Verifying the Formula Relating EMM to the Mole Percent of ASA

The quantities determined from the pH titration of the mixture are the weight of the sample titrated and the volume of NaOH used. The number of moles of NaOH, \( n_{NaOH} \), used is equal to the total number of moles of the two acids in the sample. I.e., the sum of the number of moles of SA, \( n_{SA} \) and the total number of moles of ASA, \( n_{ASA} \). The weight of the sample titrated, \( w_{SA+ASA} \), is equal to the weight of SA + the weight of ASA. These are also related to the numbers of moles of SA and ASA. The mole percent of SA is \( 100 \frac{n_{SA}}{n_{SA+ASA}} \)

Let us write the above two relationships algebraically:

\[
\begin{align*}
w_{SA+ASA} &= w_{SA} + w_{ASA} = 138.1 \frac{n_{SA}}{n_{SA+ASA}} + 180.1 \frac{n_{ASA}}{n_{SA+ASA}} \quad (1) \\
n_{NaOH} &= n_{SA} + n_{ASA} \quad (2)
\end{align*}
\]

If we had titrated a single acid, the results of the titration would have determined its molar mass. The molar mass would be the result of dividing the weight of the acid by the number of moles of NaOH.

But we have two acids with different molar masses, so we will call the result of that division the Effective Molar Mass (EMM) of the mixture. I.e,

\[
EMM = \frac{w_{SA+ASA}}{n_{NaOH}} \quad (3)
\]

We solve equation (2) for \( n_{SA} \),

\[
n_{SA} = n_{NaOH} - n_{ASA} \quad (4)
\]

and substitute in equation 1,

\[
w_{SA+ASA} = 138.1 \left(n_{NaOH} - n_{ASA}\right) + 180.1 n_{ASA} \quad (5)
\]

Solve for \( n_{ASA} \),

\[
n_{ASA} = \frac{\left(w_{SA+ASA} - 138.1 n_{NaOH}\right)}{(180.1 - 138.1)} \quad (6)
\]

Dividing both sides by \( n_{NaOH} \) and multiplying by 100 gives:

\[
100 \frac{n_{ASA}}{n_{NaOH}} = 100 \left(\frac{w_{SA+ASA}}{n_{NaOH}} - 138.1\right) / (180.1 - 138.1) \quad (7)
\]

Substituting EMM for \( \frac{w_{SA+ASA}}{n_{NaOH}} \) and \( n_{ASA} + n_{SA} \) for \( n_{NaOH} \) gives:

\[
100 \frac{n_{ASA}}{n_{ASA} + n_{SA}} = 100 \left(EMM - 138.1\right) / (180.1 - 138.1) \quad (8)
\]

But the left hand side is just the **mole percent of ASA**.

QED

The percent by weight of ASA can be calculated by multiplying the above by 180.1 and dividing by \( w_{SA+ASA} \), i.e.: 

\[
% \text{ASA (by weight)} = \frac{(180.1 \times 100 / w_{SA+ASA})(EMM - 138.1)}{(180.1 - 138.1)}
\]