a mass of 3.00g at 20'C and 95kPa. Further analysis showed the gas was 86% C and 14% H by mass. Find the molecular formula. (Ans = $C_{11}H_{22}$)

6. A solution of Br_2 in CCl_4 is 0.08 mol/L. What volume of this solution will react with 0.196g of 3-methyl-2-hexene? (Ans = 25 mL)

7. Analysis revealed 40.7% C, 8.5% H, 23.7% N and the remainder oxygen for an organic compound. When vapourized 0.25 g of the compound gave 52.3 mL of gas at 98.6 kPa and 20'C. Find the molar mass of the compound. (Ans = 118.1 g/mol)

8. When a hydrocarbon is burned the carbon dioxide's mass is 1.83 times as much as the water formed. Assuming complete combustion find the molecular formula of the hydrocarbon. (Ans = C_3H_8)

9. When 32.0 mL of benzene is reacted with 79.9g of liquid bromine 30.0g of bromobenzene is formed.
   a) Find theoretical yield of bromobenzene. (Ans = 56.6g)
   b) What is the percentage yield? (Ans = 52.2%)

Note: the density o liquid benzene is 879 kg/m^3

10. When 0.601 g of an organic compound with the empirical formula CH_2O is vapourized at 200'C and 101.3 kPa the gas volume is 388 mL. This same volume is occupied by ethane under the same conditions.
    a) What is the molecular formula of the compound? (Ans = $C_2H_4O_2$)
    b) If 1 mol of the same compound reacts slowly with Zn to yield 0.5 mol $H_{2(g)}$ what is the compound's name and structural formula? (ethanoic acid CH3COOH)

11. A 100 mg sample of a compound containing C, H, and O was found to give 149 mg of CO_2 and 45.5 mg of H_2O when burned completely. Find the empirical formula. (Ans = $C_2H_3O_2$)

12. What mass of ethanol can be made by reacting NaOH (aq) with 50 g of bromoethane? What assumption is made in this calculation? (Ans = 21.12g)

Organic Problems Assignment

1. Write chemical equations for the following:
   a) 2,2-dimethyl-1-propanol reacting with butanoic acid
   b) 2,2,3-trimethyl pentane (the "octane" in gasoline) burning completely in air
   c) hydroidic acid reacting with 1-butene
   d) the formation of N-ethyl ethanamide from ethanol and any inorganic reagents (not just one reaction)

2. A sample of liquid consisting of only C, H, and O has a mass of 0.5438g. This sample was burned in pure oxygen with the release of 1.039g of CO_2 and 0.639g of H_2O. What is the empirical formula of the compound?

3. When 1 mole of a hydrocarbon is burned, the carbon dioxide released has a mass equal to 2.09524 times the mass of the water released. Assuming complete combustion, what is the formula for the hydrocarbon?

4. One mole of NaCN reacts with one mole of bromoethane to form 45g of cyanoethane.
   a) What is the theoretical yield of cyanoethane in grams?
   b) What is the percentage yield of cyanoethane?
   c) Given 8.53g of NaCN and 10.98g of bromoethane and taking into account the percentage yield, find the volume of liquid cyanoethane (C_2H_5CN) produced? (d=0.783 g/mL).

5. When 1.202g of an organic compound with empirical formula $C_3H_6O_2$ is vapourized at 673 ° C and at 2 atm pressure, the gas volume is 630.5 mL.
   a) What is the molecular formula of the compound?
   b) If one mole of the same compound reacts slowly with Zn to yield 0.5 mol of $H_{2(g)}$, what is the compound's name and structural formula? R= 0.08206 $L*atm*k^{-1}*mol^{-1}$

6. Sodium hydroxide reacts with bromoethane to give ethanol. If the percentage yield for this reaction is 72%, what mass of ethanol can be made by reacting $NaOH_{(ag)}$ with 85 g of bromoethane? (bromoethane is the limiting reagent)

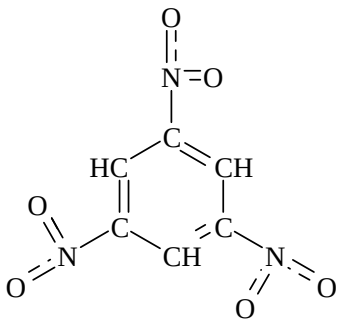
7. 20 mL of a Br_2 (solute) solution in CCl_4 (solvent) reacts with 0.23g of 4-methyl-2-heptene. What is the concentration of Br_2 solution?

8. The motor of an airplane is equipped with a condenser so that all of the steam formed during the complete combustion of fuel can be used on board while the CO_2 is released (into the atmosphere, increasing the CO_2 concentration there, thus increasing the greenhouse effect, inevitably destroying all life on earth). Will the airplane gain or lose mass? Calculate the gain or loss per 50 kg of 2,2,4-trimethylpentane fuel burned.

9. Analysis of an organic compound revealed % O = 36.36, %C = 27.27 , %N = 31.82 and the rest hydrogen. When vapourized a 0.4 g sample of the compound gave 139.13 mL at 100°C and 1 atm pressure. Find the molecular formula of the compound.

10. Name:

a)



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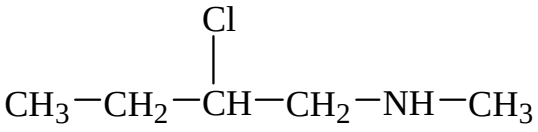

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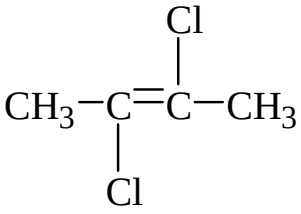
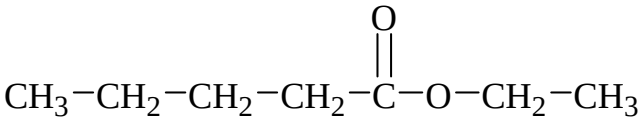


d)



e) Write the equations using structural formula for:

i) 2-hexyne + 1 mole of $H_{2\,(g)}$

ii) benzoic acid + ethanol

iii) oxidation of butanal

iv) 2-pentene + HCl