2019 PRACTICE EXAM

CHEMISTRY UNITS 3&4

Question Booklet & Worked Solution Booklet

ATARNotes

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ATARNotes

STUDENT NUMBER | | | | | | | | | | Letter | |

CHEMISTRY
Written examination

2019

Reading time: 9:00 a.m. to 9:15 a.m. (15 minutes)
Writing time: 9:15 a.m. to 11:45 a.m. (2 hours 30 minutes)

QUESTION AND ANSWER BOOK

Structure of book

Section	*Number of questions*	*Number of questions to be answered*	*Number of marks*
A	30	30	30
B	10	10	90
			Total 120

- Students are permitted to bring into the examination room: pens, pencils, highlighters, erasers, sharpeners, rulers, and one scientific calculator.
- Students are NOT permitted to bring into the examination room: blank sheets of paper and/or correction fluid/tape.

Materials supplied
- Question and answer book of 34 pages
- Data book
- Answer sheet for multiple-choice questions

Instructions
- Write your **student number** in the space provided above on this page.
- Check that your **name** and **student number** as printed on your answer sheet for multiple-choice questions are correct, **and** sign your name in the space provided to verify this.
- Unless otherwise indicated, the diagrams in this book are **not** drawn to scale.
- All written responses must be in English.

At the end of the examination
- Place the answer sheet for multiple-choice questions inside the front cover of this book.
- You may keep the data book.

Students are NOT permitted to bring mobile phones and/or any other unauthorised electronic devices into the examination room.

SECTION A – Multiple-choice questions

Instructions for Section A

Answer **all** questions in pencil on the answer sheet provided for multiple-choice questions.
Choose the response that is **correct** or that **best answers** the question.
A correct answer scores 1; an incorrect answer scores 0.
Marks will **not** be deducted for incorrect answers.
No marks will be given if more than one answer is completed for any question.
Unless otherwise indicated, the diagrams in this book are **not** drawn to scale.

Question 1

Chlorine can be produced through the dissociation of phosphorous pentachloride. When this reaction takes place in a sealed container, equilibrium is reached. The corresponding thermochemical equation is shown below.

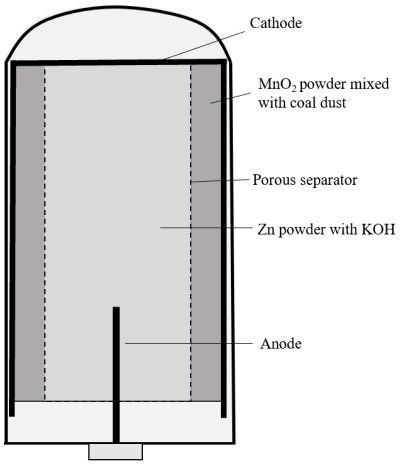
$$PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g) \qquad \Delta H = -88 \text{ kJ mol}^{-1}$$

If pressure and volume is kept constant as the temperature is increased, the rate of the forward reaction will

A. increase and $[Cl_2]$ will increase.
B. increase and $[Cl_2]$ will decrease.
C. decrease and $[Cl_2]$ will increase.
D. decrease and $[Cl_2]$ will decrease.

Question 2

One of the most popular batteries to be mass produced is the alkaline cell. At the anode is a paste consisting of zinc powder and potassium hydroxide. At the cathode is a paste consisting of manganese oxide and coal dust. The battery eventually stops producing a current when zinc oxide covers the anode, preventing the passage of charge. A diagram of an alkaline cell is shown below.



The half-equation for the reaction that occurs at the anode as the cell discharges is:

A. $Zn(s) + 2OH^-(aq) \rightarrow Zn^{2+}(aq) + H_2O(l) + H^+(aq) + e^-$
B. $Zn(s) + 2OH^-(aq) \rightarrow ZnO(s) + H_2O(l) + 2e^-$
C. $2MnO_2(s) + H_2O(l) + 2e^- \rightarrow Mn_2O_3(s) + 2OH^-(aq)$
D. $Zn^{2+}(aq) + H_2O(aq) \rightarrow ZnO(s) + 2H^+(aq)$

Question 3

The nutrition information panel on a granola bar includes the following information

Nutrition information average serving size = 45 g	
	Average quantity per 100 g
protein	17.4 g
fat, total	13.3 g
- saturated	1.4 g
carbohydrate, total	47.3g
- sugars	15.8g
dietary fibre	5.0g
sodium	13.2mg

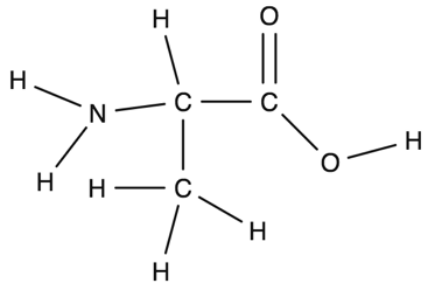
Using the information provided above, the percentage energy content due to protein in an average serving of this bar is

A. 51%
B. 19%
C. 31%
D. 40%

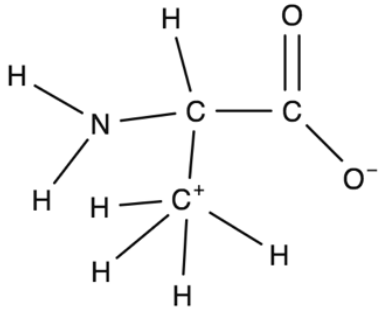
Question 4

Which one of the following is a zwitter-ion?

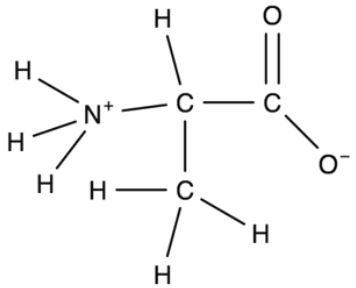
A.



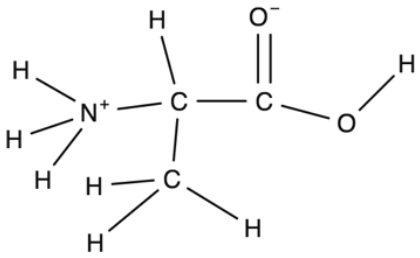
B.



C.

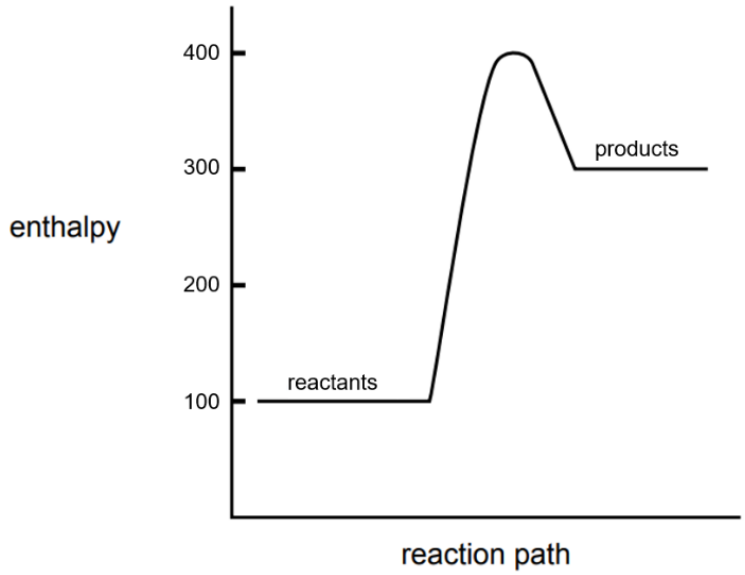


D.



Question 5

The relative enthalpies of the reactants and products of a chemical reaction are represented on the following diagram.



The numerical value of the enthalpy change, ΔH, of the reverse reaction is

A. +300
B. -300
C. +200
D. -200

Question 6

A 150.0 mL compressed air canister contains O_2 stored at 5.2 atmospheres and 25 ^{O}C. The mass, in g, of O_2 in the canister is

A. 1.02 g
B. 1.01 g
C. 12.2 g
D. 2.04 g

Question 7

A Year 12 Chemistry student conducted their practical investigation on the various properties of biodiesel and petrodiesel. The student made the following conclusions:

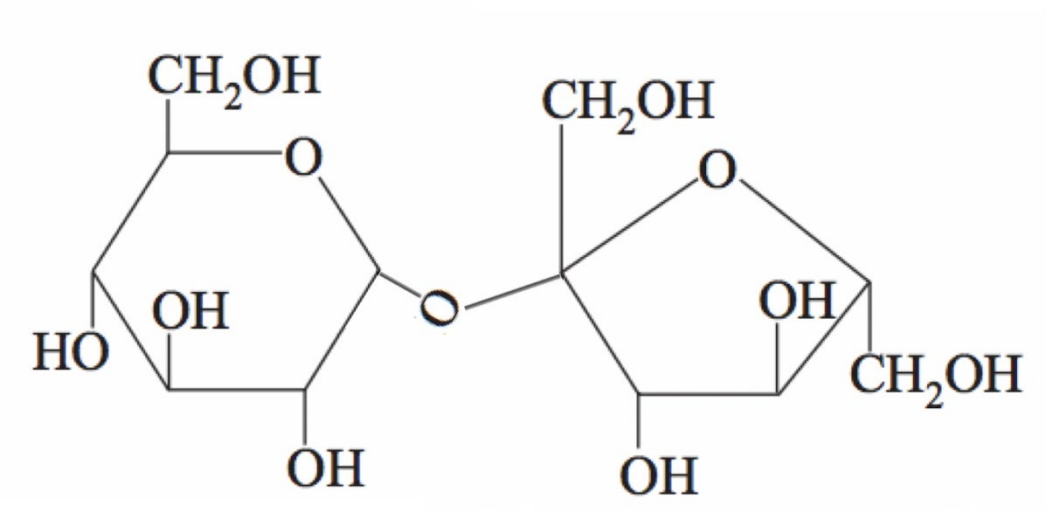
I. Biodiesel is more viscous than petrodiesel
II. Petrodiesel has a higher cloud point
III. Petrodiesel is considered relatively more carbon neutral than biodiesel
IV. Petrodiesel is hygroscopic whereas biodiesel is not

Which of the above conclusions are correct?

A. I only
B. I and II
C. I, III, and IV
D. I, II, and IV

Question 8

The following disaccharide undergoes hydrolysis.



The products of this reaction are

A. β-lactose
B. β-glucose and β-glucose
C. β-glucose and α-fructose
D. α-glucose and β-fructose

Question 9

Enzymes are biological catalysts. Which of the following statements is true about enzymes?

A. Coenzymes are often large molecules, similar in size to enzymes that bind to a tertiary protein to form its quaternary structure
B. All enzymes require a coenzyme to function
C. Coenzymes change the surface shape of an enzyme and hence the binding properties of the active site
D. Coenzymes denature enzymes

Question 10

The compound that forms when 2,4-dimethylpentan-1-ol is oxidised is

A. 2,3-dimethylpentanal
B. 2,4-dimethylpentanoic acid
C. 2-methylpentan-4-en-1-ol
D. 1,5-dimethylpentanal

Question 11

Pearwei, a new smartphone company based in Northern Russia plans to release a new phone that promises to maintain a 10-hour battery capacity. However, in real-world testing they discover that after 3 discharge-recharge cycles, the battery only lasts a few hours before needing to be recharged.
The most likely reason for this is

A. It is very cold in Northern Russia
B. Discharging and recharging the battery greatly reduces capacity
C. The products of the discharge cycle are spontaneous and react immediately
D. The products of the discharge cycle remain in contact with the electrodes

Question 12

The glycaemic index (GI) indicates how quickly carbohydrates in food are broken down and raise a person's blood glucose levels. The table below summarises the carbohydrate content of 4 foods, X, Y, W, and Z.

Food	Amylose (g 100g)	Amylopectin (g per 100g)
X	5	14
Y	4	12
W	7	19
Z	10	20

Based on the information in the above table, which one of the foods would be expected to have the lowest GI value?

A. Food X
B. Food Y
C. Food W
D. Food Z

Question 13

The decomposition of nitrogen dioxide to form nitric oxides is a multi-step process as given below

$$2NO_2(g) \rightleftharpoons 2NO(g) + O_2(g)$$
$$2NO(g) \rightleftharpoons N_2(g) + O_2(g)$$

The overall equation for the **formation** of $NO_2(g)$ is given by

A. $N_2(g) + 2NO(g) + 3O_2(g) \rightleftharpoons 4NO_2(g)$
B. $2NO_2(g) \rightleftharpoons 2O_2(g) + 2NO_2(g)$
C. $NO(g) + O_2(g) \rightleftharpoons NO_2(g)$
D. $N_2(g) + 2O_2(g) \rightleftharpoons 2NO_2(g)$

Question 14

The combustion of octane is represented by the reaction below

$$C_8H_{20}(g) + 13O_2(g) \rightarrow 8CO_2(g) + 10H_2O(l)$$

The amount of oxygen in grams, required to produce 14L of carbon dioxide gas at SLC is closest to

A. 31 g
B. 49 g
C. 36 g
D. 29 g

Question 15

Humans are unable to synthesise most vitamins, meaning we must obtain them from dietary sources. Vitamins that can be synthesised internally are referred to as non-essential. Which of the following is a non-essential vitamin?

A. Ascorbic acid
B. Thiamin
C. Vitamin E
D. Vitamin D

Question 16

Ammonium can be produced by reacting ammonia with water. The equation for the reaction is given by

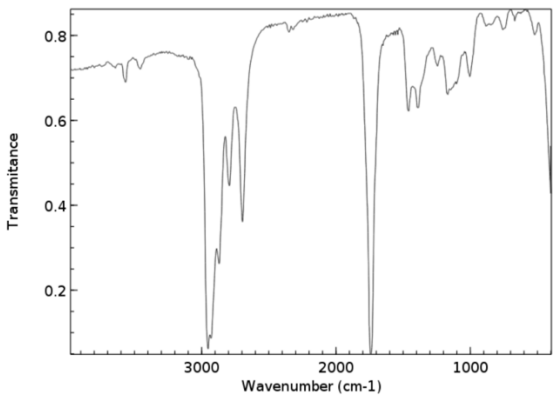
$$NH_3(aq) + H_2O(l) \rightleftharpoons NH^+_4(aq) + OH^-(aq)$$

0.9 mol of NH_3 is added to 1.5 L of water, and the reaction is allowed to reach equilibrium. At equilibrium thre is 0.8 mol of NH_3. K for this reaction is closest to

A. 8.3×10^{-3} M
B. 5.6×10^{-3} M^{-2}
C. 1.3×10^{-2} M
D. 8.3×10^{-4} M^{-2}

Question 17

Below is the infrared spectrum for an organic compound



The compound most likely to have produced this spectrum is

A. Butan-1-ol
B. Propene
C. Pentanal
D. Butane

Question 18

Which of the following statements is correct about catalysts?

A. Catalysts increase the rate of the forwards reaction only
B. Catalysts lower the activation energy of a reaction by providing an alternative reaction pathway
C. Catalysts alter the value of the equilibrium constant for a reaction
D. Catalysts lower the activation energy of a reaction but have no effect on how long it takes for a reaction to achieve equilibrium

Question 19

The thermochemical equation for the reaction of the complete combustion of octan-1-ol is given below

$$CH_3(CH_2)_7OH(l) + 12O_2(g) \rightarrow 8CO_2(g) + 9H_2O(l) \qquad \Delta H = -5294 \text{ kJ mol}^{-1}$$

The amount of energy produced when 42 g of octan-1-ol is combusted is closest to

A. 1300 kJ mol^{-1}
B. 1.8×10^{-3} kJ mol^{-1}
C. 1450 kJ mol^{-1}
D. 1.7×10^{3} kJ mol^{-1}

Question 20

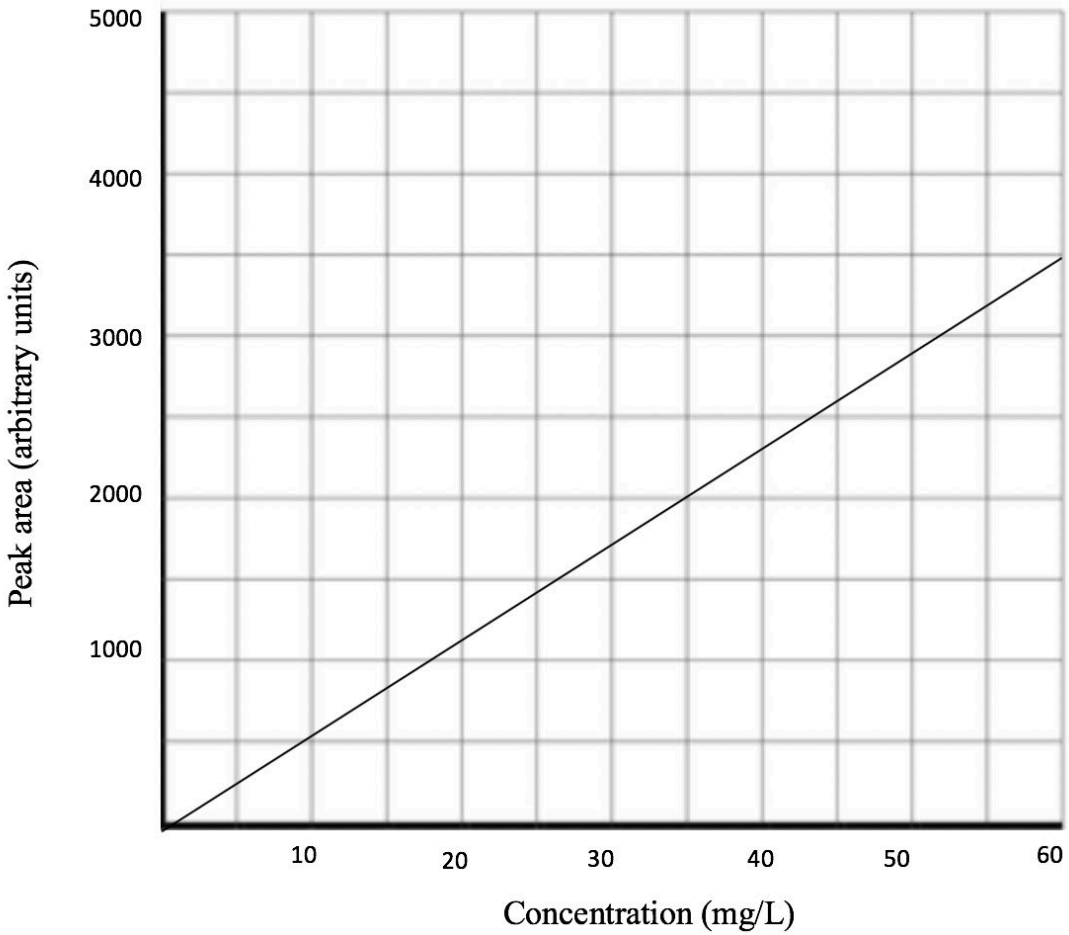
A galvanic cell containing a $Fe^{2+}//Fe^{3+}$ half-cell produces 2.43 V at SLC. The equation for the reaction at the anode is

A. $Al^{3+}(aq) + 3e^- \rightarrow Al(s)$
B. $Fe^{3+}(aq) \rightarrow Fe^{2+}(aq) + e^-$
C. $Au^{+}(aq) + e^- \rightarrow Au(s)$
D. $Al(s) \rightarrow Al^{3+}(aq) + 3e^-$

Use the following information to answer Questions 21 – 23.

The mass of caffeine in a particular energy drink was determined by high-performance liquid chromatography (HPLC).

The calibration curve produced from running standard solutions of caffeine through a HPLC is shown below.



A 1.0 mL aliquot of the drink was diluted to 50.0 mL with de-ionised water. A sample of the energy drink was run through the HPLC column under identical conditions to those used to obtain the calibration curve. The peak area obtained for this diluted sample was 2800 arbitrary units.

Question 21

Identify the correct statements about HPLC

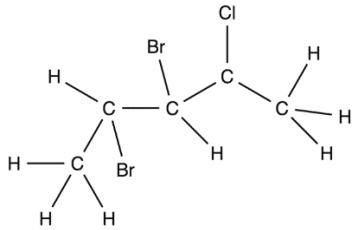
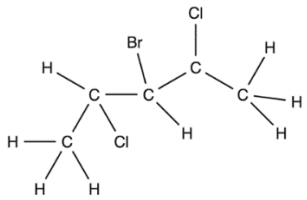
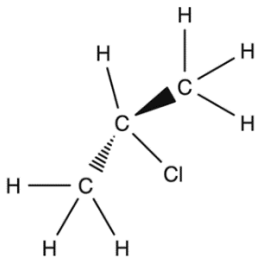
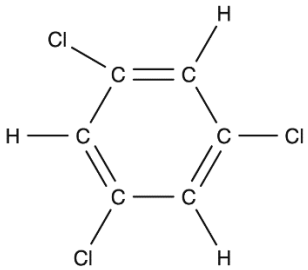
I. HPLC separates compounds based on their affinity for the stationary phase
II. In HPLC the mobile phase is pumped through the column at high pressure
III. HPLC is a less accurate method for identifying compounds than volumetric analysis
IV. Lipid solvents tend to absorb a non-polar stationary phase

A. III only
B. I, II, and III
C. I, II, and IV
D. II and IV

Question 22
The HPLC column used a polar stationary phase. The most suitable mobile phase is
A. Hexane
B. Methane
C. Methanol
D. Hexanol

Question 23
The mass of caffeine in grams, in a 330 mL can of energy drink is closest to
A. 49 mg
B. 16 mg
C. 830 mg
D. 750 mg

Question 24

Which of the following carbon compounds has an optical isomer?
A.
B. 
C. 
D. 


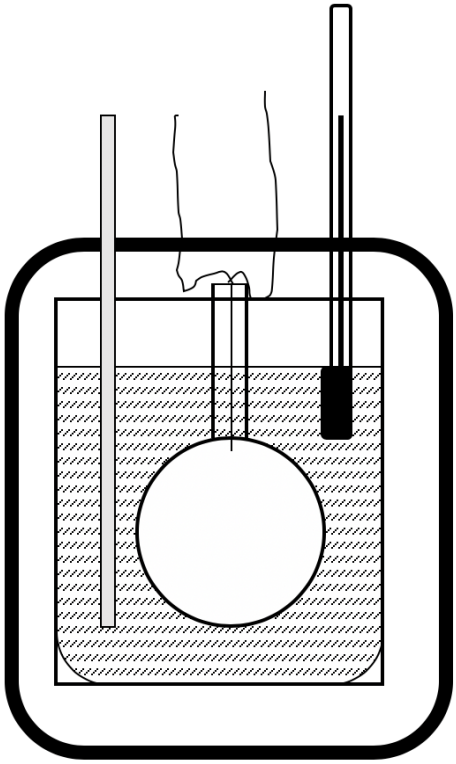
Question 25

Which of the following is correct about proteins?

A. All proteins exist in their quaternary structure
B. The functional groups on amino acids determine the shape of a protein
C. Proteins found in the human body will denature at very low temperatures
D. Proteins are not denatured by pH

Question 26

The following bomb calorimeter was constructed to measure the heat of combustion from a 2-carbon fuel. The calorimeter consists of a small chamber submerged in 260 mL of water.

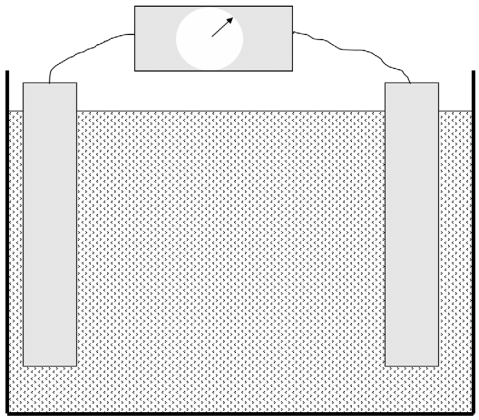


The temperature of the water was initially 278 K and rose to 338 K. Given that 0.05 mol of gas was placed in the chamber, and using the information in the data booklet, the gas most likely used was

A. Ethane
B. Ethanol
C. Ethyne
D. Ethene

Question 27

The diagram below represents a basic set-up of an electrolytic cell.

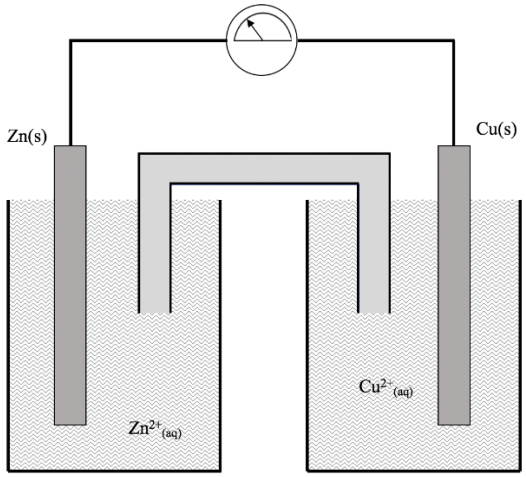


The cell consists of inert electrodes and aqueous sodium chloride. A current is passed through the cell, and the reaction was observed. The equation for the reaction at the anode is

A. $2H_2O(l) \rightarrow O_2(g) + 4H^+(aq) + 4e^-$
B. $2Cl^-(aq) \rightarrow Cl_2(g) + 2e^-$
C. $Na(s) \rightarrow Na^+(aq) + e^-$
D. $2H_2O(l) + e^- \rightarrow H_2(g) + 2OH^-$

Question 28

A Daniell cell is a galvanic cell consisting of a copper anode and a zinc cathode. The cell contains 1 M solutions of Cu^{2+} at the anode and Zn^{2+} at the cathode. A typical set-up of the Daniell cell is shown below.



The cell is run for 5 minutes and the current is measured. The cell produced an average current of 4.2 A across the 5 minutes. The decrease in mass of the anode is closest to

A. 0.9 g
B. 0.8 g
C. 0.4 g
D. 0.3 g

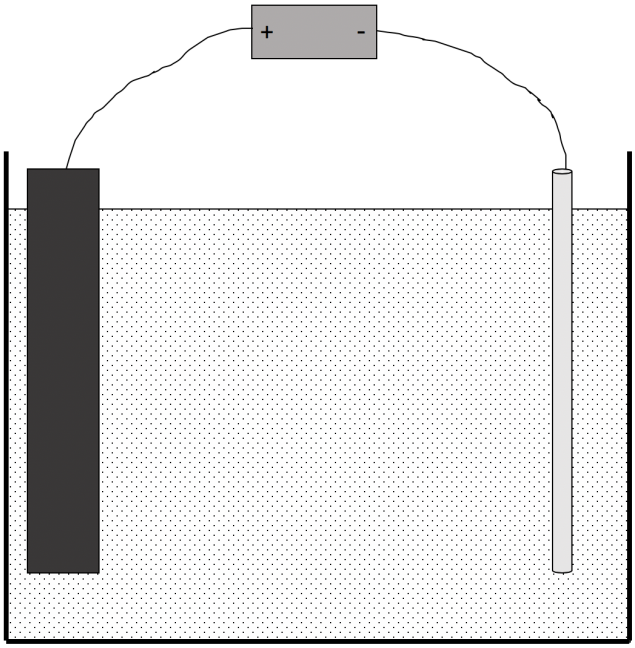
Question 29

A student wishes to clarify the composition of an unknown solution of metal ions. The best way to determine the species of the solution is

A. Titrate aliquots of the unknown solution and the standard hydrogen half-cell and record the voltage
B. Construct a galvanic cell with the unknown solution and the standard hydrogen half-cell and record the voltage
C. ^{13}CNMR
D. High Performance Liquid Chromatography

Question 30

A student investigated the process of electroplating a copper straw with silver. Below is the setup used by the student.



The cell contains a s silver anode and a solution of silver nitrate in solution. In order to sufficiently plate the straw, the student calculates they will need exactly 4.3 g of silver. The amount of time the student would have to apply a charge of 6.2 A is closest to

A. 9 minutes
B. 620 seconds
C. 11 minutes
D. 1440 seconds

SECTION B

Instructions for Section B

Answer **all** questions in the spaces provided. Write using blue or black pen.

Give simplified answers to all numerical questions, with an appropriate number of significant figures; unsimplified answers will not be given full marks.

Show all working in your answers to numerical questions; no marks will be given for an incorrect answer unless it is accompanied by details of the working.

Ensure chemical equations are balanced and that the formulas for individual substances include an indication of state, for example, $H_2(g)$, NaCl(s).

Unless otherwise indicated, the diagrams in this book are **not** drawn to scale.

Question 1 (9 marks)

An international trucking company develops its own unique blend of petrodiesel and biodiesel that can be interchanged in its trucks depending on factors such as climate and distance travelled without needing to use different engines. In general, petrodiesel and biodiesel are not pure substances, but a mixture of compounds.
The table below summarises the composition of the company's blends of fuel.
Assume each fuel has a density of 1 g mL^{-1}.

Fuel	Major Component	Energy Content (MJ/L of fuel)	CO_2 emission (kg CO_2/L of fuel)	Cost ($/L of fuel)
Petrodiesel	$C_{14}H_{30}$	52	3.11	1.21
Biodiesel	$C_{21}H_{44}O_2$	47	2.96	1.05

a. With reference to structure and bonding, explain the difference in viscosity of the two fuels in a cold environment.

3 marks

b. Assume combustion occurs in an unlimited supply of oxygen for the following calculations.
Using the data from page 21:

i. Calculate the mass of petrodiesel required to be combusted to produce the same amount of energy as 62 L of biodiesel.

2 marks

_____

_____

_____

ii. The trucks require 395 MJ to travel 100 km. Calculate which fuel option will be cheaper on the trucks journey from Melbourne to Sydney, a distance of 880 km.

3 marks

_____

_____

_____

_____

_____

c. In some circumstances there is a limited supply of oxygen.
Write a balanced chemical equation for the incomplete combustion of the major component of biodiesel.

1 mark

_____

Question 2 (9 marks)

Industrially, propanol, C_3H_7OH is made in a two-step process.
The first step involves a reaction between ethene, carbon monoxide, and hydrogen to produce propanal, according to the following equation.

$$CH_2CH_2(g) + CO(g) + H_2(g) \rightarrow CH_3CH_2CHO(l)$$

The second step involves the hydrogenation of propanal.

a.

i. Write the balanced chemical equation for the hydrogenation reaction of propanal to produce propanol.

1 mark

_____

ii. Write the overall equation for the industrial production of propanol.

1 mark

_____

b. Propanol can be converted back into propanal under certain conditions. Identify this type of reaction in which an alcohol reacts to form an aldehyde. Explain what properties of propanol allow it to produce an aldehyde in a single step process.

2 marks

_____

_____

c. Propanol can react with a carboxylic acid to form an ester.

i. Identify the reagent in this type of reaction.

1 mark

_____

ii. Write an equation for this reaction between a suitable carboxylic acid and propanol.

2 marks

_____

iii. Draw and name an ester that could form from the reaction between propanol and a suitable carboxylic acid.

2 marks

Question 3 (8 marks)

The formation of sulphur trioxide is given by the following reaction

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$$

a. A scientist adds 0.200 mol of SO_2 and 0.900 mol of O_2 into a 1.5 L empty reaction vessel and allows the system to reach equilibrium. At equilibrium, there is only 0.050 mol of SO_2.
Calculate K for this reaction.

4 marks

b. Identify and explain two ways the scientist could increase the yield of SO_3.

4 marks

Question 4 (9 marks)

There are a number of structural isomers for the molecular formula $C_4H_{10}O$. Three of these are butan-2-ol, butan-1-ol, methylpropan-2-ol.

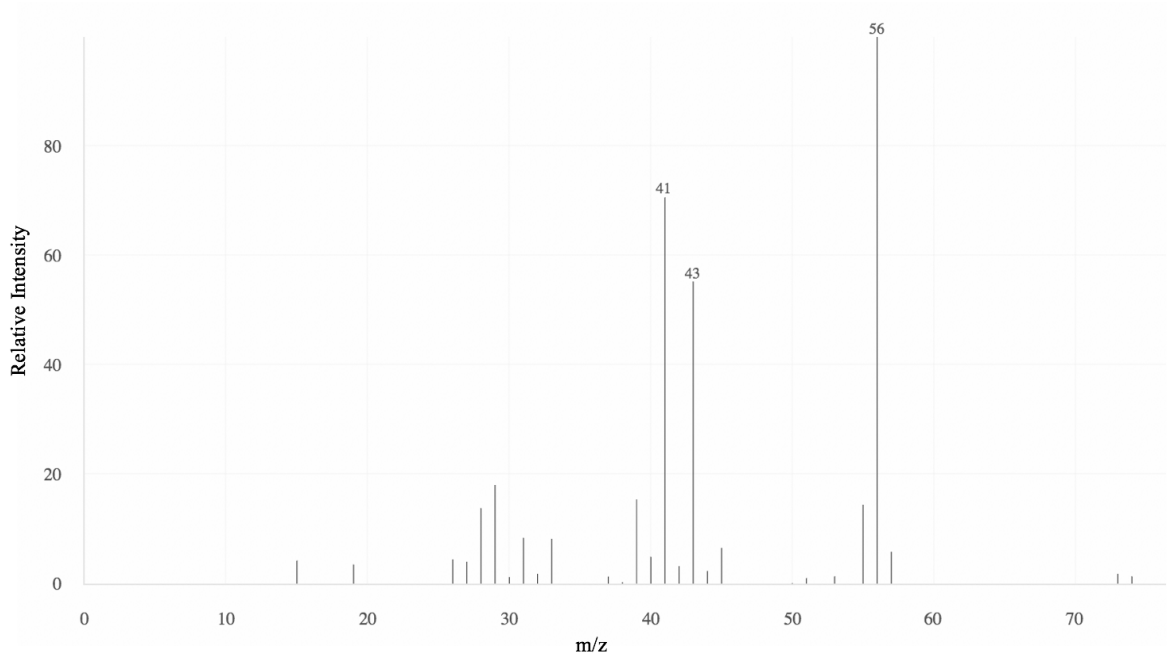
a. **i.** Draw the structure of methylpropan-2-ol.

1 mark

ii. Draw another structural isomer for $C_4H_{10}O$, that has not been named above.

1 mark

b. The mass spectrum of an isomer of $C_4H_{10}O$ is given below.



i. Identify the semi structural formula for the fragment at 43 m/z.

1 mark

ii. Name the isomer of $C_4H_{10}O$ that produced this spectrum and justify your answer.

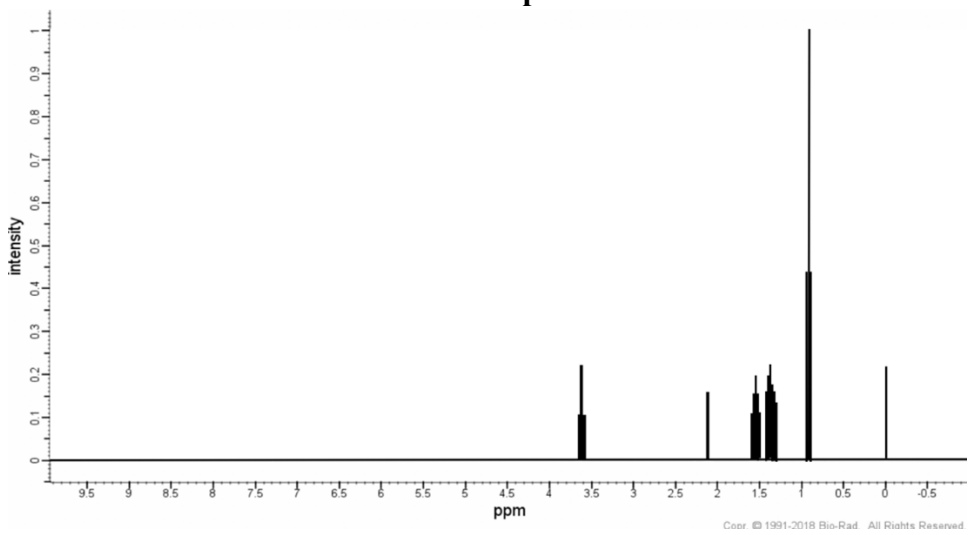
2 marks

iii. What produces the peak at 75 m/z?

1 mark

Consider the ^{1}HNMR and ^{13}CNMR spectral information below

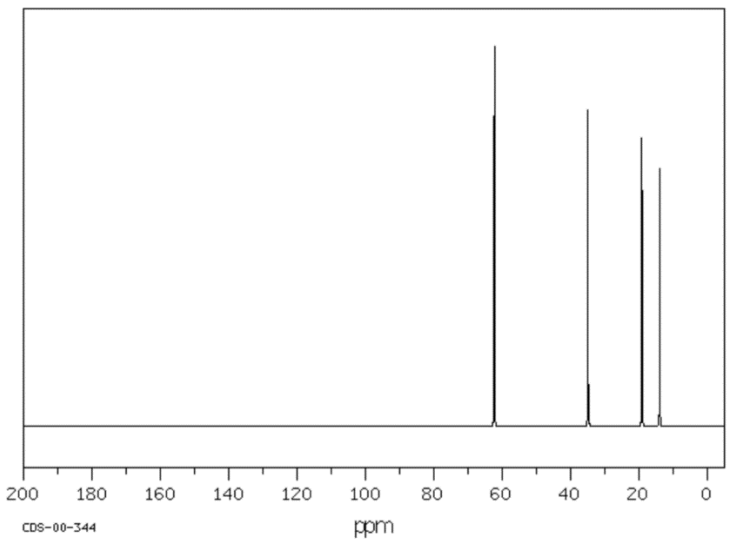
^{1}HNMR Spectrum



^{1}HNMR Data

Chemical Shift (ppm)	Relative Peak Area	Peak Splitting
3.6	2	3
2.2	1	1
1.5	2	5
1.3	2	6
0.94	3	3

^{13}CNMR Spectrum



c. Which of the three named isomers produced the NMR spectra on pages 28-29? Justify your answer using the information provided.

3 marks

_____

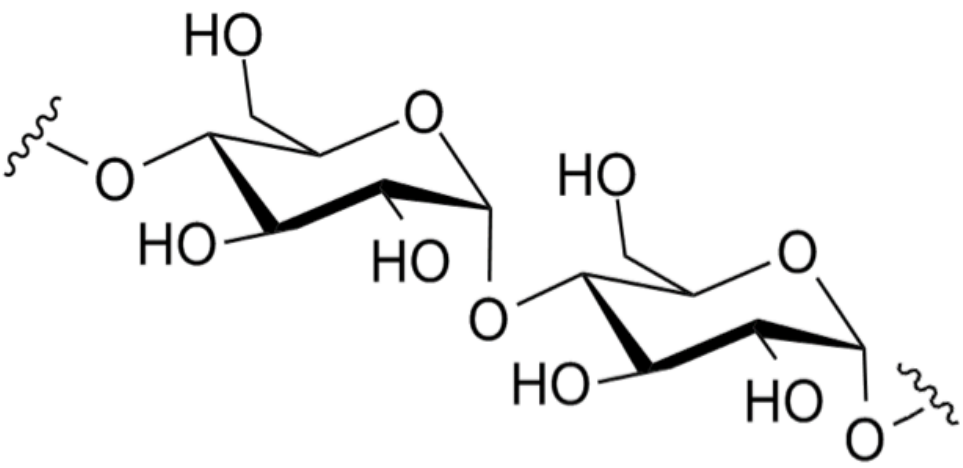
_____

_____

_____

Question 5 (10 marks)

a. The following is a polysaccharide, amylose



i. What is the monosaccharide subunit that forms amylose?

1 mark

_____

ii. What is the type of bond that joins monosaccharides together to form a polysaccharide?

1 mark

_____

b. Below is a section of the amino acid sequence from insulin.
Gly-Ile-Val-Glu-Gln-Cys-**Thr-Ser-Ile**-Cys-Ser-Leu-Tyr-Gln-Leu-Glu-Asn-Tyr-Cys-Asn

i. Draw the amino acid sequence highlighted in bold.

3 marks

ii. Describe the bonding that is found in the primary and secondary structures of the insulin molecule

3 marks

_____

_____

_____

iii. Explain the difference between essential and non-essential amino acids

2 marks

_____

_____

Question 6 (10 marks)

Below is a table of fatty acids and their melting points

Fatty Acid	Melting Point (K)
Lauric	316
Palmitic	339
Linoleic	268
Linolenic	263

a. With reference to structure and bonding, explain the difference in melting points between

i. Palmitic acid and Lauric acid

2 marks

_____

_____

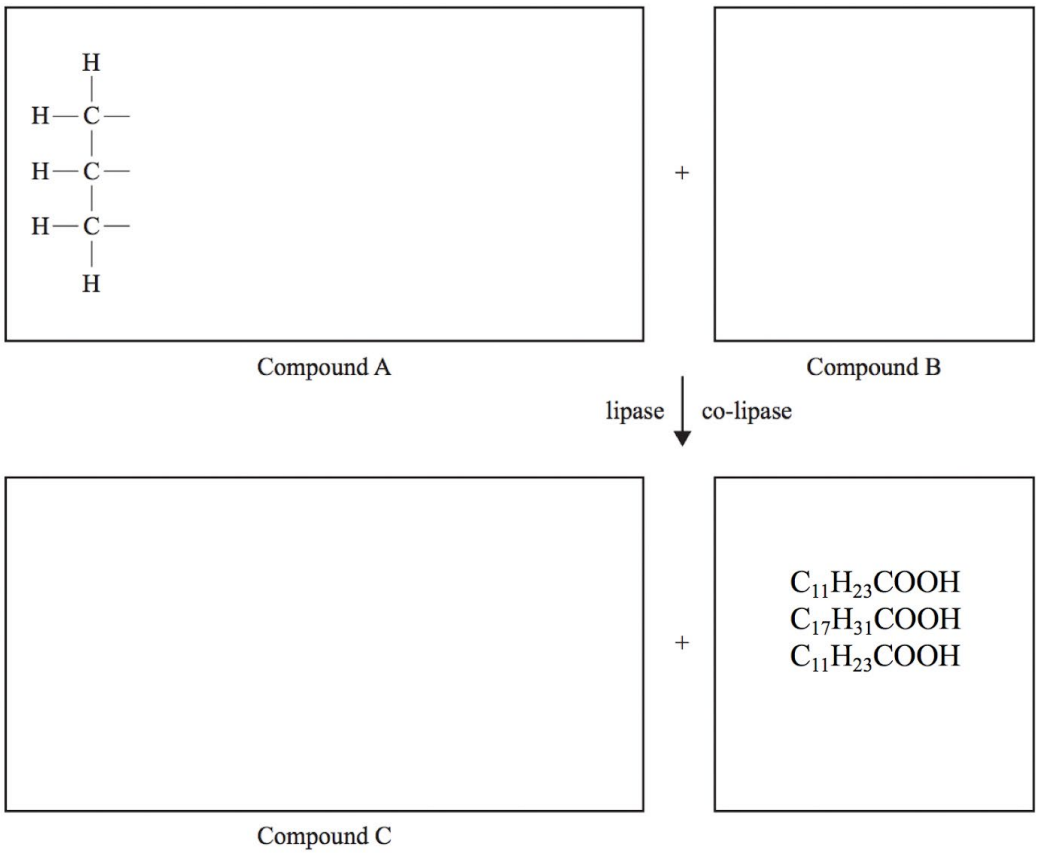
ii. Lauric acid and Linolenic acid

2 marks

_____

_____

b. A particular triglyceride found in fish, Compound A, contains three fatty acid chains: lauric, linoleic, lauric. Compound A undergoes hydrolysis before its nutrients can be absorbed by the body. The reaction pathway is given below



i. Complete the semi-structural formula of Compound A in the box provided

2 marks

ii. Write the formula, and its correct stochiometric ratio, of Compound B in the box provided

1 mark

iii. Draw the structural formula of Compound C in the box provided

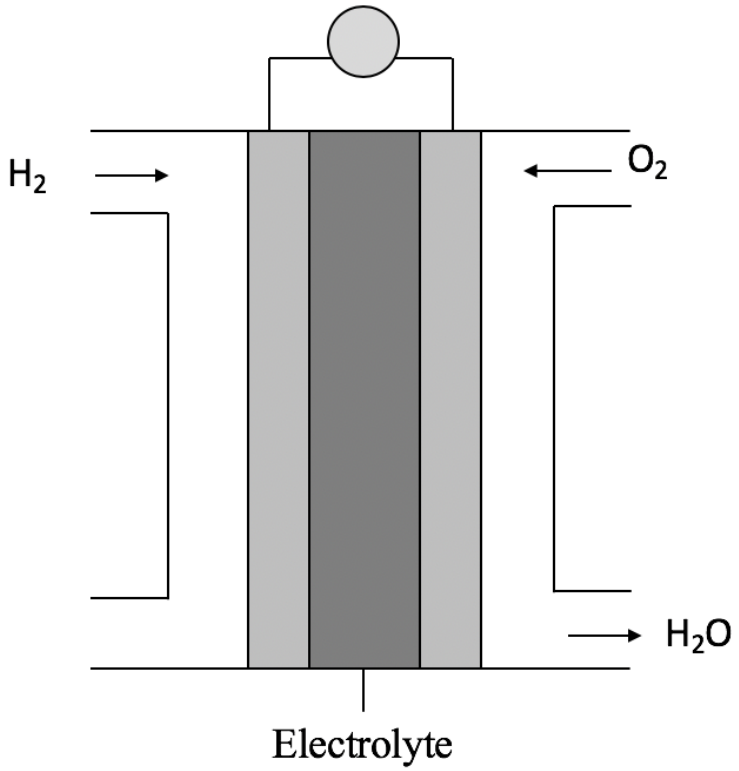
1 mark

c. Lipase and colipase work together for the reaction in part b. Describe how the enzymes and coenzymes work together to catalyse a reaction.

2 marks

Question 7 (8 marks)

Hydrogen fuel cells are a potential alternative for powering cars. One such car company, Hydra, is developing cars to run on the hydrogen fuel cell as depicted below, instead of a conventional petrol engine.



a. Outline the purpose of an electrolyte in a fuel cell

1 mark

_____

b. Using the information in your electrochemical series, write the balanced overall equation for this fuel cell.

1 mark

_____

c. It was found that the fuel cell operated at a lower than expected voltage when tested in a car. Suggest and justify one possible reason for this.

2 marks

_____

_____

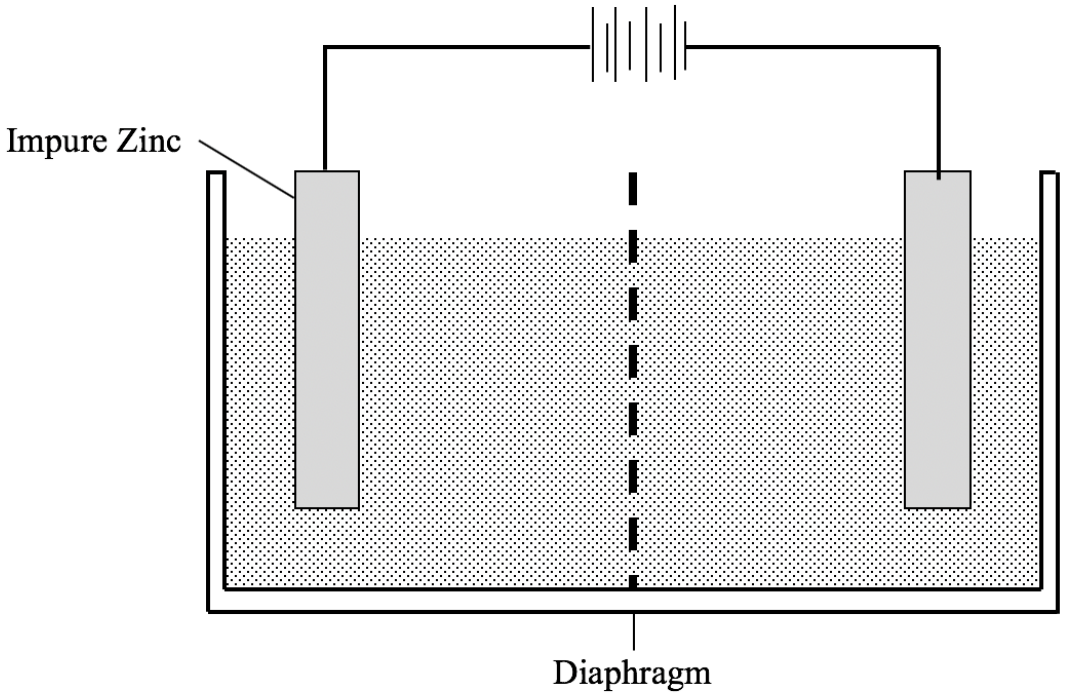
_____

d. State **two** and advantages, and **two** disadvantages to using **this** fuel cell instead of a regular petrol engine.

4 marks

Question 8 (10 marks)

A potential method for obtaining pure zinc is electrorefining. In this process, a lump of impure zinc metal with magnesium and aluminium impurities, is placed in an aqueous electrolytic cell and a current of -0.72 V is applied. A diaphragm is used to prevent metal ions larger than zinc from travelling through the electrolyte



a. Show the movement of electrons on the diagram above

1 mark

b. Write the suitable half equation for a reaction occurring at the anode of this cell

1 mark

_____

c. The cell is run for 10 minutes, at a current of 9.5 A.

i. Identify a product at the cathode

1 mark

_____

ii. Calculate the mass of product at the cathode in grams

3 marks

_____

_____

_____

d. The chemist setting up this electrolytic cell does not have access to a platinum or graphite electrode. Using the information in your electrochemical series, justify a potential reactive electrode that could be used at the cathode.

3 marks

Question 9 (13 marks)

Hydrogenase is an enzyme that catalyses the reaction to convert hydrogen ions to hydrogen gas. A group of scientists set out to investigate the effects of varying concentration of this enzyme on hydrogen gas production. A summary of their report is given below.

Equation For Reaction:

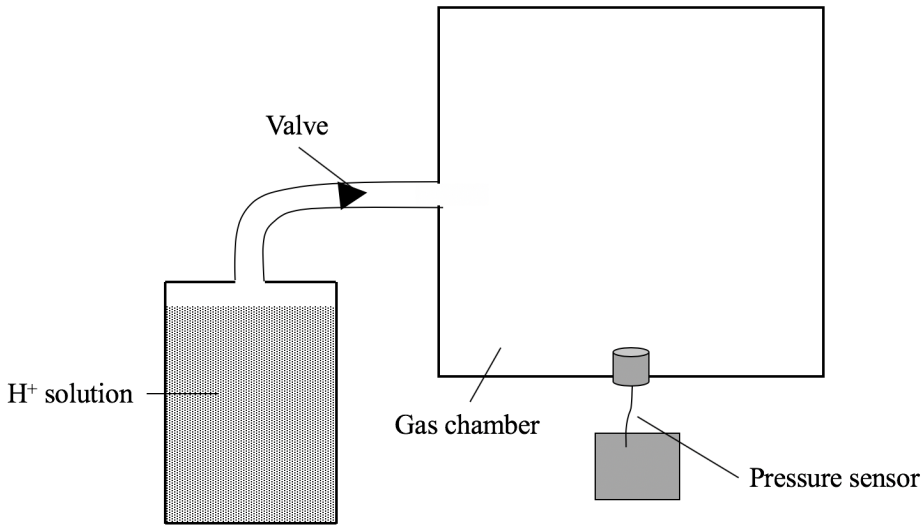
$$2H^+(aq) + 2e^- \rightarrow H_2(g)$$

Aim:

To determine the effect of varying enzymatic concentration on hydrogen production

Method:

Hydrogenase was weighed and added to a sealed beaker of 1 M H^+ ions at pH 7.0. The hydrogen gas produced passed through a tube with a one-way valve to an evacuated 0.5 L chamber, and the change in pressure was measured.



Results:

Trial	Conc. Hydrogenase (µg/mL)	Change in pressure (kPa)
1	0	0
2	100	+ 700
3	200	+ 1200
4	300	+ 1400
5	400	+ 1500

Calculations:

$$n(H_2) = \frac{500\ kPa \times 0.5\ L}{8.314\ J\ mol^{-1}L^{-1} \times 298\ K} = 0.28 \text{ mol}$$

Conclusion:

Increasing enzymatic concentration will increase the production of hydrogen gas.

a. What is the independent variable for this experiment?

1 mark

_____

b. Suggest a potential controlled variable for this study and explain why it needs to be controlled.

2 marks

_____

_____

_____

c. Using your knowledge of enzymes, suggest why there is only a small increase in production of H_2 between trials 4 and 5. Provide a reasonable explanation for your suggestion.

2 marks

_____

_____

_____

d. Consider the method in this study. Identify two factors that may have affected either precision or accuracy and provide an explanation for each.

4 marks

e. What is one limitation of this study. How could this limitation be addressed?

2 marks

f. Identify a potential safety hazard in this experiment. How should this safety issue be addressed?

2 marks

Question 10

With the rising concern of the environmental impact of petrol-powered engines, electric vehicles are becoming an increasing popular alternative. However, these engines can be complex, and are often charged from the standard electricity grid.

a. Using the chemistry, you have studied so far this year, analyse the effectiveness of electric vehicles as a replacement to traditional petrol engines.

4 marks

_____

_____

_____

_____

_____

b. Suggest an improvement to these electric vehicles that would make them relatively carbon neutral.

1 mark

_____

END OF QUESTION AND ANSWER BOOK