

# Analysis of Alum, $\text{AlK}(\text{SO}_4)_2 \cdot 12 \text{H}_2\text{O}$

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## Purpose:

The purpose of this experiment is to verify the identity of the alum by finding the properties of the substance; melting point and mole ratio of the water to the anhydrous. Every substance has unique characteristics which help to determine the identity of it. The actual values of the properties can be compared to the experimental values. In real life, this can be used to determine the unknown medicines.

## Hypothesis:

The hypothesis is that the alum can be verified by finding the properties; the actual melting point of alum is 92.5 (<http://cookeatshare.com/popular/melting-point-of-alum>) and the actual mole ratio of alum to water is 12:1, By finding the melting point and alum to water mole ratio, it can be compared to the real values

## Equipment Part 1:

Aluminum potassium sulfate (1.5 g)  
150 mL beakers (3)  
Bunsen burners (3)  
Capillary tubes (3)  
Mortar and pestle  
Notched stopper (3)  
Ring Stand (3)  
Thermometer, 0c ~ 100c (3)  
Clamp (3)  
Glycerol (few drops)

## Equipment part 2:

Aluminum potassium sulfate (6g)  
Balance, 0.0001g precision  
Bunsen burner (3)  
Crucible and lid, 30mL (3)  
Tongs (3)  
Ring stands (3)  
Pipe stem (3)  
Wire gauzes (3)

## Procedure part 1:

1. Pack the alum into a capillary tube with a length of 1 ~ 2 cm
2. Tie the capillary tube to the thermometer using a rubber band with it's opening upside down.
3. Dip the top of the thermometer into glycerol
4. Push the thermometer through the stopper
5. Fasten the stopper with a clamp
6. Fill the beaker with 150 mL distiller water covering the tip of the thermometer and the capillary tube in the beaker.
7. boil the beaker until the alum in the capillary tube dissolves
8. Recoded the temperature change at which the alum melts
9. Repeat step #1~8 for 2 more trials

## Procedure part 2

1. Get a ring stand that has a ring clamp.
2. Place a clay pipe stem on top of the ring clamp and the Bunsen burner beneath the ring clamp
3. Adjust the ring clamp so that it is one cm above the ring clamp
4. Place the crucible on top of the clay pipe stem a little slanted to the side
5. Light the Bunsen burner and heat it
6. Heat it until the crucible turns red hot
7. Using tongs, remove the crucible and place it on the wire gauze.
8. Wait for the crucible cool down completely
9. Mass the crucible and record the exact mass.
10. Add about 2g of alum and record the exact mass used
11. Place the crucible on top of the clay pipe stem a little slanted to the side
12. Gently heat the crucible until bubbling
13. After the bubbling has stopped, strongly heat it for additional five minutes
14. Using a tong, remove the crucible and place it on wire gauze
15. Wait for 10 minutes for it to cool down
16. Mass the crucible and record the exact mass of it
17. Repeat procedure #1~#16 for 2 more trials

## Results:

### Analysis of alum Part 1: (melting point)

Analysis of alum	Trial 1	Trial 2	Trial 3
Measured melting point (Celsius)	87	91.5	89
Literature melting point (Celsius) <a href="http://cookeatshare.com/popular/melting-point-of-alum">http://cookeatshare.com/popular/melting-point-of-alum</a>	92.5	92.5	92.5

### Analysis of alum Part 2: Determination of the Water of Hydration in Alum Crystals

Analysis of alum	Trial 1	Trial 2	Trial 3
Mass of crucible and cover (g)	45.9447	41.5092	43.2373
Mass of crucible, cover, and alum crystals (g)	47.9482	43.5127	45.2412
Mass of alum crystals (g)	2.0035	2.0035	2.0039
Mass of crucible, cover and alum after heating #1 (g)	47.0442	42.6023	44.336
Mass of crucible, cover and alum after heating #2 (g)	47.0217	42.5846	44.3265
Mass of water driven off (g)	0.9265	0.9281	0.9147
Mass of anhydrous alum, $\text{AlK}(\text{SO}_4)_2$ (g)	1.077	1.0754	1.0892
Moles $\text{H}_2\text{O}$ (moles)	0.05143	0.05152	0.05077
Moles $\text{AlK}(\text{SO}_4)_2$ (moles)	0.00417	0.00416	0.00422
Mole ratio; moles $\text{H}_2\text{O}$ / moles $\text{AlK}(\text{SO}_4)_2$	12.33025	12.36992	12.03686

**Observation:**

When the alum was a powder it looked like thin flour. When the alum was heated it formed bubbles and turned into a gel like substance. Gradually as it was heated the bubbles looked more like foam turning from a transparent color to white. When the alum was heated second time, it looked like marshmallows but hard. It also was brittle and could be crushed into powder.

**Analysis:**

Mass of water driven off:

(Mass of crucible, cover, and alum crystals) - (Mass of crucible, cover and alum after heating #2)

Trial 1:  $47.9482 - 47.0217 = 0.9265\text{g}$

Trial 2:  $43.5127 - 42.5846 = 0.9281\text{g}$

Trial 3:  $45.2412 - 44.3265 = 0.9147\text{g}$

Mass of anhydrous alum,  $\text{AlK}(\text{SO}_4)_2$ :

(Mass of alum crystals) - (Mass of water driven off)

Trial 1:  $2.0035 - 0.9265 = 1.0770\text{g}$

Trial 2:  $2.0035 - 0.9281 = 1.0754\text{g}$

Trial 3:  $2.0039 - 0.9147 = 1.0892\text{g}$

Moles  $\text{H}_2\text{O}$ :

(Mass of water driven off) / (Molar mass of  $\text{H}_2\text{O}$ )

Trial 1:  $0.9265 / 18.015 = 0.05143\text{mol}$

Trial 2:  $0.9281 / 18.015 = 0.05152\text{ mol}$

Trial 3:  $0.9147 / 18.015 = 0.05077\text{ mol}$

Moles  $\text{AlK}(\text{SO}_4)_2$  :

(Mass of anhydrous alum,  $\text{AlK}(\text{SO}_4)_2$ ) / (Molar mass of  $\text{AlK}(\text{SO}_4)_2$ )

Trial 1:  $1.0770 / 258.212 = 0.00417\text{ mol}$

Trial 2:  $1.0754 / 258.212 = 0.00416\text{ mol}$

Trial 3:  $1.0892 / 258.212 = 0.00422\text{ mol}$

Mole ratio; moles  $\text{H}_2\text{O}$ / moles  $\text{AlK}(\text{SO}_4)_2$ :

(Moles  $\text{H}_2\text{O}$ ) / (Moles  $\text{AlK}(\text{SO}_4)_2$ )

Trial 1:  $0.05143 / 0.00417 = 12.33025$

Therefore: 12mol  $\text{H}_2\text{O}$  : 1mol  $\text{AlK}(\text{SO}_4)_2$

Trial 2:  $0.05152 / 0.00416 = 12.36992$

Therefore: 12mol  $\text{H}_2\text{O}$  : 1mol  $\text{AlK}(\text{SO}_4)_2$

Trial 3:  $0.05077 / 0.00422 = 12.0369$

Therefore: 12mol  $\text{H}_2\text{O}$  : 1mol  $\text{AlK}(\text{SO}_4)_2$

Percent error in mole ratio:

$100 * ((\text{Mole ratio}) - (\text{actual mole ratio})) / (\text{actual mole ratio})$

Trial 1:  $100 * ((12.33025 - 12) / 12) = 2.752\%$

Trial 2:  $100 * ((12.36992 - 12) / 12) = 3.083\%$

Trial 3:  $100 * ((12.03690 - 12) / 12) = 0.308\%$

Average percent error:

$(\text{trial 1} + \text{trial 2} + \text{trial 3}) / 3$

$(2.771 + 3.083 + 0.308) / 3 = 2.05\%$

Percent error in measured melting point:

$$100 - [(Measured\ melting\ point) / (Literature\ melting\ point) * 100]$$

$$\text{Trial 1: } 100 - [(87 / 92.5) * 100] = 5.95\%$$

$$\text{Trial 2: } 100 - [(91.5 / 92.5) * 100] = 1.08\%$$

$$\text{Trial 3: } 100 - [(90 / 92.5) * 100] = 2.70\%$$

$$\text{Average percent error: } (Trial\ 1 + Trial\ 2 + Trial\ 3) / 3$$

$$(5.95 + 1.08 + 2.70) / 3 = 3.24\%$$

Overall, the hypothesis of mole ratio has been confirmed; however, it contains a small percentage error. Neither the mole ratio nor the measured melting point has over 5% error. The mole ratio has 2.05% error and the measured melting point has 3.24% error.

Conclusion:

The hypothesis has been generally proven according to the analysis. The percent accuracy of the measured melting point 96.76% and the mole ratio is 97.05%. However, the result wasn't accurate since lots of error has occurred during the experiment. For example human errors have occurred while measuring the melting point of alum. Observing the melting point of alum in the experiment was precise but not accurate, because the exact point where the alum melts wasn't observable by human eyes. In the future there could be ways to eliminate this issue. The experiment could provide more trials or should wait for the alum to boil longer until it was fully melted, by that it will reach certain temperature when the substances fully melts. The other possible error that could have occurred during the experiment would be in procedure # 13, the heat energy might not be hot enough. By that the alum might not be fully dehydrated, therefore it would cause the mass of anhydrous alum to increase which leads to the increase of the mole ratio. In order to prevent this from happening again in future experiments, we should extend the heating time to around 15 minutes.



Procedure #13 of the experiment part 2



Dehydrated Alum



While grinding the alum