PART 3 (50 marks = 25% 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 where appropriate, 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 naturally occurring organic compound is known to contain the elements hydrogen, carbon, nitrogen and oxygen. To determine its empirical formula, 4.50 g of the organic compound was completely burnt in oxygen to produce 2.70 g of liquid water and 3.36 L of a gaseous mixture containing only nitrogen and carbon dioxide only. The gas mixture was then reacted with a concentrated solution of sodium hydroxide which absorbs all the carbon dioxide. 2.69 L of the gas was absorbed leaving 0.67 L of nitrogen gas unreacted. All gas volumes are given at STP.

   Find the empirical formula. [8 marks]

2. A sample of impure calcium carbonate weighing 0.2450 g is dissolved in 100 mL of standardised 0.0905 mol L^{-1} hydrochloric acid solution. After the reaction is complete, it is found that the excess acid required 17.0 mL of 0.250 mol L^{-1} sodium hydroxide solution for complete neutralization using phenolphthalein indicator. Find the percentage of calcium carbonate in the sample.

[10 marks]

3. Three reactions involved in the manufacture of sulphuric acid are shown here:

$$S_{(s)} + O_{2(g)} \rightarrow SO_{2(g)}$$

$$SO_{2(g)} + O_{2(g)} \rightarrow SO_{3(g)}$$

$$SO_{3(g)} + H_2O_{(l)} \rightarrow H_2SO_{4(l)}$$

a) Using this equation determine the mass of sulphuric acid that can be produced from 1.250 tonnes of sulphur. [6 marks]

b) What volume of oxygen gas would be required to ensure all of the sulphur is consumed, if the conditions were; pressure 300 kPa and temperature 600˚C? [4 marks]

4. $Ni(CO)_4$ can be made by reacting finely divided nickel with gaseous CO. If you have CO in a 1.50 L flask at a pressure of 418 mmHg at 25.0 ˚C, along with 0.450 g of Ni powder, what is the maximum number of grams of $Ni(CO)_4$ that can be made?

[8 marks]

5. A shipment of urea, $CO(NH_2)_2$ has become contaminated with an unreactive water soluble impurity which is known to contain no nitrogen. An analytical chemist has been asked to determine the percentage purity of the urea. The chemist takes a representative sample of the impure urea weighing 6.350 g and converts all the nitrogen it contains into ammonia which is then dissolved in water and made up to a volume of 250.0 mL.

The chemist would like to titrate a 20.0 mL aliquot of this ammonia solution against some hydrochloric acid she has, however she is does not know the acids concentration, and has to standardise it against a known solution of sodium hydroxide first. The sodium hydroxide had a concentration of 0.600 mol L^{-1}.

The two sets of titration results are as follows

Set 1 (hydrochloric against sodium hydroxide)

Titration	1	2	3	4
Final volume (mL)	11.78	23.75	13.99	18.01
Initial volume (mL)	0.25	12.35	2.52	6.57
Total volume (mL)				

Set 2 (hydrochloric against urea)

Titration	1	2	3	4
Final volume (mL)	21.3	25.84	28.30	18.74
Initial volume (mL)	5.25	10.31	12.86	3.23
Total volume (mL)				

Calculate the percentage purity of the urea shipment. [14 marks]