PART 3 (42 marks = % of the paper)

Answer ALL questions in Part 3. The calculations are to be set out in detail in this Question/Answer Booklet. Marks will be allocated for correct answers and clear setting out, even if you cannot complete the problem. When questions are divided into sections, clearly distinguish each section using (a), (b) and so on. **Express your final numerical answers to three (3) significant figures or as appropriate to the question, and provide units where applicable.** Information which may be necessary for solving the problems is located on the separate Chemistry Data Sheet. Show clear reasoning: if you don't, you will lose marks.

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1. A sample of 5.318 g of a chlorofluorocarbon (a compound containing carbon, fluorine and chlorine only) was analysed as follows:

   All the carbon in the sample was converted into carbon dioxide gas, and all its chlorine was converted into hydrochloric acid. The carbon dioxide weighed 1.703 g, and the hydrochloric acid formed required 56.6 mL of 2.052 mol L-1 ammonia solution for complete neutralisation.

   A second sample of the same chlorofluorocarbon of mass 1.542 g occupied 0.2516 L at 104.3 kPa and 17.63°C .

   (a) Determine the empirical formula of the compound. [8 marks]

(b) Determine the molecular formula of the compound. [2 marks]

2. Nitric acid reacts with metals differently than other acids, but still reacts as ‘normal’ when mixed with a base.

A 2.972 g sample of an unknown metallic element (M) was dissolved in 125.0 mL of 2.107 mol L^{-1} $HNO_{3\,(aq)}$. The reaction produced a soluble salt with the formula $M(NO_3)_4$.

$$3\ M_{(s)} + 16\ HNO_{3(aq)} \rightarrow 3M(NO_3)_{4(aq)} + 4NO_{(g)} + 8H_2O_{(l)}$$

The remaining solution which was known to contain excess HNO_3 was diluted to 250.0 mL. A 20.00 mL sample of the diluted solution containing excess HNO_3 was titrated to equivalence using 32.95 mL of 0.3152 mol L^{-1} NaOH.

Using the above equation, calculate the molar mass of the metal, and hence identify the metal element.

[10 marks]

3. A 3.65 sample of pure NaOH was added to 431 mL of 0.335 mol L^{-1} H_2SO_4. The solution was then placed in a 500.00 mL volumetric flask and filled up to the line with distilled water.

(a) Determine the pH of the final mixture.

[6 marks]

You are given standard solutions of 0.1000 mol L^{-1} NaOH and 0.10000 mol L^{-1} HCl.

(b) Select the appropriate standard solution, and calculate the volume required to neutralise a 20mL sample of the original solution.

[6 marks]

4. The concentration of the atmospheric pollutant sulphur dioxide (SO_2) can be found by bubbling are through a dilute $KMnO_4$ solution of known concentration.

$$5\ SO_{2(g)} + 2\ MnO_4^-{}_{(aq)} + 2\ H_2O_{(l)} \rightarrow 5\ SO_4^{2-}{}_{(aq)} + 2\ Mn^{2+}{}_{(aq)} + 4\ H^+{}_{(aq)}$$

The concentration of the remaining $KMnO_4$ can be found by titration with standardised oxalic acid. This allows the amount of $KMnO_4$ reacting with sulphur dioxide to be found and thus its concentration in the air sample can be calculated. In such a procedure 51.802 kg of SO_2 polluted air was bubbled through 215.0 mL of 5.007×10^{-3} mol L^{-1} $KMnO_4$. The unreacted $KMnO_4$ was acidified and diluted to a volume of 250.0 mL. 20.00 mL samples of this diluted $KMnO_4$ solution were titrated to equivalence with 38.50 mL of 2.194×10^{-3} mol L^{-1} oxalic acid solution. What is the concentration of the $SO_{2(g)}$ in ppm.

[12 marks]

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