TRIAL CHEMISTRY EXAM

Name _____

VCE CHEMISTRY

Unit 3 Trial Exam 2024

Reading time: 15 minutes
Writing time: 90 minutes

QUESTION AND ANSWER BOOK

Section	Number of questions	Number of questions to be answered	Number of marks
A	20	20	20
B	8	8	55
			Total 75

- 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 26 pages
- VCAA Data book
- Multiple Choice Question Answer Sheet

Instructions

- Write your name in the space provided above on this page.
- Unless otherwise indicated, the diagrams in this book are not drawn to scale.
- All written responses must be in English.
- Give simplified answers to all numerical questions, with an appropriate number of significant figures; unsimplified answers will not be given full marks.
- Ensure chemical equations are balanced and that the formulas for individual substances include an indication of state, for example, $H_{2(g)}$, $NaCl_{(s)}$.

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

Which of the following is **not** a renewable fuel source?

A. biogas

B. biodiesel

C. natural gas

D. bioethanol

Question 2.

What type of organisms **cannot** photosynthesise?

A. green-leafed plants

B. animals

C. blue-green algae

D. all of the above

Question 3

Select the correct statement:

A. Bioethanol supplies more energy per mol when completely combusted compared to the same amount of ethanol

B. Bioethanol can be synthesized through the anaerobic breakdown of animal waste

C. Bioethanol can be produced by the fermentation of glucose obtained from plant matter

D. The production of bioethanol is an application of the process of a linear economy

Question 4

The methane in biogas is completely combusted in oxygen, at SLC, according to the following equation.

$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(l)$

5.00 g of methane combusts with 20.00 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.	oxygen	0.806 mol
B.	oxygen	0.180 mol
C.	methane	0.616 mol
D.	methane	0.180 mol

Question 5.

Select the correct thermochemical equation for the complete combustion of butane at SLC.

A. $2C_4H_{10}(g) + 13O_2(g) \rightarrow 8CO(g) + 10H_2O(l)$ $\Delta H = -2880$ kJ

B. $2C_4H_{10}(g) + 13O_2(g) \rightarrow 8CO_2(g) + 10H_2O(l)$ $\Delta H = -5760$ kJ

C. $2C_4H_{10}(g) + 13O_2(g) \rightarrow 8CO_2(g) + 10H_2O(g)$ $\Delta H = -5760$ kJ

D. $C_4H_{10}(g) + O_2(g) \rightarrow CO_2(g) + H_2O(l)$ $\Delta H = -2880$ kJ

Question 6

Which of the following is a redox reaction?

A. $AgNO_3(aq) + NaCl(aq) \rightarrow NaNO_3(aq) + AgCl(s)$

B. $CH_3COOH(aq) + KOH(aq) \rightarrow KCH_3COO(aq) + H_2O(l)$

C. $H_2SO_4(l) + NaOH(aq) \rightarrow Na_2SO_4(aq) + H_2O(l)$

D. $H_2(g) + F_2(g) \rightarrow 2HF(g)$

Question 7

Consider the following redox equation

$$Cr_2O_7^{2-}(aq) + 14H^+(aq) + 6Fe^{2+}(aq) \rightarrow 2Cr^{3+}(aq) + 7H_2O(l) + 6Fe^{3+}(aq)$$

Identify the oxidising agent:

A. $Cr_2O_7^{2-}$

B. Cr

C. H^+

D. Fe^{2+}

Question 8

Consider the following half equation:

$$NO_3^-(aq) + 2H^+(aq) + e^- \rightarrow NO_2(g) + H_2O(l)$$

Identify a conjugate redox pair:

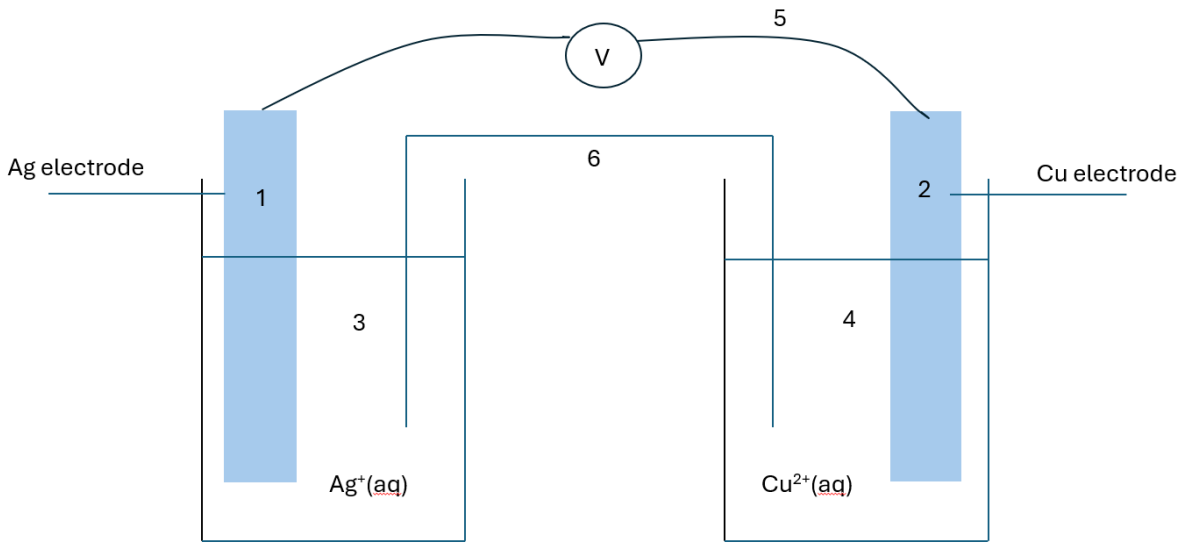
A. NO_3^-/H^+

B. H_2O/NO_2

C. NO_2/H^+

D. NO_3^-/NO_2

Use the following information to answer Question 9, Question 10 and Question 11



Question 9

Select the option that correctly identifies some of the components of the cell.

	1	2	5	6
A.	cathode	anode	external circuit	internal circuit
B.	cathode	anode	internal circuit	external circuit
C.	anode	cathode	internal circuit	external circuit
D.	anode	cathode	external circuit	internal circuit

Question 10

Filter paper is often used to make a salt bridge in the internal circuit of a galvanic cell.

Select an appropriate substance to soak the filter paper in, before connecting the circuit

A. silver nitrate

B. sodium chloride

C. copper(II) nitrate

D. potassium nitrate

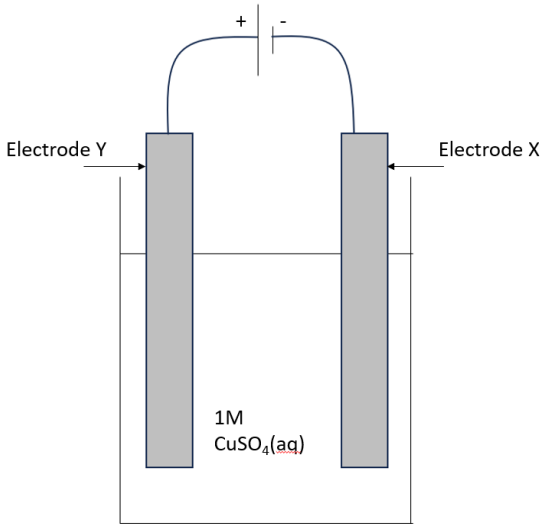
Question 11

When the cell is operating, the copper 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 12

An electrochemical cell is shown in the following diagram.



Select the correct description:

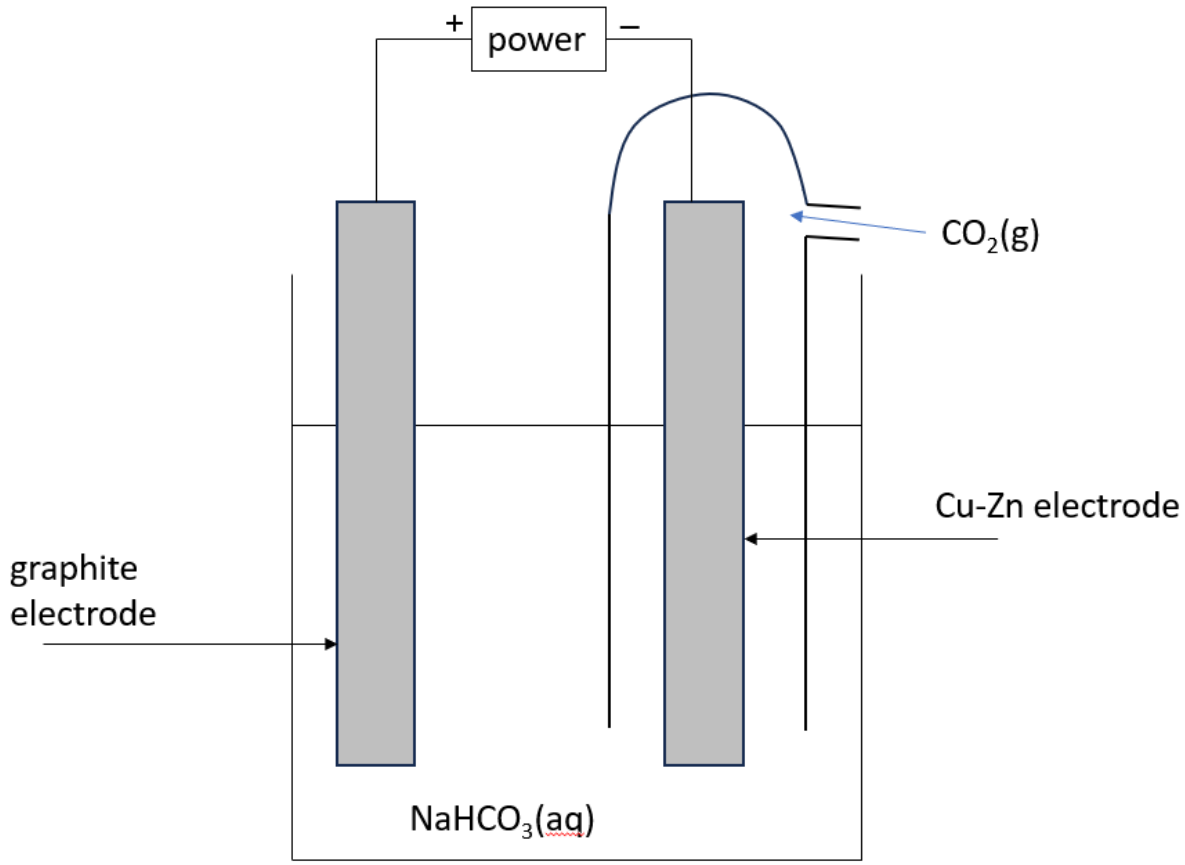
	Type of cell	Description of electrode X
A.	fuel	anode
B.	fuel	cathode
C.	electrolytic	cathode
D.	electrolytic	anode

Question 13. Select the correct option:

	Negative polarity of anode	**Continuous removal of products**
A.	Fuel cell	Fuel cell
B.	Primary cell	Primary cell
C.	Electrolytic cell	Fuel cell
D.	Fuel cell	Primary cell

Question 14

The following electrolytic cell can be used to produce ethanol. The electrolyte used in this cell is an aqueous solution of sodium hydrogen carbonate, $NaHCO_3(aq)$.



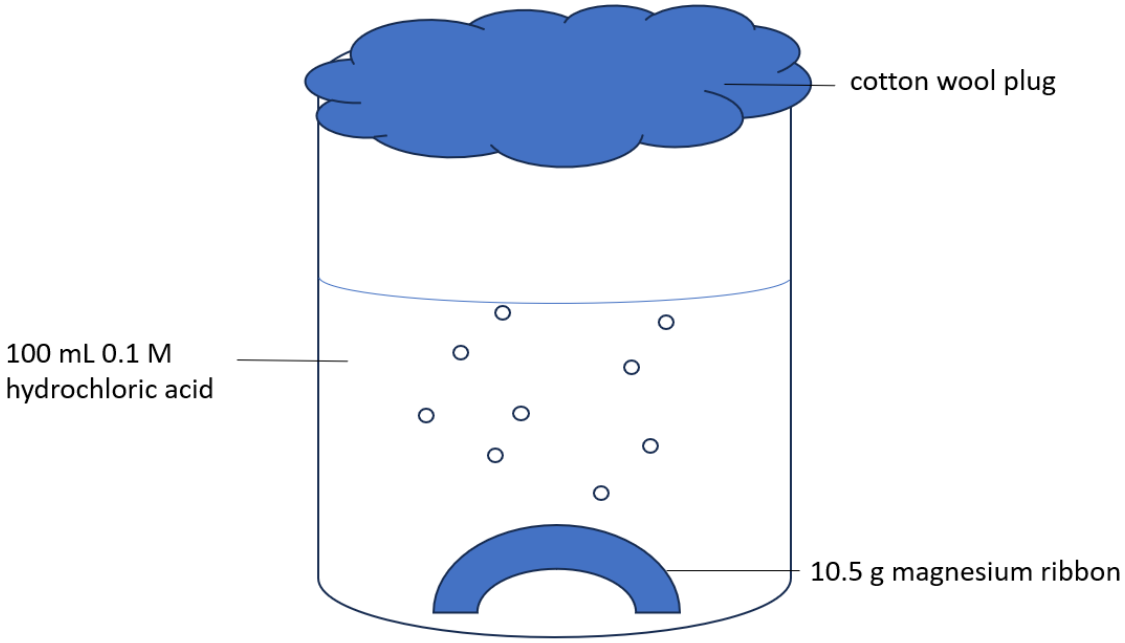
Choose the correct alternative regarding this cell.

	Polarity of Cu-Zn electrode	**Classification of graphite electrode**
A.	positive	cathode
B.	positive	anode
C.	negative	anode
D.	negative	cathode

Question 15.
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 will **not** increase the rate of reaction?

A. Substituting powdered magnesium instead of using magnesium ribbon,

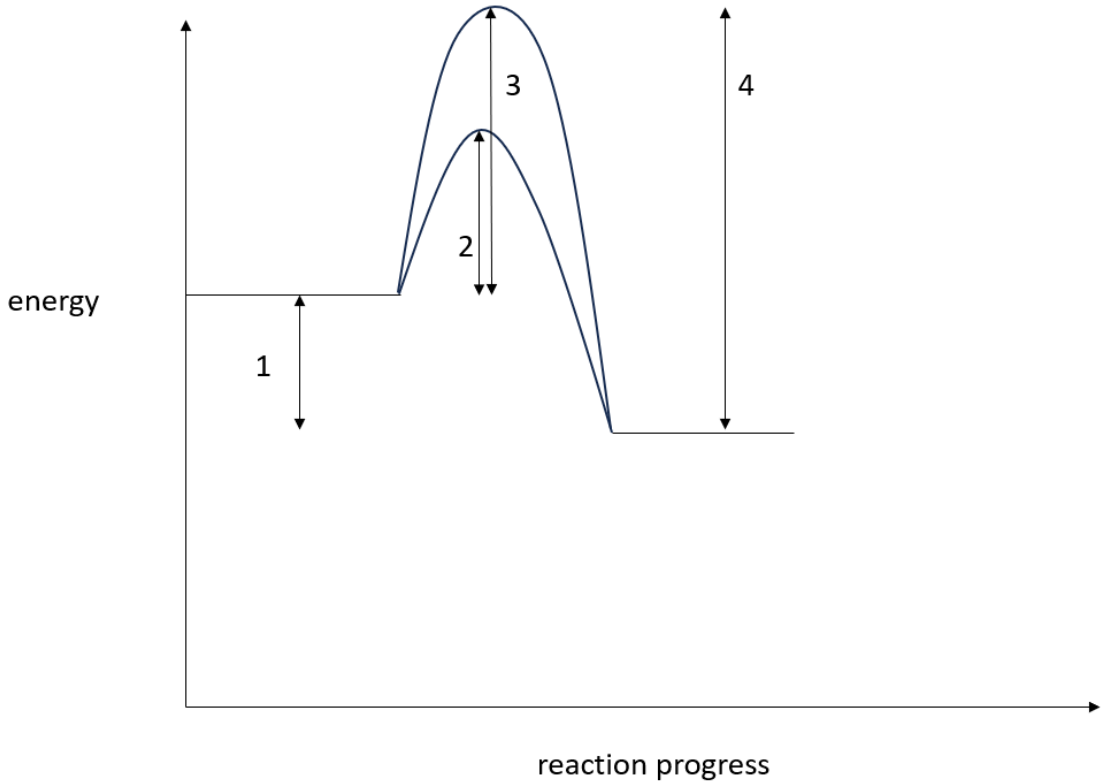
B. Allowing hydrogen gas to escape.

C. Increasing the temperature of the hydrochloric acid,

D. Increasing the concentration of hydrochloric acid.

Question 16

Consider the energy profile shown:



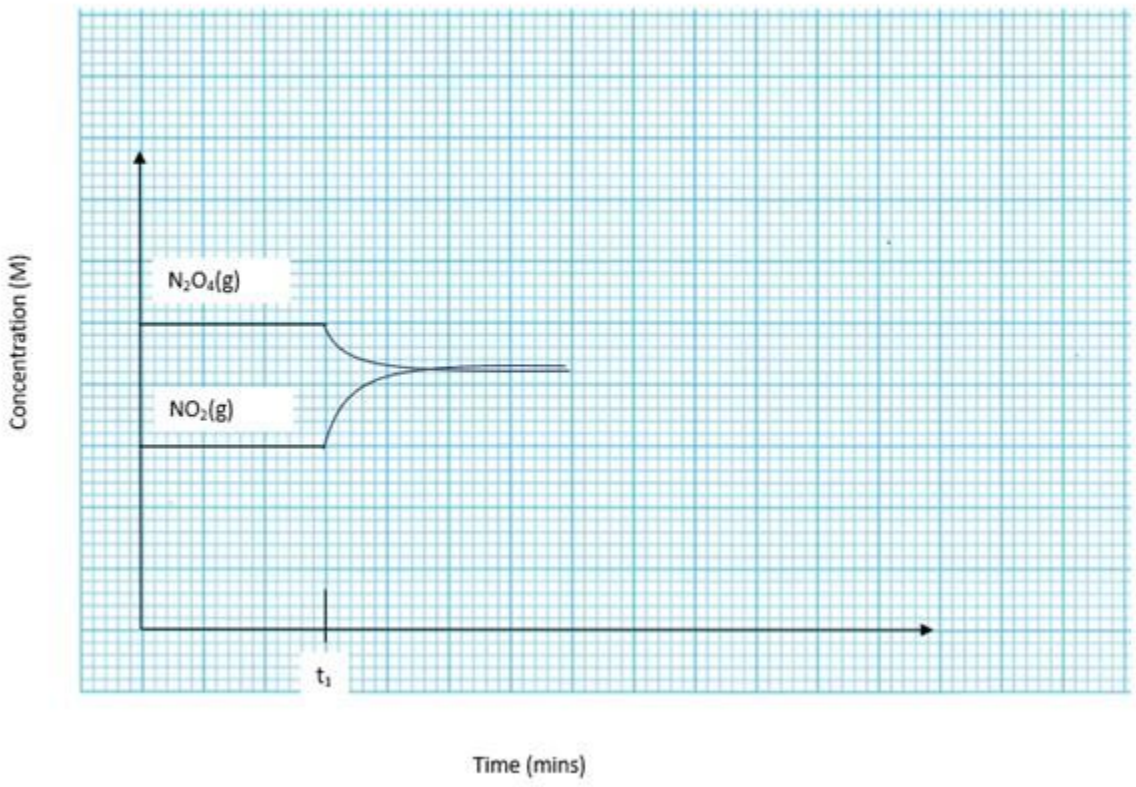
The numbered components on the energy profile represent:

	Enthalpy change ΔH	**Activation energy, E_a of the catalysed reaction**
A.	1	2
B.	2	1
C.	1	4
D.	3	1

Question 17

Consider the gaseous equilibrium represented by the equation:

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



At time t_1

A. NO_2 was added to the container.

B. the temperature of the system was decreased.

C. the temperature of the system was increased.

D. the volume of the system was reduced.

Question 18

Consider the gaseous equilibrium system:

$$\underset{\text{colourless}}{N_2O_4(g)} \rightleftharpoons \underset{\text{brown}}{2NO_2(g)} \quad \Delta H>0$$

If the volume of the equilibrium system is halved it would be expected that

A. the equilibrium mixture would instantly lighten in colour then become darker but not as dark as initially

B. the equilibrium mixture would instantly lighten in colour then no further change occurs

C. the equilibrium mixture would instantly darken in colour and then become a lighter shade of brown

D. the equilibrium mixture would immediately increase in darkness of colour then no further change occurs

Question 19

Consider the gaseous equilibrium system:

$$Br_2(g) + I_2(g) \rightleftharpoons 2IBr(g) \; K = 1.2 \times 10^2 \text{ at } 150\ ^oC$$

The equilibrium constant, K for the reaction $2IBr(g) \rightleftharpoons Br_2(g) + I_2(g)$ at 150 ^oC is

A. 8.3×10^{-3}

B. 1.1×10^{1}

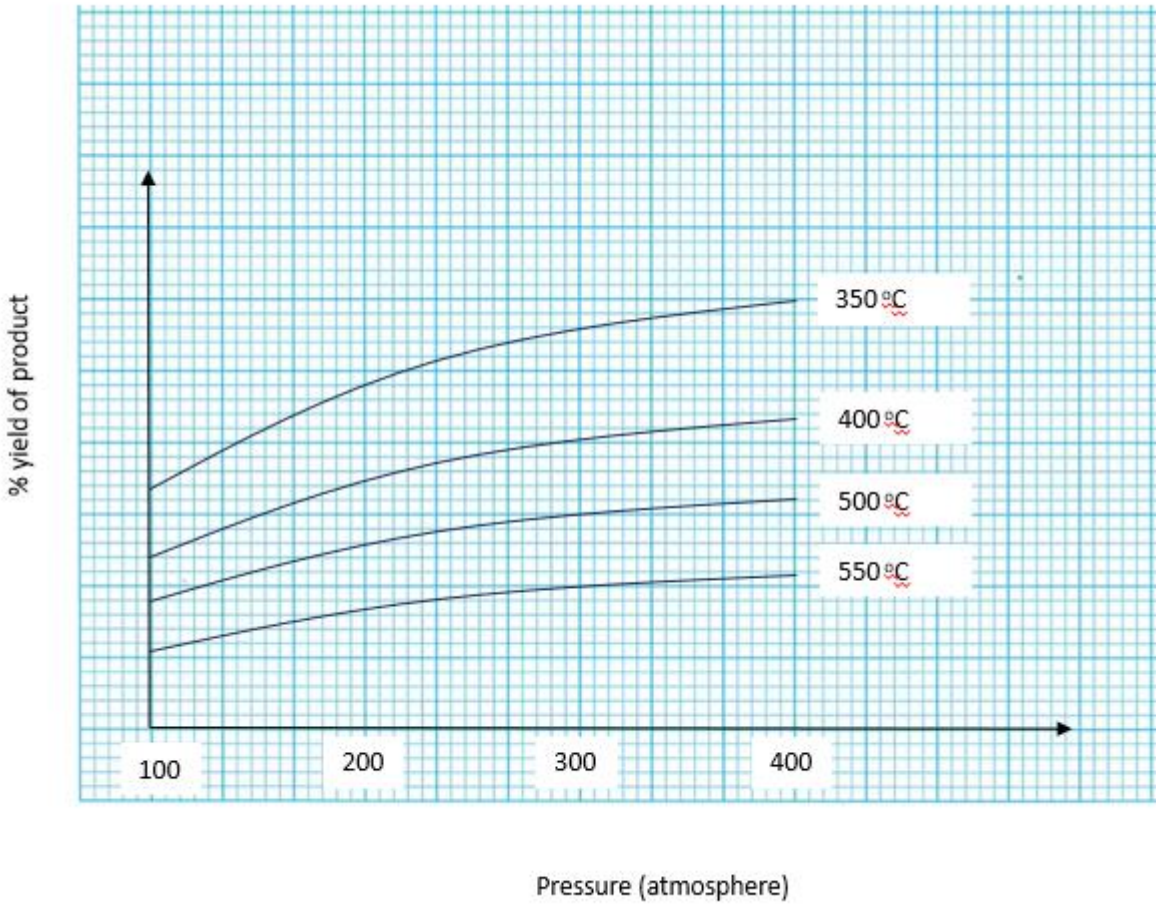
C. 2.4×10^{2}

D. 1.4×10^{4}

Question 20

The graph below refers to the following gaseous equilibrium system:

$$aA(g) + bB(g) \rightleftharpoons cC(g) + dD(g)$$



According to the graph a higher yield of product is obtained:

A. when the volume is reduced and the temperature is low

B. when the volume is increased and the temperature is high

C. when the volume is reduced and the temperature is high

D. when the volume is increased and the temperature is low

SECTION B – Short answer questions

Instructions for Section B

Answer **all** questions in the spaces provided. Write using black or blue pen. To obtain full marks for your responses you should

- Give simplified answers with an appropriate number of significant figures to all numerical questions; unsimplified answers will not be given full marks.
- Show all working in your answers to numerical questions. No credit will be given for an incorrect answer unless it is accompanied by details of the working.
- Make sure chemical equations are balanced and that the formulas for individual substances include an indication of state; for example, $H_2(g)$; NaCl(s).

Question 1 (4 marks)

a. Write a balanced equation for cellular respiration 2 marks

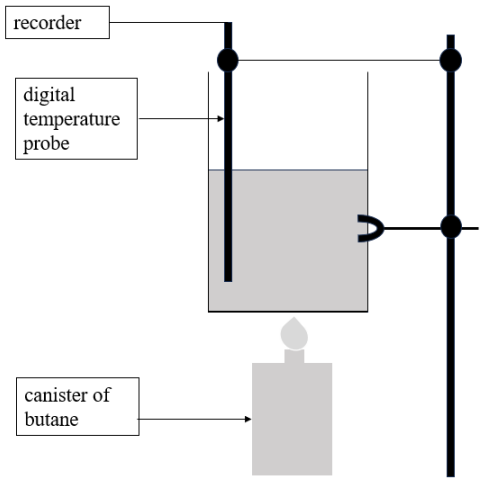
b. Enzymes in yeast can be used to ferment glucose. Write a balanced equation for the fermentation of glucose. 2 marks

Question 2. (5 marks)

a. Butane is a useful fuel. Circle the classification of butane 1 mark

renewable **non-renewable**

b. A student combusts butane to heat a beaker containing 202.12 g of water as shown in the following diagram.



Complete combustion of 1.87 g of butane increased the temperature of the water from 20.4 to 48.7 °C. Calculate the percentage of the butane's energy that was transferred to the water during heating. 4 marks

Question 3. (8 marks)

The Haber process is represented by the equilibrium reaction:

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

a. Write the equilibrium expression for this reaction including appropriate units 1 mark

b. Use collision theory to explain how temperature can be used to increase the rate of reaction. 2 marks

c. Use Le Chatelier's Principle to explain how temperature can be changed to increase the yield of ammonia. 2 marks

d. (i) Indicate whether chemical engineers should select a high, moderate or low temperature to achieve an acceptable rate and extent of reaction when synthesising ammonia by circling the correct response. 1 mark

high temperature **moderate temperature** **low temperature**

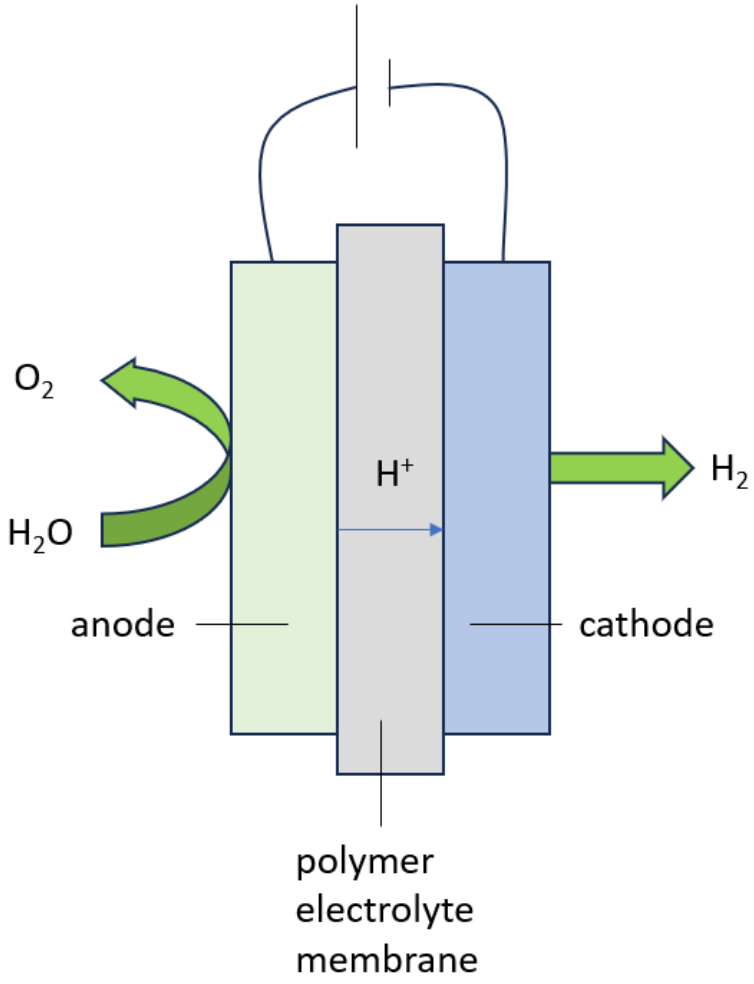
(ii) Identify one way chemical engineers could further improve the yield of ammonia 1 mark

(iii) Identify one way chemical engineers could further improve the rate of production of ammonia 1 mark

Question 4 (15 marks)

On 8th April 2024, the Queensland State Government announced plans for Australia's first commercial green hydrogen electrolyser production plant, to be built in the town of Gladstone. The manufacturer will use Proton Exchange Membrane (PEM) hydrolyser technology.

The following diagram represents a simplified PEM cell.



a. Write the equations for the synthesis of green hydrogen using the PEM electrolyser powered by solar energy. The starting reactant is water. 3 marks

Reduction equation	
Oxidation equation	
Overall equation	

b. In a trial at the Gladstone green hydrogen electrolyser plant, a chemist electrolysed 1000 L of fresh water. Calculate the volume of green hydrogen that could be produced from the water, at SLC, if a current of 15.0 A is supplied for 2.0 weeks.
3 marks

c. Identify a potential safety issue with the hydrogen produced in **part b**. Suggest an appropriate safety measure to reduce the risk. 2 marks

d. The CSIRO defines grey hydrogen as that generated from non-renewable sources such as methane. Outline one reason why hydrogen synthesised using a Proton Exchange Membrane hydrolyser is preferable to grey synthesis (use pages 22 and 23 of the VCAA data book). 2 marks

"Hydrogen is diverse and can be used in a range of ways including transport fuel, for industrial heating, and as a feedstock for other chemicals such as methanol."

Ref:*https://statements.qld.gov.au/statements/100075#:~:text=%E2%80%9CFortescue's%20Gladstone%20Electrolyser%20Facility%20is,the%20largest%20in%20the%20world.*

e. Define the term feedstock as used in chemistry. 1 mark

Carbon dioxide can be reacted with hydrogen that has been produced following green chemistry principles, to produce methanol and water. Methanol, produced in this way would be classified as green methanol.

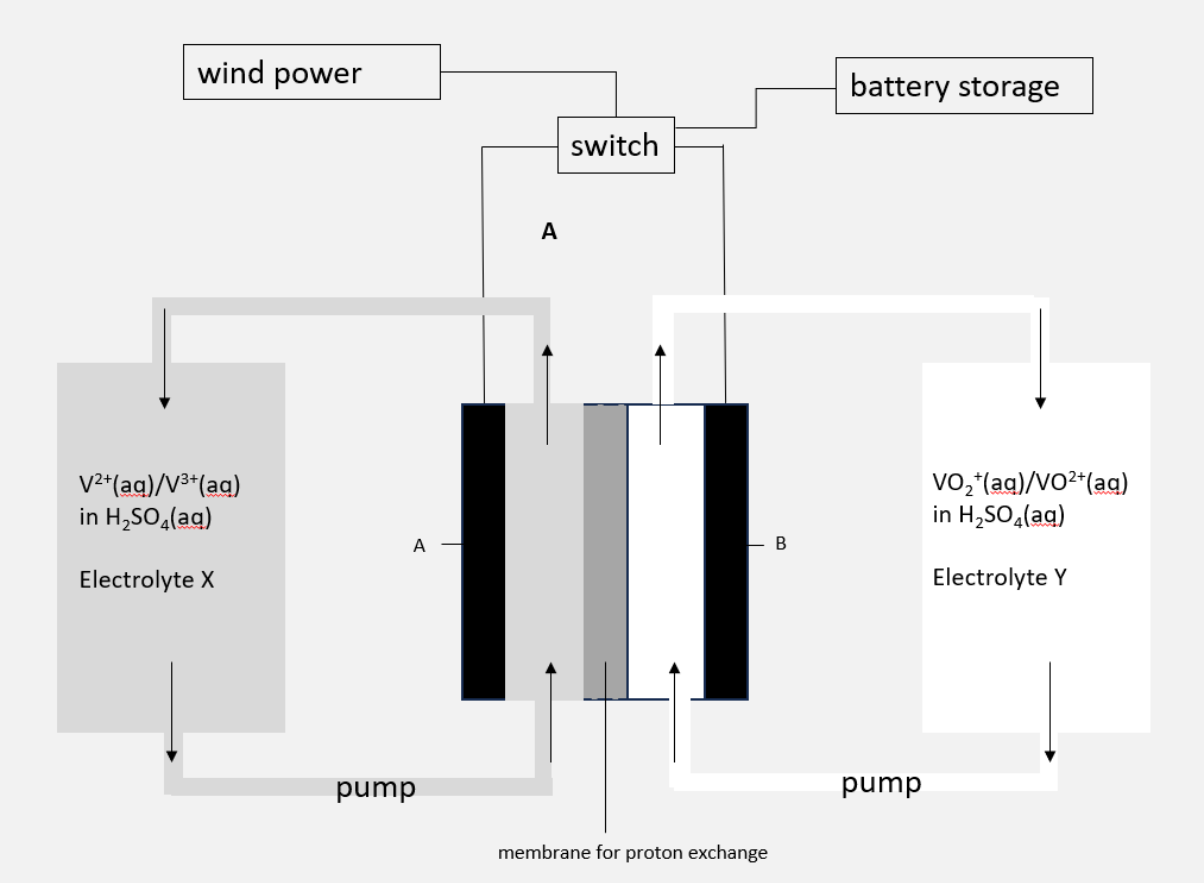
f. Write an equation to represent this reaction. States are not required. 1 mark

g. Write a thermochemical equation to represent the complete combustion of methanol at SLC 2 marks

h. Identify the specific covalent bond in a molecule of methanol that has the greatest bond enthalpy in kJ mol^{-1} at 25^{o}C. 1 mark

Question 5 (7 marks)

The vanadium redox flow battery is used to store energy at a wind farm. The following diagram shows the various components of the battery.



The relevant half-equations for this battery are:

$$V^{3+}(aq) + e^- \rightleftharpoons V^{2+}(aq) \qquad E^0 = -0.26\ V$$

$$VO_2^+(aq) + 2H^+(aq) + e^- \rightleftharpoons VO^{2+}(aq) + H_2O(l) \qquad E^0 = +1.00\ V$$

a. Write the oxidation numbers of vanadium above each half equation 1 mark

b. Write the reduction half-equation during discharge 1 mark

c. Calculate the theoretical cell voltage during discharge 1 mark

d. Write the overall reaction during recharge 1 mark

e. In which directions do electrons flow through the switch during recharge? 1 mark

Circle the correct response

left to right **right to left**

f. Circle the correct response for the name and polarity of electrode A during discharge. 1 mark

cathode/negative **cathode/positive** **anode/negative** **anode/positive**

g. The redox vanadium flow battery can be described as a hybrid of a fuel cell and secondary cell. Explain why. 1 mark

Question 6 (8 marks)

Parmesan cheese contains 35.8% protein, 25.0% fat and 3.2% carbohydrate.

a. Calculate the energy content of 100 g of Parmesan Cheese 2 marks

b. A student eats 30 g of Parmesan cheese with a meal. The student has an average energy requirement of 8700 kJ per day. Calculate the percentage of the daily energy intake provided by consuming 30 g of the Parmesan cheese. 2 marks

c.For their Area of Study 3 project, a student decides to compare the energy content of various foods. Identify the independent variable 1 mark

The following table compares the nutrient content of Parmesan cheese and apples.

Food	Fat content g per 100 g	Carbohydrate g per 100 g	Protein g per 100 g	Energy content kJ per 100 g
Parmesan cheese	25.0	3.2	35.8	1585
Apples	0.5	28	0.6	467

(i) Compare the energy content of 100 g of Parmesan cheese with 100 g of apples. 1 mark

(ii) Discuss how the total fat content per 100g of each food and the relative contribution of energy provided by the various nutrients leads to this difference in energy of 100 g of Parmesan cheese and 100 g of apples. 2 marks

Question 7 (5 marks)

Hydrogen can be synthesized from methane using the steam reforming process according to the equation:

$$CH_4(g) + H_2O(g) \rightarrow CO(g) + 3H_2(g).$$

The next step involves oxidizing carbon monoxide to carbon dioxide.

The CSIRO classifies the hydrogen produced through this process as grey hydrogen because the carbon dioxide emissions are released to the environment.

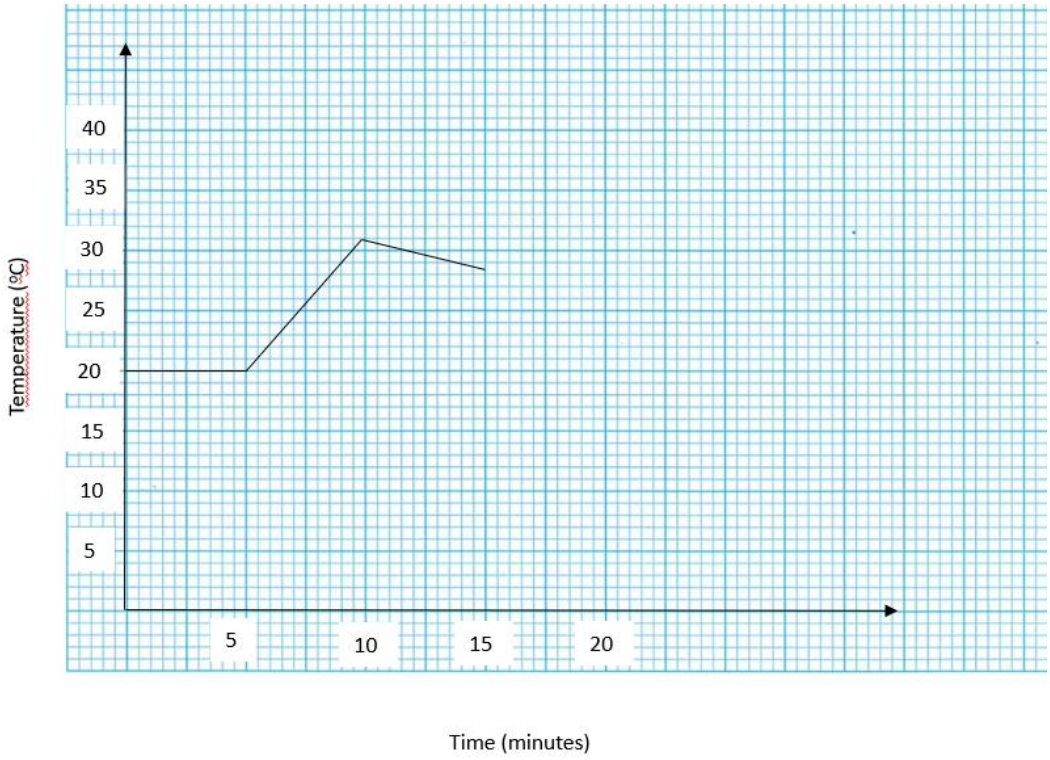
a. Identify the limiting reactant and determine the volume of carbon monoxide that would be produced from the reaction of 3.50 kg methane and 1500 L steam. 4 marks

Carbon monoxide is a highly toxic gas.

b. Recommend a safety measure that could be used to protect workers in this industrial facility. 1 mark

Question 8 (3 marks)

A solution calorimeter was electrically calibrated. 100 mL of water was added to the calorimeter. A current of 3.12 A, at a voltage of 5.00 V was passed through the water for 5.00 minutes. Consider the temperature – time graph of the electrical calibration of the calorimeter.



Calculate the calibration factor of the calorimeter in J $^{o}C^{-1}$. 3 marks

END OF TRIAL EXAM