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| **Foundation Year** | **Strong and Weak Acids / Titration Curves and Indicators** | **Semester 2** |

**Strong and Weak Acids / Titration Curves and Indicators**

**Aim**

To use a pH probe to measure the pH values of different solutions enabling titration curves to be drawn for different types of acid-base titrations, and hence to determine why a particular indicator is best suited to a particular titration.

**Introduction**

Through experimentation you can compare weak and strong acids by using ethanoic acid as a typical weak acid and hydrochloric acid as a typical strong acid. pH is less sensitive to changes in weak acid concentration than strong acid concentration based on the extent of dissociation of the acid and this can be monitored throughout a titration experiment.

**Skills associated with this practical**

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| **Practical Skills**   * Using a pH probe * Performing a titration | **Scientific Skills**   * Calculating pH values of strong and weak acids. * Plotting a graph |

**Signposts**

Chemistry, Conoley & Hills, 3rd Edition, Chapter 17.

**Understanding Hazard and Minimising Risk**

You must stand up throughout the practical, and safety glasses must be worn at ALL times in the lab. You must wear a labcoat whilst you are carrying out ALL practical work. Long hair must be tied back, and trousers (jeans are OK) must be worn. Open-toed shoes and clothing revealing bare skin are not permitted.

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| Substance | Amount | Hazards | Minimising Hazards | Disposal / Spillage |
| Dilute sodium hydroxide solution | 200 cm3 | May be harmful if inhaled, swallowed and absorbed through skin. May cause respiratory, skin and eye irritation. | Gloves are optional, goggles and lab coat. | Pour down sink with lots of water. |
| Dilute hydrochloric acid | 200 cm3 | Causes skin irritation.  Causes serious eye irritation. | Gloves are optional, goggles and lab coat. | Pour down sink with lots of water. |
| Dilute ammonia solution (NH4OH) | 200 cm3 | Irritant. | Wear gloves, lab coat. | Pour down sink with copious amounts of water. |
| Dilute ethanoic acid solution | 200 cm3 | Irritant. | Wear gloves, lab coat. | Pour down sink with copious amounts of water. |
| Methyl orange | A few drops | Hazardous in case of skin contact (irritant), of eye contact (irritant), of ingestion, of inhalation (toxic). | Wear gloves, goggles and lab coat. | Pour down sink with lots of water. |
| Phenolphthalein | A few drops | Classified as low hazard, but avoid contact with skin and eyes (skin and eye irritation). | Wear gloves, goggles and lab coat. | Pour down sink with lots of water. |

Apparatus

PER PAIR:

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| pH probe | Phenolphthalein indicator |
| 100 cm3 beaker | Methyl orange indicator |
| 2 x 250 cm3 conical flask | Pipette filler |
| 2 x 25 cm3 volumetric pipette | Deionised water for rinsing |
| Approx. 100 cm3 of 0.1 M Ammonia solution | Retort stand and clamp |
| Approx. 100 cm3 of 0.1 M NaOH |  |

Solutions of hydrochloric acid (0.1, 0.03, 0.01, 0.003 and 0.001 M)

Solutions of ethanoic acid (0.1, 0.03, 0.01, 0.003 and 0.001 M)

Method

It is suggested that you record your observations in a table. Consider the procedure below and determine a suitable structure for your table. Draw your results table *before* you start the experiment.

**Measuring pH Values**

1. Draw a suitable results table in which to record your results. Include a column for ‘Calculated pH value’.
2. Measure the pH of the 0.001 mol dm-3 hydrochloric acid using a pH probe. Take a photo of you doing this for your key *Skills Portfolio*. Record the pH in your table. **You can place the probe directly into the solution you have been provided with.**
3. Repeat step (2) with the 0.003 mol dm-3 hydrochloric acid, and then each of the other hydrochloric acid solutions in order of increasing concentration. **Note that it is not necessary to rinse the pH probe between measurement of the the different HCl solutions so long as you work through them in order of increasing concentration.**
4. After completing the pH measurements of the HCl solutions, rinse the pH probe with distilled water. Repeat steps (2) and (3) using the ethanoic acid solutions, ensuring that you work from the lowest concentration solution to the highest.

**Further Tasks (complete these in your laboratory notebook)**

1. Explain what is meant by the term *strong acid*. How is this different from a *concentrated acid*?
2. Explain why you would expect a 10-fold change in the concentration of a strong acid to lead to a 10-fold change in [H+(aq)].
3. From your results, what appears to be the pH change associated with:
   1. a 10-fold change in the concentration of hydrochloric acid?
   2. a 100-fold change in the concentration of ethanoic acid?
4. Write an expression for pH.
5. Write an expression for the acidity constant (*K*a) for ethanoic acid (you can abbreviate the formula to HA for convenience).
6. It is reasonably accurate to regard [H+(aq)] and [A–(aq)] as being equal in the solutions of ethanoic acid used in this activity. Explain why we can do this.
7. Another reasonable assumption is to regard [HA(aq)] as equal to the amount of acid used to make 1 dm3 of each solution. For example, we can say [HA] = 0.1 mol dm–3 in ethanoic acid solution of concentration 0.1 mol dm–3. Explain why this is a reasonable assumption.
8. Using your knowledge of pH, calculate the pH values of **two** of the solutions of hydrochloric acid whose pH values you measured above. Write the calculated value next to the measured value in your results table.
9. Select **one** of the 5 ethanoic acid solutions whose pH values you measured and calculate the pH value using the method you were taught in lectures last week. Write the calculated value next to the measured value in your results table.

**Titration Curves and Indicators**

1. You are provided with 0.1 M solutions of hydrochloric acid, ethanoic acid, sodium hydroxide and aqueous ammonia. Plan an experiment which will allow you to plot a titration curve showing the variation of pH (on the y-axis) with the volume of titrant (on the x-axis) during an acid-base titration. Choose one of the following combinations for your titration: strong acid vs strong base, strong acid vs weak base, weak acid vs strong base or weak acid vs weak base. **Note that when performing your titration, you should place the acid in the burette and the alkali in the conical flask.**
2. Identify which indicator is suitable for your titration and add a few drops to the conical flask containing the alkali.
3. Before carrying out your main titration, perform an ‘overshoot’ titration to determine roughly how much acid is required to neutralise 25.0 cm3 of alkali. **This will help you to plan when you will take your pH readings to record in your results table.**
4. Perform your titration, measuring the pH at the beginning and as you proceed after each addition from the burette. Record your results in an appropriate table. Ensure that you identify the endpoint (i.e. where the indicator changed colour) of the titration and mark this in some way in your results table. Continue the titration past the endpoint to record what happens to the pH as more acid is added (add no more than 40 cm3 of acid in total).
5. Plot a titration curve on graph paper and clearly mark where the endpoint occurred. Ensure that your axes are labelled appropriately and that your graph has a title. Take a photo of your titration curve for your *Skills Portfolio*.
6. Complete the whole process for a different acid/base/indicator combination. Take a photo of the resulting titration curve for your *Skills Portfolio*.
7. Rinse all glassware and tidy your tray so the equipment is as it was when you arrived.

**Deadlines, Assessment and Feedback on Performance**

You are required to complete the *Skills Portfolio* document associated with this practical. This should be completed electronically with all photos inserted in the appropriate places and accompanying text typed in. The submission deadline for *Skills Portfolio*s will normally be midnight on the Sunday following the practical, although you will be given specific guidance during the practical session. Submission is via the e-submission system Turnitin which you will be able to access in the appropriate folder in the Laboratories and Coursework Blackboard course.