



Carmel School

Semester 1 Examination, 2017

Question/Answer Booklet 1

ATAR CHEMISTRY Unit 3

Student Name:

Teacher Name:

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 | 10 | 10 | 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.

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

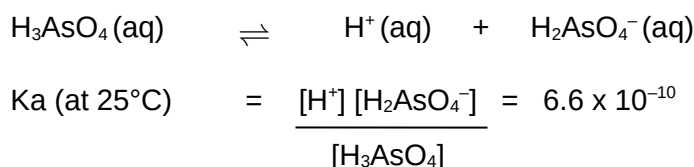
This section has **25** questions. Answer **all** questions on the separate Multiple-choice Answer Sheet provided. For each question, shade the box to indicate your answer. Use only a blue or black pen to shade the boxes. If you make a mistake, place a cross through that square then shade your new answer. 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.

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.

Questions 2 and 3 relate the following information:

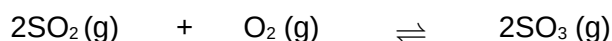
Consider the following information for a 1.00 mol L^{-1} solution of arsenous acid, (H_3AsO_4) :



2. At equilibrium at 25°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) $\text{OH}^-(\text{aq})$
3. 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.
4. 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.
5. 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).

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



- (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 ΔH .
7. 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) $\text{H}_2(\text{g}) + \text{F}_2(\text{g}) \rightleftharpoons 2\text{HF}(\text{g})$

8. The conjugate base of the acid HPO_3^{2-} is:

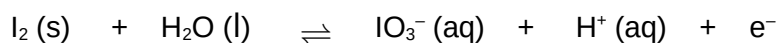
- (a) H_2PO_3^-
(b) PO_3^{2-}
(c) H_3PO_3
(d) PO_3^{3-}

9. 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).

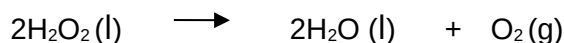
Which one of the following statements about this titration is true?

- (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.

10. 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
11. Consider the statements about the following reaction:



- 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 and II only
(d) I, II and III only
12. Which choice correctly describes the properties of aqueous solutions of the following salts?

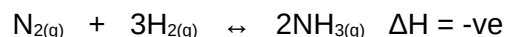
| | Sodium ethanoate (NaCH_3COO) | Potassium nitrate (KNO_3) | Ammonium chloride (NH_4Cl) |
|-----|---|---|---|
| (a) | neutral | acidic | basic |
| (b) | basic | neutral | acidic |
| (c) | acidic | neutral | basic |
| (d) | basic | acidic | neutral |

13. In which of the following processes is chlorine being oxidised?

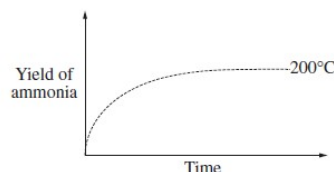
- i. $\text{PCl}_3 + \text{Cl}_2 \rightarrow \text{PCl}_5$
ii. $\text{Cl}_2 + \text{H}_2\text{O} \rightarrow \text{Cl}^- + \text{HClO} + \text{H}^+$
iii. $2\text{Cl}^- \rightarrow \text{Cl}_2 + 2\text{e}^-$
iv. $\text{HClO}_3 + \text{H}_2\text{O}_2 \rightarrow \text{HClO}_4 + \text{H}_2\text{O}$

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

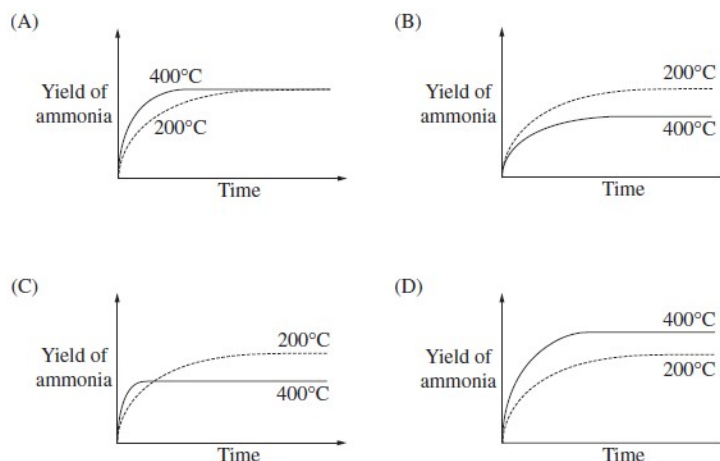
14. Ammonia is produced from hydrogen and nitrogen, according to the equation:



The graph shows the yield of ammonia produced at 200°C and 100kPa.



Which graph shows a correct comparison of the yield of ammonia produced at a temperature of 400°C and 100kPa with the yield produced at 200°C and 100kPa



15. What types of reaction occurs in the Haber process during the production of ammonia?

- (a) Redox and synthesis
- (b) Hydration and redox
- (c) Decomposition and oxidation
- (d) Reduction and decomposition

16. Nitrosyl chloride(NOCl) is a highly toxic gas that decomposes according to the equation



To investigate the reaction, 1.2 mol of $\text{NOCl}_{(g)}$ is placed in an empty 1.0 L flask and allowed to reach equilibrium. The flask and its contents are kept at a constant temperature.

If $[\text{Cl}_{2(g)}] = 0.02 \text{ mol L}^{-1}$ at equilibrium, what is the equilibrium concentration of $\text{NOCl}_{(g)}$?

- (a) 0.80 mol L^{-1}
- (b) 1.00 mol L^{-1}
- (c) 1.10 mol L^{-1}
- (d) 1.40 mol L^{-1}

17. A chemist prepares 0.10 mol L^{-1} solutions of each of the following acids. Which has the lowest pH?

- (a) CH_3COOH
- (b) HNO_3
- (c) HCN
- (d) HOCl

18. Barium hydroxide is soluble in water. The pH of a $0.0050 \text{ mol L}^{-1}$ of $\text{Ba}(\text{OH})_2$ is:

- (a) 2
- (b) 2.3
- (c) 11.7
- (d) 12

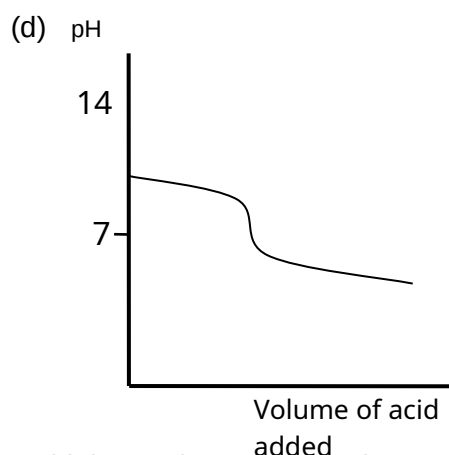
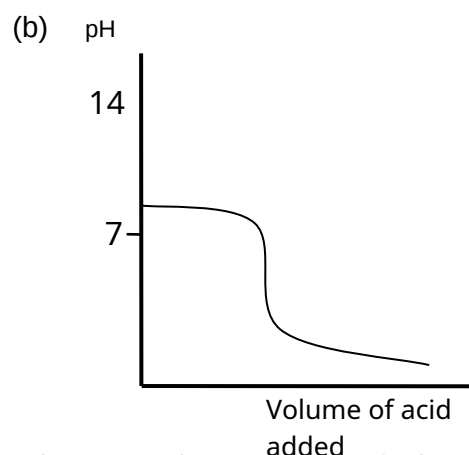
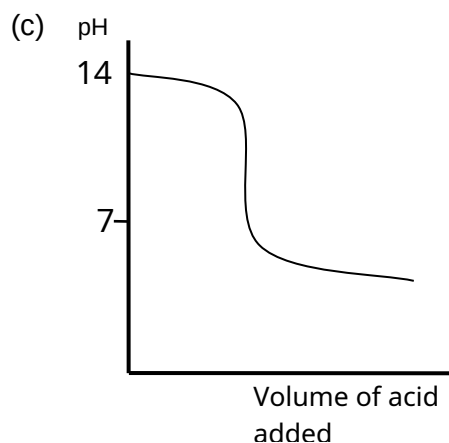
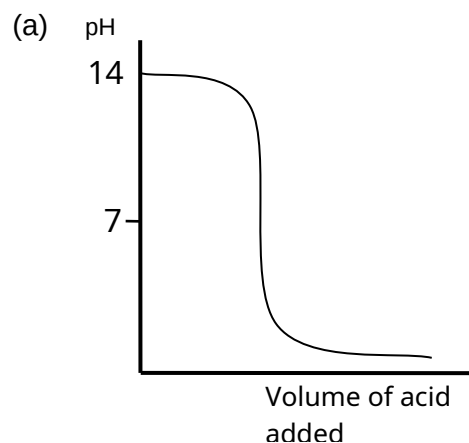
Questions 19, 20 and 21 relate the following information:

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

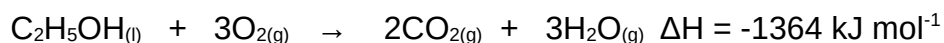
20. If the ethanoic acid was added until it was slightly in excess, which of the following pH graphs would show the variation of pH during the titration?



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

22. The combustion of ethanol occurs according to the equation



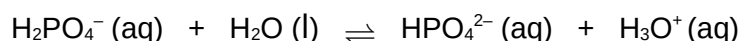
This means that

- (a) burning 1.0 g of liquid ethanol produces 1364 kJ of energy
 - (b) two moles of liquid ethanol burns to produce 2728 kJ of energy
 - (c) 1364 kJ of energy is produced when one mole of gaseous ethanol is burned
 - (d) the activation energy for the combustion of one mole of liquid ethanol is 1364 kJ
23. 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.
24. 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 mol L⁻¹ sodium hydroxide solution to the buffer solution?

- (a) The forward reaction rate would be unaffected.
 - (b) The concentration of H₂PO₄⁻ (aq) present in the system would increase.
 - (c) The pH of the system would decrease.
 - (d) The equilibrium would shift to the right.
25. In which one of the following pairs of substances does the **bolded** species have the same oxidation state?

- (a) **Mn**₂O₃ **Mn**O₂
- (b) **Mn**²⁺ **Mn**O₂
- (c) **Cr**O₄²⁻ **Cr**₂O₇²⁻
- (d) **Cr**O₄²⁻ **Cr**³⁺

End of Section One

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

This section has **10** 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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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)

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.

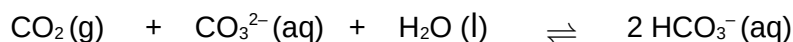
- (a) Write balanced chemical equations showing carbon dioxide reacting with water to form carbonic acid, and then the two successive ionisation reactions that carbonic acid undergo in water. (3 marks)

(i) _____

(ii) _____

(iii) _____

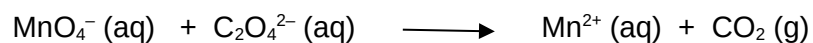
One of the most significant consequences of ocean acidification is the effect that it has on shellfish and other marine life that produce calcium carbonate and relies on it as a major component of the exoskeleton or other supporting structure. If the water is sufficiently acidic, the carbonate structures 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.



- (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)

Question 28**(8 Marks)**

- a) The following chemical equation represents an unbalanced redox reaction.



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

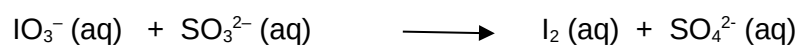
(4 marks)

Oxidation:

Reduction:

Overall Redox:

- b) The following chemical equation represents an unbalanced redox reaction.



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

(4 marks)

Oxidation:

Reduction:

Overall Redox:

Question 29**(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:

Explanation:

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

(3 marks)

Colour:

Explanation:

Question 30**(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 31**(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.

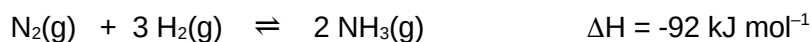
Complete the following table by stating the pH, and give a supporting balanced chemical equation to explain the pH for each of the substances listed.

(6 marks)

| Substance | pH (acidic, basic or neutral) | Equation |
|---|-------------------------------|----------|
| Mg(CH ₃ COO) ₂ (aq) | | |
| NH ₄ Cl (aq) | | |
| NaHSO ₄ (aq) | | |

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.

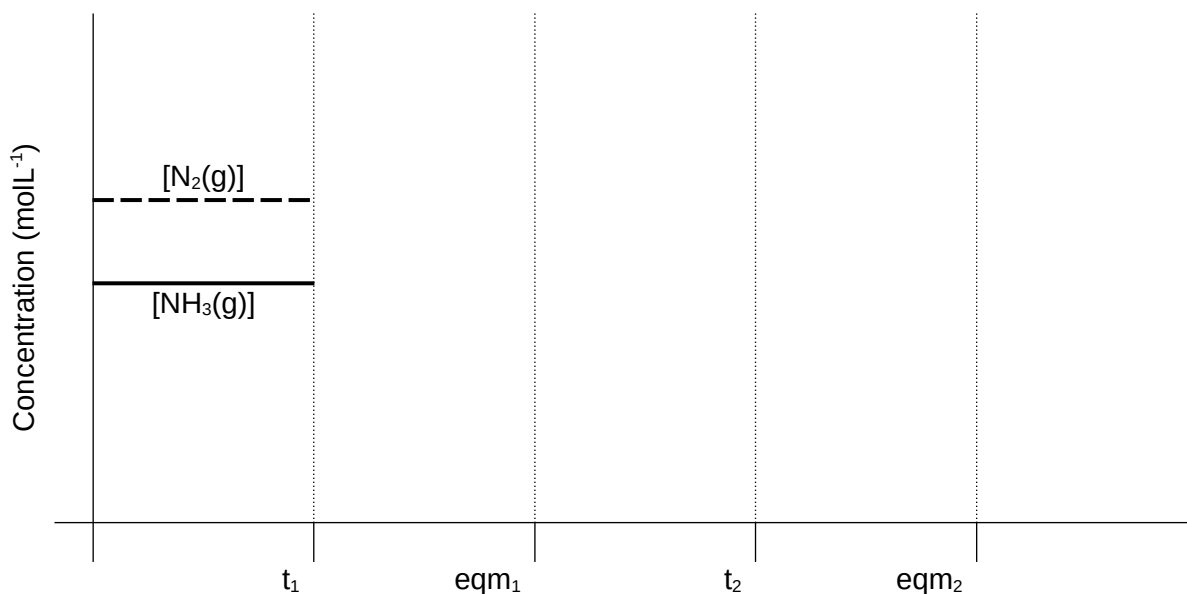
- (a) In the space provided below, draw a fully labelled enthalpy level diagram for the Haber process, showing ΔH , E_A , **catalysed** and **uncatalysed** reaction pathways, and **axes with correct units** stated.

(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.

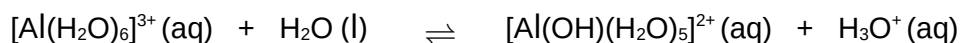


(4 marks)

Question 33

(10 Marks)

Aluminium salts are acidic due to the presence of the hexaaqualuminate ion, $[\text{Al}(\text{H}_2\text{O})_6]^{3+}$ 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.

- (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.

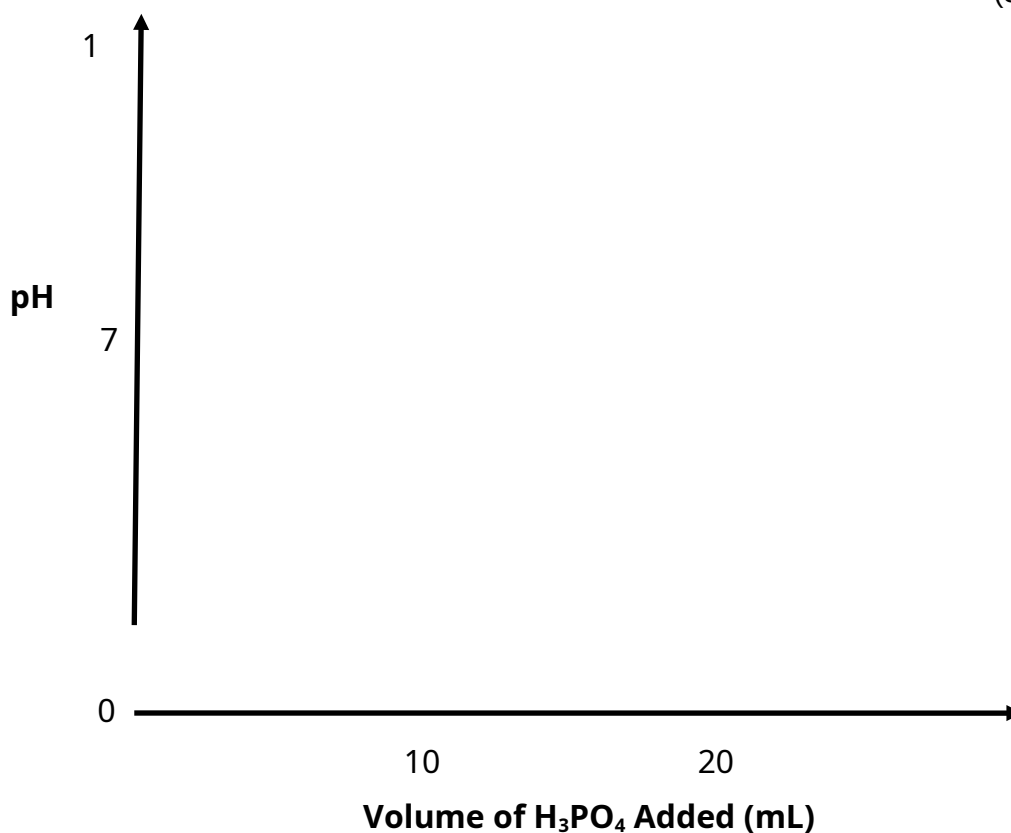
(3 marks)

Question 34**(9 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? Explain. (2 marks)
-
-

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

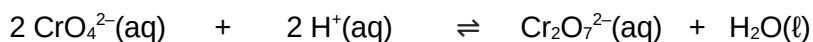
Methyl orange
(pH 3.1 – 4.4)

Phenolphthalein
(pH 8.3 – 10.0)

Bromothymol blue
(pH 6.0 – 7.6)

Question 35**(7 Marks)**

A group of students was investigating the equilibrium between dichromate and chromate ions. The equation for the system is shown below:

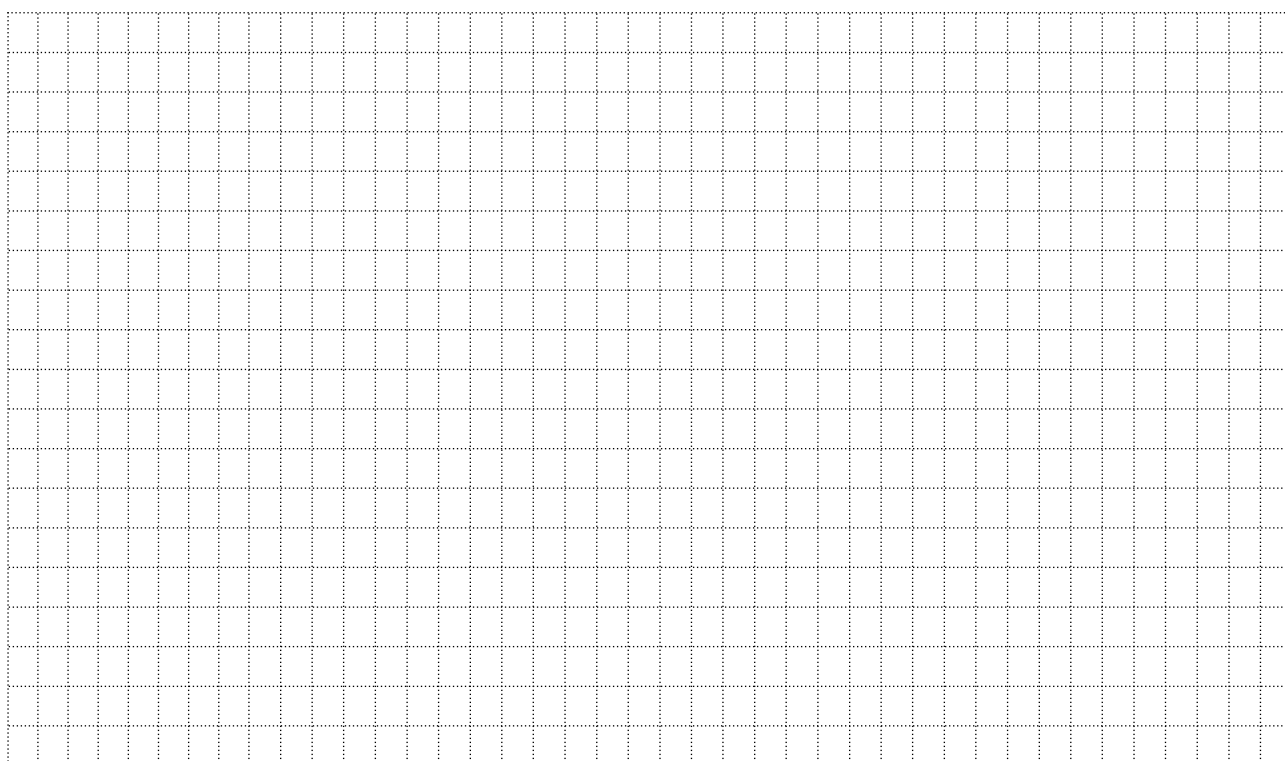


They started with 50.0 mL of a solution of 0.10 mol L⁻¹ potassium chromate, and gradually added hydrochloric acid to the solution. They recorded the colour of the solution and the pH using a pH meter. Their results are shown below.

Table 1. Colour of a solution of potassium chromate on addition of 1.0 mol L⁻¹ hydrochloric acid

| Measurement | Volume of HCl(aq) (mL) | pH | Colour of solution |
|-------------|------------------------|-----|--------------------|
| 1 | 0.0 | 10 | green/yellow |
| 2 | 0.5 | 9.9 | green/yellow |
| 3 | 1.0 | 9.8 | green/yellow |
| 4 | 1.5 | 9.7 | green/yellow |
| 5 | 2.0 | 7.3 | yellow |
| 6 | 2.5 | 6.5 | orange |
| 7 | 3.0 | 4.5 | orange |
| 8 | 3.5 | 3.4 | orange |
| 9 | 4.0 | 2.1 | orange |

- (a) Plot a graph on the grid below showing the variation of pH against volume of hydrochloric acid added. *(a spare grid is provided at the end of the questions if required)* (4 marks)



- (b) Suggest why there was no significant change in pH for the first four measurements.

(1 mark)

- (c) Based on these results, the students concluded that potassium chromate could be used as an indicator in an acid-base titration. Evaluate this conclusion.

(2 marks)

End of Section Two

Carmel School

ATAR Chemistry: Semester 1 Examination, 2017

Question/Answer Booklet 2

Student Name:

Teacher Name:

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.

- 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.

Question 36

(11 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. (2 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 $0.0502 \text{ mol L}^{-1}$.
- 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. (1 mark)

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

(d) Calculate the number of moles of carbonate in the 20.0 mL aliquots. (1 mark)

- (4 marks)

[illegible]

- (2 marks)

Artificially low

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Question 37

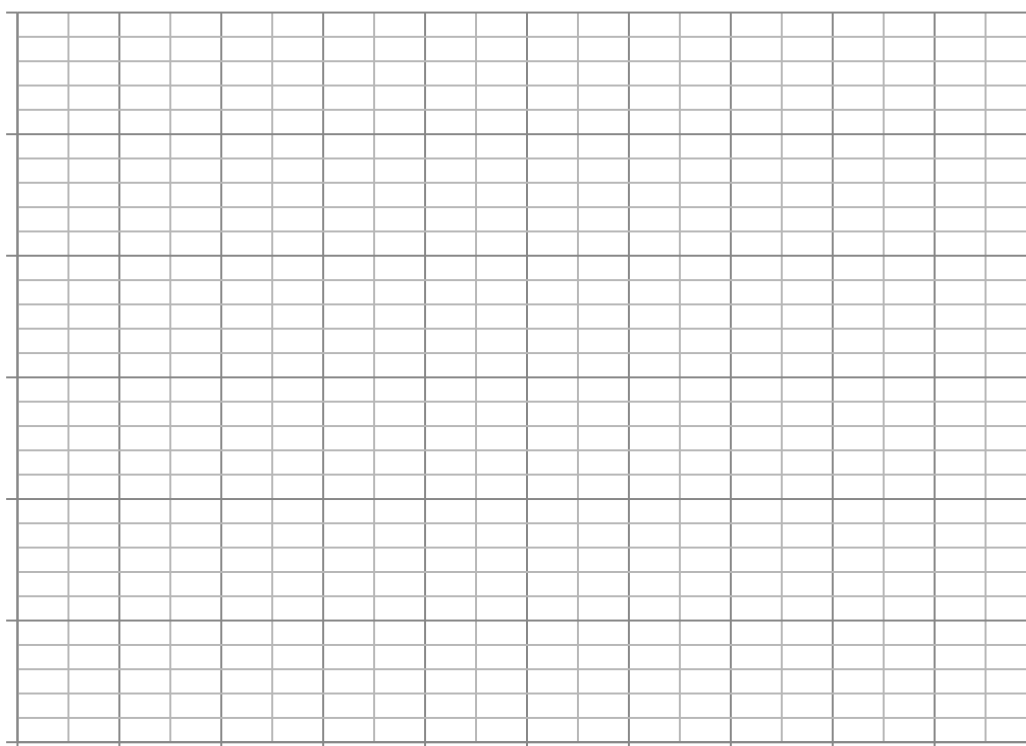
(22 marks)

Propanoic acid, $\text{CH}_3\text{CH}_2\text{COOH}$, 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 |
|---------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 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)



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)

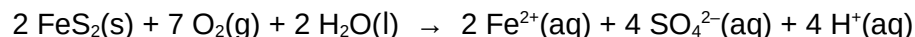
- (d) Use an appropriate chemical equation, to describe and explain why the reaction mixture in the flask was able to act as a buffer before less than 20 mL of sodium hydroxide was added. (4 marks)

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)

Question 38**(14 marks)**

When soils containing iron pyrite (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.

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 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)

- (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)

- (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 39**(18 marks)**

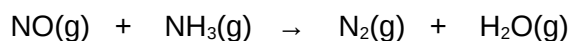
Many industrial processes create waste products such as chimney gases. These gases may contain serious atmospheric pollutants, such as oxides of nitrogen (for example, NO and NO₂).

- (a) State an environmental issue linked to the release of oxides of nitrogen into the atmosphere.

(1 mark)

One way to remove these nitrogen oxides is to treat the chimney gases with ammonia. This treatment converts the oxides of nitrogen in the chimney gases to nitrogen and water. These are then released into the atmosphere.

- (b) Balance the equation for this reaction shown below:



(2 marks)

- (c) 500 kL of ammonia gas is added to the same volume of nitrogen oxide at 25°C and 101.5 kPa. Calculate the amount of nitrogen released into the atmosphere at this temperature and pressure.

(6 marks)

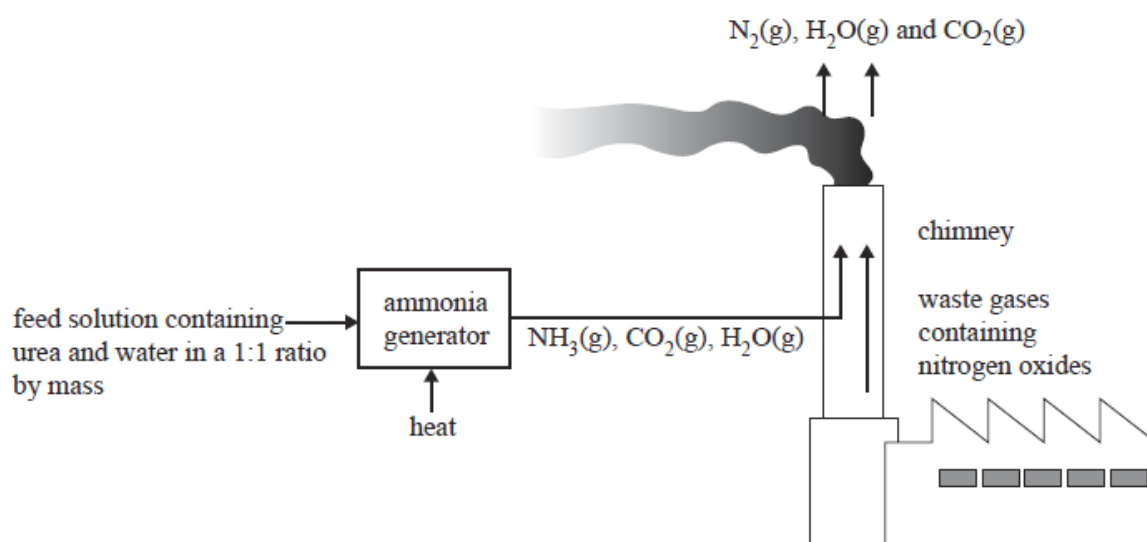
- (d) Calculate the volume of excess reagent not reacted.

(3 marks)

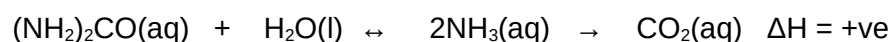
- (e) It is important to adjust the amount of ammonia mixing with the chimney gases to give the correct mole ratio of ammonia to nitrogen oxide (NO). Explain the effect on the composition of the gases released into the atmosphere if the amount of ammonia was too low or too high.

(1 mark)

The ammonia can be produced on site in industrial plants using small scale generators. The ammonia is produced by reacting urea with water. A simplified diagram of such a plant is shown below.



- (f) The chemical reaction occurring in the ammonia generator is:



In a particular generator a 1:1 mass ratio of urea and water is used.

- i which reactant is in excess?

(2 marks)

- ii In this chemical reaction is the excess of one reactant an issue.

(1 mark)

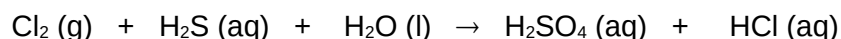
Changing the temperature of the reaction mixture in the ammonia generator can control the amount of ammonia gas produced.

- iii Explain the effect of increasing the temperature on the amount of ammonia formed in the generator. (2 marks)

Question 40**(15 marks)**

Hydrogen sulfide (H_2S) is a common contaminant in drinking water and causes the water to have an unpleasant taste and odour. The addition of chlorine gas is one method by which the hydrogen sulfide can be removed and the water purified.

A tank containing contaminated water was to be treated in this way to remove the hydrogen sulfide. The unbalanced equation below illustrates the reaction that occurs when chlorine is added.



- (a) Balance the equation

(2 marks)

The process represented by the equation above is a redox reaction.

- (b) State which substance has been oxidised and which has been reduced. Use oxidation numbers to support your answer. (3 marks)

The tank held 20 000 L of contaminated water. The concentration of hydrogen sulfide in the water was $7.13 \times 10^{-4} \text{ g L}^{-1}$.

- (c) Calculate the volume of chlorine at STP that would be required to remove all the hydrogen sulfide from the water. (4 marks)

- (d) Calculate the final concentration of HCl (in mol L⁻¹) that would be present in the tank after the chlorination process was complete. (2 marks)

Both of the products in this reaction (hydrochloric and sulfuric acid) are strong acids.

- (e) Explain the difference between a strong and weak acid. (2 marks)

- (f) Sulfuric acid is 'diprotic'. Explain what this term means, using equations to support your answer. (2 marks)

End of Questions

Spare graph paper

Question number: _____

