Determining the pKa value of a weak acid with half titration

Chemistry > Inorganic chemistry > Acids, bases, salts

Chemistry > Analytical Chemistry > Titration

Difficulty level	Group size	Preparation time	Execution time
hard	2	10 minutes	30 minutes

This content can also be found online at:

http://localhost:1337/c/638badf823a87a0003a27307

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Teacher information

Application

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Experimental setup

Acid-base titration using indicators is used in analytical chemistry for the preliminary examination of corresponding solutions. With their help, initial statements can be made about the concentration of the substance under investigation. A precise examination is then usually carried out with the help of pH electrodes.

The pKs value of a weak acid can also be determined with the help of an indicator.

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Other teacher information (1/3)

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Prior knowledge

The students should have gained first experimental experience in dealing with acids and bases. The functioning of volumetric measuring instruments (graduated pipette, burette, pipetting ball) should be known to the students.

Principle

This titration is a measurement-analytical procedure for determining the pKs value of acetic acid.

Here, a weak acid of unknown concentration with known volume is presented and a suitable indicator (here: phenolphthalein) is added. The solution of the base with known concentration (measured solution) is filled into the burette and now added drop by drop to the analysis solution up to the transition point of the indicator. The volume read off the burette gives the amount of sodium hydroxide solution that must be added to the solution so that the pH value of the solution is equal to the pKs value of the acetic acid.

Other teacher information (2/3)

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Learning objective

The students should be shown and taught the use of indicators in analytical chemistry as well as the basics of dimensional analysis by way of example.

Tasks

The students are to determine the pKs value of acetic acid with the help of a suitable indicator (here: phenolphthalein). A known volume of this acid is titrated with a volume of a sodium hydroxide solution of known concentration (measured solution) until the indicator changes colour. The volume of sodium hydroxide solution consumed is then read off the burette. Exactly half of this volume of hydrochloric acid is then added to the original solution and the pH is determined using a test stick. This pH value is then equal to the pKs value of the acetic acid.

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Other teacher information (3/3)

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Preparation

An approx. 0.1 M solution of salts 1-4 must be prepared in each case.
0.1 M sodium chloride solution: 1.46 g sodium chloride to 250 ml distilled water.
0.1 M sodium bromide solution: 2.57 g sodium bromide to 250 ml distilled water.

0.1 M sodium sulphate solution: 3.55 g sodium sulphate to 250 ml distilled water.
0.1 M sodium carbonate solution: 2.64 g sodium carbonate to 250 ml dist. water.

Likewise, a 5% hydrochloric acid solution (put approx. 40 ml of dist. Water into a volumetric flask, pipette 13 ml of 37% hydrochloric acid and make up to 100 ml with distilled water), A 5% nitric acid solution (add approx. 40 ml dist. water to a volumetric flask, pipette 13 ml 37% hydrochloric acid and make up to 100 ml with dist. water). Water into a volumetric flask, pipette 50 ml 10% hydrochloric acid and make up to 100 ml with dist. water) and 10% bar. water) and a 10% barium chloride solution (10 g barium chloride to 100 ml dist. water) must be prepared.

Safety instructions

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- Acids and bases cause severe burns.
- Use protective goggles/gloves!
- The general instructions for safe experimentation in science lessons apply to this experiment.
- For H and P phrases, please refer to the safety data sheet of the respective chemical.

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Student information

Motivation

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Vinegar

How can the strength of a weak acid be determined?

We encounter many acids in everyday life and in the chemistry lab. Whether as vinegar in salad or as battery acid in the car. They can be found everywhere.

In order to be able to handle them safely in the laboratory, it is important to know their strength. The pKs value is a measure of the strength of an acid.

With the help of a suitable indicator and a base, one can determine the pKs value of a weak acid. This procedure is called half titration.

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Task

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Experimental setup

Determine the pKs value of acetic acid with the help of a half titration. Use phenolphthalein as an indicator and 0.1 molar sodium hydroxide as a base.

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Equipment

Position	Material	Item No.	Quantity
1	Burette with straight stopcock, 25 ml Graduation 0.1 ml	47153-01	1
2	Pipette with rubber bulb	64701-00	1
3	Erlenmeyer flask, Borosilicate, wide neck, 100 ml	46151-00	1
4	Funnel, diameter = 40 mm, plastic (PP)	36888-00	1
5	Graduated pipette, 5 ml : 0,1	36599-00	1
6	Protecting glasses, clear glass	39316-00	1
7	Pipettor,bulb,3 valves,100ml max.	47127-02	1
8	Burette clamp, roller mount.,1pl.	37720-01	1
9	Support base, variable	02001-00	1
10	Support rod, stainless steel, l=370 mm, d=10 mm	02059-00	1
11	Wash bottle, 250 ml, plastic	33930-00	1
12	Laboratory pen, waterproof, black	38711-00	1
13	Phenolphthalein, 0,5% soution in ethanol, 100 ml	31715-10	1
14	pH test sticks 0-14, 100 sticks	30301-08	1
15	Water, distilled 5 l	31246-81	1
16	Acetic acid 99...100%, 500 ml	31301-50	1
17	Hydrochloric acid 37 %, 1000 ml	30214-70	1
18	Beaker, 50 ml, plastic (PP)	36080-00	2

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Set-up (1/7)

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1. Put the two halves of the stand foot together (**Fig. 1**).
2. Attach the stand rod to the stand foot (**Fig. 2**).
3. Attach the burette clamp to the stand rod (**Fig. 3**).

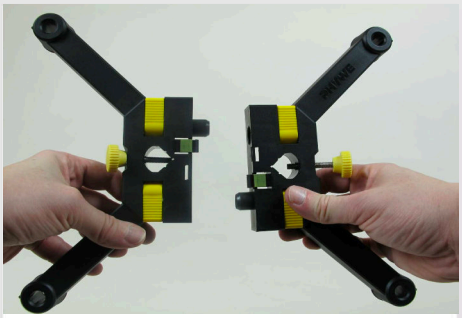

Fig. 1

Fig. 2

Fig. 3

Set-up (2/7)

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Press the two levers of the burette clamp together with your thumb and forefinger (**Fig. 4**) and place the burette between the four rubberised rollers (**Fig. 5**). Fix the burette by slowly releasing the two levers.

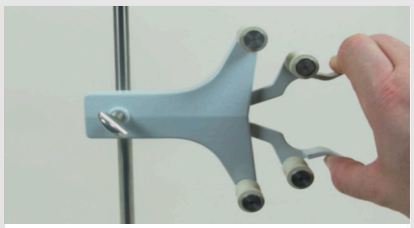

Fig. 4

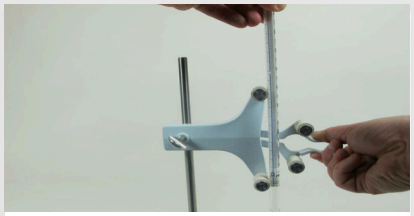

Fig. 5

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Set-up (3/7)

Fill the burette with the 0.1 molar sodium hydroxide solution using the funnel. Use the two laboratory beakers and label them to avoid any risk of confusion.

Carefully fill the 10 ml burette to above the upper calibration mark. Make sure that there are no air bubbles in the burette and that nothing is overflowing (**Fig. 6**).

Place one of the laboratory beakers under the tap of the burette and open it carefully. Drain off as much sodium hydroxide solution as necessary until the top calibration mark of the liquid column is reached (**Fig. 7**).

Fig. 6

Fig. 7

Set-up (3/7)

PHYWE

Fill the burette with the 0.1 molar sodium hydroxide solution using the funnel. Use the two laboratory beakers and label them to avoid any risk of confusion.

Carefully fill the 10 ml burette to above the upper calibration mark. Make sure that there are no air bubbles in the burette and that nothing is overflowing (**Fig. 6**).

Place one of the laboratory beakers under the tap of the burette and open it carefully. Drain off as much sodium hydroxide solution as necessary until the top calibration mark of the liquid column is reached (**Fig. 7**).

Fig. 6

Fig. 7

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Set-up (4/7)

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A downward curvature forms on the surface of the liquid column in the burette, the so-called meniscus (Greek meniskos = half moon). To measure exactly when the liquid column touches the top of the burette, orientate yourself to the lowest point of this curvature. Your eyes should be exactly at the level of the calibration line (**Fig. 8**).

Put the pipetting ball on the graduated pipette (**Fig. 9**). Press the valve "A" together with your thumb and index finger. Press air out of the pipetting ball with the other fingers (**Fig. 10**).

Fig. 8

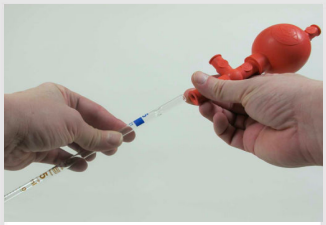

Fig. 9

Fig. 10

Set-up (5/7)

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Hold the pipette vertically and insert its tip into the prepared acetic acid. By carefully squeezing the valve "S", the pipette slowly fills with the acid. Make sure that the pipette does not fill too quickly. There must be no air bubbles in the liquid. Caution: No acid should get into the pipetting ball!

Fill the graduated pipette to about six millilitres (**Fig. 11**).

Squeeze the valve "E" and let as much acid run out of the graduated pipette until there is exactly 5 ml of liquid in it (**Fig. 12**).

The reading of the filling level is done here as described above.

Fig. 11

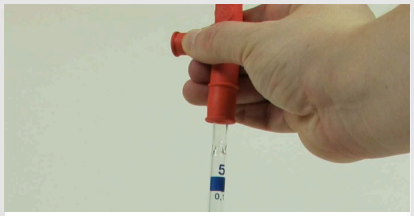

Fig. 12

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Set-up (6/7)

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Carefully remove the graduated pipette from the acetic acid and insert it into the Erlenmeyer flask. Squeeze the valve "E" to empty it completely into the vessel (**Fig. 12**).

A small drop remains in the tip of the graduated pipette when it runs out. This has already been taken into account when calibrating the pipette so that it does not have to be removed from the pipette.

Place the Erlenmeyer flask under the tap of the burette and fill up with a little water using the squirt bottle (**Fig. 13**). There should be no more than about two centimetres of liquid in the flask.

Fig. 13

Set-up (7/7)

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Using the pipette with rubber cap, add 3 to 5 drops of phenolphthalein to the acid solution (**Fig. 14**).

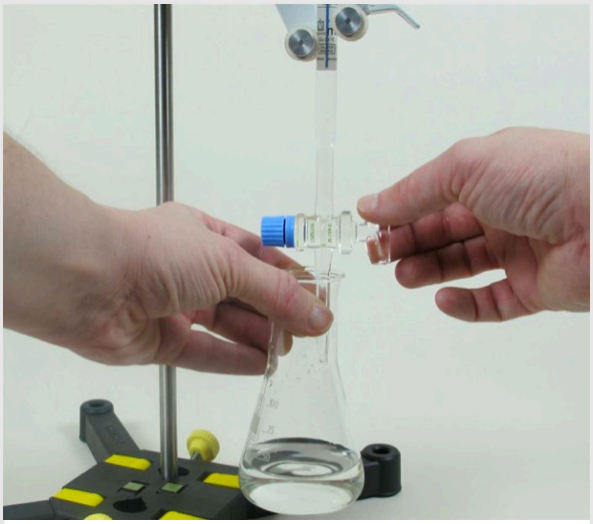

Fig. 14

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Procedure (1/3)

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By carefully turning the tap of the burette, a medium dripping speed is set.

It must be possible to observe individual drops.

The Erlenmeyer flask with the acid is carefully swayed back and forth (**Fig. 15**). There must be no splashes (**Attention: Acid!**).

As soon as a colour change appears in the acid solution, reduce the dripping speed by carefully turning the burette tap.

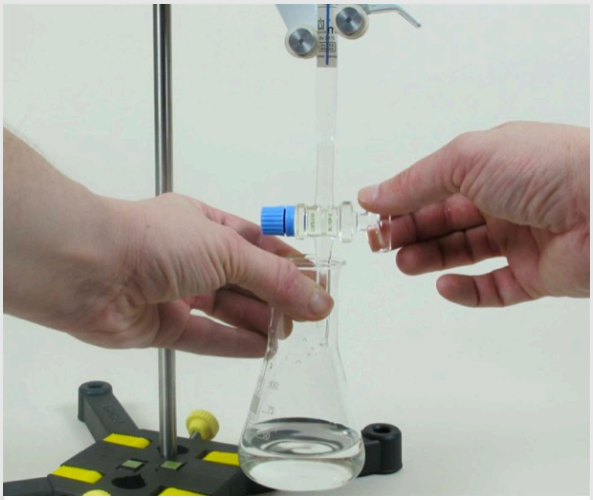

Fig. 15

Procedure (2/3)

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After the first drop, where the colour change remains permanent, the burette tap is closed. The volume of sodium hydroxide solution consumed is read off the burette and noted.

Using the graduated pipette, add half the volume of acetic acid indicated on the burette to the analysis solution. It is important here to add the weak acid to the solution in the Erlenmeyer flask. (Do not confuse with the sodium hydroxide solution!).

Hold a pH test stick in the now decolourised solution and compare the colour change on the stick with the colour table.

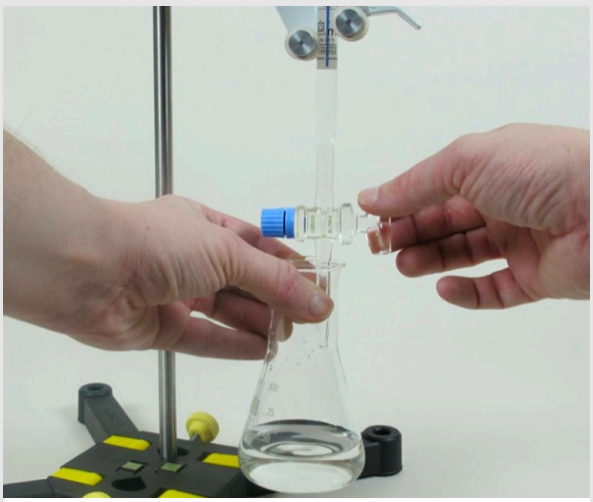

Fig. 16

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Procedure (3/3)

Disposal

The solutions used in this experiment can be disposed of in the acid and base waste container.

Report

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Observation

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What is the pKs value of acetic acid determined by half titration?

Task 1

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Why does the equation pH = pKs apply at the half titration point? Derive the formula!

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Task 2

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Drag the terms into the correct gaps in the text.

The mass concentration _____ is the _____ of the mass _____ of a dissolved substance and the _____ of the solution. The unit of the amount of substance concentration is _____, that of the amount of substance is _____.

- mol
- mol/L
- (n)
- (c)
- volume (V)
- quotient

Check

Task 3

PHYWE

Which statement is true for the pK_S-value to?

- ○ The pK_S-value is equal to the pH value.
- ○ The greater the pK_S-value, the stronger the acidity.
- ○ The smaller the pK_S-value, the stronger the acidity.

Check

Chemistry lab

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