



**Methodist Ladies' College
Semester 1 Examination, 2016**

Question/Answer Booklet

**CHEMISTRY
ATAR Year 12**

Student Name: _____

Teacher Name: _____

Time allowed for this paper

Reading time before commencing work: 10 minutes

Working time for paper: Three hours

Materials required/recommended for this paper

To be provided by the supervisor

This Question/Answer Booklet

Multiple-choice Answer Sheet

Chemistry Data Sheet

To be provided by the candidate

Standard items: pens (blue/black preferred), pencils (including colours),
sharpener, correction fluid/tape, eraser, 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 this paper

Section	Number of questions available	Number of questions to be answered	Suggested working time (minutes)	Marks available	Percentage of total exam	Your mark
Section One: Multiple-choice	25	25	50	25	25	
Section Two: Short response	11	11	60	70	35	
Section Three: Extended answer	6	6	70	80	40	
Total					100	

Instructions to candidates

- The rules for the conduct of ATAR course examinations are detailed in the 2016 Year 12 Information Handbook. Sitting this examination implies that you agree to abide by these rules.
- Answer the questions according to the following instructions.

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

Sections Two and Three: Write your answers in this Question/Answer Booklet. Wherever possible, confine your answers to the line spaces provided. Use a black or blue pen for this section. Only graphs and diagrams may be drawn in pencil.
- When calculating numerical answers, show your working or reasoning clearly. Express numerical answers to **three** significant figures and include appropriate units where applicable.
- You must be careful to confine your responses to the specific questions asked and to follow any instruction that are specific to a particular questions.
- 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 questions that you are continuing to answer at the top of the page.
- The Chemistry Data Sheet is **not** to be handed in with your Question/Answer Booklet.



Section One: Multiple-choice

25% (50 Marks)

This section has 25 questions. Answer **all** questions on the separate Multiple-choice Answer Sheet Provided. For each question shade the box to indicate your answer. Use only a blue or black pen to shade the boxes. If you make a mistake, place a cross through that square, do not erase or use correction fluid, and shade your new answer. 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

1. Solution **X** has a pH of 4.38. When it is diluted tenfold the pH changes to 4.88.

X is likely to be:

- (a) an insoluble acid
 - (b) a buffered acid
 - (c) a strong acid
 - (d) a weak acid
2. A lemon juice is found to have a pH of 3 and an apple juice a pH of 5. The concentration of hydrogen ions in the lemon juice compared with the apple juice are in the ratio:
- (a) 100 : 1
 - (b) 1 : 100
 - (c) 20 : 1
 - (d) 3 : 5
3. A solution of sodium hydroxide is diluted with water. Which option shows the changes that occur?

	[H ⁺]	[OH ⁻]	electrical conductivity
(a)	decreases	increases	increases
(b)	decreases	increases	decreases
(c)	increases	decreases	increases
(d)	increases	decreases	decreases

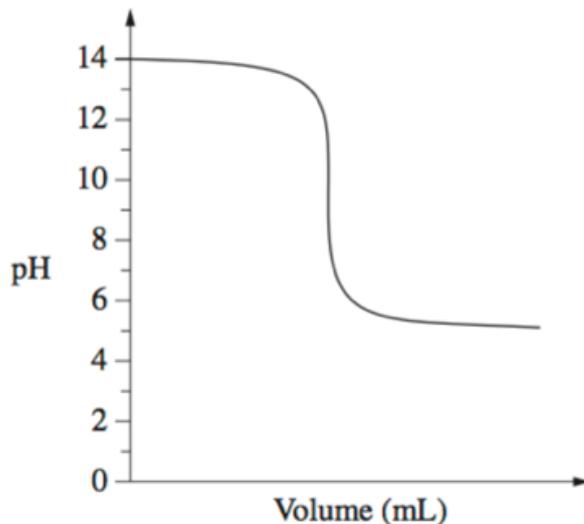
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4. The graph below shows the changes in pH during a titration.



Consider the following acid-base indicators.

Indicator	pH range of colour change	colour change
methyl red	4.4 – 6.2	red to yellow
bromothymol blue	6.0 – 7.6	yellow to blue
phenolphthalein	8.3 – 10.0	colourless to pink

Which of the following statements is correct?

- (a) Bromothymol blue would be a good choice of indicator for this titration.
 - (b) With phenolphthalein the titration should be stopped when the solution in the conical flask shows the first permanent pink colour.
 - (c) With methyl red the endpoint would occur after the equivalence point.
 - (d) Methyl red is a good choice as the final pH lies between 4 and 6.
5. Which of the following could not be used to prepare a buffer solution?
- (a) nitric acid and ammonia solutions
 - (b) nitric acid and potassium nitrate solutions
 - (c) ethanoic acid and potassium ethanoate solutions
 - (d) ethanoic acid and potassium hydroxide solutions

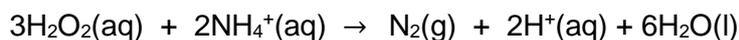
6. Which of the following shows the correct acid-base properties of the salts listed?

	NaF	Fe(NO ₃) ₂	K ₂ CO ₃
(a)	basic	neutral	basic
(b)	basic	acidic	acidic
(c)	neutral	neutral	acidic
(d)	neutral	acidic	basic

7. $\text{ClO}_3^-(\text{aq}) + 6\text{H}^+(\text{aq}) + n\text{e}^- \rightarrow \text{Cl}^-(\text{aq}) + 3\text{H}_2\text{O}(\text{l})$

What is the value of n ?

- (a) 4
(b) 5
(c) 6
(d) 7
8. The reaction between hydrogen peroxide and ammonium ions is represented by the following equation.



Which of the following statements is correct?

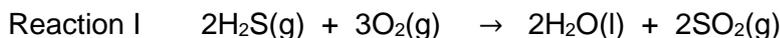
- (a) NH_4^+ is the oxidant
(b) $\text{H}_2\text{O}_2(\text{aq})$ is reduced to $\text{H}^+(\text{aq})$
(c) $\text{H}_2\text{O}_2(\text{aq})$ is oxidised to $\text{H}_2\text{O}(\text{l})$
(d) $\text{N}_2(\text{g})$ is the product of oxidation
9. Which of the following pairs of reactants **will not** undergo a spontaneous redox reaction?
- (a) gold(III) nitrate solution and sodium bromide solution.
(b) potassium iodide solution and gaseous chlorine
(c) gaseous fluorine and metallic gold.
(d) tin(II) nitrate solution and metallic silver



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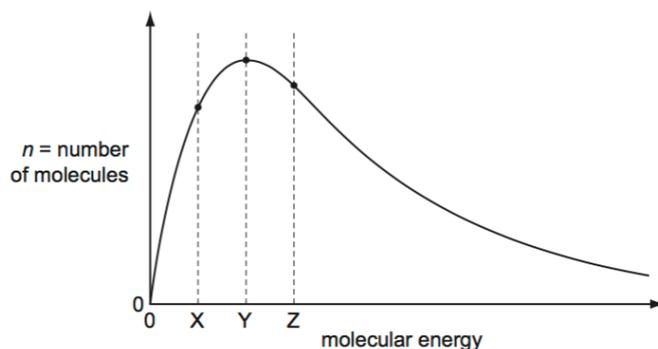
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10. Many crude oils contain H_2S . During refining, by the Claus process, the H_2S is converted into solid sulphur, which is then removed.



Which statements about the Claus process are correct?

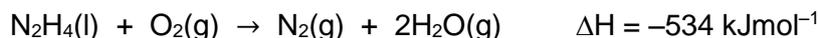
- (i) H_2S is oxidised in reaction 1.
 (ii) SO_2 oxidises H_2S in reaction II.
 (iii) Hydrogen is oxidised in reaction II.
- (a) (i), (ii) and (iii)
 (b) (ii) and (iii)
 (c) (i) and (ii)
 (d) (i) only
11. The Boltzman (kinetic energy) distribution for a gas at constant temperature is shown below.



If the temperature is reduced by 10°C the graph changes shape. What happens to the values of n for the molecular energies X, Y and Z?

	X	Y	Z
(a)	higher	lower	higher
(b)	higher	lower	lower
(c)	lower	higher	lower
(d)	lower	lower	lower

12. Hydrazine, N_2H_4 , is used as a rocket fuel because it reacts with oxygen as shown, producing 'environmentally friendly' gases.



Despite its use as a rocket fuel, hydrazine does not burn spontaneously in oxygen. Which statement best explains why hydrazine does not burn spontaneously?

- (a) hydrazine is a liquid
(b) the activation energy is high
(c) there are more moles of product species than reactant species
(d) the reaction is exothermic
13. Which of the following processes is exothermic?
- (a) water freezing
(b) $\text{I}_2(\text{s}) \rightarrow \text{I}_2(\text{g})$
(c) $\text{I}_2(\text{g}) \rightarrow 2\text{I}(\text{g})$
(d) $\text{K} \rightarrow \text{K}^+ + \text{e}^-$

14. The reaction shown below



can be described as: 1. redox 2. acid-base 3. precipitation

- (a) 1. only
(b) 1. and 2.
(c) 2. and 3.
(d) 1. and 3.
15. In which of the following would an increase in volume of the reacting system, at constant temperature, favour the forward reaction?

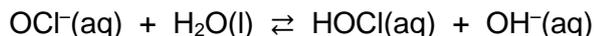
- I $\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightleftharpoons 2\text{NH}_3(\text{g})$
II $\text{CH}_3\text{COO}^-(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightleftharpoons \text{CH}_3\text{COOH}(\text{aq}) + \text{OH}^-(\text{aq})$
III $\text{Cr}_2\text{O}_7^{2-}(\text{aq}) + 2\text{OH}^-(\text{aq}) \rightleftharpoons 2\text{CrO}_4^{2-}(\text{aq}) + \text{H}_2\text{O}(\text{l})$
IV $\text{Cl}_2(\text{g}) + \text{F}_2(\text{g}) \rightleftharpoons 2\text{FCl}(\text{g})$

- (a) I only
(b) II only
(c) I and III
(d) II and IV



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16. NaOCl dissociates in water to form $\text{Na}^+(\text{aq})$ and $\text{OCl}^-(\text{aq})$. In solution $\text{OCl}^-(\text{aq})$ undergoes slight hydrolysis:



100mL of pure water at constant temperature is added to 100mL of 0.10 mol L^{-1} NaOCl. When the solution re-establishes equilibrium, the:

- (a) pH of the solution has decreased
(b) $[\text{OH}^-]$ has increased
(c) value of the equilibrium constant has halved
(d) $[\text{OCl}^-]$ has increased
17. Q, R and S are three elements from period 3 of the Periodic Table. Given the information below:
- the oxide of S dissolves in water to produce a solution that turns blue litmus paper red
 - Q reacts vigorously with water forming a solution that turns red litmus paper blue
 - R forms an oxide with a high melting point that is insoluble in both water and hydrochloric acid solution

If the elements are arranged in order of increasing atomic number, the correct order would be:

- (a) QSR
(b) SRQ
(c) RQS
(d) QRS
18. For which conversion is an oxidising agent required?
- (a) $\text{H}_2\text{O}_2(\text{aq}) \rightarrow \text{O}_2(\text{l})$
(b) $\text{F}_2(\text{g}) \rightarrow 2\text{F}^-(\text{aq})$
(c) $\text{MnO}_2(\text{s}) \rightarrow \text{Mn}_2\text{O}_3(\text{s})$
(d) $\text{Fe}^{3+}(\text{aq}) \rightarrow \text{Fe}^{2+}(\text{aq})$

19. A solution of lead(II) nitrate is to be stored in a metal container. Which one of the following metals would be best to use?
- (a) Ni
 - (b) Zn
 - (c) Fe
 - (d) Cu

20. Consider the data below on the two allotropes of oxygen.

Name	Formula	colour of liquid/solid	Melting point °C	Boiling point °C	Density of liquid (g mL ⁻¹)	Polarity
oxygen	O ₂	pale blue	-219	-183	1.1	non-polar
ozone	O ₃	deep blue	-193	-111	1.6	polar

Equal masses of oxygen and ozone at -190°C are shaken together. When the system settles, what is observed?

- (a) a homogeneous mid-blue liquid
 - (b) a deep blue solid below a pale blue liquid
 - (c) a pale blue liquid layer below a deep blue liquid layer
 - (d) a deep blue liquid layer below a pale blue liquid layer
21. Which of the following is likely to be least soluble in water?
- (a) propan-1-ol
 - (b) propanal
 - (c) propanoic acid
 - (d) propan-2-ol
22. The following substances are mixed. In which one of these will there be no visible reaction?
- (a) hydrogen peroxide solution and sodium iodide solution
 - (b) sulfuric acid and barium hydroxide solution
 - (c) carbonic acid solution and calcium nitrate solution
 - (d) calcium hydroxide solution and sodium nitrate solution

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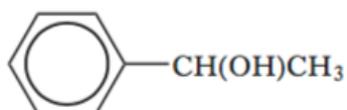
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23. How many unsaturated isomers have the formula $C_3H_4F_2$?

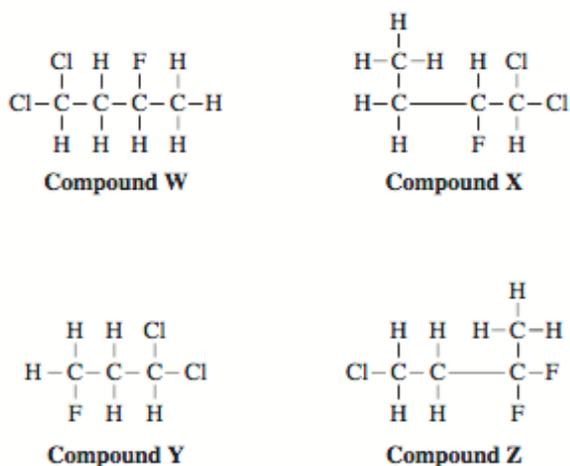
- (a) 5
- (b) 6
- (c) 7
- (d) 8

24. Which of the following statements about the compound below is correct?



- (a) It is likely to be basic in aqueous solution
- (b) It can be oxidised to a ketone
- (c) It reacts readily with bromine solution
- (d) It can be oxidised to a carboxylic acid

25. Four compounds, W, X, Y and Z, are represented below.



Which of the following is a pair of isomers?

- (a) W and X
- (b) W and Y
- (c) X and Y
- (d) X and Z

END OF SECTION 1

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Section Two: Short answer

35% (70 Marks)

This section has eleven (11) questions. Answer all questions. Write your answers in the spaces provided.

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.

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Suggested working time: 60 minutes

Question 26

(5 marks)

- (a) The equilibrium constant expression for a reaction involving A, B, C and D is:

$$K = \frac{[C]^3[D]}{[A][B]^2}$$

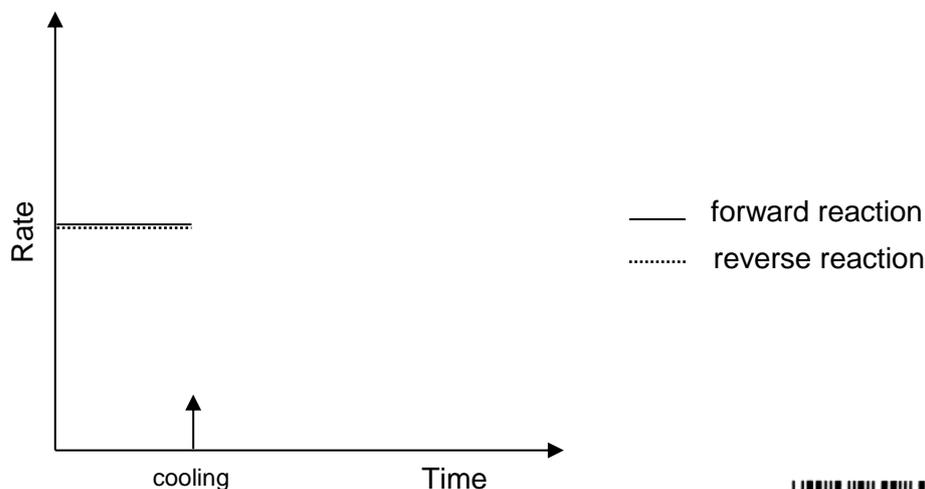
Write the chemical equation for this reaction (2 marks)

- (b) At 150°C the value of K is 25 and at 350°C the value of K is 73. Is the forward reaction endothermic or exothermic?

_____ (1 mark)

- (c) Using your answer to (b), complete the rates graph below, showing the effect of decreasing the temperature of an equilibrium mixture of A, B, C and D.

(2 marks)



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Question 27

(6 marks)

Complete the table by writing the name or formula for a substance that fits the description.

Description	Name or Formula
the conjugate base of H_2AsO_4^-	
a strong monoprotic acid	
a white solid that dissolves in water to form a slightly basic solution	
the halogen that is the best oxidant	
a yellow malleable solid	
a green solid that decomposes on heating to form a black solid and a colourless gas	

Question 28

(5 marks)

When the green solid potassium manganate, K_2MnO_4 , is sprinkled on water, it initially dissolves and then the manganate ion undergoes disproportionation (simultaneous oxidation and reduction), forming MnO_2 solid and the aqueous ion MnO_4^- .

- (a) Write the oxidation and reduction half equations and the balanced redox equation for the disproportionation of the manganate ion.

(3 marks)

reduction
oxidation
balanced redox

- (b) Give full observations for this reaction.

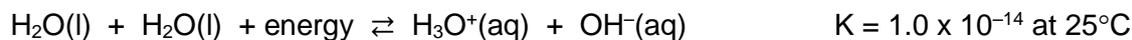
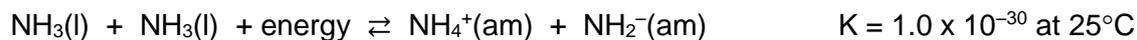
(2 marks)

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Question 29

(7 marks)

Pure liquid ammonia, like water undergoes self-ionisation.



(am) represents dissolved in liquid ammonia

- (a) At 25°C which liquid, water or ammonia, has the higher electrical conductivity? Explain your choice.

(2 marks)

- (b) Predict the pH of a solution of sodium amide, NaNH_2 . Circle the correct answer.

(2 marks)

Acidic

Basic

Neutral

Write an equation to justify your choice.

- (c) At 90°C the pH of pure water is 6.2. The water is still described as neutral. Explain.

(3 marks)

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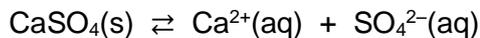
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Question 30

(9 marks)

Calcium sulfate is slightly soluble in water. An equilibrium mixture of a saturated solution of calcium sulfate in contact with excess solid calcium sulfate is set up. The equilibrium is represented by the following equation.



Three test-tubes are set up, each containing the equilibrium mixture which appears as a small amount of white solid under a colourless solution.

- (a) Complete the table below to show how the equilibrium responds when it is disturbed and give expected observations.

(6 marks)

Test tube	What is done	equilibrium shift: write \rightarrow , \leftarrow or no change	expected observation
1	a small quantity of solid calcium sulfate is added		
2	a few drops of concentrated sulphuric acid is added		
3	a small quantity of solid sodium nitrate is added		

- (b) Using collision theory and reaction rates, explain the equilibrium shift in test tube 2.

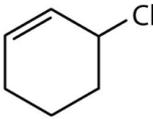
(3 marks)

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Question 31

(6 marks)

Complete the table below by giving the structural formulae or naming the following organic substances.

IUPAC Name	Structural formula
methylpropene	
cyclobutanone	
2,3-dichloropentanal	
	$\begin{array}{cccc} \text{H} & \text{H} & \text{H} & \text{Br} \\ & & & \\ \text{H}-\text{C} & -\text{C} & -\text{C} & -\text{C}-\text{H} \\ & & & \\ \text{H} & \text{Br} & \text{Cl} & \text{H} \end{array}$
	
	$\begin{array}{c} \text{O} \\ \\ \text{H}-\text{C}-\text{OH} \end{array}$

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Question 32

(6 marks)

The following chart shows the colour ranges for the indicators methyl orange, bromothymol blue and phenolphthalein.



- (a) Deduce the possible pH of a chemical that is yellow with methyl orange, blue with bromothymol blue and colourless with phenolphthalein. (1 mark)

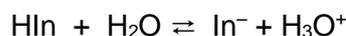
pH = _____

- (b) Give the expected colour of the indicator in the following solutions. (2 marks)

methyl orange in a solution with $[\text{OH}^-(\text{aq})]$ of $1.0 \times 10^{-5} \text{ mol L}^{-1}$ _____

phenolphthalein in a $1.0 \times 10^{-9} \text{ mol L}^{-1}$ hydrochloric acid solution _____

- (c) Indicators are themselves weak acids. The indicator and its conjugate base have distinctly different colours.



- i) Identify the two conjugate acid/base pairs in the equilibrium. (2 marks)

- ii) For bromothymol blue state the colour of HIn. _____ (1 mark)

Question 33

(2 marks)

Write a balanced ionic equation for the reaction of sulfuric acid solution and barium hydroxide solution.

Question 34

(6 marks)

A number of alcohols have the molecular formula $C_5H_{11}OH$. Give the structural formulae and IUPAC name of a primary, secondary and tertiary alcohol with this molecular formula.

Primary

Name _____

Secondary

Name _____

Tertiary

Name _____

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Question 35**(4 marks)**

1.35 g of aluminium chloride is dissolved in a little water and made up to 500.0 mL in a volumetric flask. Each mL of solution has a mass of 1.00 g. Determine the chloride ion concentration in parts per million (ppm).

Question 36**(14 marks)**

Consider the following five 0.10 mol L⁻¹ aqueous solutions at 25°C.

Sulfuric acid

Sodium hydroxide

Ethanoic acid

Ammonia

Nitric acid

(a) Explain which solution has the highest electrical conductivity.

(2 marks)

(b) Explain which solution has the lowest hydrogen ion concentration.

(2 marks)

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- (c) The ammonia solution has a pH of 10.2. Write an equation for the ionisation of ammonia and determine the percentage ionisation at 25°C.

(4 marks)

- (d) i) Choose two solutions from the list and describe how you could prepare 300 mL of a buffer solution using only your chosen solutions.

(3 marks)

- ii) Write an equation representing your buffer system

(1 mark)

- iii) Explain how your buffer system responds to the addition of a strong acid.

(2 marks)

End of Section Two



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Section Three: Extended answer

40% (80 Marks)

This section contains six (6) questions. You must answer all questions. Write your answers in the spaces provided.

Where questions require an explanation and/or description, marks are awarded for the relevant chemical content and also for coherence and clarity of expression.

Final answers to calculations should be expressed to **three (3)** significant figures and include appropriate units.

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.

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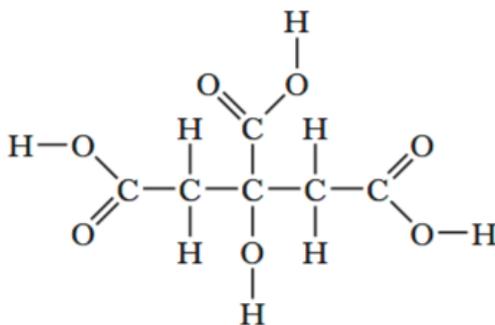
Suggested working time: 70 minutes

Question 37

(14 marks)

Sherbet is a sweet powder that fizzes on the tongue.

- (a) Sherbet contains the weak triprotic acid, citric acid.



Circle and name the two types of functional group in the citric acid molecule.

(2 marks)

1. _____

2. _____



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Another triprotic acid is phosphoric acid. Consider the following information.

Acid	pH 0.10 molL ⁻¹ solution
Citric, C ₆ H ₈ O ₇	3.9
Phosphoric, H ₃ PO ₄	2.6

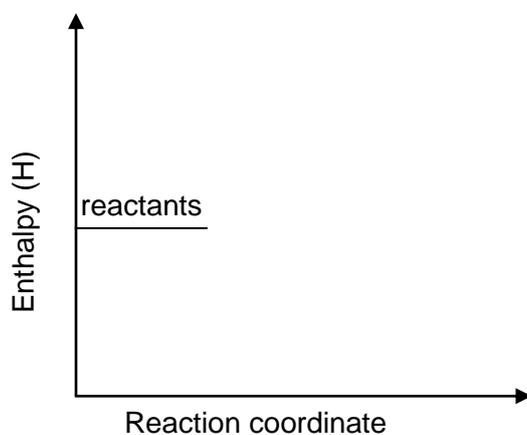
- (b) Explain which acid would have the smallest value equilibrium constant for its first ionisation.

(2 marks)

- (c) When sherbet fizzes on the tongue a cold sensation is felt.

- (i) Complete the reaction profile diagram to show the energy pathway for the reaction. Label the enthalpy change, ΔH .

(2 marks)



- (ii) If the energy term was included in the equation for this reaction, would it be a reactant or product?

(1 mark)

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- (d) A sherbet is made by mixing 15.0 g of sodium hydrogen carbonate with 15.0 g of citric acid, which react according to the equation below.



- (i) Which reactant is the limiting reagent? (4 marks)

- (ii) Calculate the maximum volume of carbon dioxide that could be released from this sherbet at 37°C and 101 kPa. (3 marks)

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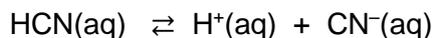


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Question 38

(11 marks)

Hydrogen cyanide, HCN, is a toxic gas that dissolves in water to produce the weak acid hydrocyanic acid.



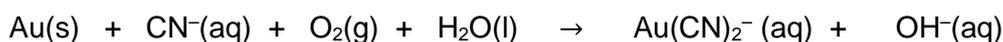
(a) Hydrocyanic acid reacts with sodium hydroxide solution.

(i) Write an ionic equation for this reaction. (2 marks)

(ii) If the reactants are mixed in stoichiometric quantities, suggest and explain, including relevant equations, the likely pH value of the resultant solution. (2 marks)

(b) One of the main uses for sodium cyanide is in the extraction of precious metals, such as gold, from ores. In the presence of oxygen and water, trace amounts of gold in the ore react with the sodium cyanide and dissolve out of the rock.

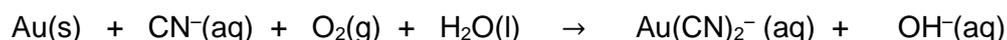
(i) Use oxidation numbers to identify the: (2 marks)



oxidising agent _____

reducing agent _____

(ii) Balance the equation (2 marks)



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- (c) If the pH of the extraction process is too low, toxic hydrogen cyanide gas is produced. To prevent this, the reaction mixture is maintained at pH 10.2 by addition of calcium hydroxide. Calculate the concentration in, mol L⁻¹, of calcium hydroxide in a pH 10.2 solution.

(3 marks)

Question 39

(9 marks)

7.65 L of hydrogen chloride gas at 102 K Pa and 27°C was dissolved in water and made up to 500 mL in a volumetric flask. A 20.0 mL sample of this solution was pipetted into a beaker and 30.0 mL of 1.20 mol L⁻¹ barium hydroxide was added to the beaker.

Calculate the pH of the final solution.

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Question 40

(23 marks)

Four separate organic liquids with similar molar masses are known to be:

3-methylbutan-1-ol	butanoic acid	pentan-2-one	3-methylpent-2-ene
88g mol ⁻¹	88g mol ⁻¹	86g mol ⁻¹	84g mol ⁻¹

(a) To identify the liquids a student decided to observe the boiling points of each liquid. The results are tabulated below.

(i) Complete the table by matching each liquid to its boiling point (2 marks)

Liquid	Boiling Point (°C)	Liquid is:
1.	164	
2.	132	
3.	102	
4.	68	

(ii) Explain your choices in terms of intermolecular forces. Diagrams may support your answer.

(4 marks)

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- (b) Another student decided to identify each liquid by carrying out a series of chemical tests as outlined in the table below. Complete the table.

(9 marks)

Chemical test	Name of liquid expected to give a positive test	Expected observations (positive test)	Structural formula of the organic product
add Br ₂ (aq) to a sample of each organic liquid and shake			
warm a sample of the remaining liquids with acidified K ₂ Cr ₂ O ₇ (aq)			
add NaHCO ₃ (aq) to a sample of the remaining liquids			

- (c) Write the oxidation and reduction half equations and the balanced redox equation for the reaction between the organic liquid and acidified potassium dichromate solution, as mentioned in the second chemical test of the table above. Assume the chemical oxidation is complete.

(3 marks)

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- (d) Draw and name two structural isomers of pentan-2-one. (4 marks)

name _____	name _____
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- (e) 3-methylpent-2-ene exhibits geometric isomerism. Give the structural formula of the 'cis' isomer. (1 mark)



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Question 41

(13 marks)

Many important industrial chemical reactions are reversible and reach equilibrium and this often results in low yields of the desired product.

Consider the information below on five important industrial processes.

(a) Balance the equations (in the table) for the Contact, Ostwald and Deacon processes. (3 marks)

(b) (i) In the Ostwald Process, how is yield affected by an increase in temperature? (1 mark)

(ii) How is the value of the equilibrium constant, K, related to rate of reaction? (1 mark)

Process	equation	ΔH	Equilibrium constant, K at 373K	Equilibrium constant, K at 773K
Contact	$_ \text{SO}_2(\text{g}) + _ \text{O}_2(\text{g}) \rightleftharpoons _ \text{SO}_3(\text{g})$	-196	1×10^{23}	2×10^{13}
Birkeland-Eyde	$\text{N}_2(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{NO}(\text{g})$	+180	3×10^{-23}	4×10^{-11}
Ostwald	$_ \text{NH}_3(\text{g}) + _ \text{O}_2(\text{g}) \rightleftharpoons _ \text{NO}(\text{g}) + _ \text{H}_2\text{O}(\text{g})$	-905	$>1 \times 10^{99}$	9×10^{68}
Deacon	$_ \text{HCl}(\text{g}) + _ \text{O}_2(\text{g}) \rightleftharpoons _ \text{Cl}_2(\text{g}) + _ \text{H}_2\text{O}(\text{g})$	-117	2×10^{14}	1×10^9
Cativa	$\text{CO}(\text{g}) + \text{CH}_3\text{OH}(\text{g}) \rightleftharpoons \text{CH}_3\text{COOH}(\text{g})$	-135	5×10^{28}	7×10^{13}

Process	Actual conditions		
	Temp °C	Pressure kPa	catalyst
Contact	450	200	V_2O_5
Birkeland-Eyde	3000	100	none
Ostwald	200	1000	Pt
Deacon	450	100	RuO_2
Cativa	140	3000	IrCl_4

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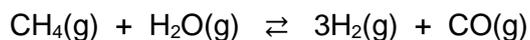
- (c) Four of the five processes use a catalyst. Suggest why catalysts are particularly useful in these processes.

(2 marks)

- (d) Often the 'actual' conditions of temperature and pressure chosen for important industrial processes are not the same as those that 'in theory' would produce maximum yield. Discuss, two examples of this, with reference to the industrial processes described.

(4 marks)

- (e) Hydrogen gas is produced industrially by treating natural gas (methane) with steam.



3.50 x 10³ L of methane is reacted with excess steam at 400°C and 112 KPa. Under the same conditions of temperature and pressure 9.27 x 10³ L of hydrogen is produced.

Determine the efficiency of the process.

(2 marks)

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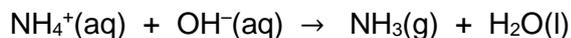
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Question 42

(10 marks)

A 1.481 g sample of an ammonium sulfate fertiliser was dissolved in water, filtered and made up to 250 mL in a volumetric flask. 20.0 mL of this solution was pipetted into a conical flask containing 20.0 mL of 0.1124 mol L⁻¹ (an excess) of sodium hydroxide solution. The flask was heated to convert all the ammonium ions to ammonia and drive off the ammonia gas from the solution.



When all the ammonia gas was driven off the inner walls of the conical flask were washed down with distilled water and then titrated with 0.1189 mol L⁻¹ hydrochloric acid using phenolphthalein as the indicator. The average titre was found to be 9.55 mL.

- (a) Calculate the moles of sodium hydroxide remaining, unreacted, after all the ammonia had been driven off.

(2 marks)

- (b) Calculate the moles of hydroxide ions in the conical flask before the 20.0 mL of fertiliser solution was added.

(1 mark)

- (c) Determine the % by mass of ammonium sulfate present in the 1.481 g sample of fertiliser.

(4 marks)

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- (d) During the analysis, why did the student wash the inner walls of the conical flask with distilled water? (1 mark)

- (e) Phenolphthalein was a good choice of indicator for this titration. What must be considered when choosing an indicator for an acid-base titration. (2 marks)

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END OF QUESTIONS



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