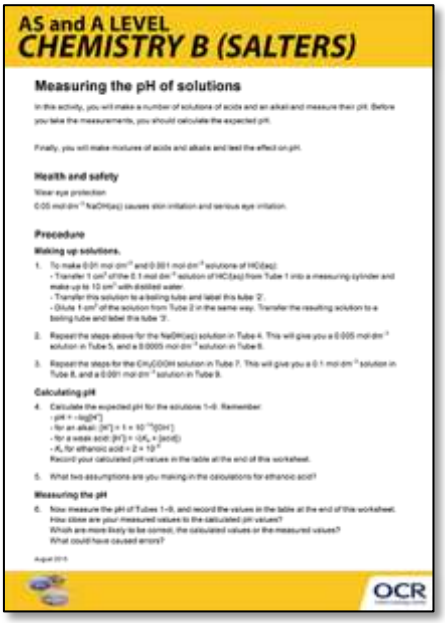
Measuring the pH of solutions

Instructions and answers for teachers

These instructions should accompany the OCR resource 'Measuring the pH of solutions' which supports OCR A Level Chemistry B.


AS and A LEVEL
CHEMISTRY B (SALTERS)

Measuring the pH of solutions

In this activity, you will make a number of solutions of acids and an alkali and measure their pH. Before you take the measurements, you should calculate the expected pH.

Finally, you will make mixtures of acids and alkalis and test the effect on pH.

Health and safety

Wear eye protection

0.05 mol dm^{-3} NaOH(aq) causes skin irritation and serious eye irritation.

Procedure

Making up solutions.

1. To make 0.01 mol dm^{-3} and 0.001 mol dm^{-3} solutions of HCl(aq):
   - Transfer 1 cm^3 of the 0.1 mol dm^{-3} solution of HCl(aq) from Tube 1 into a measuring cylinder and make up to 10 cm^3 with distilled water.
   - Transfer this solution to a boiling tube and label this tube '2'.
   - Dilute 1 cm^3 of the solution from Tube 2 in the same way. Transfer the resulting solution to a boiling tube and label this tube '3'.
2. Repeat the steps above for the NaOH(aq) solution in Tube 4. This will give you a 0.005 mol dm^{-3} solution in Tube 5, and a 0.0005 mol dm^{-3} solution in Tube 6.
3. Repeat the steps for the CH_3COOH solution in Tube 7. This will give you a 0.1 mol dm^{-3} solution in Tube 8, and a 0.001 mol dm^{-3} solution in Tube 9.

Calculating pH

4. Calculate the expected pH for the solutions 1–9. Remember:
   - pH = $-\log[H^+]$
   - for an alkali: $[H^+] = 1 \times 10^{-14}/[OH^-]$
   - for a weak acid: $[H^+] = \sqrt{K_a \times [acid]}$
   - K_a for ethanoic acid = 2×10^{-5}

   Record your calculated pH values in the table at the end of this worksheet.
5. What two assumptions are you making in the calculations for ethanoic acid?

Measuring the pH

6. Now measure the pH of Tubes 1–9, and record the values in the table at the end of this worksheet.
   How close are your measured values to the calculated pH values?
   Which are more likely to be correct, the calculated values or the measured values?
   What could have caused errors?

August 2015

OCR

The Activity:

This practical activity involves making and diluting solutions of acids and alkalis. Learners calculating the theoretical pH then measure the pH with a meter. They then make mixtures of acids and alkalis, including a buffer solution which they then test.

This activity offers an opportunity for maths skills development.

Learning Outcomes

This lesson element relates to the specification learning outcomes O(j), O(k), O(l), O(m).

Associated materials:

'Measuring the pH of solutions' Lesson Element learner activity sheet.

AS and A LEVEL CHEMISTRY B (SALTERS)

Introduction

Learners need to know the definition of pH, strong and weak acids, and how to calculate pH. They should be shown how to calibrate and use a pH meter.

Instructions

Learners follow the instructions on the activity sheet.

Health and safety

Before carrying out any experiment or demonstration based on this guidance, it is the responsibility of teachers to ensure that they have undertaken a risk assessment in accordance with their employer's requirements, making use of up-to-date information and taking account of their own particular circumstances. Any local rules or restrictions issued by the employer must always be followed. Learners should wear eye protection throughout this activity.

Chemicals

Each learner or group will need:

- 10 cm^3 0.1 mol dm^{-3} hydrochloric acid (HC*l*) in a boiling tube labelled '1'; no hazard classification
- 10 cm^3 0.05 mol dm^{-3} sodium hydroxide (NaOH) in a boiling tube labelled '4';
  additional 5 cm^3 0.05 mol dm^{-3} sodium hydroxide (NaOH) in a separate boiling tube; WARNING causes skin irritation and serious eye irritation
- 10 cm^3 0.1 mol dm^{-3} ethanoic acid (CH_3COOH); no hazard classification
- distilled water
- universal indicator solution; flammable.

Apparatus

Each learner or group will need:

- teat pipettes
- 10 cm^3 measuring cylinder
- 10 boiling tubes
- access to a calibrated pH meter

Instead of a pH meter, learners could use narrow-range pH paper, which determines pH to within 0.2–0.4. For most solutions, learners should therefore get a result that agrees with their calculations (if their calculations are correct). Learners can use the results of their calculations to decide which range of pH paper to use.

Expected results

Tube	Contents	Concentration / mol dm^{-3}	Calculated pH	Measured pH
1	Hydrochloric acid	0.1	1	1.3
2	Hydrochloric acid	0.01	2	2.0
3	Hydrochloric acid	0.001	3	3.1
4	Sodium hydroxide	0.05	12.7	12.4
5	Sodium hydroxide	0.005	11.7	11.4
6	Sodium hydroxide	0.0005	10.7	9.4
7	Ethanoic acid	0.1	2.8	2.7
8	Ethanoic acid	0.01	3.3	3.4
9	Ethanoic acid	0.001	3.8	3.9
2+5	Hydrochloric acid	0.0025	2.6	2.5
7+4	Ethanoic acid + sodium ethanoate		4.7	4.5
Tube	**Drops of 0.05 mol dm^{-3} sodium hydroxide needed to raise pH above 7**			
7+4	~230			
3	~10			

Depending on the quality of the pH meter used, the measured pH values may differ from the calculated values to a greater extent. Discrepancies between the calculated and measured pH values are usually largely due to inaccuracy of the pH meter.

The instructions on the activity sheet do not explicitly state that learners should wash the measuring cylinder between making each dilution. Learners who have neglected to do this should consider this as a potential source of error (though in practice it should not make a vast amount of difference).

We'd like to know your view on the resources we produce. By clicking on the 'Like' or 'Dislike' button you can help us to ensure that our resources work for you. When the email template pops up please add additional comments if you wish and then just click 'Send'. Thank you.