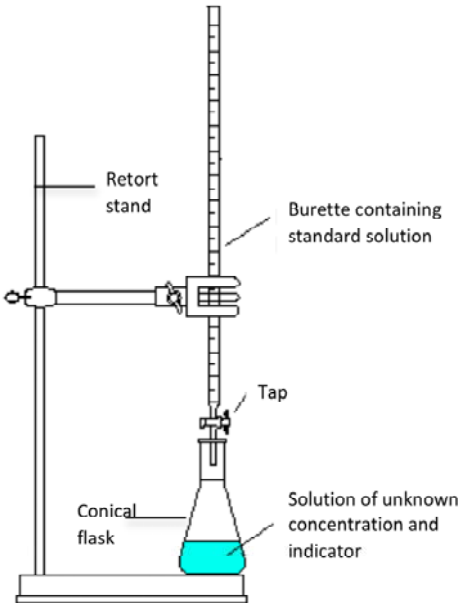
Name: _____ ( ) Date: _____

Class: _____

9. Volumetric analysis (Acid-base titration)

A **standard solution** is a solution of accurately _____. A standard solution is made by dissolving a known mass of _____ in _____ to make up a known amount of solution in a _____. The standard solution can be used to determine the concentration of an unknown solution through **titration**.

In titration, a standard solution is used to determine the concentration of an unknown solution. This is done by adding the standard solution from a _____ into a _____ that contains a known volume (usually 20.0 cm^3 or 25.0 cm^3, measured with a _____) of the unknown solution and a small quantity (2-3 drops) of an _____. The titration is stopped when the indicator _____. This is the end-point of the titration. The concentration of the unknown solution can then be determined based on the volumes of solutions used.



Practical points to think about:

- Burette / pipette should be rinsed out with the relevant solutions.
- Conical flask should be rinsed out with deionised water.
- Burette/pipette should be read at eye level.
- Burette reading: to 2 d.p., Pipette reading: to 1 d.p..
- The standard solution should be added while swirling the conical flask.
- The sides of the conical flask can be flushed with deionised water. Why would this not affect the titration readings?

Commonly used indicators:

- Phenolphthalein – _____ in acid, _____ in base
  Why is phenolphthalein only used when the base is in the burette and not in the conical flask?

- Methyl orange – _____ in acid, _____ in base, _____ at colour change.

- Screened methyl orange – _____ in acid, _____ in base, _____ at colour change.

Titration procedures to think about:

- The first titration is usually a rough titration.
- The titration is repeated, adding the standard solution dropwise towards the end of the titration.
- The titration should be repeated until at least 2 consistent (+/- 0.10 cm^3) results are obtained.
- Readings should be recorded in a table.

Worked example 1:
P is an aqueous solution of sodium hydroxide (NaOH) of concentration 0.250 mol/dm^3.
Q is an aqueous solution of hydrochloric acid (HC*l*).
Calculate the concentration of HC*l* based on your titration results.

Titration number	1	2		
Final burette reading / cm^3				
Initial burette reading / cm^3				
Volume of NaOH used / cm^3				
Best titration results (√)				

Summary

_____ cm^3 of NaOH required _____ cm^3 of HC*l* for complete reaction.

Colour change of _____ indicator from _____ to _____.

Step 1: Write a balanced equation.

Step 2: Calculate the number of moles of NaOH used.

Step 3: Use the mole ratio to determine the number of moles of HC*l* present

Step 4: Calculate the concentration of HC*l*.

Worked example 2:
16.80 cm^3 of sulfuric acid was required to exactly neutralize 25.0 cm^3 of a 0.102 mol/dm^3 NaOH solution. Calculate the concentration of the sulfuric acid.

Step 1: Write a balanced equation

Step 2: Calculate the number of moles of NaOH used

Step 3: Use the mole ratio to determine the number of moles of H_2SO_4 present

Step 4: Calculate the concentration of the sulfuric acid

Worked example 3:
A household ammonia solution was analysed to determine its ammonia content. 25.0 cm^3 of the ammonia required 21.90 cm^3 of 0.110 mol/dm^3 sulfuric acid to achieve the end-point of titration. Calculate the concentration, in mol/dm^3, of the household ammonia solution.

Worked example 4:
16.6 g of a metal carbonate, M_2CO_3, was made up to 1000 cm^3 of aqueous solution. 25.0 cm^3 of this solution required 30.00 cm^3 of 0.200 mol/dm^3 HC*l* for complete neutralisation.

a) Calculate the number of moles of HC*l* used in this reaction

b) Write the equation for the reaction between $M_2CO_3$and HC*l*.

c) Calculate the number of moles of M_2CO_3 present in 25.0 cm^3 of solution, and hence, 1 dm^3 of solution.

d) Calculate the relative molecular mass of M_2CO_3 and the relative atomic mass of M.

e) Identify the metal M.

Worked example 5:
4 g of an insoluble metal M (that is known to form M^{2+} ions) oxide was added to 100 cm^3 of 2.00 mol/dm^3 HCl. After all the oxide has reacted, the resulting solution required 40.00 cm^3 of 2.50 mol/dm^3 NaOH solution for neutralisation. Calculate the molar mass of the metal oxide and hence, identify the element.