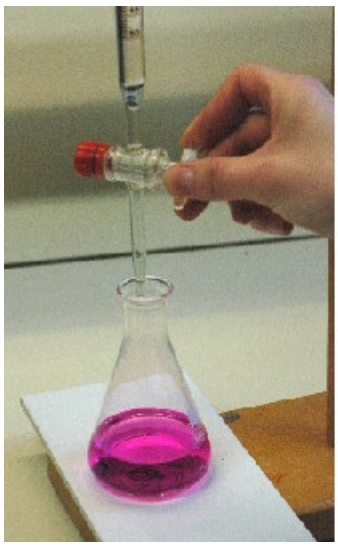
TESTING TIMES
Taking part in a laboratory proficiency test



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Languages available
English, Hungarian

Summary
Imagine you run an analytical laboratory. How can you persuade potential clients to use your laboratory? They probably have lots to choose from. You would want to be accredited. But you might also want to do a proficiency test. After all these are testing times.

Activity type **A**
Use of scientific knowledge and understanding to solve problems
Working in teams to solve problems

Techniques
Acid-base titration
Redox titrations
Complexometric titrations

Field
Pharmaceuticals

Time
Practical lessons: 180 minutes
Theory lessons: 60 minutes
Out of class time: 30 minutes

StandardBase procedures
Determination of ibuprofen using acid/base titration
Determination of aspirin using acid/base titration

Determination of iron(II) sulfate (ferrous sulfate) using redox titration
Determination of calcium in calcium carbonate using complexometric titration
Determination of paracetamol using redox titration

StandardBase techniques
Volumetric and gravimetric analysis

Other resources
LGC (www.lgc.co.uk)
VAM (www.vam.org.uk)
Others are found in the activity

Student's document

TESTING TIMES: Taking part in a laboratory proficiency test

Imagine you run an analytical laboratory. How can you persuade potential clients to use your laboratory? They probably have lots to choose from. To start, you would want accreditation from a recognised organisation such as UKAS (the United Kingdom Accreditation Service). This means showing, amongst other things, that you have suitably qualified staff and appropriate equipment. But that may not be enough. It's likely that many laboratories are accredited. So what else can you do? Many laboratories take part in proficiency tests.
You can find out more at
http://www.vam.org.uk/proficiencytesting/proficiency.asp

Your brief

You are a member of the analytical team in a laboratory that carries out routine analyses on pharmaceutical products. The laboratory is already accredited, but now it wants to enhance its reputation by taking part in a proficiency test. It will receive a number of samples for analysis. The team must carry out the analyses and evaluate them against the actual compositions of the test samples.

Your investigation

Planning

You will work in a small group.
The group will be given samples of pharmaceutical ingredients for analysis from this list (how many depends on the number of people in your group):

- Sample A: contains ibuprofen
- Sample B: contains aspirin
- Sample C: contains calcium carbonate
- Sample D: contains iron(II) sulfate
- Sample E: contains paracetamol.

Each sample should be analysed by at least two different analysts. Obtain copies of the standard procedures you need to use. Read them carefully and decide which analysis or analyses each member in the group will do.

Practical activity

Your teacher will tell you when the proficiency test is to be carried out. You will need to set out your work area. Collect apparatus, solutions and chemicals needed and set them out. Remember that a risk assessment must have been carried out before you start work.

If you haven't encountered back-titration before this definition may be helpful:
'A back titration can be used to find out the amount of a substance (A). A measured quantity of A is reacted with an excess of reagent B in a solution of known concentration. The amount of unreacted B is determined by titration against reagent C in a solution of known concentration. From the amount of unreacted B, the amount of A can be calculated'.

Recording and Data sheets

You will be given an '*Analysis recording sheet*' for each analysis you are responsible for. Each member of the group will also be given a '*Summary sheet*' on which the group's analytical results must be written. Complete and hand in

both. Before you start, make sure you have the correct standard procedures and recording sheets.
Once the group has completed all the analyses they will be given a '*Composition of samples'* **datasheet**.

Tips for finding information
You may be given the standard procedures or be asked to find them yourself. If you are asked to find them, here are two possibilities:

- Go to the website http://standardbase.vapronet.nl/ and click on 'View or conduct a StandardBase procedure'. Use a keyword search using the names of the substances being analysed.
- Go to the website http://www.chemsoc.org/networks/learnnet/standprocgcse.htm and search the files listed.

Your teacher may give you other suggestions.

Procedures
Depending on the samples being analysed, the group should select from this list of standard procedures for the determination of:

- ibuprofen using acid/base titration
- aspirin using acid/base titration
- calcium carbonate using complexometric titration
- iron(II) sulfate (ferrous sulfate) using redox titration
- paracetamol using redox titration.

A risk assessment must be carried out before starting practical work.

Your findings
Write your results and conclusions on:

- **Analysis recording sheet**
- **Summary sheet**

Your group's proficiency will be assessed by your teacher. Remember, in a laboratory proficiency test it is not the individual members who are being assessed, it is the team as a whole.

The compositions of the samples will be known by your teacher and, once the analyses are complete, you will be given the Composition of samples datasheet. For each pharmaceutical ingredient, you will analyse a number of samples and record the results of your analyses in a table like this (see Summary sheet):

Purity: percentage by mass (grams of pharmaceutical ingredient per 100 g of sample)			**Actual composition of sample (g/100 g)**	**Comparison of analytical results with actual value**
Name of analyst: Purity (g/100 g):	Name of analyst: Purity (g/100 g):	Name of analyst: Purity (g/100 g):		

1. Record the values for purity for all samples of the pharmaceutical ingredient tested, writing the name of the analysts and the calculated purity.

2. Write the actual composition of the sample (your teacher will tell you or you can find it from the *Composition of samples* **datasheet**). This composition tells you the actual purity.

3. For each sample, calculate the percentage difference between the value for each sample and the actual value. This will be a positive value if your value it too high or negative value if your result is too low.

4. To pass the laboratory proficiency tests your group must produce analyses that fall within acceptable percentage errors. Your teacher will tell you what these are.

Student self assessment

This activity was about using scientific knowledge and understanding to solve problems and working in teams to solve problems. In 50-100 words say:

- what scientific skills and knowledge you used and how effectively you used them.
- how you worked as a team and give examples of how you supported others in your group or were supported by them. What is the advantage of working in a team?

Student sheet: LABORATORY PROFICIENCY TEST Analysis recording sheet

Pharmaceutical ingredient: _____

Titration of _____ against _____

	1	2	3	4
1st burette reading / cm^3				
2nd burette reading / cm^3				
difference / cm^3				

Calculations:

Pharmaceutical ingredient: _____

Titration of _____ against _____

	1	2	3	4
1st burette reading / cm^3				
2nd burette reading / cm^3				
difference / cm^3				

Calculations:

Student sheet: LABORATORY PROFICIENCY TEST Summary sheet

Pharmaceutical ingredient	Purity: percentage by mass (grams of pharmaceutical ingredient per 100 g of sample)			Actual composition of sample (g/100 g)	Comparison of analytical results with actual value
	Name of analyst: Purity (g/100 g):	Name of analyst: Purity (g/ 100 g):	Name of analyst: Purity (g/100 g):		
	Name of analyst: Purity (g/100 g):	Name of analyst: Purity (g/100 g):	Name of analyst: Purity (g/100 g):		
	Name of analyst: Purity (g/100 g):	Name of analyst: Purity (g/100 g):	Name of analyst: Purity (g/100 g):		
	Name of analyst: Purity (g/ 100 g):	Name of analyst: Purity (g/100 g):	Name of analyst: Purity (g/100 g):		
	Name of analyst: Purity (g/100 g):	Name of analyst: Purity (g/ 100 g):	Name of analyst: Purity (g/100 g):		
	Name of analyst: Purity (g/ 100 g):	Name of analyst: Purity (g/ 100 g):	Name of analyst: Purity (g/100 g):		

Teacher's document

Overview

Students work as analysts in a laboratory specialising in the analysis of pharmaceutical products. This simulation is designed to give students insight into how analytical laboratories establish their credibility and quality. The activity puts them in the position of an analytical laboratory undertaking a proficiency test. To be effective they need to have appropriate scientific skills and knowledge and to be able to work together as a team.

Students learn to:

- tackle scientific problems by applying their practical skills and their knowledge and understanding of volumetric analysis
- observe, measure and analyse data collected from volumetric analyses, and to evaluate these
- work with others and manage relationships with people.

Developing students' skills

Each student will carry out two titrations. They should receive feed back during the first titration to help them, if necessary, to improve with the second one. Appropriate questions should be asked as prompts to think about.

Summative assessment will depend on the required assessment objectives for the course being followed by the students. The completed 'Analysis recording sheet' and 'Summary sheet' provide summative assessment evidence, judged against published grading criteria.

Organising and managing the class

Students should have experience of volumetric analysis. However, they may not have experience of back titration or reflux apparatus. If this is the case you may need to show students how to use reflux apparatus before the experiment and give additional help working out calculations. It is suggested that the pure pharmaceutical ingredients and methods of analysis are:

Ref	pharmaceutical ingredient	Analytical method
A	ibuprofen	acid-base titration
B	aspirin	acid-base titration
C	calcium carbonate	complexometric titration
D	iron(II) sulfate	redox titration
E	paracetamol	redox titration

The pure substances should be mixed with known quantities of an 'inert' (in terms of affecting the titration) substance. Details are given later.

The first step is to decide which analyses the students will carry out. This will depend on the precise requirements of the course they are following.

It is suggested that students work in groups of three to five. Select the titrations most appropriate to the course the students are following. For example, some courses only require acid-base titrations. Others require acid-base, redox and complexometric.

The proficiency of the group as a whole is being assessed, not individuals. However, students must share the work. Each student in a group should be given at least two or three samples to analyse, depending on time available and the prior experiences of students. It is suggested that each student should carry out a straightforward acid-base titration to analyse the ibuprofen or aspirin sample.

Two suggestions for organising groups and allocating work

1. Three students: course requires only acid-base titrations

Each student carries out an analysis of:

- ibuprofen
- aspirin.

Collectively the group will have three analyses for each sample.

2. Six students: course requires all three types of titrations

Student	**Analyses**	
1	ibuprofen	calcium carbonate
2	ibuprofen	paracetamol
3	ibuprofen	iron(II) sulfate
4	aspirin	calcium carbonate
5	aspirin	paracetamol
6	aspirin	iron(II) sulfate

Collectively the group will have two analyses for each sample. It is also arranged so that no two students do the same pair of analyses.

Guidance and help

Students need to recognise the importance of taking care and pride in their work. They need to be gently reminded of this while they are working. They may need three types of help.

- Help with technical details, including manipulative skills and correct handling of chemicals and equipment.
- Help with, and vigilance over, health and safety issues.
- Help with working relationships in their group.

For guidance on how to set students up into groups see;
http://www.presentingscience.com/aflchem/key/groupwork.htm

Session plan for teachers

A suggested approach is (times are minimum times):

- Introduce the activity and check prior knowledge (about 15 minutes). Some of this can be done at home.
- Arrange students into groups to discuss and allocate the work (about 30 minutes).
- Carry out the practical work (about 180 minutes).
- Group comes together to share and discuss results (about 15 minutes).
- Complete reporting forms and draw conclusions (about 30 minutes). Some of this can be done at home.

Technical notes

Preparation

To complete this activity in the time allowed, standard solutions should be made up by a technician prior to the lesson. However, if additional time is available, students could make them.

It is suggested that the following compositions of 'pharmaceutical ingredients' are made up for analysis:
9.50 g ibuprofen + 0.50 g sodium chloride, i.e. 95.0% purity
9.00 g aspirin + 1.00 g sodium chloride, i.e. 90.0% purity
9.50 g calcium carbonate + 0.50 g sodium carbonate-10-water, i.e. 95.0% purity
9.25 g iron(II) sulfate + 0.75 g sodium chloride, i.e. 92.5% purity
9.50 g paracetamol + 0.50 g sodium chloride, i.e. 95.0% purity

Of course, the quantity of inert chemical can be varied and the actual percentage purity calculated.

A cheaper alternative, is for students to investigate the purity of tablets bought from a pharmacist. A technician or teacher will need to run the experiment before students begin work to determine the purity of the tablets.

For ibuprofen
Phenolphthalein solution: Weigh out 1 g of phenolphthalein and dissolve in a mixture of 95% ethanol/5% water, making the solution up to 100 cm^3.
Standardised 0.10 mol dm^{-3} sodium hydroxide solution: This must be free of carbonate. Prepare a 50% by mass solution of sodium hydroxide several days in advance. Allow the precipitate of sodium carbonate to settle. (This may take several days.) Store this concentrated solution in a polythene bottle. Dilute a suitable volume of the concentrated solution with freshly boiled distilled water in the ratio 1:100. The exact concentration of sodium hydroxide in solution is determined using 0.1 mol dm^{-3} hydrochloric acid. This, in turn, is standardised against solid potassium hydrogencarbonate.

For aspirin
0.5 mol dm^{-3} sodium hydroxide solution: Weigh 20.0 g sodium hydroxide on a balance and carefully dissolve it in about 200 cm^3 of distilled water in a beaker. Transfer this solution to a 1 dm^3 standard volumetric flask, and make up to the mark with distilled water and ensure the solution is completely mixed.
Standardised 0.1 mol.dm^{-3} hydrochloric acid: Transfer 8.8 cm^3 of concentrated hydrochloric acid to a standard 1 dm^3 volumetric flask. Make up to 1 dm^3 with distilled water and homogenise the solution. This solution should then be standardised using a primary standard, for example, sodium carbonate or potassium hydrogencarbonate.
Alternatively, hydrochloric acid 0.100 mol dm^{-3} 'Analar' may be used (available from *BCDH Merck eurolab*) or its equivalent could be used.
Phenol red indicator: Dissolve 0.1 g of phenol red in 28.5 cm^3 of 0.1 mol dm^{-3} sodium hydroxide solution in a beaker. Transfer the solution to a 100 cm^3 standard volumetric flask and make up to the mark with distilled water.

For calcium carbonate
2 mol dm^{-3} hydrochloric acid: Carefully add 175 cm^3 of concentrated hydrochloric acid of density 1.18 g cm^{-3} to about 250 cm^3 of distilled water with stirring and then dilute with distilled water to 1 dm^3 in a graduated flask.
10 mol dm^{-3} sodium hydroxide: Weigh out 40 g of sodium hydroxide and add to about 50 cm^3 of pure water while stirring and then dilute to 100 cm^3 with distilled water in a graduated flask. This solution is VERY CORROSIVE.
0.1 mol dm^{-3} disodium edetate: Weigh out 37.25 g of the dihydrate salt and dissolve in about 500 cm^3 of pure water. Dilute to 1 dm^3 with distilled water in a graduated flask.
Murexide indicator: Mix 1 g of murexide with 100 g potassium nitrate.

For iron(II) sulfate
Standard 0.10 mol dm^{-3} ammonium cerium(IV) sulfate: Weigh out 31.628 g of $2(NH_4)_2SO_4.Ce(SO_4)_2.2H_2O$ into a solution prepared by adding 14 cm^3 of concentrated sulfuric acid to 250 cm^3 of distilled water. Stir the mixture until the solid has dissolved. Transfer to a 500 cm^3 volumetric flask, and make up to the mark with distilled water. This solution should be standardised using a solution of ammonium iron(II) sulfate-6-water, which has itself been standardised against potassium dichromate(VI) solution in the presence of sulfuric acid and phosphoric acid and diphenylamine as indicator.
1 mol dm^{-3} sulfuric acid: Carefully add, while stirring, 55 cm^3 of 98% sulfuric acid to about 500 cm^3 of distilled water. Dilute to 1 dm^3 with distilled water.
Ferroin indicator: This may be purchased from chemical suppliers ready for use. Alternatively it may be prepared by weighing out 0.696 g of iron(II) sulphate-7-water and 1.487 g of 1,10-phenanthroline hydrate into a 50 cm^3 beaker. Dissolve the mixed solid in about 30 cm^3 of distilled water while stirring. Transfer the solution to a 100 cm^3 volumetric flask and make up to the mark with distilled water.

- **Equipment and materials**

Materials and their CAS numbers
(these include requirements to make up any necessary reagent solutions)

For ibuprofen

sodium hydroxide	CAS number 1310-73-2
methanol	CAS number 67-56-1
phenolphthalein	CAS number 77-09-8

For aspirin

sodium hydroxide	CAS number 7647-01-0
hydrochloric acid	CAS number 1310-73-8
phenol red	CAS number 252-057-8

For calcium carbonate

calcium carbonate	CAS number 471-34-1
Murexide	CAS number 3051-09-0
hydrochloric acid	CAS number 7647-01-0
potassium nitrate	CAS number 7757-9-1
sodium hydroxide	CAS number 1310-73-2
disodium EDTA-2-water	CAS number 6381-92-6

For iron(II) sulfate

iron(II) sulfate-7-water	CAS number 7782-63-0
ammonium cerium(IV) sulfate-2-water	CAS number 10378-47-9
sulfuric acid	CAS number 7664-93-9
1,10-phenanthroline hydrate	CAS number 12678-01-0

For paracetamol

ammonium cerium(IV) sulfate-2-water	CAS number 7664-93-9
1 mol dm^{-3} sulfuric acid	CAS number 7664-93-9
iron(II) sulfate-7-water	CAS number 7782-63-0
1,10-phenanthroline hydrate	CAS number 12678-01-0

Equipment

Each student will need:

For ibuprofen

- 250 cm^3 conical flask
- 50 cm^3 measuring cylinder
- magnetic stirrer (optional)
- dropping pipette
- 50 cm^3 burette
-

For aspirin

- analytical balance (accurate to 0.001 g)
- 3 x 250 cm^3 conical flasks with ground glass joints
- 250 cm^3 standard volumetric flask
- hot plate
- 25 cm^3 and 50 cm^3 pipettes
- 50 cm^3 burette
- pipette filler
-

For calcium carbonate

- 250 cm^3 volumetric flask
- 250 cm^3 conical flask
- 25 cm^3 pipette
- 50 cm^3 (or 10 cm^3) burette
- 10 cm^3, 25 cm^3 and 50 cm^3 measuring cylinders
- pipette filler
- funnel
- droppers
- analytical top pan balance (three decimal places)
-

For iron(II) sulfate

- 250 cm^3 conical flask
- 10 cm^3 measuring cylinder
- weighing bottle
- 1 cm^3 dropping pipette
- 50 cm^3 burette
- analytical top pan balance

For paracetamol

- 100 cm^3 and 500 cm^3 volumetric flasks
- 250 cm^3 conical flask
- 50 cm^3 burette
- 50 cm^3 measuring cylinders
- 50 cm^3 beaker
- 100 cm^3 round bottom flask
- 20 cm^3 pipette
- heating mantle

Datasheet: LABORATORY PROFICIENCY TEST Composition of samples

This needs to be completed by the teacher or technician making up the samples

Pharmaceutical ingredient	**Sample reference number**	**Composition of sample** (g/100 g)

TESTING PRIOR KNOWLEDGE

1. Ibuprofen reacts with sodium hydroxide:

$(CH_3)_2CHCH_2C_6H_4CH(CH_3)COOH + NaOH \rightarrow (CH_3)_2CHCH_2C_6H_4CH(CH_3)COONa + H_2O$

a. What type of reaction is this? Acid-base

b. How many moles of sodium hydroxide are there in 20 cm^3 of 0.1 mol dm^{-3} sodium hydroxide solution? 0.002 moles

c. How many moles of ibuprofen will react with 20 cm^3 of 0.1 mol dm^{-3} sodium hydroxide solution? 0.002 moles

d. What is the mass of 1 mole of ibuprofen? 206 g

e. What mass of ibuprofen will react with 20 cm^3 of 0.1 mol dm^{-3} sodium hydroxide solution? 0.412 g

2. The European Pharmacopoeia says 1 cm^3 of 0.5 mol dm^{-3} sodium hydroxide solution is equivalent to 0.04504 g aspirin. The analysis uses an acid-base reaction:

$C_6H_4(OOCCH_3)COOH + 2NaOH \rightarrow C_6H_4(OH)COONa + CH_3COONa + H_2O$

Explain how this statement is obtained by answering these questions:

a. How many moles of sodium hydroxide are there in 1 cm^3 of 0.5 mol dm^{-3} sodium hydroxide solution? 5×10^{-4} moles

b. How many moles of aspirin will react with 1 cm^3 of 0.5 mol dm^{-3} sodium hydroxide solution? 2.5×10^{-4} moles

c. What is the mass of 1 mole of aspirin? 180 g

d. What mass of aspirin will react with 1 cm^3 of 0.5 mol dm^{-3} sodium hydroxide solution? 0.045 g

3. The reaction between ammonium cerium(IV) sulfate and iron(II) sulfate can be represented by the simplified equation:

$Fe^{2+}(aq) + Ce^{4+}(aq) \rightarrow Fe^{3+}(aq) + Ce^{3+}(aq)$

a. What type of reaction is this? Redox

b. How many moles of $Ce^{4+}(aq)$ are there in 25 cm^3 of 0.1 mol dm^{-3} $Ce^{4+}(aq)$? 0.0025 moles

c. How many moles of $Fe^{2+}(aq)$ will react with 25 cm^3 of 0.1 mol dm^{-3} $Ce^{4+}(aq)$? 0.0025 moles

d. What is the mass of 1 mole of iron(II) sulfate-7-water? 277.8 g

e. What mass of iron(II) sulfate-7-water will react with 25 cm^3 of 0.1 mol dm^{-3} $Ce^{4+}(aq)$? 0.6954 g

Note: answers are given in red. These need to be removed before the test is used.

TESTING PRIOR KNOWLEDGE

1. Ibuprofen reacts with sodium hydroxide:

$(CH_3)_2CHCH_2C_6H_4CH(CH_3)COOH + NaOH \rightarrow (CH_3)_2CHCH_2C_6H_4CH(CH_3)COONa + H_2O$

a. What type of reaction is this?
b. How many moles of sodium hydroxide are there in 20 cm^3 of 0.1 mol dm^{-3} sodium hydroxide solution?
c. How many moles of ibuprofen will react with 20 cm^3 of 0.1 mol dm^{-3} sodium hydroxide solution?
d. What is the mass of 1 mole of ibuprofen?
e. What mass of ibuprofen will react with 20 cm^3 of 0.1 mol dm^{-3} sodium hydroxide solution?

2. The European Pharmacopoeia says 1 cm^3 of 0.5 mol dm^{-3} sodium hydroxide solution is equivalent to 0.04504 g aspirin. The analysis uses an acid-base reaction:

$C_6H_4(OOCCH_3)COOH + 2NaOH \rightarrow C_6H_4(OH)COONa + CH_3COONa + H_2O$

Explain how this statement is obtained by answering these questions:
a. How many moles of sodium hydroxide are there in 1 cm^3 of 0.5 mol dm^{-3} sodium hydroxide solution?
b. How many moles of aspirin will react with 1 cm^3 of 0.5 mol dm^{-3} sodium hydroxide solution?
c. What is the mass of 1 mole of aspirin?
d. What mass of aspirin will react with 1 cm^3 of 0.5 mol dm^{-3} sodium hydroxide solution?

3. The reaction between ammonium cerium(IV) sulfate and iron(II) sulfate can be represented by the simplified equation:

$Fe^{2+}(aq) + Ce^{4+}(aq) \rightarrow Fe^{3+}(aq) + Ce^{3+}(aq)$

a. What type of reaction is this?
b. How many moles of $Ce^{4+}(aq)$ are there in 25 cm^3 of 0.1 mol dm^{-3} $Ce^{4+}(aq)$?
c. How many moles of $Fe^{2+}(aq)$ will react with 25 cm^3 of 0.1 mol dm^{-3} $Ce^{4+}(aq)$?
d. What is the mass of 1 mole of iron(II) sulfate-7-water?
e. What mass of iron(II) sulfate-7-water will react with 25 cm^3 of 0.1 mol dm^{-3} $Ce^{4+}(aq)$?