



# AUSTRALIAN ISLAMIC COLLEGE

## CHEMISTRY

### Practice SEMESTER ONE EXAM UNIT 3

Name: \_\_\_\_\_

Teacher: \_\_\_\_\_

#### TIME ALLOWED FOR THIS PAPER

Reading time before commencing work: ten minutes

Working time for the paper: three hours

#### MATERIALS REQUIRED/RECOMMENDED FOR THIS PAPER

##### To be provided by the supervisor:

This Question/Answer Booklet

Multiple-choice Answer Sheet

Chemistry Data Book

##### To be provided by the candidate:

Standard items: pens (blue/black preferred), pencils (including coloured), sharpener, eraser, correction tape/fluid, ruler, highlighters

Special items: up to three non-programmable calculators approved for use in the WACE examinations

#### IMPORTANT NOTE TO CANDIDATES

No other items may be taken into the examination room. It is **your** responsibility to ensure that you do not have any unauthorised notes or other items of a non-personal nature in the examination room. If you have any unauthorised material with you, hand it to the supervisor **before** reading any further.

### Structure of this paper

Section	Number of questions available	Number of questions to be answered	Suggested working time (minutes)	Marks available	Percentage of exam
Section One: Multiple-choice	25	25	50	/50	/25
Section Two: Short answer	9	9	60	/72	/35
Section Three: Extended answer	5	5	70	/78	/40
					/100

### Instructions to candidates

1. Answer the questions according to the following instructions.

Section One: Answer all questions on the separate Multiple-choice Answer Sheet provided. For each questions shade the box to indicate your answer. Use only a blue or black pen to shade the boxes. If you make a mistake, place a cross through that square then shade your new answer. Do not erase or use correction fluid/tape. Marks will not be deducted for incorrect answers. No marks will be given if more than one answer is completed for any question.

Sections Two and Three: Write your answers in this Question/Answer Booklet.

2. When calculating numerical answers, show your working or reasoning clearly. Express numerical answers to the appropriate number of significant figures and include appropriate units where applicable.
3. You must be careful to confine your responses to the specific questions asked and to follow any instructions that are specific to a particular question.
4. Spare pages are included at the end of this booklet. They can be used for planning your responses and/or as additional space if required to continue an answer.
  - Planning: If you use the spare pages for planning, indicate this clearly at the top of the page.
  - Continuing an answer: If you need to use the space to continue an answer, indicate in the original answer space where the answer is continued, i.e. give the page number. Fill in the number of the question(s) that you are continuing to answer at the top of the page.
5. The Chemistry Data Book is **not** handed in with your Question/Answer Booklet.

**Section One: Multiple-choice****25% (50 marks)**

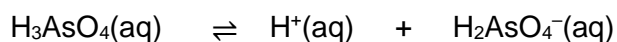
This section has **25** questions. Answer **all** questions on the separate Multiple-choice Answer Sheet provided. For each question, shade the box to indicate your answer. Use only a blue or black pen to shade the boxes. If you make a mistake, place a cross through that square then shade your new answer. Do not erase or use correction fluid/tape. Marks will not be deducted for incorrect answers. No marks will be given if more than one answer is completed for any question.

Suggested working time: 50 minutes.

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1. In a chemical reaction at constant temperature, the addition of a catalyst:
    - (a) increases the concentration of the products at equilibrium.
    - (b) increases the energy of the molecules so more can successfully collide.
    - (c) lowers the amount of energy released in the overall reaction.
    - (d) decreases the time required for equilibrium to be reached.
  
  2. An experiment is set up to electroplate an antique brass spoon with silver. Which of the following statements describes how the experiment should be set up?
    - (a) The cathode is made of silver and the spoon is the anode.
    - (b) The spoon is the cathode and the electrolyte is a solution of silver nitrate.
    - (c) The spoon is the anode and the electrolyte is a solution of copper sulfate.
    - (d) The cathode is made of silver and the electrolyte is a solution of silver nitrate.
  
  3. The conjugate base of the acid  $\text{HPO}_3^{2-}$  is:
    - (a)  $\text{H}_2\text{PO}_3^-$
    - (b)  $\text{PO}_3^{2-}$
    - (c)  $\text{H}_3\text{PO}_3$
    - (d)  $\text{PO}_3^{3-}$

**Questions 4 and 5 relate the following information:**

Consider the following information for a  $1.00 \text{ mol L}^{-1}$  solution of arsenous acid, ( $\text{H}_3\text{AsO}_4$ ):



$$K_a (\text{at } 25^\circ\text{C}) = \frac{[\text{H}^+][\text{H}_2\text{AsO}_4^-]}{[\text{H}_3\text{AsO}_4]} = 6.6 \times 10^{-10}$$

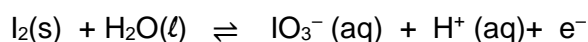
4. At equilibrium at  $25^\circ\text{C}$ , which of the following species will be present in the greatest concentration?
  - (a)  $\text{H}^+(\text{aq})$
  - (b)  $\text{H}_2\text{AsO}_4^-(\text{aq})$
  - (c)  $\text{H}_3\text{AsO}_4(\text{aq})$
  - (d)  $\text{OH}^-(\text{aq})$

5. Which of the following statements best describe the value of the equilibrium constant (K) for arsenous acid at 25° C?
- (a) Arsenous acid is a strong acid existing essentially as molecules.
  - (b) Arsenous acid is a weak acid existing essentially as molecules.
  - (c) Arsenous acid is a weak acid existing essentially as ionic species.
  - (d) Arsenous acid is strong acid existing essentially as ionic species.
6. The pH of a solution was measured with a pH meter during a titration, and was observed to decrease from 4.0 to 2.0. Which of the following statements about the hydrogen ion concentration in the solution is correct?
- (a) It doubled.
  - (b) It decreased by half.
  - (c) It increased by a factor of 100.
  - (d) It decreased by a factor of 100.
7. The following statements refer to the chemical reaction between magnesium carbonate granules, (MgCO<sub>3</sub>) and a dilute hydrochloric acid solution, (HCl). Which one of the following statements about this reaction is FALSE?
- (a) The rate of the reaction decreases with increasing time.
  - (b) The rate of reaction increases with increasing initial temperature.
  - (c) The rate of reaction increases with increasing initial concentration of HCl (aq).
  - (d) The initial rate of reaction is independent of the state of sub-division of MgCO<sub>3</sub> (s).
8. Which one of the following statements about the following reversible reaction is TRUE?
- $$2\text{SO}_2(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{SO}_3(\text{g})$$
- (a)  $K = \frac{[\text{SO}_2]^2[\text{O}_2]}{[\text{SO}_3]^2}$
  - (b) K is constant under all reaction conditions.
  - (c) Sulfur trioxide is being formed when the reaction is at equilibrium.
  - (d) A catalyst increases the yield of sulfur trioxide by increasing  $\Delta H$ .
9. In which of the following reactions at equilibrium and at constant temperature is there a shift to the "left" if the pressure of the closed system is increased?
- (a)  $2\text{NO}_2(\text{g}) \rightleftharpoons \text{N}_2\text{O}_4(\text{g})$
  - (b)  $\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightleftharpoons 2\text{NH}_3(\text{g})$
  - (c)  $\text{H}_2\text{O}(\text{g}) + \text{C}(\text{s}) \rightleftharpoons \text{H}_2(\text{g}) + \text{CO}(\text{g})$
  - (d)  $\text{H}_2(\text{g}) + \text{F}_2(\text{g}) \rightleftharpoons 2\text{HF}(\text{g})$

10. Bromophenol blue is an acid-base indicator that has a colour change from yellow to blue between pH 3.0 and 4.6. A potassium hydroxide solution (in a conical flask), containing a few drops of bromophenol blue indicator, is titrated with an acetic (ethanoic) acid solution (from a burette).

Which one of the following statements about this titration is true?

- (a) The end point and the equivalence point occur at the same time.
  - (b) The end point occurs after the equivalence point.
  - (c) The end point occurs before the equivalence point.
  - (d) The indicator will be yellow at the equivalence point of the titration.
11. How many moles of electrons are required when the following half-equation is balanced using the smallest possible coefficients?



- (a) 2
  - (b) 5
  - (c) 10
  - (d) 12
12. Consider the statements about the following reaction:



- I  $\text{H}_2\text{O}_2$  is reduced.
- II  $\text{H}_2\text{O}_2$  is oxidised.
- III  $\text{H}_2\text{O}_2$  acts as a reducing agent.
- IV This is not a redox reaction.

Which of the above statements is/are true?

- (a) IV only
  - (b) II and III only
  - (c) I only
  - (d) I, II and III only
13. Which choice correctly describes the properties of aqueous solutions of the following salts?

	Sodium ethanoate ( $\text{NaCH}_3\text{COO}$ )	Potassium nitrate ( $\text{KNO}_3$ )	Ammonium chloride ( $\text{NH}_4\text{Cl}$ )
(a)	neutral	acidic	basic
(b)	basic	neutral	acidic
(c)	acidic	neutral	basic
(d)	basic	acidic	neutral

14. Which one of the following statements **BEST** describes the function of an anode in an electrolytic cell?

- (a) The anode is the electrode at which reduction occurs.
- (b) The anode is the only electrode at which  $\text{OH}^-$  (aq) ions are produced.
- (c) The anode is the electrode which attracts positive ions.
- (d) The anode is the electrode that is oxidised.

15. Which of the following combinations will form a buffer solution?

- i.  $\text{NH}_3(\text{aq}) / \text{NH}_4\text{Cl}(\text{aq})$
- ii.  $\text{NH}_3(\text{aq}) / \text{HCl}(\text{aq})$
- iii.  $\text{HCl}(\text{aq}) / \text{NH}_4\text{Cl}(\text{aq})$
- iv.  $\text{H}_2\text{PO}_4^-(\text{aq}) / \text{HPO}_4^{2-}(\text{aq})$
- v.  $\text{H}_2\text{SO}_4(\text{aq}) / \text{HSO}_4^-(\text{aq})$

- (a) i and iv only
- (b) i, iv and v only
- (c) i, ii and iv only
- (d) iv only

16. Which of the following reactions will occur spontaneously?

- i.  $2 \text{I}^-(\text{aq}) + \text{Br}_2(\text{aq}) \rightarrow 2 \text{Br}^-(\text{aq}) + \text{I}_2(\text{aq})$
- ii.  $\text{Cu}(\text{s}) + 2 \text{HCl}(\text{aq}) \rightarrow \text{CuCl}_2(\text{aq}) + \text{H}_2(\text{aq})$
- iii.  $\text{Sn}(\text{s}) + \text{Cd}^{2+}(\text{aq}) \rightarrow \text{Sn}^{2+}(\text{aq}) + \text{Cd}(\text{s})$
- iv.  $\text{H}_2\text{O}_2(\text{aq}) + \text{Ni}^{2+}(\text{aq}) \rightarrow \text{O}_2(\text{g}) + 2 \text{H}^+(\text{aq}) + \text{Ni}(\text{s})$

- (a) i and iv only
- (b) i only
- (c) iii and iv
- (d) iv only

17. Consider the following statements about fuel cells.

- I A fuel cell converts chemical energy to electrical energy via a redox reaction.
- II Fuel cell technology involves the continuous supply of reactants to the cells and the continuous removal of the products.
- III A fuel cell can be recharged by reversing the direction of current flow through the cell.
- IV Fuel cells are considered a low-emission technology.

Which of the above statements about fuel cells are true?

- (a) I only
- (b) I and II
- (c) I, III and IV
- (d) I, II and IV

18. Hydrogen can be produced by the steam reforming of methane as in the following reaction:



Which one of the following will increase the equilibrium yield of hydrogen?

- (a) Increasing the total pressure of the reaction system.
- (b) Decreasing the partial pressure of the water vapour.
- (c) Removing the carbon monoxide from the system as it is produced.
- (d) Decreasing the temperature of the system.

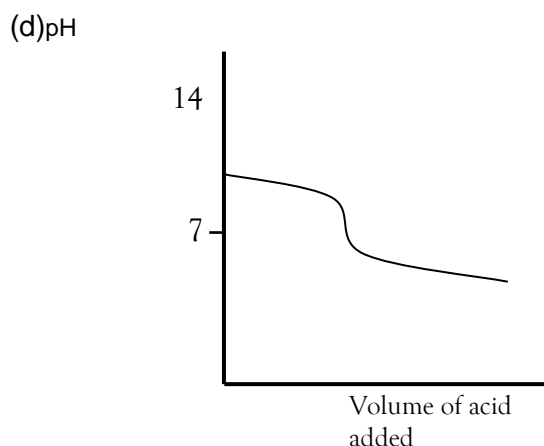
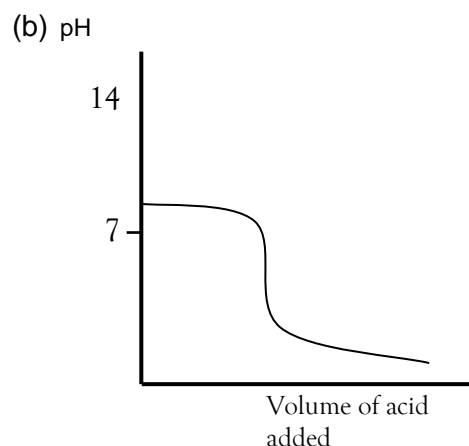
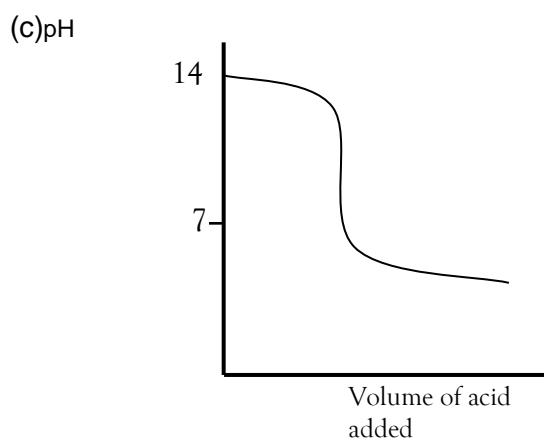
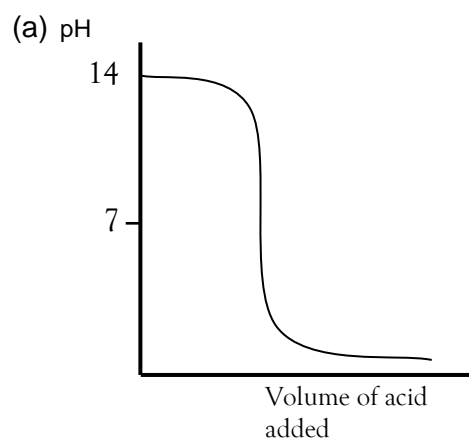
**Questions 19, 20 and 21 relate the following information:**

A student was asked to determine the concentration of a solution of ethanoic acid that had a concentration of approximately  $0.400 \text{ mol L}^{-1}$ . He pipetted  $20.0 \text{ mL}$  of a  $0.500 \text{ mol L}^{-1}$  solution of sodium hydroxide into a conical flask, and titrated the ethanoic acid against the standardised sodium hydroxide solution, using phenolphthalein as the indicator.

19. What is the pH of the sodium hydroxide solution at the start of the titration?

- (a) 13.7
- (b) 7.00
- (c) 14.0
- (d) 12.7

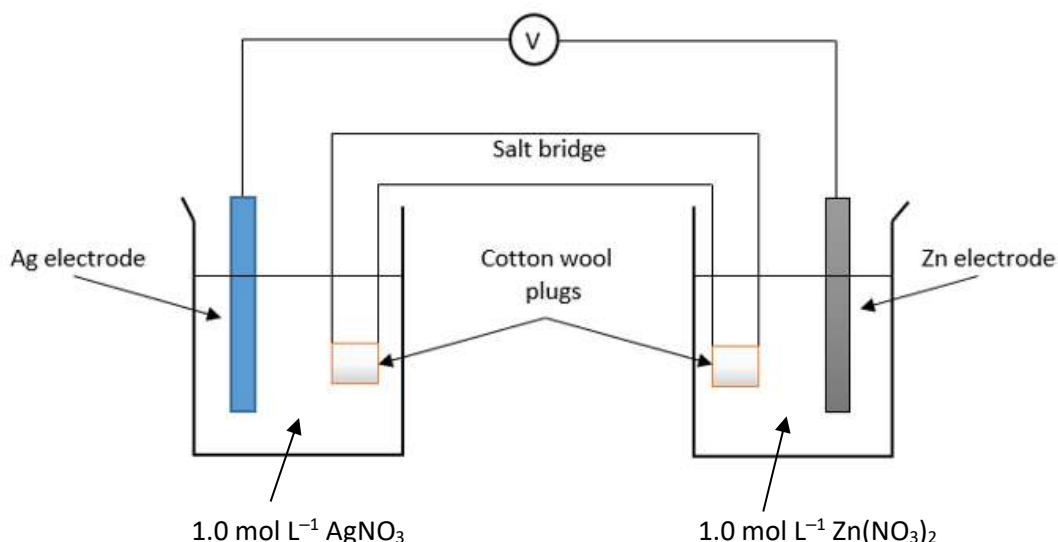
20. If the ethanoic acid was added until it was slightly in excess, which of the following pH graphs would show the variation of pH during the titration?



21. What approximate volume of ethanoic acid would the student expect to have added at the end point of the titration?

- (a) 20 mL
- (b) 30 mL
- (c) 25 mL
- (d) 35 mL

Questions 22, 23 and 24 relate to the following electrochemical cell at 25°C:



22. Which of the following reactions will occur during the normal operation of this cell?

- (a)  $2\text{Ag}^+(\text{aq}) + \text{Zn}(\text{s}) \longrightarrow 2\text{Ag}(\text{s}) + \text{Zn}^{2+}(\text{aq})$   $E^\circ = 1.56 \text{ V}$
- (b)  $2\text{Ag}^+(\text{aq}) + \text{Zn}(\text{s}) \longrightarrow 2\text{Ag}(\text{s}) + \text{Zn}^{2+}(\text{aq})$   $E^\circ = 0.04 \text{ V}$
- (c)  $\text{Zn}^{2+}(\text{aq}) + 2\text{Ag}(\text{s}) \longrightarrow \text{Zn}(\text{s}) + 2\text{Ag}^+(\text{aq})$   $E^\circ = 1.56 \text{ V}$
- (d)  $\text{Zn}^{2+}(\text{aq}) + 2\text{Ag}(\text{s}) \longrightarrow \text{Zn}(\text{s}) + 2\text{Ag}^+(\text{aq})$   $E^\circ = 0.04 \text{ V}$

23. Which of the following statements about the two electrodes is correct?

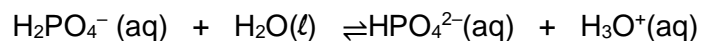
- (a) The mass of the silver electrode will decrease.
- (b) The zinc electrode is the cathode.
- (c) The mass of the zinc electrode will decrease.
- (d) The silver electrode is the anode.

24. Which of the following statements about the flow of charge is INCORRECT?

- (a) Electrons will flow from the zinc electrode to the silver electrode through the external circuit.
- (b) Cations will flow through the salt bridge towards the silver half-cell.
- (c) Electrons will flow from the silver electrode to the zinc electrode through the salt bridge.
- (d) Anions will flow through the salt bridge towards the zinc half-cell.



25. Consider the buffer solution represented by the chemical reaction below:



Which of the following would be **true** after the addition of a small volume of  $2.0 \text{ mol L}^{-1}$  sodium hydroxide solution to the buffer solution?

- (a) The forward reaction rate would be unaffected.
- (b) The concentration of  $\text{H}_2\text{PO}_4^- (\text{aq})$  present in the system would increase.
- (c) The pH of the system would decrease.
- (d) The equilibrium would shift to the right.

**End of Section One**

See next page

**Section Two: Short answer****35% (72 marks)**

This section has **11** questions. Answer **all** questions. Write your answers in the spaces provided.

When calculating numerical answers, show your working or reasoning clearly. Express numerical answers to the appropriate number of significant figures and include appropriate units where applicable.

Spare pages are included at the end of this booklet. They can be used for planning your responses and/or as additional space if required to continue an answer.

- Planning: If you use the spare pages for planning, indicate this clearly at the top of the page.
- Continuing an answer: If you need to use the space to continue an answer, indicate in the original answer space where the answer is continued, i.e. give the page number. Fill in the number of the question(s) that you are continuing to answer at the top of the page.

Suggested working time: 60 minutes.

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**Question 26****(4 marks)**

Write observations for any reactions that occur in the following procedures. In each case describe in full what you would observe, including any:

- colours
- odours
- precipitates (give the colour)
- gases evolved (give the colour or describe as colourless).

If no change is observed, you should state this.

(Note: No chemical equations necessary).

- (a) Some hydrochloric acid solution is mixed with solid sodium carbonate. (2 marks)

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- (b) Some solid copper (II) hydroxide is mixed with a dilute nitric acid solution. (2 marks)

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**Question 27****(6 Marks)**

The uptake of carbon dioxide from the atmosphere by the oceans is leading to gradual acidification of the oceans (i.e. the oceans are becoming more acidic). When carbon dioxide dissolves, it reacts with water to form carbonic acid, which in turn forms hydrogen carbonate and then carbonate ions.

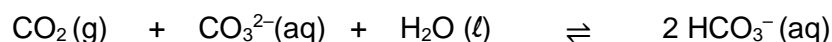
- (a) Write balanced chemical equations showing carbon dioxide reacting with water to form carbonic acid, and then the two successive ionisation reactions that carbonic acid undergoes in water. Mention states also. (3 marks)

(i) \_\_\_\_\_

(ii) \_\_\_\_\_

(iii) \_\_\_\_\_

One of the most significant consequences of ocean acidification is the effect that it has on shellfish and other marine life that produce calcium carbonate and relies on it as a major component of the exoskeleton or other supporting structure. If the water is sufficiently acidic, the carbonate structures may not form completely. Ocean acidification is thought to lead to a reduction in the availability of carbonate ions. Further reaction of the dissolved carbon dioxide occurs as shown below.



- (b) Identify a conjugate acid-base pair in this reaction, and explain why it is classified as a Brønsted – Lowry acid-base reaction. (3 marks)

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**Question 28****(6 Marks)**

The Brønsted – Lowry theory can be used to account for the acidic and basic properties of a much wider array of substances whose properties cannot be easily explained using earlier theories.

Complete the following table by stating the pH, and give a supporting balanced chemical equation to explain the pH for each of the substances listed.

**(6 marks)**

Substance	pH (acidic, basic or neutral)	Equation
$\text{Mg}(\text{CH}_3\text{COO})_2 (\text{aq})$		
$\text{NH}_4\text{Cl} (\text{aq})$		
$\text{NaHSO}_4 (\text{aq})$		

**Question 29****(6 Marks)**

Tellurium (Te) is a rare, silver metalloid that can be used in solar panels and as a semiconducting material. It can be produced by reacting the mineral tellurite ( $\text{TeO}_2$ ) with hypophosphoric acid ( $\text{H}_3\text{PO}_2$ ). This produces tellurium metal and phosphorous acid ( $\text{H}_3\text{PO}_3$ ).

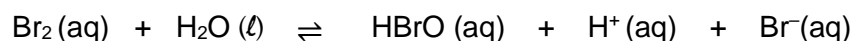
Write the oxidation and reduction half-equations and the overall redox equation for this reaction, assuming acidic conditions.

Oxidation half-equation	
Reduction half-equation	
Overall redox equation	

See next page

**Question 30****(6 Marks)**

Bromine water, which is a dilute aqueous solution of bromine in water, is slightly acidic because of its reaction with water, represented by the following equation:



In aqueous solution, bromine,  $\text{Br}_2(\text{aq})$  is brown. Hypobromous acid,  $\text{HBrO}(\text{aq})$ , and bromide ions,  $\text{Br}^-(\text{aq})$  are both colourless.

State and explain the colour changes that would be observed, if the following changes are made to the system at equilibrium.

- (a) Addition of  $\text{NaOH}(\text{aq})$ .

**(3 marks)**

Colour:

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Explanation:

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- (b) Addition of excess  $\text{HCl}(\text{aq})$ .

**(3 marks)**

Colour:

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Explanation:

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**Question 31****(5 marks)**

Calculate the pH of the resultant solution, if 25.0 mL of 2.00 molL<sup>-1</sup> sodium hydroxide and 52.0 mL of 1.00 molL<sup>-1</sup> hydrochloric acid are mixed together. (5 marks)

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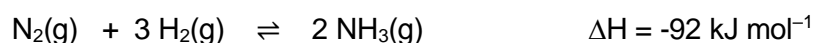
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**Question 32****(9 Marks)**

The manufacture of ammonia on an industrial scale is carried out using the Haber process, which relies on the reversible reaction of nitrogen and hydrogen in the presence of an iron catalyst, as shown in the following equation:



The conditions for the reaction in industry must be chosen carefully, taking into consideration not only the yield, but also the rate of the reaction. Commonly, a temperature of around 500°C is used, and the reaction operated at a pressure of around 20,000 kPa. Since ammonia has a much higher boiling point than the other gases, it can easily be removed from the equilibrium mixture by condensation.

- (a) In the space provided below, draw a fully labelled enthalpy level diagram for the Haber process, showing  $\Delta H$ ,  $E_A$ , **catalysed** and **uncatalysed** reaction pathways, and **axes with correct units** stated.

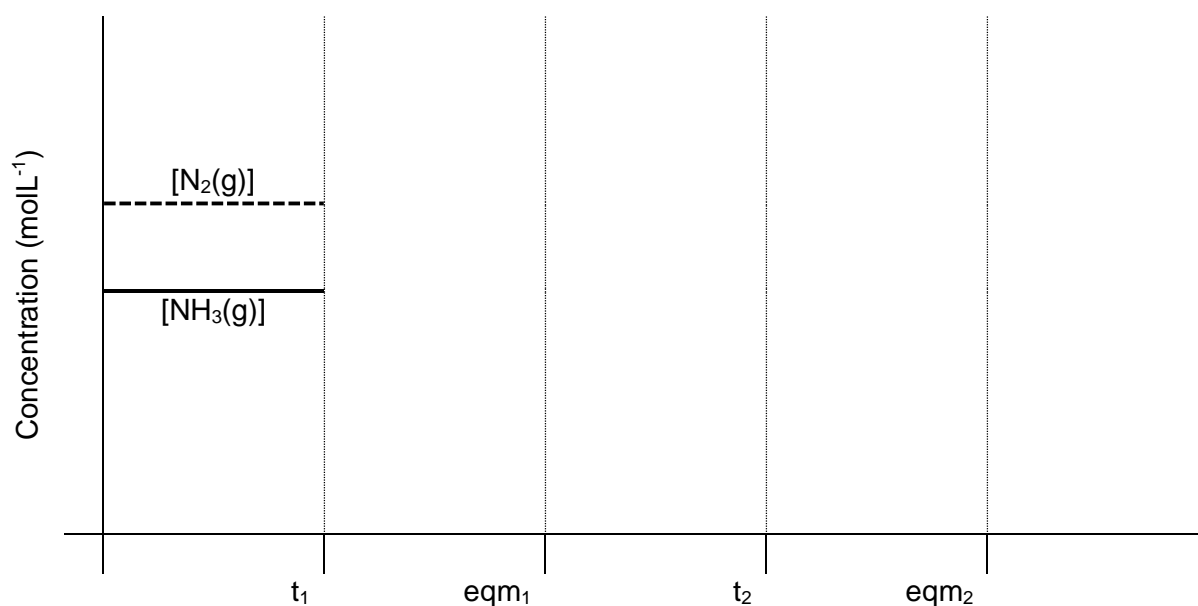
**(5 marks)**

A sealed vessel containing an equilibrium mixture of nitrogen, hydrogen and ammonia was subjected to the following changes in conditions:

- At a time,  $t_1$ , the temperature of the vessel was increased
- At a time,  $eqm_1$ , the system had returned to equilibrium
- At a time,  $t_2$ , all ammonia was removed from the system
- At a time,  $eqm_2$ , the system had again returned to equilibrium

- (b) Complete the following graph, to show what happens to the concentrations of nitrogen and ammonia as the above changes are made.

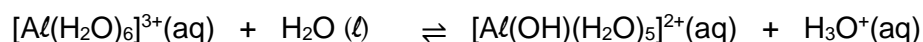
(4 marks)



### Question 33

(10 Marks)

Aluminium salts are acidic due to the presence of the hexaaqualuminate ion,  $[Al(H_2O)_6]^{3+}$  which is formed when a soluble aluminium salt is dissolved in water. This ion undergoes hydrolysis as follows:



- (a) Write the equilibrium constant (K) expression for this reaction. (1 mark)

- (b) A solution of aluminium nitrate has a pH of 5.6.

See next page

- (i) Using the above equilibrium reaction, explain how the pH of the solution would change, if more crystals of hydrated aluminium nitrate were dissolved into the solution.

(3 marks)

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- (ii) When a small volume of dilute sodium hydroxide was added to a sample of the original solution, the pH initially increased from 5.6 to 6.0, and then decreased back to 5.8. Explain these observations.

(3 marks)

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- (c) It was found that when the aluminium nitrate solution was warmed, the pH of the solution decreased. From this information, deduce whether the forward reaction in the above equilibrium is endothermic or exothermic. Explain your reasoning.

(3 marks)

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**Question 34****(8 Marks)**

Phosphoric acid is a weak, **triprotic** acid. In an experiment, a solution of approximately  $0.2 \text{ mol L}^{-1}$  phosphoric acid ( $\text{H}_3\text{PO}_4$ ) is titrated with a standard solution of  $0.200 \text{ mol L}^{-1}$  sodium hydroxide in order to determine the accurate concentration of the acid.  $30.00 \text{ mL}$  of the sodium hydroxide solution was pipetted into a conical flask, and the phosphoric acid added from the burette.

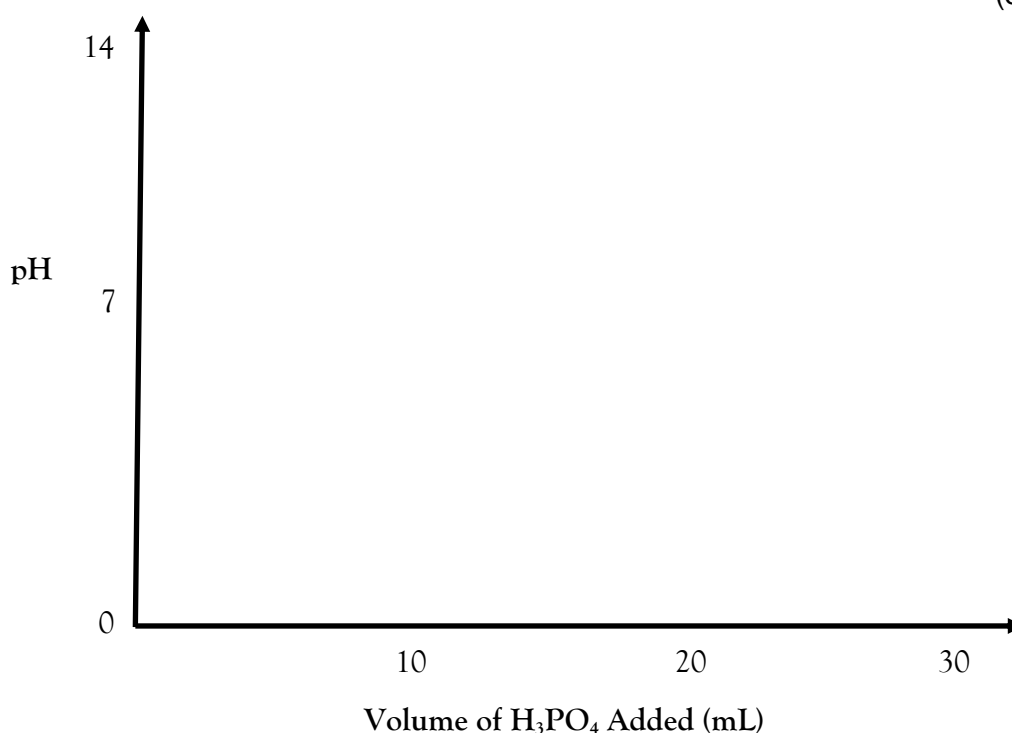
- (a) Write a balanced molecular equation, including state symbols, for the reaction occurring.

(2 marks)

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- (b) On the axis below, sketch a graph showing how the pH would be expected to change during the titration, until an excess of the acid was added.

(3 marks)



- (c) On the graph above, label the equivalence point for this reaction.

(1 mark)

- (d) What should the pipette be rinsed with, immediately prior to use?

(1 mark)

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- (e) From the list below, circle the correct indicator, that would be suitable for use in this particular titration.

(1 mark)

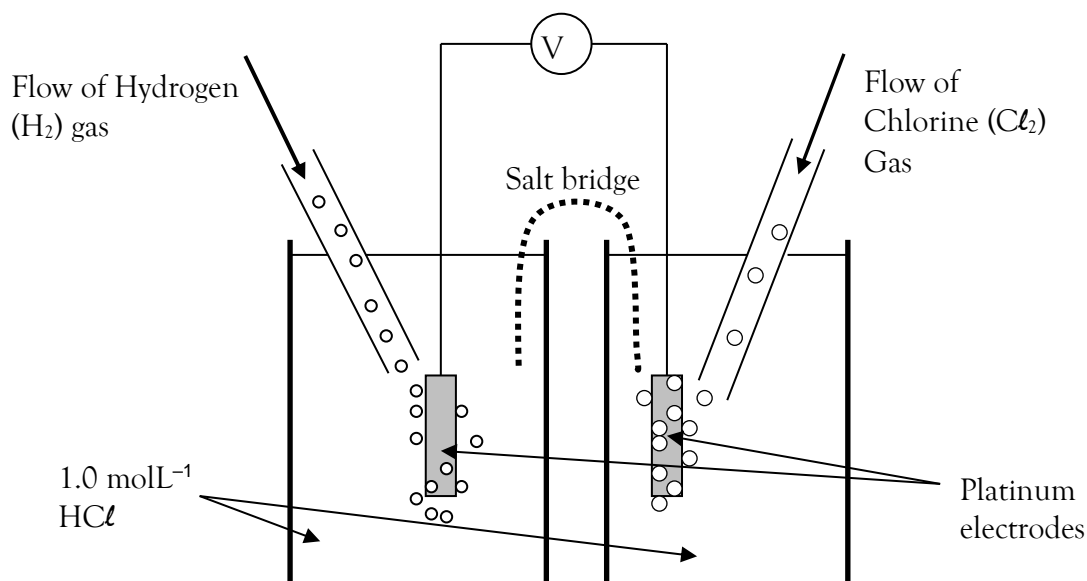
**Methyl orange**  
(pH 3.1 – 4.4)

**Phenolphthalein**  
(pH 8.3 – 10.0)

**Bromothymol blue**  
(pH 6.0 – 7.6)

**Question 35****(6 Marks)**

Below is a representation of an electrochemical cell, which involves the reaction of hydrogen and chlorine gases:



- (a) Give the half equation for the reactions occurring at the anode and at the cathode, and then write an overall balanced redox equation for the reaction occurring in the cell.

**(3 marks)**

Cathode half-equation:

Anode half-equation:

Overall equation:

- (b) Using the standard reduction potential values from the data sheet, calculate the maximum theoretical voltage (e.m.f.) that could be produced by this cell.

**(1 mark)**

- (c) Show the direction of the flow of electrons in the external circuit by means of an **arrow**, “(→)” in the diagram above.

**(1 mark)****See next page**

- (d) Suggest a reason why platinum is used for the electrodes. (1 mark)

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**Question 36****(6 Marks)**

Use the Standard Reduction Potentials from your Data Booklet to answer the following questions. In each case, write all relevant half-equations with their respective  $E^\circ$  values. (If the reaction is likely to occur, write an overall balanced redox equation with the resultant cell voltage). Then you must state clearly if the reaction is likely or unlikely to occur as described.

- (a) A piece of aluminium metal is placed in a  $1.00 \text{ mol L}^{-1}$  nickel nitrate solution. (3 marks)

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- (b) Silver metal is added to a  $1.00 \text{ mol L}^{-1}$  sulfuric acid solution. (3 marks)

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**End of Section Two**

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**Section Three: Extended answer****40% (78 marks)**

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

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 the appropriate number of significant figures.

Spare pages are included at the end of this booklet. They can be used for planning your responses and/or as additional space if required to continue an answer.

- Planning: If you use the spare pages for planning, indicate this clearly at the top of the page.
- Continuing an answer: If you need to use the space to continue an answer, indicate in the original answer space where the answer is continued, i.e. give the page number. Fill in the number of the question(s) that you are continuing to answer at the top of the page.

Suggested working time: 70 minutes.

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**Question 37****(16 marks)**

Rising carbon dioxide levels in the atmosphere are believed to play an important role in the life of organisms known as calcifiers, a group that includes many forms of coral and crustaceans. These organisms use a precipitation reaction between calcium ions and carbonate ions present in sea-water to form shells and skeletons.

Measurements have detected a fall of around 0.1 in the pH of the oceans since the beginning of the industrial revolution at the end of the 18<sup>th</sup> century. Scientists believe this acidification can be attributed to an increase in the partial pressure of carbon dioxide in the atmosphere over the same period.

- (a) Use appropriate chemical equations, to explain why a rise in the partial pressure of carbon dioxide in the atmosphere has caused a decrease in the pH of the oceans. (3 marks)

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A student wished to investigate the composition of prawn shells. In order to do this, the student carried out a series of reactions to convert all the carbonate in the shells, (present as  $\text{CaCO}_3$ ), to a soluble form, (i.e.  $\text{CO}_3^{2-}$ ).

The steps that the student carried out were as follows:

- The shells of 10 prawns were ground to a fine powder using a mortar and pestle.
- 2.17 g of the powder was placed in a beaker, where it was chemically treated to convert all the carbonate into a soluble form.
- The resulting mixture was then filtered to remove any insoluble substances and the filtrate transferred to a 250 mL volumetric flask and made up to the mark with distilled water.
- 20 mL aliquots of the solution in the volumetric flask were titrated against a standard solution of nitric acid with a concentration of  $0.0502 \text{ mol L}^{-1}$ .
- All burette readings were taken from the **top of the meniscus**.
- The average titre of nitric acid used was 35.05 mL.

(b) Write a balanced ionic equation for the titration reaction. (2 marks)

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(c) Calculate the number of moles of nitric acid titrated from the burette. (1 mark)

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(d) Calculate the number of moles of carbonate in the 20.0 mL aliquots. (2 marks)

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- (e) Calculate the number of moles of carbonate in the original 2.17 g of powdered prawn shells, and thus calculate the percentage by mass of calcium carbonate in the sample of prawn shells. (You may assume that the moles of  $\text{CaCO}_3$  are equal to the moles of  $\text{Na}_2\text{CO}_3$ ).

(5 marks)

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- (f) State and explain what effect the student's decision to read the burette from the top of the meniscus would have had on the calculated percentage by mass. (3 marks)

(3 marks)

**Effect on calculated percentage (circle one)**

Artificially high

No effect

Artificially low

### Explanation

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**Question 38****(15 marks)**

The electroplating of various metals plays an extremely important role in industry. These reactions can be carried out on a small scale in the laboratory using standard laboratory equipment.

A typical spoon can be electroplated with chromium metal, utilising a chromium electrode and an acidified aqueous chromium nitrate solution. Using a labelled diagram, explain the process involved in electroplating the spoon.

Your answer should pay particular attention to the following areas:

- (a) How the cell can be constructed. (A diagram with clear labels for the anode, cathode, electrolyte, direction of flow of electrons and ions). (6 marks)
- (b) Describe the processes occurring at each electrode. (Including half-equations). (4 marks)
- (c) Observations made at each electrode. (2 marks)
- (d) The role of the electrolyte. (1 mark)
- (e) Two examples for the industrial importance or application of the process. (2 mark)

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**Question 39****(22 marks)**

Aspartic acid ( $\text{C}_4\text{H}_7\text{O}_4\text{N}$ ) is a diprotic  $\alpha$ -amino acid. Aspartic acid has solubility of  $4.5 \text{ g L}^{-1}$  at  $25^\circ\text{C}$  and a  $K_a$  value of  $1.26 \times 10^{-4}$ . Aspartic acid increases resistance to fatigue and is often found in food supplements, especially those used by athletes and body builders.

A chemist was asked to analyse the contents of a food supplement to check the manufacturer's claims that it contained 97.0% aspartic acid by mass. To check this claim, the following experiment was carried out. (It can be assumed that aspartic acid is the only active ingredient in the supplement)

1. 1.546 g of the supplement powder was weighed and dissolved in warmed distilled water in a beaker.
2. The solution is transferred to a 500.0 mL volumetric flask and was made up to the mark with distilled water.
3. 25.00 mL aliquots of the resulting solution were titrated, using phenolphthalein indicator, against  $0.0570 \text{ mol L}^{-1}$  sodium hydroxide solution.

The results obtained are shown below.

Burette readings (mL)	Titrations			
	1	2	3	4
Final volume	20.30	40.05	19.80	39.50
Initial volume	0.00	20.30	0.00	19.80
Titration volume (titre)				

- (a) Calculate the percentage purity of the supplement. (7 marks)

- (b) Consider the method used in this experiment.
- (i) In Step 1, suggest a reason why the distilled water was warmed. (1 mark)
  - (ii) In Step 2, the solution was transferred from a beaker into the volumetric flask. Explain why this process could be a source of systematic error. (2 marks)
  - (iii) Phenolphthalein changes colour at between pH 9 –10. Methyl orange changes colour at between pH 4 –5. In Step 3, predict and explain the effect on the final result if methyl orange was used as the indicator instead of phenolphthalein. (3 marks)

- (c) (i) Due to the low solubility of the aspartic acid, it was suggested to the students that they use a 'back titration'. This would require the addition of a known amount of sodium hydroxide (in excess) to the aspartic acid and the titration of the unreacted hydroxide against a standard solution of acid.

Sodium hydroxide solution with a concentration of  $0.202 \text{ mol L}^{-1}$  is used and there is a standard solution of  $0.100 \text{ mol L}^{-1}$  hydrochloric acid available.

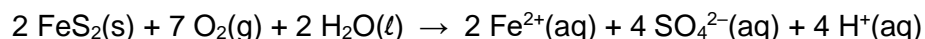
There are three pipettes to choose from (20.00 mL, 25.00 mL or 50.00 mL) for adding sodium hydroxide solution to the 1.546 g of the supplement powder.

Calculate which volume pipette the student should use to add the sodium hydroxide in order to get a titration volume (titre) of approximately 20 mL of the hydrochloric acid. (7 marks)

- (ii) Explain why having a titre of less than 20 mL could increase the random error in this experiment. (2 marks)

**Question 40****(14 marks)**

When soils containing iron pyrite ( $\text{FeS}_2$ ) are exposed to air, the following reaction occurs.



These types of soils are called acid sulfate soils. The pH of groundwater in these soils will decrease. If this groundwater discharges into lakes and rivers it will also cause their pH to decrease.

- (a) Explain how this reaction causes the pH of groundwater to decrease. (2 marks)

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A titration was carried out on a sample of lake water, suspected of being contaminated with acid soils, to determine its pH.

A student placed a standardised solution of  $0.005 \text{ mol L}^{-1}$  NaOH in the burette.

The student then titrated the NaOH solution against 50.0 mL samples of the lake water and obtained the following results.

	Trial 1	Trial 2	Trial 3	Trial 4
Final burette reading (mL)	4.25	8.05	12.00	16.05
Initial burette reading (mL)	0.00	4.10	8.10	12.05
Volume of NaOH used (mL)				

- (b) Determine the average volume of NaOH used. (2 marks)

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- (c) Calculate the average number of moles of NaOH used to neutralise the acid. (1 mark)

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- (d) Assuming that the lake water is the only source of  $\text{H}^+$  ions and that complete ionisation of the acid in the lake water has occurred, determine the pH of the lake water. (3 marks)

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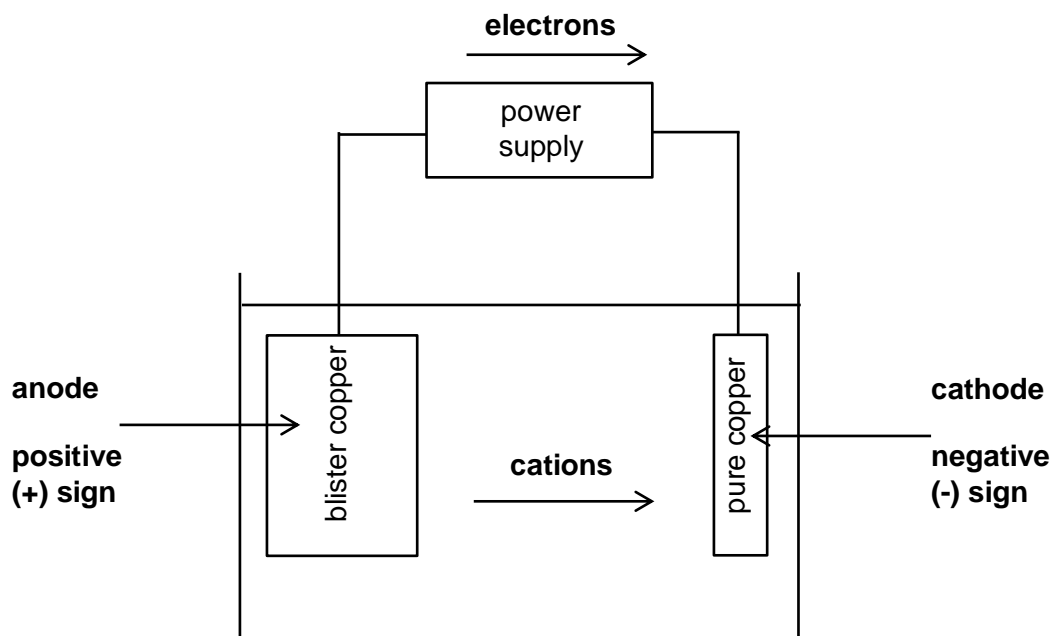
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- (e) Complete the following table (6 marks)

Equipment	What is it used for in this experiment?	What should it be rinsed with before use?
Burette		
Pipette		
Conical flask		

**Question 41****(11 marks)**

A group of chemistry students set up an experiment to replicate the electrolytic refining of copper metal. They obtained some impure 'blister copper' as well as a thin piece of pure copper and set up an electrochemical cell as shown in the diagram below.



- (a) Explain the chemical principles of an electrolytic cell. (2 marks)
- (b) On the diagram above label; (4 marks)
- the anode and cathode
  - the sign of each electrode
  - the direction of cation flow
  - the direction of electron flow
- (c) State two (2) safety considerations the students would have to take into account when conducting this experiment. (2 marks)

The students recorded the mass of the blister copper and pure copper electrodes before allowing the cell to run for a period of time. They then recorded the mass of each electrode again. Their results are shown in the table below.

	Blister copper	Pure copper
Initial mass (g)	65.8	11.9
Final mass (g)	52.3	25.1

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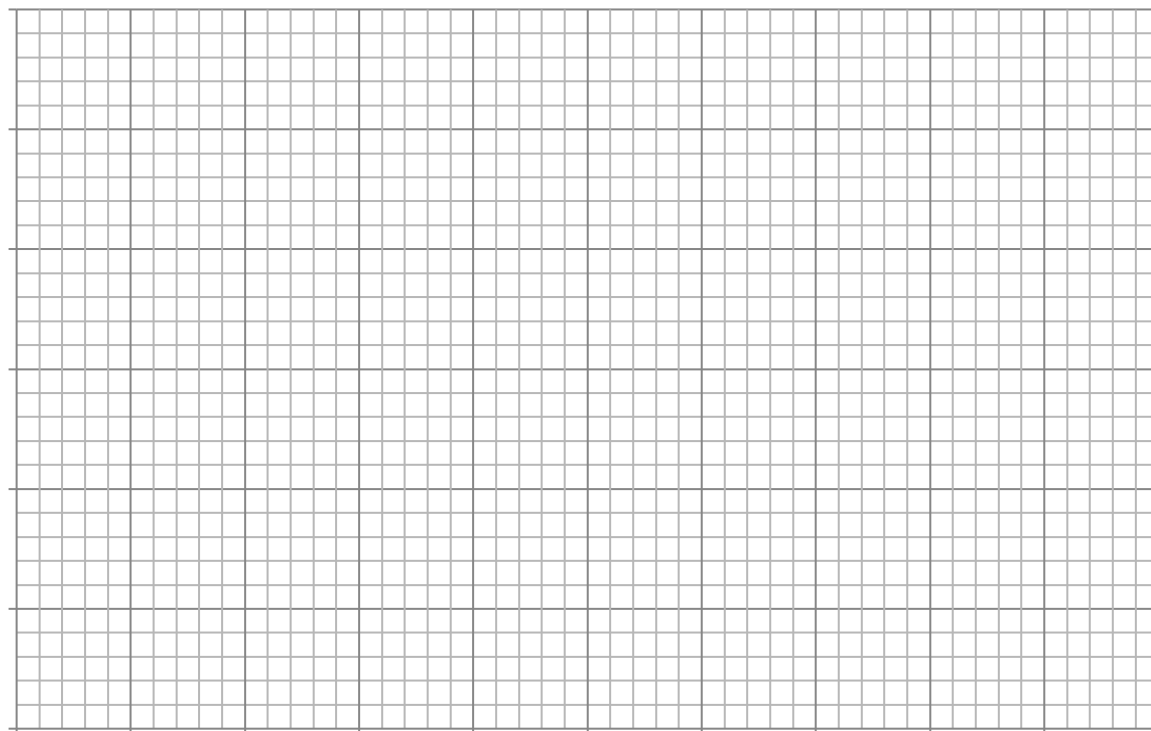


- (d) Calculate the percent purity of the blister copper. (3 marks)

**End of Questions**

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Question number: \_\_\_\_\_



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WATP acknowledges the permission of School Curriculum and Assessment Authority in providing instructions to students.