PART 3 Calculations

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 equations and clear setting out, even if you cannot complete the problem. When the questions are divided into sections, clearly distinguish each section using (a) , (b) ,etc. etc. Express your final numerical answers to three (3) significant figures where appropriate, and provide units where applicable. Information that may be necessary to solve problems is located on the separate Chemistry Data Sheet. Show clear reasoning. If you don't, marks will be lost. This part carries 50 marks (25% of the total).

1. A 95.00kg sample of 2,500 ppm aluminium nitrate solution is added to 90.0mL of 0.1537 $molL^{-1}$ sodium carbonate solution..

   (a) Write a balanced equation for this reaction (1)
   (b) Determine by calculation, which reactant is limiting (3)
   (c) Calculate the mass of precipitate formed (3)
   (d) Calculate the final concentrations of aluminium ions and carbonate ions in $molL^{-1}$ units (3)

2. A 20.00 kg sample of 85.5% solid KOH is accidentally added to a 1250.0L tank.

   (a) Calculate the pH of the solution in the tank. (4)

   Since the tank cannot be drained, a farmer adds battery acid (35.0% sulfuric acid). He adds a mass of 48.00 kg of it. The volume of the acid added was 25.00L

   (b) Calculate the final pH of the contents of the tank (5)
   (c) Calculate the final concentration of sulfate ions in solution. (1)

3. Naturally occurring galactite is pure chromium III carbonate. A 30.00mL sample of dilute hydrochloric acid was added to 0.8973 g of galactite; after the reaction was completed the unreacted solid was filtered, washed, dried and reweighed. The mass of the unreacted galactite was 0.3921 g

   (a) Write a balanced equation to describe this reaction. (2)
   (b) Calculate the concentration of the hydrochloric acid (5)
   (c) Calculate the volume of CO_2 released, measured at 28^{o}C and 107.0kPa pressure. (3)

4. A 125.5g sample ore containing iron III carbonate is crushed and dissolved in 7.500L of 1.249 $molL^{-1}$ nitric acid such that all the iron(III)carbonate is dissolved and excess hydrogen ions remain. 20.00 mL lots of this remaining acid solution requires 15.74 mL of 0.08972molL-1 sodium hydroxide solution to reach end point.

   (a) Calculate the number of moles of excess H^+ ions remaining after all the iron III carbonate had been dissolved in the original nitric acid. (4)
   (b) Write a balanced equation for the reaction between nitric acid and iron III carbonate. (2)
   (c) Calculate the % iron in the ore. (4)

5. A mixture of sodium iodide and sodium phosphate is dissolved in water and made up to a solution volume of 500.0mL . 20.00mL lots of this solution are treated with excess zinc chloride solution; the precipitate that forms is filtered, washed, dried and weighed-its weight is 0.198g.

   (a) Write an equation for the reaction that produced the precipitate (1)
   (b) Calculate the mass sodium phosphate in the mixture (3)

   Another 20.00mL sample of the solution was treated with excess lead nitrate . The solids precipitated were filtered, washed and dried. The weight of these precipitates were 0.9645g

   (c) Write equations for the two reactions producing the two precipitates. (2)
   (d) Calculate the mass of the second compound in the original mixture (4)

Part 4 Extended Answers

Answer **ONE** of the following extended answer questions. Where applicable use equations, diagrams and illustrative examples of the chemistry you are describing .

Marks are awarded for the relevant chemical content of your answer, but you will lose marks if what is written is unclear or lacking coherence. Your answer should be presented in 2-3 pages.

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1 In the cylinder of a motor car engine at high temperature, nitrogen and oxygen combine to form NO_2. This NO_2 is a source of environmental pollution.

$$N_{2\,(g)} + 2O_{2(g)} \leftrightarrows 2NO_{2(g)} \qquad H = +126\ kJmol^{-1}$$

The source of this mixture of nitrogen and oxygen is the air that is added to the vaporised octane to be ignited by the spark plugs to power the vehicle.

The energy to drive the car is obtained from explosive combustion of a vaporised petrol (octane) / air mixture in the cylinders of the engine.

$$2\,C_8H_{18(g)} + 25O_{2(g)} \leftrightarrows 16CO_{2(g)} + 18H_2O_{(g)} \qquad H = -1540kJmol^{-1}$$

As a chemical engineer, use chemical principles to design the engine features that would minimise the **yield** of NO_2 emissions - consider the factors such as the size (volume) of the cylinders, temperature at which the engine operates (it may vary from 110^{o}C to 195^{o}C) and the amount of air added to the octane for the second reaction. Also discuss how these conditions would affect the **rate of reaction.**

Whatever your recommendations, describe the impact of this design on the efficiency of the combustion reaction in terms of the same equilibrium and rate principles.

2 Consider the following substances when 1 mole of each is dissolved in aqueous solution in a beaker.

KNO_3 K_2CO_3 H_3PO_4 NH_4CH_3COO $Ba(OH)_2$ H_2SO_4 NH_3

For each substance,

(i) draw a clear diagram to illustrate all the particles present and the relative quantities of each

(ii) describe the source of H^+ and OH^{1-} ions for each substance and hence predict and explain the estimated pH of each solution