Hale School
Year 12 Semester 2 Examination, 2017

Write your name below:

_____

Yr12 ATAR CHEMISTRY UNITS 3 & 4

Circle your teacher's initials:

JWZ JJF KF AD

TIME ALLOWED FOR THIS PAPER

Reading time before commencing: Ten minutes
Working time for paper: Three hours

For Examiners only	
Section 1	
Section 2	
Section 3	
Total	

MATERIAL REQUIRED/RECOMMENDED FOR THIS PAPER

TO BE PROVIDED BY THE SUPERVISOR

This Question/Answer booklet for Sections 1 & 2.
A separate Question/Answer booklet for Section 3.
A separate Multiple Choice Answer sheet for Section 1.
A Chemistry Data Sheet.

TO BE PROVIDED BY THE CANDIDATE

Standard Items: Pens, pencils, eraser, ruler

Special Items: A calculator satisfying the conditions set by the Curriculum Council, and a '2B' pencil for the separate Multiple Choice Answer sheet.

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. Please check carefully, and if you have any unauthorised material with you, hand it to the supervisor **BEFORE** reading any further.

INSTRUCTIONS TO CANDIDATES

This paper consists of **THREE SECTIONS** as follows:

SECTION 1 contains **25 questions worth 2 marks each.** It is the multiple choice section.

Answer **ALL** questions in Section 1 on the Separate Multiple Choice Answer Sheet. Use a **'2B' PENCIL**. **DO NOT USE A BALL POINT OR INK PEN**. If you consider that two or more of the alternative answers are correct then select the BEST alternative. Marks will **NOT** be deducted for incorrect answers. This part is worth 50 marks and should take about 50 minutes.

Do not use pencil for Sections 2 & 3.

SECTION 2 contains **8 short answer questions**. You should answer **ALL** the questions. The answers are to be written in the spaces provided in this Examination booklet. This part is worth 70 marks and should take about 60 minutes.

SECTION 3 contains **5 extended response and calculation questions**. You should answer **ALL** the questions in detail in the **separate question/answer booklet provided.** This part is worth 80 marks and should take about 70 minutes.

At the end of the examination make sure that your **name** is on this Examination paper, the separate Question/Answer Booklet for Section 3 and your Multiple Choice Answer Sheet.

SPECIAL INSTRUCTIONS

Chemical Equations

For full marks, chemical equations should refer only to those species consumed in the reaction and any new species produced. These species may be **ions** [for example $Ag^+(aq)$], **molecules** [for example $NH_3(g)$, $NH_3(aq)$, $CH_3COOH(l)$, $CH_3COOH(aq)$] or **solids** [for example $BaSO_4(s)$, $Cu(s)$, $Na_2CO_3(s)$].

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	8	8	60	70	35
Section Three: Extended answer	5	5	70	80	40
				Total	100

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

This section has **25** questions. Answer **all** questions on the separate Multiple-choice Answer Sheet provided. Use a '2B' PENCIL. DO NOT USE A BALL POINT OR INK PEN. If you consider that two or more of the alternative answers are correct then select the BEST alternative. Marks will NOT be deducted for incorrect answers. This part is worth 50 marks and should take about 50 minutes.

Questions 1 and 2 relate to the following reaction:

$$4\ NH_3(g) + 3\ O_2(g) \rightleftharpoons 2\ N_2(g) + 6\ H_2O(g) \quad \Delta H = -1267\ kJ$$

1. Which one of the following will increase the yield of this reaction?

   (a) decreasing the temperature
   (b) dissolving the ammonia gas in water
   (c) adding a catalyst
   (d) increasing the volume of the reaction vessel

2. Which one of the following will increase the rate of the reverse reaction?

   (a) decreasing the temperature
   (b) increasing the volume of the reaction vessel
   (c) removing N_2 from the reaction vessel
   (d) adding a catalyst

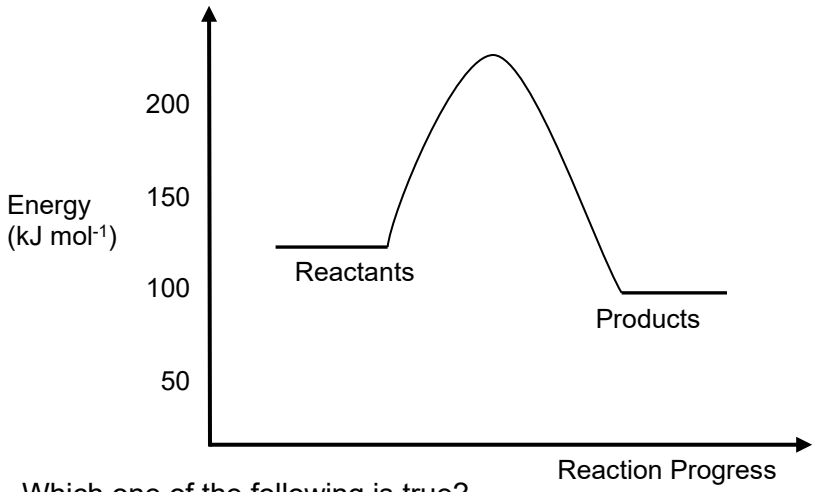
3. Which one of the following statements describing the Brønsted-Lowry theory of acids and bases is true?

   (a) The conjugate base of a weak acid is always a strong base.
   (b) The anion produced by the ionisation of ethanoic acid in water is basic.
   (c) All bases dissociate to form hydroxide ions in solution.
   (d) The hydronium ion (H_3O^+) is the conjugate acid of the hydroxide ion.

4. Which one of the following species **cannot** act as a Brønsted-Lowry acid?

   (a) HCO_3^-
   (b) H_2O
   (c) $C_2O_4^{2-}$
   (d) HSO_4^-

5. An energy profile diagram for a reversible chemical reaction is shown below.



Which one of the following is true?

(a) The forward reaction is endothermic.
(b) Adding a suitable catalyst can reduce the enthalpy change for the reaction.
(c) The activation energy for the reverse reaction is higher than for the forward reaction.
(d) Increasing the temperature will reduce the rate of the forward reaction.

6. Each of the following substances was dissolved in water. Which one of the following answers correctly classifies the resulting solutions?

	$NaHCO_3(aq)$	$KC\ell(aq)$	$NaHSO_4(aq)$	$NH_4NO_3(aq)$
(a)	acidic	basic	acidic	neutral
(b)	basic	neutral	acidic	acidic
(c)	basic	neutral	basic	neutral
(d)	neutral	neutral	acidic	acidic

7. A solution of sodium hydroxide with a pH of 10 was diluted so that the concentration of hydroxide ions was reduced by a factor of 100. Which one of the following would be the pH of the resulting solution?

(a) 0.1
(b) 9
(c) 12
(d) 8

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

(a) $HNO_3(aq)$ / $NO_3^-(aq)$
(b) $HSO_4^-(aq)$ / $SO_4^{2-}(aq)$
(c) $NH_4C\ell$ (aq) / $NH_4NO_3(aq)$
(d) $H_2SO_4(aq)$ / $HSO_4^-(aq)$

9. In which one of the following reactions is water acting as a reducing agent?

(a) $2\ Na(s) + 2\ H_2O(\ell) \rightarrow 2\ Na^+(aq) + 2\ OH^-(aq) + H_2(g)$
(b) $CO_2(s) + H_2O(\ell) \rightleftharpoons H_2CO_3(aq)$
(c) $4\ C\ell O^-(aq) + 2\ H_2O(\ell) \rightarrow C\ell_2(g) + 4\ OH^-(aq) + O_2(g)$
(d) $H_2CO_3(aq) + H_2O(\ell) \rightleftharpoons HCO_3^-(aq) + H_3O^+(aq)$

10. During an acid-base titration experiment, a standard solution was made by dissolving a measured mass of solid sodium carbonate and then titrating the sodium carbonate solution against 20.0 mL aliquots of a solution of hydrochloric acid with an unknown concentration. Which one of the following is classified as a source of systematic error for this experiment?

(a) Weighing out the solid sodium carbonate.
(b) Rinsing the conical flask with distilled water before use.
(c) Not dissolving all the solid sodium carbonate that was weighed.
(d) Crushing the solid sodium carbonate before use.

11. Which one of the following species listed below contains nitrogen with the **lowest** oxidation state?

(a) N_2
(b) N_2H_4
(c) HNO_3
(d) NO_2

12. Consider the following reaction:

$C\ell O_3^- + H_2O_2 \rightarrow C\ell O_4^- + H_2O$

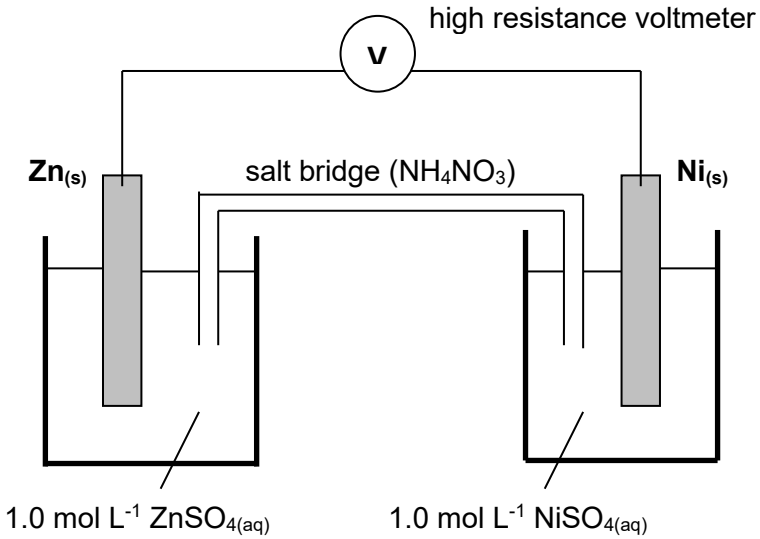
For this reaction, which one of the following is true?

(a) Chlorine is undergoing disproportionation (oxidised and reduced).
(b) Hydrogen peroxide is being oxidised.
(c) The $C\ell O_3^-$ is acting as an oxidising agent.
(d) The oxidation state of hydrogen remains unchanged.

13. Which one of the following substances is capable of oxidising zinc metal but not lead metal?

(a) Co
(b) $AgNO_3$
(c) CdBr
(d) $MgC\ell_2$

The following diagram relates to questions 14 and 15 and shows a cell set up to investigate the redox behaviour of zinc and nickel.



14. Which one of the following is the standard electrode potential of the cell?

(a) -1.00 V
(b) +0.52 V
(c) +1.00 V
(d) -0.76 V

15. When the circuit is connected, which one of the following correctly lists the expected observations?

	Mass of nickel electrode	Mass of zinc Electrode	Colour of $ZnSO_4$ solution	Colour of $NiSO_4$ solution
(a)	increases	decreases	colourless	green colour fades
(b)	increases	decreases	colourless	green colour intensifies
(c)	decreases	no change	colourless	green colour fades
(d)	increases	decreases	turns to green	green colour fades

16. Silver oxide button cells are primary cells used in devices such as watches and hearing aids. The two half half-equations involved in these cells are shown below.

$Zn(s) + 2\ OH^-(aq) \rightarrow ZnO(s) + H_2O(\ell) + 2\ e^-$
$Ag_2O(s) + H_2O(\ell) + 2\ e^- \rightarrow 2\ Ag(s) + 2\ OH^-(aq)$

Which one of the following statements regarding the silver oxide cell is true?

(a) Zinc is acting as the cathode in the cell.
(b) Electrons flow from the anode to the cathode through the electrolyte.
(c) Water will be used up as the cell discharges.
(d) Silver oxide is being reduced as the cell discharges.

17. Steel motorcycle fittings are often electroplated with nickel and then plated with chromium to improve their appearance and resistance to corrosion (the nickel is used to help the chromium adhere to the object).

An experiment is set up to electroplate a motorcycle headlight with nickel.

Which one of the following statements describes how the experiment should be set up?

(a) The cathode is made of nickel and the headlight is the anode.
(b) The headlight is the anode and the electrolyte is a solution of nickel sulfate.
(c) The headlight is the cathode and the electrolyte is a solution of nickel nitrate.
(d) The headlight is the cathode; the anode is made of steel and the electrolyte is nickel carbonate.

18. Which one of the following statements about soaps is correct?

(a) Soaps are typically the sodium or potassium salts of fatty acids.
(b) Soaps act as surfactants because they contain ions with a positively charged end and a negatively charged end.
(c) Soaps are manufactured by using an esterification reaction.
(d) Glycerol is used as a reactant in the manufacture of soaps.

19. Which one of the following is the empirical formula of propyl pentanoate?

(a) $C_8H_{16}O_2$
(b) C_4H_8O
(c) $C_7H_{14}O_2$
(d) CH_2O

20. Which one of the following compounds is the product of the complete oxidation of 2,2-dimethylbutan-1-ol?

(a) $CH_3CH_2COCH(CH_3)_2$
(b) $CH_3CH_2C(CH_3)_2CHO$
(c) $CH_3CH_2(CH_3)_2COOH$
(d) $CH_3CH_2C(CH_3)_2COOH$

21. Which one of the following pairs of compounds would produce biodiesel if reacted together?

(a) a triglyceride and a strong alkali
(b) a carboxylic acid and a strong oxidising agent
(c) an alcohol and a triglyceride
(d) a fatty acid and an ester

22. Which one of the following dipeptides would be produced by the reaction of valine and serine? (Use the structures of amino acids given in your Data Booklet to help with this question)

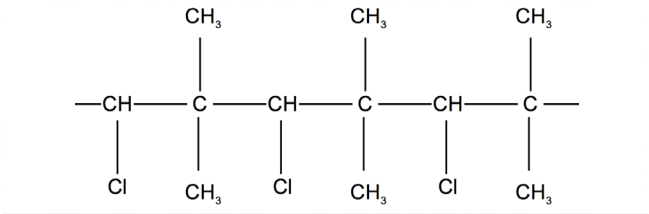
(a) $HOOCCH(CH_3)NHCOCH(CH_3)_2NH_2$

(b) $CH_3CH(CH_2OH)NHCOCH(CH(CH_3)_2)NH_2$

(c) $HOOCCH(CH_3)NHCOCH(CH(CH_3)_2)NH_2$

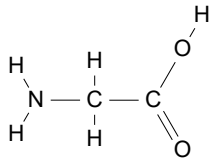
(d) $HOOCCH(CH_2OH)NHCOCH(CH(CH_3)_2)NH_2$

23. Which one of the monomers shown below can be used to synthesise the following polymer?



(a) 1-chloro-2,2-dimethylethene
(b) 1-chlorobut-2-ene
(c) 1-chloromethylpropene
(d) 3-chloro-2-methylbut-2-ene

24. Consider the amino acid with the structural formula below:



Which one of the following is true?

(a) A solution of the amino acid can act as a buffer.
(b) The amino acid has a lower melting point than propanoic acid.
(c) The amino acid can form an addition polymer with itself.
(d) In an acidic solution, the amino acid exists as an ion with an overall negative charge.

25. Which one of the following statements regarding ß-pleated sheets in proteins is true?

(a) The ß-pleated sheets form part of the tertiary structure of proteins.
(b) Hydrogen bonds are responsible for the formation of the ß-pleated sheets.
(c) The ß-pleated sheet structure is created when side chains on the protein interact.
(d) A protein that contains ß-pleated sheets cannot also contain the α-helix structure.

End of section one

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

This section has **8** questions. Answer **all** questions. Write your answers in the spaces provided.

Additional working space pages at the end of this Question/Answer booklet are for planning or continuing an answer. If you use these pages for planning, indicate at the original answer, the page number it is planned/continued on and write the question number being planned/continued on the additional working space page.

Suggested working time: 60 minutes.

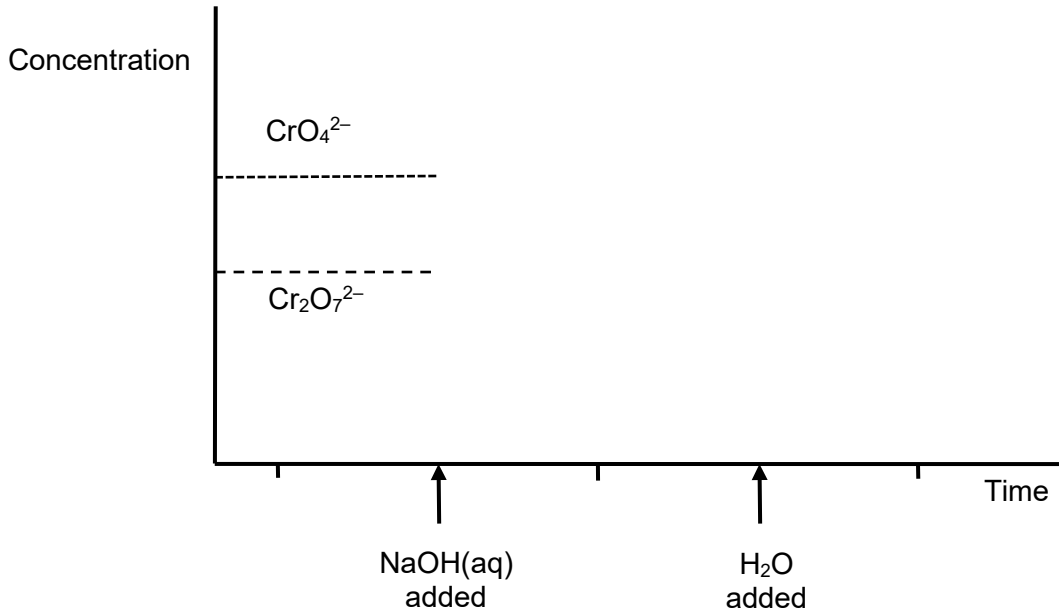
Question 26 **(6 marks)**

A student investigated changes to the following equilibrium.

$$2\ CrO_4^{2-}(aq)\ +\ 2\ H^+(aq) \rightleftharpoons Cr_2O_7^{2-}(aq)\ +\ H_2O(\ell)$$

She took 50 mL of a solution of sodium dichromate/chromate and added sodium hydroxide pellets to the solution. The solution was left to return to a state of equilibrium. She then added 50 mL of distilled water to the beaker and stirred.

(a) Complete the following graph showing the changes to the concentrations of the chromate and dichromate ions involved in the reaction until a new equilibrium is reached. (4 marks)



(b) Describe the colour changes expected over the same time. (2 marks)

_____

_____

_____

Question 27 **(9 marks)**

In April 2017 carbon dioxide levels in the atmosphere reached 410 ppm, a level not reached for millions of years. The increase in levels of carbon dioxide is causing increased ocean acidification. Two symptoms of ocean acidification are the increase in concentration of hydrogen ions and the decrease in the concentration of carbonate ions.

(a) Using relevant equations, explain how increased levels of atmospheric carbon dioxide causes:

(i) an increase in concentration of hydrogen ions in the ocean. (2 marks)

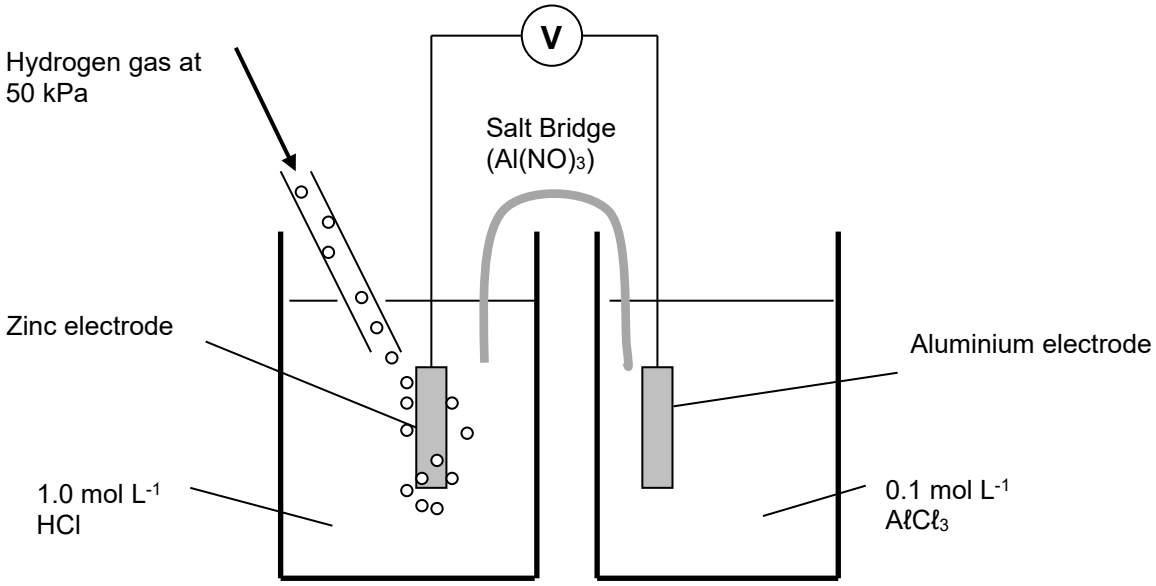
(ii) a decrease in the concentration of carbonate ions. (2 marks)

(b) Explain, using a chemical equation as part of your answer, how the sustainability of coral reefs is put at risk if the concentration of carbonate ions in the ocean is reduced. (3 marks)

(c) Briefly describe why a global commitment to reducing carbon dioxide gas emissions over the next few decades will slow the increase of average temperatures on surface of the Earth. (2 marks)

Question 28 **(7 marks)**

The following electrochemical cell, was used to measure the standard reduction potential of aluminium. The reaction was carried out 30°C.



(a) State four (4) reasons why the measured cell reduction potential of aluminium was different than expected. (4 marks)

(b) (i) On the diagram, label the anode. (1 mark)

(ii) Using the term oxidising agent in your answer, explain your reasoning for identifying this as the anode. (2 marks)

Question 29 (11 marks)

The tertiary structure of proteins is caused by a variety of types of bonding between side groups on the amino acids that make up the protein.

(a) Draw a labelled diagram to show how dispersion forces can occur between two side chains on a protein molecule. (2 marks)

(b) Draw a labelled diagram to show how ionic bonding can occur between two side chains on a protein molecule. (3 marks)

(c) In the case of ionic bonding in part (b), the strength of the attractions between the side groups will be dependent on the pH of the environment that the protein is in.

(i) Using your answer to part (b) above, explain why the strength of the ionic bond will be reduced if the protein was placed in a highly acidic solution.
(3 marks)

(ii) Explain briefly why an alteration in the strength of this bonding may affect the function of the protein molecule. (3 marks)

Question 30 **(11 marks)**

Describe how you could distinguish between the following pairs of compounds using chemical tests. For each test, write one equation for a reaction that occurred. (In (b) the test must not involve using an acid-base indicator*)

<table>
<tr><th></th><th>Compounds</th><th>Description of Test</th><th>Observations</th></tr>
<tr><td rowspan="3">(a)</td><td>butan-1-ol</td><td rowspan="2"></td><td>butan-1-ol</td></tr>
<tr><td>methylpropan-2-ol</td><td>methylpropan-2-ol</td></tr>
<tr><td colspan="3">Equation: (state symbols not required)</td></tr>
<tr><td rowspan="3">(b)</td><td>a solution of methylpropan-2-ol</td><td rowspan="2">*(not involving an acid-base indicator)</td><td>methylpropan-2-ol</td></tr>
<tr><td>a solution of propanoic acid</td><td>propanoic acid</td></tr>
<tr><td colspan="3">Equation: (state symbols required)</td></tr>
</table>

Question 31 **(6 marks)**

Write observations for the changes occurring when the substances below are mixed. In your answers include the appearance of the reactants and any product(s) that form.

If no change is observed, you should state this.

(a) Solid iodine is added to a solution of potassium chloride. (2 marks)

(b) Iron(III) chloride solution is added to solid copper. (2 marks)

(c) Ethene gas is bubbled through a solution of aqueous bromine. (2 marks)

Question 32 **(11 marks)**

(a) 20.0 mL of 0.0400 mol L^{-1} hydrochloric acid solution was added to 45.0 mL of 0.0200 mol L^{-1} sodium hydroxide solution. Calculate the pH of the resulting solution.

(5 marks)

(b) The experiment in (a) was repeated, but this time using 20.0 mL of 0.0400 mol L^{-1} ethanoic (acetic) acid solution instead of the hydrochloric acid. Would the pH of the final solution be the same or different from the answer calculated in part (a)?
Explain your reasoning (no calculations are required).

(3 marks)

(c) The experiment in (a) was repeated again, but this time using 20.0 mL of 0.0400 mol L^{-1} sulfuric acid solution instead of the hydrochloric acid. Would the pH of the final solution be the same or different from the answer calculated in part (a)?
Explain your reasoning.

(3 marks)

Question 33 **(9 marks)**

Carbon disulfide (CS_2) can be manufactured using an endothermic reaction between sulfur trioxide gas and carbon dioxide as shown below:

$$2\ SO_3(g)\ +\ CO_2(g) \rightleftharpoons CS_2(g)\ +\ 4\ O_2(g)$$

(a) Write an expression for the equilibrium constant of the reaction. (1 mark)

(b) Predict how each of the following changes to an equilibrium mixture would affect the yield of CS_2. (increase, decrease or no effect)

(i) addition of CO_2 (at constant total volume) (1 mark)

(ii) increasing the temperature (1 mark)

(iii) adding a catalyst (1 mark)

(iv) increasing the pressure by introducing argon gas into the reaction vessel (at constant volume) (1 mark)

(c) In the production plant, the carbon disulfide is removed from the reaction vessel on a regular basis. Using collision theory, explain how this technique will increase the yield of the reaction. (4 marks)

End of section two

Spare answer page

Question number: _____

Spare answer page

Question number: _____

Hale School
Semester Two Examination, 2017

Write your name below:

_____

Yr12 ATAR CHEMISTRY UNITS 3 & 4

JWZ AD JJF KF

For Examiners only	
Part 3	

Section 3 Question and Answer Booklet.

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

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

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

Final answers to calculations should be expressed to 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 that you are continuing to answer at the top of the page.

Suggested working time: 70 minutes.

Question 34 **(19 marks)**

The opening of Perth Children's Hospital has been delayed due to lead contamination of the drinking water. Lead is a neurotoxin that is particularly harmful to children. One of the possible causes of the contamination was brass fittings. Brass is a metal alloy made of copper and zinc but lead is sometimes added to improve its malleability.

A recent large-scale study on water samples in New South Wales found that low-level lead contamination of water is widespread in Australian homes, with brass tap fittings the most likely source. In a subsequent experiment, the researchers tested water before and after it passed through brass taps and stainless-steel taps. Lead was only found in water that had passed through brass ones.

In 2014, the US government mandated a lead limit of 0.25 percent in plumbing fittings. Taps in Australia are typically made of brass that contains lead at a level of about 2 to 4 percent.

(a) Use evidence from the list of standard reduction potentials on your data sheet to explain why lead from brass is more likely than copper to corrode into drinking water.
(2 marks)

(b) Write an ionic equation, including state symbols, for the reaction of sulfuric acid with metallic lead. (2 marks)

(c) In the experiment described in the passage above, identify the independent and dependent variable. (2 marks)

An experiment was carried out to calculate the percentage of lead in a sample of brass. A 45.13 g sample of brass was dissolved in excess 6.00 mol L^{-1} hydrochloric acid and any non-metallic insoluble solids were filtered out. Then an excess of 0.500 mol L^{-1} sodium sulfate solution was added to precipitate lead(II) sulfate. After washing and drying, this precipitate had a mass of 2.33 g.

(d) (i) Calculate the percentage, by mass, of lead in the sample. (5 marks)

(ii) Write an ionic equation for the precipitation reaction used in this experiment and calculate the minimum volume of the 0.500 mol L^{-1} sodium sulfate solution required.

(4 marks)

Lead acts as a poison by displacing biologically-active metal cations, such as calcium and zinc, from their proteins that act as enzymes. Calmodulin, for example is an enzyme that regulates a number of body functions, including muscle contraction, metabolism and memory. Lead displaces one calcium atom from the enzyme molecule, thus reducing the enzyme's efficiency.

(e) Briefly describe how the enzymes catalyse chemical reactions occurring in the body.

(2 marks)

(f) Using evidence from the periodic table, suggest why the replacement of calcium in an enzyme molecule by lead will significantly affect the function of the enzyme.

(2 marks)

Question 35 **(15 marks)**

A diprotic amino acid, known to only contain carbon, hydrogen, oxygen and nitrogen underwent analysis to determine its formula. When a 12.50 g sample of the amino acid was combusted in oxygen, 18.69 g of carbon dioxide, 6.89 g of water, and 3.91 g of nitrogen dioxide was produced.

2.27 g of the acid was dissolved in 50.0 mL of water. 10.0 mL of this solution required 24.70 mL of 0.250 mol L^{-1} sodium hydroxide solution for complete neutralisation.

(a) Calculate the empirical formula of the amino acid. (7 marks)

(b) Calculate the molecular mass of the amino acid. (4 marks)

(c) Use your data booklet to name the amino acid. (1 mark)

Note: If you were unable to determine an answer to part (c), use aspartic acid for the remainder of this question

(d) Draw the structure of the amino acid that would exist in a solution with a pH of 10.

(1 mark)

(e) Write an equation, using structural formulae, for the reaction between the amino acid and glycine to form a dipeptide.

(2 marks)

Question 36 **(14 marks)**

The reaction for the production of ethanol from ethene is shown below.

$$CH_2CH_2(g) + H_2O(g) \rightleftharpoons CH_3CH_2OH(g) \qquad \Delta H = -45 \text{ kJ mol}^{-1}$$

(a) Use green chemistry principles to explain why it is beneficial to achieve a high yield of ethanol.

(2 marks)

(b) Use sustainability principles to explain why it may be beneficial to source ethanol through a fermentation process rather than the reaction shown above.

(2 marks)

(c) It was found that 170.8 kg of ethanol was produced from 200.0 kg of ethene gas. Calculate the percentage yield of this reaction.

(4 marks)

The ethanol in this reaction can be used to make ethyl ethanoate.

(d) Write an equation for this reaction, and state the conditions required. (2 marks)

(e) If this reaction has a yield (efficiency) of 67.0%, calculate the mass of ethanol required to produce 1.00 tonne (1.00×10^6 g) of the ethyl ethanoate. (4 marks)

Question 37 **(20 marks)**

A team of students competing in a competition to test their titration skills were tasked with using a standard solution of 0.1023 mol L^{-1} hydrochloric acid to standardise a solution of sodium hydroxide. They then had to use this sodium hydroxide solution to determine the concentration of a solution of acetic (ethanoic) acid, CH_3COOH.

They were provided with two indicators, whose names and pH ranges are given below.

Indicator	Acid colour	pH range of colour change	Base colour
Phenolphthalein	colourless	8.2 – 10.0	deep pink
Methyl Red	red	4.8 – 6.0	yellow

The students placed the sodium hydroxide solution in the burette for both titrations and used methyl red indicator for the standardisation of the sodium hydroxide and phenolphthalein for the standardisation of the acetic acid.

They found that an average of 23.55 mL of sodium hydroxide solution was required to neutralise 20.00 mL of the 0.1023 mol L^{-1} hydrochloric acid.

(a) Calculate the concentration of the sodium hydroxide solution. (3 marks)

They then titrated the sodium hydroxide against 25.00 mL of the acetic acid and obtained the following results, using phenolphthalein as the indicator.

Volume of sodium hydroxide	Titrations			
	1	2	3	4
Final Reading (mL)	17.70	35.15	19.45	36.85
Initial Reading (mL)	0.00	17.70	2.00	19.45
Titre (mL)				

(b) Complete the table and calculate the concentration of the acetic acid solution.

Note: if you were unable to calculate the concentration of the sodium hydroxide solution in part (a), use a concentration of 0.1032 mol L^{-1} for the rest of this question.

(i) in moles per litre. (4 marks)

(ii) as a percentage by mass (assume mass of 25.0 mL sample = 25.0 g) (3 marks)

The team was then asked to calculate the concentration of a second solution of acetic acid. They carried out the same method and discovered that only 4.15 mL of the sodium hydroxide was required to neutralise the sample of ethanoic acid. Because of the low volumes for the titre, the effect of any random error in these results is increased.

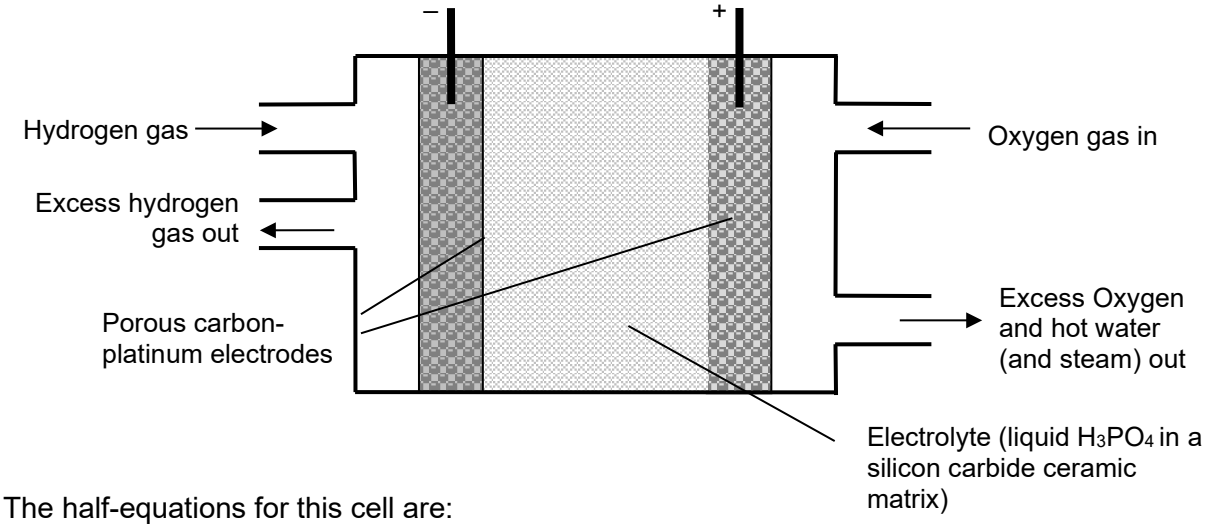
(c) Describe, including quantities of chemicals, how the method of the experiment can be revised to ensure that the volumes of the titres of sodium hydroxide from the burette are approximately 20.00 mL, thus giving more accurate results. (4 marks)

(d) Another, less well-trained team, used the indicators the wrong way, with phenolphthalein indicator for the standardisation of the sodium hydroxide and methyl red for the standardisation of the acetic acid.

Explain in detail how this mistake would affect their results. You can use sketches of graphs in your response. (6 marks)

Question 38 **(12 marks)**

The following diagram represents a phosphoric acid fuel cell. These cells operate at temperatures between 150–200°C and are used as backup power and energy supply for places like banks and hospitals.



The half-equations for this cell are:

Anode: $H_2(g) \rightarrow 2\ H^+(aq) + 2\ e^-$

Cathode: $O_2(g) + 4\ H^+(aq) + 4\ e^- \rightarrow 2\ H_2O(\ell \text{ and } g)$

(a) Examine the diagram and

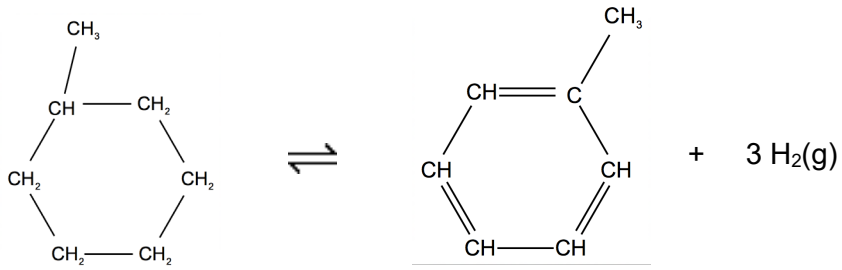
(i) describe the specific role of the phosphoric acid in this cell. (2 marks)

(ii) explain why the porous nature of the electrode aids the process occurring at the anode. (2 marks)

(iii) suggest specifically why a high temperature is used in this cell. (1 mark)

(b) Write the overall redox reaction from the fuel cell and describe one advantage and one disadvantage of the use of the fuel cell directly related to this equation. (3 marks)

(c) The hydrogen used in fuel cells can be synthesised using a range of reactions. One example is the endothermic dehydrogenation of methyl cyclohexane into methylbenzene (toluene) shown below. To maximise the yield the reaction occurs at a high pressure and temperature.



Assuming an 80.0% yield for this reaction, calculate the volume of hydrogen gas at 500°C and 650 kPa produced for every 1000 g of methyl cyclohexane. (4 marks)

End of Questions

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