Section Three: Extended answer   **40% (80 marks)**

This section contains **five (5)** questions. You must answer **all** questions. Write your answers in the spaces provided.

Where questions require an explanation and/or description, marks are awarded for the relevant chemical content and also for coherence and clarity of expression. Lists or dot points are unlikely to gain full marks.

Final answers to calculations should be expressed to an appropriate number of significant figures.
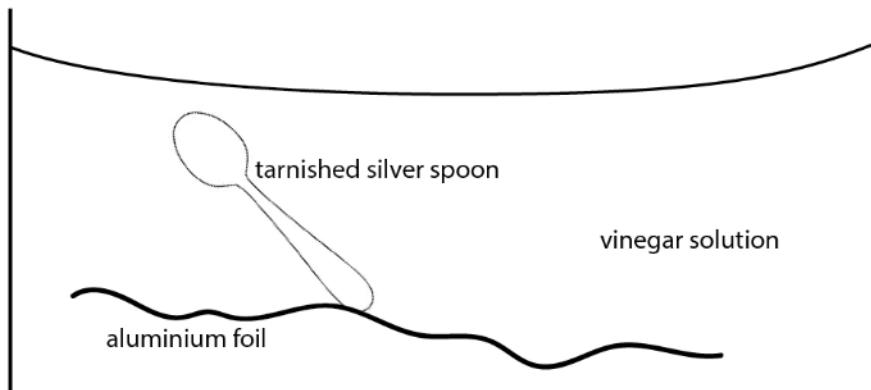
Supplementary pages for planning/continuing your answers to questions are provided at the end of this Question/Answer booklet. If you use these pages to continue an answer, indicate at the original answer were the answer is continued, i.e. give the page number.

Suggested working time: 70 minutes.
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Question 35   **(22 marks)**

Silver has been valued as a precious metal and used for ornamentation for over 7000 years. An issue with its use is that over time its lustre fades. This is because the silver reacts with sulfur containing compounds in the air, forming a layer of tarnish (Ag_2S).

One home remedy for cleaning silver is to place the tarnished items in a sink with a piece of aluminium foil, and to cover both with a solution of water and some vinegar (CH_3COOH). This converts the Ag_2S (s) back to Ag (s). The aluminium reacts to form Al_2O_3. Hydrogen sulfide gas (H_2S) is also formed on the surface of the silver.

(a) Write balanced oxidation and reduction half equations and a full redox equation for the reaction between aluminium and silver sulfide.   (6 marks)

Oxidation	
Reduction	
Overall equation	

(b) Using the diagram on page 26 as a reference:

    (i)   state which part of the cleaning system acts as the anode.   (1 mark)

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    (ii)   state the direction of flow of CH_3COO^- (aq) by circling an option below:

         toward the aluminium   toward the silver   (1 mark)

(c) Is it necessary for the aluminium foil and silver item to be in contact for the tarnish to be removed? Explain your answer.   (2 marks)

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(d) Name another metal that could be used in place of the aluminium to remove the silver tarnish.   (1 mark)

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(e)   Due to the high cost, jewellery and decorative items are often made of silver plated nickel rather than pure silver. In the space below, draw a labelled diagram of a cell that could be used to plate a nickel spoon with silver. Your diagram should clearly label the spoon, the pure silver, the anode, cathode, the name of a suitable electrolyte, the direction of the flow of electrons and ions.   (5 marks)

(f)   When a piece of nickel is placed in a solution of 1 molL^{-1} HCℓ, it dissolves, the solution becomes slightly green and bubbles of a colourless, odourless gas are produced.
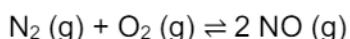
   (i)   Account for these observations.   (2 marks)

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(ii)   Fully describe the observations you would make if the piece of nickel was half coated with silver before being fully submerged in the acid solution. Clearly highlight any differences with the observation described in part (i).   (4 marks)

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Question 36   **(10 marks)**

At high temperatures, N_2 (g) and O_2 (g) can react to produce nitrogen monoxide, NO (g), as represented by the following equation.

$$N_2 \text{ (g)} + O_2 \text{ (g)} \rightleftharpoons 2\,NO \text{ (g)}$$

A student injects N_2 (g) and O_2 (g) into a previously evacuated rigid container. The temperature is raised to 2000°C and the mixture is allowed to reach equilibrium. The K value at this temperature is 0.0016.

(a)   Explain what this K value indicates about the reaction.   **(1 mark)**

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(b)   Argon gas was then injected into the container to double the internal pressure. Circle the option below to indicate the effect that this would have on the concentration of N_2.
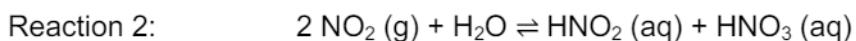
                                                              (1 mark)

                      Decrease   no change   increase

(c)   Nitrogen monoxide (NO) can undergo further reactions to produce acids such as HNO_2, a weak acid. First, the nitrogen monoxide reacts with oxygen in the air to form NO_2, a brown gas. The NO_2 then disproportionates to form HNO_2 and HNO_3.

         Reaction 1:   NO (g) + O_2 (g) $\rightleftharpoons NO_2$ (g)

         Reaction 2:   2 NO_2 (g) + $H_2O \rightleftharpoons HNO_2$ (aq) + HNO_3 (aq)
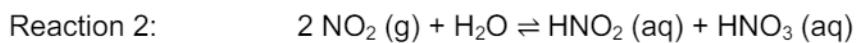
         Justify why Reaction 2 is classified as a disproportionation reaction.   **(2 marks)**

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(d)   15.1 L of NO_2 gas is completely dissolved in water at STP, forming 1.50 L of solution. The resultant pH is 0.646. Assuming that Reaction 2 goes to completion, determine the % of the weak acid HNO_2 that ionises.

The equation from part (c) is copied below for your convenience.   (6 marks)

Reaction 2: $2\ NO_2\ (g) + H_2O \rightleftharpoons HNO_2\ (aq) + HNO_3\ (aq)$

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Question 37   **(15 marks)**

The pH of swimming pools needs to be tightly controlled in order to prevent the growth of bacteria. One chemical that is often used as part of a buffer system in salt water pools is boric acid. The formulae of boric acid and its conjugate base, borate, are shown below.

Boric acid	H_3BO_3
Borate	$H_2BO_3^-$

(a)   A student wanting to investigate the levels of boric acid used in swimming pool buffers, made 300 mL of a buffer solution containing an equimolar mixture of boric acid and its conjugate base.

Describe how this buffer could be made, using only solutions selected from the list below.

- 1.00 molL^{-1} H_3BO_3
- 1.00 molL^{-1} NaOH
- 1.00 molL^{-1} HCℓ   (2 marks)

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(b)   Explain how this buffer works to minimise the change in pH when a small amount of concentrated HCℓ is added. Include any relevant equations in your answer.

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(c) A second student made a similar buffer by dissolving 0.500 moles of H_3BO_3 (s) into 500 mL of 1.00 molL^{-1} NaH_2BO_3.

Explain which is more resistant to changes in pH when a strong base is added, the buffer prepared in part a) or this second buffer. Justify your answer. (2 marks)

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(d) In order to try and determine the boric acid concentration present in a sample of water from a swimming pool, the students conducted a titration of the swimming pool water against a standard solution of NaOH.

Below is a list of indicators that the students considered when designing their analysis.

indicator	pH range	Colour change
Bromothymol blue	6.2 – 7.6	Yellow → blue
Methyl orange	3.1 – 4.4	Red → yellow
Phenolphthalein	8.3 – 10.0	Colourless → pink

(i) Select the most appropriate indicator and explain your choice with the use of relevant equations. (4 marks)

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(ii)   The students used the concordant results from their titration to calculate the concentration of boric acid in the swimming pool. The result they obtained gave them a concentration that was significantly higher than the range they were expecting. They repeated the experiment three times with different water samples and obtained very similar results each time.

Based on these results, state whether the following statements are true or false.

(2 marks)

Statement	True / False
The results are unreliable	
The results are imprecise	

(iii)   Assuming that the students did not make any procedural errors in their titration, suggest a possible reason why their calculated boric acid concentration was higher than expected.

(1 mark)

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Question 38   **(17 marks)**

Methanamine is a weak base with the formula CH_3NH_2.

To determine the concentration of an unknown methanamine solution, a 20.00 mL aliquot of the methanamine solution was added to a volumetric flask and distilled water added to make 250.0 mL. 25.00 mL of the diluted methanamine was then transferred to a conical flask using a pipette. An appropriate indicator was added and it was titrated against a standard 0.1031 $molL^{-1}$ HCℓ solution.

The results of the titration are given below:

	1	2	3	4
Initial volume (mL)	10.13	28.58	3.71	22.34
Final volume (mL)	28.58	47.19	22.34	40.92
Titre volume (mL)				

(a)   Complete the table above and hence calculate the average titre volume.   (1 mark)

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(b)   Which solutions should you use to rinse the following pieces of glassware just prior to use:

(4 marks)

(i)   the conical flask: _____

(ii)   the 25 mL pipette: _____

(iii)   the burette: _____

(iv)   the 20 mL pipette: _____

(c)   Write an ionic equation to represent the reaction taking place during the titration.

(2 marks)

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(d)   Determine the concentration of the original methanamine solution.   (5 marks)

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(e)   A student followed an incorrectly written procedure and made the following errors during the titration. Complete the table below, describing the effect of each error. Use the terms more, less or unchanged.   (3 marks)

Error	Volume of HCℓ (aq) used to reach end point.	Calculated $[CH_3NH_2]$
Rinse conical flask with the original CH_3NH_2 solution prior to the titration.		
Use phenolphthalein indicator (end point pH 8.3-10).		

(f)   Are the above two errors examples of random or systematic errors? Explain your choice.
                                                                                (2 marks)

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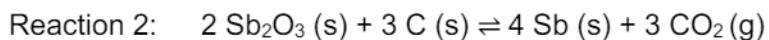
Question 39 (16 marks)

Australia is a significant producer of antimony (Sb). Antimony has a wide range of uses, including in the manufacture of plastics, pigments and match heads.

High-grade antimony ores are converted to the metal through the use of a blast furnace.
- Antimony sulfide ore is first heated to convert it to an oxide.
- Antimony oxide is then heated with carbon to convert it to the metal.

The following equations represent these two reactions:

Reaction 1: $2\ Sb_2S_3\ (s) + 9\ O_2\ (g) \rightleftharpoons 2\ Sb_2O_3\ (s) + 6\ SO_2\ (g)$

Reaction 2: $2\ Sb_2O_3\ (s) + 3\ C\ (s) \rightleftharpoons 4\ Sb\ (s) + 3\ CO_2\ (g)$

6.00 tonnes of the ore, containing 92% antimony sulfide, was added to the blast furnace, together with 700 kg of carbon.

(a) Determine the limiting reagent, and hence determine the total mass of pure antimony formed. (7 marks)

(b)   Hence, determine the volume of CO_2 produced, collected at 400°C and 150 kPa.

(2 marks)

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(c)   One application of antimony is in the form of antimony pentachloride ($SbCl_5$), used as a catalyst in the production of plastics. Care needs to be taken with the storage of $SbCl_5$, as in gaseous form it decomposes in a reversible reaction to form $SbCl_3$ (g) and Cl_2 (g). The decomposition of $SbCl_5$ is an endothermic process.
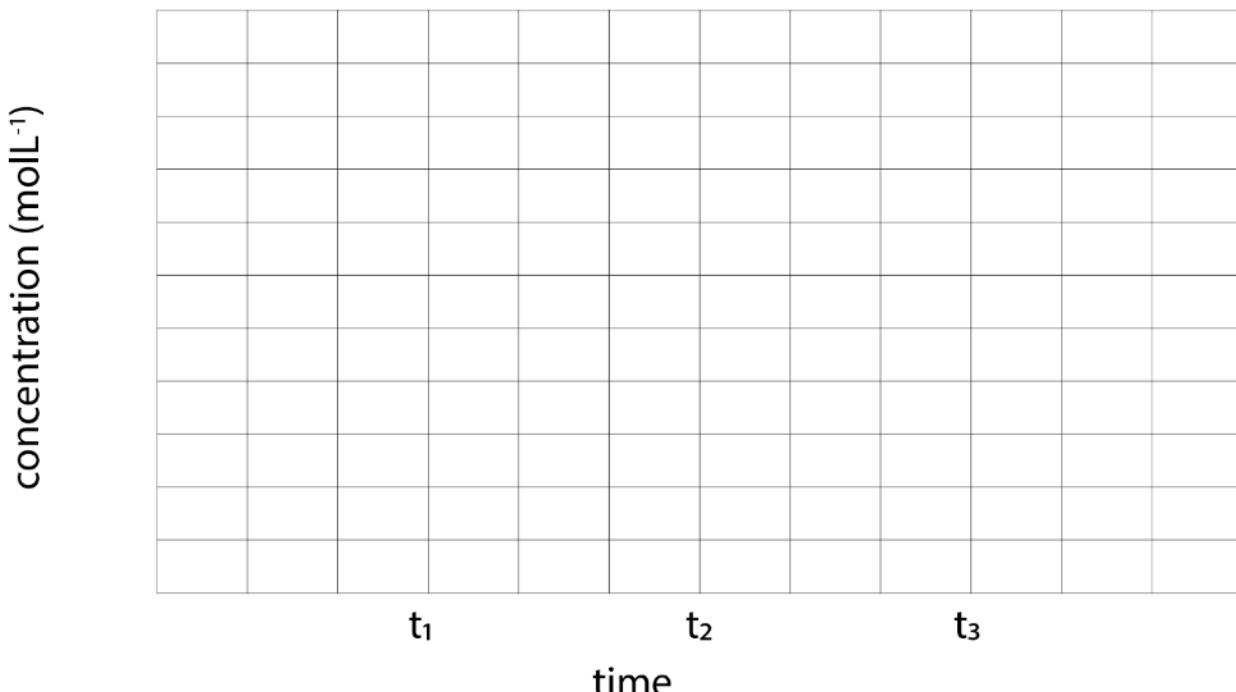
(i)   Write a balanced equation for the decomposition reaction.   (1 mark)

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(ii)   5.00 moles of $SbCl_5$ (g) is added to a 2.00 L container and allowed to reach equilibrium at point t_1. At point t_1, the concentration of both $SbCl_3$ and Cl_2 is 1.00 $molL^{-1}$. At point t_2, the volume of the container is halved. Equilibrium is reestablished at point t_3. At this point, the concentration of $SbCl_5$ is 3.5 $molL^{-1}$.

Using the above information, use the grid below to draw a clearly labelled graph showing the changes in the concentration of $SbCl_5$ and $SbCl_3$ over time.

(5 marks)

concentration ($molL^{-1}$)

t_1 t_2 t_3

time

(iii)   How would the changes outlined above in part (ii) have been affected if a catalyst were present in the system.   (1 mark)

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End of questions