Cambridge Assessment International Education

Teaching Pack
Preparing a solution of a primary standard

Cambridge International AS & A Level Chemistry 9701

Version 1

Cambridge Pathway

Contents

Icons used in this pack:

Briefing lesson

Planning lesson

Lab lesson

Debriefing lesson

Introduction

This pack will help you to develop your learners' experimental skills as defined by assessment objective 3 (AO3 Experimental skills and investigations) in the course syllabus.

Important note

Our *Teaching Packs* have been written by **classroom teachers** to help you deliver topics and skills that can be challenging. Use these materials to supplement your teaching and engage your learners. You can also use them to help you create lesson plans for other experiments.

This content is designed to give you and your learners the chance to explore practical skills. It is not intended as specific practice for Paper 3 (Advanced Practical Skills) or Paper 5 (Planning, Analysis and Evaluation).

This is one of a range of *Teaching Packs* and each pack is based on one experiment. The packs can be used in any order to suit your teaching sequence.

The structure is as follows:

Briefing lesson (1 hour*)

This lesson reinforces the key concepts, relevant skills, knowledge and understanding linked to the experiment.

↓

Planning lesson (1 hour*)

This lesson focuses on planning an experiment.
It ends with a demonstration video of the experiment.

↓

Lab lesson (1 hour*)

This lesson focuses on carrying out the experiment including the collection and recording of observations, measurements and estimates.

↓

Debriefing lesson (1 hour*)

This lesson focuses on the analysis and interpretation of data.
This includes making conclusions, evaluating methods and the quality of data and how improvements could be made.

** the timings are a guide only; you may need to adapt the lessons to suit your circumstances.*

In this pack you will find lesson plans, worksheets and teacher resource sheets.

Experiment: Preparing a solution of a primary standard

This *Teaching Pack* focuses on the preparation of a solution of a primary standard.

Primary standards are used in titration experiments in the accurate determination of concentration.

This experiment has links to the following syllabus content (see syllabus for detail):

- 25.1 Ionic equilibria

The experiment covers the following experimental skills, as listed in **AO3: Experimental skills and investigations:**

- plan experiments and investigations
- collect, record and present observations, measurements and estimates
- analyse and interpret data to reach conclusions
- evaluate methods and quality of data and suggest improvements.

Prior knowledge

Knowledge from the following syllabus topics is useful for this experiment.

- 2.4 Reacting masses and volumes (of solutions and gases)

Briefing lesson: Terms associated with titrations

Resources	• Bottle of 5% vinegar or suitable image • Sodium hydroxide pellets • Tare boat • Top pan balance • Worksheet A and corresponding answer sheet.

Learning objectives	By the end of the lesson: • ***all*** learners should be able to define the terms in question one but may require significant assistance in completing question two. • ***most*** learners should be able to define the terms in question one and answer question two with guidance. • ***some*** learners will be able to define and use all the terms correctly.

Timings	Activity
15 min	**Starter/Introduction** Gather learners at the front of the lab and show them a bottle of 5% vinegar (or image if you do not have it). Ask them what the 5% represents. [ethanoic acid] Next ask learners to offer ideas as to how this claim could be verified in a school laboratory. [lead learners in the direction of a titration if they cannot come up with the answer]. Ask for a definition of titration. [In titration a solution of an unknown concentration is reacted with a solution of accurately known titration. The purpose of doing this is often to learn the concentration of the unknown.] Encourage learners to recall titrations they have performed previously [e.g. Acid-base titrations] Show part of the video, starting at 00.00 and finishing at 01:03. Then ask learners what the problem is in trying to verify the % of ethanoic acid in a bottle of vinegar when titrating with sodium hydroxide. [Discuss that it absorbs water from the atmosphere - highlight the word HYGROSCOPIC on the board.]. Pour a sample of sodium hydroxide pellets into a tare boat and place it on a sensitive balance. Zero the reading and observe the mass increase. Ask learners why this is happening. [If the balance is quite sensitive, the increase in mass should be apparent immediately but if it measures to only 1dp, you should wait longer or use a larger mass of sodium hydroxide pellets to start with. Alternatively, one could come return to the balance after 10 minutes and see the change more clearly.]. Explain that in the main lesson, learners are going to prepare a solution of a PRIMARY STANDARD, the concentration of which is known accurately and remains constant over time.

Timings	Activity
5 min 25 min	**Main lesson** Ask learners which equipment they used to perform titrations in the past. [burette, pipette, volumetric flask] Elicit suggestions from learners why beakers, conical flasks and even measuring cylinders are not suitable for titration analyses, despite having graduations for volume marked on them. [They are not suitable because they are not accurate enough.] Explain to learners that in this part of the lesson, they will study and apply key vocabulary and terms necessary for understanding quantitative analysis. Handout Worksheet A and allow learners to work in pairs on this activity. Q1 is concerned with the characteristics associated with the ideal primary standard. If time allows, as an additional short activity, learners could research the names of some typical primary standards used in analytical chemistry. Q2. The following terms are discussed: % error, precision, concordant, % uncertainty, reliability, accurate. Many of these terms cause difficulty with learners and thus expect plenty of teacher input for this question. Some learners may also require help with the mole calculations.
15 min	**Plenary** Handout Worksheet A - answers and go through each example with learners carefully.

Planning lesson: Preparing a primary standard solution of KHP

Resources	• Worksheet B • Worksheet B – answers • Access to inspect laboratory equipment

Learning objectives	By the end of the lesson: • ***all*** learners should be able to produce an equipment list with guidance and be able to write a basic procedure for the experiment with guidance. • ***most*** learners should be able to provide a suitable equipment list and write an experimental procedure with some guidance. • ***some*** learners will be able to provide an accurate equipment list and write a thorough and accurate experimental procedure independently.

Timings	Activity
5 min	**Starter/Introduction** Start this session by asking learners what the key characteristics of a primary standard are. Next ask what standard solutions are, and why they need to be prepared.
40 min	**Main lesson** Handout Worksheet B to learners working in pairs. It would be helpful if learners could have access to/be able to view the standard laboratory equipment. Depending on the group, you may consider grouping all the possible pieces of equipment together for measuring volume. The tasks are as follows: Q1. Learners decide on the equipment/materials they will need for the experiment and write the function of each piece. To save any weaker learners writing a procedure which will clearly not work, you may wish to guide them in the correct direction. For example, if their plan does not involve the use of a volumetric flask, it would be a good idea to discuss which piece of apparatus would be the best for containing the KHP solution and why. Q2. A diagram of the experimental set-up is drawn by the learners. Q3. Learners write a step-by-step procedure using the equipment/materials in Q1.
15 min	**Plenary** Handout Worksheet B - answers and discuss learners' answers. Q1. Ensure that learners have used a verb to describe the function for each piece of equipment. Q2. Check procedures for accuracy.

Lab lesson: Preparing a standard solution of potassium hydrogen phthalate (KHP)

Resources	• as detailed in the teacher notes section • Instruction sheet for this activity is Worksheet B answers

Learning objectives	By the end of the lesson: • ***all*** learners should manage to prepare the standard solution of KHP with some guidance • ***most*** learners should be able to prepare the standard solution of KHP without any extra guidance • ***some*** learners will be able to prepare the standard solution and perform the calculation unassisted.

Timings	Activity
5 min	**Starter/Introduction** To set the practical session in context, have a brief discussion why standard solutions need to be prepared.
40 min	**Main lesson** Learners may work in pairs for this activity. They should follow the procedure detailed in Worksheet B - answers. (question 2). **Safety** Circulate the classroom at all times during the experiment so that you can make sure that your learners are safe.
10 min	**Calculating the concentration of the standard solution** Most learners should need little assistance with this basic mol calculation, but be wary that some may neglect to convert the volume of the standard flask from cm^3 to dm^3 Sample calculation (using a 2 d.p. top pan balance): Amount of KHP = mass/M_r $= 4.97g / 204.23gmol^{-1}$ $= 0.0243mol$ (note: learners should not round this value – it should be carried through unchanged to the next part of the calculation). Concentration of KHP = mol/ volume $= 0.0243mol / 0.25dm^3$ $= 0.0972\ moldm^{-3}$

Timings	Activity
	The final task should be to label their volumetric flask with the exact concentration of their solution
5 min	**Plenary** Get each group to write the concentration of their standard solution on the board. Re-emphasise that it does not matter whether the value is slightly above or below 0.10 $mol dm^{-3}$

Teacher notes

Watch the 'Preparing a solution of a primary standard' (Teacher walkthrough) and read these notes.

Before you begin

Each group will require:

- 250cm3 volumetric flask
- 100cm3 glass beaker
- A metal spatula
- A tare boat
- A glass stirring rod
- A glass funnel
- distilled water
- a wash bottle.

Additionally, the following will be required:

- potassium hydrogen phthalate (analytical grade)
- a top pan balance (minimum 2 d.p.).

Safety

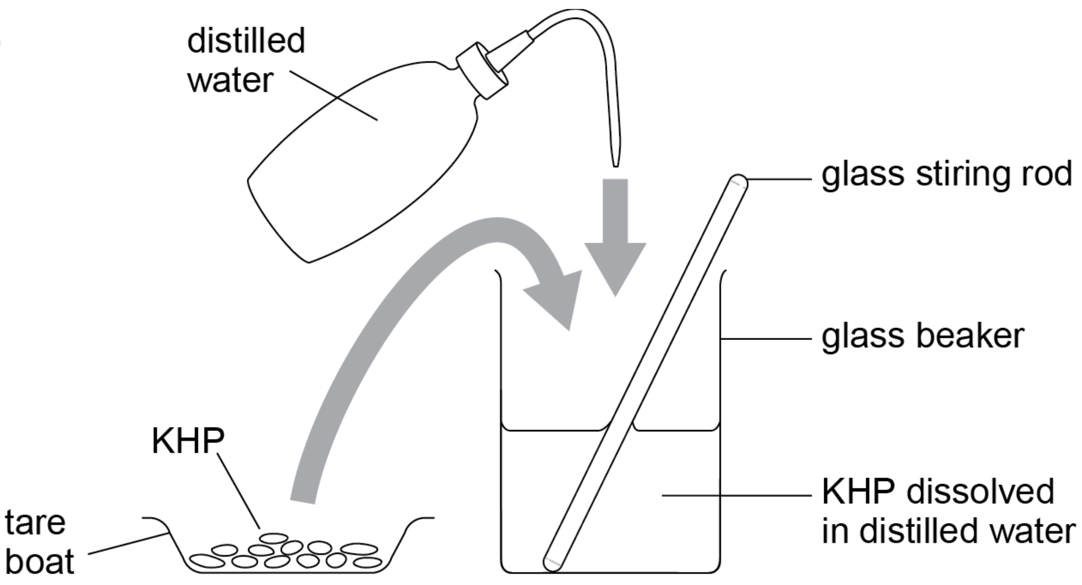
The information in the table below is a summary of the key points you should consider before undertaking this experiment with your learners.

It is your responsibility to carry out an appropriate risk assessment for this experiment.

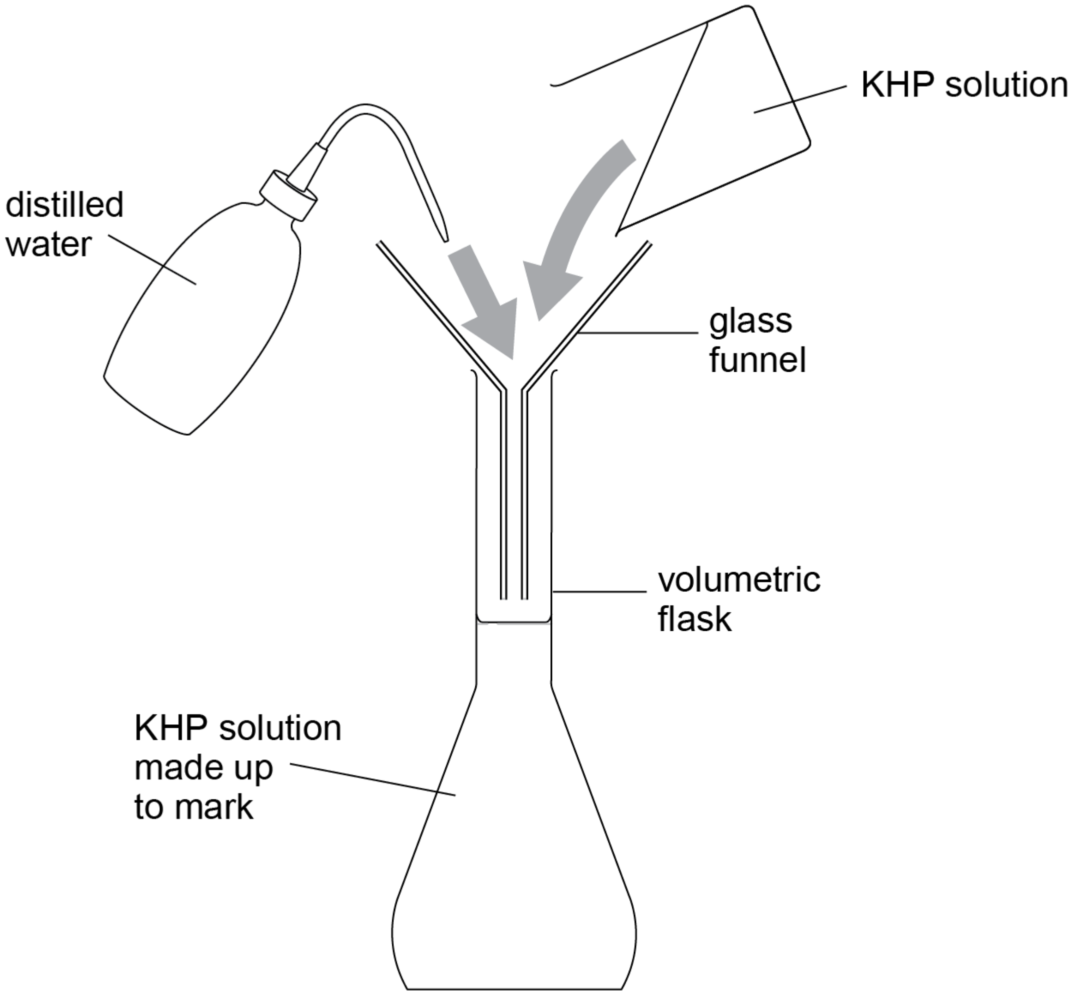
Substance	Hazard	First aid
Potassium hydrogen phthalate	Not a hazardous substance or mixture according to Regulation (EC) No. 1272/2008	**In the eye:** Flood the eye with gently-running tap water for 10min. See a doctor if pain persists. **Swallowed:** Wash out the mouth with water. Do not induce vomiting. Sips of water may help cool the throat and help keep the airway open. See a doctor. **Spilt on the skin or clothing:** Brush compound off contaminated clothing. Rinse clothing or the skin as necessary. **Spilt on the floor, bench, etc.:** Brush up compound spills, trying to avoid raising dust, then wipe with a damp cloth.

Experiment set-up

a)



b)



Teacher method

This is your version of the method for this experiment that accompanies the *Teacher walkthrough* video.

Do not share this method with learners.

Before you begin

Plan how you will group your learners during the experiment session.

Think about:

- the number of pairs you will need
- the amount of equipment/chemicals required

Experiment

Walk around the learners during the experiment in case they encounter any difficulties.

Step	Notes
1. Place a tare boat on a top pan balance and tare it.	Ensure the balance is clean and that learners keep it this way during the experiment.
2. Using a spatula weigh out approximately 5g KHP into a tare boat accurately.	Learners frequently wish to obtain a balance reading of exactly 5.00g. Explain to these learners that the important point is that they should record the exact reading, whether it is slightly above or below 5.00g.
3. Carefully transfer the solid into a clean 250cm^3 glass beaker.	
4. Re-weigh the tare boat and calculate the mass of KHP added to the beaker by difference.	
5. Carefully add about 50cm^3 of distilled water to the beaker and stir the mixture with a glass stirring rod until the KHP dissolves.	Learners may try to add more than 50cm^3 which may cause loss of some of the KHP solution by spillage
6. After stirring, wash the stirring rod with distilled water several times to ensure that none of the KHP remains on the stirring rod.	Ensure that learners do not put the stirring rod down on the bench whereby they may lose some of the compound leading to inaccuracies in their result.
7. Using a glass funnel, transfer the solution carefully to the 250cm^3 volumetric flask. Don't forget to rinse the funnel several times.	
8. To the volumetric flask, add more distilled water until the level is almost to the graduated mark.	
9. At eye level, add the last few drops of distilled water until the bottom of the meniscus is exactly on the graduation line.	Help learners understand the importance of parallax errors and the need to make measurements to the bottom of the meniscus.
10. Stopper the volumetric flask and invert it a few times to ensure thorough mixing.	Demonstrate how to do this safely so that material is not lost.

Step	Notes
11. Label the outside of the volumetric flask appropriately.	

Clean-up

After the experiment learners should:

- clean all glassware
- tidy up their workspace
- ensure any spillages have been mopped up
- return all equipment and any unused chemicals to you.

Debriefing lesson: Errors and uncertainty

Resources	• thermometer • Worksheet C and corresponding answer sheet. • If available show a Class A and B volumetric flask for question 3.

Learning objectives	By the end of the lesson: • ***all*** learners should be able to complete question 1 independently. Some will need help completing question 2 in particular. • ***most*** learners should be able to work through worksheet C correctly with minimum guidance • ***some*** learners will be able to answer all questions on worksheet C without assistance.

Timings	Activity
5 min	**Starter/Introduction** **Types of error in experiments** Ask learners what the two types of error are in experiments. [random and systematic] Hold a thermometer up in front of the class. Using the example of a thermometer ask learners to explain how systematic and random errors can arise. [Systematic error: if the thermometer is calibrated incorrectly and therefore always reads the wrong temperature]. [Random error: when the operator reads it incorrectly. Also explain that unlike systematic errors, the value obtained may be greater or less than the actual value]
30 min	**Main lesson** Handout Worksheet C to the learners who may work in pairs on this activity. This is a topic which is often poorly understood by learners and may require considerable teacher input. Question 1: with the explanation above in the starter learners should be able to cope with the examples given. Question 2: In this question, emphasize that the mass calculated should be the same. 4.97g and 4.970g. Learners may need prompting that since the balance is used twice, two separate errors must be taken into consideration. Question 3 and 4: If available show learners a Class A and Class B volumetric flask. Explain that the 'tolerance' is the same as the uncertainty value.

Timings	Activity
	It would be worth discussing that % uncertainty and absolute uncertainty are merely different ways of expressing the same information. Sometimes it is easier to comprehend an absolute value when comparing two values.
10 min	**Plenary** Handout Worksheet C - answers to the learners and help them check carefully through their answers. Points to note: Question 2b: the significance of the much more accurate 3dp balance can be emphasised. Question 3: you might like to ask learners if they find it easier to comprehend an absolute uncertainty value or a percentage value.

Worksheets and answers

	Worksheet	Answers
For use in *Briefing lesson*:		
A: Terms associated with titration	**18**	**25**
For use in *Planning lesson*:		
B: Planning lesson	**21**	**28**
For use in *Lab lesson*:		
B: Planning lesson	**21**	**28**
For use in *Evaluation lesson*:		
C: Errors and Uncertainty	**22**	**30**

Worksheet A: Terms associated with titration

The following questions are all connected with the quantitative analysis technique called titration.

1. Explain why each of the following characteristics are important when choosing a substance as a **primary standard**.

Must be of high purity

Must have a high Mr

Must be soluble in the solvent used

Must be chemically stable

Must contain no water of hydration

Must not be hygroscopic

Worksheet A: Terms associated with titration, *continued*

2. A titration was carried out to determine the concentration of a solution of hydrochloric acid using a standard solution of 0.1 mol dm^{-3} sodium hydroxide. The standard solution was placed in the burette. For each trial, 25.0 cm^3 of hydrochloric acid was taken from the same bottle of unknown concentration, using a 25cm^3 glass pipette and a few drops of phenolphthalein indicator were added.

The following titration results were obtained.

	Burette readings for sodium hydroxide		
Run	**Initial volume (cm^3)**	**Final volume (cm^3)**	**Titre volume (cm^3)**
Rough	0.00	23.50	23.50
1st	0.00	22.75	22.75
2nd	22.75	45.55	22.80
3rd	0.00	22.75	22.75

a. Calculate the average titre volume of sodium hydroxide solution used.

b. Calculate the amount of sodium hydroxide used.

c. Find the concentration of hydrochloric acid.

Worksheet A: Terms associated with titration, *continued*

d. The concentration of the hydrochloric acid determined by an expert was found to be 0.93 mol dm^{-3}

i. Calculate the % error in the value for concentration obtained in c.

ii. In the context of your calculation, explain the meaning of **accuracy**.

e. Explain the terms **precision** and **concordant** in context relating to the data given.

f. Calculate the **percentage uncertainty** when 22.75cm^3 sodium hydroxide is delivered from the burette.

g. Comment on the **reliability** of the three titration runs.

Worksheet B: Planning lesson

Your task in this exercise is to choose the relevant laboratory equipment and write a clear procedure to be able to prepare a 250 cm^3 standard solution of potassium hydrogen phthalate (KHP) of **accurate** concentration.

1. Write a full list of the equipment and materials you will need for the experiment and explain the function of each.

2. Write a step-by-step procedure for carrying out the experiment.

Worksheet C: Errors and uncertainty

1. Think about the preparation of the KHP primary standard solution. Indicate by writing an 'R' or 'S', whether the following potential errors are **systematic** or **random** in nature.

KHP not being dry ________

Reading the graduation mark of the volumetric flask ________

Spilling some of the KHP on the bench after weighing _______

The distilled water not being pure ________

Using a dirty volumetric flask _______

Measuring out the wrong solid (not KHP) _________

Calculating the incorrect Mr of KHP _______

Misreading the digital balance _______

Calibration of the balance being incorrect __________

2. A sample of KHP is weighed by difference, using two different top pan balances.

a) Compare the percentage uncertainty obtained when using a 2-decimal place balance compared to using a 3-decimal place balance.

2dp balance	3dp balance
Mass of beaker + KHP = 152.28g	Mass of beaker + KHP = 152.281g
Mass of beaker = 147.31g	Mass of beaker = 147.311g
Mass of solid = ………………. g	Mass of solid = ……………….. g

Using the 2dp balance:

Using the 3dp balance:

b) What do the answers obtained show?

Worksheet C: Errors and uncertainty, *continued*

3. Compare the absolute uncertainty values when using the following two 250 cm^3 volumetric flasks.

Class A volumetric flask +- 0.15cm^3

Class B volumetric flask +- 0.30cm^3

<u>Using the Class A flask</u>, the % uncertainty:

<u>Using the Class B flask</u>, the % uncertainty:

Worksheet C: Errors and uncertainty, *continued*

4. What is the absolute uncertainty in the concentration of a solution of KHP which is 0.0972 moldm^{-3}. The % uncertainty in its concentration is 1.5%.

Worksheet A: Answers

1. Explain why each of the following characteristics are important when choosing a substance as a **primary standard**.

Be of high purity

The primary standard should be a solid which is as close to 100% pure as possible. It should not contain any contaminants.

Have a high Mr

To prepare a standard solution, a certain amount of the solid must be weighed on a balance. The higher the relative molecular mass, the larger the mass will be weighed per mole. The larger the mass measured out, the smaller the error will be, relative to the error inherent in using the balance.

Be soluble in the solvent used

Often the solvent used will be water. Since a standard solution is being prepared, a readily soluble solid will make the process of preparation quicker and easier.

Be chemically stable

A substance used to prepare a standard solution must be stable in air. It must have a good shelf-life and not decompose when taken out of the bottle.

Contain no water of hydration

Water of hydration can be lost, especially under warmer conditions. If there is no water of hydration to lose, the mass of the substance will be constant.

Not be hygroscopic

A hygroscopic substance absorbs moisture from the air. Since the weighing process must be as accurate as possible, hygroscopic substance should not be considered for use as primary standards.

Worksheet A: Answers, *continued*

2. A titration was carried out to determine the concentration of a solution of hydrochloric acid using a standard solution of 0.1 mol dm^{-3} sodium hydroxide. The standard solution was placed in the burette. For each trial, 25.0 cm^3 of hydrochloric acid was taken from the same bottle of unknown concentration, using a 25cm^3 glass pipette and a few drops of phenolphthalein indicator were added.

The following titration results were obtained.

	Burette readings for sodium hydroxide		
Run	**Initial volume (cm^3)**	**Final volume (cm^3)**	**Titre volume (cm^3)**
Rough	0.00	23.50	23.50
1st	0.00	22.75	22.75
2nd	22.75	45.55	22.80
3rd	0.00	22.75	22.75

1a. Calculate the average titre volume of sodium hydroxide solution used.

22.75 + 22.80 + 22.75 / 3 = 22.77 cm^3 sodium hydroxide.

The rough titre should not be used in the calculation.

b. Calculate the amount of sodium hydroxide used.

Mol = c x V

Mol = 0.1 x 22.77/1000

*Mol = 0.1 x 0.02277 = **0.002277 mol***

c. Find the concentration of hydrochloric acid.

$NaOH_{(aq)} + HCl_{(aq)} \longrightarrow NaCl_{(aq)} + H_2O_{(l)}$

From the equation, the reagents react in a 1:1 ratio

Therefore, the amount of hydrochloric used also equals 0.002277mol

Mol = c x V

Hence, c = mol/V

Worksheet A: Answers, *continued*

c = 0.002277/V   the volume of the pipette = 25cm³ = 25/1000 = 0.025dm³

c = 0.002277/0.025 = ***0.91 mol dm⁻³***

d. The concentration of the hydrochloric acid determined by an expert was found to be 0.93 mol dm^{-3}

i. Calculate the % error in the value for concentration obtained in c.

% error *= experimental value – accepted value/accepted value x 100*

% error = 0.91 – 0.93/0.93 x 100 = 2.2% error

ii. In the context of your calculation, explain the meaning of **accuracy**.

Accuracy is determined by comparing the experimental value with the actual value. In other words, it is the closeness of agreement between the two values.

e. Explain the terms **precision** and **concordant** in context relating to the data given.

Precise results are those which are close to each other. The 1st, 2nd and 3rd titration runs are precise results because they are in close agreement with each other (within $0.10cm^3$).

In titration, runs which are this precise, are known as concordant results.

f. Calculate the **percentage uncertainty** when $22.75cm^3$ sodium hydroxide is delivered from the burette.

Volume delivered = $22.75cm^3$

There is an uncertainty of +- $0.05cm^3$ associated with each burette reading.

Therefore, the total uncertainty = +-$0.1cm^3$

The % uncertainty = 0.1/22.75 x100 = ***0.44%***

g. Comment on the **reliability** of the three titration runs.

The reliability of the experiment is high since the 3 runs of the experiment yielded concordant results (within $0.10cm^3$ of each other).

Worksheet B: Answers

Your task in this exercise is to choose the relevant laboratory equipment and write a clear procedure to be able to prepare a 250 cm^3 standard solution of potassium hydrogen phthalate (KHP) of **accurate** concentration.

1. Write a full list of the equipment and materials you will need for the experiment and explain the function of each.

250 cm^3 volumetric flask – this contains a precise volume (of KHP solution)

A top pan balance (minimum 2 d.p.) – this is to weigh out the mass of the KHP accurately (The more decimal places the balance reads to the better)

A metal spatula – to transfer the solid

A tare boat – a vessel to hold the KHP whilst weighing

A glass stirring rod – used to stir the KHP when it is dissolving in the distilled water

A glass funnel – used to transfer the solution without spillage

Distilled water – necessary to dissolve the KHP and for rinsing glassware

A wash bottle – to enable the dropwise addition of distilled water

A 100cm^3 glass beaker – a vessel large enough to hold the KHP solution, so that can be stirred without loss due to splashing

Potassium hydrogen phthalate (high purity/Analytical grade) – this is the primary standard. It is of analytical grade so it contains virtually no impurities

Worksheet B: Answers, *continued*

2. Write a step-by-step procedure for carrying out the experiment.

i. Place a tare boat on a top pan balance and tare it.

ii. Using a spatula weigh out approximately 5g KHP into a tare boat accurately. (it does not have to be exactly 5.00g (if using a 2d.p. balance) but the exact mass ex. 4.98g should be recorded).

iii. Carefully transfer the solid into a clean 250cm^3 glass beaker.

iv. Re-weigh the tare boat and calculate the mass of KHP added to the beaker by difference.

v. Carefully add about 50cm^3 of distilled water to the beaker and stir the mixture with a glass stirring rod until the KHP dissolves.

vi. After stirring, wash the stirring rod with distilled water several times to ensure that none of the KHP remains on the stirring rod.

vii. Using a glass funnel, transfer the solution carefully to the 250cm^3 volumetric flask. Don't forget to rinse the funnel several times.

viii. To the volumetric flask, add more distilled water until the level is almost to the graduated mark.

ix. At eye level, add the last few drops of distilled water until the bottom of the meniscus is exactly on the graduation line.

x. Stopper the volumetric flask and invert it a few times to ensure thorough mixing.

xi. Label the outside of the volumetric flask appropriately.

Worksheet C: Answers

1. Think about the preparation of the KHP primary standard solution. Indicate by writing an 'R' or 'S', whether the following potential errors are **systematic** or **random** in nature.

KHP not being dry ___S____

Reading the graduation mark of the volumetric flask ____R___

Spilling some of the KHP on the bench after weighing ___S___

The distilled water not being pure __S_____

Using a dirty volumetric flask __S____

Measuring out the wrong solid (not KHP) ___S_____

Calculating the incorrect Mr of KHP __S____

Misreading the digital balance ___R___

Calibration of the balance being incorrect ____S_____

2. A sample of KHP is weighed by difference, using two different top pan balances.

a) Compare the percentage uncertainty obtained when using a 2-decimal place balance compared to using a 3-decimal place balance.

2dp balance	3dp balance
Mass of beaker + KHP = 152.28g	Mass of beaker + KHP = 152.281g
Mass of beaker = 147.31g	Mass of beaker = 147.311g
Mass of solid = 4.97g	Mass of solid = 4.970g

Using the 2dp balance:

There is an error of 0.005g for each measurement made and therefore a total of 0.01g (0.005g + 0.005g) overall

% error = 0.01g x100/ 4.97g = 0.2%

Worksheet C: Answers, *continued*

Using the 3dp balance:

There is an error of 0.0005g for each measurement and therefore a total of 0.001g overall

% error = 0.001g x100/ 4.970g = 0.02%

b) What do the answers obtained show?

The 3dp balance produces a much lower % error and therefore measures the same mass much more accurately.

3. Compare the absolute uncertainty values when using the following two 250 cm^3 volumetric flasks.

Class A volumetric flask +- 0.15cm^3

Class B volumetric flask +- 0.30cm^3

Using the Class A flask, the % uncertainty:

0.15 x 100/250 = 0.06%

Then, the absolute uncertainty value = % uncertainty x measurement/100

0.06% x 250/100 = 0.15cm^3

Therefore, the volume measured = 250cm^3 +- 0.15cm^3

Using the Class B flask, the % uncertainty:

0.30 x 250/100 = 0.75cm^3

Therefore, the volume measured = 250cm^3 +- 0.75cm^3

Worksheet C: Answers, *continued*

4. What is the absolute uncertainty in the concentration of a solution of KHP which is 0.0972 $mol dm^{-3}$. The % uncertainty in its concentration is 1.5%.

$1.5/100 \times 0.0972 = 0.00146\ mol dm^{-3}$

The absolute uncertainty in concentration is therefore:

$0.0972\ mol dm^{-3}$ +- $0.00146\ mol dm^{-3}$

Cambridge Assessment International Education
The Triangle Building, Shaftesbury Road, Cambridge, CB2 8EA, United Kingdom
t: +44 1223 553554
e: **info@cambridgeinternational.org** **www.cambridgeinternational.org**