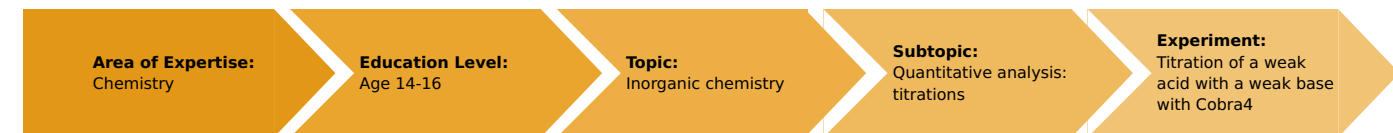


Titration of a weak acid with a weak base with Cobra SMARTsense (Item No.: P7510969)

Curricular Relevance



Difficulty



Intermediate

Preparation Time



10 Minutes

Execution Time



30 Minutes

Recommended Group Size



2 Students

Additional Requirements:

- PHYWE measureAPP

Experiment Variations:

- classic: P7510900

Keywords:

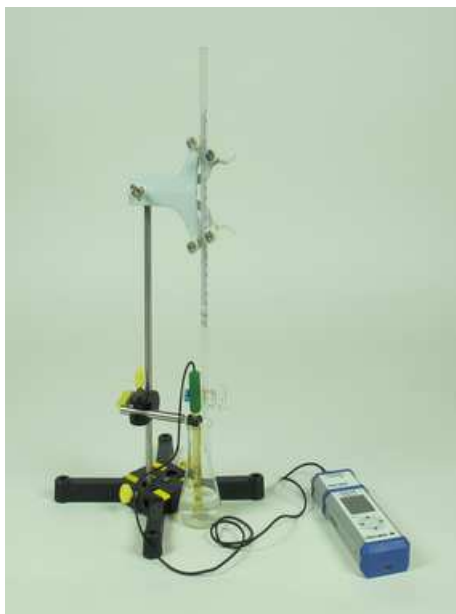
weak acids, weak bases, pH-value, neutralisation, amount of substance, volumetric (titrimetric) analysis, titration curves, concentration

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 weak acid vs. a weak 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, peplus ball) is advised.

Principle

Potentiometric titrations are mostly used to follow the course of chemical reactions and to characterize acids and bases. A weak base (here: ammonia, 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 weak base. The solution of a weak acid with known concentration (here: acetic acid, 0.1 M) is filled into the burette. The acid is added in 1 ml steps to the acid, the pH value will be determined after every step. The equivalence point is determined with a suitable indicator (here bromothymol blue).

Notes concerning set-up and execution of the experiment

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

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 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 ammonia-solution: Fill 7.51 ml ammonia-solution, 25 % into a suitable vessel, fill up to 1 l with distilled water.

0.1 M acetic acid: Add 250 ml distilled water to a suitable volumetric flask, pipette 2.88 ml of concentrated acetic acid and fill up to 500 ml with 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
	Ammonia solution, 25%, 250 ml	30933-25	
	Water, distilled, 5 l	31246-81	
	Acetic acid, 99-100%, 500 ml	31301-50	
	Buffer solution tablets, pH 4, 100 pcs	30281-10	
	Buffer solution tablets, pH 10, 100 pcs	30283-10	
	Bromothymol blue solution, 0.1%, 50 ml	48004-05	
Additional material			
	Paper towels		
	PHYWE measureAPP		

Android

iPad



Safety information



Hazard and precautionary statements

Acetic acid (1 M)

H226:	Flammable liquid and vapour.
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.
P307 + P310:	IF exposed: 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.

Ammonia (0.1 M)

H221:	Flammable gas.
H331:	Toxic if inhaled.
H314:	Causes severe skin burns and eye damage.
H400:	Very toxic to aquatic life.
P210:	Keep away from heat/sparks/open flames/hot surfaces. — No smoking.
P260:	Do not breathe dust/fume/gas/mist/vapours/spray.
P273:	Avoid release to the environment.
P304 + P340:	IF INHALED: Remove victim to fresh air and keep at rest in a position comfortable for breathing.
P303 + P361 + P353:	IF ON SKIN (or hair): Remove/Take off immediately all contaminated clothing. Rinse skin with water/shower.
P305 + P351 + P338:	IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing.
P377:	Leaking gas fire: Do not extinguish, unless leak can be stopped safely.
P381:	Eliminate all ignition sources if safe to do so.
P405:	Store locked up.
P403:	Store in a well-ventilated place.

Hazards

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

Titration of a weak acid with a weak base with Cobra SMARTsense (Item No.: P7510969)

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 ammonia with a potentiometric titration. Identify the equivalence point with a suitable indicator (here: bromothymol blue). Create a titration curve with your data and examine its characteristics.

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
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	Bromothymol blue solution, 0.1%, 50 ml	48004-05	
Additional material			
	Paper towels		
	PHYWE measureAPP		

Android

iPad



Set-up and procedure


Set-up

Hazards

- Acids and bases have a strong irritating effect!
- 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).

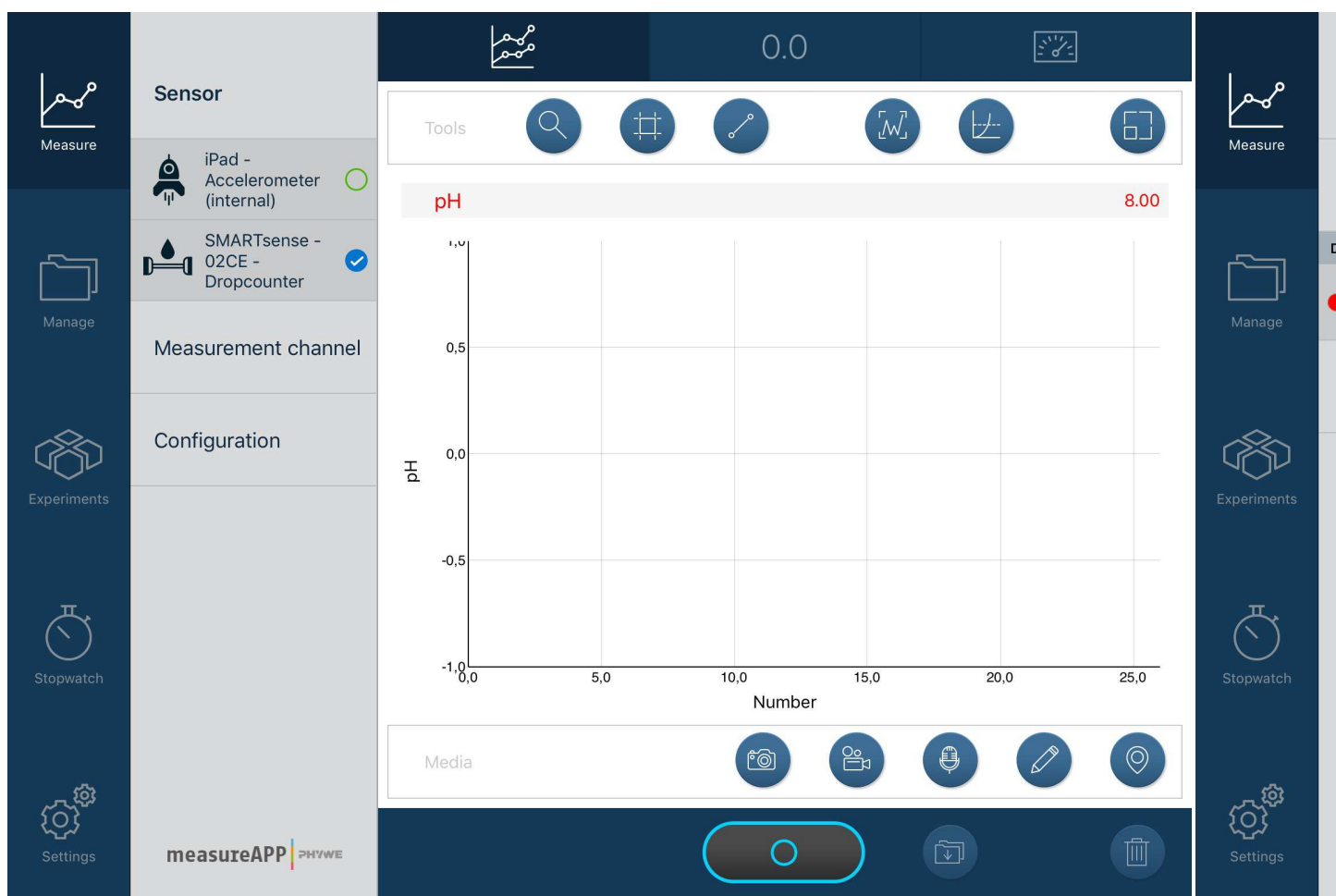


Fig. 1

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).

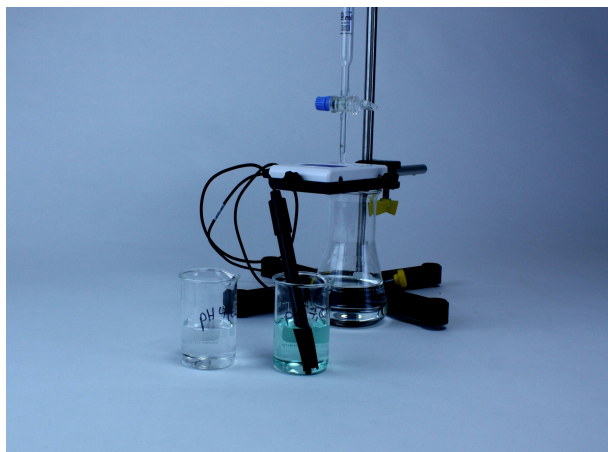


Fig. 3

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.

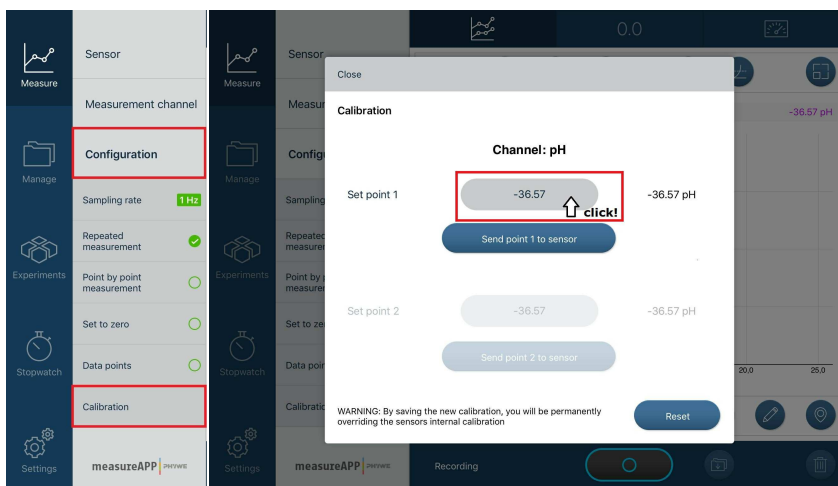


Fig. 4

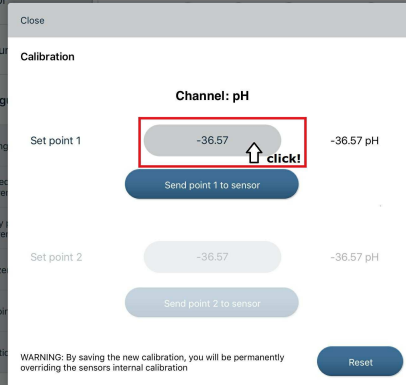


Fig. 5

- 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).

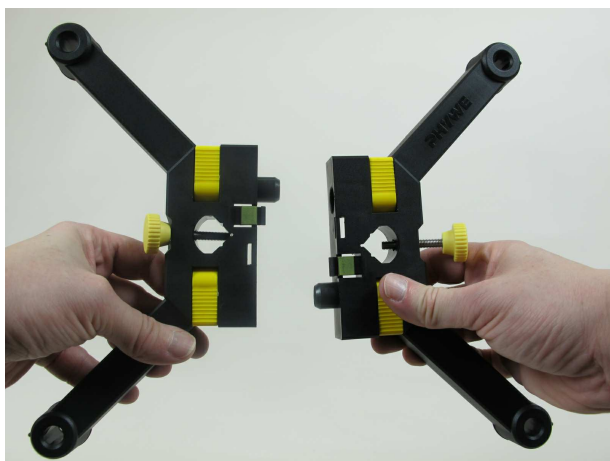


Fig. 6



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

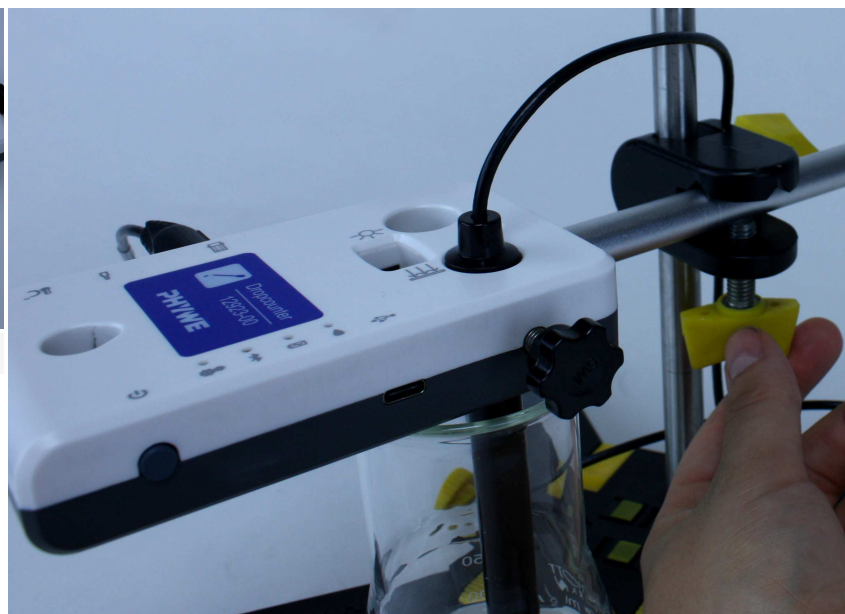


Fig. 9



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. 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).

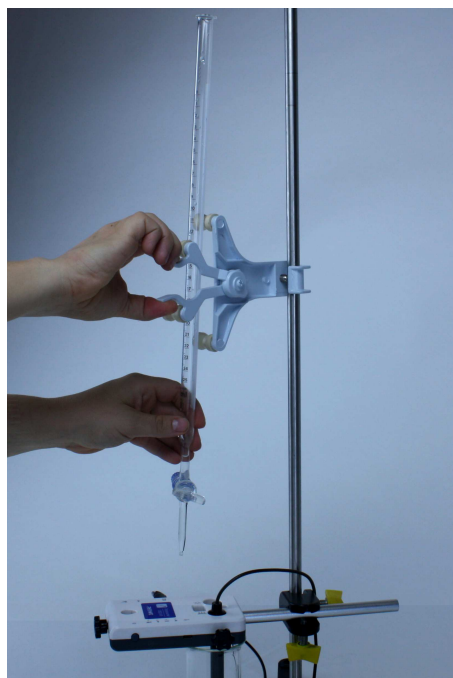


Fig. 12

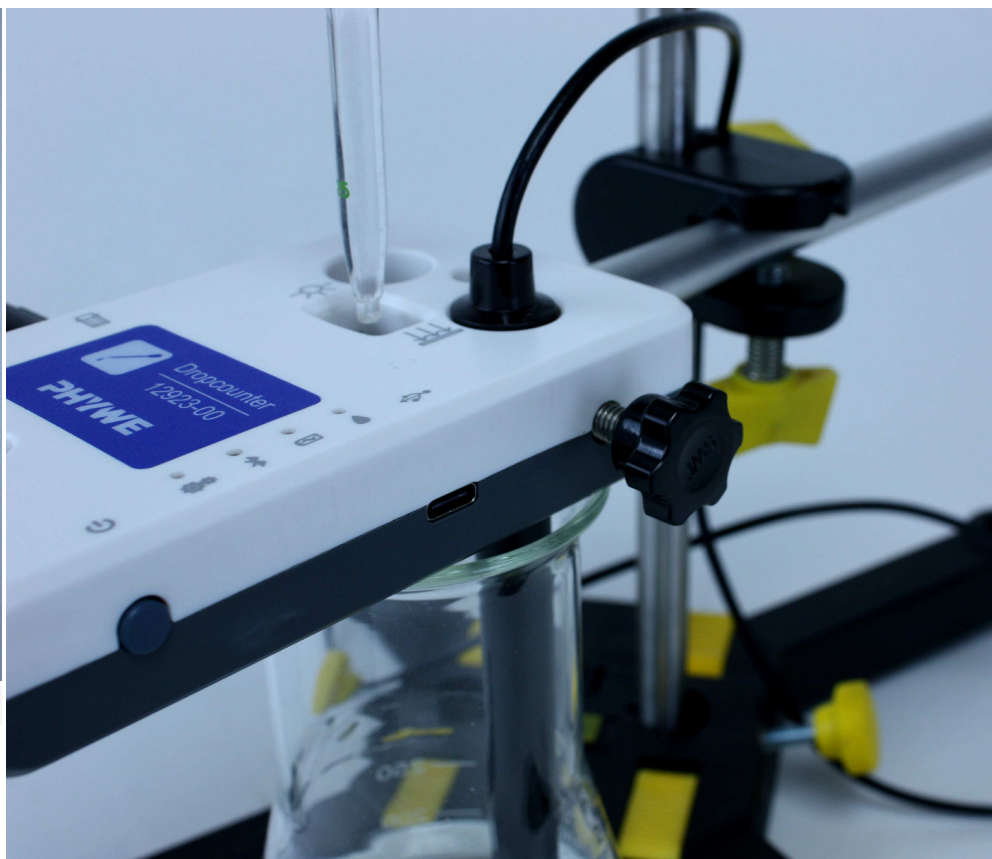


Fig. 13

Fill the burette with the 0.1 M Ammonia 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 of the ammonia solution flow out until the liquid column reaches the upper calibration mark (Fig. 15).



Fig. 14

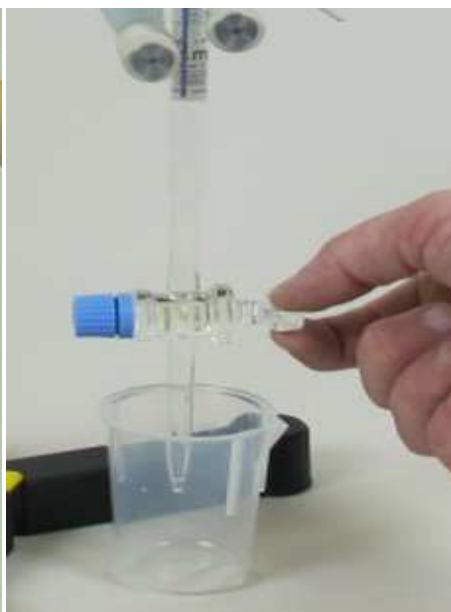


Fig. 15

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 30 ml of the given acetic acid solution into an Erlenmeyer flask (Fig. 17). Position the Erlenmeyer flask under the stopcock of the burette. Immerse the pH electrode until its tip is sufficiently coated by the solution (Fig. 18).

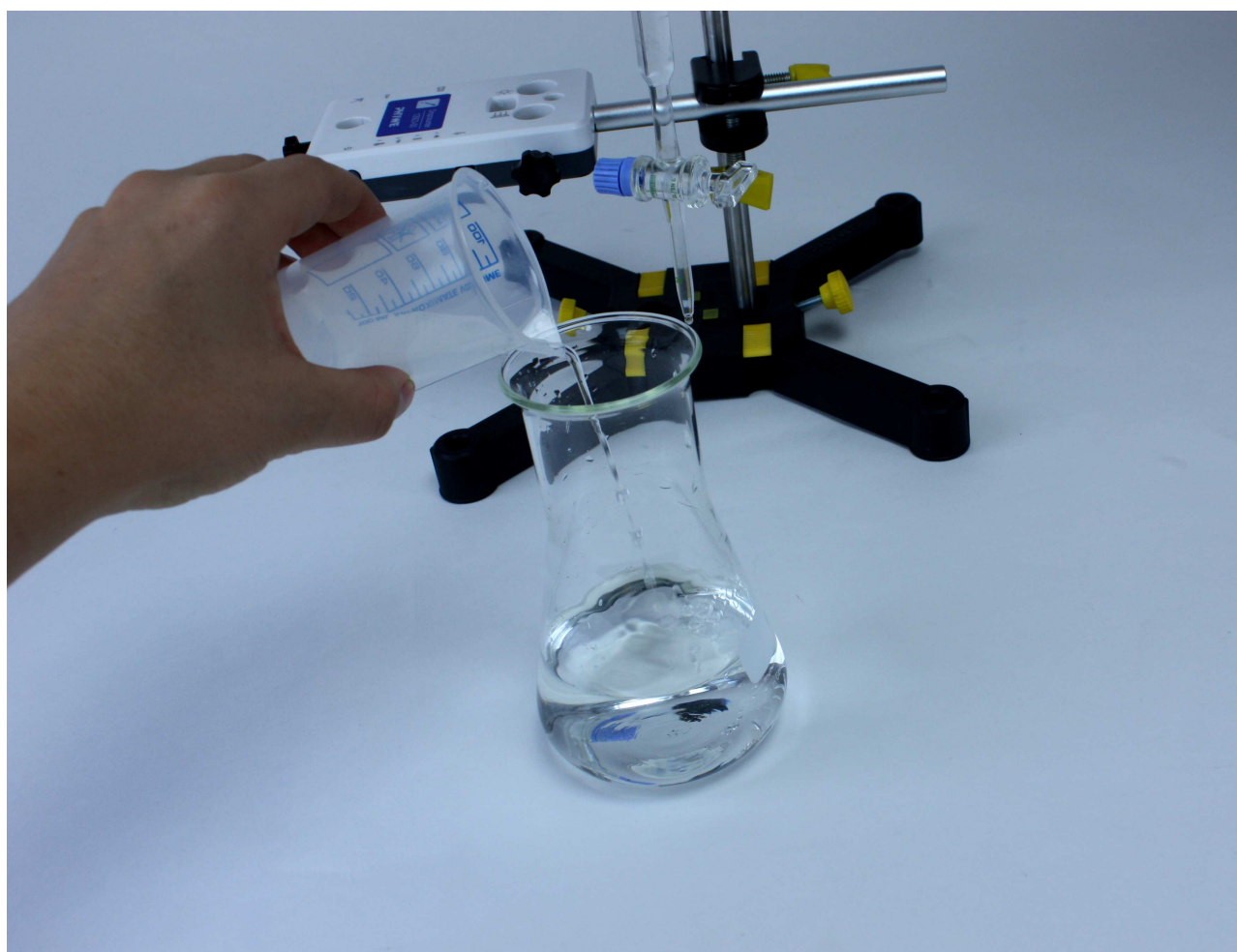



Fig. 17

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

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

Procedure

Procedure

In total, you will titrate 10 ml of acetic acid. Start measurement with  (c.f. Fig. 19).

- Gently open the stopcock, add 1 ml of acetic acid to the ammonia solution (Fig. 19). Carefully 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 acetic acid are titrated. To determine the equivalence point, titrate in 0.2 ml step (always note pH value after each step). After the equivalence point is determined, continue as described above in 1 ml steps.

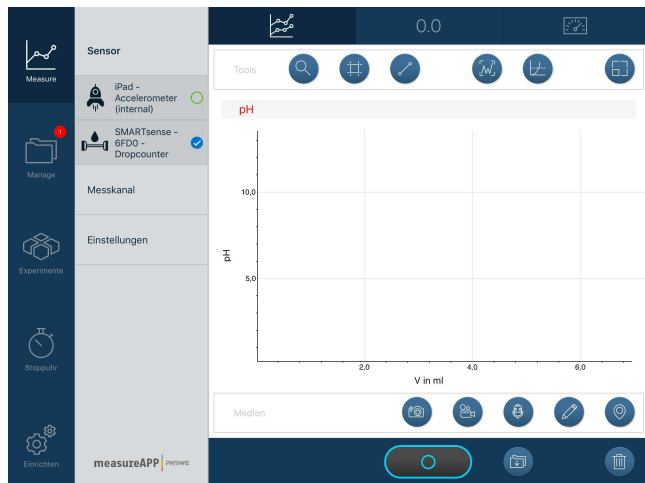




Fig. 19



Fig. 20

Stop measurement with  and save your measurements with .

Fill the report's table with your collected data and analyse the titration curve. Also note the change of colour (pH and volume of acetic acid).

Disposal

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