Section Two: Short Answer **35% (70 marks)**

This section has **nine (9)** questions. Answer **all** questions. Write your answers in the spaces provided.

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 where the answer is continued, i.e. give the page number.

Suggested working time: 60 minutes.

Question 26 **(9 marks)**

An equilibrium system was set up in three test tubes by suspending some finely powdered copper sulfide in a dilute solution of hydrochloric acid. The equation for the equilibrium is:

$$\mathbf{CuS\ (s) + H^+\ (aq) \rightleftharpoons Cu^{2+}\ (aq) + HS^-\ (aq)}$$

A change was made to each test tube, as indicated in the table below.

Complete the table, describing the changes to the system that would take place once equilibrium is re-established. Use the terms ‘increases’, ‘decreases’ or ‘no change’.

Change made to equilibrium system	**rate of forward reaction**	**concentration of HS^-(aq)**	**moles of Cu^{2+}(aq)**
HCℓ (g) is bubbled into the solution			
Distilled water is added to double the volume			
Additional solid CuS is added			

Question 27 **(6 marks)**

Complete the table below by writing the formula of a substance that fits each description.

Description	Formula
A primary standard used in acid-base titrations	
A weak monoprotic acid	
Contains oxygen with an oxidation number of -1	
The halogen that is the strongest oxidant	
An acidic salt	
A solution capable of oxidising copper but not silver	

See next page

Question 28 **(7 marks)**

Both water and liquid ammonia undergo self-ionisation.

$NH_3(\ell) + NH_3(\ell) + \text{energy} \rightleftharpoons NH_4^+(am) + NH_2^-(am)$ $K = 1.0 \times 10^{-30}$ at 25°C

$H_2O(\ell) + H_2O(\ell) + \text{energy} \rightleftharpoons H_3O^+(aq) + OH^-(aq)$ $K = 1.0 \times 10^{-14}$ at 25°C

Note: (am) represents a substance that is dissolved in liquid ammonia

(a) At 25°C which liquid has the higher electrical conductivity?
Circle your choice. (1 mark)

Water Ammonia

(b) Explain your choice. (2 marks)

(c) Write the formulae for the conjugate acid and base of ammonia. (1 mark)

Conjugate acid	Conjugate base

(d) At 90°C the pH of pure water is 6.2 but it is still described as neutral. Explain this statement fully. (3 marks)

Question 29 **(5 marks)**

The equilibrium constant expression for an exothermic reaction involving A, B, C, D and E is:

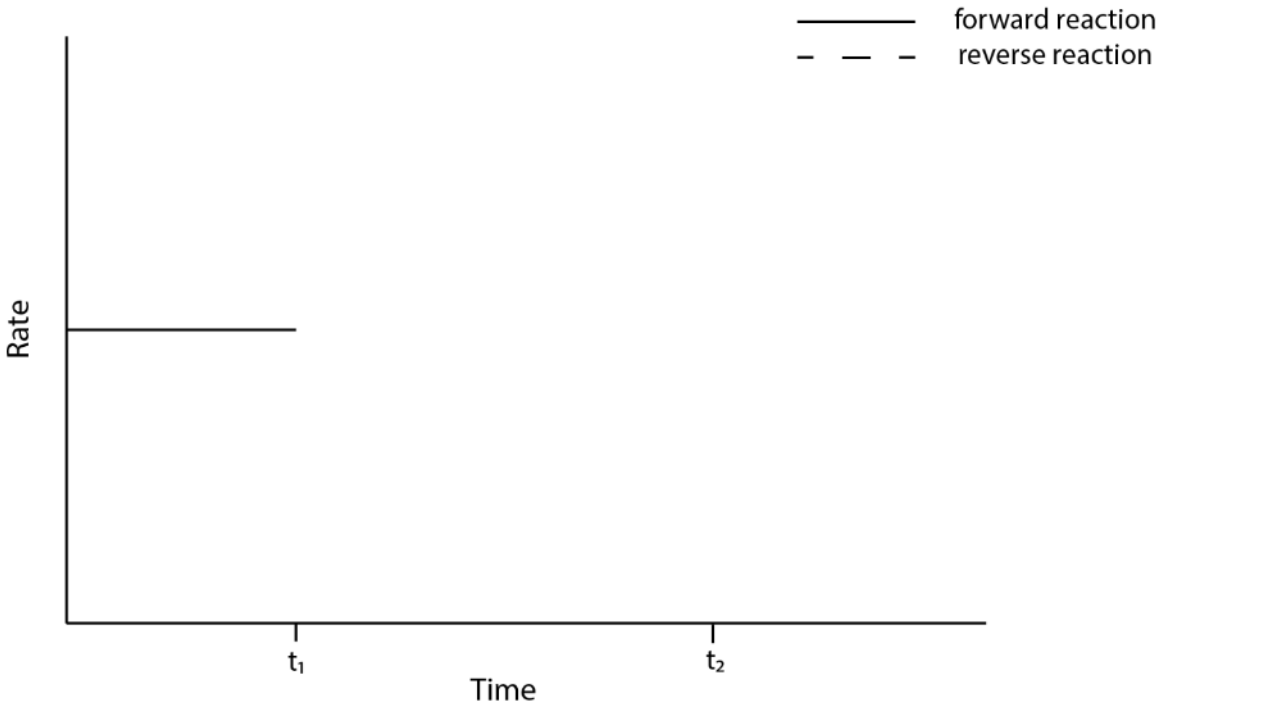
$$K = \frac{[C]^3[D]}{[A]\,[B]^2}$$

(a) Write a possible chemical equation for this reaction, including state symbols. (2 marks)

(b) A mixture of A, B, C, D and E was placed in a sealed container and equilibrium was established. The temperature of the mixture was then decreased at t_1 and equilibrium was reestablished at t_2.

Use this information to complete the graph below, showing the relative rates of both the **forward** and **reverse** reactions.

(2 marks)



(c) Which reaction would have the higher activation energy, the forward or the reverse?

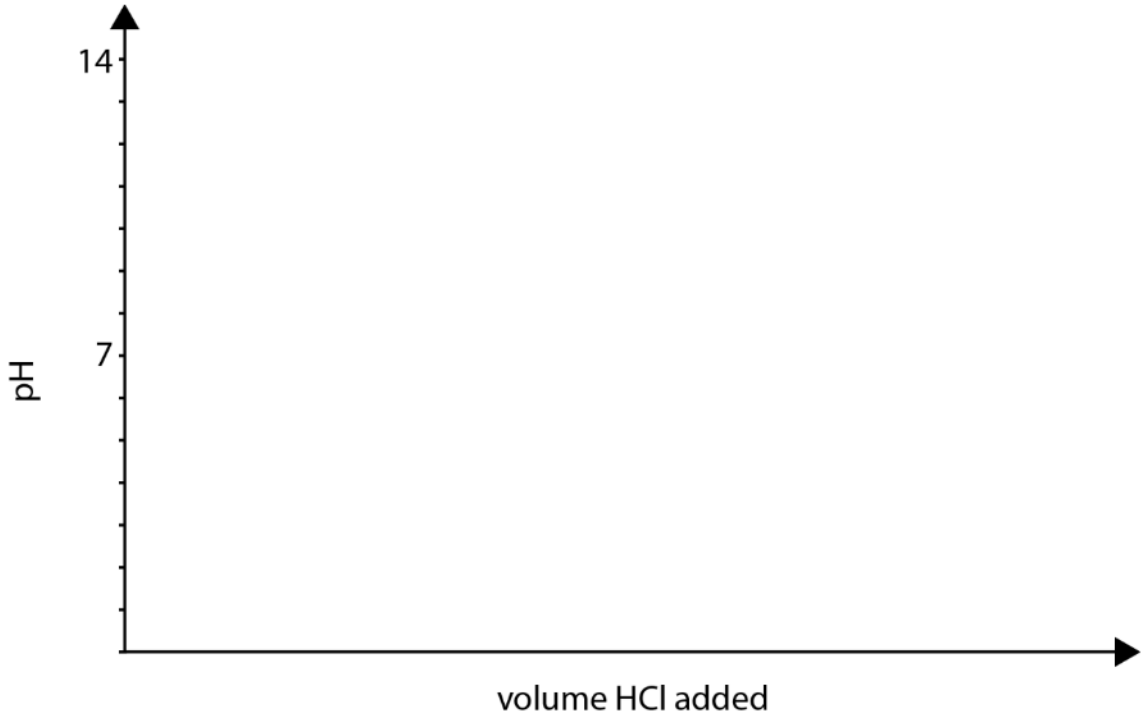
(1 mark)

See next page

Question 30 **(8 marks)**

The ocean's buffering capacity is very large, but gradual changes in pH can have serious impacts on marine life. As part of a marine study, the buffering capacity of sea water was tested. Increasing amounts of 0.01 $molL^{-1}$ hydrochloric acid were dissolved in two beakers; beaker A, containing pure distilled water, and beaker B, containing sea water (pH 7.9) at 25°C. The pH in each beaker was measured as the concentration of the acid dissolved in the beaker was increased.

(a) On the axes below, sketch and label two lines to show the expected results as the hydrochloric acid is dissolved in both Beaker A and Beaker B. (2 marks)



(b) The major species responsible for the buffering capacity of seawater are HCO_3^- (aq) and CO_3^{2-} (aq). Write stepwise equations to show how this buffer may arise from the dissolution of atmospheric CO_2 (g). (4 marks)

(c) In recent years, the level of atmospheric CO_2 (g) has increased. This has had measurable effects on small marine organisms such as bivalves (shellfish). Describe two ways in which marine organisms may be affected. (2 marks)

Question 31 **(9 marks)**

Sodium cyanide solution is used in the extraction of precious metals such as gold. It is produced when the weak acid hydrocyanic acid (HCN) reacts with sodium hydroxide solution.

(a) Write an ionic equation for this reaction, including state symbols. (2 marks)

(b) HCN and sodium hydroxide are mixed together in stoichiometric quantities.
Would the resultant solution be acidic, basic or neutral? Circle your answer below.

(i) acidic neutral basic (1 mark)

(ii) Explain your answer to part (i), using equations as necessary. (3 marks)

See next page

(c) Sodium cyanide is used in the presence of oxygen and water to extract trace amounts of gold from ores. The gold is dissolved out of the rock as shown in the unbalanced redox equation below:

$$Au\ (s) + CN^-\ (aq) + O_2\ (g) + H_2O\ (\ell) \rightarrow Au(CN)_2^-\ (aq) + OH^-\ (aq)$$

(i) Identify the reductant: _____ (1 mark)

(ii) Balance the equation, writing the coefficients in the boxes provided. Working out space is provided if needed. (2 marks)

_____

_____

_____

☐ Au + ☐ CN^- + ☐ O_2 + ☐ H_2O → ☐ $Au(CN)_2^-$ + ☐ OH^-

Question 32 **(12 marks)**

Blister copper contains 97-98% copper. It is produced when oxygen is blasted through copper (I) sulfide. Sulfur dioxide is also produced.

(a) Write a balanced equation for the production of blister copper. (2 marks)

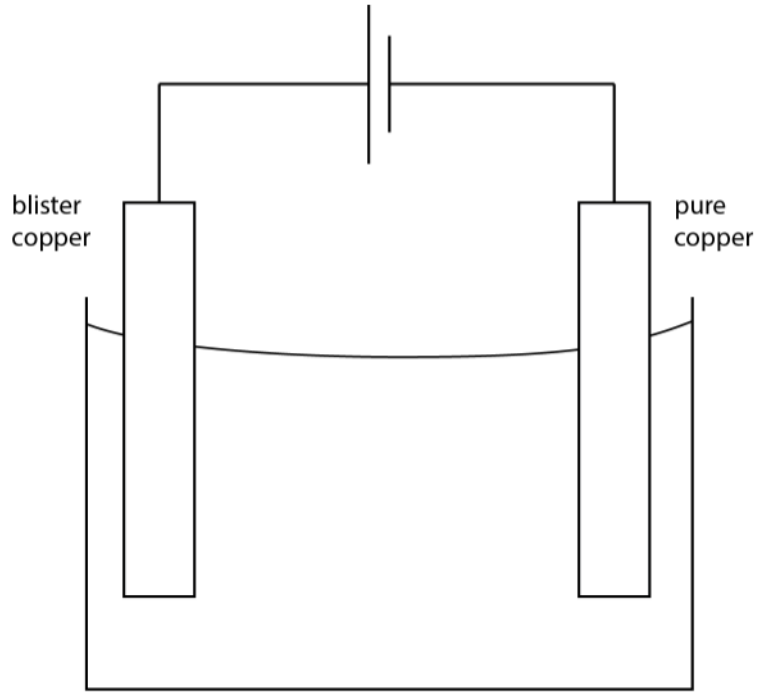
_____

(b) Identify the elements being oxidised and reduced. (2 marks)

Oxidised: _____

Reduced: _____

The impure copper produced by the reaction above is referred to as blister copper because bubbles of sulfur dioxide gas on the surface of the copper look like blisters. Blister copper then undergoes electrolysis to extract the pure copper, as shown below:



(c) Write the half-equation for the reaction occurring at the positive electrode. (1 mark)

(d) On the diagram above, use labelled arrows to show the direction of the flow of electrons through the wire and negative ions through the solution.

(2 marks)

(e) Blister copper contains small amounts of impurities such as zinc, silver and gold.

(i) Describe what happens to the silver and gold impurities in the blister copper. Explain why this occurs. (2 marks)

See next page

(ii) Describe what happens to the zinc impurities in the blister copper. Explain why this occurs. (3 marks)

Question 33 **(8 marks)**

Hydrogen gas is produced industrially in the steam methane reforming (SMR) reaction. Methane reacts with steam to form carbon monoxide and hydrogen gas.

$$CH_4\ (g) + H_2O\ (g) \rightleftharpoons 3\ H_2\ (g) + CO\ (g) \qquad \Delta H = +245\ kJ$$

(a) Determine the efficiency of the SMR process if 3.50×10^3 L of methane is reacted with excess steam at 400°C and 112 kPa producing 9.27×10^3 L of hydrogen gas under the same temperature and pressure conditions. (2 marks)

(b) The main considerations when selecting the temperature and pressure conditions for this process are the yield of H_2 and its rate of production.

Complete the table below, circling the most likely choice of conditions. (2 marks)

Condition	Choice
Temperature	Low moderate high
Pressure	Low moderate high

(c) Using Collision Theory, explain the relationship between the temperature of the system and the yield of hydrogen gas. (4 marks)

See next page

Question 34 **(6 marks)**

The Haber process uses hydrogen gas produced via SMR to make ammonia NH_3. In the industrial process a mixture of nitrogen and hydrogen is passed over iron at a temperature of about 450°C and 200 atmospheres pressure. The equation below shows the reaction in which ammonia is formed.

$$N_2(g) + 3\ H_2(g) \rightleftharpoons 2\ NH_3(g) + \text{Heat}$$

The table below shows the percentage yield of ammonia at different temperatures and pressures.

Pressure (kPa)	Percentage yield at 350°C	Percentage yield at 500°C
5 000	25	5
10 000	37	9
20 000	52	15
30 000	63	20
40 000	70	23
50 000	74	25

(a) Draw a graph of the percentage yield vs pressure for each temperature using the graph paper on page 25. Label each line clearly. (4 marks)

(b) Use your graph to determine the conditions needed to give a yield of 30% ammonia. (1 mark)

_____

(c) On the same axes, sketch and label the line that you would expect to see for a temperature of 450°C. (1 mark)

End of Section Two

See next page