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| https://upload.wikimedia.org/wikipedia/en/3/33/BSHS_Logo.jpg | Bunbury Senior High School | | | | | |
| **CHEMISTRY UNIT 3 & 4** | | | | | | |
| **Practical:** | | | | | | |
| **Calculations using second-hand data** | | | | | | |
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| **NAME:** | | |  | | | |
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| **Time allowed for this paper** | | | | | | |
| Reading time: | | 5 minutes | | | | |
| Working time: | | 50 minutes | | | | |
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| **Structure of this paper:** | | | | | | |
| Section | | | Number of questions | Marks available | | Marks achieved |
| Calculation questions | | | 5 | 50 | |  |
|  | | |  | | **Total** | \_\_\_\_\_\_ / 50 |

1. **(8 marks)**

As part of a practical test, a student needed to determine the concentration of sulfuric acid in a sample of acid from a car battery. They performed the experiment in the following way:

**Step 1:** The concentration of sodium hydroxide was determined by titration against 0.105 mol L-1 hydrochloric acid, using phenolphthalein as the indicator. 20.00 mL of hydrochloric acid required 22.34 mL of sodium hydroxide solution to reach the end point.

**Step 2:** 5.00 mL of battery acid was diluted to 500.0 mL in a volumetric flask

**Step 3:** The diluted battery acid was titrated with the sodium hydroxide solution which was standardised in Step 1. 19.15 mL of the standard sodium hydroxide solution was required to react completely with 20.00 mL of the diluted battery acid using phenolphthalein as the indicator.

* 1. Using the information in Step 1, calculate the concentration of sodium hydroxide solution. (3 marks)
  2. Using the information in Step 3, calculate the concentration of the diluted battery acid. (3 marks)
  3. Using the information in Step 2, calculate the concentration of the battery acid.  
     Give your answer to three significant figures. (2 marks)

1. **(16 marks)**

A herbicide which contains only carbon, hydrogen, nitrogen and chlorine was analysed to determine its empirical formula. A combustion analysis of 0.6678 g of the compound produced 1.09 g of carbon dioxide and 0.390 g of water.

A separate 0.3320 g sample of the compound was reacted with silver nitrate, producing 0.221 g of silver chloride precipitate.

* 1. Determine the empirical formula of the compound. (11 marks)
  2. 7.35 g of the compound was vapourised and was found to occupy 0.956 L at 150 °C and 125.4 kPa. Determine the molecular formula of the compound. (5 marks)

1. **(9 marks)**

When concentrated nitric acid is added to copper, nitrogen dioxide gas is produced. This reaction can be represented by the following equation:

Cu + 4 HNO3 → Cu(NO3)2 + 2 NO2 + 2 H2O

If 4.56 g of copper is added to 25.0 mL of 5.55 mol L-1 solution of nitric acid:

* 1. Identify the limiting reagent (show all working). (4 marks)
  2. Calculate the volume of NO2 formed at 28 °C and 0.983 atm (3 marks)
  3. Calculate the moles of excess (unused) reactant left over at the end of the reaction. (2 marks)

1. **(8 marks)**

The equations for the production of sulfuric acid in the Contact Process are given as follows:

Step 1 S + O2 → SO2

Step 2 2 SO2 + O2 → 2 SO3

Step 3 SO3 + H2SO4 → H2S2O7

Step 4 H2S2O7 + H2O → 2 H2SO4

Steps 1, 3 and 4 are 100% efficient. Step 2 is 95% efficient.

* 1. Calculate the volume of SO2 produced at 101.3 kPa and 600 °C from burning 1.00 tonne of sulfur.  
     (1 tonne = 1000 kg) (3 marks)
  2. Calculate the mass of sulfur trioxide (SO3) produced from burning 1.00 tonne of sulfur. (2 marks)
  3. Calculate the volume of sulfuric acid produced from burning 1.00 tonne of sulfur if the concentration of sulfuric acid produced in Step 4 is 8.50 mol L-1. (3 marks)

1. **(9 marks)**

A sample of ore was known to contain the elements nickel and sulfur. No other elements were present.

An industrial chemist was tasked with determining the empirical formula of the ore. The chemist roasted 500 kg of the ore in air, which released the sulfur in the formed of sulfur dioxide (SO2). The sulfur dioxide was trapped in a hydrogen peroxide “scrubbing” solution. The scrubbing process converted the sulfur dioxide into sulfate ions.

SO2(aq) + H2O2(aq) → 2 H+(aq) + SO42-(aq)

A 2.50 mL aliquot of the 10,000 L scrubbing solution was then taken. Barium nitrate was adding to the aliquot of the scrubbing solution, producing 0.480 g of barium sulfate (BaSO4) precipitate.

Given that the ore contains only nickel and sulfur, deduce the masses of sulfur and nickel in the 500 kg sample of ore and hence find its empirical formula.

* 1. Using the mass of barium sulfate produced from the 2.50 mL aliquot of the scrubbing solution, calculate the moles of SO42- in the original 10,000 L scrubbing solution. (3 marks)
  2. Calculate the moles of sulfur in the original 500 kg sample of ore. (1 marks)
  3. Calculate the moles of nickel in the original 500 kg sample of ore. (3 marks)
  4. Determine the empirical formula of the ore. (2 marks)

**SPARE WORKING**