CORPUS CHRISTI COLLEGE
SEQUERE DOMINUM

Corpus Christi College

ATAR Course Examination 2016

Question/Answer booklet

CHEMISTRY

STUDENT NUMBER: In figures | | | | | | | | |

In words _____

_____

Time allowed for this paper

Reading time before commencing work: Ten minutes
Writing time for the paper: Three hours

Materials required/recommended for this paper

To be provided by the supervisor

This Question/Answer Booklet
Separate Multiple Choice Answer Sheet
Separate Chemistry Data Sheet

To be provided by the candidate

Standard Items: Pens, pencils, eraser, sharpener, correction fluid/tape, ruler, highlighters.
Special Items: Non-programmable calculators approved for use in the WACE examinations.

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 notes or other items of a non-personal nature in the examination room. If you have any unauthorised material with you, hand it to the supervisor **before** reading any further.

Structure of the 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	50	25
Section Two: Short Answer	10	10	60	70	35
Section Three: Extended Answer	5	5	70	80	40
				Total	100

Instructions to candidates

1. The rules for the conduct of Western Australian external examinations are detailed in the *Year 12 Information Handbook 2016*. Sitting this examination implies that you agree to abide by these rules.

2. Answer the questions according to the following instructions.

   Section 1: Answer all the questions on the separate Multiple Choice Answer Sheet provided. For each question shade the box to indicate your answer. Use only a blue or black pen to shade the boxes. If you make a mistake, place a cross through that square then shade your new answer. Do not erase or use correction fluid/tape. Marks will not be deducted for incorrect answers. No marks will be given if more than one answer is completed for any question.

   Sections 2 and 3: Write your answers in this Question/Answer Booklet. A blue or black ballpoint or ink pen should be used.

3. When calculating numerical answers, show your working or reasoning clearly. Express numerical answers to **three** significant figures and include appropriate **units** where applicable.

4. You must be careful to confine your responses to the specific questions asked and to follow any instructions that are specific to a particular question.

5. Spare pages are included at the end of this booklet. They can be used for planning your responses and/or as additional space if required to continue an answer.
   - Planning: If you use the spare pages for planning, indicate this clearly at the top of the page.
   - Continuing an answer: If you need to use the space to continue an answer, indicate in the original answer space where the answer is continued, i.e. give the page number. Fill in the number of the question(s) that you are continuing to answer at the top of the page.

6. The Chemistry Data Sheet is **not** handed in with your Question/Answer Booklet.

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SECTION ONE - Multiple Choice **25% [50 marks]**

Answer all the questions on the separate Multiple Choice Answer Sheet provided. For each question shade the box to indicate your answer. Use only a blue or black pen to shade the boxes. If you make a mistake, place a cross through that square then shade your new answer. Do not erase or use correction fluid/tape. Marks will not be deducted for incorrect answers. No marks will be given if more than one answer is completed for any question.

Suggested working time: 50 minutes

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1. Consider the following system at equilibrium.

$$Pb^{2+}_{(aq)} + 2\ Br^{-}_{(aq)} \rightarrow PbBr_{2(s)} + \text{heat}$$

Which one of the following changes would cause the concentration of lead(II) ions to be lowered (compared to the original concentration) once equilibrium is re-established?

(a) Adding potassium iodide solution.
(b) Stirring the mixture.
(c) Warming the system.
(d) Adding solid lead(II) bromide to the system.

2. The five (5) substances named below were dissolved in water and the pH of each was determined by adding a few drops of universal indicator. For which of these substances is the observed pH **unable** to be explained by the Arrhenius theory of acids and bases?

(i) Hydrochloric acid, HCl
(ii) Ethanoic acid, CH_3COOH
(iii) Ammonia, NH_3
(iv) Calcium carbonate, $CaCO_3$
(v) Sodium hydroxide, NaOH

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

3. In which of the following is there an element with the same oxidation number as sulfur in HSO_4^- ?

(a) P_4O_{10}
(b) $K_2Cr_2O_7$
(c) $KMnO_4$
(d) VO^{2+}

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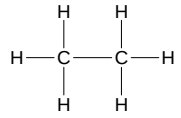
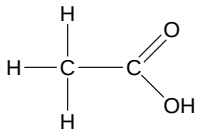
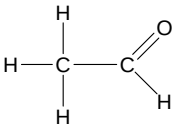
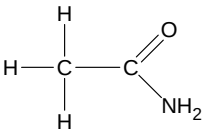
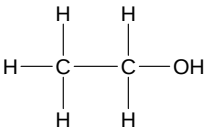
Questions 4 and 5 refer to the information below.

Consider the following five (5) organic compounds.

(i)	(ii)	(iii)	(iv)	(v)
				
CH_3CH_3	CH_3COOH	CH_3CHO	CH_3CONH_2	CH_3CH_2OH

4. Which of the following lists contain compounds that **all** have the ability to form hydrogen bonds?

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

5. Which of the following statements regarding the five compounds is **not** correct?

   (a) CH_3CONH_2 is water-soluble.
   (b) CH_3COOH is miscible with CH_3CH_2OH.
   (c) CH_3CH_3 has the highest boiling point.
   (d) CH_3CHO is able to form dipole-dipole forces.

6. Consider the following equation.

   $$2NH_{3(g)} \rightleftharpoons N_{2(g)} + 3H_{2(g)} \qquad \Delta H = +91 \text{ kJ/mol}$$

   Which of the following changes will increase the concentration of the product, but decrease the yield of the reaction?

   (a) Addition of a catalyst and an increase in the vessel temperature
   (b) A decrease in the volume of the reaction vessel
   (c) A decrease in the temperature of the reaction vessel
   (d) An increase in the volume of the reaction vessel

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7. What energy change occurs when 1.5 g of hydrogen gas reacts with 7.0 g of oxygen according to the following equation?

$$2H_{2(g)} + O_{2(g)} \rightleftharpoons 2H_2O_{(g)} \qquad \Delta H = -572 \text{ kJ/mol}$$

(a) 429 kJ of energy absorbed
(b) 429 kJ of energy released
(c) 125 kJ of energy released
(d) 215 kJ of energy released

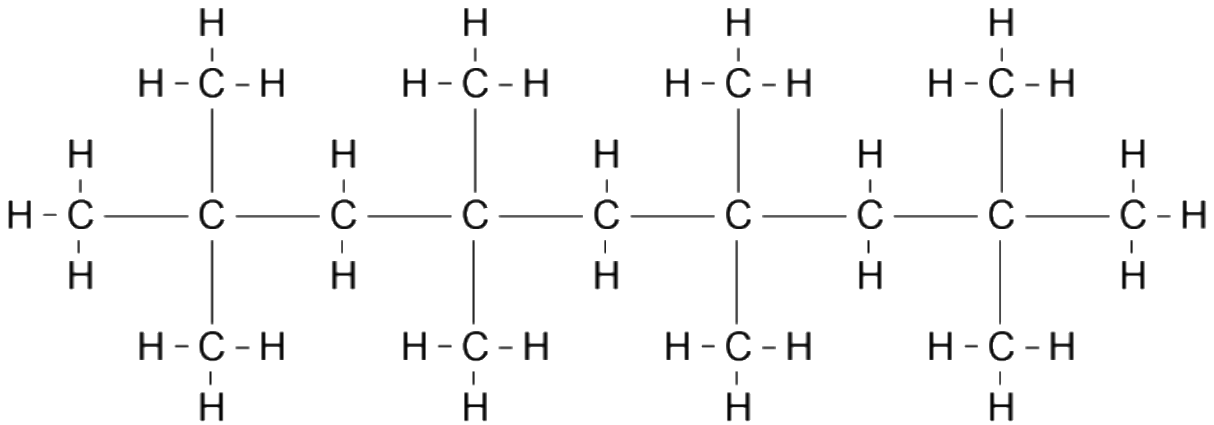
8. In which one of the following reactions is the carbon-containing species acting as a Bronsted-Lowry acid?

(a) $NaHCO_{3(s)} + H^+_{(aq)} \rightarrow Na^+_{(aq)} + H_2O_{(\ell)} + CO_{2(g)}$
(b) $CO_{2(g)} + H_2O_{(\ell)} \rightarrow H_2CO_{3(aq)}$
(c) $H_2CO_{3(aq)} + NaOH \rightarrow NaHCO_{3(aq)} + H_2O_{(\ell)}$
(d) $CO_3^{2-}{}_{(aq)} + Ca^{2+}_{(aq)} \rightarrow CaCO_{3(s)}$

9. Rank the following substances in order of increasing **nitrogen** oxidation number (i.e. from species with nitrogen in lowest oxidation state to highest oxidation state).

	$\mathbf{N}O_3^-$		$\mathbf{N}_2O$		$H\mathbf{N}O_2$		$\mathbf{N}H_4^+$		$\mathbf{N}_2$
(a)	NH_4^+	<	N_2	<	N_2O	<	HNO_2	<	NO_3^-
(b)	NO_3^-	<	N_2O	<	HNO_2	<	N_2	<	NH_4^+
(c)	NH_4^+	<	HNO_2	<	N_2	<	NO_3^-	<	N_2O
(d)	N_2	<	NH_4^+	<	NO_3^-	<	N_2O	<	HNO_2

10. Consider the section of the polymer below.



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

(a) but-1-ene
(b) but-2-ene
(c) 2-methylpropene
(d) 2,2-dimethylethene

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

(a) sodium hydrogencarbonate
(b) ammonium chloride
(c) sodium ethanoate
(d) sodium hydrogenphosphate

Questions 12, 13 and 14 relate to the equilibrium system below.

At temperatures greater than 1000 °C, gaseous octasulfur (S_8) can undergo an endothermic decomposition to form gaseous disulfur (S_2) as shown in the equation below.

$$S_{8(g)} \rightleftharpoons 4\,S_{2(g)}$$

Some $S_8(g)$ was placed in an empty rigid container and allowed to establish equilibrium at 1052°C. At this temperature the value of K for this equilibrium system is 324.

12. Once the system has established equilibrium, which of the following statements are **correct**?

(i) The total pressure inside the container will be constant.
(ii) The pressure inside the container will be higher than initially.
(iii) The colour of the gaseous mixture will be constant.
(iv) The rates of the forward and reverse reactions will be equal.
(v) The concentration of S_8 and S_2 will be equal.

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

13. Which of the following statements regarding K for this equilibrium system is **correct**?

(a) At equilibrium there is a higher concentration of $S_8(g)$ present than $S_2(g)$.
(b) If the temperature of the system was decreased the value of K would increase.
(c) The equilibrium constant expression can be written $K = \frac{[S_8]}{[S_2]}$
(d) The equilibrium constant expression can be written $K = \frac{[S_2]^4}{[S_8]}$

14. Once the system had established equilibrium, various changes were imposed on the system and the effects of these changes were predicted using Le Chatelier's principle. Which of the following is **not** correct (i.e. the predicted effect on the equilibrium position does **not** match the imposed change stated)?

	Imposed change	**Effect on equilibrium position**
(a)	Pressure increase	←
(b)	Removal of S_2	←
(c)	Temperature increase	→
(d)	Addition of S_8	→

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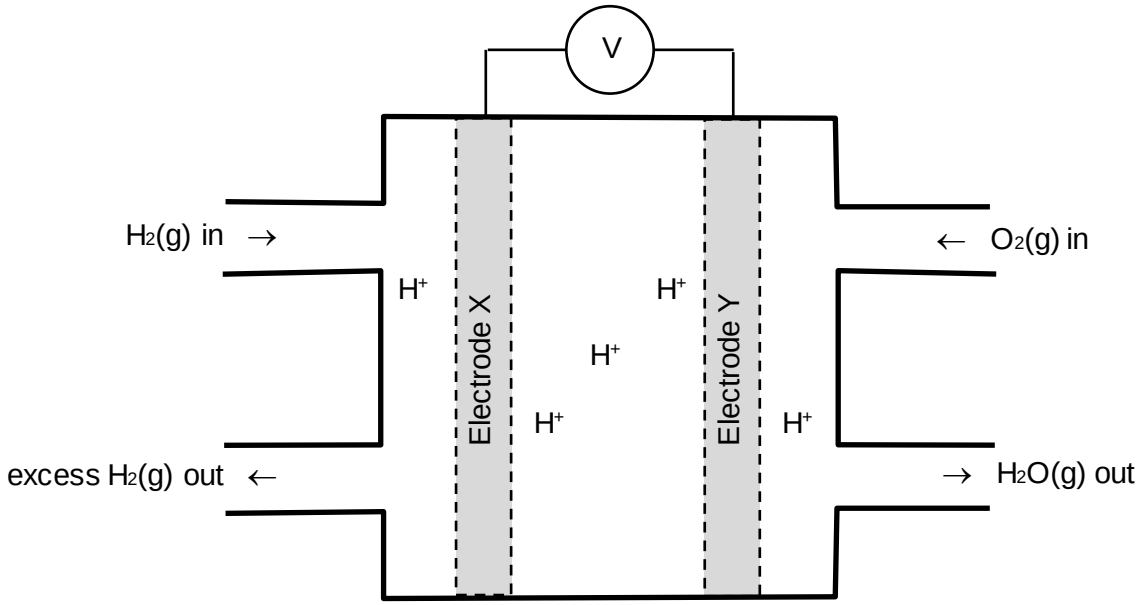
Questions 15 and 16 refer to the information below.

There are several different types of fuel cells, which mostly differ in terms of the fuel being utilised. One of the most common fuel cells is the hydrogen / oxygen fuel cell. A partially completed sketch of an hydrogen / oxygen fuel cell operating with an acid electrolyte is shown in the diagram below. The only overall chemical product of the hydrogen / oxygen fuel cell is water.



15. Which of the following statements are **correct**, regarding **fuel cells in general**?

(i) Fuel cells involve a redox reaction.
(ii) Fuel cells require continuous input of reactants to operate.
(iii) Fuel cells are a type of galvanic cell.
(iv) Fuel cells are a type of secondary cell.
(v) Fuel cells do not produce any sources of pollution.

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

16. Which of the following statements is **correct,** regarding the **hydrogen/oxygen fuel cell** shown in the diagram above?

(a) Reduction occurs at X.
(b) Electrons move from Y to X.
(c) Cations move towards Y.
(d) The EMF of this cell under standard conditions is 1.15 volts.

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17. The molecule that could be oxidised to form propanoic acid is

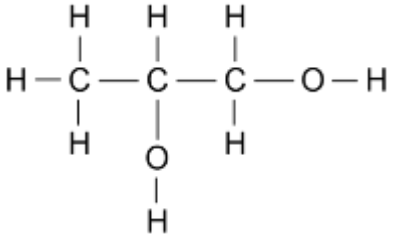
(a) CH_3CH_2OH
(b) CH_3CH_2COOH
(c) $(CH_3)_2CHOH$
(d) $CH_3CH_2CH_2OH$

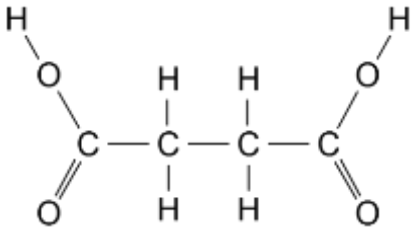
18. Which of the following will form a buffer solution

i. $NH_{3(aq)}$ / $NH_4Cl_{(aq)}$
ii. $NH_{3(aq)}$ / $HCl_{(aq)}$
iii. $HCl_{(aq)}$ / $NH_4Cl_{(aq)}$
iv. $H_2PO_4^-{}_{(aq)}$ / $HPO_4^{2-}{}_{(aq)}$
v. $H_2SO_{4(aq)}$ / $HSO_4^-{}_{(aq)}$

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

19. The following substances were reacted together





Which one of the following would be the type of product produced?

(a) a soap
(b) a fatty acid
(c) a polyester
(d) a protein

20. Consider the dipeptide below:

$HOOCCH(CH_3)NHCOCH(CH_2OH)NH_2$

Use your data sheet to identify which pair of amino acids below would form this peptide.

(a) alanine and valine
(b) valine and threonine
(c) glycine and serine
(d) serine and alanine

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21. Which of the following statements about volumetric analysis is INCORRECT?

(a) All titrations need an indicator added in order to detect the end point.
(b) The end point can occur after the equivalence point
(c) Pipettes deliver an aliquot
(d) Rinsing the burette with the solution it will deliver will not alter the result

22. The equation for the autoionisation of water is shown below, along with two values for K_w at two corresponding temperatures.

$$H_2O(l) + H_2O(l) \rightleftharpoons H_3O^+(aq) + OH^-(aq)$$

$K_w = 1.0 \times 10^{-14}$ at 25 °C
$K_w = 2.9 \times 10^{-14}$ at 40 °C

Considering the information provided, which of the following statements is **not** correct?

(a) The autoionisation of water is an endothermic process.
(b) The concentration of H_3O^+ in water at 40 °C is higher than water at 25 °C.
(c) The pH of water at 40 °C is lower than water at 25 °C.
(d) The water at 40 °C is slightly more acidic than water at 25 °C.

23. Which one of the following are NOT bonds between sections of a protein that contribute to the tertiary structure of the protein?

(a) C=O bonds
(b) hydrogen bonds
(c) S-S bonds
(d) dispersion forces

24. Which of the following reactions will occur spontaneously?

i. $2\ I^-_{(aq)} + Br_{2(aq)} \rightarrow 2\ Br^-_{(aq)} + I_{2(aq)}$
ii. $Cu_{(s)} + 2\ HC\ell_{(aq)} \rightarrow CuC\ell_{2(aq)} + H_{2(aq)}$
iii. $Sn_{(s)} + Cd^{2+}_{(aq)} \rightarrow Sn^{2+}_{(aq)} + Cd_{(s)}$
iv. $H_2O_{2(aq)} + Ni^{2+}_{(aq)} \rightarrow O_{2(g)} + 2\ H^+_{(aq)} + Ni_{(s)}$

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

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25. Which one of the following pairs of compounds would from propyl methanoate when warmed with concentrated sulfuric acid?

(a) CH_4 and CH_3CH_2COOH
(b) CH_3OH and $CH_3CH_2CH_2OH$
(c) CH_3OH and CH_3CH_2COOH
(d) $HCOOH$ and $CH_3CH_2CH_2OH$

END OF SECTION ONE

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SECTION TWO – Short answers **35%** **[70 marks]**

This section has 10 questions. Answer all questions in the spaces provided.

Suggested working time: 60 minutes

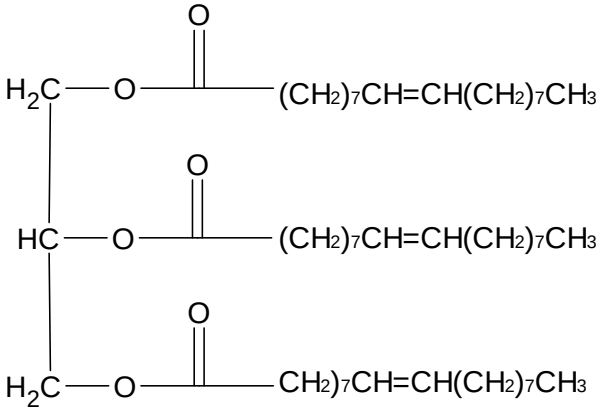
When calculating numerical answers, show your working or reasoning clearly. Express numerical answers to three significant figures and include appropriate units where applicable.

Spare pages are included at the end of this booklet. They can be used for planning your responses and/or as additional space if required to continue an answer.

- Planning: If you use the spare pages for planning, indicate this clearly at the top of the page.
- Continuing an answer: If you need to use the space to continue an answer, indicate in the original answer space where the answer is continued, i.e. give the page number. Fill in the number of the question(s) that you are continuing to answer at the top of the page.

Question 26 **(5 marks)**

Biodiesel is a fuel that can be synthesised from natural oils and fats. The molecule below is a triglyceride present in vegetable oil that can be used for this process.



Biodiesel can be synthesised using a base-catalysed reaction with methanol. The triglyceride breaks down into fatty acids and these undergo esterification with methanol to form methyl esters. The methylesters are the main components of biodiesel.

(a) State why the compound above is described as an unsaturated oil. (1 mark)

(b) Draw the structural formula of the methyl ester formed from the section of the molecule circled in the above diagram. (1 mark)

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(c) Name a catalyst that can be used in this process. (1 mark)

_____

(d) As well as the methyl esters (the biodiesel), there is one other product of this reaction. Name and draw the structural formula of this product. (2 marks)

Name _____

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Question 27 **(5 marks)**

(a) Calculate the pH of a solution of 0.500 mol L^{-1} hydrochloric acid? (2 marks)

(b) A student was asked to dilute 50.0 mL of this solution to produce a solution of hydrochloric acid with a pH of 2.00. Calculate the volume of distilled water that she would need to add.

(3 marks)

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Question 28 **(8 marks)**

Although many new secondary cells have been developed, isolated houses still use the lead accumulator battery to store solar energy generated by photovoltaic cells. The discharge reaction of the lead accumulator cell is given below.

$$Pb_{(s)} + PbO_{2(s)} + 2H_2SO_{4(aq)} \rightarrow 2PbSO_{4(s)} + 2H_2O(l) \qquad E^o = 2.05\ V$$

(a) Which substance is undergoing oxidation in the above reaction?

_____ (1 mark)

(b) Write the half-reaction for the reduction.

_____ (2 marks)

(c) In order to generate the 12 V used in many solar-powered houses, how many cells must be connected in series?

_____(1 mark)

(d) If the cell is discharging, describe what is happening at the lead electrode.

_____ (1 mark)

(e) Write the oxidation half-reaction occurring during recharging of the battery.

_____ (2 marks)

(f) What will be happening to the pH of the battery during recharging?

_____

_____ (1 mark)

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Question 29 **(8 marks)**

Consider the equation for the following reversible chemical system. Gaseous hydrogen and bromine were injected into an empty flask and allowed to establish equilibrium at 25 °C.

$$H_2(g) + Br_2(g) \rightleftharpoons 2\ HBr(g) \qquad \Delta H = -104\ kJ\ mol^{-1}$$

The activation energy for this reaction is 188 kJ mol $^{-1}$. The value of K_c for this reaction at 25 °C is 2.0×10^{19}.

(a) Does this question refer to an open or closed system? Explain. (2 marks)

_____

_____

_____

(b) What information does the value of K_c provide about the; (2 marks)

(i) equilibrium position?

_____

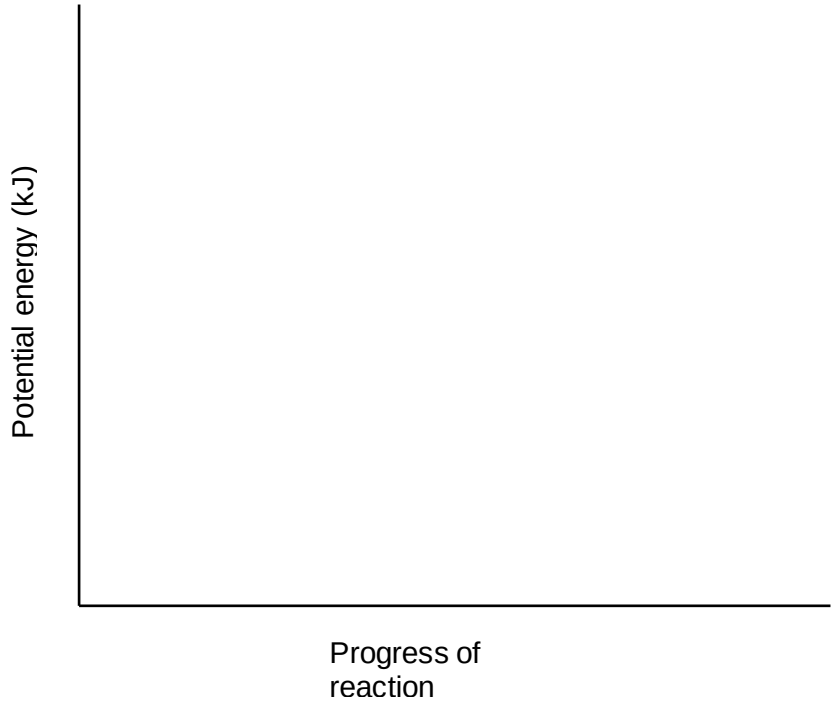
_____

(ii) rate of reaction?

_____

_____

(c) Draw an energy profile diagram for this reaction. Label the activation energy and the enthalpy change. (4 marks)



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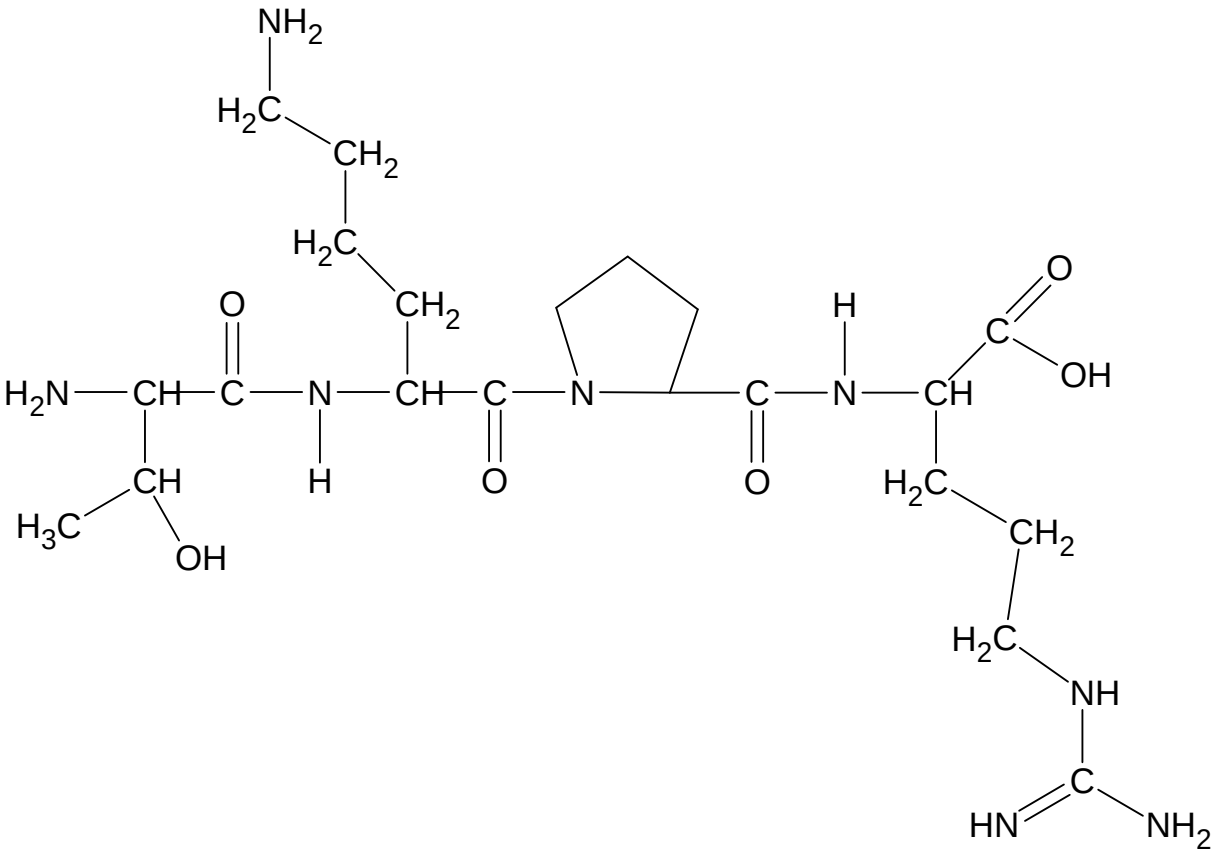
Question 30 **(8 marks)**

Tuftsin is a tetrapeptide (a molecule consisting of four amino acid residues) which is produced by the spleen. It has been found that people with low levels of tuftsin in their bodies are susceptible to repeated frequent infections of the skin, lymph nodes and lungs. Low tuftsin levels can be inherited genetically or can be the result of a spleen operation. The tuftsin tetrapeptide molecule is shown below.



(a) On the diagram above, circle the peptide bonds and then complete the primary sequence of tuftsin below using the standard three letter abbreviations. (3 marks)

thr – lys – _____ – _____

One medical study has shown that some people have a genetic mutation which causes the lysine residue in tuftsin to be replaced with a glutamic acid residue instead.

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(b) Draw a diagram of glutamic acid in zwitterion form and use this example to explain what a zwitterion is. (2 marks)

In the mutated form of tuftsin, the primary sequence of the tetrapeptide has been changed, altering its function.

(c) In general terms, explain how alteration of the primary sequence of a protein can affect its secondary and tertiary structures. (3 marks)

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Question 31 **(6 marks)**

Tin is a metallic element located in Group 14 of the periodic table. It is used to make many different alloys such as bronze and solder, as well as finding application in the plating of steel to produce 'tin cans' for storage.

A chemistry student had 1.0 mol L^{-1} solutions of the following four substances;

$Ni(NO_3)_2$ $Zn(NO_3)_2$ $Pb(NO_3)_2$ $Mg(NO_3)_2$

(a) Which of these solutions could **not** be stored in a tin container? Explain your answer using a relevant chemical equation. (3 marks)

_____

_____

_____

_____

_____

_____

When tin metal is placed in an acidified solution containing the weak acid hydrogen chromate ($HCrO_4^-$) a deep green solution containing chromium(III) ions is formed, and the tin metal dissolves producing tin(II) ions.

(b) Write the oxidation and reduction half-equations and the overall redox equation for this reaction. (3 marks)

Oxidation half-equation	
Reduction half-equation	
Overall redox equation	

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Question 32 **(8 marks)**

A variety of substances are listed below. Use these substances to answer the following questions. Not all substances must be used, but each substance can only be used once.

Na_2CO_3	Na	H_3PO_4	NaCl
Au	H_2SO_4	Na_3PO_4	Cu
$CuCl_2$	Na_2SO_4	Ni	

(a) Which two substances could be mixed together to form a buffer? (1 mark)

_____

(b) Which two substances could be mixed together in water to form a green precipitate?

_____(1 mark)

(c) Which substance could be classified as a 'basic salt'? Write a hydrolysis equation to support your answer. (2 marks)

_____

_____

(d) Which substance would react with acid to produce hydrogen gas? (1 mark)

_____

(e) Which substance would react with water to produce hydrogen gas? (1 mark)

_____

(f) Which metal would displace the silver ions from a solution of silver nitrate? Write the equation for this reaction including only those species that react. (2 marks)

_____

_____

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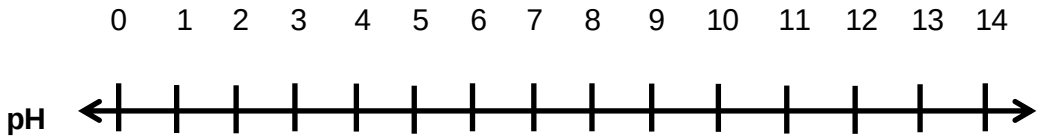
Question 33 **(6 Marks)**

Bromocresol green is an indicator that can be used in biological laboratories when growing microorganisms, as well as for titrations or as a tracking dye. It displays two colours, yellow and blue, as shown in the diagram below.



yellow	blue

(a) What colour would the following aqueous solutions turn, if a few drops of bromocresol green was added to each? Explain your answers, using a chemical equation where appropriate. (4 marks)

Solution	**Colour**	**Chemical equation**
$Mg(NO_3)_2(aq)$		
$Na_2SO_3(aq)$		

A standardised solution of hydrochloric acid, HCl (aq), was being used in a titration with a sodium hydrogencarbonate solution, $NaHCO_3$ (aq), of unknown concentration.

(b) Would bromocresol green be an appropriate indicator for this titration? Justify your answer. (2 marks)

_____

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Question 34 **(8 marks)**

The final step in the production of methanol is shown in the equation below.

$$CO\,(g) + 2\,H_2\,(g) \leftrightarrows CH_3OH\,(g) + \text{heat}$$

This reaction is carried out at a high pressure of 50-100 atmospheres, using a $Cu/ZnO/Al_2O_3$ catalyst.

(a) Explain how the use of high pressure will affect the reaction rate. (2 marks)

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(b) Explain how the use of high pressure will affect the yield of methanol. (3 marks)

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(c) What conditions of temperature would increase the yield of methanol? (1 mark)

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(d) State two (2) benefits of using a catalyst in an industrial process. (2 marks)

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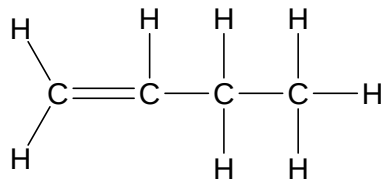
Question 35 **(9 marks)**

But-2-ene is produced from crude oil and its main use is in the production of petrol.

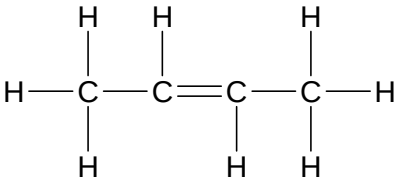
(a) Explain why but-2-ene exhibits *cis-trans* (geometric) isomerism while but-1-ene does not.

(3 marks)

but-1-ene



but-2-ene



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A chemistry fact sheet about but-2-ene stated, *"But-2-ene is often used to produce the solvent butanone via hydration to butan-2-ol followed by oxidation"*.

(b) Elaborate on this statement, by giving a brief description of the reaction processes involved and using chemical equations to illustrate the reaction sequence described. (6 marks)

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

This section contains **five (5)** questions. You must answer **all** questions. Write your answers in the spaces provided below.

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.

Spare pages are included at the end of this booklet. They can be used for planning your responses and/or as additional space if required to continue an answer.

- Planning: If you use the spare pages for planning, indicate this clearly at the top of the page.
- Continuing an answer: If you need to use the space to continue an answer, indicate in the original answer space where the answer is continued, i.e. give the page number. Fill in the number of the question(s) that you are continuing to answer at the top of the page.

Suggested working time: 70 minutes.

Question 36 **(22 marks)**

Aspartic acid ($C_4H_7O_4N$) is a diprotic α-amino acid. Aspartic acid has solubility of 4.5 g L^{-1} at 25 °C and a Ka value of 1.26 x 10^{-4}. Aspartic acid increases resistance to fatigue and is often found in food supplements, especially those used by athletes and body builders.

A chemist was asked to analyse the contents of a food supplement to check the manufacturer's claims that it contained 97.0% aspartic acid by mass. To check this claim, the following experiment was carried out. (It can be assumed that aspartic acid is the only active ingredient in the supplement)

1. 1.546 g of the supplement powder was weighed and dissolved in warmed distilled water in a beaker.
2. The solution was transferred to a 500.0 mL volumetric flask and was made up to the mark with distilled water.
3. 25.00 mL aliquots of the resulting solution were titrated, using phenolphthalein indicator, against 0.0570 mol L^{-1} sodium hydroxide solution.

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The results obtained are shown below.

Burette readings	Titrations			
(mL)	1	2	3	4
Final Volume	20.30	40.05	19.80	39.50
Initial Volume	0.00	20.30	0.00	19.80
Titration Volume (Titre)				

(a) Calculate the percentage purity of the supplement. (7 marks)

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(b) Consider the method used in this experiment.

(i) In Step 1, suggest a reason why the distilled water was warmed. (1 mark)

(ii) In Step 2, the solution was transferred from a beaker into the volumetric flask. Explain why this process could be a source of systematic error. (2 marks)

(iii) Phenolphthalein changes colour at between pH 9 –10. Methyl orange changes colour at between pH 4 –5. In Step 3, predict and explain the effect on the final result if methyl orange was used as the indicator instead of phenolphthalein. (3 marks)

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(c) (i) Due to the low solubility of the aspartic acid, it was suggested to the students that they use a 'back titration'. This would require the addition of a known amount of sodium hydroxide (in excess) to the aspartic acid and the titration of the unreacted hydroxide against a standard solution of acid.

Sodium hydroxide solution with a concentration of 0.978 mol L-1 is used and there is a standard solution of 0.100 mol L-1 hydrochloric acid available.

There are three pipettes to choose from (20.00 mL, 25.00 mL or 50.00 mL) for adding sodium hydroxide solution to the 1.546 g of the supplement powder.

Calculate which volume pipette the student should use to add the sodium hydroxide in order to get a titration volume (titre) of approximately 20 mL of the hydrochloric acid.

(7 marks)

(ii) Explain why having a titre of less than 20 mL could increase the random error in this experiment. (2 marks)

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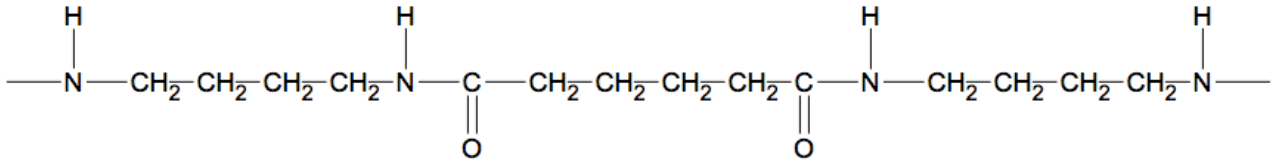
Question 37 **(15 marks)**

'Nylon 4/6' is a polymer which can be obtained as a fibre, film, rod or sheet. It has wide ranging applications owing to its high heat and chemical resistance in comparison with other nylons. It is most often used for electrical and electronic components, in particular those that must withstand high temperatures for a long period of time.

A segment of nylon 4/6 is shown in the diagram below.



(a) Nylons have the ability to form hydrogen bonds between polymer strands. How does this bonding affect the physical properties of nylon polymers? (2 marks)

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(b) Draw the two (2) monomers from which nylon 4/6 is composed. (2 marks)

(c) Name and briefly describe the process by which these monomers are able to form this nylon polymer. (2 marks)

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A pure sample of an amine (containing only the elements carbon, hydrogen and nitrogen) was analysed to determine its composition. The amine was combusted in oxygen and produced 6.43 g of carbon dioxide, 3.93 g of water and 2.04 g of nitrogen gas.

(d) Calculate the empirical formula of the amine. (7 marks)

(e) Did this analysis provide sufficient information to identify whether this amine is one of the monomers used to produce nylon 4/6? Explain. (2 marks)

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Question 38 **(15 marks)**

Chromium, the sixth most abundant transition metal in the Earth's crust was discovered in 1797. It was named after the Latin *chroma* meaning 'colour'. Chromium metal is extracted in large part from an ore containing chromite, $FeCr_2O_4$, via a multistep process. It is estimated that 70% of the world's chromite reserves are located in South Africa, with additional deposits in India, Kazakhstan and Zimbabwe.

One process used to extract chromium metal from the chromite ore is shown below.

In the first step, the aerial oxidation of chromite ($FeCr_2O_4$) takes place in molten alkali, producing sodium chromate (Na_2CrO_4).

Step 1: $4\ FeCr_2O_4 + 8\ Na_2CO_3 + 7\ O_2 \rightarrow 8\ Na_2CrO_4 + 2\ Fe_2O_3 + 8\ CO_2$

In the second step, the sodium chromate is converted to sodium dichromate ($Na_2Cr_2O_7$) by an acid.

Step 2: $2\ Na_2CrO_4 + H_2SO_4 \rightarrow Na_2Cr_2O_7 + Na_2SO_4 + H_2O$

In the third step, the sodium dichromate is reduced to chromium (III) oxide (Cr_2O_3) with carbon.

Step 3: $Na_2Cr_2O_7 + 2\ C \rightarrow Cr_2O_3 + Na_2CO_3 + CO$

The fourth step involves converting the chromium (III) oxide to the final pure chromium via an aluminothermic reaction.

Step 4: $Cr_2O_3 + 2\ Al \rightarrow 2\ Cr + Al_2O_3$

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A 4.11 tonne sample of chromite ore, known to be 58.2% pure, was reacted with 482 kL of oxygen gas at a pressure of 209 kPa and temperature of 356 °C (in the presence of excess sodium carbonate).

(a) Calculate the limiting reagent. (5 marks)

(b) Calculate the mass of excess reagent. (3 marks)

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(c) Calculate the mass of chromium (III) oxide produced if the combined yield of the first three steps is 73.4%. (3 marks)

The factory owner wishes to obtain 0.75 tonne of pure chromium from this sample of ore.

(d) What would the minimum possible yield of the fourth step need to be, to ensure this target is reached? (3 marks)

(e) In step 4, is the chromium oxidised or reduced? Explain. (1 mark)

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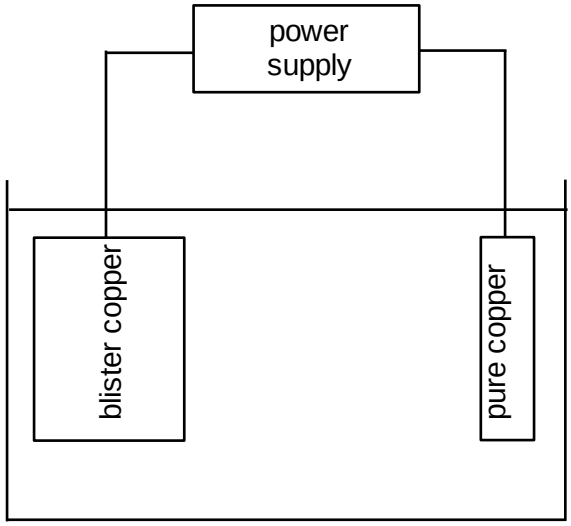
Question 39 **(13 marks)**

A group of chemistry students set up an experiment to replicate the electrolytic refining of copper metal. They obtained some impure 'blister copper' as well as a thin piece of pure copper and set up an electrochemical cell as shown in the diagram below.



(a) Explain the chemical principles of an electrolytic cell. (2 marks)

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(b) On the diagram above label; (4 marks)

(i) the anode and cathode
(ii) the sign of each electrode
(iii) the direction of cation flow
(iv) the direction of electron flow

(c) State two (2) safety considerations the students would have to take into account when conducting this experiment. (2 marks)

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The students recorded the mass of the blister copper and pure copper electrodes before allowing the cell to run for a period of time. They then recorded the mass of each electrode again. Their results are shown in the table below.

	Blister copper	Pure copper
Initial mass (g)	65.8	11.9
Final mass (g)	52.3	25.1

(d) Calculate the percent purity of the blister copper. (3 marks)

(e) What factors or problems with an experiment can cause; (2 marks)

(i) random error? _____

(ii) systematic error? _____

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Question 40 **(15 marks)**

This question is about the production of sulfuric acid (H_2SO_4). This process is carried out through a number of steps:

Step 1

Liquid sulfur is reacted with dry air to produce sulfur dioxide (SO_2).

Step 2

The sulfur dioxide is oxidised to sulfur trioxide using vanadium(V) oxide as a catalyst. This step is called the Contact Process. The equation for the reaction is shown below.

$$2\ SO_2(g) + O_2(g) \rightleftharpoons 2\ SO_3(g) \qquad \Delta H = -196\ kJ\ mol^{-1}$$

Step 3

Concentrated sulfuric acid (98.0 % by mass) is used to dissolve sulfur trioxide where it forms oleum ($H_2S_2O_7$).

Step 4

The oleum is mixed with water to obtain more sulfuric acid.

A team of chemical engineers carried out step 2 at a variety of temperatures to inform decisions about the optimum conditions for the reaction. Their results are shown on the next page.

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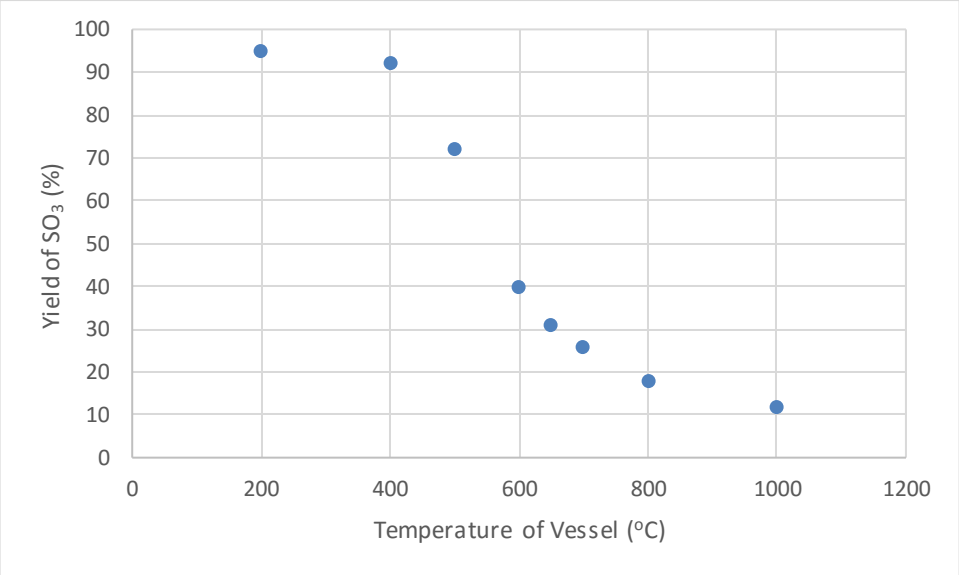
Table 1. Yield of sulphur trioxide for contact process reaction carried out at 150 kPa pressure, with a V_2O_5 catalyst at a range of temperatures.

Temperature of reaction vessel (°C)	**Yield of SO_3 (%)**
200	95
400	92
500	72
600	40
650	31
700	26
800	18
1000	12

The data is displayed in the graph on the grid below.



(b) Use your graph to predict the yield of the reaction at 550 °C. (1 mark)

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(c) Describe the trend shown by these results. (2 marks)

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(d) As a result of these findings, the chemical engineer decided to operate the sulfuric acid plant at a temperature of 200 °C. However, the amount of sulphur dioxide produced was very low. Suggest a reason for this. (1 mark)

_____

_____

(e) After further tests, it was decided to operate the plant at 400 °C. With reference to your graph, explain why this temperature, and not a higher temperature, was chosen. (2 marks)

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(f) Assuming a yield of 92.0%, Calculate the volume of oxygen, at 400 °C and a pressure of 150 kPa, required to produce 1.00 tonne (1.00×10^6 g) of sulphur trioxide in the Contact Process: (4 marks)

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

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(g) Sulfuric acid is used to produce agricultural fertiliser, including superphosphate, which is a mixture of two calcium salts. The reaction is shown below:

$$Ca_3(PO_4)_2(s) + 2\ H_2SO_4(aq) + 4\ H_2O(\ell) \rightarrow Ca(H_2PO_4)_2(s) + 2\ CaSO_4 \cdot 2H_2O(s)$$

If 98.0 % (by mass) sulfuric acid is used, calculate the mass of the super phosphate that can be produced from 1.00 tonne of the sulfuric acid. (assume 100% yield)

(5 marks)

SEE NEXT PAGE

Spare answer page

Question Number: _____

SEE NEXT PAGE

Spare answer page

Question Number: _____

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