Government of **Western Australia**
**School Curriculum and Standards Authority**

## ATAR course examination, 2023

## Question/Answer booklet

# CHEMISTRY

Place one of your candidate identification labels in this box.
Ensure the label is straight and within the lines of this box.

WA student number: In figures

In words

## Time allowed for this paper

Reading time before commencing work: ten minutes
Working time: three hours

Number of additional answer booklets used (if applicable):

## Materials required/recommended for this paper

***To be provided by the supervisor***

This Question/Answer booklet
Multiple-choice answer sheet
Data booklet

***To be provided by the candidate***

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

Special items: up to three calculators, which do not have the capacity to create or store programmes or text, are permitted in this ATAR course examination

## 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 material. 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 examination |
|---|---|---|---|---|---|
| Section One Multiple-choice | 25 | 25 | 50 | 25 | 25 |
| Section Two Short answer | 9 | 9 | 60 | 79 | 35 |
| Section Three Extended answer | 5 | 5 | 70 | 86 | 40 |
| | | | | **Total** | 100 |

## Instructions to candidates

1. The rules for the conduct of the Western Australian external examinations are detailed in the *Year 12 Information Handbook 2023: Part II Examinations*. Sitting this examination implies that you agree to abide by these rules.

2. Answer the questions according to the following instructions.

   Section One: 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. Do not use erasable or gel pens. 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 preferably using a blue/black pen. Do not use erasable or gel pens.

3. When calculating numerical answers, show your working or reasoning clearly. Your working should be in sufficient detail to allow your answers to be checked readily and for marks to be awarded for reasoning. Express numerical answers to the appropriate number of significant figures and include appropriate units where applicable.

4. You must be careful to confine your answers to the specific questions asked and to follow any instructions that are specific to a particular question.

5. Supplementary pages for planning/continuing your answers to questions are provided at the end of this Question/Answer booklet. If you use these pages to continue an answer, indicate at the original answer where the answer is continued, i.e. give the page number.

6. The Chemistry Data booklet is not to be handed in with your Question/Answer booklet.

**See next page**

**Section One: Multiple-choice** **25% (25 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. Do not use erasable or gel pens. 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. Which of the following is likely to occur due to the increase of carbon dioxide levels in the atmosphere?

   (a) oceans cool and absorb less carbon dioxide from the atmosphere
   (b) it will be more difficult for crustations to construct their shells
   (c) the pH of oceans will increase, becoming more acidic
   (d) the availability of carbonate ions to marine organisms will increase

2. Which of the following formulae represents an amide?

   (a) $CH_3CH(NH_2)CH_3$
   (b) $CH_3COOCH_3$
   (c) $CH_3CONHCH_3$
   (d) $CH_3COCH_2NH_2$

3. The concentration of chloride ions in the ocean is approximately 35 000 ppm. Which of the following ions is **unlikely** to be present?

   (a) $Ag^+$
   (b) $Pb^{2+}$
   (c) $Mg^{2+}$
   (d) $K^+$

4. In which of the following is vanadium in a +4 oxidation state?

   (a) $NH_4VO_3$
   (b) $VOSO_4$
   (c) $V(H_2O)_6^{3+}$
   (d) $V_2O_5$

5. Identify the oxidant in the following equation.

   $$2\ BrO_3^-(aq) + 10\ I^-(aq) + 12\ H^+(aq) \rightarrow Br_2(aq) + 5\ I_2(aq) + 6\ H_2O(\ell)$$

   (a) $BrO_3^-(aq)$
   (b) $I^-(aq)$
   (c) $H^+(aq)$
   (d) $Br_2(aq)$

**See next page**

Questions 6 to 13 refer to the following information.

A student set up an experiment to investigate the relationship between the temperature of an acid and the rate of carbon dioxide production when reacted with a base. In each trial the student timed how long in seconds it took to produce 100 mL of carbon dioxide in a gas syringe. The results are shown below.

| Temperature of acid (°C) | Time taken to produce 100 mL of carbon dioxide (s) |
|---|---|
| 30 | 91 |
| 40 | 65 |
| 50 | 64 |
| 60 | 21 |

6. Which of the following is an appropriate hypothesis for this investigation?

(a) How does temperature affect the rate of carbon dioxide production?
(b) If 100 mL of carbon dioxide is produced, then the acid is at a low temperature.
(c) Increasing the temperature of the acid will decrease the time taken to produce 100 mL of carbon dioxide.
(d) Decreased volumes of carbon dioxide will be produced if the acid temperature is increased.

7. Which of the following is the dependent variable?

(a) temperature of the acid
(b) time to heat the acid
(c) volume of carbon dioxide produced
(d) time to produce 100 mL of carbon dioxide

8. Which of the following are control variables in this investigation?

(i) volume of carbon dioxide produced
(ii) temperature of the acid
(iii) volume of the acid
(iv) amount of base used
(v) concentration of the acid

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

9. Which of the following substances would be the base used in this investigation?

(a) sodium hydroxide
(b) magnesium
(c) calcium carbonate
(d) copper oxide

**See next page**

10. Which of the following would improve the reliability of the data produced in this investigation?

(i) conduct multiple trials for each temperature
(ii) change the concentration of the acid
(iii) use a range of bases to react with the acid
(iv) increase the range of temperatures investigated

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

11. Which of the following would be classified as a random error?

(a) judging when 100 mL of carbon dioxide is produced
(b) heating the acid in a water bath
(c) using the same balance to weigh out the base
(d) an error in the stopwatch calibration

12. Which of the following would be classified as a systematic error?

(a) judging when 100 mL of carbon dioxide is produced
(b) heating the acid in a water bath
(c) using the same balance to weigh out the base
(d) an error in the stopwatch calibration

13. Which of the following statements **best** describes the relationship between the dependent and independent variables?

(a) The volume of carbon dioxide is decreased as the temperature decreases.
(b) As the temperature of the acid increases, the time taken to produce 100 mL of carbon dioxide decreases.
(c) The rate at which carbon dioxide is produced decreases as the temperature increases.
(d) The change in temperature has no effect on the rate of production of carbon dioxide.

14. Identify the type of structure from the following description:

An organic molecule containing a carboxylic acid group, a side chain and an amine group bound to the same carbon atom.

(a) polyester
(b) soap
(c) α-amino acid
(d) biodiesel



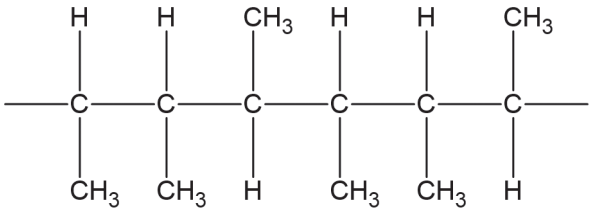
**See next page**

15. Which of the following reactions will occur spontaneously under standard conditions at 25 °C?

(i) $H_2(g) + O_2(g) \leftrightharpoons H_2O_2(aq)$
(ii) $Ni^{2+}(aq) + 2\ Fe^{2+}(aq) \leftrightharpoons Ni(s) + 2\ Fe^{3+}(aq)$
(iii) $H_2O_2(aq) + 2\ CO_2(g) \leftrightharpoons H_2C_2O_4(aq) + O_2(g)$
(iv) $O_2(g) + 2\ H_2S(aq) \leftrightharpoons 2\ S(s) + 2\ H_2O(\ell)$

(a) i and iv
(b) ii and iii
(c) iii and iv
(d) i and ii

16. Identify the monomer for the polymer shown below.



(a) $CH_3CH_2CH_3$
(b) $CH_2CHCH_3$
(c) $CH_3CH_2CH_2CH_3$
(d) $CH_3CHCHCH_3$

17. In the conversion between sulfur dioxide and sulfur trioxide in a sealed vessel, the following equilibrium is established:

$$2\ SO_3(g) \leftrightharpoons 2\ SO_2(g) + O_2(g) \quad \Delta H = 198\ kJ\ mol^{-1}$$

For this system, which of the following statements about the equilibrium constant K is correct? K will

(a) increase if the temperature of the system is decreased.
(b) decrease if the partial pressure of $SO_2(g)$ is increased.
(c) increase if the temperature of the system is increased.
(d) increase if the pressure of the system is increased.

18. Which of the following lists contains compounds that will all produce a basic solution when dissolved in water?

(a) sodium hydroxide, ammonium chloride, potassium carbonate, sodium ethanoate
(b) sodium ethanoate, barium hydroxide, ammonia, sodium carbonate
(c) ammonium iodide, copper(II) sulfate, sodium sulfite, sodium oxide
(d) potassium hydrogencarbonate, iron(III) oxide, sodium iodide, lead(II) sulfate

19. What can be concluded from the statement $K_w = [H^+][OH^-] = 1.0 \times 10^{-14}$ at 25 °C?

(a) Pure water has a pH of 14.
(b) Pure water does not react with acids or bases.
(c) The concentration of hydrogen and hydroxide ions is not equal.
(d) The concentration of hydrogen ions is $1.0 \times 10^{-7}$ mol $L^{-1}$.

**See next page**

20. An electrochemical cell, reaction shown below, has an E° value of +0.89 V.

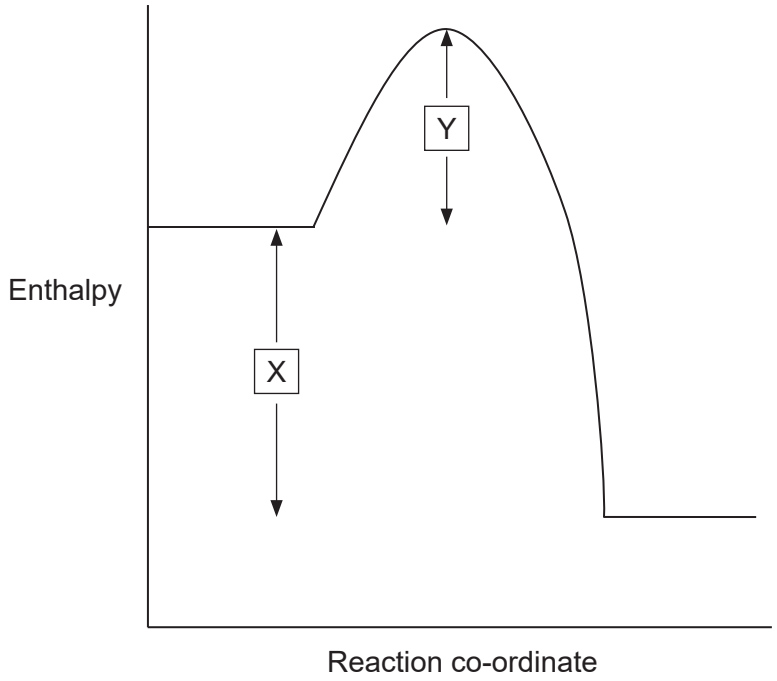
$$4\ V^{3+}(aq) + 2\ H_2O(\ell) + O_2(g) \leftrightharpoons 4\ VO^{2+}(aq) + 4\ H^+(aq)$$

What is the standard reduction potential for the half-equation below?

$$VO^{2+} + 2\ H^+ + e^- \leftrightharpoons V^{3+} + H_2O$$

(a) –0.34 V
(b) +1.57 V
(c) +0.34 V
(d) –1.57 V

21. Consider the following energy profile diagram for a reversible chemical reaction.




Which of the following statements about this reaction are correct?

(i) The reaction mixture will cool as the reaction proceeds.
(ii) Y will reduce in magnitude if a catalyst is used.
(iii) The activation energy for the reverse reaction is X – Y.
(iv) $\Delta H$ for the reverse reaction is +X.
(v) The forward reaction is likely to be faster than the reverse reaction.

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



See next page

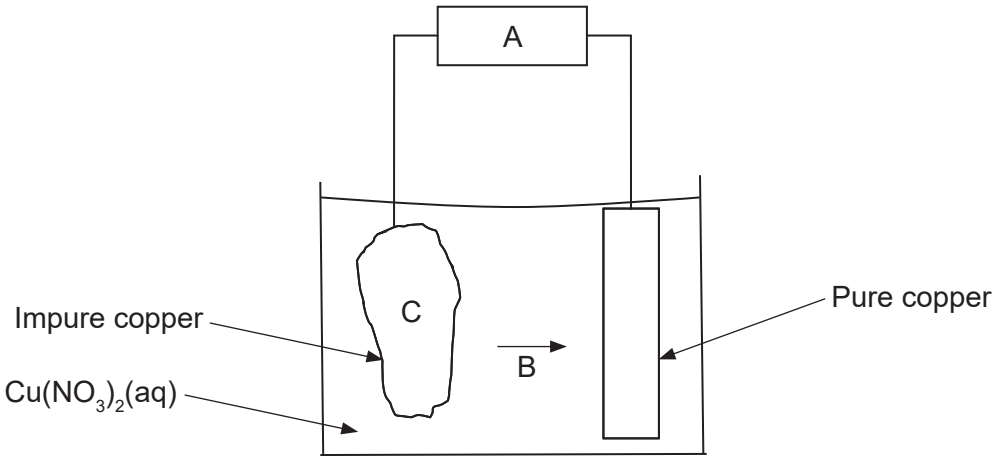
22. The table below shows some properties of a variety of polymers.

| Polymer | Properties |
|---|---|
| Polyvinyl chloride | hard<br>brittle<br>electrically insulating |
| Polypropene | low density<br>tough |
| Polyethylene terephthalate | strong<br>chemical resistant |
| Polytetrafluoroethene | high melting point<br>chemically stable<br>low friction |

From the properties given above, which of the polymers would be the **best** to use to create a non-stick coating on pans?

(a) polyvinyl chloride
(b) polypropene
(c) polyethylene terephthalate
(d) polytetrafluoroethene

23. The cell below was set up by a student to demonstrate the purification of copper.

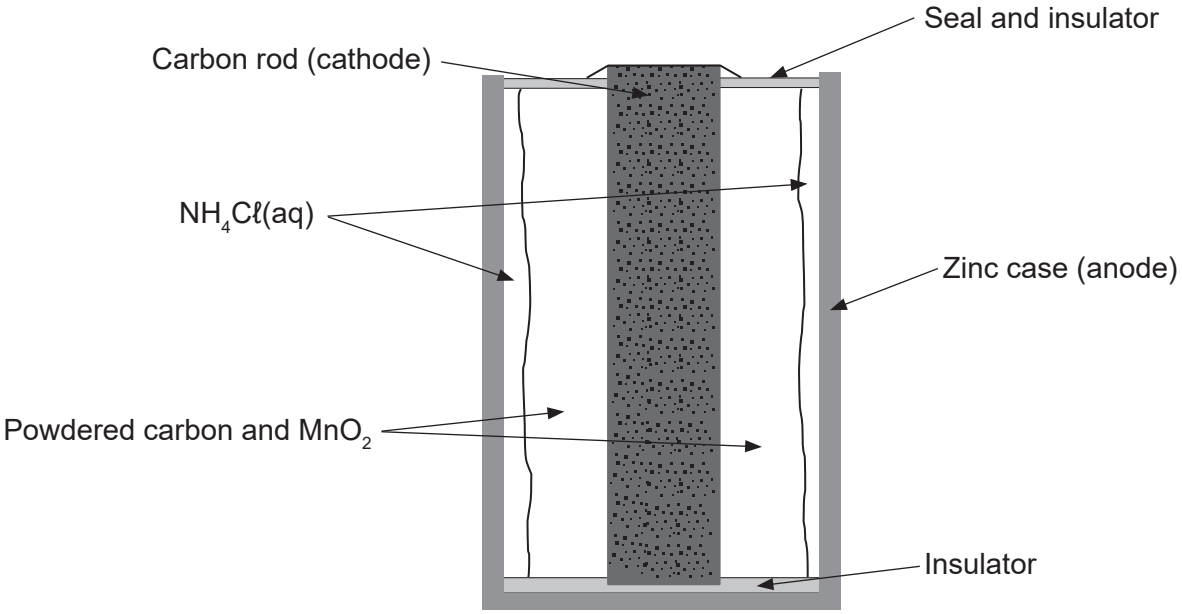



Which of the following are the correct labels, A, B and C, on the diagram?

| | A | B | C |
|---|---|---|---|
| (a) | Voltmeter | Direction of anion flow | Anode |
| (b) | Power supply | Direction of cation flow | Anode |
| (c) | Voltmeter | Direction of anion flow | Cathode |
| (d) | Power supply | Direction of cation flow | Cathode |

**See next page**

Question 24 refers to the following diagram.




24. For the Leclanché dry cell shown above, which of the following statements **best** describes the role of the electrodes?

(a) The zinc is oxidised; reduction of manganese dioxide occurs at the carbon.
(b) The zinc is reduced; carbon is oxidised.
(c) The carbon is reduced; oxidation of manganese dioxide occurs at the zinc.
(d) The carbon is reduced; zinc is oxidised.

25. Which of the following statements **best** differentiates the cleaning action of soaps and detergents?

(a) Soaps contain a long, non-polar hydrocarbon tail, whereas detergents contain a carboxylate head that dissolves in grease.
(b) Detergents form micelles on agitation, whereas the anionic head of soap dissolves in grease.
(c) Detergents do not form precipitates with divalent ions found in water, whereas soaps will precipitate out in similar conditions.
(d) Soaps contain a sulfonate group that dissolves in water, whereas detergents contain a carboxylate group that dissolves in water.

**End of Section One**

**See next page**

**Section Two: Short answer** **35% (79 Marks)**

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

Supplementary pages for planning/continuing your answers to questions are provided at the end of this Question/Answer booklet. If you use these pages to continue an answer, indicate at the original answer where the answer is continued, i.e. give the page number.

Suggested working time: 60 minutes.

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**Question 26** **(11 marks)**

Nitrous acid, $HNO_2$, and formic acid, HCOOH, are both monoprotic weak acids.

(a) Outline the difference between the terms 'monoprotic' and 'polyprotic'. Use equations to illustrate your answer. (4 marks)

(b) Using the Brønsted-Lowry model of acids and bases, write the ionisation equations for both acids. (2 marks)

| | |
|---|---|
| Nitrous acid | |
| Formic acid | |

(c) In the equations above, circle the Brønsted-Lowry bases. (2 marks)

(d) Using **one** of the two acids as an example, describe how Arrhenius theory of acids and bases differs from Brønsted-Lowry theory. Include an appropriate Arrhenius theory equation in your answer. (3 marks)

**Question 27** **(10 marks)**

A carpenter left a pair of pliers outside over a rainy period, which subsequently became rusty, causing the joint to seize. Rather than buy a new pair of pliers, the carpenter decided to submerge the rusty part of the pliers in phosphoric acid to remove the rust. Phosphoric acid converts rust into another substance that can easily be washed away.


(a) Write an equation for the action of phosphoric acid on the rust. Assume rust is iron(III) oxide. Include state symbols in your answer. (3 marks)

(b) Identify the best method that the carpenter could use to protect the pliers from rusting further. Explain how this method would be effective. (3 marks)

Method: _____

Explanation: _____

The carpenter noticed that his toolboxes in the back of his truck were also rusting. He decided to explore the use of a sacrificial anode as an option to prevent the toolboxes rusting.

(c) State what a sacrificial anode is and explain how it is effective in preventing corrosion of the toolboxes. You should state which metal could be used for a sacrificial anode in your answer. (4 marks)

**See next page**

**Question 28** **(8 marks)**

The pH of blood is maintained in a narrow range by the carbonic acid and hydrogencarbonate buffer system, represented by the following equilibrium:

$$H_2CO_3(aq) + H_2O(\ell) \leftrightharpoons HCO_3^-(aq) + H_3O^+(aq)$$

(a) Define the term 'buffer' and identify the chemical species in this system responsible for its buffering capacity. Specify the role of each chemical species you identify in your answer. (3 marks)

(b) Explain what will happen in the blood when there is an elevated concentration of carbon dioxide. Predict how blood pH is affected. Include relevant equations in your answer. (5 marks)



**See next page**

**Question 29** **(8 marks)**

Electrochemical cells are categorised as either galvanic cells or electrolytic cells. Identify **three** similarities and **three** differences with which to compare galvanic and electrolytic cells, using relevant examples of each cell type. You may choose to use diagrams to illustrate your answer.

Similarities:

Differences:



**See next page**

**Question 30** **(12 marks)**

Write a balanced ionic equation for any reactions occurring between the following substances and state any observations before and after mixing.

If there is no reaction, write 'no reaction' for the equation and if there is no change observed write 'no visible reaction'. Use the colours stated in the Data booklet if required.

(a) A piece of iron wool is added to a 0.1 mol $L^{-1}$ solution of copper(II) sulfate. (4 marks)

Equation

Observations

(b) Calcium hydrogencarbonate powder is added to excess 1 mol $L^{-1}$ nitric acid. (4 marks)

Equation

Observations

(c) Excess chlorine gas is bubbled through a 0.1 mol $L^{-1}$ sodium bromide solution. (4 marks)

Equation

Observations



**See next page**

**Question 31** **(9 marks)**

Condensation reactions between α-amino acids form polypeptides called proteins. The function performed by any given protein is determined by its structure, and the structures of proteins are described in terms of levels: primary, secondary and tertiary.

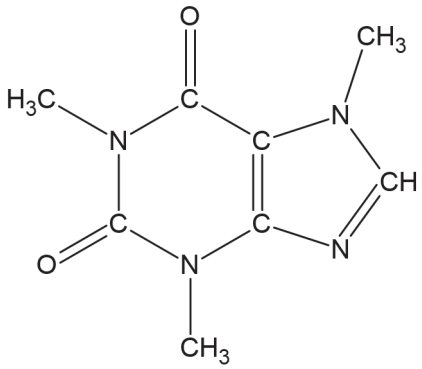
(a) Define the primary structure of a protein, including a description and an annotated diagram to explain how the α-amino acid monomers are joined. (4 marks)

(b) Explain the difference between the secondary and tertiary structures of proteins. Include a description of each level of the structure and how it forms in your answer. (5 marks)

**See next page**

**Question 32** **(5 marks)**

Decaffeinated coffee is coffee from which the caffeine has been removed. The structure of caffeine is shown below.




In the decaffeination process, the solvent used should only dissolve caffeine so it can be removed, leaving compounds that are responsible for the flavours of coffee. Using your understanding of intermolecular forces, explain why dichloromethane, $CH_2C\ell_2$, can act as a solvent to remove caffeine.

**Question 33** **(7 marks)**

A barium hydroxide solution is titrated against an ammonium chloride solution to produce barium chloride, ammonia and water.

(a) Write a balanced ionic equation for this reaction. (2 marks)

Consider the following indicators

| Indicator | pH change range | Colour change |
|---|---|---|
| Methyl orange | 3.1–4.4 | Red to yellow |
| Bromothymol blue | 6.2–7.6 | Yellow to blue |
| Phenolphthalein | 8.3–10.0 | Colourless to pink |

(b) Identify the most appropriate indicator for this titration and justify your choice, using an equation to support your answer. (5 marks)



**See next page**

**Question 34** **(9 marks)**

Sorbic acid is a monoprotic weak acid that occurs widely in nature and is used as a food preservative due to its antimicrobial properties. The ionisation of sorbic acid in water to the sorbate ion and hydronium ion is shown in the equation below:

$$CH_3(CH)_4COOH(aq) + H_2O(\ell) \leftrightharpoons CH_3(CH)_4COO^-(aq) + H_3O^+(aq)$$

(a) Write the equilibrium constant K expression for the ionisation of sorbic acid in water. (2 marks)

(b) Under certain conditions, a 0.250 mol $L^{-1}$ aqueous solution of sorbic acid has a pH of 2.23. Calculate the concentration of $H_3O^+$ to determine the percentage yield of the sorbate ion at equilibrium in 1.00 L of the solution. (4 marks)

(c) Explain the classification of sorbic acid as a weak acid with reference to **both** your answer to part (b) above and its acidity constant value $K_a = 1.73 \times 10^{-5}$ (20 °C). (3 marks)

**End of Section Two**

**See next page**

**Section Three: Extended answer** **40% (86 Marks)**

This section contains **five** 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 and include appropriate units where applicable.

Supplementary pages for planning/continuing your answers to questions are provided at the end of this Question/Answer booklet. If you use these pages to continue an answer, indicate at the original answer where the answer is continued, i.e. give the page number.

Suggested working time: 70 minutes.

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**Question 35** **(14 marks)**

The Ostwald process is used in the conversion of ammonia to nitric acid according to the equations below.

Equation 1: $4\ NH_3(g) + 5\ O_2(g) \rightarrow 4\ NO(g) + 6\ H_2O(g) \quad \Delta H = -905.2\ kJ\ mol^{-1}$

Equation 2: $2\ NO(g) + O_2(g) \leftrightharpoons 2\ NO_2(g) \quad \Delta H = -114.0\ kJ\ mol^{-1}$

Equation 3: $3\ NO_2(g) + H_2O(\ell) \rightarrow 2\ HNO_3(aq) + NO(g) \quad \Delta H = -117.0\ kJ\ mol^{-1}$

(a) The reaction in Equation 1 is carried out with a platinum-rhodium catalyst at approximately 850.0 °C and 1500 kPa. Using collision theory, account for these conditions. (8 marks)

**See next page**

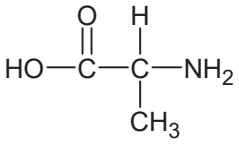
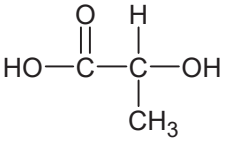
(b) A nitric acid plant requires a production of 1095 tonnes of nitric acid by means of the Ostwald process each day. If the conversion of ammonia to nitric acid is 77.65% efficient, calculate the volume of ammonia at standard temperature and pressure (STP) that must be fed into the process each day. Give your answer to the appropriate number of significant figures. (6 marks)



See next page

**Question 36** **(18 marks)**

The molecular structures of alanine and lactic acid are shown below with their molecular formulae and melting points. Alanine is an α-amino acid while lactic acid may be classified as an α-hydroxy acid.

| **Compound name** | Alanine | Lactic acid |
|---|---|---|
| **Molecular structure** |  |  |
| **Molecular formula** | $C_3H_7NO_2$ | $C_3H_6O_3$ |
| **Melting point** | 297 °C (decomposes) | 16.8 °C |

Lactic acid is the active constituent in a popular brand of liquid toilet cleaner. A chemist transferred a 10.00 mL sample of the toilet cleaner into a beaker and found it weighed 11.218 g. To confirm the amount of lactic acid in the toilet cleaner, a volumetric analysis on this sample was completed as follows. The liquid sample was diluted with water to 100.0 mL in a volumetric flask and 10.00 mL aliquots titrated against standardised sodium hydroxide solution with a concentration of $9.861 \times 10^{-3}$ mol $L^{-1}$. The average titre for this analysis was 22.74 mL.

(a) Describe the procedure for transferring the sample to the volumetric flask and diluting it for this analysis. (4 marks)



**See next page**

(b) Calculate the concentration of lactic acid in the toilet cleaner, in g $L^{-1}$. (5 marks)

(c) Account for the large difference in melting points between alanine and lactic acid. (4 marks)



See next page

**Question 36** (continued)

(d) Under certain conditions, both alanine and lactic acid form condensation polymers which produce water molecules. Draw the structures of each polymer, showing all atoms and bonds. Each polymer should contain three repeating units. (5 marks)

Polymer formed between alanine molecules

Polymer formed between lactic acid molecules



**See next page**

**Question 37** **(29 marks)**

A 2.31 g sample of a hydrocarbon was combusted, and 7.25 g of carbon dioxide and 2.97 g of water were produced.

(a) Determine the empirical formula of the hydrocarbon. (4 marks)

(b) A second 4.67 g sample of the hydrocarbon was vaporised and found to occupy 1.42 L at 150 °C and 205 kPa. Calculate the molar mass of the compound and determine its molecular formula. (5 marks)



**See next page**

**Question 37** (continued)

(c) The hydrocarbon has three straight-chain isomers (no branching). Complete the table below by drawing the structure of and naming the three isomers. Show all atoms and bonds in each structure. (9 marks)

If you were unable to determine an answer to part (b) use $C_5H_{10}$ as the molecular formula for the remaining parts of this question.

| Structure | IUPAC Name |
|---|---|
| | |
| | |
| | |

(d) State which isomer reacts with water to produce a primary alcohol. Write an equation for this reaction. (3 marks)

Isomer: _____

**See next page**

The alcohol produced in part (d) on page 26 can be fully oxidised by acidified potassium dichromate solution.

(e) (i) Write an ionic equation for this reaction. (3 marks)

(ii) Describe fully the observations for this reaction. (2 marks)

(f) (i) Write an equation for the reaction between the organic products from parts (d) and (e). (2 marks)

(ii) Name the organic product of this reaction. (1 mark)



See next page

**Question 38** **(10 marks)**

Groundwater, in addition to dam water and desalinated seawater, is part of the water supply to Perth homes. Groundwater contains a wide variety of chemicals that can affect the quality of drinking water. One of the contaminants is iron, often found in the form of iron(II) hydrogencarbonate.

The iron can be removed by the addition of chlorine gas. Enough calcium hydrogencarbonate is added to maintain a slightly basic pH. The reaction can be represented by the following equation:

$$2\ Fe(HCO_3)_2 + C\ell_2 + Ca(HCO_3)_2 \rightarrow\ 2\ Fe(OH)_3 + CaC\ell_2 + 6\ CO_2$$

(a) 7.00 g of chlorine gas is bubbled through 30 000 L of groundwater containing 39 010 mg of iron(II) hydrogencarbonate to which 16.22 g of calcium hydrogencarbonate has been added. Calculate the mass of iron(III) hydroxide that will be precipitated. (8 marks)

(b) Calculate the concentration of calcium chloride in the final solution. (2 marks)

**See next page**

**Question 39** **(15 marks)**

Ethanol can be produced either from plant materials or from petrochemical sources.

(a) When ethanol is produced from plant sources, the material is ground up. The starches and cellulose in the material are then converted into sugars. Yeast or zymase is mixed with the sugars at 25 to 37 °C and a pH of between 3 and 5 at atmospheric pressure. The products of the fermentation process are ethanol and carbon dioxide.

(i) Justify the conditions used for fermentation. (2 marks)

(ii) Write an equation for the fermentation process, using $C_6H_{12}O_6$ as the sugar. Use condensed structures in your equation. (2 marks)

Ethanol can also be produced by the endothermic hydration of ethene. This is carried out at 250 to 300 °C and 6000 to 7000 kPa in the presence of an acid catalyst.

(b) (i) Write an equation for the hydration of ethene. Use condensed structures in your equation. (3 marks)

**Question 39** (continued)

(ii) Justify the temperature and pressure used for the hydration of ethene. (5 marks)

(c) State **three** reasons why the fermentation process to produce ethanol is more common than the hydration of ethene. (3 marks)

One:

Two:

Three:

**End of questions**

Supplementary page

Question number: _____

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