CHEMISTRY

UNIT 3

2017

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	/70	/35
Section Three: Extended answer	5	5	70	/80	/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.

See next page

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 HPO_3^{2-} is:

   (a) $H_2PO_3^-$
   (b) PO_3^{2-}
   (c) H_3PO_3
   (d) PO_3^{3-}

Questions 4 and 5 relate the following information:

Consider the following information for a 1.00 mol L^{-1} solution of arsenous acid, (H_3AsO_4):

$$H_3AsO_4(aq) \rightleftharpoons H^+(aq) + H_2AsO_4^-(aq)$$

$$Ka \text{ (at 25°C)} = \frac{[H^+]\,[H_2AsO_4^-]}{[H_3AsO_4]} = 6.6 \times 10^{-10}$$

4. At equilibrium at 25°C, which of the following species will be present in the greatest concentration?

   (a) $H^+(aq)$
   (b) $H_2AsO_4^-(aq)$
   (c) $H_3AsO_4(aq)$
   (d) $OH^-(aq)$

See next page

5. Which of the following statements best describe the value of the equilibrium constant (K) for arsenous acid at 25o 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, ($MgCO_3$) 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 $MgCO_3$ (s).

8. Which one of the following statements about the following reversible reaction is TRUE?

$$2SO_2\,(g) + O_2\,(g) \rightleftharpoons 2SO_3\,(g)$$

(a) $K = \dfrac{[SO_2]^2\,[O_2]}{[SO_3]^2}$
(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 ΔH.

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) $2NO_2\,(g) \rightleftharpoons N_2O_4\,(g)$
(b) $N_2\,(g) + 3H_2\,(g) \rightleftharpoons 2NH_3\,(g)$
(c) $H_2O\,(g) + C\,(s) \rightleftharpoons H_2\,(g) + CO\,(g)$
(d) $H_2\,(g) + F_2\,(g) \rightleftharpoons 2HF\,(g)$

See next page

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?

$$I_2\,(s) + H_2O\,(l) \rightleftharpoons IO_3^-\,(aq) + H^+\,(aq) + e^-$$

(a) 2
(b) 5
(c) 10
(d) 12

12. Consider the statements about the following reaction:

$$2H_2O_2\,(l) \longrightarrow 2H_2O\,(l) + O_2\,(g)$$

I H_2O_2 is reduced.
II H_2O_2 is oxidised.
III H_2O_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 ($NaCH_3COO$)	Potassium nitrate (KNO_3)	Ammonium chloride (NH_4Cl)
(a)	neutral	acidic	basic
(b)	basic	neutral	acidic
(c)	acidic	neutral	basic
(d)	basic	acidic	neutral

See next page

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 $OH^-(aq)$ ions are produced.
(c) The anode is the electrode which attracts positive ions.
(d) The anode is the electrode that is oxidised.

Questions 15 and 16 relate the following information:

The overall redox reaction occurring in a dry cell, (Leclanché cell), is shown below.

$$Zn\,(s) + 2\,NH4+\,(aq) + 2\,MnO2\,(s) \longrightarrow Zn2+(aq) + Mn2O3\,(s) + H2O\,(l) + 2NH3\,(aq)$$

15. Which of the following statements regarding the dry cell are correct?

I The zinc outer casing is acting as the anode.
II The oxidation state of manganese decreases from +4 to +3.
III Ammonium chloride acts as an electrolyte for the cell.

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

16. Which of the following will NOT increase the rate of the redox reaction?

(a) Increasing the concentration of ammonium ions.
(b) Grinding up the MnO_2 into a finer powder.
(c) Using a thicker zinc outer casing.
(d) Warming up the cell.

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

See next page

(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:

$CH_4\,(g) + H_2O\,(g) \rightleftharpoons CO\,(g) + 3H_2\,(g) \qquad \Delta H > 0$

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.

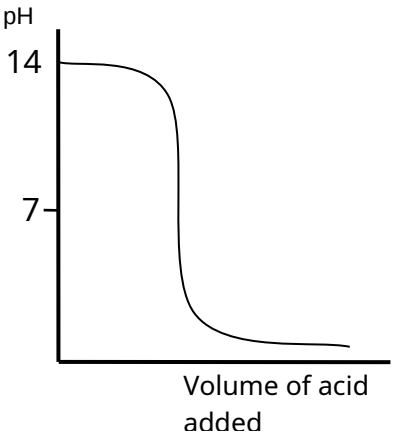
Questions 19, 20 and 21 relate the following information:

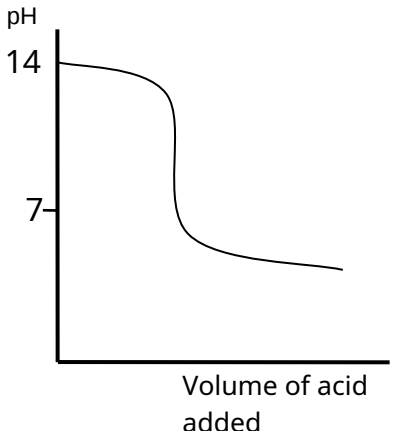
A student was asked to determine the concentration of a solution of ethanoic acid that had a concentration of approximately 0.400 mol L^{-1}. He pipetted 20.0 mL of a 0.500 mol L^{-1} solution of sodium hydroxide into a conical flask, and titrated the ethanoic acid against the standardised sodium hydroxide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

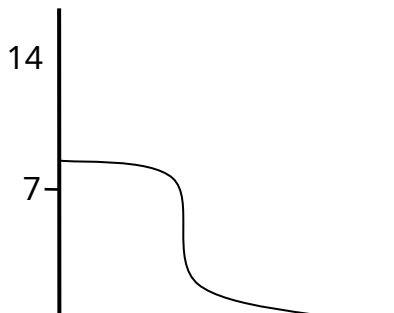
19. What is the pH of the sodium hydroxide solution at the start of the titration?

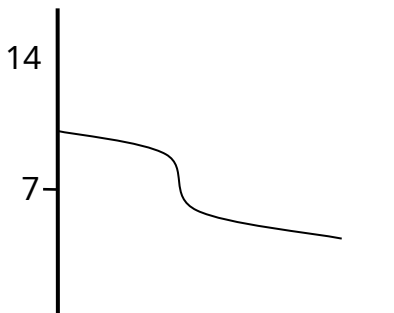
(a) 13.7
(b) 7.00
(c) 14.0
(d) 12.7

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?

(a)


(c)


(b)


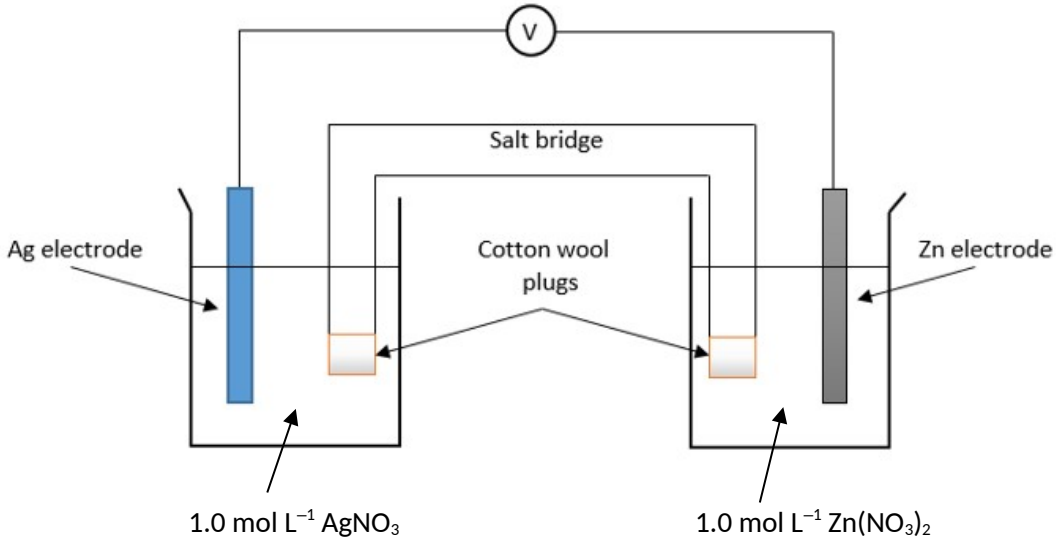
(d)


See next page

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) $2Ag^+(aq) + Zn(s) \longrightarrow 2Ag(s) + Zn^{2+}(aq)$ $E^o = 1.56$ V
(b) $2Ag^+(aq) + Zn(s) \longrightarrow 2Ag(s) + Zn^{2+}(aq)$ $E^o = 0.04$ V
(c) $Zn^{2+}(aq) + 2Ag(s) \longrightarrow Zn(s) + 2Ag^+(aq)$ $E^o = 1.56$ V
(d) $Zn^{2+}(aq) + 2Ag(s) \longrightarrow Zn(s) + 2Ag^+(aq)$ $E^o = 0.04$ 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?

See next page

(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:

$$H_2PO_4^-(aq) + H_2O(l) \rightleftharpoons HPO_4^{2-}(aq) + H_3O^+(aq)$$

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

(a) The forward reaction rate would be unaffected.
(b) The concentration of $H_2PO_4^-$ (aq) present in the system would increase.
(c) The pH of the system would decrease.
(d) The equilibrium would shift to the right.

See next page

End of Section One

See next page

Section Two: Short answer **35% (70 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.

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- 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.

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)

_____

_____

_____

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

_____

_____

_____

See next page

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 undergo in water. (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.

$$CO_2(g) + CO_3^{2-}(aq) + H_2O(l) \rightleftharpoons 2\,HCO_3^-(aq)$$

(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)

_____

_____

_____

_____

_____

_____

_____

_____

See next page

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
$Mg(CH_3COO)_2$ (aq)		
NH_4Cl (aq)		
$NaHSO_4$ (aq)		

Question 29 **(4 Marks)**

The following chemical equation represents an unbalanced redox reaction.

$$MnO_4^-\ (aq) + C_2O_4^{2-}\ (aq) \longrightarrow Mn^{2+}\ (aq) + CO_2\ (g)$$

In the appropriate spaces below, write the two separate half-equations and the overall balanced redox equation.

(4 marks)

Oxidation:

_____

Reduction:

_____

Overall Redox:

_____

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:

$$Br_2(aq) + H_2O(l) \rightleftharpoons HBrO(aq) + H^+(aq) + Br^-(aq)$$

In aqueous solution, bromine, $Br_2(aq)$ is brown. Hypobromous acid, HBrO (aq), and bromide ions, $Br^-(aq)$ 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 NaOH (aq). (3 marks)

Colour:

_____

Explanation:

_____

_____

_____

(b) Addition of excess HCl (aq). (3 marks)

Colour:

_____

Explanation:

_____

_____

_____

See next page

Question 31 **(5 marks)**

Calculate the pH of the resultant solution, if 25.0 mL of 2.00 mol L^{-1} sodium hydroxide and 52.0 mL of 1.00 mol L^{-1} hydrochloric acid are mixed together. (5 marks)

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:

$$N_2(g) + 3\,H_2(g) \rightleftharpoons 2\,NH_3(g) \qquad \Delta H = -92 \text{ kJ mol}^{-1}$$

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 **ΔH**, **E_A**, **catalysed** and **uncatalysed** reaction pathways, and **axes with correct units** stated.

(5 marks)

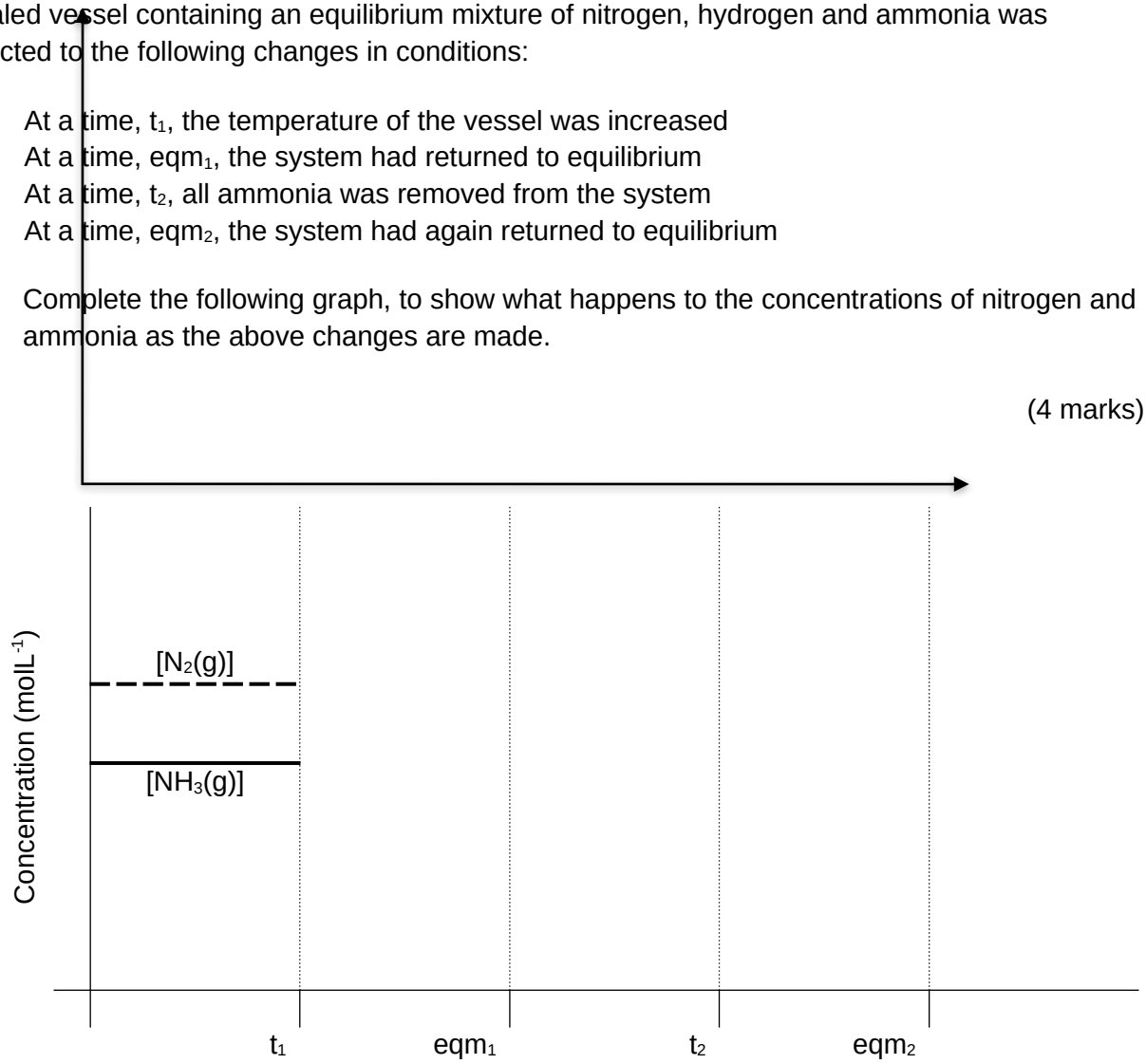
See next page

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:

$$[Al(H_2O)_6]^{3+}(aq) + H_2O(l) \rightleftharpoons [Al(OH)(H_2O)_5]^{2+}(aq) + H_3O^+(aq)$$

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

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

(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)

(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)

(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)

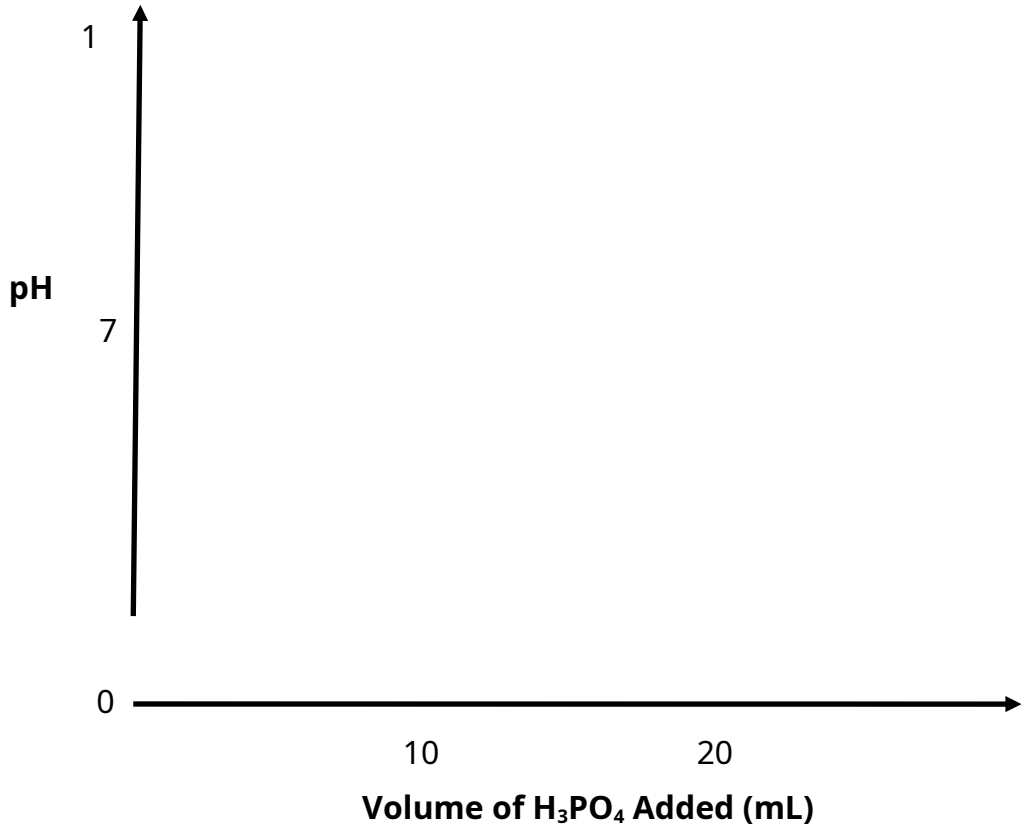
See next page

Question 34 **(8 Marks)**

Phosphoric acid is a weak, **triprotic** acid. In an experiment, a solution of approximately 0.2 mol L^{-1} phosphoric acid (H_3PO_4) is titrated with a standard solution of 0.200 mol L^{-1} sodium hydroxide in order to determine the accurate concentration of the acid. 30.00 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)

(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)

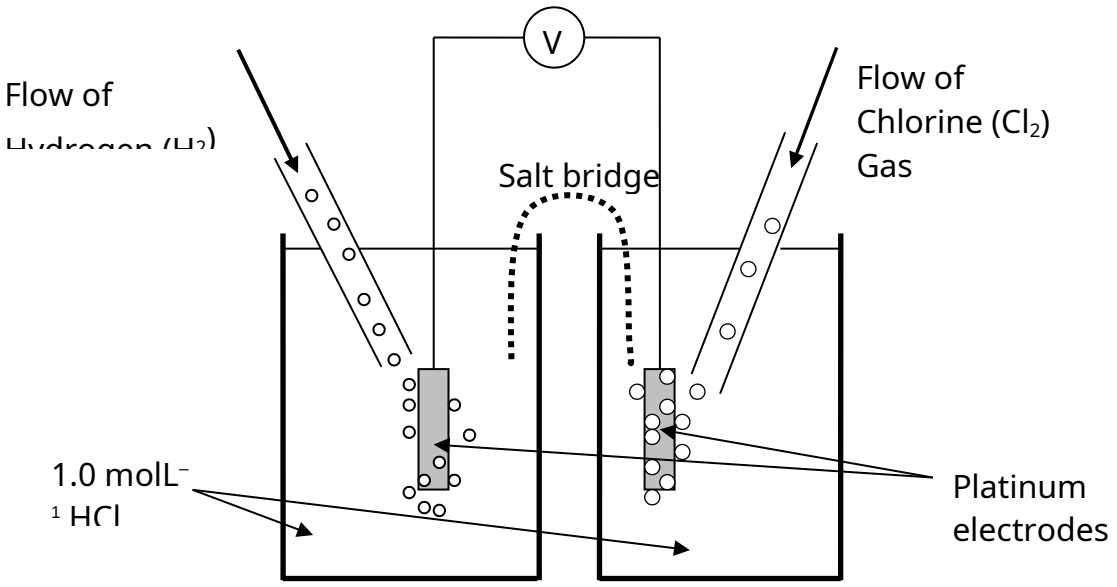
See next page

(e) From the list below, circle the correct indicator, that would be suitable for use in this particular titration. (1 mark)

Methyl orange	**Phenolphthalein**	**Bromothymol blue**
(pH 3.1 – 4.4)	(pH 8.3 – 10.0)	(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:

See next page

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)

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

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^o 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 <u>likely or unlikely to occur</u> as described.

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

(3 marks)

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

(3 marks)

See next page

End of Section Two

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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 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.

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Suggested working time: 70 minutes.

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 18th 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)

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 $CaCO_3$), to a soluble form, (i.e. 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 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)

(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)

(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 $CaCO_3$ are equal to the moles of Na_2CO_3).

(5 marks)

(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)

Effect on calculated percentage (circle one)	Artificially high	No effect	Artificially low

Explanation

Question 38 **(14 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) An example for the industrial importance or application of the process. (1 mark)

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Question 39 **(22 marks)**

Propanoic acid, CH_3CH_2COOH, is a weak monoprotic acid that is produced by bacteria in the skin. In an experiment to determine the concentration of an aqueous solution of propanoic acid, a student titrated 25.0 mL aliquots of the solution with a previously standardised 0.976 mol L^{-1} solution of sodium hydroxide in a conical flask, using a pH meter to monitor the change in pH. The student's results are shown in the table below.

Volume of NaOH (mL)	20.75	20.80	20.85	20.90	20.95	21.00	21.05	21.10	21.15

See next page

pH of solution	4.7	5.3	5.2	5.6	7.9	12.7	13.0	13.2	13.3

(a) Explain why a failure to standardise the sodium hydroxide solution would have led to a systematic error, and what effect it would have on the calculated value for the concentration of the acid. (3 marks)

(b) Plot the results from the experiment on the graph paper provided below, and use your graph to estimate the pH at the equivalence point. Include clearly labelled axes and an appropriate scale. (5 marks)

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Estimated pH at equivalence point: _____ (1 mark)

(c) Use an appropriate equation, to describe and explain the pH at the equivalence point of this titration.

(3 marks)

(d) Use an appropriate chemical equation, to describe and explain why the reaction mixture in the flask was able to act as a buffer before less than 20 mL of sodium hydroxide was added. (4 marks)

After repeating the experiment a number of times, the student found the concentration of the propanoic acid solution was 0.815 mol L^{-1}.

(e) Using the data provided, calculate the pH of the mixture in the flask if 30.0 mL of sodium hydroxide is added to a 25.0 mL aliquot of propanoic acid. (6 marks)

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Question 40 **(14 marks)**

When soils containing iron pyrite (FeS_2) are exposed to air, the following reaction occurs.

$$2\ FeS_2(s) + 7\ O_2(g) + 2\ H_2O(l) \rightarrow 2\ Fe^{2+}(aq) + 4\ SO_4^{2-}(aq) + 4\ H^+(aq)$$

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.

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 $molL^{-1}$ 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)

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

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

See next page

(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 **(14 marks)**

The cell, Cu(s) / Cu^{2+}(aq) and $C\ell_2$(g) / $C\ell^-$(aq) with a platinum electrode, was set up as shown in the diagram below. **Beaker A** contained a 1.00 mol L^{-1} aqueous solution of ammonium chloride, and the filter paper shown in the diagram was soaked in an aqueous solution of potassium nitrate before being placed in the two beakers.

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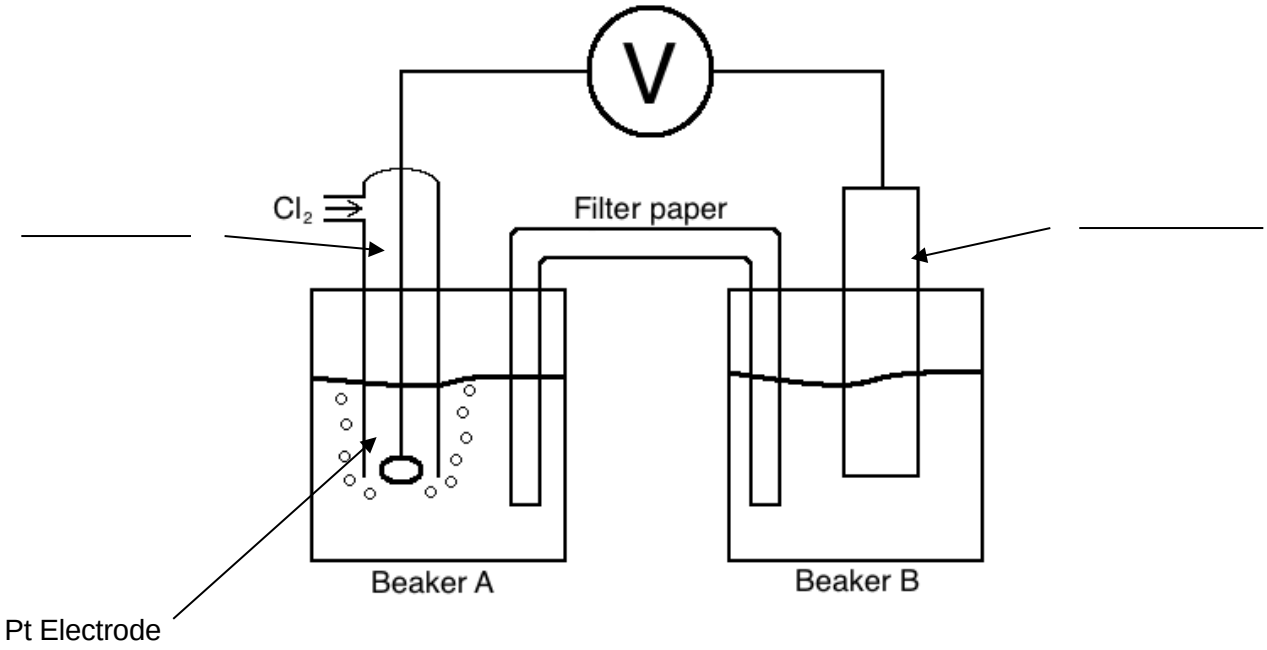

(a) Give the name or formula of a suitable electrolyte for use in **Beaker B**. (1 mark)

(b) Label the **anode** and **cathode** in the diagram above, including their respective **polarities**. (2 marks)

(c) Give **two** reasons why potassium nitrate was a suitable material for soaking the filter paper. (2 marks)

(d) Calculate the maximum theoretical EMF you could measure for the cell. (2 marks)

(e) Give **one** reason why the measured cell potential might differ from the value calculated in part (d) above. (1 mark)

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(f) Describe the changes that would be observed in **Beaker B** during the operation of the cell?
(2 marks)

(g) Using relevant chemical theory and a chemical equation, state and explain how the voltmeter reading would change if a few drops of silver nitrate solution were placed in **Beaker A**.
(4 marks)

End of Questions

See next page

Spare graph paper

Question number: _____

Spare answer page

Question number: _____

Spare answer page

Question number: _____

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