TRIAL CHEMISTRY EXAM

Unit 3 & 4 Chemistry
Question and Answer Book
VCE Trial Examination 2024

Reading time is 15 minutes: _____ to _____
Writing time is 2 hours 30 minutes _____to _____

Materials supplied

- Question and Answer Book of 36 pages
- Data Book
- Multiple-Choice Answer Sheet

Instructions

- Follow the instructions on your Multiple-Choice Answer Sheet
- At the end of the examination, place your Multiple-Choice Answer Sheet inside the front cover of this book

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

Contents pages

Approved materials and equipment

- Normal stationery requirements (pens, pencils, highlighters, erasers, sharpeners and rulers)
- One scientific calculator

Section A – Multiple-choice questions

Instructions

- Answer **all** questions in pencil on the Multiple-Choice Answer Sheet
- 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

Use items 10 and 11 of the Data Book to determine the strongest covalent bond.

A. C-C
B. C-H
C. C-Cl
D. C-I

Question 2

The equilibrium constant for the reaction $H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$ is 3.51.
What is the equilibrium constant at the same temperature for the reaction $2H_2(g) + 2I_2(g) \rightleftharpoons 4HI(g)$?

A. 1.76
B. 3.51
C. 7.02
D. 12.3

Question 3

Consider the gaseous equilibrium system

$N_2O_4(g) \rightleftharpoons 2NO_2(g)$ $\Delta H > 0$

Which factor will increase the yield of NO_2, nitrogen dioxide?

A. Remove N_2O_4
B. Decreasing pressure
C. Adding a catalyst
D. Halving the volume of the reaction chamber

Question 4

The following equations represent different equilibrium systems.

Equation 1 $3H_2(g) + N_2(g) \rightleftharpoons 2NH_3(g)$ $\Delta H < 0$

Equation 2 $I_2(g) + H_2(g) \rightleftharpoons 2HI(g)$ $\Delta H < 0$

Equation 3 $CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g)$ $\Delta H > 0$

Equation 4 $N_2O_4(g) \rightleftharpoons 2NO_2(g)$ $\Delta H > 0$

In which system would a decrease in temperature and an increase in pressure result in a greater yield?

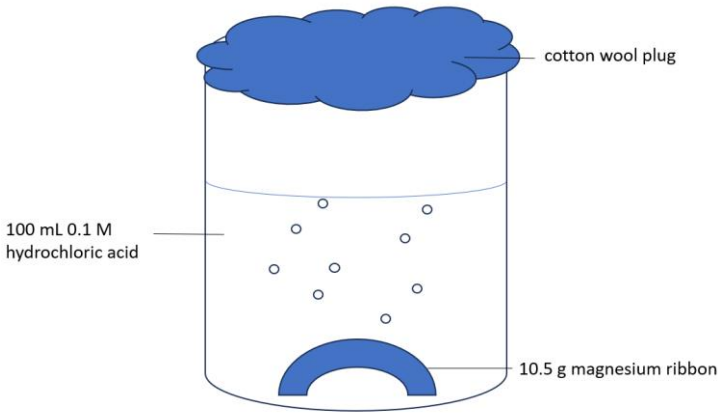
A. Equation 1 only
B. Equations 3 and 4 only
C. Equations 2 and 3 only
D. Equations 1, 2 and 3 only

Question 5

A student added a piece of magnesium ribbon, Mg(s) to a beaker and added dilute hydrochloric acid, HCl(aq).

The reaction can be represented by the equation:

$$Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$$

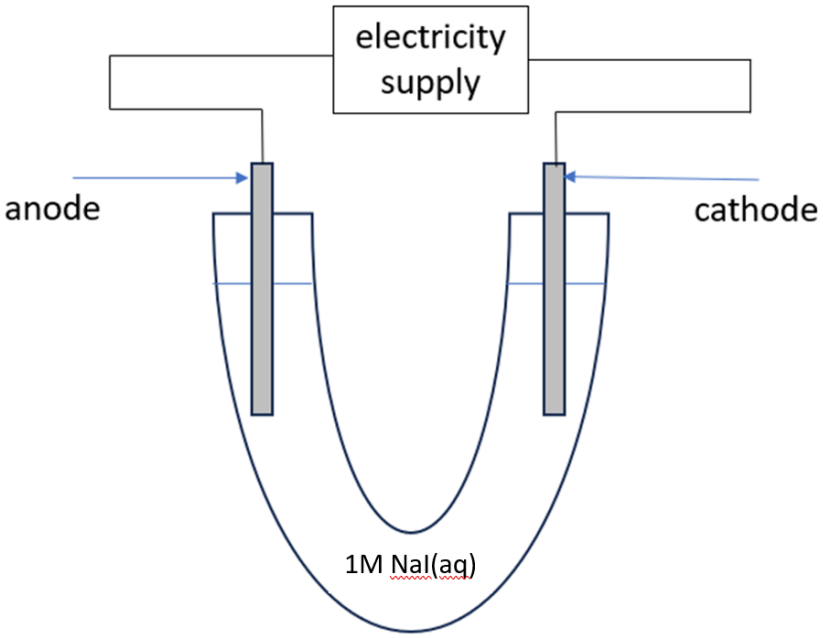


Which of the following could **not** be used to determine the rate of the reaction?

A. by measuring the volume of the solution over time
B. by measuring the mass loss of the system on a weighing balance over time
C. by collecting the gas produced in a syringe and measuring the volume of gas produced over time
D. by measuring the change in pH of the solution over time

Question 6

A student electrolysed a 1M solution of sodium iodide, NaI, with graphite electrodes.

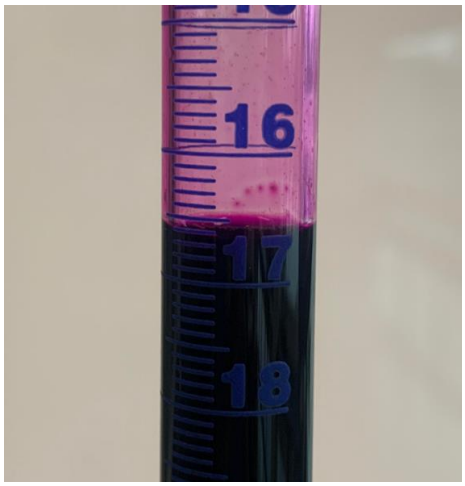


Predict the product at the anode.

A. Na(s)
B. $I_2(s)$
C. $H_2(g)$
D. $O_2(g)$

Question 7

Winnie conducted a redox titration using a standard solution of acidified potassium permanganate, $KMnO_4$.



Identify the resolution value and measured value of the burette.

	Resolution value	Measured value
A.	1.0 mL	16.55 mL
B.	0.1 mL	16.55 mL
C.	1.0 mL	17.45 mL
D.	0.1 mL	17.45 mL

Question 8

Bioethanol is completely combusted in oxygen, at SLC, according to the following equation.

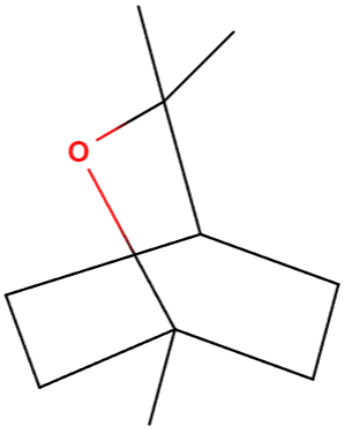
$CH_3CH_2OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l)$

30.00 g of ethanol combusts with 40.0 L of oxygen gas. Identify the limiting reactant and the amount of excess reactant remaining after the reaction is complete.

	Name of limiting reactant	**Amount of excess reactant remaining after the reaction is complete**
A.	ethanol	0.652 mol
B.	ethanol	0.115 mol
C.	oxygen	0.115 mol
D.	oxygen	1.61 mol

Question 9.

The skeletal structure of eucalyptol (1,8 cineole) is represented as follows:

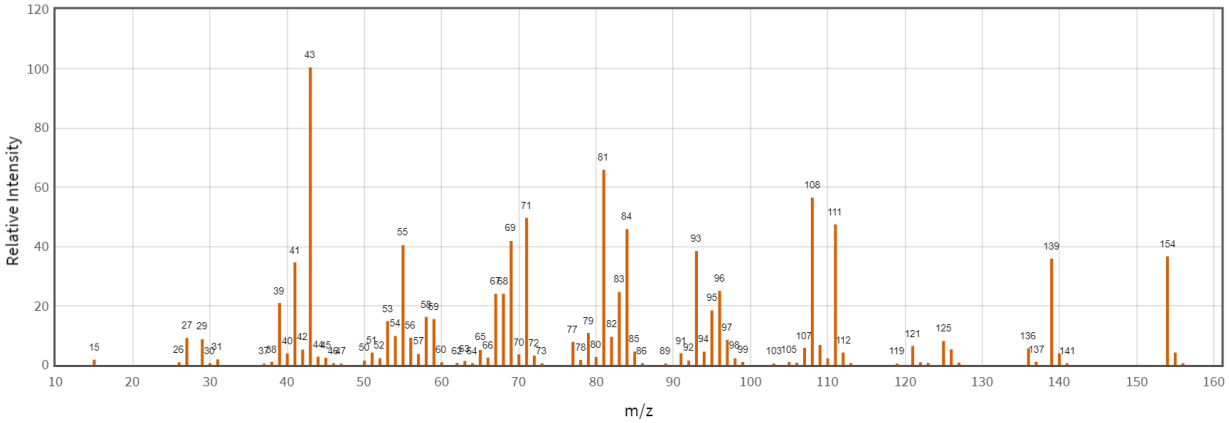


Which would be the most suitable solvent to use to extract this medicinal compound from eucalyptus leaves?

A. water
B. ethanol
C. methanoic acid
D. cyclohexane

Question 10

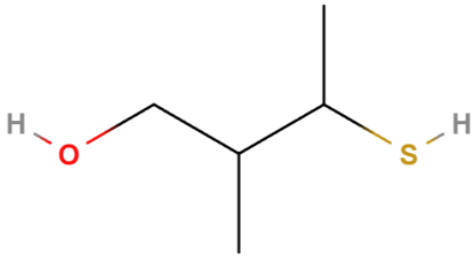
Eucalyptol (1,8 cineole) is a medicinal compound found in eucalyptus leaves. Identify the type of spectrum shown of eucalyptol.



source: https://webbook.nist.gov/cgi/cbook.cgi?ID=470-82-6

A. Mass spectrum
B. Infra-red spectrum
C. ^{13}C NMR spectrum
D. High resolution ^{1}H NMR spectrum

Question 11
Consider the following molecule



How many peaks will be observed in a ^{13}C NMR spectrum of this molecule?

A. 4
B. 5
C. 6
D. 7

Question 12

Fish oil contains the fatty acid docosahexaenoic acid (DHA). 16.29 g of DHA reacted with 2.10 g of iodine. The molar mass of DHA = 328.5 g mol^{-1}. Calculate the number of C=C bonds in DHA.

A. 3
B. 4
C. 5
D. 6

Question 13

A mixture of organic compounds was separated using fractional distillation. The mixture contained $CH_3(CH_2)_3CH_3(l)$, $CH_3(CH_2)_3CH_2OH(l)$ and $CH_3(CH_2)_3COOH(l)$.

List the molecules in order from lowest to highest boiling point.

A. $CH_3(CH_2)_3COOH(l)$, $CH_3(CH_2)_3CH_2OH(l)$, $CH_3(CH_2)_3CH_3(l)$
B. $CH_3(CH_2)_3CH_3(l)$, $CH_3(CH_2)_3COOH(l)$, $CH_3(CH_2)_3CH_2OH(l)$
C. $CH_3(CH_2)_3CH_3(l)$, $CH_3(CH_2)_3CH_2OH(l)$, $CH_3(CH_2)_3COOH(l)$
D. $CH_3(CH_2)_3COOH(l)$, $CH_3(CH_2)_3CH_3(l)$, $CH_3(CH_2)_3CH_2OH(l)$

Question 14

Which of the following is **not** a qualitative test for the presence of carboxyl groups?

A. When bromine water decolorises
B. When a gas is produced when reacted with sodium hydrogen carbonate
C. When an odour is produced when an alcohol is mixed with a compound in the presence of concentrated sulfuric acid
D. When a colour change of an acid-base indicator takes place.

Use the following information to answer Questions 15 and 16.

Consider the following reaction

$$CH_3CH_2CH_2COOH(l) + CH_3CH_2CH_2OH(l) \xrightarrow{H_2SO_4(l)} CH_3CH_2CH_2COOCH_2CH_2CH_3\ (l) + H_2O(l)$$

Question 15

Identify the type of reaction represented by the reaction equation

A. esterification
B. transesterification
C. hydrolysis
D. oxidation

Question 16

Calculate the percentage atom economy for the formation of the organic compound

A. 12.16 %

B. 75.62 %

C. 87.84 %

D. 100.0 %

Question 17

The high resolution ^{1}H NMR spectrum of an organic compound has 3 set of peaks which include a singlet, a quartet and a triplet
The compound could be

A. pentanoic acid

B. 2,3,3-trichloropentane

C. butan-2-one

D. hex-3-ene

Question 18

Consider the following equation

$2MnO_4^-(aq) + 6H^+(aq) + 5H_2O_2(aq) \rightarrow 2Mn^{2+}(aq) + 8H_2O(l) + 5O_2(g)$

Identify the oxidising agent

A. MnO_4^-

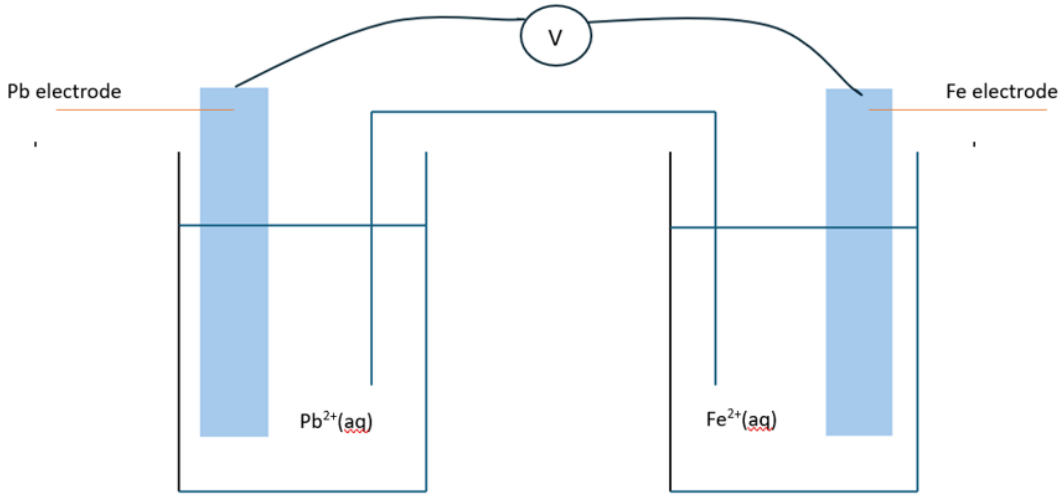
B. H^+

C. H_2O_2

D. Mn^{2+}

Question 19

Consider the following diagram of a galvanic cell.

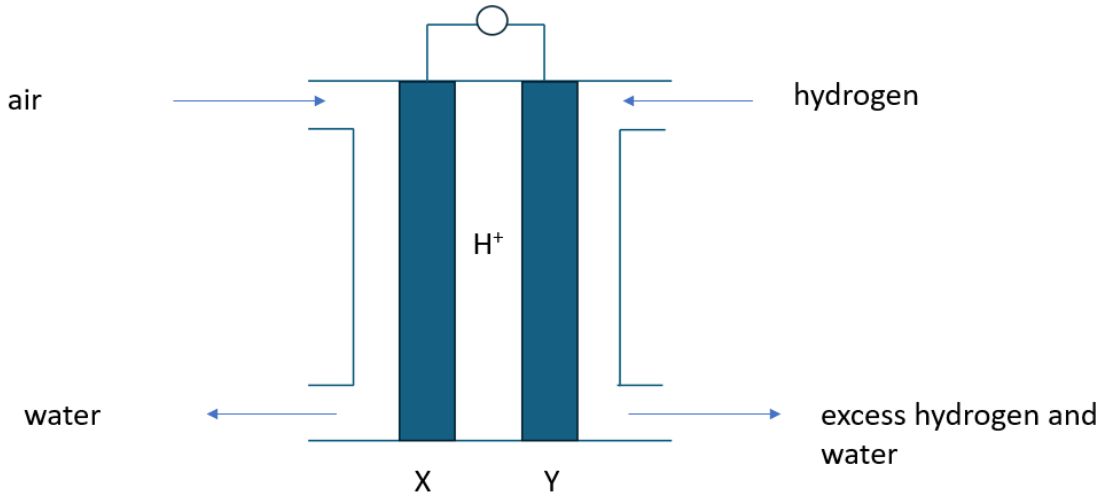


When the cell is operating, the iron electrode

	Polarity	**Process occurring**
A.	Has a negative polarity	Is the site of reduction
B.	Has a negative polarity	Is the site of oxidation
C.	Has a positive polarity	Is the site of reduction
D.	Has a positive polarity	Is the site of oxidation

Question 20

Consider the fuel cell represented in the following diagram.



The oxidation half-equation when this cell is operating at 80°C is

A. $2H_2O(l) \rightarrow O_2(g) + 4H^+(aq) + 4e^-$

B. $2H_2O(l) + 2e^- \rightarrow H_2(g) + 2OH^-(aq)$

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

D. $O_2(g) + 4H^+(aq) + 4e^- \rightarrow 2H_2O(l)$

Use the following information to answer Questions 21 - 23

The villages on Waya Island in Fiji use petrodiesel as a source of energy for lighting, air-conditioning refrigeration, desalination of sea water and other essential services.

Fiji grows coconut palms. The coconut fruit is rich in triglycerides (lipids). These molecules are useful feedstocks for the production of organic chemicals.

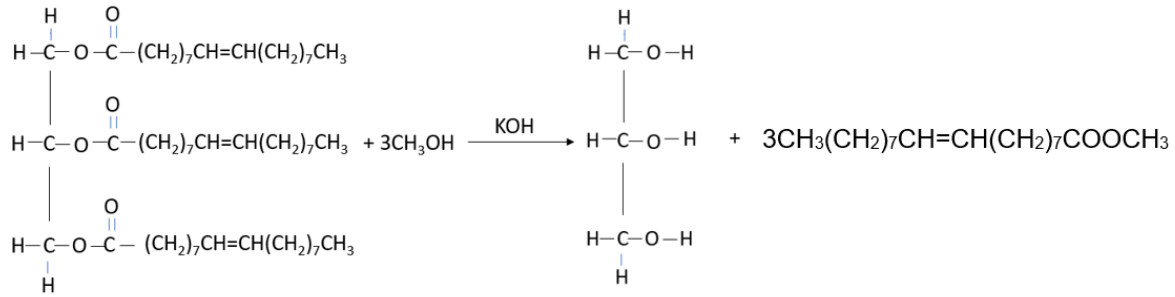
Question 21

Select the appropriate classification of petrodiesel

A.	renewable	fossil fuel
B.	renewable	biofuel
C.	non-renewable	fossil fuel
D.	non-renewable	biofuel

Question 22

Identify the type of reaction shown in the following equation



A. hydrolysis of a triglyceride
B. transesterification of a triglyceride
C. hydrolysis of a carbohydrate
D. synthesis of a triglyceride

Question 23

Suggest sources of renewable energy that could be used in the village for air conditioning, refrigeration and desalination of sea water.

A. biofuels, solar, wind, green hydrogen
B. fossil fuels, solar, wind
C. biofuels, blue hydrogen, solar
D. solar, wind, grey hydrogen

Question 24

A recent news article stated that

> *Bega (NSW) will become Australia's most circular economy by 2030 if Australian businessman Barry Irvin has his way. "We could get 30 per cent of the economy circular by then [2030], and 50 per cent within a decade," Mr Irvin said.*
>
> *"Circularity's a virtuous circle where everybody wins, and that's from an economic, social and environmental point of view," Mr Irvin said.*

Source: https://www.abc.net.au/news/2024-07-21/bega-circular-economy-renewable-target-sustainable-waste/104108834

A circular economy is an alternative to a/an

A. linear economy

B. financial economy

C. social economy

D. environmental economy

Question 25

An aqueous alkaline solution is electrolysed to produce hydrogen and oxygen gas. The half-equation for the reaction occurring at the cathode in this cell is

A. $2H_2O(l) \rightarrow O_2(g) + 4H^+(aq) + 4e^-$

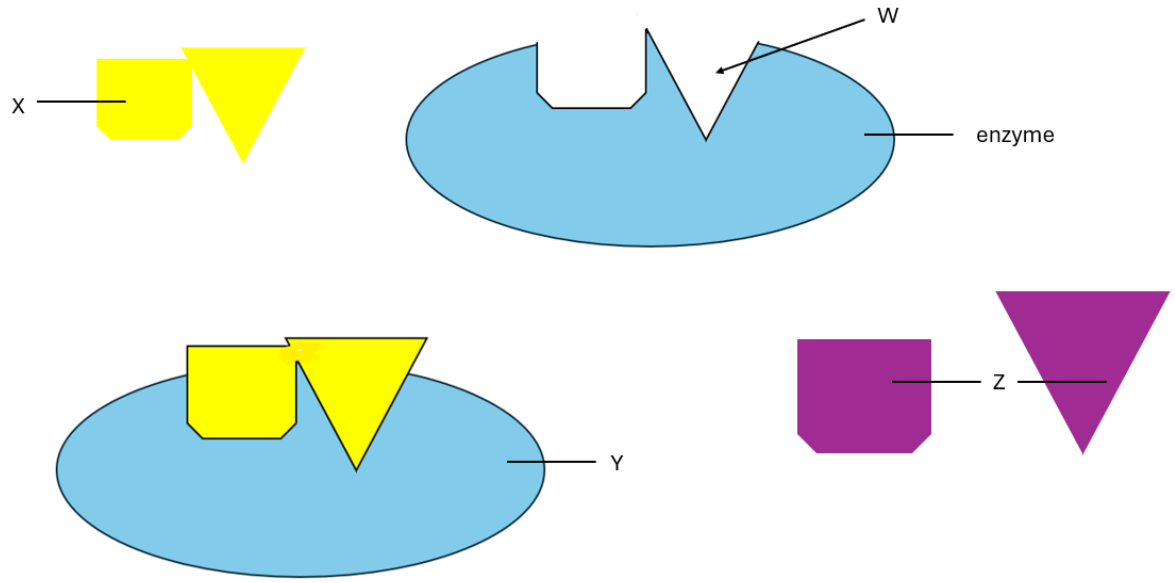
B. $H_2O_2(aq) + 4e^- \rightarrow O_2(g) + 4H^+(aq)$

C. $O_2(g) + 2H_2O(l) + 4e^- \rightarrow 4OH^-(aq)$

D. $2H_2O(l) + 2e^- \rightarrow H_2(g) + 2OH^-(aq)$

Question 26

The lock and key mechanism of enzyme catalysis is represented in the following diagram



Identify key components.

	W	X	Y	Z
A.	Enzyme-substrate complex	Active site	Products	Substrate
B.	Active site	Enzyme-substrate complex	Substrate	Products
C.	Substrate	Active site	Products	Enzyme-substrate complex
D.	Active site	Substrate	Enzyme-substrate complex	Products

Question 27

The equation for the complete combustion of propane at standard laboratory conditions (SLC) is shown below.

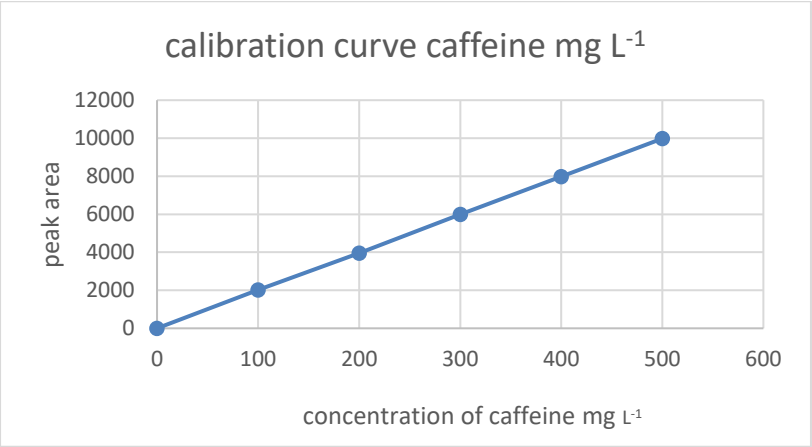
$$C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(l)$$

Given that the molar mass of carbon dioxide is 44.0 g mol^{-1}, the combustion of 5.00 mol of propane under these conditions will produce which of the following?

	Mass of CO_2 gas	Volume of greenhouse gas (L)
A.	220 g	372 L
B.	660 g	868 L
C.	73.3 g	124 L
D.	660 g	372 L

Question 28

Standard solutions of caffeine were injected into an HLPC machine. The peak area for each sample was measured. The calibration curve obtained is presented below:



An unknown sample had a peak area of 6996 when run through the HPLC column under the same conditions. Calculate the mass of caffeine in a 375 mL can of the drink.

A. 131 mg

B. 350 mg

C. 570 mg

D. 933 mg

Question 29

In which parts of a scientific poster should in-text references (e.g. Lennard, 2024) to reliable sources of information be found?

A. Results and Conclusion

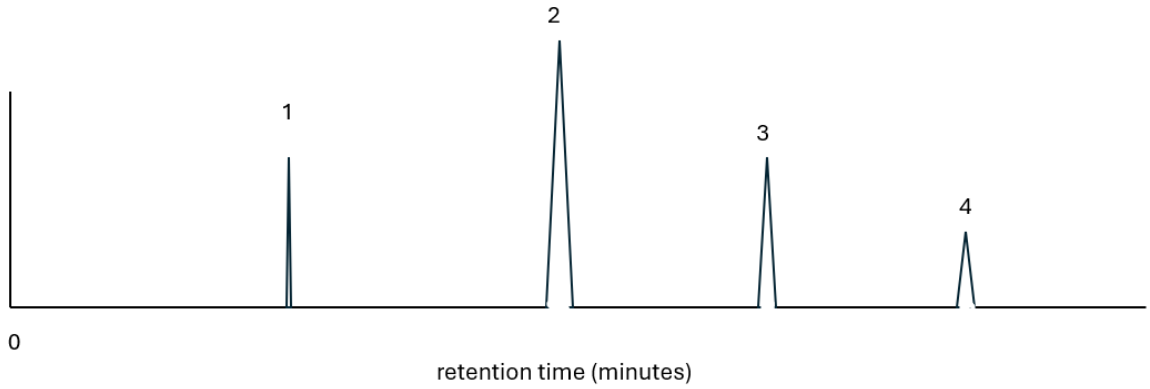
B. Introduction and Discussion

C. Results and Discussion

D. Introduction and Results

Question 30

A mixture of organic compounds was passed through an HPLC column that had a non-polar stationary phase and a polar mobile phase. The chromatogram obtained is shown below



Peak 1 is most likely to be

A. methanoic acid

B. propanoic acid

C. ethanoic acid

D. octane

End of Section A

Section B

Instructions

- Answer **all** questions in the spaces provided.
- Write your responses in English.
- 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

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Question 1 (16 marks)

Cooked chickpeas were analysed and the composition is shown in the following table.

Nutrient	g per 100 g
Protein	6.3
Carbohydrate	13.3
Fat	2.1

a. Calculate the energy content per 40 g serving. 2 marks

b. One of the amino acids present in the protein in chickpeas is the essential amino acid, leucine.

i. Draw the structural formula of leucine at pH 2. Refer to item 20 of the data book.

2 marks

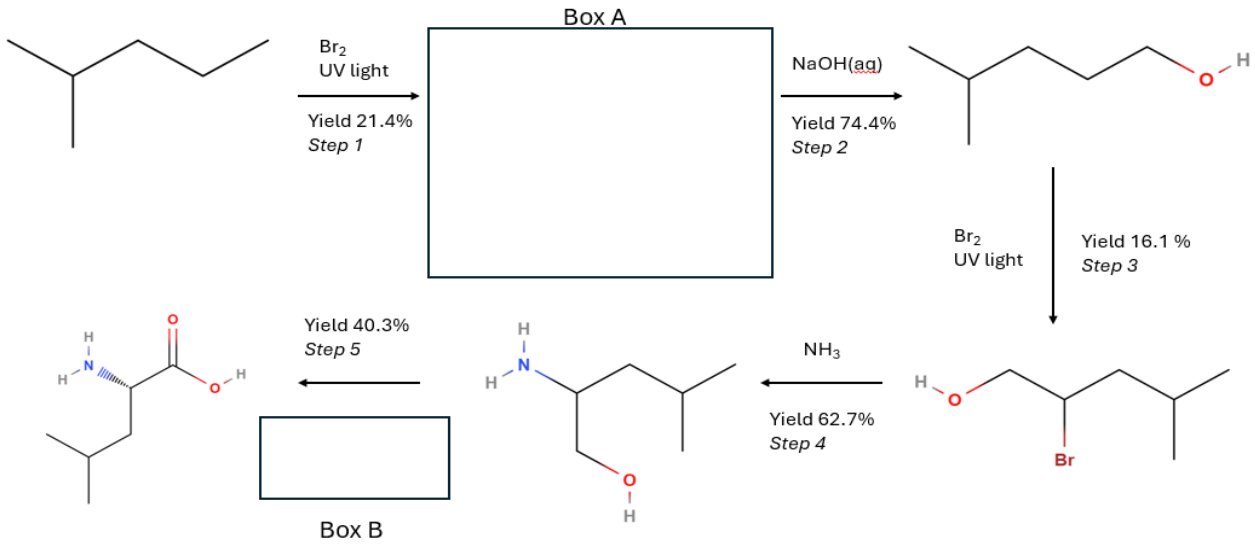
ii. Circle the description of the side chain on leucine (more than one description can be circled) 1 mark

Acidic **Basic** **Non-polar** **Polar**

iii. What type of intermolecular forces would occur between adjacent leucine residues in a protein? 1 mark

c. Leucine can be synthesised in a number of steps using the Pathway A.

Pathway A



i. Calculate the overall percentage yield of Pathway A. 1 mark

ii. Calculate the atom economy of step 3. 1 mark

iii. Draw the structural formula of the organic compound formed in Box A. 1 mark

Box A

iv. Complete Box B by writing reagents and reaction conditions required for step 5 1 mark

d. Waste collagen (animal protein) can be used as an alternative source to synthesise leucine.

Name the type of reaction that can be used to synthesise leucine from the protein collagen.

1 mark

e. The major carbohydrates in chickpeas (starch/amylose/amylopectin) break down when digested to form glucose.

i. Write a thermochemical equation for the complete combustion of glucose at SLC.

2 marks

ii. Glucose can be fermented by yeast and bacteria to produce ethanol. Write a balanced chemical equation for this reaction. 2 marks

iii. Name the process that should be used to separate ethanol from the fermentation mixture.

1 mark

Question 2 (14 marks)

The Haber Process can be represented by the following equation.

$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$

a. Identify the type and number of bonds to be broken. 2 marks

b. Identify the type and number of bonds to be formed. 1 mark

c. Calculate the theoretical enthalpy change for this reaction. Use the average bond enthalpies in item 10 of the Data Book 2 marks

d. Is the equation as written endothermic or exothermic? 1 mark

This is an equilibrium reaction.

e. How should the equation above be modified to show that this is an equilibrium reaction?

1 mark

f. **i.** 27.8 mol of N_2 and 76.2 mol of H_2 are pumped into a 5.00 L sealed container at 298 K. At equilibrium, the concentration of NH_3 is 9.80 M.

Write an equilibrium expression for this reaction. 1 mark

ii. Calculate the equilibrium constant at this temperature. 4 marks

iii Circle the correct response describing the composition of the equilibrium system at 298 K.

1 mark

Mainly reactants present	**Significant quantities of reactants and products**	**Mainly products present**

g. In another investigation also performed at 298K, the magnitude of the reaction quotient, Q, was found to be 500 after 30 seconds. Which direction will the system move? Circle the correct response 1 mark

system will not move	**forward direction**	**reverse direction**

Question 3 (4 marks)

Hydrogen iodide is a useful reducing agent.
Hydrogen iodide can be formed from the reaction of hydrogen, H_2 and iodine I_2.

$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$

A chemical engineer conducted two experiments on the equilibrium reaction.

Experiment X 10 mol of HI was injected into an empty, sealed 3.0 L container at constant temperature.

Experiment Y 20 mol of HI was injected into an empty, sealed 3.0 L container at constant temperature

a. Which experiment had the highest initial rate of reaction? Circle the correct response 1 mark

Experiment X **Experiment Y** **Rates are equal**

b. Explain your answer to part **a**., using appropriate chemical theory. 2 marks

c. Hydrogen iodide is toxic and corrosive. Suggest a safety measure that should be used by workers in the industrial facility producing hydrogen iodide. 1 mark

Question 4 (6 marks)
Proteases are enzymes that hydrolyse the primary structure of proteins.

a. Complete the following table 4 marks

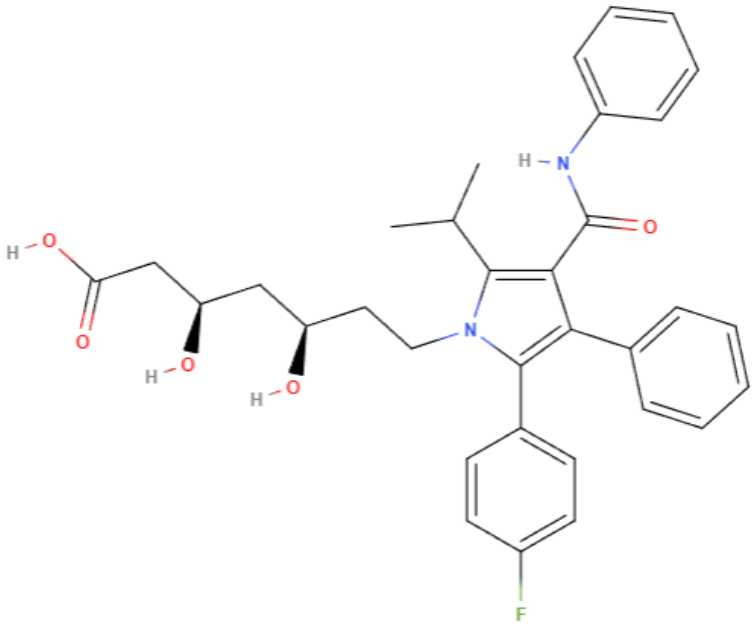
Level of protein structure	Type(s) of bonding involved
Primary	
Secondary	
Tertiary	
Quaternary	

b. A particular protease works optimally at 37 ^{o}C. Explain what would happen to the activity of the enzyme if it was heated to 60^{o}C.

2 marks

Question 5 (4 marks)

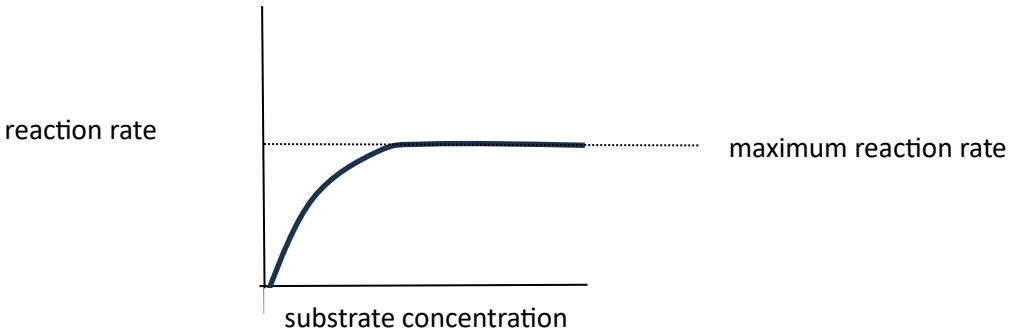
Atorvastatin is an enzyme inhibitor medication. It inhibits the enzyme HMG-Co reductase in humans, which results in lower blood cholesterol levels in patients who consume the medication.



a. Circle and name two different functional groups in atorvastatin. 2 marks

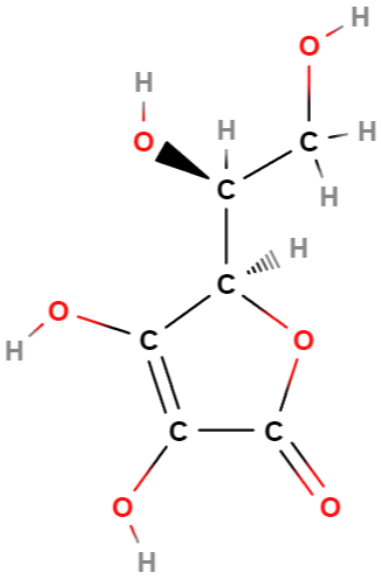
b. Describe how a **competitive inhibitor** functions. 1 mark

c. Draw a graph on the axes below to show the effect of a competitive inhibitor (atorvastatin) on the rate of an enzymatic reaction. 1 mark



Question 6 (18 marks)

Grapefruit juice contains vitamin C (ascorbic acid). Pasteurisation is a heat treatment applied to processed food in order to destroy harmful bacteria. Roberta designed and conducted an investigation to study the effect of pasteurisation temperature on the vitamin C content of Fruity grapefruit juice. She varied the pasteurisation temperature using 60°C, 70°C, 80°C and 90°C and compared this to the vitamin C content of unpasteurised grapefruit juice stored at 4°C. All pasteurisation treatments took place for 120 seconds.



Vitamin C

The concentration of Vitiamin C in the grapefruit juice was determined by performing a titration with iodine solution. The overall redox equation for the titration can be represented as

$$C_6H_8O_6(aq) + I_2(aq) \rightarrow C_6H_6O_6(aq) + 2H^+(aq) + 2I^-(aq)$$

A standard solution of 9.521×10^{-4} M iodine was added to a burette. A few drops of starch solution were added to the grapefruit juice in the conical flask. Iodine was added to the solution in the conical flask until the first permanent blue colour appeared.

a. Identify the independent variable in this investigation. 1 mark

b. Identify the dependent variable in this investigation 1 mark

c. List two variables that should be controlled in order to have a valid investigation. 1 mark

d.

i. Write a half equation for the oxidation reaction. 1 mark

ii. Write a half equation for the reduction reaction 1 mark

e.

A clean, dry 100 mL conical flask was weighed. The conical flask was reweighed after 5 mL of filtered grapefruit juice was added to the flask. The mass of grapefruit juice pasteurised at 60^{o}C was 4.88 g. The average concordant titre of iodine solution was 19.35 mL.

Use the experimental data provided above to calculate the concentration of Vitamin C (%m/m) in the grapefruit juice pasteurised at 60 ^{o}C. 4 marks

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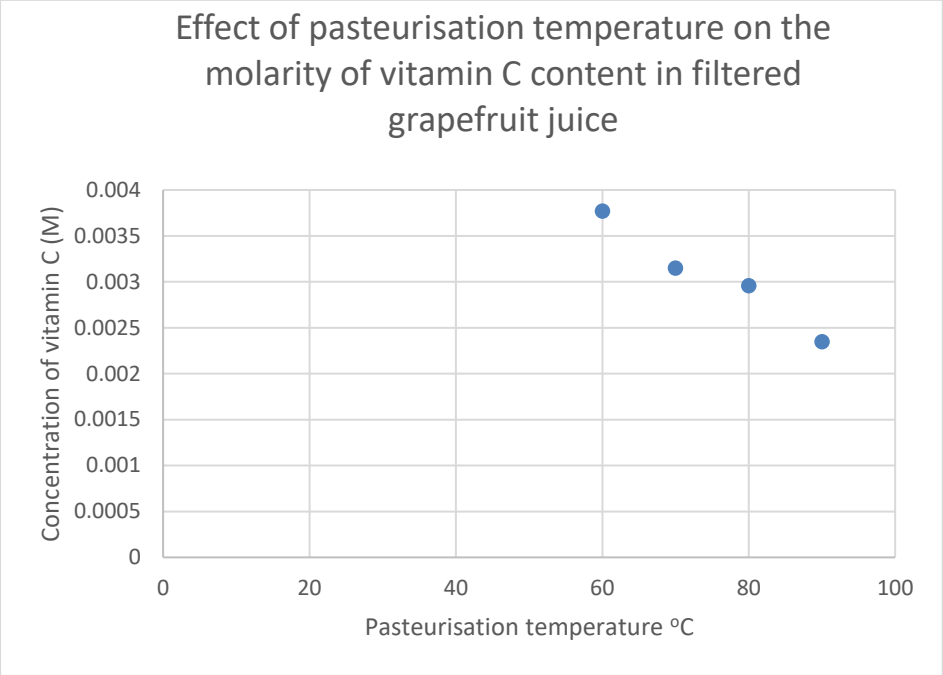
f. In which section of a scientific poster should the balanced redox equation be communicated? 1 mark

In another experiment the following results were obtained:



g. Describe the relationship between vitamin C concentration and pasteurisation temperature.

1 mark

h. Predict the vitamin C concentration of unpasteurised grapefruit juice (i.e. not heat treated). Circle the correct response. 1 mark

3.77 10^{-3} M **less than 3.77 x 10^{-3} M** **more than 3.77 x 10^{-3} M**

i. Outline an experimental error that would result in an underestimation of the concentration of vitamin C in the grapefruit juice. 1 mark

j. **i.** Define accuracy 1 mark

ii. Comment on the impact on the accuracy of the calculated concentration of vitamin C in the grapefruit juice if the conical flask was rinsed with distilled water before the titration.

1 mark

k. Another student conducted the same experiment.

Calculate the titre.

1 mark

Initial burette reading (mL)	10.25
Final burette reading (mL)	29.85
Titre (mL)	

l. Circle the concordant titres in the following list 1 mark

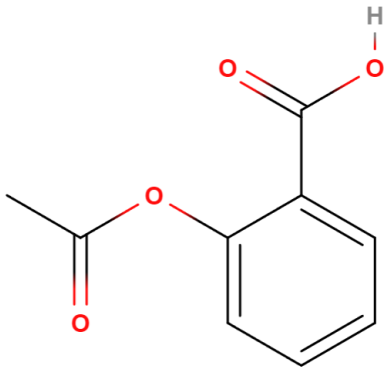
20.35 mL **19.95 mL** **20.00 mL** **20.05 mL** **20.20 mL**

m. Suggest another independent variable that could be investigated relating to Vitamin C using a titration technique.

1 mark

Question 7 (10 marks)

Aspirin is a common pain-relieving medication. It can be synthesised from salicylic acid found in the bark of the Willow tree.



a. Is aspirin chiral or achiral? Circle the correct response. 1 mark

Chiral **Achiral**

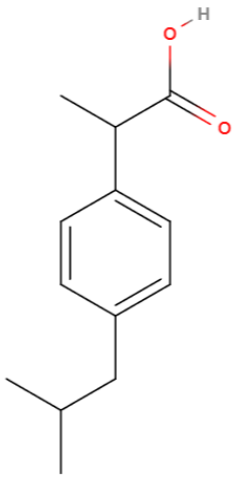
b. Determine the molar mass of aspirin 1 mark

c. Calculate the amount of aspirin, in mol, in a 500 mg tablet. 1 mark

d. At what m/z ratio on a mass spectrum would you expect the parent molecular ion to be shown? 1 mark

e. Write an equation for the formation of the parent molecular ion during mass spectrometry. States not required. 1 mark

Ibuprofen is another pain-relieving medication. Its structure is represented as



f. Place an asterisk on the chiral carbon in this molecule.

1 mark

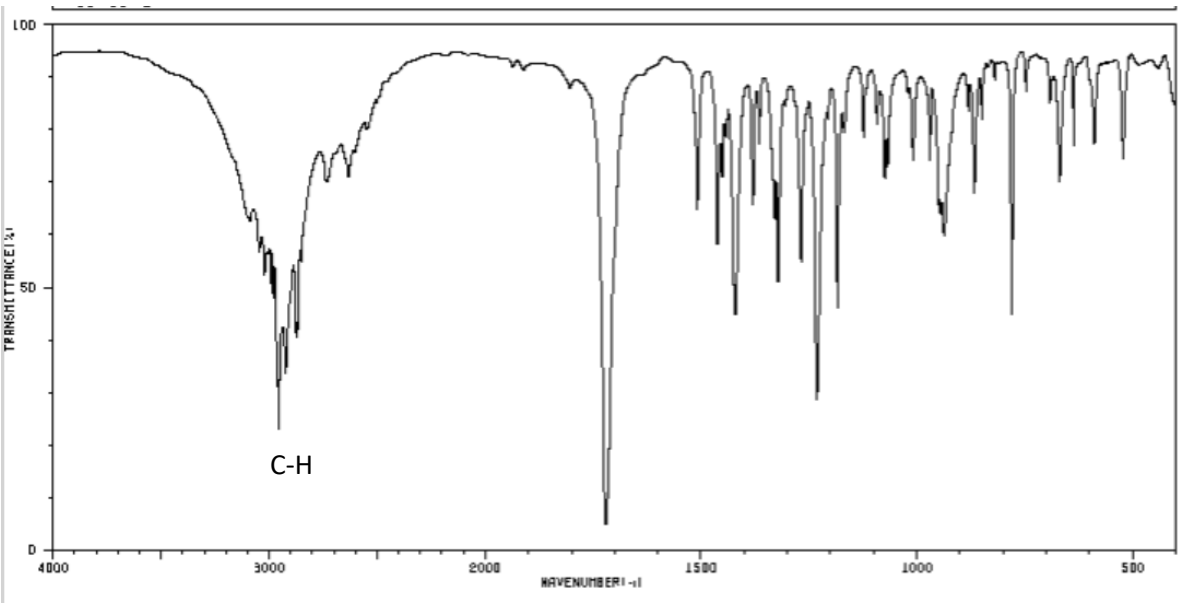
g. Circle and name all functional groups in ibuprofen 2 marks

A sample of ibuprofen was analysed using infra-red radiation.

h. Annotate the following spectrum to show the fingerprint region. 1 mark

i. The C-H bond is labelled on the spectrum. Identify another covalent bond present in ibuprofen.

1 mark

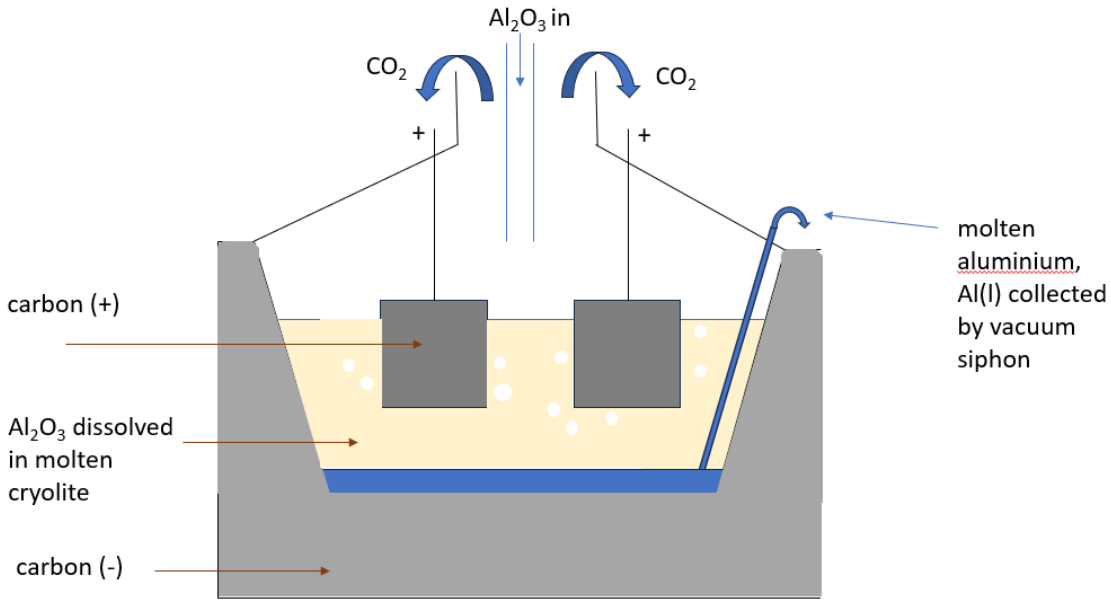


Source: https://sdbs.db.aist.go.jp/IrSpectralView.aspx?fname=NIDA57772&sdbsno=10570

Question 8 (10 marks)

The Hall-Heroult cell is a commercial electrolytic cell used to produce aluminium metal from alumina, Al_2O_3. The carbon anodes are reactive in this cell.

The oxidation half-equation is $C(s) + 2O^{2-}(\text{in cryolite}) \rightarrow CO_2(g) + 4e^-$.



a. Write the reduction half-equation 1 mark

b. Write the overall redox reaction for the cell 1 mark

c. Outline the purpose of the molten cryolite 1 mark

d. On the diagram above label the anode and cathode 1 mark

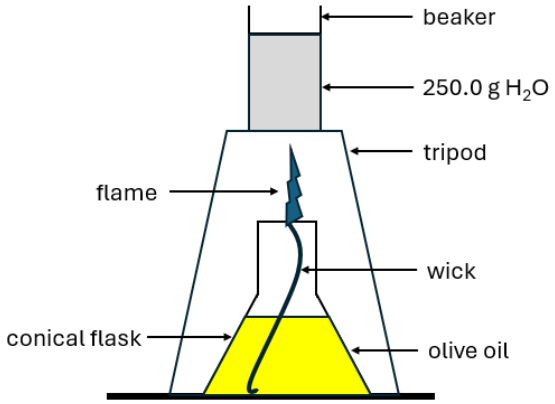
e. A current of 150,000 A was passed through the Hall-Heroult cell. The cell has an efficiency of 92.8%.
Calculate the time take in hours for this cell to consume 1000 kg of molten alumina. 5 marks

f. Why must a molten electrolyte rather than an aqueous electrolyte be used for the production of aluminium through electrolysis?

1 mark

Question 9 (8 marks)

A sample of olive oil containing a wick was ignited and used to heat a beaker containing 250.0 g water. 3.61 g of olive oil was completely combusted. Olive oil contains 100% fat/oil. The initial temperature of the water was 21 °C. In this experiment 76% of the energy was lost to the environment.



a. Calculate the final temperature of the water. 4 marks

b. Would the error associated with heat loss to the environment be classified as a random or systematic error? Circle the correct response. 1 mark

random **systematic**

c. Suggest a modification to the experimental set-up that would reduce heat loss to the environment. 1 mark

d. **i.** The main fatty acid in olive oil is oleic acid. State the degree of unsaturation of oleic acid.

1 mark

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ii. Draw the skeletal structure of oleic acid. 1 mark

END OF TRIAL EXAM