BIRDWOOD HIGH

**STAGE 2 CHEMISTRY**

**ASSESSMENT TYPE 2: SKILLS AND APPLICATIONS TASK**

NAME: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Purpose

This supervised assessment task provides you with the opportunity to demonstrate:

* your knowledge and understanding of chemical concepts and interrelationships,
* your ability to apply chemical concepts and evidence from investigations to solve problems in new or familiar contexts using the appropriate chemical terms and conventions,
* your ability to critically analyse and evaluate chemical information and procedures,

in relation to the topic:

Topic 2: *Analytical Techniques*

Description of assessment

Complete the questions in the task using the spaces provided, ensuring you:

* communicate your knowledge and understanding clearly and concisely,
* use chemical terms correctly,
* present information in an organized and logical sequence,
* include only information that is relevant to the question,
* show all steps and reasoning in your answer,
* give answers with appropriate units when required.

Assessment conditions

A supervised 60-minute (with 5 minutes reading time) closed book assessment completed under test conditions.

A calculator may be used.

You may use the Periodic table and the table of SI Units provided.

|  |  |  |
| --- | --- | --- |
| ***Learning Requirements*** | ***Assessment Design Criteria*** | ***Capabilities*** |
| 1. demonstrate and apply knowledge and understanding of chemical concepts and interrelationships  2. formulate questions, manipulate apparatus, record observations in practical chemical activities, and design and undertake chemistry investigations  3. demonstrate an understanding of how knowledge of chemistry can be used to make informed conclusions or decisions, taking into account social and environmental contexts  4. develop possible solutions to a variety of problems in chemistry, in new or familiar contexts  5. critically analyse and evaluate chemical information and procedures from different sources  6. communicate in a variety of forms using appropriate chemical terms and conventions. | Investigation  The specific features are as follows:  I1 Design and implementation of a chemistry investigation plan.  I2 Selection and acknowledgment of information about chemistry and issues in chemistry from different sources.  I3 Manipulation of apparatus and technological tools using safe and ethical investigation procedures.  I4 The obtaining, recording, and display of findings of investigations using appropriate conventions and formats.  Analysis and Evaluation  The specific features are as follows:  AE1 Analysis of connections between data, concepts, and issues in chemistry.  AE2 Evaluation of procedures, with suggestions for improvements.  AE3 Analysis and evaluation of data and other evidence to formulate relevant predictions.  Application  The specific features are as follows:  A1 Application of chemistry concepts and evidence from investigations to solve problems in new and familiar contexts.  A2 Use of appropriate chemistry terms, conventions, formulae, and equations.  A3 Demonstration of skills in individual and collaborative work.  *Knowledge and Understanding*  The specific features are as follows:  KU1 Demonstration of knowledge and understanding of chemistry concepts.  KU2 Use of knowledge of chemistry to understand and explain social or environmental issues.  KU3 Communication of knowledge and understanding of chemistry in different forms. | Communication  Citizenship  Personal Development  Work  Learning  (delete those which do not apply to this assessment) |

**STAGE 2 CHEMISTRY**

BIRDWOOD HIGH SCHOOL

**SAT 1**

Time : 1 hour

*Approved dictionaries and calculators may be used.*

1 You will have 5 minutes to read the paper. You must not write in your question booklets during this reading time but you may make notes on the scribbling paper provided.

2 You will be expected to extract information such as atomic number and relative atomic mass from the periodic table supplied.

3 This paper consists of four questions.

4 There is no need to fill all of the space provided; clear well-expressed answers are required. If you delete part or all of an answer you should clearly indicate your final answer.

5 The total mark is 65. The four questions are of approximately equal value.

|  |  |
| --- | --- |
| **For Examiner’s Use Only** | |
| **1** | /14 |
| **2** | /17 |
| **3** | /17 |
| **4** | /17 |
| **Total** | /65 |

# **QUESTION 1**

Volumetric analysis is a technique that can be used to determine the concentration of a substance using a standard solution of known concentration.

(a) To find accurately, the concentration of an approximately 0.150 mol L-1 hydrochloric acid solution, a student titrated it with a previously prepared standard solution of potassium carbonate (K2CO3).

Calculate the mass of potassium carbonate that must be dissolved in 250.0 mL of solution to prepare a solution of concentration 0.250 mol L-1.

n = cv

n = 0.25 x 0.25

n = 0.0625 mol

m = nM

m = 0.0625 x (39.10 x 2 + 12.01 + 16 x 3)

m = 8.64 g (3sf)

(2 marks)

1. 20.0 mL aliquots of the approximate 0.150 mol L-1 hydrochloric acid solution were placed in a conical flask and titrated with the potassium carbonate solution using phenolphthalein as an indicator. Phenolphthalein is colourless in acid solutions and pink in basic solutions.

The results of 3 student’s titrations were:

|  |  |  |  |
| --- | --- | --- | --- |
| **Titration** | **Student 1** | **Student 2** | **Student 3** |
| 1 | 19.30 | 19.35 | 19.50 |
| 2 | 19.35 | 19.50 | 19.20 |
| 3 | 19.20 | 19.60 | 19.35 |

The actual correct titre value was 19.40 mL.

(i) Name the apparatus that would have been used to deliver the 20.0 mL aliquots.

volumetric pipette\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ (1 mark)

(ii) State what should have been used to rinse this apparatus.

distilled water, then the hydrochloric acid solution\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ (1 mark)

(iii) Describe two *precautions* that should have been taken to ensure that the volume delivered

was 20.0 mL.

held against side of glass\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

allow 15 sec to drain and allow last drop to stay in the pipette\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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(iv) State which student, 1, 2 or 3, had the titration values that were most accurate.

student 3 had an average of 19.35, which was closest to the true value (although poor precision) (1 mark)

(v) State the colour change of the indicator at the end-point.

clear to pink at end point\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ (1 mark)

(vi) A student, in using the burette, gave it a final rinse with distilled water instead of hydrochloric acid solution.

State and explain the effect this would have on the titration readings.

Effect on titration readings: higher than expected\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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Explanation: the water would dilute the solution in the burette, causing more being required to reach the end point, hence a higher than expected titration reading.\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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(c) The elements titanium and zinc make important contributions to modern society.

TiO2 is used in products that prevent sunburn. One sunburn cream contains a 3.0% w/v concentration

of TiO2.

Calculate the mass, in g, of TiO2 needed to prepare 350 g of this sunburn cream.

3.0% of 350 g

0.03 x 350 g = 10.5 g

(1 mark)

1. Foods have varying amounts of protein, carbohydrates and fats.

(i) In one household muesli bar, the concentration of sugar is 5.7 g per 20 g serve.

Calculate the percentage, by mass, of sugar in the muesli bar.

5.7 / 20 x 100 = 28.5 % w/w

(2 marks)

(ii) Assuming all of the sugar from the bar is digested and absorbed by the blood, calculate the blood sugar concentration in mol L-1. (Average human body has 5L of blood)

5.7 g sugar, 5 L blood

C = 5.7 / 5

C = 1.14 gL-1

1.14 / (12.01 x 6 + 1.008 x 12 + 16 x 6) = 0.00633 mol L-1

(2 marks)

(e) The glucose content of a mixture of sugars can be determined by a redox titration.

Sodium hydroxide solution is added to a solution of sugars.

An excess of iodine is then added to the mixture.

The following equation shows the redox reaction that takes place in this titration.

C6H12O6 + 3OH- + I2 C6H11O7- + 2H2O + 2I-

Identify the substance which is the *oxidizing agent* in this reaction and state a reason for your choice.

Substance: I2\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Reason. oxidation number changes from 0 to -1. reduction in oxidation number indicates reduction. I2 is reduced, therefore it is the oxidising agent.\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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TOTAL: 17 marks

**QUESTION 2**

Limestone is a sedimentary rock composed largely of calcium carbonate (CaCO3)

The following is a method for determining the concentration of calcium carbonate in limestone:

**Step 1** An excess quantity of standard 0.500 M HCl solution is added to a sample of crushed limestone

CaCO3(aq) + 2HCl(aq) CaCl2(aq) + H2O(l) + CO2(g)

**Step 2** The excess HCl is titrated with standard NaOH solution in the presence of an indicator:

HCl(aq) + NaOH(aq) NaCl(aq) + H2O(l)

The appearance of a pink colour indicates the end point of the titration.

In one analysis, 1 g of limestone was covered with 40.0 mL of HCl. After the reaction was complete the limestone solution was titrated with 0.100 M NaOH. An average titre of 16.1 mL was recorded

1. The burette used in this titration was prepared carefully, to ensure that the results were accurate.

State *two* steps that would have been followed in the preparation of the burette, and state *why*

each step was necessary to ensure accuracy.

Rinsed with distilled water. This is important to remove any impurities that may be in the burette which could react with either reagent and adversely affect the results.

Rinse with the NaOH solution. This removes the water from the burette so that the solution is not diluted by any residual water left behind from the initial rinse.

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(b) State if this analysis would be classified as a qualitative or a quantitative analysis and explain your answer.

quantitative\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ (1 mark)

Explanation: this analysis gives the amount of CaCO3 in the limestone. The results give both a number and unit of measurement and it is therefore a quantitative measurement.

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*Credit will be given for the correct use of significant figures in answers to part (c).* (1 mark)

(c) (i) Calculate the number of moles of HCl in the 40 mL solution

n = CV

n = 0.500 x 0.0400

n = 0.0200 mol (3sf)

This is the total HCl

(2 marks)

(ii) Calculate the number of moles of NaOH that reacted in the titration at **Step 2**.

n = CV

n = 0.100 x 0.0161

n = 0.00161 mol (3sf)

(2 marks)

1. Calculate the number of moles of HCl that reacted in **Step 1** and hence the number of moles of

CaCO3 in the original sample limestone

n(HCl step 2) = n(NaOH) as mole ratio is 1:1

= 0.00161 this is the unreacted HCl from Step 1.

n(HCl reacted) = n(HCl total) - n(HCl unreacted)

= 0.02 - 0.00161

= 0.01839 mol

n(CaCO3) = n(HCl reacted) / 2 as mole ratio is 1:2

= 0.009195 mol

= 0.00920 mol (3sf)

(3 marks)

(iv) Calculate the concentration of calcium carbonate, in %w/w, in the original sample of limestone

m = nM

m = 0.00920 x (40.08 + 12.01 + 16 x 3)

m = 0.920 g

original mass of limestone = 1.0g

therfore %w/w = 0.920 / 1.0

= 92 % w/w (2sf)

(3 marks)

TOTAL: 17 marks

**QUESTION 3**

(a) Atomic absorption spectroscopy can be used to determine the concentration of potassium ions

in soil water. Several solutions of known concentration of potassium ions were tested so that

a calibration graph could be prepared. Three samples at each concentration were tested and their average absorbance was calculated. The results are shown in the table below:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Solution** | **Concentration of K+(aq)**  **(mg L-1)** | **Absorbance** | | | **Average absorbance** |
| **Sample 1** | **Sample 2** | **Sample 3** |
| Blank | 0.00 | 0.008 | 0.006 | 0.008 | 0.007 |
| Standard 1 | 0.55 | 0.150 | 0.147 | 0.153 | 0.150 |
| Standard 2 | 1.10 | 0.290 | 0.312 | 0.301 | 0.301 |
| Standard 3 | 2.20 | 0.595 | 0.601 | 0.596 | 0.597 |
| Standard 4 | 4.40 | 1.202 | 1.200 | 1.204 | 1.202 |

(i) State one advantage of using an average absorbance to plot the calibration graph.

accounts for random error and gives a clearer calibration curve\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ (1 mark)

(ii) State what would need to be done to the component(s) of the atomic absorbance spectrometer

if the concentration of sodium ions in the soil water were to be determined instead.

Lamp would need to be changed to a sodium lamp. (ie emit wavelengths equal to the energy gaps present in sodium metal)\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ (1 mark)

(iii) Compare the set of sample absorbances for Standard 2 with that of Standard 3.

(1) Identify the set of results that is more precise.

Standard 3\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ (1 mark)

(2) State one reason for your answer.

Standard 3 has a maximum difference of 0.006 between values, which is a lower variance than standard 2 \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ (1 mark)

(iv) On the grid below, draw a calibration graph, using the average absorbance data in the table.

(5 marks)

(v) Use the calibration graph to determine the concentration of potassium ions, in mg L-1,

in the soil water, that has an absorbance of 0.450.

1.64 mg L-1\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ (1 mark)

(vi) Convert your answer in part (v) to mol L-1.

0.0000419 mol L-1\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ (1 mark)

(vii) Errors affect the precision and accuracy of experimental data.

(1) Identify the type of error that affects accuracy.

systematic errors\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ (1 mark)

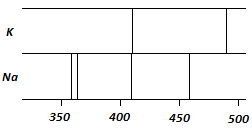
(2) Describe the appearance of your graph if it had low accuracy

The line of best fit would not go through the origin, indicating systematic errors \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ (1 mark)

(viii) The soil water that was tested also contained dissolved sodium ions.

Wavelengths of radiation emitted and absorbed by potassium and sodium ions over a

limited range of the spectrum are shown in the diagram below:



Identify a wavelength of radiation in the spectrum above that would be suitable to use

for the analysis of potassium in this soil water.

Explain your answer.

The two possible choices for potassium are ~410nm and ~490nm. The choice of 490nm would be more appropriate because sodium has an absorbance very close to 410nm. Using 410 could produce errors due to sodium being mistaken for potassium during the test. The wavelength of 490 does not have a corresponding absorbance in sodium.

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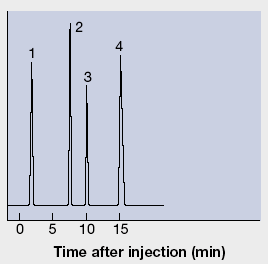
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TOTAL : 17 marks

**QUESTION 4**

(a) Four drugs were analysed using chromotography. A non polar stationary phase was used with a polar mobile phase.



1. Determine the retention time of **Drug 1** in minutes, to 1 significant figure.

2 min\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ (1 marks)

1. State which component, **Drug 2** or **3**, moved more slowly through the chromatography column.

Drug 3 moved more slowly\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ (1 mark)

(iii) State and explain which component, **Drug 2** or **3**, is more polar.

Drug 2 moved through the column more quickly than drug 3 due to it being more attracted to the mobile phase. Polar compounds are more attracted to polar solvents due to dipole-dipole interactions. Because Drug 2 was more attracted to the polar mobile phase it was the more polar of the two drugs.

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(b) The metabolites of **Drug 2** were analysed using thin layer chromatography with a polar stationary phase

and a non-polar mobile phase. The Rf values obtained for **Drug 2** and its two products are

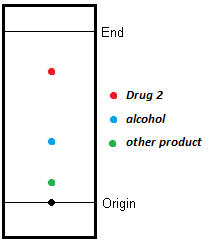
shown in the table below:

|  |  |
| --- | --- |
| **Component** | **Rf** |
| **Drug 2** | 0.7 |
| alcohol | 0.3 |
| other product | 0.1 |

(i) State which of these three components is the least polar.

Drug 2 (least attracted to the polar stationary phase, ie it moved the furthest) (1 mark)

(ii) On the chromatogram below, show the positions of the three components according to their Rf values.



(2 marks)

(2 marks)

(c) Solid copper (Cu) can undergo a redox reaction with nitirc acid (HNO3) to form copper ions (Cu2+) and nitric oxide gas (NO)

(i) Write the reaction as two balanced half equations.

**Cu** **Cu2+** + 2e-

**HNO3** + 3H+ + 3e- **NO** + 2H2O

(3 marks)

(ii) Using part i, write an overall equation for the reaction between copper and nitric acid

multiply equation 1 by 3 and equation 2 by 2 to give 6e- in both.

3Cu + 2HNO3 + 3H+ 3Cu2+ + 2NO + 4H2O

(3 marks)

TOTAL: 14 marks