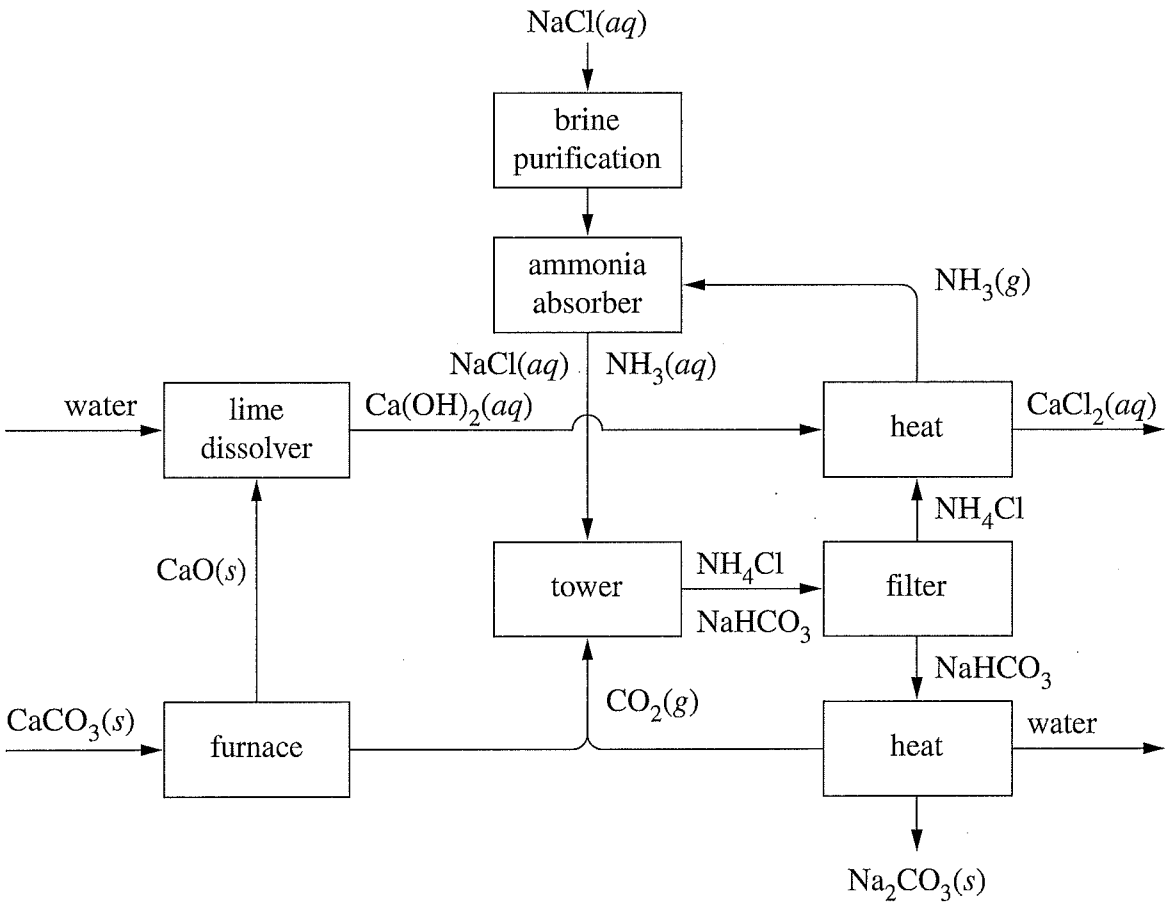
Marks

Question 28 — Industrial Chemistry (25 marks)

(a) The diagram is a flowchart of the reactions involved in an important industrial process.



(i) Identify this industrial process and write a balanced equation to represent the overall chemical reaction that occurs. **2**

(ii) The products of the reaction formed in the tower are sodium hydrogen carbonate and ammonium chloride. **2**

Describe how these two substances are separated.

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(b) Over the past century the production of sodium hydroxide has evolved from the mercury process, to the diaphragm process, to the membrane process. **6**

Analyse the factors that contributed to each of the changes in the production process.

(c) Hydrogen sulfide can be removed from natural gas via the following process.

$$2H_2S(g) + SO_2(g) \rightleftharpoons 3S(s) + 2H_2O(g) \qquad \Delta H = -145 \text{ kJ mol}^{-1}$$

(i) Write the equilibrium constant expression for this reaction. **1**

(ii) Calculate the equilibrium constant, when 1.00 mol of H_2S and 1.00 mol of SO_2 react in a 1.00 L vessel at 373 K to give 0.50 mol of water vapour under equilibrium conditions. **2**

(iii) Identify FOUR factors that would maximise the removal of $H_2S(g)$ in this reaction. **2**

(d) Describe the impact that saponification products have had on society and the environment. **4**

(e) You performed a first-hand investigation to model an equilibrium reaction.

(i) Outline the procedure used and the results you obtained. **2**

(ii) Identify a risk associated with this procedure. **1**

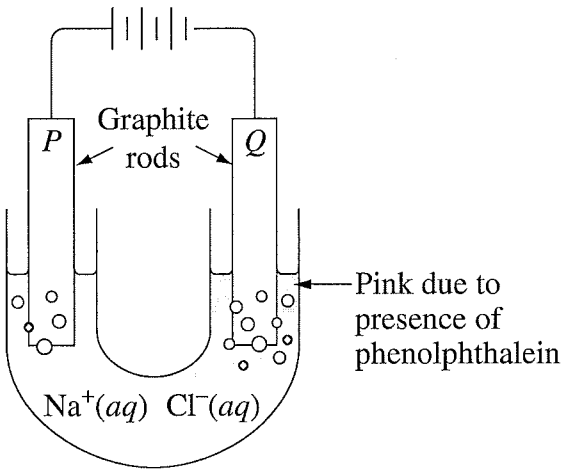
(iii) Describe how this procedure models equilibrium and state a limitation of the model. **3**

End of Question 28

Question 34 — Industrial Chemistry (25 marks)

Answer parts (a)–(c) in Section II Answer Booklet 1.

(a) The following equipment was set up and the reaction allowed to proceed. Gases were produced at both electrodes. **3**



Name this process and identify the gas at each electrode.

(b) The equilibrium constant expression for a gaseous reaction is as follows:

$$K = \frac{[N_2][O_2]}{[NO]^2}$$

(i) Write the equation for this reaction. **1**

(ii) 0.400 moles of NO was placed in a 1.00 L vessel at 2000°C. The equilibrium concentration of N_2 was found to be 0.198 mol L^{-1}. **3**

Calculate the equilibrium constant for this reaction and use this value to describe the position of the equilibrium.

(iii) What could be changed that would result in a different value of K for this equilibrium? **1**

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Question 34 (continued)

(c) The production of sulfuric acid is shown.

$$S(s) \longrightarrow SO_2(g) \longrightarrow SO_3(g) \longrightarrow \boxed{\text{oleum}} \longrightarrow H_2SO_4(l)$$

(i) Describe the production of oleum and its conversion to concentrated sulfuric acid. Include chemical equations in your answer. **3**

(ii) SO_3 can react with water to produce a solution of H_2SO_4. **2**

Why is it essential to convert SO_3 to oleum before the formation of H_2SO_4?

Answer parts (d)–(e) in Section II Answer Booklet 2.

(d) (i) Outline how one of the steps involved in the Solvay process can be chemically modelled in the school laboratory. Include a balanced chemical equation in your answer. **3**

(ii) Identify ONE risk factor and ONE difficulty associated with the laboratory modelling of the step. **2**

(e) Initially soap was the only product of the surfactant industry. Due to societal pressures and chemical developments, production in this industry has evolved to include a wide range of products. **7**

Account for these changes over time with reference to the structure and uses of surfactants.

End of Question 34