Practical Session n°19: Quality control of a vinegar

From M. Smith, in charge of the quality control, to the lab staff

I need your services in order to answer a consumer's request concerning our vinegar.

We aim at checking that its percent acidity is equal to 8%.

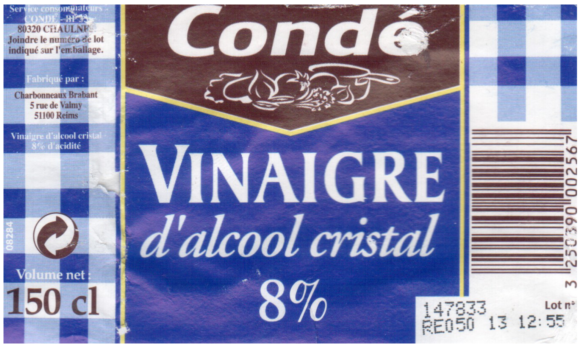
Could you please anticipate your experimental procedure and all the equipment you need?

You will have at your disposal a brand new solution of sodium hydroxide at a concentration C_B = 1.0 10^{-1} mol.L^{-1}.

Don't forget to show your procedure to the person in charge of your lab for approval before starting your experiment.

I'm expecting, as usual, a completely detailed report (one per group will be all right) including your anticipation, the description of your experiment (with diagrams), a curve if necessary, your calculations and all the explanations that are needed to well-understand your work.

Thank you for your collaboration.



P.S. Here are a few data that could be useful for your work

Document 1: Percent acidity of a vinegar

Vinegar is a liquid mainly composed of water and ethanoic acid (also called acetic acid, a weak acid).
Commercial solutions have their concentrations expressed in percent acidity.
The percent acidity of a vinegar corresponds to the mass, in grams, of pure ethanoic acid that is contained in 100g of vinegar.

Document 2: Principle of a titration

- The **analyte** is the species in aqueous solution whose concentration is unknown and has to be determined.
- The **standard** is the species in solution whose concentration is known.
- The **reaction** between the analyte and the standard has to be **unique**, **total** and **fast**. The titration uses just enough of the standard to react with all of the analyte, thereby allowing the present amount of analyte to be determined.

Document 3: Necessary conditions to perform a titration

- The values of the **analyte** and the standard solutions concentrations should be close.
- The volume of standard solution that must be added to reach the **end point** should be lower than the total volume of the burette.

Document 4: Available equipment

- a bottle ofcommercial 8% vinegar
- a brand new sodium hydroxide solution (soda) of concentration 1.0 10^{-1} mol. L^{-1}
- a magnetic stirrer (+ a stir bar)
- a graduated burette of 25mL
- glassware: volumetric flasks, beakers, volumetric pipettes, graduated cylinders…
- a pH-meter
- pH indicators

Document 5: How to exploit the titration reaction

Let a species A in aqueous solution be the analyte. It is titrated by a reaction of equation: aA + bB → cC + dD
The **equivalent point** of the titration is reached when the mixture of A and of the standard B is stoichiometric. Both reactants are thus totally consumed at the final state.

At the equivalent point: $\frac{n_i(A)}{a} = \frac{n_E(B)}{b}$

That is to say: $\frac{C_A.V_A}{a} = \frac{C_B.V_{BE}}{b}$

Document 6: pH-titration

The titration reaction must be an acid-base reaction.
A pH-meter can be used to measure the pH of the reaction mixture for different added volumes of standard solution.
The pH titration curve (that gives the pH curve versus the added volume of standard solution) enables to detect the end point of the titration.

Document 7: How to use pH indicators

A pH indicator can be used (instead of a pH-meter) to detect the end point as it has the property to change colour with pH.

How to choose the pH indicator:
The range of change in colour of the selected indicator must contain the value of the pH at the end point.

Remark:
For the titration of a vinegar, the pH at the end point is between 8 and 9.

Transition pH ranges for a few pH indicators

Indicator	Low pH color	Transition pH range	High pH color
Thymol blue (first transition)	red	1.2–2.8	orange
Methyl red	red	4.4–6.2	yellow
Bromothymol blue	yellow	6.0–7.6	blue
Thymol blue (second transition)	yellow	8.0–9.6	blue
Phenolphthalein	colorless	8.3–10.0	purple