2025/4409
Web version of 2024/73884

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

ATAR course examination, 2024
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	10	10	60	81	35
Section Three Extended answer	5	5	70	87	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 2024: 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. Consider the following system at equilibrium.

$$MgCO_3(s) \leftrightharpoons MgO(s) + CO_2(g) \qquad \Delta H = +ve$$

Which of the following changes will result in a decrease in the mass of magnesium oxide when equilibrium is re-established?

(a) addition of carbon dioxide
(b) addition of magnesium carbonate
(c) increase in temperature
(d) addition of a catalyst

2. In which of the following is vanadium in the lowest oxidation state?

(a) V_2O_5
(b) VO_2
(c) VO^+
(d) $V_4O_9^{2-}$

3. Which of the following represents an acid-base reaction in which the underlined species is acting as a Brønsted-Lowry acid?

(a) $2\ CrO_4^{2-} + 2\ \underline{HCO_3^-} \leftrightharpoons Cr_2O_7^{2-} + 2\ CO_3^{2-} + H_2O$
(b) $CH_3CH_2CH_2COOH + \underline{NaOH} \leftrightharpoons CH_3CH_2CH_2COONa + H_2O$
(c) $\underline{NH_3} + O^{2-} \leftrightharpoons NH_2^- + OH^-$
(d) $HC\ell O_3 + \underline{CH_3NH_2} \leftrightharpoons C\ell O_3^- + CH_3NH_3^+$

See next page

4. Cresol red is an acid-base indicator with the following colour changes:

Indicator	pH for colour change	Colour change
cresol red	7.2 – 8.8	yellow to purple

A few drops of cresol red were added to four 1 mol L^{-1} solutions. Which of the responses below gives the correct colour for each solution?

	Sodium ethanoate	Potassium hydroxide	Sulfuric acid	Ammonium chloride
(a)	yellow	purple	yellow	yellow
(b)	purple	purple	yellow	yellow
(c)	purple	yellow	purple	purple
(d)	yellow	purple	yellow	purple

5. Which statement **best** outlines the difference between systematic and random errors?
Systematic errors

(a) will consistently produce measured values either above or below the actual value, while random errors will produce measured values above and below the actual value.
(b) can be reduced through multiple trials and averaging of results, while random errors cannot be reduced.
(c) are generally accurate but not precise, while random errors are generally precise but may not be accurate.
(d) are difficult to avoid, while random errors can be readily improved.

Use the following information to answer Questions 6 to 8.

A group of students conducted a series of titrations to determine the concentration of acetic acid in vinegar using the following steps:

i. A sample of vinegar was pipetted into a volumetric flask that had been rinsed with the vinegar and then deionised water added up to the mark.
ii. The volumetric flask was stoppered, and the diluted solution mixed thoroughly.
iii. Aliquots of the diluted vinegar solution were pipetted into conical flasks that had been rinsed with deionised water and a few drops of indicator added to each flask.
iv. A standardised sodium hydroxide solution was added to a burette that had been rinsed with deionised water.
v. Two samples of diluted vinegar were titrated against the sodium hydroxide solution and both values were used to calculate the concentration of the vinegar.

See next page

6. Phenolphthalein was chosen as the indicator for the titration. Which of the following **best** explains why this was an appropriate indicator?

(a) The titration was between a strong base and a weak acid, so the final solution would be slightly basic.
(b) Phenolphthalein changes colour in the basic range, at a similar pH to the equivalence point of the titration.
(c) Phenolphthalein is pink in the acidic range and colourless in the basic range, and so the end point is easy to identify.
(d) At the equivalence point $[OH^-] > [H^+]$; therefore, phenolphthalein is an appropriate indicator as its colour change occurs at a basic pH.

7. The students found it difficult to obtain consistent results from their titrations. Which of the steps could have been responsible for the difficulties?

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

8. Which of the following does **not** explain why Step v contributed to the errors in the titration?

There were insufficient titrations

(a) hence the sample size was too small.
(b) to determine if either was an outlier.
(c) to reduce random errors by averaging.
(d) to identify the colour change.

9. Which of the following is **not** a definition of an acid?

An acid

(a) contains replaceable hydrogen.
(b) is a proton donor.
(c) reacts with all metals.
(d) produces protons when added to water.

10. Sulfuric acid has a lower pH than nitric acid at the same concentration. Which of the following statements **best** explains this observation?

(a) Sulfuric acid is a stronger acid than nitric acid.
(b) Sulfuric acid has more protons available for ionisation than nitric acid.
(c) Nitric acid is a stronger acid than sulfuric acid.
(d) Nitric acid has more protons in solution than sulfuric acid at the same concentration.

See next page

11. Which of the following is the **strongest** acid? The K_a values are at 25 °C.

(a) H_3PO_4 $K_a = 7.1 \times 10^{-3}$
(b) HSO_4^- $K_a = 1.0 \times 10^{-2}$
(c) HSO_3^- $K_a = 6.5 \times 10^{-8}$
(d) $H_2C_2O_4$ $K_a = 5.6 \times 10^{-2}$

12. One limitation of the Brønsted-Lowry Theory of acids and bases is that it

(a) does not explain reactions between acidic and basic oxides, such as $SO_3(g) + MgO(s) \rightarrow MgSO_4(s)$, as they do not involve the transfer of protons.
(b) does not explain the production of a neutral salt solution resulting from the reaction between a strong acid and strong base.
(c) links acids and bases into conjugate acid-base pairs rather than accounting for the transfer of protons.
(d) cannot explain the acidity and basicity of acidic and basic salts.

13. Which of the following is a physical change in a closed system?

(a) electrolysing water in a sealed container
(b) freezing water in a lake
(c) water evaporating from skin
(d) boiling water in a saucepan with the lid on

14. Which of the following is a characteristic of a system at equilibrium?

(a) rates of the forward and reverse reactions are zero
(b) concentrations of the reactants equal the concentrations of the products
(c) temperature of the system will rise if the forward reaction is exothermic
(d) colour of the system remains constant

15. The precipitation reaction between solutions of lead(II) nitrate and potassium iodide is very rapid at room temperature. This can be explained by the

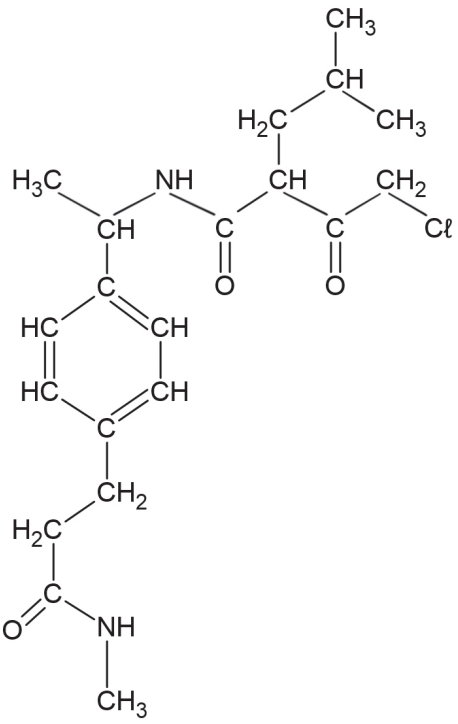
(a) low activation energy of the reaction.
(b) reaction being very exothermic.
(c) large number of types of particles involved in the reaction.
(d) need for a flame to cause the reaction to occur.

16. How many straight-chain structural isomers have the formula C_4H_9Br?

(a) one
(b) two
(c) three
(d) four

See next page

17. Consider the following organic structure:



Which of the following lists functional groups present in the above structure?

(a) carboxylic acid, amine and alcohol
(b) amide, ketone and halide
(c) carboxylate, amide and ketone
(d) alcohol, amide and halide

18. Which of the following lists the compounds from lowest to highest boiling points?

(a) pentane < butanal < butan-1-amine < butan-1-ol
(b) butanal < butan-1-amine < butan-1-ol < pentane
(c) butan-1-ol < butan-1-amine < butanal < pentane
(d) butan-1-amine < butan-1-ol < pentane < butanal

19. Which of the following compounds has cis-trans isomers?

(a) CH_2CHCH_3
(b) $CH_3CHCHCH_3$
(c) CH_3CH_2OH
(d) $CH_3CH_2CH_3$

20. Classify the type of reaction represented in the following equation:

$$CH_2CH_2(g) + HC\ell(g) \rightarrow CH_2C\ell CH_3(\ell)$$

(a) addition
(b) oxidation
(c) combustion
(d) condensation

See next page

21. Which of the following is **not** a product of the oxidation of pentan-1-ol?

(a) $CH_3CH_2CH_2CH_2CHO$
(b) CO_2
(c) $CH_3CH_2CH_2COCH_3$
(d) $CH_3CH_2CH_2CH_2COOH$

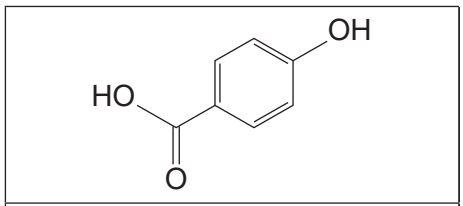
22. Which of the following does **not** contribute to the specific properties and uses of polymers in plastics? The

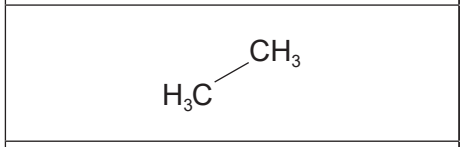
(a) length of the polymer chains.
(b) amount of cross-linking between the chains.
(c) types of intermolecular forces that exist between the chains.
(d) process used to produce the polymer.

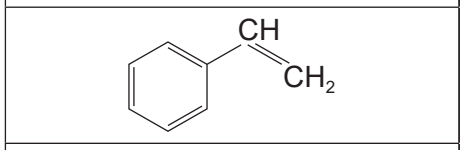
23. Which of the following is **not** a use of polytetrafluoroethene?

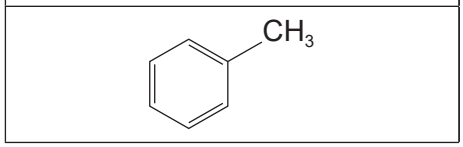
(a) non-stick frypans
(b) electrical wires
(c) coatings for tanks
(d) lubricants

24. Which of the following monomers will produce addition polymers?

(a) 

(b) 

(c) 

(d) 

25. Which of the following can be used to distinguish between butan-2-one and butanal?

(a) bromine water
(b) acidified potassium permanganate solution
(c) hydrochloric acid solution
(d) acetic acid solution, with a sulfuric acid catalyst

End of Section One

See next page

Section Two: Short answer **35% (81 Marks)**

This section has **10** 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.

Question 26 **(9 marks)**

Consider the following system that is at equilibrium. Cobalt(II) chloride is dissolved in concentrated hydrochloric acid. The colour of the solution at initial equilibrium is blue.

$$\underset{\text{blue}}{CoCl_4^{2+}(aq)} + 6\ H_2O(l) \leftrightharpoons \underset{\text{pink}}{Co(H_2O)_6^{2+}(aq)} + 4\ Cl^-(aq) \qquad \Delta H = -ve$$

For each of the applied changes after equilibrium is re-established, predict the:
- shift in equilibrium position (left, right or no change)
- rate of the forward reaction compared to the original rate (increase, decrease or no change)
- colour of the reaction mixture.

Do **not** use arrows to show direction.

Change	Shift in equilibrium position (left, right or no change)	Rate of the forward reaction compared to the original rate (increase, decrease or no change)	Colour of reaction mixture
A few drops of $AgNO_3(aq)$ are added			
A small volume of water is added			
The system is heated			

See next page

Question 27 **(12 marks)**

Write balanced ionic equations for any reactions 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 magnesium strip is added to excess dilute hydrochloric acid solution. (4 marks)

Equation

Observations

(b) A few drops of bromine liquid are added to a potassium iodide solution. (4 marks)

Equation

Observations

(c) A piece of aluminium foil is added to a 0.1 mol L^{-1} nickel(II) nitrate solution. (4 marks)

Equation

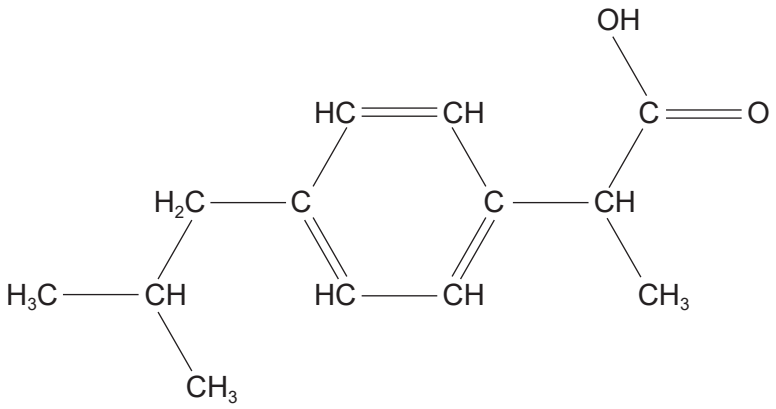
Observations

See next page

Question 28 **(6 marks)**

Ibuprofen is a chemical used as a pain killer and anti-inflammatory. It is insoluble in water, but it is soluble in ethanol. The structure of ibuprofen is shown below.

Using your understanding of intermolecular forces, explain the observed solubilities of ibuprofen.



Question 29 **(7 marks)**

Formation of zwitterions is a characteristic property of α-amino acids.

(a) Describe the structure of a zwitterion and explain its formation from an α-amino acid. Include the structural formula of the α-amino acid, serine, as a zwitterion in your answer. (4 marks)

Serine zwitterion structure

(b) Explain why α-amino acids have relatively high melting points compared to other polar compounds with similar molar mass. (3 marks)

See next page

Question 30 **(6 marks)**

Two major impacts of increasing atmospheric carbon dioxide levels are decreasing ocean pH and decreasing ocean calcium carbonate availability. Consider the equilibrium reactions, represented by the following equations

Equation 1	$CO_2(aq) + H_2O(aq) \leftrightharpoons H_2CO_3(aq)$
Equation 2	$H_2CO_3(aq) \leftrightharpoons H^+(aq) + HCO_3^-(aq)$
Equation 3	$HCO_3^-(aq) \leftrightharpoons H^+(aq) + CO_3^{2-}(aq)$
Equation 4	$CaCO_3(s) + H^+(aq) \leftrightharpoons HCO_3^-(aq) + Ca^{2+}(aq)$

With reference to chemical equilibrium principles and the equations provided, explain each of the following major impacts of increasing atmospheric carbon dioxide concentrations.

(a) Decreasing pH. (4 marks)

(b) Decreasing calcium carbonate availability. (2 marks)

See next page

Question 31 **(6 marks)**

A representation showing the general structure of soap and detergent species is shown below.

(a) Identify **one** similarity and **one** difference between the structure of soap and detergent. (2 marks)

Similarity: _____

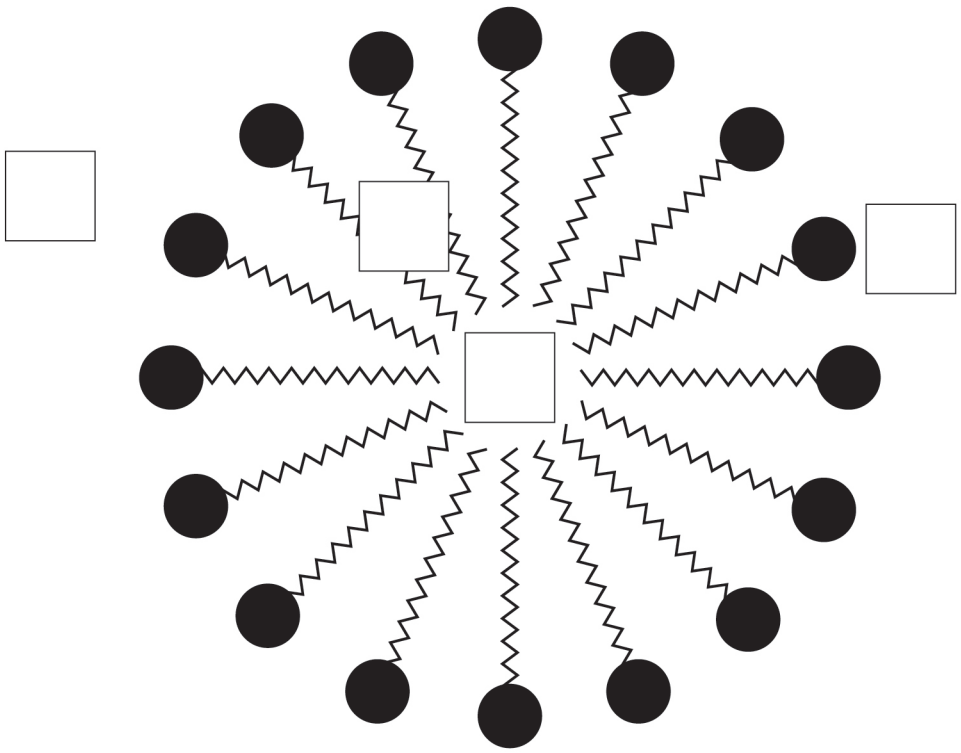
_____

Difference: _____

_____

(b) A representation of a micelle, which shows how soap and detergent species assemble in water, is given below. Label the diagram with the letter corresponding to the following features of a micelle. (4 marks)

W	Location of water molecules
X	Location of grease/dirt particles for the cleaning action
Y	Location where dispersion forces occur
Z	Location of the hydrophilic region of the micelle



See next page

Question 32 **(9 marks)**

A buffer solution containing 0.1 mol L^{-1} ammonia and 0.1 mol L^{-1} ammonium chloride is used in a laboratory-scale experiment involving a biological process.

(a) Write the equation for the equilibrium reaction in the buffer solution involving the weak acid and its conjugate base. (2 marks)

(b) Label the weak acid and its conjugate base in the above equation. (1 mark)

(c) The biological process in the experiment produces a small amount of strong acid. Predict and explain the impact on the pH of the buffer solution. (3 marks)

(d) Define the term 'buffer capacity'. (1 mark)

(e) Identify **two** factors that determine buffer capacity of a system. (2 marks)

One: _____

Two: _____

See next page

Question 33 **(12 marks)**

(a) Consider the following oxidation-reduction equation:

$$C\ell O_3^- + 3\ H_2O + 3\ SO_2 \rightarrow 3\ SO_4^{2-} + C\ell^- + 6\ H^+$$

Complete the table below by writing the appropriate formula of the species required. (3 marks)

Description	Formula
Species increasing in oxidation number	
Species with highest oxidation number	
Species acting as the oxidising agent	

(b) Write the **two** half-equations and the overall equation for the reaction between excess MnO_4^-(aq) and $CH_3OH(\ell)$ in acidic conditions. (5 marks)

Reduction half-equation

Oxidation half-equation

Overall redox equation

See next page

(c) Select a species on the Standard Reduction Potential table with which $MnO_4^-(aq)$ would **not** be expected to react. Include a calculation as part of an explanation for why this is so. (4 marks)

Species: _____

Explanation: _____

See next page

Question 34 **(8 marks)**

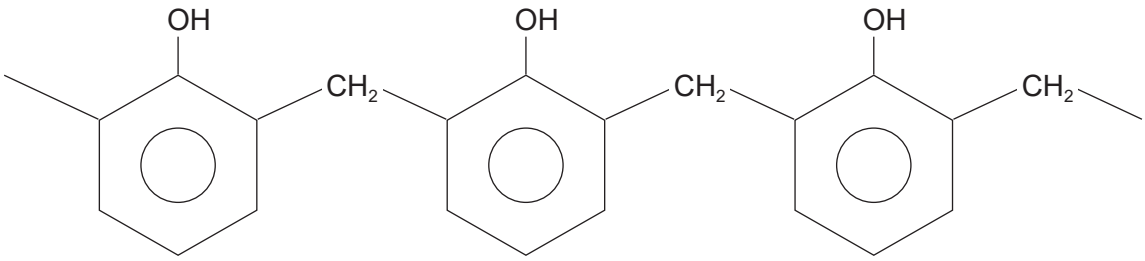
Calculate the final pH of a solution produced by adding 50.00 mL of 0.0877 mol L^{-1} hydrochloric acid solution to 38.00 mL of 0.158 mol L^{-1} barium hydroxide solution.

See next page

Question 35 **(6 marks)**

Bakelite was one of the first commercially-produced plastics. It is formed from monohydroxybenzene, C_6H_5OH, and methanal through a complex reaction that produces species that then undergo a condensation reaction to form the polymer bakelite.

A section of the bakelite polymer is shown below.



(a) Draw the structures of the initial compounds showing all atoms and bonds. (4 marks)

Monohydroxybenzene	Methanal

(b) State **two** characteristics of a condensation polymer reaction. (2 marks)

One: _____

_____

Two: _____

_____

End of Section Two

Section Three: Extended answer **40% (87 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.

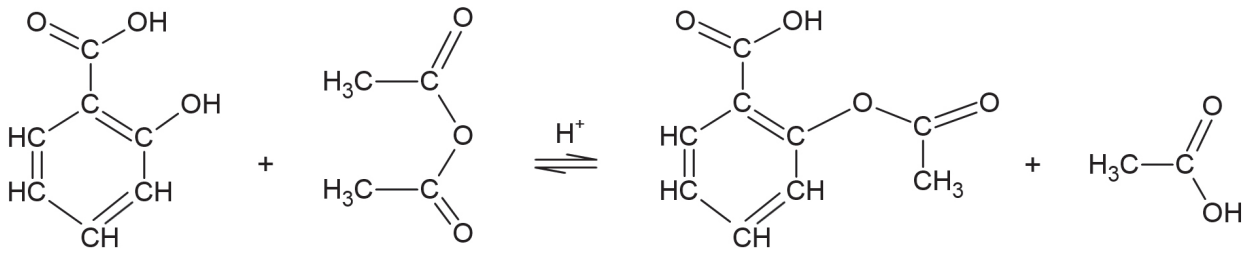
Supplementary pages for planning/continuing your answers to questions are provided at the end of this Question/Answer booklet. If you use these pages to continue an answer, indicate at the original answer where the answer is continued, i.e. give the page number.

Suggested working time: 70 minutes.

See next page

Question 36 **(16 marks)**

The active ingredient in aspirin, a painkiller, is acetyl salicylic acid. Acetyl salicylic acid is prepared by a reaction between salicylic acid and acetic anhydride in the presence of a sulfuric acid catalyst. The reaction can be represented by the following equation:



(a) Given the above reaction is endothermic, outline and justify the optimal conditions for the preparation of acetyl salicylic acid. (6 marks)

See next page

Question 36 (continued)

A packet of aspirin was purchased that was labelled as double strength and should contain 500 mg of aspirin compared to standard strength tablets, which tend to contain between 300 and 320 mg of aspirin. A student removed five tablets from the packet and ground them up. The powder was then reacted with 150.00 mL of 0.0842 mol L^{-1} sodium hydroxide solution.

The resulting solution was added to a 250.0 mL volumetric flask and deionised water added up to the mark. Aliquots (25.00 mL) of the solution were titrated against a standardised 0.03033 mol L^{-1} hydrochloric acid solution.

The molar mass of aspirin is 180.158 g mol^{-1}.

The following results were obtained.

	Trials			
	1	**2**	**3**	**4**
Final volume (mL)	16.40	30.17	18.96	32.70
Initial volume (mL)	2.40	16.40	5.25	18.96
Titre (mL)				

(b) Complete the table above and calculate the average titre. (2 marks)

See next page

(c) Calculate the mass of aspirin (in mg) in each tablet and comment on the accuracy of the packet label. (8 marks)

See next page

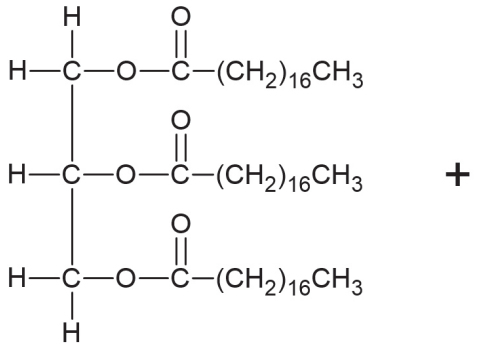
Question 37 **(22 marks)**

Triglycerides may be used in chemical synthesis processes to manufacture both soaps and biodiesel.

(a) Write balanced equations to show the reagents required and all products formed in the synthesis of soap in saponification of tristearin, and the synthesis of biodiesel in base-catalysed transesterification of tristearin. The structural formula of the reactant tristearin, a common triglyceride, and the product glycerol are given. There are separate boxes for reactants and products to help structure your answers.

(i) Balanced equation for the formation of soap from tristearin. (3 marks)

Reactants



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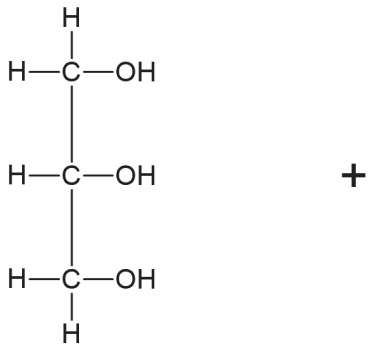
Products



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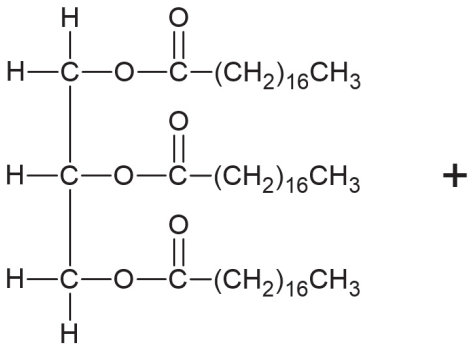
(ii) Write the balanced equation for the formation of biodiesel from tristearin. (4 marks)

Reactants



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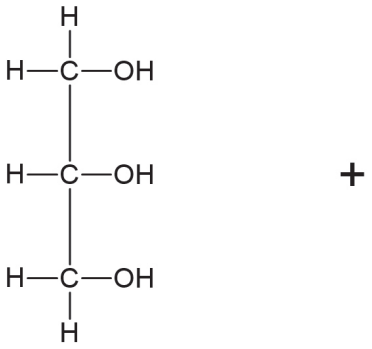
Products



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An alternative method for biodiesel synthesis is lipase-catalysed transesterification of triglycerides. Lipases are enzymes that may be isolated from many biological sources.

(b) Biodiesel production would not be viable in the absence of a base or lipase catalyst. Use collision theory to explain how the presence of catalysts makes the production of biodiesel viable in these processes. (3 marks)

See next page

Question 37 (continued)

(c) Lipase-catalysed transesterification occurs under milder conditions of temperature and pH compared to the base-catalysed process. Explain why these conditions are a requirement and state **one** advantage for biodiesel production. (3 marks)

Requirement for mild temperature and pH

Advantage for biodiesel production

Information about the structure of a lipase B enzyme (Chain A) from the yeast species *Candida antarctica* is freely available through the Protein Data Bank (PDB). Use this information to answer part (d).

(d) A portion of this lipase B structure is highlighted in a box on the image above. Identify this structural feature of the protein and state the level of protein structure. (2 marks)

Structural feature: _____

Level of protein structure: _____

See next page

Another example of this level of protein structure visible in the image are β-pleated sheets.

(e) The formation of β-pleated sheets and the structure identified in part (d), on page 26, form through the same type of intermolecular force. Name and describe this intermolecular force, including a diagram that shows which atoms of the protein structure are involved. (4 marks)

Name: _____

Description: _____

_____

_____

_____

Intermolecular force diagram:

The sequence of 317 amino acids of this lipase B protein chain is given in the PDB. The presence of three disulfide bridges is clearly represented in the data.

(f) Identify the amino acid where disulfide bridges can form. (1 mark)

_____

(g) Disulfide bridges are an example of a protein tertiary structure. Define 'tertiary structure' and outline how it forms. (2 marks)

_____

_____

_____

_____

Question 38 **(15 marks)**

Doxylamine succinate is an antihistamine, which is used to treat hay fever, and, as one of its side-effects is drowsiness, it is also used as a sleep aid. Doxylamine succinate contains carbon, hydrogen, oxygen and nitrogen.

(a) A 2.500 g sample of the compound was combusted, and 5.94 g of carbon dioxide and 1.63 g of water were produced. All of the nitrogen from a second 2.500 g sample was converted to ammonia and reacted with a 0.823 mol L^{-1} solution of hydrochloric acid. 15.6 mL of the acid was required to react completely with the ammonia.

Determine the empirical formula for doxylamine succinate. (11 marks)

See next page

(b) Doxylamine succinate is also a weak base. A 19.42 mg sample of doxylamine succinate required 1.00 mL of a 0.100 mol L^{-1} $HC\ell O_4$ acid solution for neutralisation.

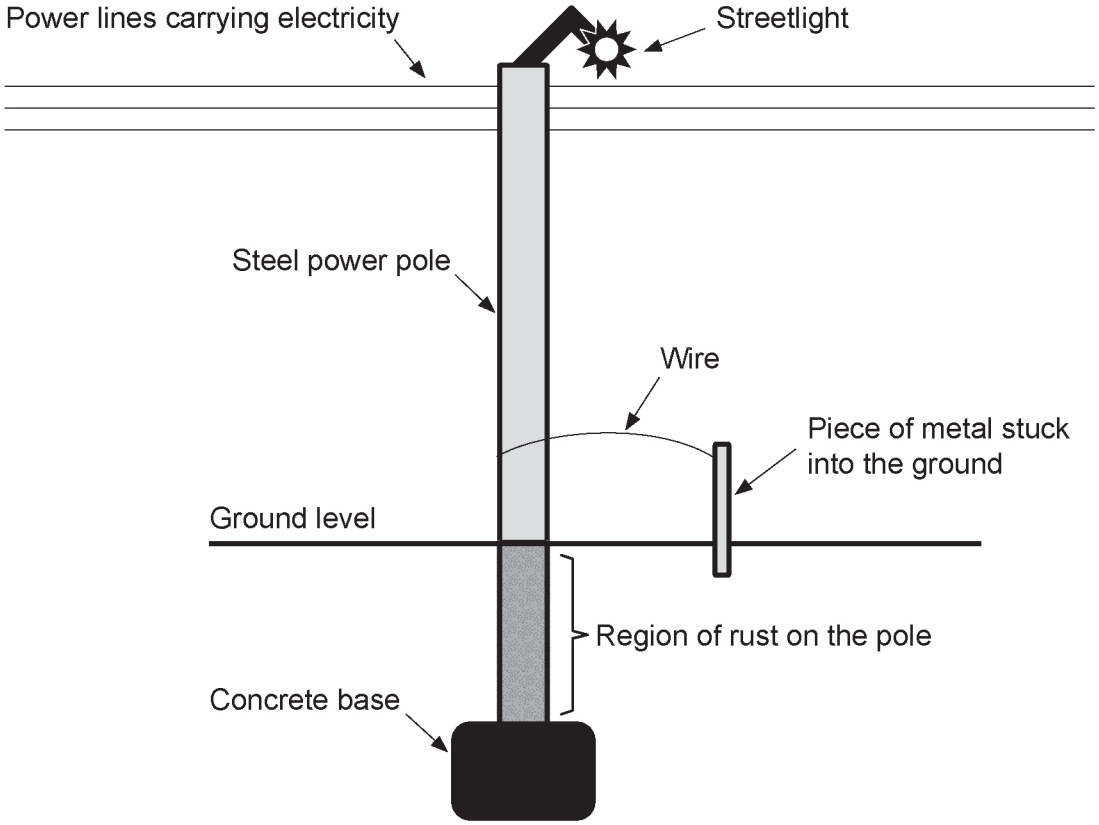
Using a calculation, identify how many protons (hydrogen ions) a doxylamine succinate molecule can accept. The molar mass of doxylamine succinate is 388.46 g mol^{-1}.

(4 marks)

See next page

Question 39 **(17 marks)**

Steel poles are used as 'power poles' to hold streetlights and carry electricity to businesses and houses. While being stronger than timber poles and not prone to rotting, they do have the capacity to rust.



A steel pole was treated to inhibit rusting but when soil was removed at its base, significant rusting could be observed.

(a) Refer to one or more equations below, representing the various parts of the rusting process, and explain why the steel pole rusts below ground level but there were no signs of rusting above ground level. (5 marks)

Equation 1 $Fe(s) \rightarrow Fe^{2+}(aq) + 2e^-$
Equation 2 $O_2(g) + 2\ H_2O(\ell) + 4\ e^- \rightarrow 4\ OH^-(aq)$
Equation 3 $4\ Fe^{2+}(aq) + 4\ H^+(aq) + O_2(aq) \rightarrow 4\ Fe^{3+}(aq) + 2\ H_2O(\ell)$
Equation 4 $Fe^{3+}(aq) + 3\ OH^-(aq) \rightarrow Fe(OH)_3(s)$
Equation 5 $4\ Fe(OH)_2(s) + O_2(g) + x\ H_2O(\ell) \rightarrow 2\ Fe_2O_3.(x+4)H_2O(s)$

See next page

Question 39 (continued)

After the surrounding soil was dug away to expose the pole, two different attempts were made to protect it from rusting any further. One was to paint the pole and the other was to connect a wire from it to a piece of metal in the ground. Neither attempt was successful in preventing further rusting.

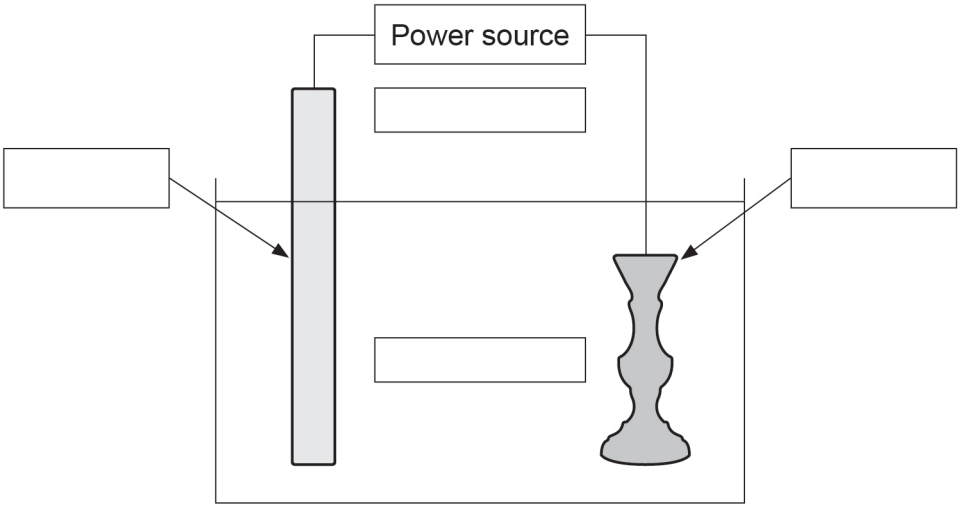
(b) Explain why these two methods did **not** work as intended. If appropriate, include an equation in your answer.

(i) Painting the pole. (2 marks)

(ii) Attaching a wire to a second metal. (3 marks)

For some iron objects, coating with a non-reactive metal is an appropriate method to reduce rusting. Electrolysis can be used to thinly coat an iron object with a metal such as chromium, a process also known as 'chrome plating'.

(c) Consider the following electrolytic cell used for the chrome plating of a candlestick. The cell consists of a lead electrode, the item to be plated and a chromium(III) chloride solution. Another chemical is added to prevent the Cr^{3+} from oxidising.



In the spaces above, label the diagram to show the:
- anode and cathode
- direction of cation flow
- direction of electron flow. (3 marks)

(d) Write ionic half-equations for the reactions occurring at the anode and the cathode. (2 marks)

Anode	
Cathode	

(e) State **two** reasons why the actual voltage required to run this cell is higher than the value that would be calculated using the standard reduction potentials. (2 marks)

One: _____

_____

Two: _____

_____

See next page

Question 40 **(17 marks)**

Nickel mining is one of the largest mining industries in Western Australia. One process for extracting nickel from nickel oxide ore is the Mond process, which was developed at the end of the 19th Century.

Step 1
Nickel(II) oxide is reacted with hydrogen to produce nickel metal and water at 200 °C, according to the equation:

$$NiO(s) + H_2(g) \leftrightharpoons Ni(s) + H_2O(g)$$

The nickel produced is impure and must be further purified.

Step 2
The impure nickel is reacted with carbon monoxide to produce nickel carbonyl ($Ni(CO)_4$).

$$Ni(s) + 4\ CO(g) \leftrightharpoons Ni(CO)_4(g)$$

The impurities in the nickel are left as solids and separated.

Step 3
The nickel carbonyl gas is then passed over a platinum catalyst, causing the compound to decompose.

$$Ni(CO)_4(g) \leftrightharpoons Ni(s) + 4\ CO(g)$$

(a) If the nickel produced in Step 1 is 95.7% pure, calculate the mass of nickel(II) oxide that would be required to produce 2245 tonne of the impure nickel. (5 marks)

See next page

(b) In Step 2, if the impure nickel mixture contains 521 tonne of pure nickel and produces 1025 tonne of $Ni(CO)_4$, calculate the percentage yield of this reaction. (4 marks)

See next page

Question 40 (continued)

(c) A 19.22 g sample of the impure nickel from Step 1, on page 34, was reacted with 90.00 mL of a 5.02 mol L^{-1} solution of nitric acid. This reaction can be represented by the following equation:

$$3\ Ni(s) + 8\ HNO_3(aq) \rightarrow 3\ Ni(NO_3)_2(aq) + 2\ NO(g) + 4\ H_2O(\ell)$$

Calculate the volume of nitrogen monoxide produced measured at standard temperature and pressure (STP). (8 marks)

End of questions

Supplementary page

Question number: _____

Supplementary page

Question number: _____

Supplementary page

Question number: _____

ACKNOWLEDGEMENTS

Question 37(d–e) Image from the RCSB Protein Data Bank (RCSB.org) of PDB ID 1LBT Uppenberg, J., Jones, T.A. (1995). *Lipase (e.c.3.1.1.3) (Triacylglycerol Hydrolase)*. PDB DOI: https://doi.org/10.2210/pdb1LBT/pdb. Retrieved April, 2024, from https://www.rcsb.org/structure/1LBT

Published by the School Curriculum and Standards Authority of Western Australia
303 Sevenoaks Street
CANNINGTON WA 6107