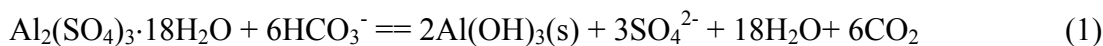


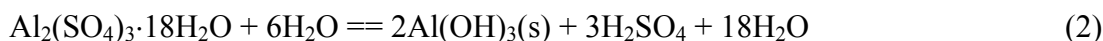
Jar Test

When 1 mole of alum ($\text{Al}_2(\text{SO}_4)_3 \cdot 18\text{H}_2\text{O}$) is added into water that contains adequate alkalinity, 6 mole of HCO_3^- (alkalinity) is consumed and produced 6 mole of CO_2 as shown in equation (1)



As we know that CO_2 in water is the same as H_2CO_3 (carbonic acid). Therefore, the reaction in equation (1) shifts the carbonate equilibrium and pH changes slightly because H_2CO_3 is a weak acid.

If water contains no alkalinity, the pH changes dramatically because sulfuric acid is produced instead of CO_2 as express in equation (2). Sulfuric acid is a strong acid that dissociate 100 % to proton, or H^+ .



Calculation for alkalinity change

MW: $\text{Al}_2(\text{SO}_4)_3 \cdot 18\text{H}_2\text{O} = 666 \text{ g/mol}$; $\text{Al}^{3+} = 2(27) = 54 \text{ g/mol}$

In the lab, the concentration of alum solution was prepared in mg/L as Al^{3+} (not as $\text{Al}_2(\text{SO}_4)_3 \cdot 18\text{H}_2\text{O}$), so we have to convert Al^{3+} to alum ($\text{Al}_2(\text{SO}_4)_3 \cdot 18\text{H}_2\text{O}$):

Assume: we get 10 mg/L (beaker # 2) of Al^{3+} as the optimum dosage (the lowest turbidity).

Since 1 mol/L (or 666 g/L) of $\text{Al}_2(\text{SO}_4)_3 \cdot 18\text{H}_2\text{O}$ contains $2(27) = 54 \text{ g/L}$ of Al^{3+}

Therefore, 54 g/L of Al^{3+} comes from $= 666 \text{ g/L}$ of $\text{Al}_2(\text{SO}_4)_3 \cdot 18\text{H}_2\text{O}$

10 mg/L, or $10(10^{-3}) \text{ g/L}$ of Al^{3+} comes from $= \frac{(666) \times 10(10^{-3})}{54} \text{ g/L}$ of $\text{Al}_2(\text{SO}_4)_3 \cdot 18\text{H}_2\text{O}$

Change $\frac{(666) \times 10(10^{-3})}{54} \text{ g/L}$ of $\text{Al}_2(\text{SO}_4)_3 \cdot 18\text{H}_2\text{O}$ to unit of mol/L

We get: $\text{Al}_2(\text{SO}_4)_3 \cdot 18\text{H}_2\text{O} = \frac{(666) \times 10(10^{-3})}{54} \text{ g/L} \left(\frac{1 \text{ mol}}{666 \text{ g}} \right) = \frac{10(10^{-3})}{54} \text{ mol/L}$

Since 1 mol of $\text{Al}_2(\text{SO}_4)_3 \cdot 18\text{H}_2\text{O}$ is equal to 6 mol of HCO_3^- from the above equation (1)

Therefore, $[\text{HCO}_3^-] = 6 \times \frac{10(10^{-3})}{54} \text{ mol/L}$

Then change the unit into mg/L as CaCO_3

$[\text{HCO}_3^-] = 6 \times \frac{10(10^{-3})}{54} \text{ mol/L} \times 61 \text{ g/mol} \times 10^3 \text{ mg/g} \times \left(\frac{50}{61} \right) = 55.55 \text{ mg/L}$ as CaCO_3

Theoretical alkalinity depleted = 55.55 mg/L as CaCO_3 .

From the lab as shown in the below Table, the alkalinity was changed = $240 - 180 = 60 \text{ mg/L}$ as CaCO_3 . The results do not show much difference between the alkalinity change in theory and practice.

Note:

- 1) Adding alum into water decreases the pH, but
- 2) If water contains some alkalinity (HCO_3^- , the major specie at neutral pH), the pH does not be dramatically reduced (compared to the condition when the alkalinity is not present).

$\text{CO}_2(\text{g})$ elaboration indicates formation of carbonic acid [$\text{H}^+ + \text{HCO}_3^- \leftrightarrow \text{H}_2\text{CO}_3^* \leftrightarrow \text{H}_2\text{O} + \text{CO}_2(\text{ag}) \leftrightarrow \text{CO}_2(\text{g})$]

Beaker #	RAW	1	2	3	4	5	6
Dosage mg/L of Alum as Al^{3+}	0	5	10	20	30	40	50
Turbidity NTU of all samples	12	10	1.0	2.0	3.0	4.0	5.3
pH of all samples	8.29	8.16	7.30	6.90	6.46	6.09	5.06
Alkalinity mg/L as CaCO_3 of RAW and one of beakers with lowest turbidity	240		180				