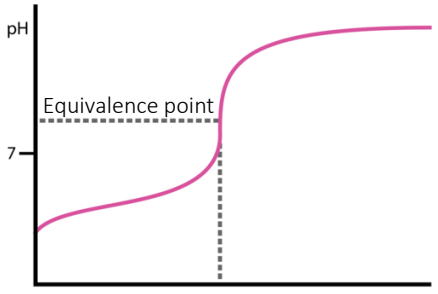
Lesson – errors in titration.

Identify errors in each procedure below and the impact it may have on the eventual average titre.

Consider the procedure below.
The acetic acid (ethanoic acid) concentration of a brand of vinegar is to be determined using volumetric analysis. A 20.00 mL pipette is used to take a sample from the original bottle of vinegar which is placed in a 200 mL volumetric flask and made to the mark with distilled water.
A volume of 25.00 mL was transferred from the volumetric flask to a 100mL conical flask, where two drops of indicator is also added and titrated to the end point using a 0.201 M NaOH as the titrant. An average titre of 20.16 mL was obtained.

The titration curve, or pH curve, for this procedure is shown on the right as is the pH range of four indicators.

The concentration of acetic acid in the original sample was found to be 5.00%m/v



Titration curve of a weak acid (CH_3COOH) with a strong base (NaOH)

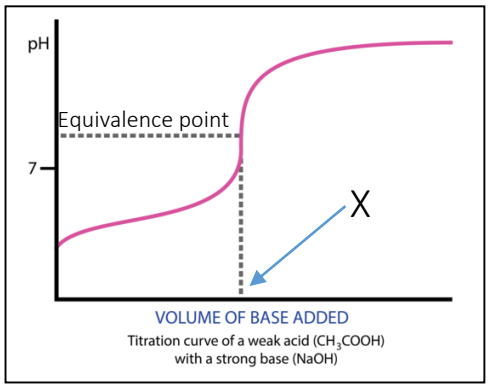
Name of indicator	pH range
methyl orange	3.1-4.4
methyl red	4.4-6.2
bromothymol blue	6.0-7.6
phenolphthalein	8.3-10.0

1. Complete the table below.

Event	Impact on the average titre	Impact on the final concentration of 5.00%m/v	Explanation
Burette was rinsed with distilled water	increase	>5.00%m/v	*A greater titre implies greater mol of acetic acid in analyte*
Methyl red was used as an indicator	decrease	< 5.00%m/v	*A lower titre implies less mol of acetic acid in analyte. End point will be around pH 4.4 which is nowhere near the equivalence point.*
Phenolphthalein was used as an indicator	*No impact*	*No impact*	*End point will take place at pH 8.3 which is very close to the equivalence point.*
The 20mL pipette was rinsed with distilled water	*Decrease*	< 5.00%m/v	*Analyte is diluted hence less is placed in the volumetric flask for dilution*
The 25mL pipette was rinsed with distilled water	*Decrease*	< 5.00%m/v	*Analyte is diluted hence less is placed in the conical flask for reaction with the titrant*
The 100 mL flask was rinsed with water	*No impact*	*No impact*	*The mol of acetic acid delivered into the conical flask in the 25mL aliquot did not change.*
The 200mL volumetric flask was rinsed with distilled water	*No impact*	*No impact*	*Since water is used to fill the volumetric flask to the mark excess water in the flask has no impact.*
Burette was rinsed with a 0.201 M NaOH	*No impact*	*No impact*	*The burette was rinsed with the titrant. This is good protocol.*
Four drops of indicator was placed in the conical flask instead of 2 drops.	*No impact*	*No impact*	*The indicator ideally takes no part in the reaction and is used in very small quantities. Two extra drops would have no impact, however, some*

			indicators are acids so over-use of indicator may impact the result.
Conical flask was rinsed with 0.201 M NaOH	*Decrease*	< 5.00%m/v	*The NaOH present in the conical flask will react with some of the available acetic acid and hence require a lower titre to reach the end point.*
Conical flask was rinsed with dilute vinegar solution from the volumetric flask	*Increase*	>5.00%m/v	*More acetic acid is present int eh conical flask than delivered by the 25mL aliquot. Hence more titre is necessary to reach the end point.*

2. Consider the pH curve of the titration in question 1. above, shown on the right.



a. what is the value of X?

Ideally X is 20.16 mL. The equivalence and end points should be identical if the right indicator is used.

b. Explain the difference between equivalence point and end point.

Equivalence point is the point in the titration where the acetic acid in the conical flask and the NaOH delivered from the burette have reacted completely according to the stoichiometric ratio of the balanced chemical equation for the reaction.

End point

End point is the point in the titration when the indicator changes colour to alert the chemist that the reaction has reached the equivalence point and the titration should cease.

ideally the end point and equivalence point should occur the same volume of titrant. Careful selection of an indicator is needed.

c. Explain why the Equivalence point is not always at pH 7.

The pH of the equivalence point is dependent on the products formed in the acid-bae reaction. For example take a strong acid reacting with a strong base.

$HCl(aq) + NaOH(aq) \rightarrow NaCl(aq) + H_2O(l)$

The products are very, very weak acids or bases. Hence what remains after the reaction will not react with water to change the pH from 7 at 25°C.

If the reaction involves a weak acid for example CH_3COOH then what is left behind after the reaction will impact on the pH of the solution and alter the equivalence point reflect the presence of key products, For example take the reaction between acetic acid and NaOH shown below.

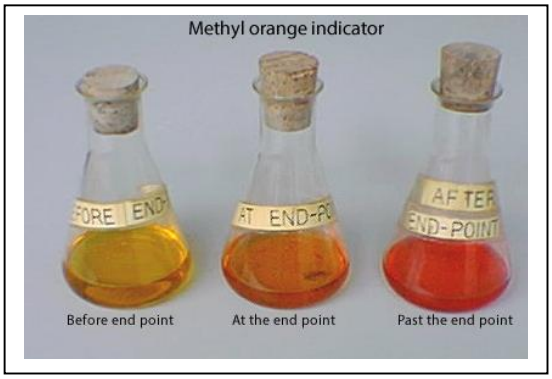
$CH_3COOH(aq) + NaOH(aq) \rightarrow NaOOCCH_3(aq) + H_2O(l)$

Now $NaOOCCH_3(aq)$ dissociates in the water to form $Na^+(aq)$ and $^-OOCCH_3(aq)$. The $^-OOCCH_3$ ion is a mild to weak base so will react with the water present to form ^-OH ions according to the equation below.

$^-OOCCH_3(aq) + H_2O(l) \rightleftharpoons OH^-(aq) + HOOCCH_3(aq)$

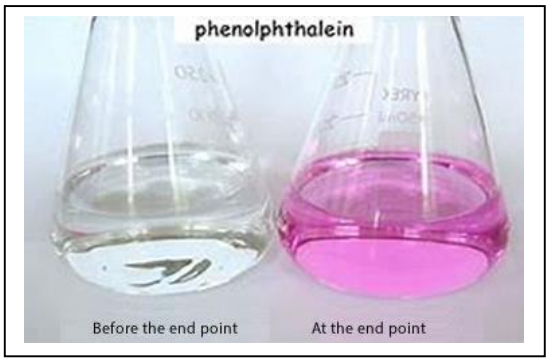
This will increase the pH of the final solution and give an equivalence point above 7.

d. The colour changes of methyl orange and phenolphthalein are shown on the right during two separate titrations.



i. Name one advantage of using an indicator such as phenolphthalein as opposed to methyl orange that is obvious from the image on the right.

Phenolphthalein changes from clear to pink and does not go through a gradual change in colour as does methyl orange which changes from yellow to orange-yellow to orange.



ii. Which indicator is suitable for the titration of acetic acid with NaOH? Justify your answer.

Phenolphthalein as the ph range of this indicator 8.3 – 10 falls in line with the equivalence point on the ph curve.