Enthalpy change of the hydration of magnesium sulphate essay sample

Objective

To determine the enthalpy change of the hydration of magnesium sulphate ($MgSO_4$) using Hess's law.

Procedures

1. The mass of a clean and dry polystyrene foam cup was weighed and recorded.

2. 50. 0 cm^3 of de-ionized water was measured by using a measuring cylinder

3. The 50. 0 cm^3 of water measured was poured it into the polystyrene foam cup.

4. The foam cup was then fitted in a 250 cm^3 beaker.

5. A thermometer was put through the hole in the lid.

6. The temperature of the de-ionized water was measured by using the thermometer.

7. The result was recorded in the table provided.

8. The mass of 0. 025 mole of anhydrous magnesium sulphate was calculated.

9. The mass of a weighing bottle was weighed.

10. According to the mass calculated in step 8, anhydrous magnesium sulphate was added to the weighing bottle carefully with a spatula.

11. The mass of the weighing bottle with anhydrous magnesium sulphate was weighed.

12. The masses weighed were recorded.

13. The weighed anhydrous magnesium sulphate was added to the water in the foam cup.

14. The mixture with the thermometer was stirred to dissolve the solid as quickly as possible.

15. The highest temperature of the solution was recorded

The apparatus used with water was washed and dried.

16. Step 1 to step 15 were repeated but 0. 025 mole of magnesium sulphate-7-water was used to replace anhydrous magnesium sulphate.

Results

Anhydrous MgSO4

Hydrated MgSO4

Initial mass of weighing bottle with magnesium sulphate/ g

13. 30

16. 74

Final mass of weighing bottle with magnesium sulphate/ g

10. 51

10. 70

Actual mass of magnesium sulphate added/ g

2. 79

6. 04

Initial temperature of water / ?

25. 00

26. 00

Highest/lowest temperature attained/ ?

29. 00

24. 00

Change in temperature / ?

4. 00

2. 00

Specific heat capacity of water = 4200 J kg-1K-1, specific heat capacity of polystyrene foam cup = 1300 J kg-1K-1, density of water = 1. 0 g cm3

Questions

1. State Hess's law.

Hess's law states that the energy change for any chemical or physical process is independent of the pathway or number of steps required to complete the process provided that the final and initial reaction conditions are the same. In other words, an energy change is path independent, only the initial and final states being of importance. This path independence is true for all state functions

2. Calculate the enthalpy change of the solution of anhydrous magnesium sulphate.

$MgSO_4(s) + 7H_2O(l)$ $MgSO_4$? $7H_2O(s)$

? H? soln [$MgSO_4(s)$] + nH_2O + nH_2O ? H? soln [$MgSO_4$? $7H_2O(s)$]

Mg^{2+} (aq)+ SO_4^{2-}(aq)

Weight of polystyrene foam cup= 2. 21g

= 0. 00221kg

? Actual mass of anhydrous magnesium sulphate added= 2. 79g

? Number of moles of anhydrous magnesium sulphate

= 2. 79/ (24. 31+32. 06+16×4) = 0. 023178532mol

? Initial temperature of water= 25oC

Highest temperature of water attained= 29oC

? Temperature rise= 4oC

Mass of solution= 50g

= 0. 05kg

???= mc??

221)(1300)+(0. 05)(4200)](4)

=-851. 492J

~-0. 851kJ

Energy change per mole of anhydrous magnesium sulphate(? H? soln [MgSO4(s)])

= -0. 851492 /0. 023178532

= -36. 73623506

~ -36. 7 kJmol-1

3. Calculate the enthalpy change of the solution of magnesium sulphate-7-water.

Weight of polystyrene foam cup= 2. 27g

= 0. 00227kg

? Actual mass of Hydrated MgSO4 added= 6. 04g

? Number of moles of anhydrous magnesium sulphate

= 6. 04/ (24. 31+32. 06+16×4+18×7)

= 0. 024515971mol

? Initial temperature of water= 26oC

Highest temperature of water attained= 24oC

? Temperature drop= 2oC

Mass of solution= 50g

= 0. 05kg

???= mc??

227)(1300)+(0. 05)(4200)](2)

= 425. 902J

~+0. 426kJ

Energy change per mole of anhydrous magnesium sulphate(? H? soln

[MgSO4? 7H2O(s)])

= 0. 425902 /0. 023178532

= 18. 3748479

~ +18. 3 kJmol-1

4. Using the enthalpy changes of the reactions calculated above, construct an energy cycle and determine the enthalpy change of the hydration of magnesium sulphate.

MgSO4(s) + 7H2O(l) MgSO4? 7H2O(s)

? H? soln [MgSO4(s)] + nH2O + nH2O ? H? soln [MgSO4? 7H2O(s)]

Mg2+ (aq)+ SO42-(aq)

The enthalpy change of the hydration of magnesium sulphate(? H? r)

= ? H? soln [MgSO4(s)]- ? H? soln [MgSO4? 7H2O(s)]

=-36. 73623506-18. 3748479

=-55. 11108296

~-55. 1kJmol-1

5. The true standard enthalpy change of the hydration of magnesium sulphate is -104. 0 kJ mol-1. Point out some factors leading to any difference between the experimental value and the true value.

There are several sources of error which causethe difference between the experimental value and the true value:

1. Heat loss to the surroundings

It was assumed that the temperature of the surroundings remain constant throughout the whole experiment. However, there might be actually a change of conditions(e. g. temperature). For instance , if the temperature is changed during the experiment, thre will be heat transfer from the higher temperature region to the lower one. Moreover, Hess's Law only holds when the final and initial reaction conditions are the same. Thus, it led to a very significant difference between the experimental value and the true value

Moreover, the heat absorbed by other material used in the experiment(e. g. thermometer) was not taken into account. This will also make a difference between the experimental value and the true value

Furthermore, a long time was taken for the magnesium sulphate to dissolve completely in water. Additionally, the temperature will change once the magnesium sulphate is added into the water. Thus, an unknown amount of heat will be lost to the surroundings when the reaction is processing.

2. Calculation error

It is assumed that the specific heat capacity and density of the solution are equal to those of water. Moreover, the mass of magnesium sulphate added was not taken into calculation since the specific heat capacity of magnesium sulphate was also unknown. Nevertheless, the specific heat capacity and density of solution is not necessarily equal to that of water.

3. Errors in temperature reading

In the experiment, adding hydrated magnesium sulphate to water can only cause a temperature change less than 2ï¿½C. The small value may cause a great percentage error. Nonetheless, only liquid-in-glass thermometers were used in the experiment. As the readings of the temperatures were only read by nake eyes, there would be inaccuracy in reading the marks. Moreover, if the actual temperature change is smaller than the precision of the liquid-in-glass thermometers(ie 1 ï¿½C), there will be round off errors . For example, if the error in measuring the temperature is found to be 0. 05oC, then the percentage error in determining the temperature change when dissolving hydrated magnesium sulphate will be 0. 05/ 2= 2. 5% which is a significant error.

4. Weighing error

Anhydrous magnesium sulphate is obtained by placing hydrated magnesium sulphate in oven for a few hours. If water of crystallization is not completely removed, the weighed mass of anhydrous magnesium sulphate is greater than the actual mass.

5. Incomplete reaction

The experimental temperature change will differ from the actual one if anhydrous magnesium sulphate or hydrated magnesium sulphate is not completely dissolved in water.

6. Explain why the enthalpy change of the hydration of magnesium sulphate cannot be measured directly in the laboratory.

If the hydration of magnesium sulphate is carried out, the saturated solution of magnesium sulphate is to be left in a certain place for a long time until the water evaporates and crystals are formed. This method takes a long time. As mentioned above, the longer the time of reaction, the larger the heat loss.

So, in this method of preparation involved a large amount of heat loss and the results would be extremely unreliable; the solution would maintain a more or less the same temperature throughout the whole experiment as the heat tranfer in a very long time. At the same time, the condition of experiment is also difficult to control. Eventually, it will be extremely difficult , if not impossible, to measure the exact temperature change in the reaction.

Furthermore, the nature of a crystallization process is governed by both thermodynamic and kinetic factors, which can make it highly variable and difficult to control. Factors such as impurity level can also make the temperature change measured in the process inaccurate.

Moreover, crystallization usually occurs at a lower temperatures. This can only mean that a crystal is more easily destroyed than it is formed. Similarly, it is usually much easier to dissolve a perfect crystal in a solvent than to grow again a good crystal from the resulting solution.

Therefore, normally, the enthalpy change of the hydration of magnesium sulphate will not be measured directly.

* Conclusion

The enthalpy change of the hydration of magnesium sulphate (MgSO4) founded in the experiment is -55. 1kJmol-1.

* Reference

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