Student Name: ________omar khan______________________________

Student Number: _____8130417_______________________________

Partner's Name and Student #: ___martin VandenBroek_____8189747_________________

Demonstrator's Name: ___M. Majbur Rahman______________________________

PLEASE NOTE: If ANY of the above information is UNCLEAR or not provided, your grade will NOT be recorded!!

Lab Day (circle): Tues aft Tues night Wed Thurs aft Thurs night Fri

Lab Week (circle): 1 2

Laboratory Report Cover Page

Experiment 2.

Enthalpy of Various Reactions

Checklist:

- Raw Data Sheet written in pen, signed by TA and attached
- 8 curves [2 for metal; 2 for acid 1; 2 for acid 2; 2 for salt] attached

○ **Completed formal report typed and attached**

Student's Initials _ok____

Table1 (part 1)

	Trial 1	Trial 2
Mass of metal (g)	10.225	10.941
Mass of foam cup (g)	1.8246	1.8246
Volume of water (ml)	19.6	20.3
Change in temperature (°C)	3.1	3.3
Heat absorbed by water (J)	253	280.2
Change in temperature by metal (°C)	-72.1	-71.6
Specific heat capacity of metal (J/(g°C)	0.35	0.36
Approximated molar mass of metal (g/mol)	71.4	69.4
Percent error of approximated molar mass	-12.4	-9.2

Observations

- The temperature for both trials rose then stabilized at the higher value

Table 2 part 2

	Trial 1	Trial 2	Trial 3	Trial 4
Volume of base (ml)	32.7	35.1	41.6	36.0
Concentration of base(M)	1.0	1.0	1.0	1.0
Volume of acid(ml)	32.7	35.1	41.6	36.0
Concentration of acid(M)	1.1	1.1	1.1	1.1
Change in temperature of solution(°C)	6.5	7.0	7.2	6.6
Volume of solution(ml)	65.4	70.2	83.6	72.0
Mass of solution(g)	65	70	84	72
Heat absorbed by solution(J)	1768	2050	2530	1988
Amount of limiting reagent (mol)	0.032	0.035	0.042	0.036
Amount of water formed (mol)	0.032	0.035	0.042	0.036
Heat of neutralization per mole of water(j/mol)	55250	58571	60238	55222
Percent error of heat of neutralization(%)	3.2%	-2.6%	-5.1%	3.2%

Observations

- Temperature for all four trials rose then stabilized at its higher temperature value

Table 3 part 3

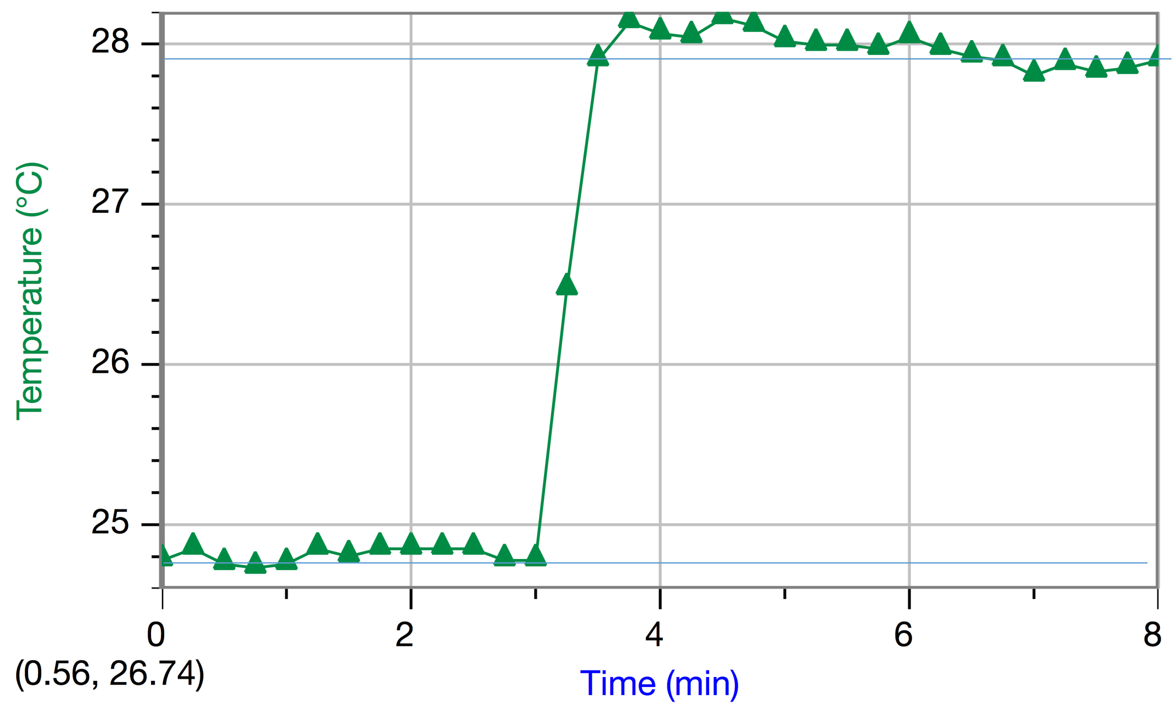
	Trial 1	Trial 2
Mass of salt (g)	1.5398	1.516
Volume of distilled water (ml)	20.0	19.9
Change in temperature of the solution (°C)	-4.1	-2
Energy released (J)	-370	-179
Enthalpy of dissolution	-17914	-8950
Percent error(%)	-13.4	43.3

Observations

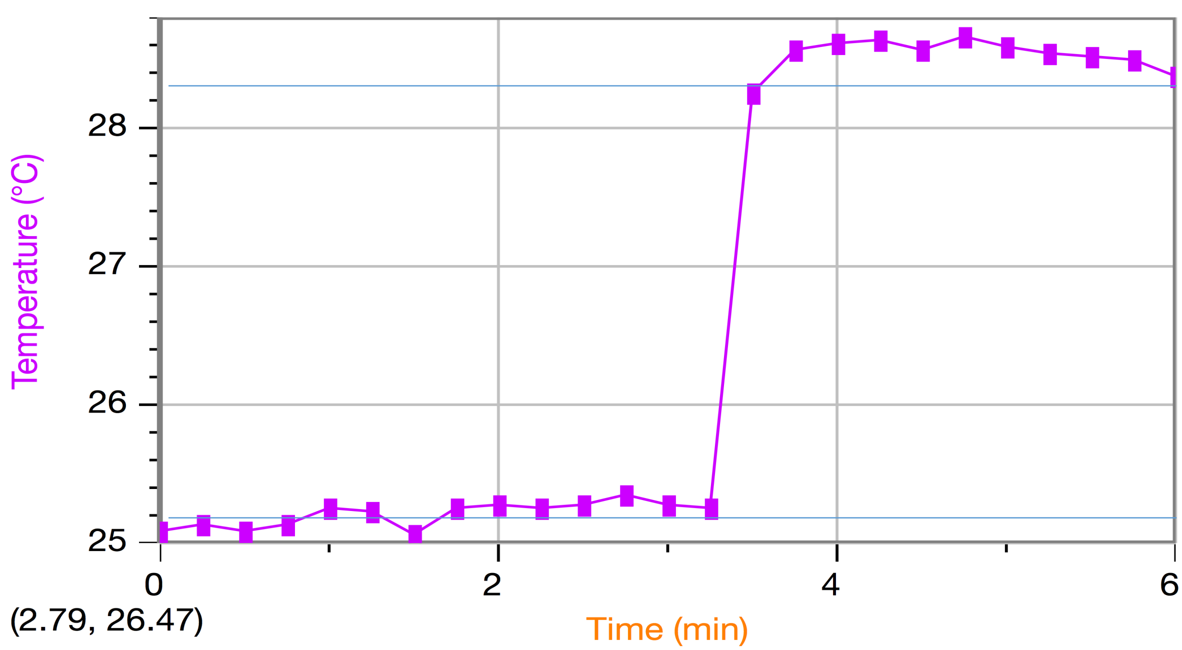
- For trial 1 temperature dropped then stabilized
- For trial 2 temperature dropped then oscillated for a while then finally stabilized at a lower value then its original temperature

Graphs

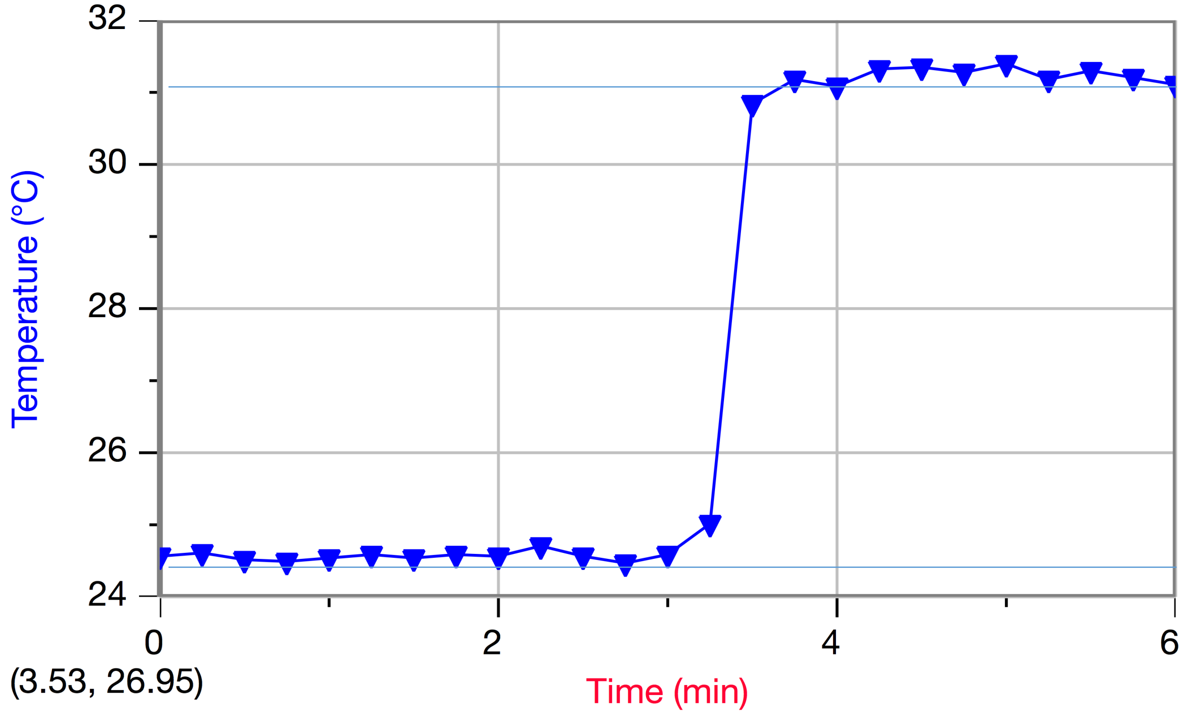
Temperature of metal over time Trial 1 Part 1



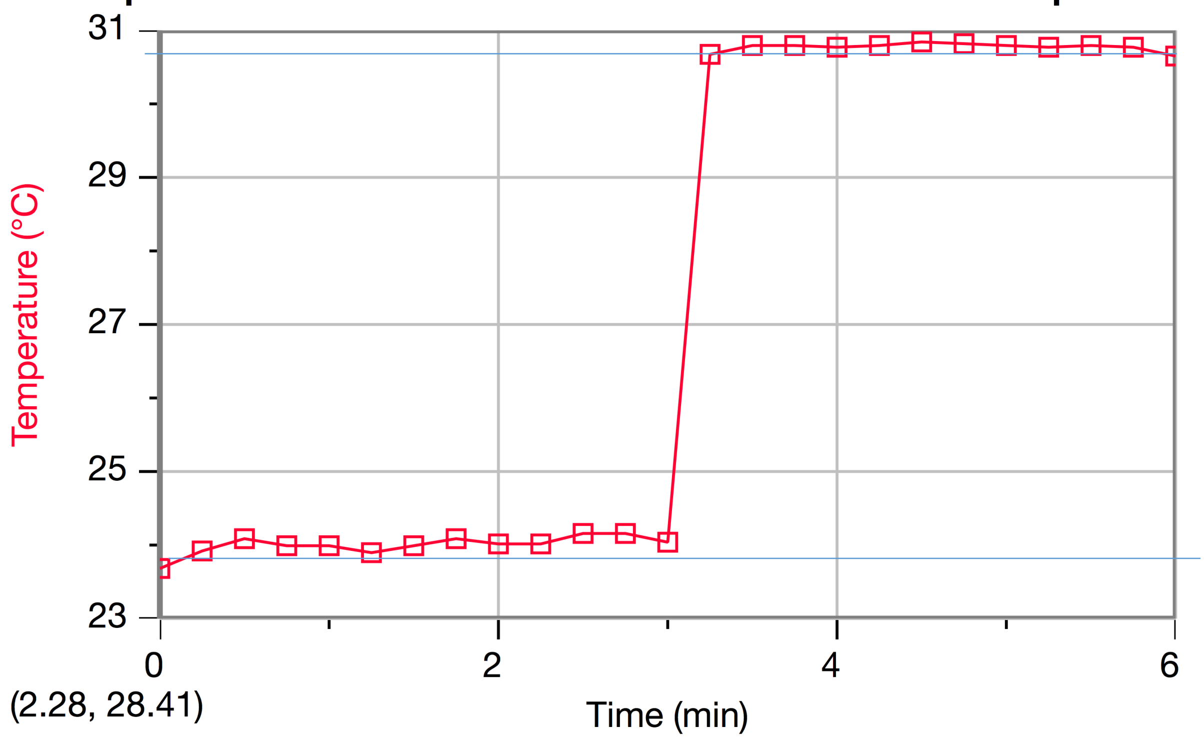
Temperature of metal over time Trial 2 part 1



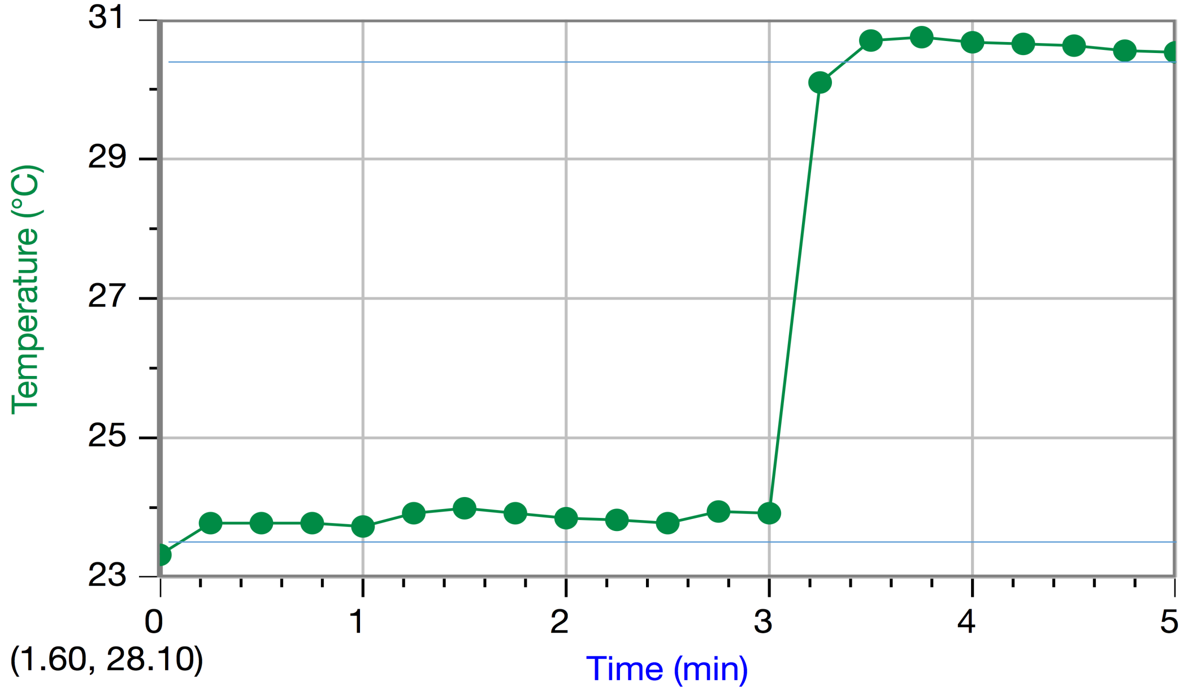
Temperature of solution over time trial1 part2



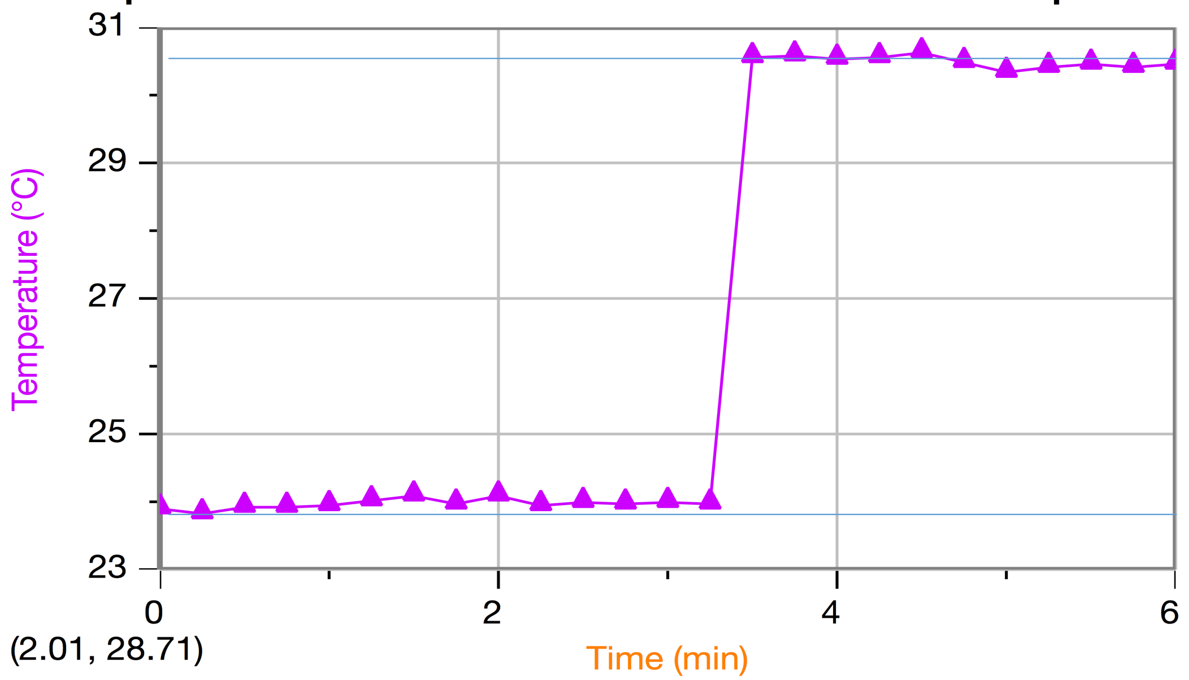
Temperature of solution over time trial2 part2

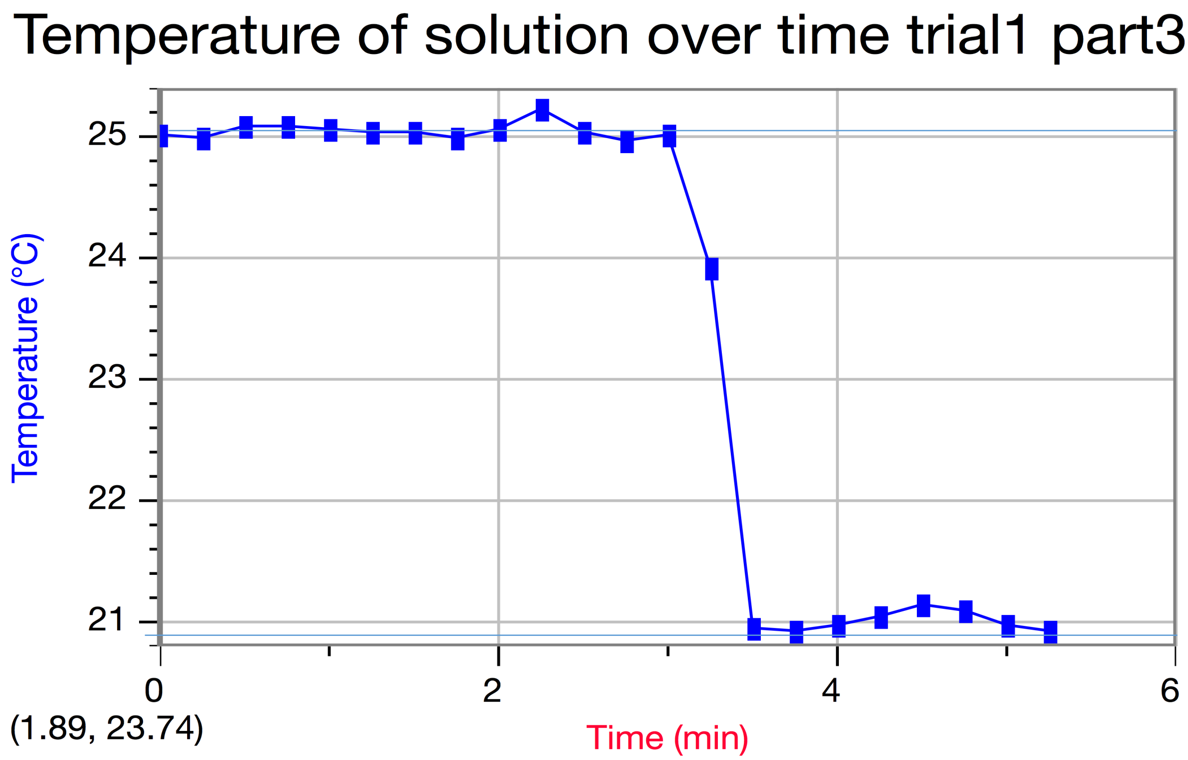


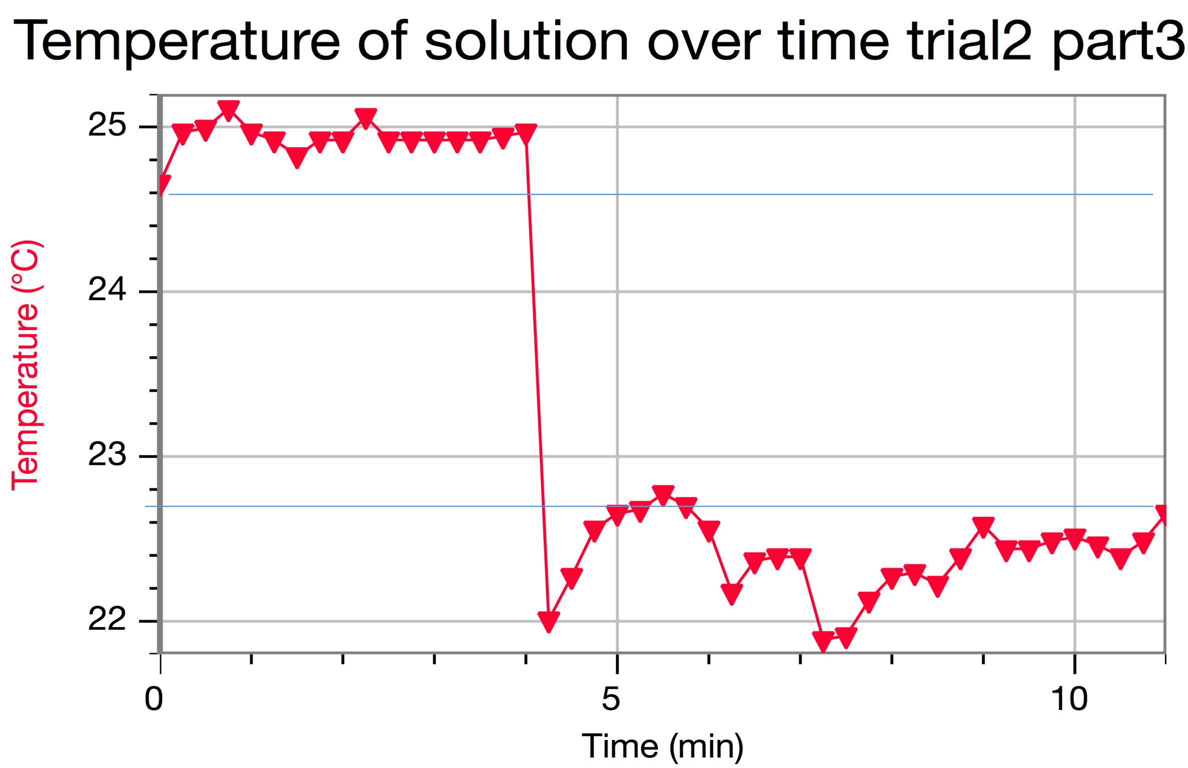
Temperature of solution over time Trial3 part2



Temperature of solution over time trial4 part2




Temperature of solution over time trial1 part3
25
24
23
22
21
Temperature (°C)
0
2
4
6
(1.89, 23.74)
Time (min)


Temperature of solution over time trial2 part3
25
24
23
22
Temperature (°C)
0
5
10
Time (min)

Calculations

1)

$$\Delta T = T_f - Ti$$
$$\Delta T = 27.9^{\circ}C - 24.8^{\circ}C$$
$$\Delta T = 3.1^{\circ}C$$

2)

$$q_{water} = mc\Delta T$$
$$q_{water} = (1g / ml \times 19.6ml) \times 4.18J / (g^{\circ}C) \times 3.1^{\circ}C$$
$$q_{water} = 253J$$

3)

$$\Delta T_{metal} = T_f - T_i$$
$$\Delta T_{metal} = 27.9^{\circ}C(finalTofwater) - 100^{\circ}C(boilingwater)$$
$$\Delta T_{metal} = -72.1^{\circ}C$$

4)

$$-c_{met} = c_{water} \times m_{water} \times \Delta T_{water} / m_{metal} \times \Delta T_{metal}$$
$$-c_{met} = 4.18J / (g^{\circ}C) \times 19.6g \times 3.1^{\circ}C / 10.225g \times -72.1^{\circ}C$$
$$-c_{met} = -0.35J / (g^{\circ}C)$$
$$c_{met} = 0.35J / (g^{\circ}C)$$

5)

$$c_{metal} \times MM_{metal} \approx 25J / mol^{\circ}C$$
$$MM_{metal} \approx 25J / mol^{\circ}C / c_{metal}$$
$$MM_{metal} \approx (25J / mol^{\circ}C) / 0.35J / (g^{\circ}C)$$
$$MM_{metal} \approx 71.4g / mol$$

6)

$$\%error = (theoretical - experimental / theoretical) \times 100\%$$
$$\%error = (63.546 g/mol - 71.4 g/mol)/(63.546 g/mol) \times 100\%$$
$$\%error = -12.4\%$$

7)

Yes, the mass of the metal will make a diference because if we had a light piece of copper then the heat capacity for copper would be greater and would therefore give us a smaller value for the approximated molar mass of copper. If we had a heavier piece of copper the opposite from the lighter piece would occur.

Part 2

8)

$$\Delta T_{solution} = T_f - T_i$$
$$\Delta T_{solution} = 31.1^\circ C - 24.6^\circ C$$
$$\Delta T_{solution} = 6.5^\circ C$$

9)

$$V_f = V_{acid} + V_{base}$$
$$V_f = 32.7 ml + 32.7 ml$$
$$V_f = 65.4 ml$$

10)

$$m_{solution} = D_{solution} \times V_{solution}$$
$$m_{solution} = 1.0 g/ml \times 65.4 ml$$
$$m_{solution} = 65 g$$

this does not matter as you are able to find the mass of the water without having to experimentally measure the mass of water.

11)

$$q_{solution} = mc\Delta T$$
$$q_{solution} = 65 g \times 4.184 J/g^\circ C \times 6.5^\circ C$$
$$q_{solution} = 1768 J$$

12)

$$mol_{OH} = C_{OH} \times V_{OH}$$
$$mol_{OH} = 1M \times 0.032L$$
$$mol_{OH} = 0.032mol$$

13)

$$NaOH_{(aq)} + HCl_{(aq)} \rightarrow NaCl_{(l)} + H_2O_{(l)}$$
$$NaOH(1:1)H_2O$$
$$mol_{H_2O} = 0.032mol$$

14)

$$\Delta H^\circ = q_{water} / n_{water}$$
$$\Delta H^\circ = 1768J / 0.032mol$$
$$\Delta H^\circ = 55250J / mol$$

15)

The heat of neautralization per mol of water for the HCl was 55250J. The heat of neutralization per mol of water for the NH3 was 60250 which was a larger value then that of the HCl solution

16)

$$\%error_{HCl} = (Theoretical - \exp erimental / Theoretical) \times 100\%$$
$$\%error_{HCl} = (57100J - 55250J) / (57100) \times 100\%$$
$$\%error_{HCl} = 3.2\%$$
$$\%error_{HNO_3} = (57300J - 60238) / (57300) \times 100\%$$
$$\%error_{HNO_3} = -5.1\%$$

17)

the trials have very different sources of error, the volume used for the base very much affected the enthalpy value because the higher the volume the greater the amount of moles for that substance was used and the lower of an ethalpy value was obtained and the opposite goes for a smaller volume base reading. The value of enthalpy of neutralization for HCl was a bit more precise then that of NH3. These results were not a surprise to us as we did expect some error in the experiment by the cause of some sources of error in the transition of metal to calorimeter or the measurement of the temperature.

Part3

18)

$$\Delta T = T_f - T_i$$
$$\Delta T = 20.9 - 25.0$$
$$\Delta T = -4.1^{\circ}C$$

19)

$$q_{solution} = mc\Delta T$$
$$q_{solution} = (1.539g + 20.0g) \times 4.184J / g^{\circ}C \times -4.1^{\circ}C$$
$$q_{solution} = -370J$$

20)

$$\Delta H^{\circ} = q_{solution} / mM_{salt}$$
$$\Delta H^{\circ} = -370J / (1.5398g / 74.55(g / mol))$$
$$\Delta H^{\circ} = -17914J / mol$$

21)

$$\%error_{solution} = (Theoretical - \exp erimental / Theoretical) \times 100\%$$
$$\%error_{solution} = ((-15800J / mol + 17914J / mol) / -15800) \times 100\%$$
$$\%error_{solution} = -13.4\%$$

22)

The mass of the salt used did affect the result as the higher the mass of the salt the higer the amount in moles and the lower the value for the enthalpy of dissolution of the salt. The opposite is true if the mass of the sakt is lower

Discussion

For the results of the molar mass of the metal were -12.4% and -9.2% for trial 1 and 2 respectively, which means that in are calculation we obtained a higher value for the molar mass of copper then the actual molar mass of copper. For the second trial we used a higher mass for copper and more volume for the water which I believe has an effect on the lower percent error that we obtained in the second trial. Possible sources of error for the molar mass was the heat lost from the piece of copper when it was transported to the calorimeter which would give a higher value for the heat absorbed by the water and a higher value for the heat capacity of copeer and finally a lower value for the experimental molar mass of copper. Also some heat could have been absorbed by the calorimeter and not the water which again would give us a higher value for the change in temperature and have the same affect as previously stated.

For the neutralization reaction the percent errors for HCl were 3.2% and -2.6% for trial 1 and 2 respectively and for the neutralization reaction for NH3, Trial 1 was -5.1% and 3.2% for trial 2. Both trials for each of the acids were slighlty different. One trial per acid was over the actualy value and one trial per acod was under the actual value. Possible errors that can help explaine the percent error is the heat loss in the calorimeter. Some of the heat was absorbed by the foam cup which mean that we would have obtained a greater value for the change in temperature of the solution. This would also give us a higher value for the heat of the solution and would also give a higher value for the heat of neutralization per mol of water. Also its possible that some water was lost when poring into calorimeter as drops get caught on the side of graduated cylinder. This would give a higher value for the volume of base and acid and a higher value for the weght of the solution which would lead to a higher value for the heat of neutralization.

Finally the percent errors for the enthalpy of dissolution were -13.4% and 43.3 percent for trials 1 and 2 respectively. It seemed as though the second trial had a very low value for the enthalpy of dissolution. Possible sources of error for this part is again the lost of heat to the surroundings. This would give us a higher value for the change in temperature which would lead to a higher value for the heat released and higher value for the enthalpy of dissolution. For the second trial I cannot explain these results in terms of sources of error, a mistake might of taken place during the experiment.

Conclusion

In conclusion for the molar mass of copper the percent error was -12.4% and -9.2% for trial 1 and 2 respectively. For the heat of neutralization per mole of water the percent error was 2.3%, -2.6%, -5.1%, 3.2% for trials 1, 2, 3, 4 respectively. Finally, for the enthalpy of dissolution the percent error were -13.4% and 43.3 % for trials 1 and 2 respectively