Titration of a polyprotic acid with a strong base with Cobra SMARTsense (Item No.: P7511069)

Curricular Relevance

Area of Expertise: Chemistry
Education Level: Age 14-16
Topic: Inorganic chemistry
Subtopic: Quantitative analysis: titrations
Experiment: Titration of a polyprotic acid with a strong base with Cobra SMARTsense

Difficulty	Preparation Time	Execution Time	Recommended Group Size
Difficult	20 Minutes	30 Minutes	2 Students

Additional Requirements:

- PHYWE measureAPP

Experiment Variations:

- classic: P7511000

Keywords:

polyprotic acids, strong bases, pH-value, neutralisation, amount of substance, concentration, volumetric (titrimetric) analysis, titration curves

Information for teachers

Introduction

Application
Acid-base titration combined with indicators is a method in analytical chemistry for the preliminary assessment of corresponding solutions. For a more precise result, one can perform potentiometric titrations with the help of pH electrodes and measurement curves. Potentiometric titrations are based on two basic laws, the law of mass action and the Nernst equation. The law of mass action allows to follow the course of simple chemical reactions.

Experiment set-up

Educational objectives
The aim of this experiment is to gain more knowledge about indicators and their usage in analytical chemistry. Furthermore the students will receive a deeper understanding of titration curves and their characteristics.

Task
During this experiment, the students create a measurement curve for a titration of a polyprotic acid vs. a strong base.
On top of that, the students will identify the titration curve's characteristics and determine the equivalence point.

Prior knowledge
The students should have already gained experimental experience concerning the handling of acids, bases and indicators.
Experience with titrations and the use of volume measuring instruments (burette, graduated pipette, peleus ball) is advised.

Principle
Potentiometric titrations are mostly used to follow the course of chemical reactions and to characterize acids and bases.
A polyprotic acid (here: phosphoric acid, 0.1 M) of unknown concentration but known volume is filled into a vessel. The pH electrode, after being calibrated, will be connected to the Cobra SMARTsense Dropcounter to determine the pH value of the polyprotic acid. The solution of a strong base with known concentration (here: sodium hydroxide, 1 M) is filled into the burette. The base is added in 1 ml steps to the acid, the pH value will be determined after every step.
Polyprotic acids have more than one equivalence point, therefore two individual indicators are added to the polyprotic acid solution. (here: bromcresol green, phenolphthalein). Although phosphoric acid has three equivalence points, the third one will not be determined as it is too complicated and not necessary for a student experiment.

Notes concerning set-up and execution of the experiment
It is advised, to conduct the experiment by dividing the class in two groups (A and B), each group will determine only one equivalence point. The results of the groups A and B will be exchanged at the end of class.

Furthermore, the students should work in groups of two. One student performs the titration, while the other student is responsible to record the pH values.

Different groups can perform the titration with different concentrations of the polyprotic acid, the different group results can be compared and analysed.

Before execution of the experiment, calibrate the pH electrode as you will receive falsified results.
During the experiment, ensure that the pH electrode is sufficiently immersed in the medium at all times.

During the set-up of the experiment, it must be ensured that the burette is properly fastened to the support rod so that the

Robert-Bosch-Breite 10
D - 37079 Göttingen
Tel: +49 551 604 - 0
Fax: +49 551 604 - 107
info@phywe.de
www.phywe.com

students can precisely read the height of the liquid column.The dripping rate of the burette should not be too high in order to ensure that the result is as precise as possible. A too low dripping rate should also be avoided, since this would unnecessarily extend the entire experiment.

The use of a magnetic stirrer (and magnetic stirring rod) is recommended.
If a magnetic stirrer is used, ensure that it is set to medium speed (to avoid splashes). Also, immerse the electrode in a way that the rotating stirring rod cannot damage it.

Prepare the following solutions:
0.1 M phosphoric acid: Add 500 ml distilled water to a suitable volumetric flask, pipette 6.8 ml of phosphoric acid, 85 % and fill up to 1 liter with distilled water.
1 M sodium hydroxide: Dissolve 8 g sodium hydroxide in 200 ml distilled water.

Disposal
After use, the solutions can be collected in the collecting tank for waste acids and bases for disposal.

Equipment

Position No.	Material	Order No.	Quantity
1	Cobra SMARTsense - Dropcounter, 0 ... ∞	12923-00	1
2	pH-Elektrode für Cobra SMARTsense pH, BNC-Stecker	12920-10	1
3	Boss head	02043-00	1
4	Support base, variable	02001-00	1
5	Electrode holder, pivoted	18461-88	1
6	Burette clamp with 1 roll holder	37720-01	1
7	Pipettor, bulb, 3 valves, 100 ml max.	47127-02	1
8	Pipette with rubber bulb	64701-00	1
9	Laboratory pencil, waterproof	38711-00	1
10	Erlenmeyer wide neck, boro, 100 ml	46151-00	1
11	Protecting glasses, clear glass	39316-00	1
12	Beaker, 50 ml, low form, plastic	36080-00	2
13	Wash bottle, 250 ml, plastic	33930-00	1
14	Funnel, plastic, dia 40 mm	36888-00	1
15	Graduated pipette, 5 ml	36599-00	1
16	Burette, 10 ml, grad. 0.05 ml	47152-01	1
17	Support rod, stainless steel, l = 370 mm, d = 10 mm	02059-00	1
	Sodium hydroxide, 500 g	30157-50	
	Ortho-phosphoric acid, 85 %, 250 ml	30190-25	
	Water, distilled, 5 l	31246-81	
	Methyl orange, 0.1%, 250 ml	31573-25	
	Phenolphthalein solution, 0.5% in ethanol, 100 ml	31715-10	
	Buffer solution tablets pH 4, 100 pcs	30281-10	
	Buffer solution tablets pH 10, 100 pcs	30283-10	
Additonal material			
	Paper towels/cloth		
	PHYWE measureAPP		

Safety information

Hazard and precautionary statements

Phosphoric acid (0.1 M)	
H290:	May be corrosive to metals.
H314:	Causes severe skin burns and eye damage.
P280:	Wear protective gloves/protective clothing/eye protection/face protection.
P301 + P330 + P331:	IF SWALLOWED: Rinse mouth. Do NOT induce vomiting.
P309 + P310:	IF exposed or if you feel unwell: Immediately call a POISON CENTER or doctor/physician.
P305 + P351 + P338:	IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing.
Sodium hydroxide (1 M)	
H290:	May be corrosive to metals.
H314:	Causes severe skin burns and eye damage.
P280:	Contains gas under pressure; may explode if heated.
P301 + P330 + P331:	IF SWALLOWED: Rinse mouth. Do NOT induce vomiting.
P305 + P351 + P338:	IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing.
P308 + P310:	IF exposed or concerned: Immediately call a POISON CENTER or doctor/physician.
Phenolphthalein (0.5% in ethanol)	
H226:	Flammable liquid and vapour.
P210:	Keep away from heat/sparks/open flames/hot surfaces. — No smoking.

Hazards

- Acids and bases have a strong irritating effect!
- Wear protective glasses!

Titration of a polyprotic acid with a strong base with Cobra SMARTsense (Item No.: P7511069)

Introduction

Application and task

What is a potentiometric titration?

Application
Potentiometric titrations are performed with the help of pH electrodes. In a chemistry lab, they are used for concentration analysis in the case that samples are turbid or coloured (indicators would be unsuitable). Furthermore, this method enables to follow the course of chemical reactions with measurement curves and also to determine the equivalence point.

Experiment set-up

Task
Determine the concentration of phosphoric acid with a potentiometric titration.

Group A: Identify the equivalence point with a suitable indicator (methyl orange).
Group B: Identify the equivalence point with a suitable indicator (phenolphthalein).

Exchange your results (A and B).

Create a titration curve with your data and examine it's characteristics.

Robert-Bosch-Breite 10
D - 37079 Göttingen
Tel: +49 551 604 - 0
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Android iPad

Set-up and procedure

Set-up

Hazards

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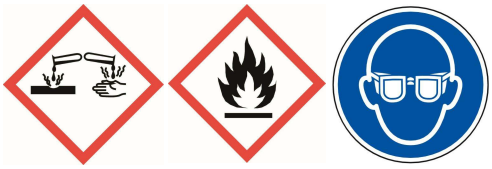
- Wear protective glasses!



Switch on the Cobra SMARTsense Dropcounter

- Switch on the Cobra SMARTsense 'Dropcounter' by pressing the power button.
- Ensure Bluetooth is activated on your device. Open the PHYWE measure App and select the sensor "Dropcounter" (Fig. 1) and the measurement channel 'pH' (Fig. 2).

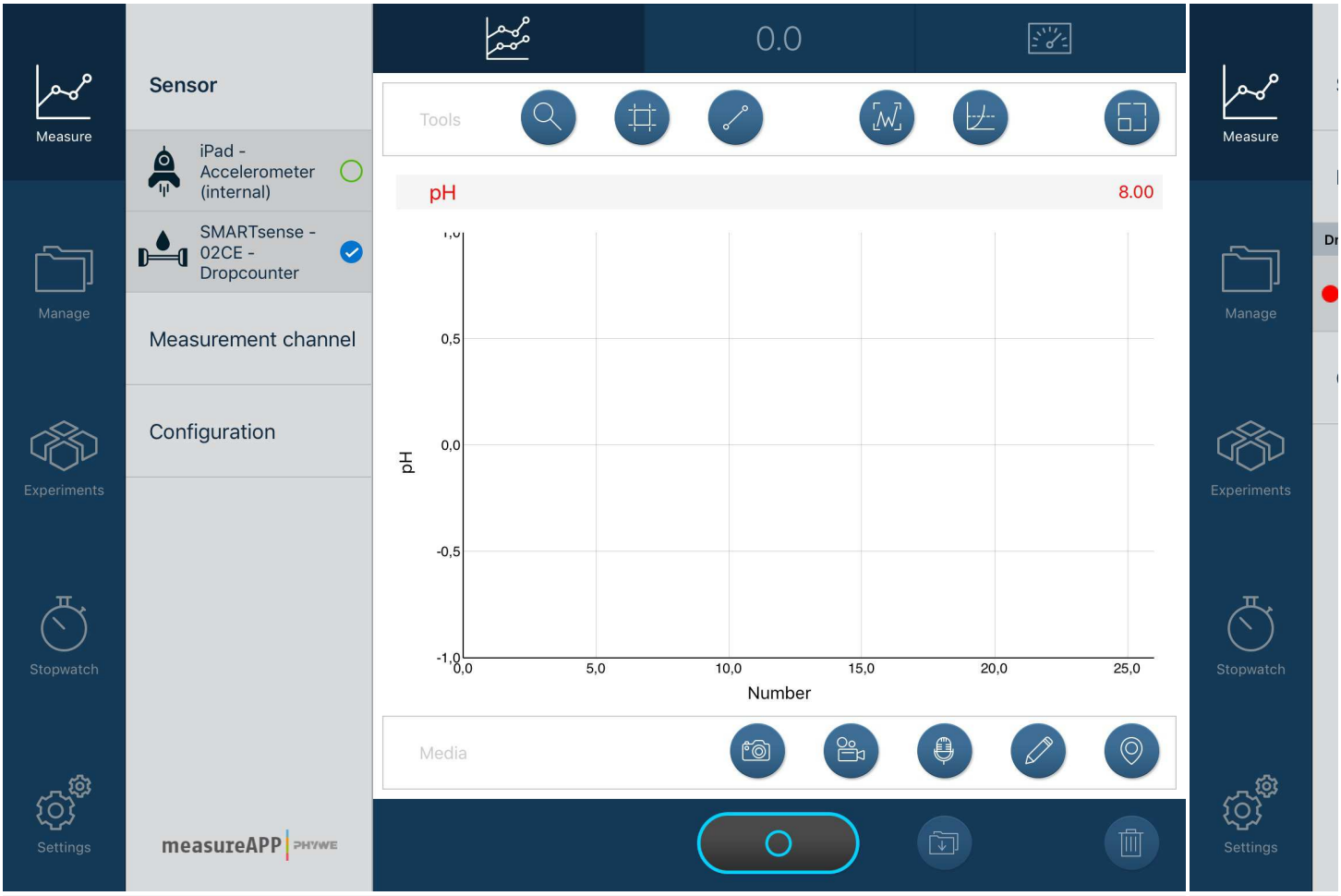


Fig. 1

Calibration of the pH electrode

- Before starting the experiment, the pH electrode needs to be calibrated. To do so, prepare two beakers with respective buffer solutions. Buffer solutions are prepared with buffer tablets by adding the respective buffer tablets to 20 mL buffer solution. Remove the protection cap of the pH electrode and submerge the electrode into the solution (Fig. 3).

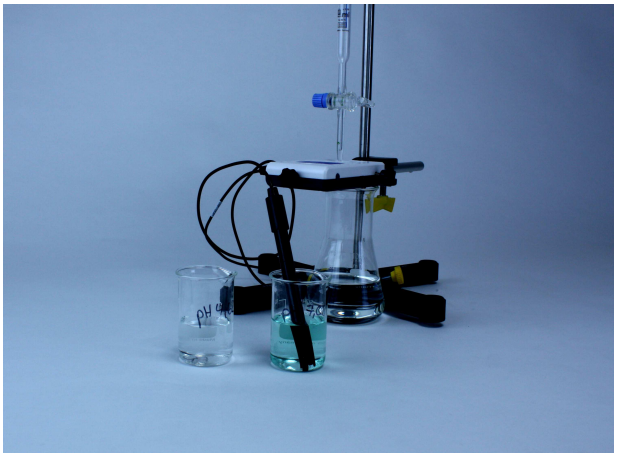


Fig. 3

1. Go to "Configuration" (Fig. 4)
2. Go to (scroll down if necessary) "Calibration" (Fig. 4)
3. Click on the value (Fig. 5)

If the electrode has already been calibrated recently, a new calibration is not necessary.

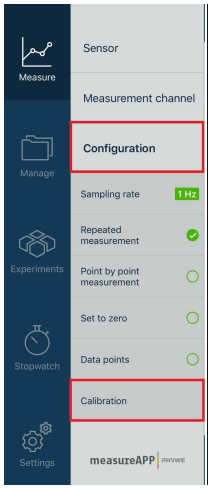


Fig. 4

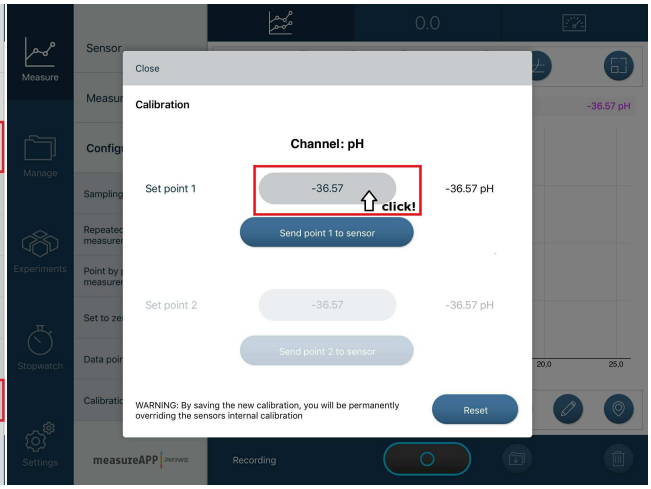


Fig. 5

- Rinse electrode with distilled water. Repeat the procedure for the second value (set point 2).

Set-up

Combine the two halves of the support base (Fig. 6). Fasten the support rod in the support base (Fig. 7).

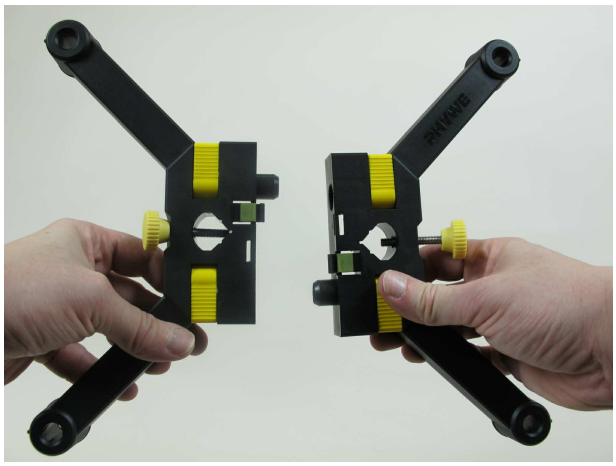


Fig. 6

Fig. 7

Screw in the support rod into the respective Dropcounter screwing device (Fig. 8). Fasten the support rod with the help of a double socket on the other support rod below the burette holder (Fig. 9). Mount the pH electrode in the sensor hole and fasten with respective screw (Fig. 10). Plug in the pH electrode into the BNC connector of the Dropcounter (Fig. 11).

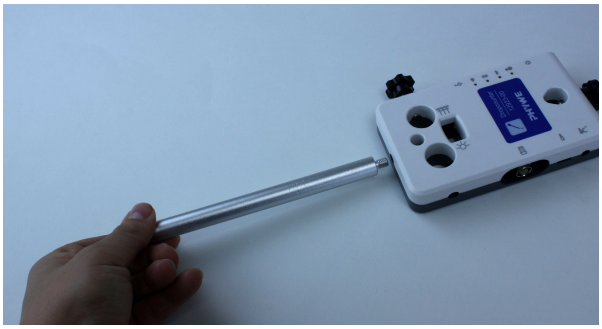


Fig. 8

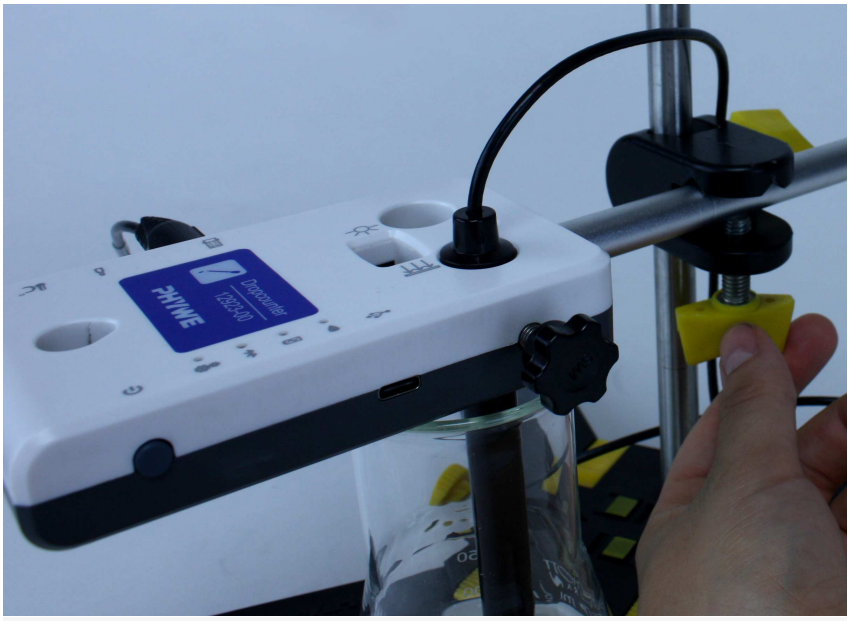


Fig. 9

Fig. 10

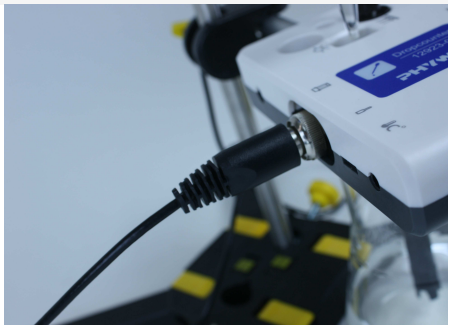


Fig. 11

Attach the burette clamp to the support rod (Fig. 12). Compress the two levers of the burette clamp with your thumb and index finger and position the burette between the four rubber rollers (Fig. 18). Secure the burette in place by slowly releasing the two levers. Make sure the burette is positioned centrally above the drop counter sensor (Fig. 13).

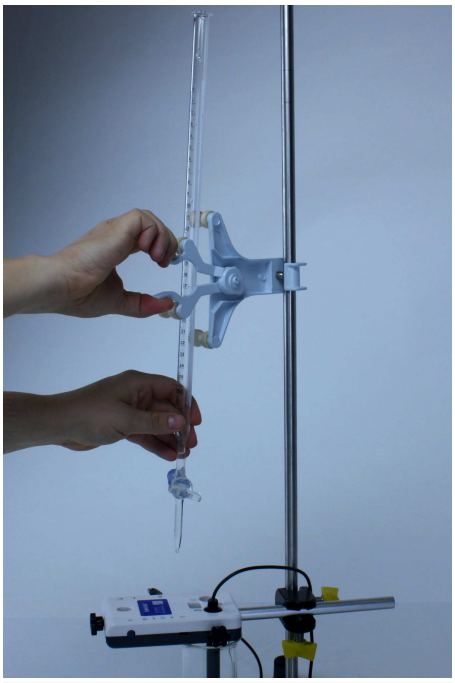


Fig. 12

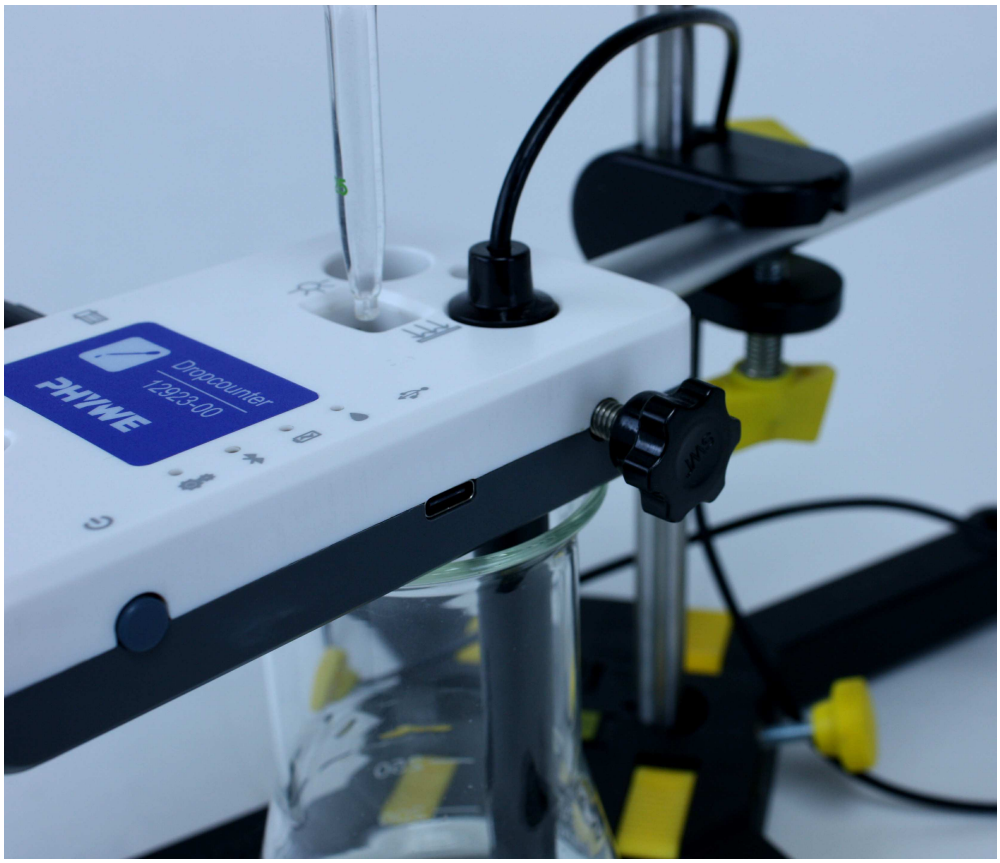


Fig. 13

Fill the burette with the 1 M sodium hydroxide solution with the aid of the funnel. Use the two laboratory beakers for this purpose and label them in order to avoid any confusion.
Fill the 10-ml-burette carefully up to above the top calibration mark. Ensure that there are no air bubbles inside the burette and that none of the liquid flows over (Fig. 14).

Position a laboratory beaker under the stopcock of the burette and open the stopcock carefully. Let some sodium hydroxide solution flow out until the liquid column reaches the upper calibration mark (Fig. 15).

Fig. 14

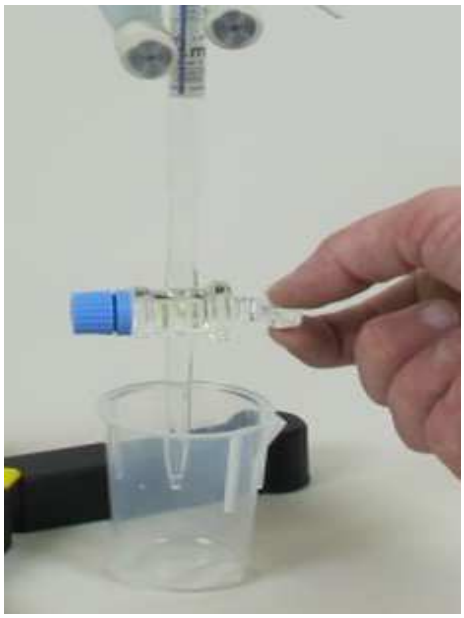


Fig. 15

A concave curve, the so-called meniscus (from Greek "meniskos" = crescent), forms on the surface of the liquid column in the burette. In order to identify precisely when the liquid column reaches the upper calibration mark, the lowest point of this curve

must be used for orientation. Your eyes should be precisely on the same level as the calibration mark (Fig. 16).

Fig. 16

Fill 50 ml of the given phosphoric acid solution into an Erlenmeyer flask (Fig. 17). Position the Erlenmeyer flask under the stopcock of the burette. Immerse the pH electrode until it's tip is sufficiently coated by the solution (Fig. 18).

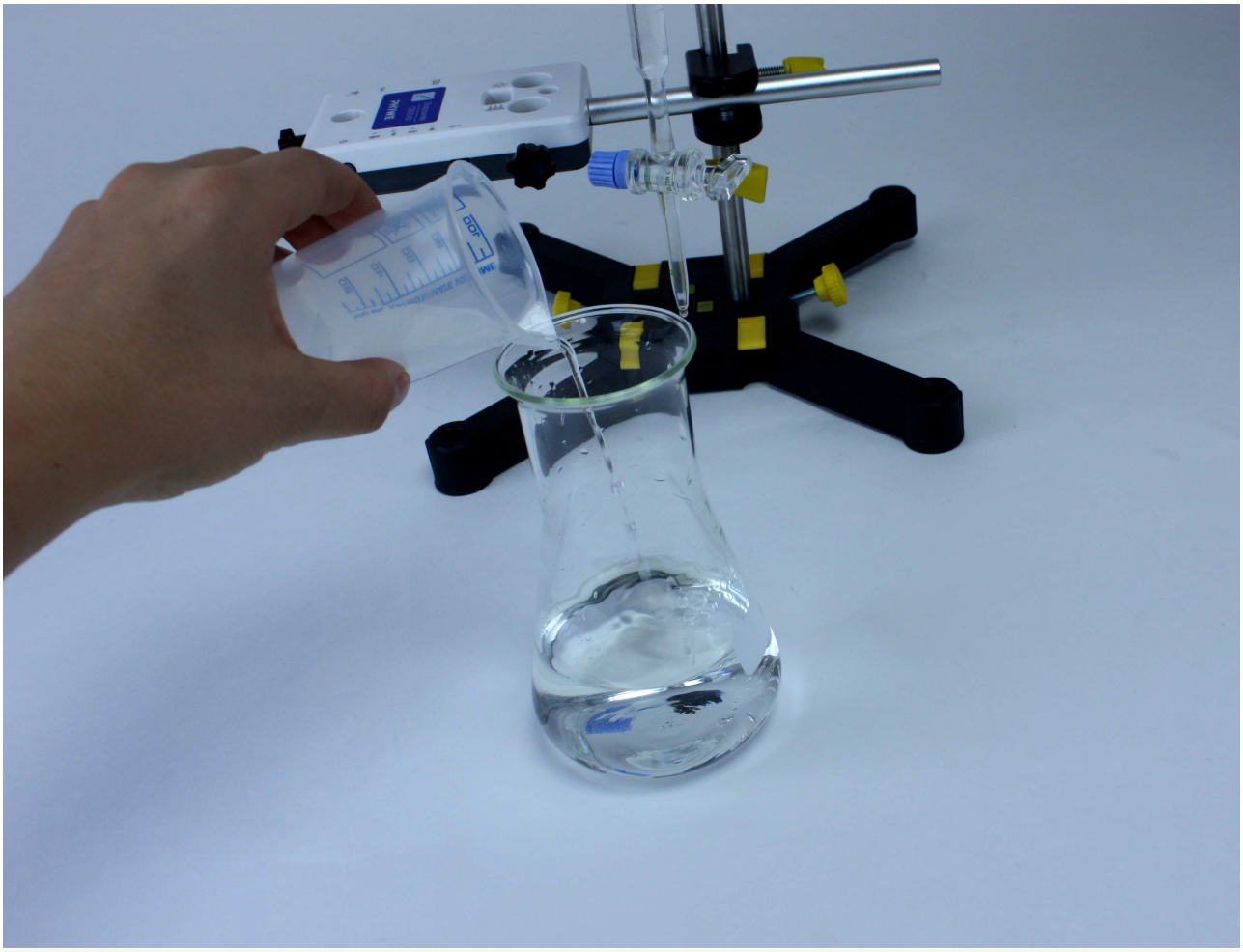


Fig. 17

Group A: Use the pipette with the rubber bulb to add 3 to 5 drops of methyl orange to the phosphoric acid solution.

Group B: Use the pipette with the rubber bulb to add 3 to 5 drops of phenolphthalein to the phosphoric acid solution.

Procedure

Procedure

Start measurement with  (c.f. Fig. 19).

Group A:
Gently open the stopcock, add 1 ml of sodium hydroxide solution to the phosphoric acid solution (Fig. 20). Gently swirl the Erlenmeyer flask to and fro. Avoid splashes (attention: irritating!). Note the pH value (when it seems to be constant).
Repeat the procedure, until 4 ml of sodium hydroxide solution are titrated. To determine the equivalence point, titrate in 0.2 ml steps (always note pH value after each step).

Group B:
Gently open the stopcock, add 1 ml of sodium hydroxide solution to the phosphoric acid solution (Fig. 20). Gently swirl the Erlenmeyer flask to and fro. Avoid splashes (attention: irritating!). Note the pH value (when it seems to be constant).
Repeat the procedure, until 9 ml of sodium hydroxide solution are titrated. To determine the equivalence point, titrate in 0.2 ml steps (always note pH value after each step).

Stop meaurement with  and save your measurements with  .

Fig. 19

Fig. 20

Exchange your results (group A and B) to create a complete titration curve.
Fill the report's table with your collected data and analyse the titration curve.
Also note the change of colour (pH and volume of sodium hydroxide solution).

Disposal
After use, the solutions can be collected in the collecting tank for waste acids and bases for disposal.

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