

Department of Chemistry Cairns Edition



CH1011 REPORTS 2007

Name:

Partner:

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CH1011 ASSIGNMENT 1 LABORATORY SAFETY

Date -_____

1. INTRODUCTION

Most laboratory work involves the use of chemicals at some stage. This practical will involve a familiarisation with the typical safety equipment in the laboratory, the use of Material Safety Data Sheets to look at the risks associated with the use of chemicals and the basic steps involved with working safely in a laboratory situation.

2. **RESULTS AND DISCUSSION**

2.1 Material Safety Data Sheets

Compound 1.

How would you deal with the situation where a large drum of this chemical had broken while putting it down in a Chemical Store room?

An accident occurs during the clean-up and the chemical is splashed into the eyes of one of the people who is assigned to the clean-up duty. What should be done next?

Compound 2.

A fire occurs in a fumecupboard which contains 2 kg of this compound sitting in a bottle at the back of the cupboard. You are the only one in the room what should you do?

In the clean up after the fire the labels on all the bottles in the fumecupboard are found to have vanished. What is an appropriate method for dealing with this situation?

2.2 Obtaining Safety Information

From the library obtain the names of two books concerned with Chemical Laboratory Safety. Provide the proper reference for these books using the system of referencing used in the chemical literature.

1. 2.

From the CRC Handbook of Chemistry and Physics in the laboratory obtain the names of chemicals with the formulae :

$C_{6}H_{12}O_{2}$	Name:
C ₅ H ₁₁ Br	Name:

Search for these compounds using the MSDS database on the WEB (http://siri.org/msds, you wish to find information on the health hazards associated with using these compounds.

Health hazards associated with the use of :

 $C_6H_{12}O_2$

 $C_5H_{11}Br$

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CH1011 ASSIGNMENT 2 BASIC VOLUMETRIC ANALYSIS

Date -____

1. **INTRODUCTION**

Some of the most basic techniques in chemistry involve the use of accurate volumetric glassware¹ and the analytical balance. They are illustrated here with a titration and the calibration of a pipette.

The calibration of a pipette is based on the fact that masses can be measured much more accurately than volumes. For any substance its density (ρ) is related to its mass (m) and volume (V) by

$$\rho = m/V \qquad \dots (1)$$

Thus provided accurate values are available for the density of water the volume of aqueous solution delivered by a pipette can be accurately determined by measuring the mass of water delivered by that burette.

Titration is used to determine the concentration of a solution. Concentration of a substance in solution is usually given as the amount of substance per unit volume of solution (mol dm⁻³ or M). The aim of any titration is to find the concentration of a substance by finding the "equivalence point" where the substance reacts with another substance for which the concentration is known. If the substances concerned, say X and Y, react according to

$$xX + yY \rightarrow \text{products}$$
 ...(2)

and at the equivalence point the amounts of each substance which were added to the reaction mixture were n_X and n_Y , in volumes V_X and V_Y , at concentrations c_X and c_Y , respectively, then

$$n_X/n_Y = x/y$$
 ...(3)

or

$$\frac{c_X V_X}{x} = \frac{c_Y V_Y}{y}$$

T 7

2. EXPERIMENTAL

In all cases B-grade volumetric apparatus was used.

2.1. Calibration of a pipette

This was done by weighing the volume of water delivered by the pipette on an analytical balance.

2.2. Determination of acetic acid in vinegar

The concentration of acetic acid in vinegar was determined by titrating an aliquot of solution with a solution of sodium hydroxide, of known concentration, using phenolphthalein indicator and working with uncalibrated B-grade volumetric apparatus.

3. **RESULTS AND DISCUSSION**

3.1 Calibration of a pipette

Measurement of the mass delivered by a 10 cm^3 pipette gave the volume (see Appendix 1) to be This value **is/is not** within the tolerance of quoted for such a pipette.

3.2 Acetic acid in vinegar (comment on variation in concentration)

Results for the acetic acid titre of ... samples of vinegar are given below in Table 1.

Table 1. Titration of acetic acid in samples of vinegar – class results.

Sample			
titre / mL			

Is the variation between the brands of vinegar significant within the **precision** of the measurement?

What does this indicate about the concentration of acetic acid in the various vinegars?

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References:

1. A. I. Vogel, Vogel's Textbook of Quantitative Inorganic Analysis, Fifth Edition, Longmans, London, 1989.

APPENDIX 1 Calibration of a pipette - calculations and measurements

MEASUREMENTS

1.



CALCULATIONS AND QUESTIONS

Temperature/ ^o C	Density of water/g
20	0.000202

Given the following data for the density of water

Temperature/° C	Density of water/g cm ⁻³
20	0.998203
21	0.997992
22	0.997770
23	0.997538
24	0.997296
25	0.997044
26	0.996783
27	0.996512
28	0.996232
29	0.995944
30	0.995646

find the volume delivered by the pipette.



Why are pipettes and burettes used for some purposes, while measuring cylinders are 2. used for others?

APPENDIX 2 Determination of acetic acid in vinegar - calculations and measurements

MEASUREMENTS

Table 1	Titration of 5 cm ³ of			vinegar
	with mo	ol dm ⁻³ NaOH solu	ution	
Titration	Burette	reading/cm ³		
number	initial	final	Titre/cm ³	Titre/dm ³
1				
2				
3				
4				
5				
			Mean Value	

Table 2	Titration of 5 cm ³ of			vinegar
	with mo	ol dm ⁻³ NaOH solu	ution	
Titration	Burette	reading/cm ³		
number	initial	final	Titre/cm ³	Titre/dm ³
1				
2				
3				
4				
5				
			Mean Value	

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CALCULATION AND QUESTIONS

Calculation of the acetic acid concentration in vinegar

The equation for the reaction involved in this titration is:

 $NaOH + CH_3COOH \rightarrow \dots + H_2O$ complete the equation

so that, at the equivalence point, the mole ratio of the reactants is:

$$\frac{n_{CH_{3}COOH}}{n_{NaOH}} = \frac{c_{CH_{3}COOH}V_{CH_{3}COOH}}{c_{NaOH}} = ----- complete the expression.$$

This equation must be rearranged to give an expression for the unknown acetic acid concentration in terms of known quantities, allowing this concentration to be determined:



Vinegar 1





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CH1011 ASSIGNMENT 3 GEOMETRIC MODELS -VALENCE SHELL ELECTRON PAIR REPULSION METHOD

Date -____

For each of the molecules given below:

- 1) find the number of shared electrons but remember there are exceptions to the octet rule especially where the central atom is not C, N,O or F!
- 2) draw the Lewis structure
- 3) identify the number of electronic regions
- 4) draw all possible electronic structures showing which is the predicted structure
- 5) draw and describe the approximate molecular structure
- 6) answer any additional questions
- **1. BF**₃ (B: $1s^2 2s^2 2p^1$ so 3 valence electrons!)



Draw the Lewis structure (to give an octet about each fluorine), draw the electron pairs about the central atom (electronic structure) and name the geometry for this electronic structure. Finally draw the molecular structure. The same procedure you will use for subsequent molecules.

2. NH₃

Draw the Lewis, electronic and molecular structures.

Describe the molecular structure.

3. NO₃⁻

Draw the Lewis, electronic and molecular structures.

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4. H₂O

Draw the Lewis, electronic and molecular structures.

Describe the molecular structure.

5. SF₆

Draw the Lewis, electronic and molecular structures.

-	-
11	
/	
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6. **POCl**₃ (N.B. the central atom is P)

Draw the Lewis, electronic and molecular structures.

Describe the molecular structure.

7. SO_4^{2-}

Draw the Lewis, electronic and molecular structures.

/1	
/1	



8. CO_3^{2-}

Draw the Lewis, electronic and molecular structures.

Describe the molecular structure.

9. SO₂

Draw the Lewis, electronic and molecular structures.



10. XeF₄

Draw the Lewis, electronic and molecular structures.

Describe the molecular structure.

11. C₂H₄

Draw the Lewis, electronic and molecular structures.

/2	



12. CIF₃

Draw the Lewis, electronic and molecular structures.

1	
10	
12	
12	

20	
/20	

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CH1011 ASSIGNMENT 4 FUNCTIONAL GROUP AWARENESS - MODEL BUILDING

Date -_____

1. Alkanes

Methane

Ethane

Isomeric C₄ Alkanes (C₄H₁₀)

IUPAC NAMES:

2. Alkenes

Ethene

Isomeric C₄ Alkenes (C₄H₈)

IUPAC NAMES:

3. Alkynes

Ethyne

4. Benzene

5. Alcohols

Methanol

Isomeric Propanols C₃H₇OH

IUPAC NAMES:

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6. Ethers

Diethyl ether

ALTERNATIVE IUPAC NAME:

7. Phenols

Phenol

8. Haloalkanes

Ethyl bromide

IUPAC NAME:

i-Propyl bromide

IUPAC NAME:

9. Amines

Trimethylamine

CLASSIFICATION:

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Methyl ethylamine

CLASSIFICATION:

10. Aldehydes and Ketones

Ethanal

TRIVIAL NAME:

Propanone

TRIVIAL NAME:

23

11. Carboxylic acids

Ethanoic acid

TRIVIAL NAME:

12. Esters

Methyl propanoate

13. Amides

Acetamide



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CH1011 ASSIGNMENT 5 REDOX TITRATIONS

Date -_____

1. INTRODUCTION

Redox reactions involve the transfer of electrons from a reactant with excess electron density (the reductant) to one with an electron deficiency (the oxidant). Thus, in the course of a redox reaction there is a net transfer of electrons from one reactant to the other. The two processes involved are reduction (gain of electrons) and oxidation (loss of electrons) and as these two processes always occur together the terms are combined and referred to as a redox process.

A redox titration operates in a similar manner to an acid-base titration in that there is a reactant used which is of known concentration (in the burette), there is an reactant of unknown concentration (in the receiving flask) and there is a known stoichiometry of reaction between the two reactants. In a similar fashion to the acid-base titration there is also a marked colour change at the "equivalence point" for the titration. This occurs in the redox titration due to a change in oxidation state of one the reactants, which generally changes from a colourless to a brightly coloured complex. Thus, in a redox titration there is not the necessity to add the pH sensitive indicator that is typically used in an acid-base titration.

2. EXPERIMENTAL

In all cases B-grade volumetric apparatus was used.

2.1. Hydrogen peroxide concentration

The concentration of hydrogen peroxide was determined by titrating an accurately known volume of a diluted solution (10:1) against a solution of potassium permanganate of known concentration. The colour of the potassium permanganate was used as the indicator.

2.2. Molecular weight of an compound containing Fe²⁺

An accurately measured mass of the unknown compound was dissolved in water and the volume made up to 250 cm^3 with a volumetric flask. The concentration of Fe²⁺, in this solution was determined by titrating an accurately known volume with a solution of potassium dichromate of known concentration using barium diphenylamine sulphonate indicator. Assuming that the unknown contained one Fe²⁺ the molar mass could then be calculated.

3. **RESULTS AND DISCUSSION**

3.1 Concentration of hydrogen peroxide

Results for the titration of hydrogen peroxide in several old and new samples of commercial hydrogen peroxide are given below in Table 1. (see Appendix for calculation of our result for Sample).

Table 1. Titres of H_2O_2 using KMnO₄ – class results.

Sample of H ₂ O ₂			
Volume KMnO ₄ / mL			

Comment on the variation between the different samples (old versus new). Is this variation within the **precision** of the method?

3.2 Determination of the molecular weight of an unknown compound of Fe²⁺ The molecular weight of an unknown compound was found to be

MEASUREMENTS

		mol dm ⁻³ KM	nO ₄ solution	
Titration	Burette	reading/cm ³		
number	initial	final	Titre/cm ³	Titre/dm ³
1				
2				
3				
4				
5				

Table 1. Titration of 10 cm³ of a diluted H₂O₂ solution with m^{-3} KMnO₂ solution

Mean Value

/3

1. CALCULATIONS AND QUESTIONS

1.1 Calculation of hydrogen peroxide concentration

(a) Concentration of the diluted hydrogen peroxide solution.

The equation for the reaction involved in this titration is:

$$2KMn0_4 + 5H_20_2 + 3H_2S0_4 \rightarrow K_2S0_4 + 2MnS0_4 + 8H_20 + 50_2$$

so that, at the equivalence point, the mole ratio of the reactants is:

 $\frac{n_{H_2O_2}}{n_{KMnO_4}} = \frac{c_{H_2O_2}V_{H_2O_2}}{c_{KMnO_4}V_{KMnO_4}} = ----$

complete the expression

This equation can be rearranged to give an expression for the unknown hydrogen peroxide concentration in terms of known quantities, allowing this concentration to be determined as follows:



(b) Calculate the concentration of the undiluted hydrogen peroxide solution.

2. Why is an indicator not needed in this titration?

APPENDIX 2 Determination of the molecular weight of an unknown Fe²⁺ compound

MEASUREMENTS

Mass of unknown in 250 cm³ of solution =

Table A2.1	Titration	of	a Fe ²⁺	solution	with	Μ	potassium	dichromate
solution.								

Titration	Burette	reading/cm ³		
number	initial	final	Titre/cm ³	Titre/dm ³
1				
2				
3				
4				
5				
<u> </u>	1	1	1	

Mean Value

g

/3

CALCULATION OF THE MOLECULAR WEIGHT OF THE UNKNOWN

The equation for the reaction involved in this titration is:

$$14 H^{+} + Cr_2 O_7^{-2} + 6 Fe^{+2} \rightarrow 2 Cr^{+3} + 6 Fe^{+3} + 7 H_2 O$$

so that, at the equivalence point, the mole ratio of the reactants is:

 $\frac{n_{Fe^{2+}}}{n_{K_2Cr_2O_7}} = ----$ complete the expression

(a) How many moles of dichromate were added at the equivalence point?

(b) How many moles of ferrous iron (Fe^{2+}) were in the 20cm³ aliquot?

(c) How many moles of ferrous iron (Fe^{2+}) were in the total volume?

(d) Calculate the molecular weight of the unknown.

[<u>Hint</u>: Number of moles of substance = $\frac{\text{mass of substance}}{\text{Molecular Weight of substance}}$ - you know the mass of the unknown iron compound

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CH1011 ASSIGNMENT 6 ISOLATION OF CAFFEINE FROM COFFFEE BEANS

Date -_____

Part A Extraction

Briefly describe the procedure used for the extraction of caffeine.

b.p. CH₂Cl₂

Description of extracted material

Mass of caffeine obtained:

	g flask + boiling chips + caffeine
-	g flask + boiling chips

=

g yield of caffeine



Part B: TLC Analysis

Impure compound	Purified compound	Impure / Pure

Comments



Answers to questions

1.

2.



CH1011 ASSIGNMENT 7 KINETICS

Date -_____

Prepare your report as a separate document to hand in. Use the format described in the Report Writing section of your laboratory notebook. You may use previous Assignments as models for your report although these may have to be modified as found necessary. Please hand in your report with this report book so that your final mark can be entered below.



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CH1011 ASSIGNMENT 8 THERMOCHEMISTRY

Date -_____

HEAT OF NEUTRALISATION

2.1	Heat Capacity of Calorimeter	
1.	Temp. of calorimeter and water before mixing	g°C
2.	Temp. of warm water	°C
3.	Maximum temperature determined from your	
	extrapolated curve	°C
4.	Heat lost by warm water (temp decrease x 50	g x 4.18 J/K-g)
	(use T from step 3, remember $\Delta T(^{\circ}C) = \Delta T(K)$	())
	=	J
5.	Heat gained by cooler water (temp. increase x (use T from step 3)	50 g x 4.18 J/K-g)
	=	J
6.	Heat lost to calorimeter $[(4) - (5)] =$	J
7.	Heat capacity of calorimeter:	
	Heat lost to calorimeter =	
	Temperature increase	J/K
		/3

2.2	Heat of Neutralisation of HCl - NaOH		
1.	Temp of calorimeter and NaOH	°C	
2.	ΔT determined from your curve after adding	g 5	
	HCl to the NaOH	°C	
3.	Heat gained by solution (temperature increa	use x 100g x 4.18 J/K.g)	
	=	J	
4.	Heat gained by calorimeter (temperature inc	crease x heat capacity of calorimeter)	
	=	J	
5.	Total joules released by reaction $[(3) + (4)]$	= J	
6.	Complete: $HCl + NaOH \rightarrow$		
7.	The number of moles of HCl in 50 mL of 3.0	M HCl (show calculations)	
	=	mol	
8.	The number of moles of H ₂ O produced in rea	action of 50 mL 3.0 M HCl and 50 m	L
	3.0 M NaOH (show calculations): =	mol	
9.	Joules released per mole of water formed:		
	<u>Total joules released (5)</u> = Number of moles water produced (8)	kJ/mol	
		/4	

2.3 Heat of Neutralisation of CH ₃ CO ₂ H	- NaOH
1. Temperature of calorimeter and NaOH	°C
2. ΔT determined from cooling curve after a	dding CH ₃ CO ₂ H to NaOH =°C
3. Heat gained by solution (temp. increase x	100 g x 4.18 J/K.g)
=	=J
4. Heat gained by calorimeter (temp. increas	e x heat capacity of calorimeter)
=	=J
5. Total joules released by reaction $[(3) + (4)]$)] =J
6. Complete: $CH_3CO_2H + Na$	$OH \rightarrow$
7. The number of moles of H_2O produced	l in reaction of 50 mL 3.0 M CH ₃ CO ₂ H and
50 mL 3.0 M NaOH (show calculations)	: = mol
8. Joules released per mole of water formed:	

Total joules released (5)	=	
Number of moles water produced (7)		 kJ/mol

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Time	Temperature	Time	Temperature
-15		105	
0		120	
15		135	
30		150	
45		165	
60		180	
75			
90			

Table 1Heat Capacity of Calorimeter

Table 2Heat of Neutralisation of HCl - NaOH

Time	Temperature	Time	Temperature
-15		105	
0		120	
15		135	
30		150	
45		165	
60		180	
75			
90			

Time	Temperature	Time	Temperature
-15		105	
0		120	
15		135	
30		150	
45		165	
60		180	
75			
90			

Table 3Heat of Neutralisation of CH3CO2H - NaOH



Figure 2.1 Temperature as a function of time



Figure 2.2 Temperature as a function of time



Figure 2.3 Temperature as a function of time

QUESTIONS

- **1.** What is the largest source of error in the experiment?
- **2.** How should the two heats of reaction for the neutralization of NaOH and the two acids differ? Why?
- **3.** The experimental procedure has you wash your thermometer and dry it after you measure the temperature of NaOH solution and before you measure the temperature of the HCl solution. Why?

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CH1011 ASSIGNMENT 9 ELECTROCHEMICAL CELLS

Date -_____

1. Iron(III) chloride and tin(II) chloride

Cell details

Negative electrode	Positive electrode
Electrode material: Solution:	Electrode material: Solution:
with E _{cell} =	
Observation(s) and explanation(s)	

From these observations the following reactions are proposed

Anode:	Cathode:

Overall:

The shorthand notation for this cell is

2. Potassium iodide and bromine water

Cell details

le material:
d

with E_{cell} =

Observation(s) and explanation(s)

From these observations the following reactions are proposed

Anode:	Cathode:
Overall:	

For this cell the shorthand notation is	

3. Copper sulphate and zinc sulphate

From these observations the following reactions are proposed

Anode:	Cathode:
Overall:	

For this cell the shorthand notation is

The predicted e.m.f. for this cell may be calculated as follows:



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Compare your answer with the experimental value and comment.

4. Silver nitrate solutions

4.1 0.1M and 0.01M silver nitrate solutions

Cell details (indicate concentrations)

Negative electrode	Positive electrode	
Electrode material:	Electrode material:	
Solution:	Solution:	

E_{cell} =

From these observations the following reactions are proposed

Anode:	Cathode:
Overall:	

For this cell the shorthand notation is: (indicate concentrations)

Calculation of E_{cell}

=



(final values & units)

4.2 0.1M and 0.001M silver nitrate solutions

Negative electrode	Positive electrode	
Electrode material:	Electrode material:	
Solution:	Solution:	
E _{cell} = From these observations the following	reactions are proposed	

Overall:

For this cell the shorthand notation is: (indicate concentrations)

Calculation of E_{cell}



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CH1011 ASSIGNMENT 10 CORROSION

Date -_____

2.1.1 Oxidation of Metals

 Fe metal
 Observations / Explanations

2.1.2

Cu metal

Observations / Explanations

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2.2 Aluminium oxide films

Al metal	Observations / Explanations	

2.3.1 Copper / iron electrochemical cell

Cu / Fe strips

Observations / Explanations

2.3.2 Cu coated Fe nail

Observations / Explanations

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2.4.1 Zinc / iron salt solution corrosion Zn sheet + Fe nail in 3% NaCl Observations / Explanations 2.4.2 Fe nail in 3% NaCl Observations / Explanations

2.5 Localised corrosion effects on iron metal

Fe sheet + Ferroxyl indicator

Observations / Explanations

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2.

2.6 Differential aeration effects on corrosion of iron metal

Fe sheetsObservations / Explanations	

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CH1011 ASSIGNMENT 11 WATER QUALITY STUDIES

Date -_____

Origin of Water sample :

2.1 Chemical Oxygen Demand

Volume of water sample _____ mL. Volume of potassium dichromate _____ M added _____ mL.

Table 1.	Titration of potassium dichromate using ferrous ammonium sulph	nate M.
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Titration	Burette	Reading / cm ³		
Number	initial	final	Titre/cm ³	Titre/dm ³
1				

Calculation of the C.O.D. of the water sample



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2.2 Degree of Acidity

	Universal Indicator (pH)	pH Meter (pH)
Sample		

• Is your water sample within the permissible limits for a drinking water supply?

2.3 Estimation of Total Chloride Content

2.3.1 Standardisation of the Ammonium Thiocyanate

 Table 3. Titration of ammonium thiocyanate using silver nitrate
 M.

Titration	Burette	reading/cm ³		
Number	initial	Final	Titre/cm ³	Titre/dm ³
1				
2				
3				
	1	<u>I</u>	Mean Value	

Calculation of the concentration of the ammonium thiocyanate.

2.3.2 Determination of Total Chloride Content of the Water Sample

Table3.Titration of residual silver ion $(AgNO_3)$ using
ammonium thiocyanateM.

Titration	Burette	Reading/cm ³		
Number	initial	Final	Titre/cm ³	Titre/dm ³
1				

Calculation of the Cl $\,$ concentration using the standardised ammonium thiocyanate (mg/L).

• Comment on your result in terms of the source of the water that you have chosen.

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CH1011 ASSIGNMENT 12 WATER HARDNESS

Date -_____

Two different methods are evaluated for the measurement of hardness in a natural water sample, a complexiometric titration and a spectrophotometric method using a calibration curve.

Origin of Water sample :

2. Experimental and Results

2.1 Hardness – Complexiometric Method

 Table 2. Titration of water samples using EDTA
 M.

Titration	Burette	reading/cm ³		
Number	initial	Final	Titre/cm ³	Titre/dm ³
1				
2				
3				
4				
5				

Mean Value

Calculation of the hardness of the water sample – complexiometric method

- What is the hardness rating.
- Is your water sample within the permissible limits for a drinking water supply.

2.2 Hardness – Spectrophotometric Method

Sample	Absorbance



Figure 2.1 _____

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Calculation of the hardness of the water sample – spectrophotometric method

- What is the hardness of the water from the spectrometric method.
- Compare the value of hardness from the spectrophotometric method with the value obtained in the complexiometric method and comment on the errors involved in both methods and how improvements could be made.

