CHEMISTRY INVESTIGATIONS MANUAL

ASSESSMENT OF STAGE 2 CHEMISTRY USING SACE PERFORMANCE STANDARDS

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2011 was the **International Year of Chemistry** which celebrated the achievements of chemists, inspired people with chemical ideas – and marked the centenary of Marie Curie's Nobel Prize for Chemistry.

The medallion above depicts **Röntgen** (who discovered X-rays), **Becquerel** (who discovered radioactivity), and **Pierre** and **Marie Curie** (who jointly studied radioactivity and recognised it as an intrinsic property of certain elements).

SUMMARY OF INVESTIGATION ACTIVITIES IN THIS MANUAL

Investigation Activity		Learning Requirements						Assessment Design Criteria			
Topic	Name of Assessment	Demonstrate and apply knowledge and understanding of chemical concepts and interrelationships	Formulate questions, manipulate apparatus, record observations in practical chemical activities, and design and undertake chemistry investigations	Demonstrate an understanding of how knowledge of chemistry can be used to make informed conclusions or decisions, taking into account social and environmental contexts	Develop possible solutions to a variety of problems in chemistry in new or familiar contexts	Critically analyse and evaluate chemical information and procedures from different sources	Communicate in a variety of forms using appropriate chemical terms and conventions	Investigation (I)	Analysis and Evaluation (AE)	Application (A)	Knowledge and Understanding (KU)
Analytical Chemistry	1 Unknown food acid	✓	✓			✓	✓	3	1, 2	2	1
Analytical Chemistry	2 Cloudy Ammonia	✓	✓			✓	✓	3, 4	1, 2	2	1
Analytical Chemistry	3 Vinegar Concentration	✓	✓			✓	✓	3, 4	1, 2	2	1
Organic Preparation	1 Ester preparation	✓	✓		✓	✓	✓	3	2	2, 3	1
Enthalpy	1 Enthalpy of Neutralisation	✓			✓		✓	3, 4	1, 2		1
Design	1 Electrolytic Cell Design	✓	✓		✓	✓	✓	1, 3, 4	1, 2	2, 3	
Design	2 Choice or Selection Topic	✓	✓		✓	✓	✓	1, 3, 4	1, 2	2, 3	3
Issues Investigation	1 Choice Topic	✓	✓	✓	✓	✓	✓	2	1	1, 2	1, 2, 3
Issues Investigation	2 Energy (or Choice)	✓	✓	✓	✓	✓	✓	2	1	1, 2	1, 2, 3

STAGE 2 CHEMISTRY

ASSESSMENT TYPE 1: Investigations Folio

Practical: Volumetric Analysis

NAME _____

Assessment Design Criteria Addressed

- **I3**
- **AE1**
- **AE2**
- **A2**
- **KU1**

Purpose

A 0.5000 mol L^{-1} solution of a food acid is supplied. It is known to be either citric acid (triprotic acid) or tartaric acid (a diprotic acid). The task is to use volumetric analysis techniques to determine the identity of the food acid.

The task provides you with the opportunity to demonstrate your ability to

- Manipulate apparatus to implement safe investigation procedures.
- Evaluate procedures with suggestions for improvement.
- Analyse and evaluate data to formulate conclusions.
- Use appropriate chemical terms, conventions, formulae, and equations.
- Demonstrate knowledge and understanding of chemistry concepts.

Description of assessment

Using the instructions provided on the attached sheet, this analysis will assess your ability to:

- Calculate the mass of oxalic acid required to prepare 200.0 mL of approximately 0.05 mol L^{-1} oxalic acid solution (to 4 significant figures)
- Prepare a standard solution of oxalic acid.
- Demonstrate skills in using an analytical pipette, burette and conical flask to carry out an accurate titration.
- Use the standard solution of oxalic acid to standardize a solution of sodium hydroxide of concentration approximately 0.1 mol L^{-1} (calculated to 4 s.f.)
- Use an analytical pipette and a volumetric flask to dilute a solution by a certain factor.
- Explain random and systematic errors and the reasoning behind suggested improvements.
- Use the results of the two titrations to calculate the reacting mole ratio of NaOH : unknown acid and use the results to determine the identity of the unknown acid.
- Achieve an accurate result.
- Discuss the precision and accuracy of the result.

Assessment conditions

The preparation of the standard solution, the dilution and the titrations will be completed in lesson under supervision. The results to the titrations will be documented on the titration results tables and checked by the teacher when the titrations have been completed.

The calculations and results will be handed in for marking no later than two days after the completion of the practical component of the task.

Students work individually on the task and present individual reports.

AIM

A 0.5000 mol L^{-1} solution of a food acid is supplied. It is known to be either citric acid (triprotic acid) or tartaric acid (a diprotic acid). The aim of this task is to identify the unknown acid.

MATERIALS

Solid oxalic acid, formula $(COOH)_2.2H_2O$
Approximately 300 mL of sodium hydroxide solution of concentration approx. 0.1 mol L^{-1}
Indicator (Phenolphthalein)
20.00 mL pipette (or 25.00 mL pipette)
Two 200.0 mL volumetric flasks (or two 250.0mL volumetric flasks)
Burette
Other glassware that is needed for a titration

INSTRUCTIONS

1. You are provided with solid oxalic acid $(COOH)_2.2H_20$
   The molar mass of oxalic acid is 126.07 g mol^{-1}.

You will need to use this to prepare a standard solution of oxalic acid of concentration approximately 0.05 mol L^{-1} (to 4 s.f.)

The solution should be prepared in a 200.0 mL volumetric flask (or 250.0 mL volumetric flask).

a. Calculate the mass of oxalic acid needed to make up the standard solution.

2 marks ***KU1***

Accurately weigh out the approximate mass of oxalic acid needed for the preparation of the standard solution.

b. Record your measurements

c. Calculate the concentration of the standard oxalic acid solution, exact to 4 significant figures.

2 marks ***KU1***

d. Describe the steps to prepare the standard oxalic acid solution.

5 marks ***I3***

2. Use the oxalic acid solution to standardize the sodium hydroxide solution.
   The oxalic acid solution should be approximately 0.05 mol L^{-1} since
   a) it is a diprotic acid.
   b) it is to be used to standardize the approximately 0.1 mol L^{-1}NaOH.

If approximately equal volumes of acid and alkali are to be used, then [$(COOH)_2$] needs to be approximately half [NaOH].

Ensure your teacher observes at least one delivery of the solution from the burette into the conical flask until the endpoint of the titration is reached

Teacher Check	

Ensure your teacher observes at least one pipette transfer

Teacher Check	

Manipulative Skills Checklist

		Comment	**Marks**
Using an analytical pipette	**Poor**_____ **Ex**		**I3** (3 marks)
Using a burette	**Poor** _____ **Ex**		**I3** (3 marks)

Record your results for this titration in the table below.

<u>Titration of oxalic acid and sodium hydroxide solutions.</u>

Concentration of oxalic acid used:_____

Number of drops of indicator used:_____

First reading						
Second reading						
Volume used						

Size of pipette used:_____

Calculate the average titre obtained.
Show clearly the values you have used to obtain your average.

2 marks ***A2***

Write a balanced equation for the reaction between the oxalic acid solution and the sodium hydroxide solution

_____

2 marks ***A2***

Calculate the concentration of the sodium hydroxide solution

2 marks ***AE1***

3. The standardized sodium hydroxide solution (from the previous titration) has a concentration of approximately 0.1 mol $L^{-1.}$
The food acid has a concentration of 0.5000 mol L^{-1}

Dilute the unknown food acid by a suitable factor so that approximately equal volumes of sodium hydroxide and the food acid solution are used **in a titration where concentration of H^+ in the food acid is determined** . Keep in mind that the food acid is either diprotic or triprotic.

Record the dilution factor you used.

Dilution factor = _____

1 mark ***AE1***

4. Titrate the diluted food acid with the standardized sodium hydroxide solution.

Record your results for this titration in the table below.

Titration of food acid and sodium hydroxide solutions

Number of drops of indicator used: _____

First reading						
Second reading						
Volume used						

Size of pipette used in the titration: _____

Average titre obtained: _____

Ensure your teacher checks your titre values

Teacher Check	

Concordance of titres 2 marks ***I3***

5. Calculate the number of moles of sodium hydroxide used in the titration.

2 marks ***AE1***

6. Calculate the number of moles of the food acid used in the titration.

1 mark ***AE1***

7. Hence form the results of the titration, determine the ratio moles of NaOH: moles of food acid.

2 marks ***AE1***

Accuracy of result 2 marks ***I3***

8. Write a balanced IONIC equation for the reaction between the sodium hydroxide solution and the H^+ ions in the unknown food acid.

2 marks **A2**

9. Determine whether the unknown food acid is citric acid or tartaric acid. Explain your reasoning

2 marks ***AE1***

INTERPRETATION AND EVALUATION OF THE EXPERIMENT

1. Describe and explain the rinsing procedures for the following apparatus used in the titration of the standard solution of oxalic acid with the sodium hydroxide solution.

a. The burette

.

2 marks ***KU1***

b. The pipette

.

2 marks ***KU1***

c. The conical flask

.

2 marks ***KU1***

2 a. Identify one source of **random error**.

.

1 mark ***AE2***

b. Explain how the effect of a random error can be minimized.

.

1 mark ***AE2***

3. a. Identify one possible source of **systematic error**.

.

1 mark***AE2***

b Describe the effect that this systematic error would have on your results.

.

2 marks ***AE2***

c. Explain how it can be detected

.

1 mark ***AE2***

4. a. Identify one factor that would indicate how **precise** your results are.

.

1 mark ***AE2***

b. Describe the precision of your results in terms of the identified factor

.

1 mark ***AE2***

5. a. Identify one factor that would indicate how **accurate** your results are.

.

1 mark ***AE2***

b. Describe the accuracy of your results in terms of the identified factor

.

1 mark ***AE2***

6. Suggest **one** improvement which could be made to the experiment

.

2 marks ***AE2***

Performance Standards for Volumetric Analysis

	Investigation I3	Analysis and Evaluation AE1, AE2	Application A2	Knowledge and Understanding KU1
A	**Manipulates apparatus and technological tools carefully and highly effectively to implement using well-organised safe and ethical investigation procedures.**	**Critically and systematically analyses data and their connections with concepts, to formulate logical and perceptive conclusions and make relevant predictions.** **Critically and logically evaluates procedures and suggests a range of appropriate improvements.**	**Uses appropriate chemical terms, conventions, formulae, and equations highly effectively.**	**Consistently demonstrates a deep and broad knowledge and understanding of a range of chemistry concepts.**
B	**Manipulates apparatus and technological tools carefully and mostly effectively to implement organised safe and ethical investigation procedures.**	**Clearly and logically analyses data and their connections with concepts, to formulate consistent conclusions and make mostly relevant predictions.** **Logically evaluates procedures and suggests some appropriate improvements.**	**Uses appropriate chemical terms, conventions, formulae and equations effectively**	**Demonstrates some depth and breadth of knowledge and understanding of a range of chemistry concepts.**
C	**Manipulates apparatus and technological tools generally carefully and effectively to implement safe and ethical investigation procedures.**	**Analyses data and their connections with concepts, to formulate generally appropriate conclusions and make simple predictions, with some relevance.** **Evaluates some procedures in chemistry and suggests some improvements that are generally appropriate.**	**Uses generally appropriate chemical terms, conventions, formulae, and equations with some general effectiveness.**	**Demonstrates knowledge and understanding of a general range of chemistry concepts.** .
D	**Uses apparatus and technological tools with inconsistent care and effectiveness and attempts to implement safe and ethical investigation procedures.**	**Describes basic connections between some data and concepts, and attempts to formulate a conclusion and make a simple prediction that may be relevant.** **For some procedures, identifies improvements that may be made.**	**Attempts to use some chemical terms, conventions, formulae, and equations that may be appropriate.**	**Demonstrates some basic knowledge and partial understanding of chemistry concepts.**
E	**Attempts to use apparatus and technological tools with limited effectiveness or attention to safe or ethical investigation procedures.** .	**Attempts to connect data with concepts, formulate a conclusion, and make a prediction.** **Acknowledges the need for improvements in one or more procedures.**	**Identifies some chemical terms or formulae.**	**Demonstrates some limited recognition and awareness of chemistry concepts.** .

Assessment Design Criteria	Maximum Mark	Mark	Teacher's Comment
I3 Manipulation of apparatus and technological tools **to implement safe** and ethical **investigation procedures**			
Correct steps in preparing a standard solution	5		
Glassware used correctly			
- analytical pipette	3		
- burette	3		
Concordance of titres			
- 3 titres out of 5 within 0.10mL	2		
- 3 titres out of 6 within 0.10mL	[1]		
Accuracy of result			
- within 0.05	2		
- within 0.20	[1]		
AE1 Analysis of data and concepts and their connections to formulate conclusions and make relevant predictions			
Calculations -concentration of NaOH solution	2		
Calculations			
- dilution factor-	1		
- no of moles of NaoH	2		
- no of moles of unknown acid.	1		
- Ratio NaOH : unknown acid	2		
Conclusion	2		
AE2 Evaluation of procedures with suggestions for improvement			
Identifying random error	1		
Explaining how the effect of random error can be minimized	1		
Identifying systematic error	1		
Explaining how systematic error affects results	2		
Explaining how systematic error can be detected	1		
Precision			
- identifying factor	1		
- discussion of precision of results	1		
Accuracy			
- identifying factor	1		
- how it can be detected	1		
Suggested improvement	2		
A2 Use of appropriate chemistry terms, conventions, formulae, and equations			
Convention for calculating average titre values	2		
Equation for the reaction between sodium hydroxide and oxalic acid	2		
Equation for the reaction between sodium hydroxide and food acid	2		
KU1 Demonstration of knowledge and understanding of chemistry concepts			
Calculations -mass of oxalic acid required	2		
-concentration of oxalic acid required	2		
Rinsing procedure described and explained.	2		
- burette	2		
- pipette	2		
- conical flask			
Appropriate number of significant figures used in calculations.	2		
Total	**55**		

I3	AE1	AE2	A2	KU1	TOTAL
15	10	12	6	12	55