CORPUS CHRISTI COLLEGE

SEQUERE DOMINUM

Semester Two examination 2017

Question/Answer Booklet

CHEMISTRY

ATAR Unit 3 and 4

Student Number: | | | | | | | | | |

Student Number in words: _____

_____

Time allowed for this paper

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

Material required/recommended for this paper

To be provided by the supervisor
This Question/Answer booklet
Multiple-choice answer sheet
Chemistry 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: non-programmable calculators approved for use in this 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	10	10	60	70	35
Section Three Extended answer	5	5	70	80	40
				Total	100

Instructions to candidates

1. The rules for the conduct of Western Australian Certificate of Education course examinations are detailed in the *Year 12 Information Handbook 2017*. 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. 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.

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 the use of planning/continuing your answer to a question have been 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 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. 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 one of the following will increase the yield of the following reaction?

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

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

2. Consider the following system, which is at equilibrium.

$$Ag^+(aq) + Br^-(aq) \rightleftharpoons AgBr(s) + heat$$

Which one of the following changes would cause a decrease in the concentration of silver ions, as the system re-establishes equilibrium?

(a) Cooling the system.
(b) Placing the system under higher pressure.
(c) Stirring the equilibrium mixture.
(d) Adding solid silver bromide to the system.

3. Which one of the following 1.0 mol L^{-1} solutions will have the lowest pH?

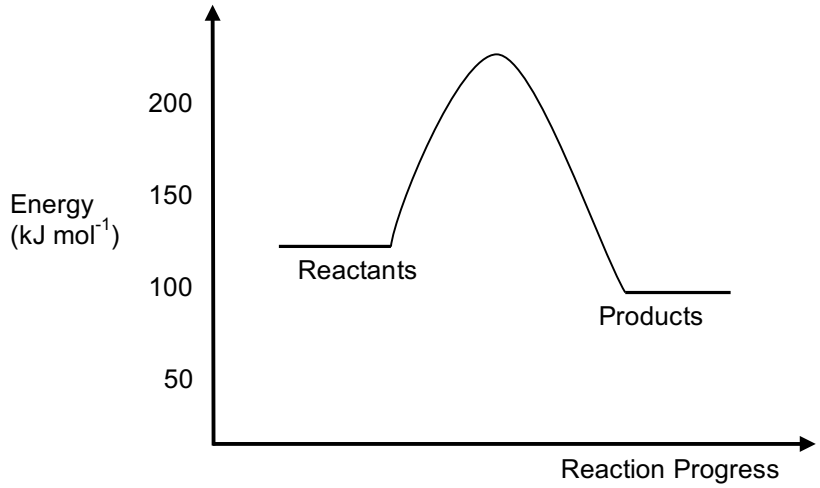
(a) Sodium ethanoate
(b) Potassium chloride
(c) Ammonium chloride
(d) Sodium phosphate

See next page

4. In which one of the following reactions is the underlined species acting as a Brønsted-Lowry acid?

(a) $\underline{KHCO_3}(s) + H^+(aq) \rightarrow K^+(aq) + H_2O(\ell) + CO_2(g)$
(b) $\underline{H_2CO_3}(aq) + NaOH \rightleftharpoons NaHCO_3(aq) + H_2O(\ell)$
(c) $\underline{CO_2}(g) + H_2O(\ell) \rightleftharpoons H_2CO_3(aq)$
(d) $\underline{CO_3^{2-}}(aq) + Ca^{2+}(aq) \rightarrow CaCO_3(s)$

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. Ocean acidification has become a modern day global concern for all of humanity. It is thought to be the direct result of increased levels of carbon dioxide in the atmosphere. Which of the following reasons is **least** likely a justification for this phenomenon?

(a) Rising global temperatures.
(b) Increasing emissions from vehicles.
(c) Continual and increasing usage of fossil fuels.
(d) Increasing global population.

7. 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) $H_2CO_3(aq) + H_2O(\ell) \rightleftharpoons HCO_3^-(aq) + H_3O^+(aq)$

See next page

8. Which of the following combinations can be used to form a buffer solution?

i. $NH_3(aq)$ / $NH_4C\ell(aq)$
ii. $HC\ell(aq)$ / $NaC\ell(aq)$
iii. $HC\ell(aq)$ / $NH_4C\ell(aq)$
iv. $H_2PO_4^-(aq)$ / $HPO_4^{2-}(aq)$
v. $H_2SO_4(aq)$ / $HSO_4^-(aq)$

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

9. In which of the following processes is bromine being reduced?

i. $PBr_3 + Br_2 \rightarrow PBr_5$
ii. $Br_2 + H_2O \rightarrow Br^- + HBrO + H^+$
iii. $2\ Br^- \rightarrow Br_2 + 2\ e^-$
iv. $HBrO_3 + H_2O_2 \rightarrow HBrO_4 + H_2O$

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

10. 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

11. Consider the following reaction:

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

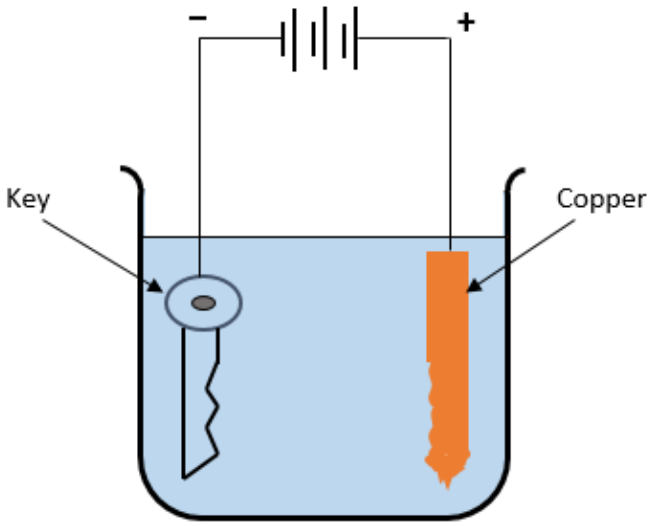
For this reaction, which one of the following is true?

(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.

See next page

Questions 12 and 13 relate to the following diagram

The following electrolytic cell was set up as shown.



12. Which of the following statements about the cell is **correct**?

(a) The key becomes the anode when the cell is operating.
(b) The key will gradually lose mass as the electrolysis process continues over an extended period of time.
(c) The cathode is the copper rod.
(d) The purpose of the anode is to replenish and maintain a steady supply of cations in the solution.

13. Which one of the following statements is **false**?

(a) Oxidation occurs at the copper electrode.
(b) The purpose of the battery is to provide a flow of electrons from anode to cathode.
(c) Cations move through the solution from the cathode to the anode.
(d) Reduction occurs at the site where electrons are made available.

See next page

14. Use the table of standard reduction potentials to determine which of the following reactions are likely to occur spontaneously under standard conditions.

i. $H_2(g) + Br_2(aq) \rightarrow 2\ Br^-(aq) + 2\ H^+(aq)$
ii. $Cu(s) + 2\ H^+(aq) \rightarrow Cu^{2+}(aq) + H_2(aq)$
iii. $Sn(s) + Cd^{2+}(aq) \rightarrow Sn^{2+}(aq) + Cd(s)$
iv. $H_2O_2(aq) + Zn^{2+}(aq) \rightarrow O_2(g) + 2\ H^+(aq) + Zn(s)$

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

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 oxidised as the cell discharges.

17. 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.

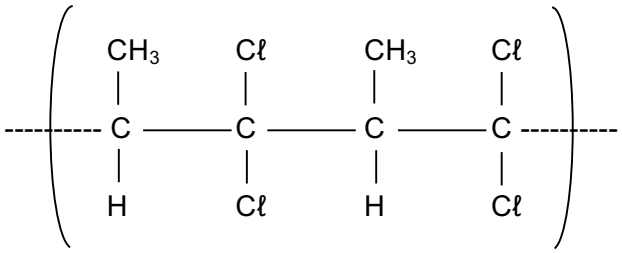
18. Which one of the following is the empirical formula of propyl pentanoate?

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

19. 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) $CH_3CH_2C(CH_3)_2COOH$

20. Consider the short section of the polymer below.



Which one of the following is the **correct** name for the monomer used to synthesise this polymer?

(a) 2,2-dichlorobut-1-ene
(b) 1,1-dichlorobut-2-ene
(c) 1,1-dichloro-2-methylethene
(d) 1,1-dichloropropene

21. Which one of the following dipeptides would be produced by the reaction of valine and serine?

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

22. An enzyme is a biological catalyst. An esterase enzyme can be used in the hydrolysis of an ester as shown below.

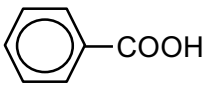
$$\text{ester} + \text{water} \overset{\text{esterase}}{\rightleftharpoons} \text{carboxylic acid} + \text{alcohol}$$

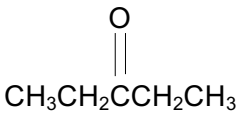
Upon the addition of esterase, which of the following statement is **correct** for this process?

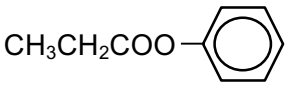
(a) The position of equilibrium for this reaction is shifted to the right.
(b) The rates of the forward and reverse reactions both increase equally.
(c) The rate of the forward reaction increases more than the rate of the reverse reaction.
(d) The rate of the forward reaction increases while the rate of the reverse reaction decreases.

See next page

Questions 23 and 24 relate to the compounds shown below

i. 

ii. 

iii. 

iv. CH_3CH_2CHO

23. Which one of the following lists places the compounds in their correct class?

	i.	**ii**	**iii**	**iv**
(a)	Ester	Aldehyde	Ketone	Carboxylic acid
(b)	Carboxylic acid	Ketone	Ester	Aldehyde
(c)	Carboxylic acid	Ester	Ketone	Aldehyde
(d)	Aldehyde	Ketone	Carboxylic acid	Ester

24. Which of the compounds shown above can be identified by using litmus paper alone?

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

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

See next page

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.

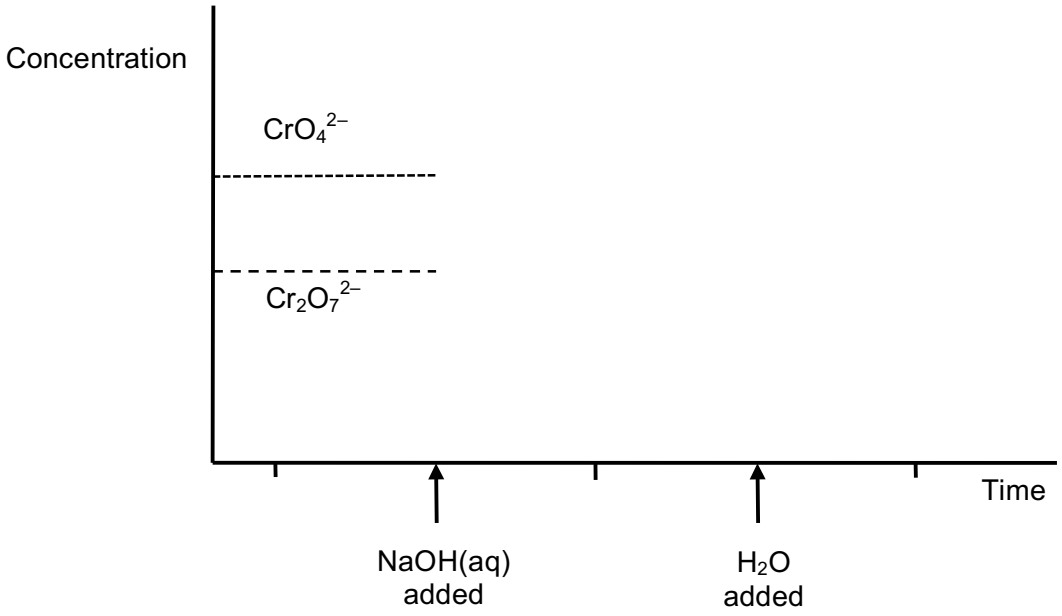
Question 26 **(6 marks)**

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)

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_____

_____

Question 27 **(4 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.

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)

See next page

Question 28 **(7 marks)**

Aluminium is refined in a two-part process from the mineral 'bauxite' and extracted directly from alumina, ($A\ell_2O_3$) using electrorefining processes. Aluminium is used to make many different alloys due to its corrosion resistance, as well as finding application in the building industry and aviation, due to its light-weight and relatively strong properties.

A student was given the following sets of aqueous 1.00 mol L^{-1} solutions and asked to find out whether any of them could be safely stored in an aluminium cup.

The solutions were: $Fe(NO_3)_2$, $Mg(NO_3)_2$, $Cu(NO_3)_2$ and $Ni(NO_3)_2$

(a) Using relevant chemical equations, explain which of the solutions could be safely stored in a cup made of aluminium metal.

(4 marks)

When aluminium metal is placed in an acidified solution of sodium hydrogendichromate, (containing the weakly acidic ion, hydrogendichromate ($HCr_2O_7^-$), a deep green solution containing chromium (III) ions is formed, and the aluminium metal dissolves producing aluminium ions.

(b) In the space below, write separate oxidation and reduction half-equations, and then the overall redox equation for this reaction.

(3 marks)

Question 29 **(4 marks)**

Sodium hypochlorite (NaCℓO) is commonly used in the textile industry as a bleach. When added to water, hypochlorous acid (HCℓO) is formed. The solution can now be considered as an equilibrium system, where hypochlorite ions are converted into hypochlorous acid.

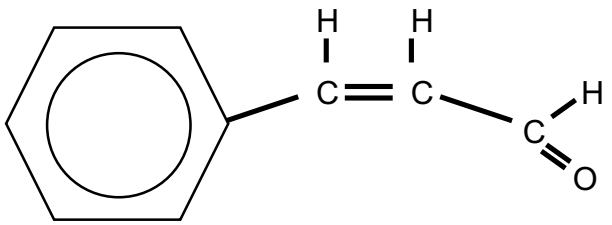
$$C\ell O^-(aq) + H_2O(\ell) \rightleftharpoons HC\ell O(aq) + OH^-(aq) + HEAT$$

Complete the following table by predicting, with reasoning, the effect that the following changes will have on the concentration of the hypochlorous acid (HCℓO) in the treated water.
(4 marks)

Imposed change	**Predicted effect to the concentration of HCℓO(aq)**	**Brief justification for your prediction**
Addition of some hydrochloric acid to the water		
Increasing the temperature of the water		

Question 30 **(8 marks)**

The compound shown below gives cinnamon its characteristic flavour and odour. It is a pale yellow liquid that occurs naturally in the bark of cinnamon trees.



(a) On the diagram above, circle and label two functional groups present in the molecule. (2)

(b) Draw a geometric isomer of the compound presented above. (1)

(c) Draw the structure of the product that would be formed if the **original** compound was mixed with some aqueous bromine (bromine water). (1)

(d) Draw the structure of the product that would be formed if the **original** compound was mixed with an acidified solution of sodium dichromate. (1)

(e) Draw the structure of the product that would be formed if the **original** compound was polymerised in the presence of an appropriate catalyst (draw three repeating units in your answer) (2)

(f) State the name given to the type of polymerisation described in part (e) above. (1)

_____

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

See next page

Question 32 **(8 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*)

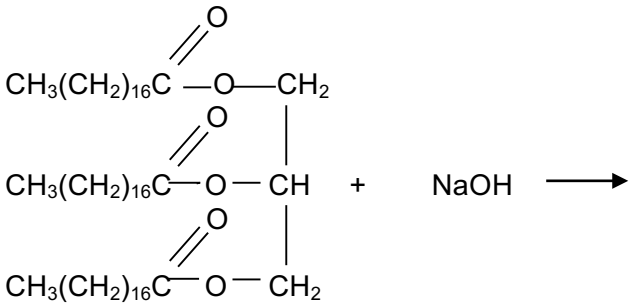
<table>
<tr><th></th><th>Compounds</th><th>Description of Test</th><th>Observations</th></tr>
<tr><td rowspan="3">(a)</td><td>butan-1-ol</td><td rowspan="2"></td><td>butan-1-ol</td></tr>
<tr><td>methylpropan-2-ol</td><td>methylpropan-2-ol</td></tr>
<tr><td colspan="3">Equation: (state symbols not required)</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>

See next page

Question 33 **(8 marks)**

Soaps and detergents are common organic substances widely used in our daily lives. While they both consist of a relatively long hydrocarbon chain which is attached to a 'polar end', there are also significant differences between the two substances, particularly in their applications as cleaning agents.

A typical soap like sodium stearate, $(CH_3(CH_2)_{16}COO^- Na^+)$, which can be produced from a reaction between tristearin and sodium hydroxide, is shown in the partially completed 'saponification' reaction below.



Tristearin

(a) Complete and balance the equation above, including any other organic products formed. (3 marks)

Soaps and detergents function to remove fats and grease from objects as they clean.

(b) Using a simplified general representation of a typical soap or detergent, explain in terms of their structure and polarity, how they are able to achieve their task as cleaners. (3 marks)

See next page

(c) Name these structures: (2 marks)

i) $CH_3CH_2COOCH_2CH_2\ CH_2CH_3$

ii) $CH_3CH_2CH(NH_2)CH_2\ CH_2CH_3$

Question 34 **(10 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. (4 marks)

See next page

(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 35 **(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

See next page

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

This section contains five **(6)** 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.

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: 70 minutes.

Question 36 **(18 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. (4 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. (3 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)

See next page

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Question 37 **(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, 18.60 g of carbon dioxide, 7.65 g of water, and 3.88 g of nitrogen dioxide was produced.

2.28 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)

See next page

(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

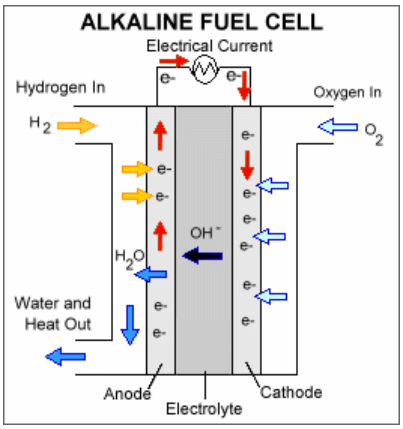
(d) Draw the structure of the amino acid that would exist in a solution with a pH of 10. (1 mark)

(e) Write an equation, using structural formulae, for the reaction between the amino acid and glycine to form a dipeptide. (2 marks)

See next page

Question 38 **(17 marks)**

An alkaline version of a typical fuel cell is shown below. It utilises the oxidation of hydrogen gas (H_2) and the reduction of oxygen gas (O_2). Both reactants are continuously 'fed into' the cell during normal operation. The major product from the overall redox reaction is water, (H_2O).



(a) During the normal operation of this cell, write the appropriate reactions that will occur:

(i) at the cathode. (1 mark)

_____

(ii) at the anode. (1 mark)

_____

(iii) for the cell. (1 mark)

_____

(b) What is the maximum EMF that this fuel cell can generate under standard conditions? (1 mark)

_____

(c) State one advantage and one disadvantage of a typical fuel cell when compared to a dry cell. (2 marks)

Advantage:

_____

_____

Disadvantage:

_____

_____

See next page

Another type of electrochemical cell utilises the following standard half-cell reactions.

$Cr^{3+}(aq) + 3e^- \longrightarrow Cr(s)$ $E^o = -0.74$ V

$C\ell_2(g) + 2e^- \longrightarrow 2C\ell^-(aq)$ $E^o = +1.36$ V

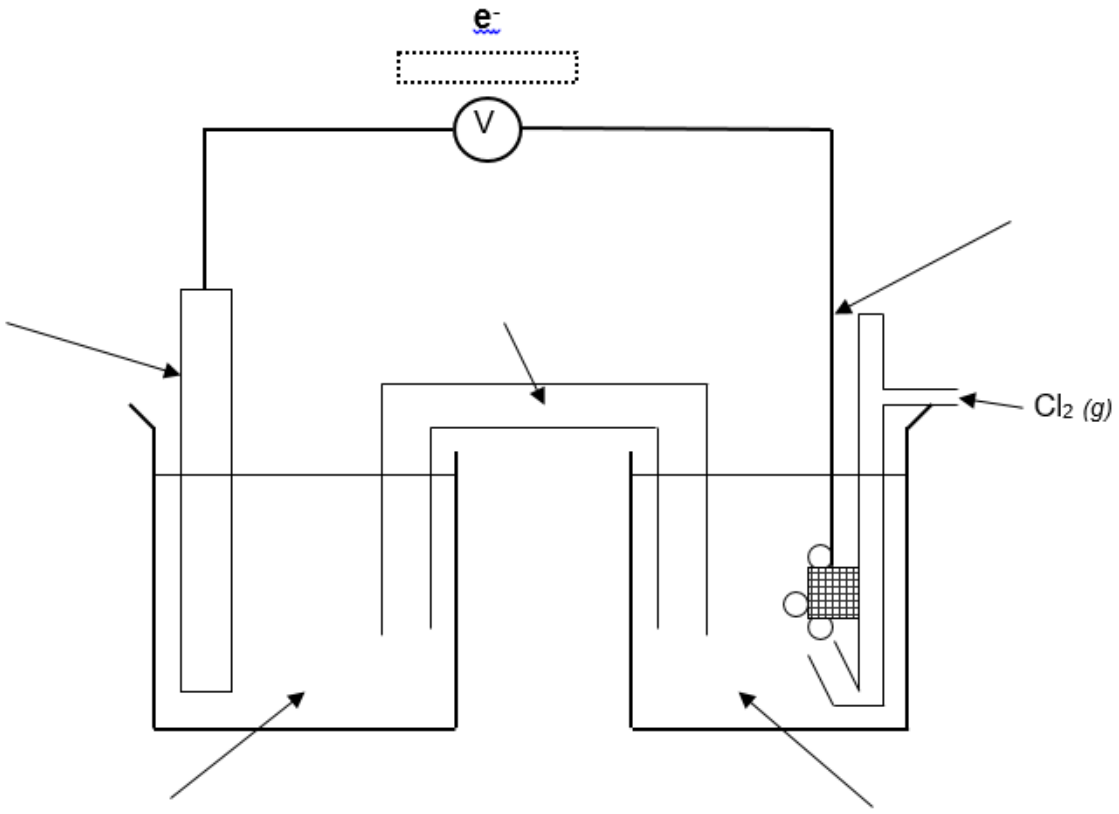
Complete the diagram below to show the construction and operation of this cell. Ensure that you fully label the cell to include:

(a) the anode and cathode, including their respective polarities. (2 marks)

(b) the electrolytes used. (2 marks)

(c) the direction of movement of cations and anions in the salt bridge. (1 mark)

(d) the direction of movement of electrons. (1 mark)



Write the overall cell reaction and calculate the cell EMF under standard conditions for this cell. (2 marks)

_____

Cell EMF = _____

See next page

(e) With reference to the cell you constructed above, and using relevant chemical theory, explain whether a solution of sodium carbonate would be a good choice for use as a salt bridge electrolyte. (Include a balanced chemical equation in your explanation).
(3 marks)

_____

_____

_____

_____

_____

_____

Question 39 **(13 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. (3 marks)

See next page

Question 40 **(17 marks)**

Standard solutions of sodium hydroxide, NaOH, must be kept in airtight containers. This is because NaOH is a strong base and absorbs acidic oxides, such as carbon dioxide, CO_2, from the air and reacts with them. As a result, the concentration of NaOH is changed to an unknown extent.

Carbon dioxide in the air reacts with water to form carbonic acid. This acid can then react with sodium hydroxide to form sodium carbonate.

(a) Write two molecular equations to illustrate the chemical process described in this reaction sequence. (2 marks)

_____

_____

(b) A freshly prepared solution of sodium hydroxide was titrated against a previously standardised solution of ethanoic acid, using standard laboratory volumetric glassware. What would be a suitable indicator for this titration?

Circle your choice from the list below. (1 mark)

Methyl orange **Phenolphthalein** **Universal indicator**

The freshly prepared sodium hydroxide solution, as described in (b) above, was found to have a concentration of 0.1150 mol L^{-1}. A 250.0 mL batch of the solution was left in a storage bottle on the laboratory bench over-night but a careless student forgot to replace the lid on the bottle. The next day, the chemistry teacher noticed this and thought it would be a good exercise for the students to determine the mass of carbon dioxide that was absorbed in the solution of sodium hydroxide so she gave the students the task of carrying out a titration to determine this, by using a previously standardised sulfuric acid solution.

(c) Write a balanced chemical equation for the reaction between sulfuric acid and sodium hydroxide.

(2 marks)

_____

See next page

20.00 mL aliquots of the sodium hydroxide solution were taken and titrated using a suitable indicator with the standardised 0.0565 mol L^{-1} sulfuric acid solution from the burette. The results of the titration are tabulated below.

(d) Complete the table and calculate the average titre of H_2SO_4 (2 marks)

Final reading (mL)	20.60	19.65	21.10	20.80	19.05
Initial reading (mL)	4.50	4.45	5.25	5.00	3.20
Titration volume (mL)					

Average titre _____

(e) Calculate the moles of acid titrated and thus the moles of sodium hydroxide in the 20.00 mL aliquots.

(3 marks)

(f) Thus calculate the concentration of the sodium hydroxide solution. (1 mark)

(g) In view of your results in (f) above and considering the original concentration of the sodium hydroxide solution:

Calculate the number of moles of sodium hydroxide that were originally present in the freshly made 250.0 mL solution. (1 mark)

See next page

(i) Calculate the actual number of moles of sodium hydroxide in the 250.0 mL solution using the results of the students' titration. (2 marks)

(ii) Using the results of (i) and (ii) above, calculate the moles of sodium hydroxide that reacted with the carbon dioxide as a consequence of the student leaving the storage bottle open over-night. (1 mark)

(iii) Use the balanced chemical equations in part (a) on the previous pages as well as the titration data, to calculate the mass of carbon dioxide absorbed by the sodium hydroxide solution. (2 marks)

End of questions

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