

PART 3

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 farmer accidentally empties a 5.000kg bag of 75.0% pure zinc nitrate hexahydrate, $\text{Zn}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$, into a water tank containing 6000.0 L of rainwater. In order to remove this he decides to precipitate the zinc ions by using washing soda, sodium carbonate decahydrate, $\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$

- (a) Write an equation to describe the removal of the zinc ions by precipitation with the sodium carbonate solution. (1)
- (b) Calculate the mass of sodium carbonate decahydrate that should be added to exactly remove all the zinc ions. (4)

However, the farmer believes that because 5.000kg of the zinc nitrate hexahydrate was added then an equal mass of $\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$ should be added to the tank and so 5.000kg of pure $\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$ is added.

- (c) Calculate whether the zinc nitrate or sodium carbonate is in excess. (2)
- (d) Calculate the mass of zinc carbonate that is precipitated when the 5.000 kg of the sodium carbonate decahydrate was added. (2)
- (e) Calculate the final concentration of Na^+ ions in the tank. (2)

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The results page of an experiment to determine the percentage purity of a sample of impure potassium carbonate, by titration against $0.1036 \text{ mol L}^{-1}$ nitric acid is reproduced below :

Object	Mass (g)
Beaker + impure potassium carbonate	87.852
Beaker	85.641

The impure potassium carbonate was dissolved in distilled water and made up to a volume of 500.0 mL in a volumetric flask

Volume of potassium carbonate solution pipetted = 20.00 mL

Burette readings The nitric acid solution was placed in a burette

Concentration of nitric acid solution in burette = $0.1036 \text{ mol L}^{-1}$

Titration	1	2	3	4	5
Initial volume (mL)	10.02	13.62	23.12	15.67	21.10
Final volume (mL)	39.65	36.04	45.66	38.15	42.10

- (a) Determine the appropriate titration volume of nitric acid solution (2)
- (b) Calculate the number of moles of potassium carbonate in the 20.00 mL sample (4)
- (c) Calculate the % purity of the potassium carbonate sample (4)

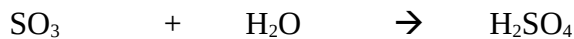
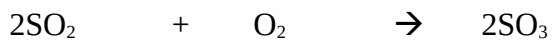
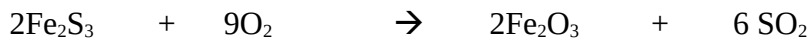
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(a) How many moles of Fe_2S_3 is needed to produce 1 mole of H_2SO_4 ? (2)

(b) What mass of Fe_2S_3 is needed to produce 200.0 kg of 95.5% pure H_2SO_4 if the process for making sulfuric acid is only 82.2 % efficient ? (7)

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 4.250 molL^{-1}

of 0.1242 molL⁻¹ NaOH solution to reach the end point.

- formed from the iron ore (2)

[illegible]

3 A swimming pool contains 40,000 litres of water. Unfortunately a bag of caustic soda (NaOH) is added to this pool and as a result the pH of the pool rises to 10.9.

(a) Calculate the concentration of OH^- ions in the pool after the caustic soda was added. (2)

(b) Calculate the mass of sodium hydroxide that was added to the pool (3)

(c) The pool owner purchases a 100 L container of 9.50 mol L^{-1} hydrochloric acid and adds the entire contents to the pool. Calculate :

(i) the final concentration of H^+ ions (4)

(ii) the final pH (1)

[illegible]

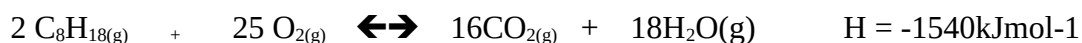
[illegible]

- 2 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.



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.



As a chemical engineer use chemical principles to design the engine features that would minimise the **yield** of NO₂ emissions- consider the factors such as the size (volume) of the cylinders, temperature at which the engine operates (it may vary from 110°C to 195°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

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