Chemistry ia enthalpy change of neutralisation assignment

To calculate the enthalpy change of neutrallzatlon of the given pairs of acid and base. Theory: When alkali neutralizes an acid, a salt and water are formed. Aqueous hydrogen ions, $H^+(aq)$ from the acid react with the hydroxide ions, $OH^-(aq)$ from the alkali, forming water. Ionic equation: (aq) +OH^- (aq) "+ H_2O (l) The Identity of the salt will depend on the nature of the acid and alkali used. The combination of H* and OH- Ions In this way releases energy. In this practical, the enthalpy changes accompanying different neutralization reactions will be measured.

It is because the number of moles of water formed varies according to the acid and alkali used, it is the convention to measure enthalpy change of neutralization In kJ mol-l when 1 mole of water is formed. We will use a simple calorimeter to determine the enthalpy change of neutralization for the pairs of acid and base given. Apparatus and Materials: 1. 0mol dm-3 sodium hydroxide solution, 1. 0 mol dm-3 hydrochloric acid, 1. 0 mol dm-3 ethanoic acid, polystyrene cup with Ild, thermometer, two 50. 00cm3 measuring cylinders, stopwatch, three 80cm3 beakers, dropper Variables: Manipulated variable: Type of acids used

In this experiment, type of acids used would be manipulating variable. Different acids such as HCI or CH3COOH are added to NaOH respectively and measure the increase in temperature respectively. Responding variable: Temperature, T Responding variable will be the temperature. First, we have to measure and record the initial temperature of the sodium hydroxide solution. After acid has been added, Controlled variable: Concentration of sodium hydroxide In this experiment, variables that have to be kept constant will be the factors that will affect the exothermic neutralization reaction.

Thus, concentration of sodium ydroxide has to be kept constant. This is to make sure the number of moles of hydroxide ions OH- reacts with H+ remains constant, so as to determine the concentration of the acids. Diagram: Thermometer Cover Polystyrene cup 25. 0 crn3 HCl Diagram 1: Set-up of the apparatus Safety and Precaution Steps: 1 . Always wear an apron and goggles in the lab. 2. Acids are corrosive; make sure that gloves are worn throughout the experiment. Procedure: 1 . Measure 25. 0 cm3 of the hydrochloric acid using a 50. 0 cm3 measuring cylinder into a polystyrene cup. Record its temperature for 3 minutes at 1 minute intervals.

This is the initial temperature. 2. Put 25. 0 cm3 of sodium hydroxide solution in a 50. 0cm3 measuring cylinder. (Ensure that the temperature of the sodium hydroxide solution is the same as the acid). Now pour this into the acid, stir and take the temperature. 3. Record the temperature of the solution at every 1 minute interval, until there is at least 20C temperature change after the maximum temperature has been attained. 4. Tabulate the results appropriately. 5. Repeat the experiment (steps 1-4) with ethanoic acid. Results: Raw Data: t/ min???? O. 002 min I I T/ oc???? 0. 50c 0. 000 1. 000 2. 000 3. 000 . 00 5. 000 6. 000 7. 000 8. 000 9. 000 10. 000 | 29. 0 | 36. 0 | 35. 5 | 35. 0 | 34. 5 | 34. 0 | 33. 5 HCl is used I Ethanoic acid is used I I T/0C???? 0. 50C I | 28. 0 | 33. 0 | 32. 5 Concentration of NaOH used = 1. 00 mol dm-3 Volume of NaOH used = 25. 0???? 0. 5 mol dm-3 Concentration of HCl = 2. 0 mol dm-3 Volume of HCl used = 25. 0???? 0. 5 mol dm-3 Concentration of CH3COOH = 2. 0 mol dm-3 volume of CH3COOH used = 25. 0???? 0. 5 mol dm-3 Observation: 1. The solution remains colorless before and after the reaction. 2. The polystyrene cup becomes warmer when acid is

added to the sodium hydroxide solution. For the reaction between HCl and NaOH, the maximum temperature is reached at t = 3 min 25s. 4. For the reaction between CH3COOH and NaOH, the maximum temperature is reached at t = 3 min 30s. *Uncertainty of time = O. Is, which includes the uncertainty of the stopwatch itself (0. 01 s) and human reaction time. Therefore, converting uncertainty of time from s to min, Uncertainty of time = 0. 160 min = 0. 00167 z ???? 0. 002 mtn Analysis of Data Graph 1: Graph of T against t when HCl is used to neutralize NaOH solution Graph 2: Graph of T against t when CH3COOH is used to neutralize NaOH solution

A. Calculation of the Enthalpy change of neutralization Heat released, H = mcAB, Where m = mass of the solution In this experiment, a few assumptions are made, that is * Density of the solution, 1 g cm-3 * Specific heat capacity of the solution = 4. 18 J g-1 OC-I * The maximum temperature is reached at 3rd minute * By extrapolating the graph to t = 3min, heat lost to the surrounding and slow response time of thermometer are compensated. Heat released during the neutralization between HCl and NaOH From the equation in Graph 1 when t= 3min, the temperature obtained is T = (-0. 3929t + 37. 4) ???? 0. 5 T = (-0. 3929 (3) + 37. 464) ???? 0. 5 T = 36. 2853 ???? 0. 5 -r z 36. 3 ???? 0. 5 OC Therefore, we assume that the maximum T is 36. 3???? 0. 5 oc of the reaction, Hence, H = p(VHCl+VNaoH) x c x = 1 x 4. 18 x [(36. 3???? 0. 5) – (29. 0???? 0. 5)] (7. 3???? 1. 0) = 1526???? 1 . 050. 0+1 . 07. 4X100% = 1526???? 237 1 530 ???? 240 -1. 53???? 0. 24 kJ Enthalpy change during the neutralization between HCl and NaOH From the chemical reaction, HCl(aq) + NaoH(aq) -+ Naci(aq) + H20(l) 1 mole of HCl + 1 mole of NaOH to form 1 mole of H20 *

Mole of HCl = 1 . ox 25. 0???? 0. 51000 = 0. 0250 ???? 0. 0005 mol * Mole NaOH = 1 . 25. 0???? 0. 51000 Therefore if HCl and NaOH is completely reacted, Mole of H20 = 0. 0250 ???? 0. 0005 mol Enthalpy change is the heat released when 1 mol of H20 molecule is formed. Thus, Enthalpy change, AH = -Heat releasedmole of H20 = -61040???? 2371 526+0. 00050. 0250X100% = -61040???? 17. 53% = -61040???? 10701 = -61000???? 10800 -61. 0???? 10. 8 kJ mol-l Heat released during the neutralization between CH3COOH and NaOH From the equation in Graph 2, when t= 3min, the temperature obtained is T = (-0. 3036t + 35. 554) ???? 0. 5 T = (-0. 3036 (3) + 35. 554) ???? 0. 5 T = 34. 6432 ???? 0. 5 -r z 34. 6???? 0. 5 OC

Therefore, we assume that the maximum T is 34. 6???? 0. 5 oc of the reaction, H = P(VCH3COOH+VNaOH) x c x = 1 x 4. 18 x [(34. 6???? 0. 5) – (28. 0???? 0. 5)] (6. 6???? 1. 0) = 1379 ???? 1 . 050. 0+1 . 06. 6X100% = 1379 ???? 237 1380 ???? 240 z 1. 38 ???? 0. 24 kJ Enthalpy change during the neautralization between CH3COOH and NaOH CH3COOH (aq) + NaoH(aq) -+ CH3C00Na(aq) + H20(l) 1 mole of CH3COOH + 1 mole of NaOH to form 1 mole of H20 * Mole of CH3COOH = 1 . ox 25. 0???? 0. 51000 Therefore if CH3COOH and NaOH is completely reacted, 0. 0250???? 0. 0005 mol CH3COOH + 0. 0250???? 0. 0005 mol NaOH to form 0. 0250???? 0. 0005 mol of H20 -55160???? 19. 9% – -55160???? 10583 -55200 ???? 10600 -55. 2 ???? 10. 6 kJ mol-l B. Calculation of the percentage error Percentage error of the enthalpy change of neutralization between HCl and NaOH The theoretical value of the enthalpy change of neutralization between HCl and NaOH = -57. 9 kJ mol-l The experimental value of the enthalpy change of neutralization between HCl and NaOH = -61. 0 ???? 10. 8 kJ mol-l Percentage error of the

enthalpy change of neutralization = Theoretical value-Experimental valueTheoretical valuex100% = 5. 35% Percentage error of the enthalpy change of neutralization between CH3COOH and

NaOH The theoretical value of the enthalpy change of neutralization between CH3COOH and NaOH = -56. 1 kJ mol-l The experimental value of the enthalpy change of neutralization between CH3COOH and NaOH = -55. 2???? 10. 6 kJ mol-l Conclusion From the graph 1 and 2, we can see that the data points scattered slightly away from the best fit-line, showing that the data collection is quite precise. However, in the calculation the percentage uncertainties of enthalpy change for both neutralizations are significantly large (HCl = 17. 53%; CH3COOH = 19. 19%). This might due to the high alues of uncertainties of the thermometer and the measuring cylinder.

Therefore, the experiment is said to have significant level of random error. Besides, the percentage uncertainty of enthalpy change is 5. 35% for the neutralization between HCl and NaOH while the percentage uncertainty of enthalpy change is 1. 60% for the neutralization between CH3COOH and NaOH. This shows that the experiment carried out for the neutralization between HCl and NaOH contains higher systematic error than that of the neutralization between CH3COOH and NaOH. However, for both experiments, the theoretical values of enthalpy change of eutralization lie within the range of uncertainties respectively (HCl: – (50. -71. 8) kJ mol-l; CH3COOH: – (44. 6-65. 8) kJ mol-l). All these show that the experiment is quite accurate consisting insignificant level of systematic error. In conclusion, since the percentage uncertainties of the enthalpy change for both neutralizations are greater than their percentage error respectively, the experiments are said to

have more random error than systematic error. Evaluation In order to improve this experiment, I have evaluated the list of limitations and suggestions for improvement in the table below.

Table 2: List of limitations and suggestions for improvement Limitations I Suggestions for improvement I 1 . The solutions might have evaporated in the beakerWhen evaporation occurs, the concentration of the solutions increases. Then we measure 25. 0 cm3 of each solution into a measuring cylinder. In fact, the number of moles of NaOH and CH3COOH has increased but we might not be aware of it. With higher number of moles of both solutions, the number of moles of H20 produced increases therefore the heat released will be higher. However in our calculation, we still assume that the number of moles of H20 produced is 1. 25. 00)1000 and uses the higher change in temperature, which causes the magnitude of enthalpy change calculated to be higher. This might be the cause for the higher value of AH between CH3COOH and NaOH. I Cover the beaker containing the solutions when the solutions are not needed. Turn of the fan while carrying out the experiment to reduce the wind movement, which will increase the rate of evaporation. | 2. Carbon dioxide might sodium hydroxide solution, the concentration of the sodium hydroxide decreases, reducing number of moles of NaOH with the same volume used; yet we might not be aware of it.

With lower numbers of moles of NaOH, it becomes a limiting reagent, causing the number of moles of H20 produced to be lower, and the heat released to be lower. However in our calculation, we still assume that the number of moles of H20 produced is 1. 0(25. 00)1000 and uses the lower change in temperature, which causes the magnitude of enthalpy to be lower.

This might be the cause for the lower value of AH between HCI and NaOH. I Cover the beaker containing the NaOH solution when the solution is not needed. This helps to reduce the rate of atmosphere carbon dioxide dissolves in the NaOH solution. | 3.

The scale of the apparatus is calibrated at 200C Since the experiment is carried at room temperature, the scale of the apparatus might have expanded. This will lead to the inaccurate reading of the volume of the solution taken. I Carry out the experiment in an air-conditioned room fixed at 200C. | 4. The assumptions made are not validSpecific heat capacity of the apparatus is not taken into consideration of the calculationThe calculation doesn't involve the heat capacity of the apparatus as we assume that heat capacity of the apparatus = O. However, in fact the apparatus involved have heat capacity.

Therefore the calculation will be inaccurate. The specific heat capacity of the solution is assumed to be 4. 18 J g-1 OC-I In the calculation, the specific heat capacity of the solution is assumed to be 4. 18 J g-1 OC-I . However, in actual case, the specific heat capacity of the solution is not known and might differ from 4. 18 J g-1 OC-I . The assumption made is not valid. The density of the solution is assumed to be 1 g cm-3. In actual case, the density of the solution might not be lg cm-3. The assumption made the enthalpy change calculated to be inaccurate.

Extrapolating the graph would compensate the heat lost to the surrounding and slow response time of the thermometer. The assumption is doubtful that it would compensate the heat lost and slow response time of thermometer.

This is because this assumption itself, assume that the neutralization occurs and completes instantaneously at, in this case, 3rd minute and reaches the maximum temperature. This assumption is doubtful as neutralization takes time to complete to release heat. Temperature is uniform throughout the solutionThe temperature might not be uniform throughout the solution.

This might affect the temperature reading obtained be higher or lower, causing the experimental result inaccurate and imprecise. I Determine the heat capacity of the apparatus before carrying out the experiment. Then, include the heat capacity of the apparatus into the calculation of heat released. Determine the specific heat capacity of the solution before carrying out the experiment. Weigh the mass of the cup and its solution and use the value obtained deducts by the mass of the cup alone, as in to find out the value of the mass of the solution, to calculate the enthalpy change.

Stir the solution to make sure that the solution has uniform temperature before taking the thermometer reading. | 5. There are not enough trialsDue to the time constraint, we have only carry out the experiment once and the result obtained might contain high level of random error. I If time permits, carry out more trials to obtain an average value. This can reduce the random error of the | 6. Thermometer used has to be more preciseThe uncertainty of experiment. vary relatively large, causing the random error of the experiment to be high. I Use a more precise thermometer with smaller value of uncertainty.