|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Description: Vertical full colour positive | Safety Bay Senior High School | | | | |
| **CHEMISTRY UNIT 3 & 4** | | | | | |
| **Practical Test #2:** | | | | | |
| **Titrations (theory component))** | | | | | |
|  | | | | | |
| **NAME:** | | |  | | |
|  | | |  | | |
| **Time allowed for this paper** | | | | | |
| Reading time: | | 5 minutes | | | |
| Working time: | | 50 minutes | | | |
|  | | | | | |
| **Structure of this paper:** | | | | | |
| Section | | | Marks available | | Marks Obtained |
| Theory component | | | 50 | | \_\_\_\_\_ / 50 |
| Practical component | | | 20 | | \_\_\_\_\_ / 20 |
|  | | |  | **Total** | \_\_\_\_\_\_ / 70 |

**Section One: Multiple Choice**

This section has 6 questions. Answer **all** questions by circling the correct option. If you make a mistake, put a cross through your answer and then circle your new answer. No marks will be given if more than one answer is completed for any question.

Suggested working time: 10 minutes

1. Which type of glassware is used in a titration to deliver an accurate volume of solution to a known volume of another solution?

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| (a) |  | (b) |  | (c) |  | **(d)** |  |

1. Methyl orange and phenolphthalein are two indicators commonly used in titrations.

Which option shows the correct indicator colour for the given substance?

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Substance** | **pH** | **Indicator** | **Colour** |
| (a) | Stomach acid | 2 | Methyl orange | Yellow |
| (b) | Lemon juice | 3 | Phenolphthalein | Pink |
| (c) | Distilled water | 7 | Phenolphthalein | Pink |
| **(d)** | **Seawater** | **8** | **Methyl orange** | **Yellow** |

1. What pieces of glassware should be used when preparing a primary standard solution?

* 1. Pipette, burette and conical flask
  2. Dropper, watch glass and pipette
  3. **Beaker, filter funnel and volumetric flask**
  4. Measuring cylinder, stirring rod and conical flask

1. Sulfuric acid (H2SO4) and nitric acid (HNO3) are both strong acids. Ethanoic acid (CH3COOH) is a weak acid.

20.00 mL solutions of 0.10 mol L-1 concentration of each of these three acids were separately titrated with a 0.10 mol L-1 solution of sodium hydroxide (in the burette).

0.10 mol L-1

H2SO4

0.10 mol L-1

HNO3

0.10 mol L-1

CH3COOH

Which of the following statements is true regarding the volume the NaOH needed for each titration?

* 1. All three acids would require the same amount of NaOH
  2. HNO3 would require more NaOH than CH3COOH, but less than H2SO4
  3. H2SO4 and HNO3 would require the same amount of NaOH, but CH3COOH would require less
  4. **CH3COOH and HNO3 would require the same amount of NaOH, but H2SO4 would require more**

1. Which statement best describes the equivalence point in a titration between a strong acid and a strong base?

* 1. The point at which the first sign of a colour change occurs
  2. The point at which equal moles of acid and base have been added together
  3. **The point at which equal moles of H+ ions and OH⁻ ions have been added together**
  4. The point at which the rate of forward reaction equals the rate of reverse reaction

1. Which of the following measurements has the highest relative uncertainty?

* 1. A pipette volume of 50.0 ± 0.1 mL
  2. A volumetric flask containing 500.0 ± 0.2 mL
  3. A titre volume of 26.5 ± 0.1 mL
  4. **A mass of 0.72 ± 0.01 g**

**Section Two: Short Answer**

Write your answers in the spaces provided. When calculating numerical answers, show your working or reasoning clearly. Express numerical answers to the appropriate number of significant figures and include appropriate units where available.

Suggested working time: 40 minutes

1. **(3 marks)**

The concentration of a solution of ammonium chloride was determined by titration against a standard solution of sodium hydroxide. The sodium hydroxide solution was placed in the burette and the ammonium chloride solution was pipetted into the conical flask.

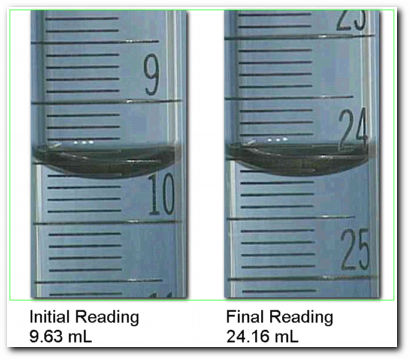
What solution of liquid would you use to rinse the following pieces of equipment just prior to use?

|  |  |
| --- | --- |
| **Answer** | **Cumulative marks** |
| Burette: Sodium hydroxide / NaOH | 1 |
| Pipette: Ammonium chloride / NH4Cl | 1 |
| Conical flask: Distilled water / Deionised water | 1 |
|  | **Total: 3 marks** |

1. **(2 marks)**

The following images show initial and final readings from a burette during a titration.

Find the titre volume for this titration. Give all answers to two decimal points.

****

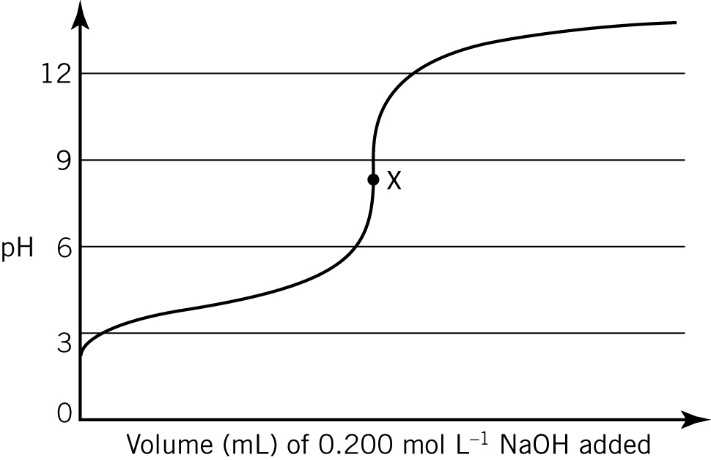
|  |  |
| --- | --- |
| **Answer** | **Cumulative marks** |
| Initial: *9.62 mL (± 0.2)* | 0.5 |
| Final: *24.15 mL (± 0.2)* | 0.5 |
| Titre volume calculated correctly (~14.5 mL) | 0.5 |
| All answers to 2 decimal places | 0.5 |
|  | **Total: 2 marks** |

1. **(5 marks)**

Benzoic acid is a weak acid used as a preservative, for example in soft drinks. In aqueous solutions it ionises according to the following equation:

C6H5COOH(aq) ⇌ C6H5COO⁻(aq) + H+(aq)

The graph below shows the changes in pH that occur when 20.00 mL of approximately 0.100 mol L-1 benzoic acid solution in a conical flask is titrated with 0.200 mol L-1 NaOH solution from a burette.



* 1. At point X, approximately what volume of NaOH solution has been added to the conical flask?

(1 mark)

|  |  |
| --- | --- |
| **Answer** | **Cumulative marks** |
| 10.00 mL | 1 |
|  | **Total: 1 mark** |

* 1. The indicator bromophenol blue changes colour between pH 3.0 (yellow) and pH 4.6 (blue). Explain whether or not bromophenol blue would be a suitable indicator for this reaction. (2 marks)

|  |  |
| --- | --- |
| **Answer** | **Cumulative marks** |
| Not appropriate | 1 |
| End point occurs before equivalence point | 1 |
|  | **Total: 2 marks** |

* 1. The reaction between benzoic acid and sodium hydroxide is often referred to as a ‘neutralisation reaction’, yet the pH of point X is not 7. Explain with the aid of a chemical equation why this is so.

(2 marks)

|  |  |
| --- | --- |
| **Answer** | **Cumulative marks** |
| The salt (benzoate) reacts with water to produce hydroxide ions | 1 |
| C6H5COO–(aq) + H2O(l) ⇌ C6H5COOH(aq) + OH-(aq) | 1 |
|  | **Total: 2 marks** |

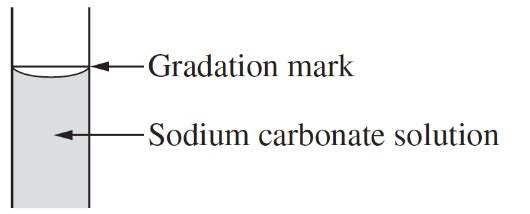
**Award 0.5 / 2 marks for “The salt is basic”**

1. **(7 marks)**

A student attempted to determine the concentration of a hydrochloric acid solution. The following steps were performed.

Step 1: A conical flask and 25.00 mL pipette were rinsed with distilled water.

Step 2: The student filled the 25.00 mL pipette with a standard solution of sodium carbonate to the level shown in the diagram.



Step 3: The standard sodium carbonate solution in the pipette was transferred to the conical flask. The student ensured that all of the sodium carbonate solution was transferred to the conical flask by blowing through the pipette. They then rinsed the inside of the conical flask using distilled water.

Step 4: Two drops of an appropriate indicator were added to the conical flask.

Step 5: A burette was rinsed with hydrochloric acid solution and then filled with hydrochloric acid. The student then carried out the titration to determine the concentration of HCℓ.

* 1. The student made at least three procedural errors in their titration. Complete the table by describing three mistakes the student made, and then show how each error would affect the volume of HCℓ required for neutralisation. (6 marks)

|  |  |
| --- | --- |
| **Mistake in procedure** | **Effect on volume of HCℓ needed** |
| Rinsed pipette with distilled water | ☑ **Decrease** volume of HCℓ |
| Did not fill volumetric flask to the bottom of the meniscus | ☑ **Decrease** volume of HCℓ |
| Blew remaining solution out of pipette | ☑ **Increase** volume of HCℓ |

|  |  |
| --- | --- |
| **Answer** | **Cumulative marks** |
| Three mistakes | 3 x 1 |
| Correct effect on V(HCℓ) for each mistake | 3 x 1 |
|  | **Total: 6 marks** |

* 1. Name an indicator that might have been used in Step 4 (1 mark)

|  |  |
| --- | --- |
| **Answer** | **Cumulative marks** |
| Any indicator with acidic pH (e.g. methyl orange, bromophenol blue) | 1 |
|  | **Total: 1 mark** |

1. **(10 marks)**

A solution of nitric acid was needed for the analysis of a series of copper samples, but before the nitric acid could be used for this purpose its exact concentration had to be determined. Anhydrous sodium carbonate was selected as a primary standard and 250 mL of 0.100 mol L-1 solution was prepared. 25.0 mL aliquots of this solution were titrated using the nitric acid. The titration was carried out several times, and the results were recorded in the table.

|  |  |
| --- | --- |
| **Titration number** | **Volume of nitric acid (mL)** |
| 1 | 27.7 |
| 2 | 24.8 |
| 3 | 24.8 |
| 4 | 24.7 |

* 1. List **four** characteristics of sodium carbonate that make it suitable to use as a primary standard.

(2 marks)

|  |  |
| --- | --- |
| **Answer** | **Cumulative marks** |
| Can be obtained with high degree of purity | 4 x 1 mark |
| Known formula |
| Undergoes known reactions |
| Doesn’t decompose |
| Doesn’t react with air |
| High molar mass |
| Readily dissolves in water |
|  | **Maximum: 4 marks** |

* 1. For the concentration of nitric acid to be accurately determined, it was necessary for the sodium carbonate to be anhydrous. Describe how this can be achieved. (2 marks)

|  |  |
| --- | --- |
| **Answer** | **Cumulative marks** |
| Heat in oven to drive off water molecules | 1 |
| Allow to cool in a desiccator | 1 |
|  | **Total: 2 marks** |

* 1. Write a balanced chemical equation for the reaction between sodium carbonate and nitric acid.

(1 marks)

|  |  |
| --- | --- |
| **Answer** | **Cumulative marks** |
| Na2CO3 + 2 HNO3 → 2 NaNO3 + CO2 + H2O | 1 |
|  | **Total: 1 mark** |

* 1. Calculate the concentration of the nitric acid solution. (3 marks)

**1 mark per step**

* 1. Comment on the **precision** of the results from this analysis. (2 marks)

|  |  |
| --- | --- |
| **Answer** | **Cumulative marks** |
| Titration #1 is an outlier / rough titration – should be discarded | 1 |
| Titrations 2-4 are highly precise – they are all very close in value  (± 0.1 mL) | 1 |
|  | **Total: 2 marks** |

1. **(6 marks)**

Pure substance ‘OT9’ is a soluble monoprotic acid. 1.031 g of OT9 was dissolved in a 250 mL volumetric flask and the volume made up to the mark.

20.00 mL aliquots of the OT9 solution were titrated with 0.1027 mol L-1 sodium hydroxide solution using phenolphthalein indicator. An average titre volume of 6.20 mL was required for the phenolphthalein to change colour.

* 1. Calculate the number of moles of ‘OT9’ acid in the 20.00 mL aliquots. (2 marks)

* 1. Calculate the number of moles of ‘OT9’ acid in the original 1.031 g sample of solid ‘OT9’. (2 marks)

*This is the most efficient way. Students may choose a more convoluted method, such as   
n(OT9 aliquot) → c(OT9 aliquot) → n(OT9 flask) → n(OT9 solid). Award part marks if appropriate.*

* 1. Calculate the molar mass of ‘OT9’. Give your answer to 3 significant figures and include the correct units. (2 marks)

**+ 1 mark for units and significant figures**

1. **(9 marks)**

The official analysis method for aspirin (acetylsalicylic acid) is to dissolve a sample in sodium hydroxide solution and titrate the excess hydroxide with standard hydrochloric acid, using phenol red indicator. The reaction of aspirin with hydroxide is given by:



Aspirin tablets contain acetylsalicylic acid and an unreactive binding material.

To analyse a supply of aspirin tablets claimed to contain 300 mg of acetylsalicylic acid in each tablet, 20 tablets weighing a total of 7.576 g were crushed and a sample of powder weighing 0.619 g was gently boiled for 10 minutes with 30.00 mL of **approximately** 0.5 mol L-1 NaOH. After cooling, the solution was titrated with 0.548 mol L-1 HCℓ using phenol red indicator. 17.62 mL of HCℓ was required.

In a separate ‘blank’ titration, 30.00 mL of the same approximately 0.5 mol L-1 NaOH was gently boiled for 10 minutes, cooled and titrated with the standard 0.548 mol L-1 HCℓ. The volume of HCℓ required was 27.65 mL.

* 1. How many moles of sodium hydroxide were consumed in the reaction with the 0.619 g of powdered sample? (5 marks)
  2. What mass of acetylsalicylic acid, C9H8O4, was in the 0.619 g sample of powder? (2 marks)
  3. How many tablets does 0.619 g of powder represent? (1 mark)
  4. What is the mass (in mg) of acetylsalicylic acid per tablet? (2 marks)
  5. The British Pharmacopoeia (an authoritative catalogue of drugs) requires that aspirin tablets contain 95-105% of the mass of acetylsalicylic acid claimed. Do the tablets fit this requirement? Justify your answer. (1 mark)

|  |  |
| --- | --- |
| **Answer** | **Cumulative marks** |
| Yes. The mass is ~101% of the stated amount. | 1 mark |
|  | **Total: 1 mark** |