

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).

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

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- (a) Write a balanced equation to describe this reaction. (2)
 (b) Calculate the concentration of the hydrochloric acid (5)
 (c) Calculate the volume of CO₂ released, measured at 28°C and 107.0kPa pressure. (3)

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

(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)

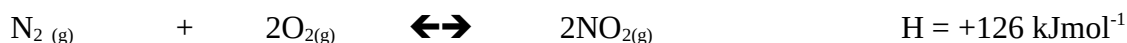
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Part 4 (20 marks = 20% of paper)

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.

- 1 In the cylinder of a motor car engine at high temperature, nitrogen and oxygen combine to form NO₂. This NO₂ 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.

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



For each substance,

- draw a clear diagram to illustrate all the particles present and the relative quantities of each
- describe the source of H⁺ and OH¹⁻ ions for each substance and hence predict and explain the estimated pH of each solution

End of part 2