Datalogging experiment (4)

Datalogging Experiment (4) Acid-base Titration using Method of Double Indicators Student Handout Purposes To determine the composition of the following mixture by double indicator method: 1. NaOH(aq) and Na2CO3(aq) 2. NaHCO3(aq) and Na2CO3(aq) Introduction Consider a mixture of NaOH(aq) and Na2CO3(aq). Reaction between HCl(aq) and Na2CO3(aq) takes place in two stages: HCl(aq) + Na2CO3(aq) âŽ¯â†’ NaHCO3(aq) + H2O(l) ..... (1) HCl(aq) + NaHCO3(aq) âŽ¯â†’ NaCl(aq) + CO2(g) + H2O(l) ..... (2) While that between HCl(aq) and NaOH(aq) completes in only one step: HCl(aq) + NaOH(aq) âŽ¯â†’ NaCl(aq) + H2O(l) .... (3) Solution mixture of reaction (1) at the equivalence point is alkaline, that of reaction (2) is acidic and that of reaction (3) is neutral. Thus the whole titration should have three breaks in the pH curve, corresponding to the above three stages. Reactions (1) and (3) can be indicated by phenolphthalein and that of reaction (2) can be indicated by methyl orange. Stoichiometry confines each of the above pH reactions to react according to a mole ratio of 1 : 1. This means, say from equation (2), the number of mole of HCl(aq) determined from the methyl orange titration is equal to the number of mole of NaHCO3(aq). Likewise, total number of moles of NaOH(aq) and Na2CO3(aq) in the solution mixture can be calculated according to the volumes of HCl(aq) added at the end point Vol. of HCl indicated by the colour change of the phenolphthalein indicator. Alternatively, the Fig. 1: Titration curve for a mixture of three break points (see Fig. 1) also indicate NaOH(aq) and Na2CO3(aq) with HCl(aq) the volume of HCl(aq) required for each reaction. 49 Datalogging Experiment (4) For the titration of a mixture of NaHCO3(aq) pH and Na2CO3(aq) with HCl(aq), only two break points are expected (see Fig. 2). Volume of HCl(aq) added for each

break point can be easily obtained by observing either the colour change at the end point or the shape of the titration curve. Vol of HCl Fig. 2: Titration curve for a mixture of NaHCO3(aq) and Na2CO3(aq) with HCl(aq) Safety Avoid skin contact with chemicals. Any acid or alkali spilt should be thoroughly washed with tap water. Materials and Apparatus Phenolphthalein indicator, methyl orange indicator FLAMMABLE EYE PROTECTION MUST BE WORN Standard 0. 15 M and 0. 2 M HCl(aq), a mixture of NaOH(aq) and Na2CO3(aq), a mixture of NaHCO3(aq) and Na2CO3(aq), deionised water, a datalogger with pH sensor, computer, magnetic stirrer, small beaker, burette and pipette, stand and burette clamp. Experimental Procedures Part A: Titration of a mixture of NaOH(aq) and Na2CO3(aq) with 0. 15 M HCl(aq) using phenolphthalein indicator followed by methyl orange indicator 1. 2. Set up the interface box and connect it to the computer. Arrange the setup for pH determination. The pH sensor should be calibrated before use. Pipette 25 cm3 of the solution mixture into a small beaker and add 2 drops of phenolphthalein indicator. Place a stirrer bar into the alkaline solution and rest the beaker on a magnetic stirrer which is covered by a white tile. Switch on the magnetic stirrer. Lower the pH electrode into the alkaline solution, ensuring that the glass bulb is completely immersed while the stirrer bar is spinning smoothly (see Fig. 3). Fig. 3: Setup for pH datalogging 50 Datalogging Experiment (4) 3. Start the datalogging software and select the pH sensor with graph display screen format. Set the pH value limits from 0 to 13. The logging mode is set to manual operation with readings taken for each cm3 addition of the titrant. Fill the burette with 0. 15 M HCl(aq). Turn the stopcock of the burette open and start recording at the same time. When approaching the first end point, as judged by the rate of disappearance of

the red colour of the solution in the beaker, adjust interval additions each to 0. 50 cm3. Allow time for the evolution of CO2 gas bubbles as their presence round the glass bulb of the electrode may interfere with pH measurements. Observe the colour change of the reaction mixture and the pH values displayed on the computer screen carefully when the titration passes the first end point. Add 3 drops of methyl orange indicator when the reaction mixture becomes colourless. Look for the second end point and continue titration as in step (4) until a total volume of 50 cm3 of the titrant has been added. Save the data file. Carefully empty the contents of the beaker, pay special attention to retain the small stirrer bar. Clean the pH electrode with deionised water. 4. 5. 6. 7. 8. Part B 9. As described above, titrate a mixture of NaHCO3(aq) and Na2CO3(aq) with 0. 20 M HCl(aq) using phenolphthalein indicator followed by methyl orange indicator. Results Table A Phenolphthalein indicator Final burette reading/cm3 Initial burette reading/cm3 Volume of 0. 15 M HCl used/cm3 Table B Phenolphthalein indicator Final burette reading/cm3 Initial burette reading/cm3 Volume of 0. 20 M HCl used/cm3 Methyl orange indicator Methyl orange indicator 51 Datalogging Experiment (4) Treatment of Data Part A 1. From the methyl orange end point, calculate the number of moles of 0. 15 M HCl(aq) added and hence the number of moles of Na2CO3(aq) in 25 cm3 of the alkaline solution mixture. From the phenolphthalein end point, calculate the number of moles of 0. 15 M HCl(aq) added and hence the total number of moles of NaOH(aq) and Na2CO3(aq) in 25 cm3 of the solution mixture. Calculate the number of mole of NaOH(aq) in 25 cm3 of the solution mixture. Calculate the mass of Na2CO3 and NaOH in 1 dm3 of the solution mixture respectively. 2. 3. 4. Part B 1. From the methyl orange end point, calculate the number of

moles of 0. 2 M HCl(aq) added and hence the number of moles of Na2CO3(aq) in 25 cm3 of the solution mixture. From the phenolphthalein end point, calculate the number of moles of 0. 2 M HCl(aq) added and hence the number of moles of NaHCO3(aq) in 25 cm3 of the solution mixture. Calculate the mass of Na2CO3 and that of NaHCO3 in 1 dm3 of the solution mixture. 2. 3. Discussion Questions 1. 2. Suggest other indicators that can be used in place of methyl orange and phenolphthalein. Explain. Can the same method be applied to determine the concentrations of Na3PO4(aq) and NaH2PO4(aq) in a solution mixture of the two salts? What factors should be considered? 52