

CHEMISTRY

Student Name/Number:	
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Section	Marks
1	/50
2	/70
3	/80
Total	/200
%	

Time allowed for this paper

Reading time before commencing work: ten 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, pencils, eraser, correction fluid, ruler, highlighters
 Special items: non-programmable calculators satisfying the conditions set out by the Curriculum Council for this course

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 exam
Section One: Multiple-choice	25	25	50	25	25
Section Two: Short answer	11	11	60	70	35
Section Three: Extended answer	6	6	70	80	40
					100

Instructions to candidates

1. 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 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.

Sections Two and Three: Write answers in this Question/Answer Booklet.

2. When calculating numerical answers, show your working or reasoning clearly unless instructed otherwise.
3. 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.
4. 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.

See next page

Section One: Multiple-choice

25% (25 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. In reading from left to right across period three of the Periodic Table, oxides, chlorides change from ionic to covalent in character.

What is a suitable explanation for this?
 - (a) Increasing size of the atom of the period three elements.
 - (b) Decreasing first ionisation energies of the period three elements.
 - (c) Increasing electronegativity of the period three elements.
 - (d) Decreasing number of valence electrons of the period three elements.

2. In which one of the following sets do all the species have the electron configuration of a noble gas?
 - (a) N^{3-} , P^{3-} , Ar^{3+}
 - (b) H^+ , Ca^{2+} , F^-
 - (c) S^{2-} , O^{2-} , Na^{2+}
 - (d) P^{3-} , K^+ , Mg^{2+}

3. Sodium and chlorine are both period 3 elements of the Periodic Table
In comparison you would expect sodium to have
 - (a) the lower 1st ionisation energy and lower electronegativity.
 - (b) the higher 1st ionisation energy and lower electronegativity.
 - (c) the lower 1st ionisation energy and the higher electronegativity.
 - (d) the higher 1st ionisation energy and the higher electronegativity.

See next page

4. Water has a higher melting point than hydrogen fluoride.
A possible explanation for this is
- (a) The covalent bond between O and H is stronger than that between F and H.
 - (b) Water forms more extensive hydrogen bonds than hydrogen fluoride.
 - (c) Water contains more ions than hydrogen fluoride.
 - (d) Water is more polar than hydrogen fluoride.
5. The table shows some properties of four solids, W, X, Y and Z.

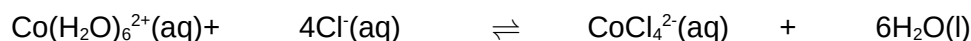
<i>Properties</i>	<i>W</i>	<i>X</i>	<i>Y</i>	<i>Z</i>
Melting Point °C	230 0	800	80	1200
Soluble in water	No	Yes	No	No
Solid state conducts electricity	No	No	No	Yes
Molten state conducts electricity	No	Yes	No	Yes

What is the correct classification of the solids?

	<i>Metallic</i>	<i>Network covalent</i>	<i>Ionic</i>	<i>Molecular</i>
(a)	<i>W</i>	<i>X</i>	<i>Y</i>	<i>Z</i>
(b)	<i>X</i>	<i>Y</i>	<i>Z</i>	<i>W</i>
(c)	<i>Y</i>	<i>Z</i>	<i>W</i>	<i>X</i>
(d)	<i>Z</i>	<i>W</i>	<i>X</i>	<i>Y</i>

See next page

6. When chloride ions are added to a solution containing $\text{Co}(\text{H}_2\text{O})_6^{2+}$ the following equilibrium is established:



Pink

Blue

Solutions containing $\text{Co}(\text{H}_2\text{O})_6^{2+}$ and Cl^- are frequently violet in colour owing to the presence of significant amounts of both $\text{Co}(\text{H}_2\text{O})_6^{2+}$ and CoCl_4^{2-} .

Which of the following statements concerning such solutions is true?

- (a) If the forward reaction is endothermic, cooling the solution will make the colour turn pink.
- (b) Adding a large amount of solid sodium chloride to the solution will make the colour turn pink.
- (c) Diluting the solution with water will make the colour turn blue.
- (d) If the forward reaction is exothermic, heating the solution will make the colour turn blue.
7. The Brønsted-Lowry theory applies in both aqueous and non-aqueous systems. The following reactions may take place in solvents other than water. Which is **NOT** a Brønsted-Lowry reaction?

- (a) $\text{NH}_4^+ + \text{NH}_2^- \rightleftharpoons 2\text{NH}_3$
- (b) $\text{CO}_2 + \text{OH}^- \rightleftharpoons \text{HCO}_3^-$
- (c) $\text{HClO}_4 + \text{CH}_3\text{COOH} \rightleftharpoons \text{CH}_3\text{COOH}_2^+ + \text{ClO}_4^-$
- (d) $\text{CH}_3\text{CH}_2\text{O}^- + \text{CH}_3\text{NH}_3^+ \rightleftharpoons \text{CH}_3\text{CH}_2\text{OH} + \text{CH}_3\text{NH}_2$

8. Four students were asked to test a solution for the presence of a cation by using various anions. The students obtained these results:

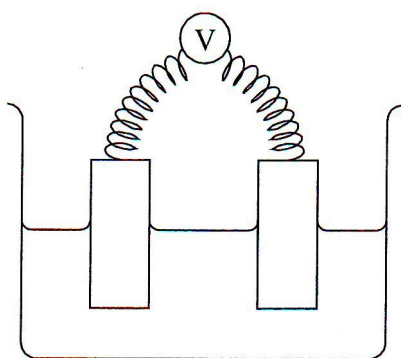
Student	Chloride	Sulfate	Carbonate
(a)	No precipitate	No precipitate	Precipitate
(b)	Precipitate	Precipitate	No precipitate
(c)	Precipitate	Precipitate	Precipitate
(d)	No precipitate	Precipitate	No precipitate

Each student
 Pb^{2+} was present.

concluded that

Which student had results consistent with this conclusion?

9. Which one of the four elements (V, P, N, Cl) underlined below has the **highest** oxidation state?
- (a) V₂O₅
(b) H₃PO₄
(c) NaNO₃
(d) ClO₄⁻
10. Which one the following solutions will have the greatest concentration of ions per litre?
- (a) 0.4 molL⁻¹ Na₂SO₄
(b) 0.3 molL⁻¹ Mg(NO₃)₂
(c) 0.5 molL⁻¹ H₂SO₄
(d) 0.4molL⁻¹ Na₃PO₄
11. The diagram below represents a cell in which two metals have been placed in a solution containing their respective metallic ions. The metals are connected to a voltmeter.

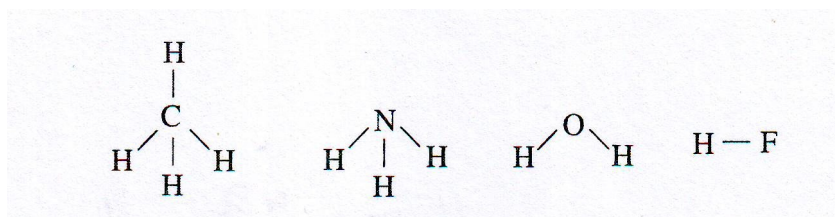


Which of the following combinations of metals would produce the highest reading on the voltmeter?

- (a) Tin and zinc
(b) Copper and zinc
(c) Copper and silver
(d) Magnesium and lead

12. Which statement best describes the equivalence point in a titration between a strong acid and a strong base?
- (a) The point at which equal moles of H^+ ions and OH^- ions have been added together.
 - (b) The point at which equal moles of acid and base have been added together.
 - (c) The point at which the first sign of a colour change occurs.
 - (d) The point at which the rate of the forward reaction equals the rate of the reverse reaction.
13. Citric acid, the predominant acid in lemon juice, is a triprotic acid. A student titrated 25.0 mL samples of lemon juice with $0.550 \text{ mol L}^{-1} \text{NaOH}$. The mean titration volume was 29.50 mL. The molar mass of citric acid is $192.12 \text{ g mol}^{-1}$.
- What was the concentration of citric acid in the lemon juice?
- (a) 1.04 gL^{-1}
 - (b) 41.06 gL^{-1}
 - (c) 125 gL^{-1}
 - (d) 374 gL^{-1}
14. Which of the following is true for a system at equilibrium?
- (a) The number of collisions per unit time between reactants is equal to the number of collisions per unit time between products.
 - (b) The product of the concentrations of the reactants is equal to the product of the concentrations of the products.
 - (c) Reactants are reacting to form products at the same rate as products are reacting to form reactants.
 - (d) All concentrations of reactants and products are equal.
15. Which one of the following alternatives lists the atoms of aluminium, calcium, silicon and phosphorus in order of increasing electronegativity?
- (a) (lowest) Al, Si, P, Ca (highest)
 - (b) (lowest) Ca, Al, Si, P (highest)
 - (c) (lowest) P, Si, Al, Ca (highest)
 - (d) (lowest) Si, Ca, Al, P (highest)
16. Which one the following alternatives lists the atoms of chlorine, fluorine, aluminium and calcium in order of increasing atomic radius?
- (a) (smallest) F, Cl, Al, Ca (largest)
 - (b) (smallest) Ca, F, Al, Cl (largest)
 - (c) (smallest) Cl, F, Al, Ca (largest)
 - (d) (smallest) Al, Ca, F, Cl (largest)

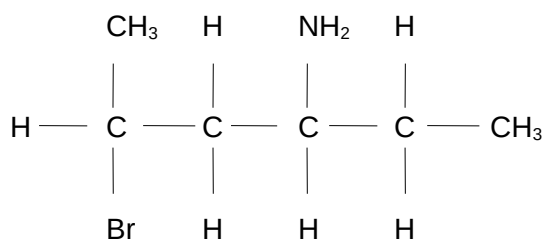
17. Which one of the following alternatives lists the atoms of chlorine, magnesium, neon and sulphur in order of first ionisation energy?
- (a) (smallest) Cl, Mg, Ne, S (largest)
(b) (smallest) Mg, S, Cl, Ne (largest)
(c) (smallest) Ne, S, Cl, Mg (largest)
(d) (smallest) Mg, Ne, S, Cl (largest)
18. The number of structural isomers that are aldehydes with the formula C_4H_8O
- (a) 1
(b) 2
(c) 3
(d) 4
19. Two of the compounds shown below react together to form a new compound with a coordinate covalent bond.



- Which of the following compounds react in this way?
- (a) Methane and ammonia
(b) Methane and water
(c) Hydrogen fluoride and ammonia
(d) Hydrogen fluoride and methane
20. Sodium hydride (NaH) reacts with water as follows.
- $$\text{NaH(s)} + \text{H}_2\text{O(l)} \rightarrow \text{Na}^+(\text{aq}) + \text{H}_2(\text{g}) + \text{OH}^-$$
- This reaction should be classified as
- (a) Acid-base but not redox.
(b) Redox but not acid-base.
(c) Both acid-base and redox.
(d) Neither redox nor acid-base.
21. Which of the following is not a chemical or physical property of an α amino acid?
- (a) React with an acid.
(b) React with a base.

See next page

- (c) Relatively soluble in water.
(d) React with an oxidising agent (oxidant).
22. Choose the best description of the solubility of soaps and detergents.
- (a) Soluble in polar solvents such as water.
(b) Soluble in non-polar solvents such as oil and grease.
(c) Soluble in polar and non-polar solvents.
(d) Insoluble in polar and non-polar solvents.
23. Given that R is a hydrocarbon chain. Which functional group would form the most polar molecule with R?
- (a) Amine
(b) Carboxylic acid
(c) Alcohol
(d) Aldehyde
24. Which of the following is a primary amine?
- (a) $\text{CH}_3\text{CH}_2\text{CH}(\text{NH}_2)\text{CH}_2\text{CH}_3$
(b) $\text{CH}_3\text{CH}_2\text{CNHCH}_2\text{CH}_3$
(c) $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}(\text{NH}_2)\text{CH}_3$
(d) $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{NH}_2$
25. What is the IUPAC name of the following compound?



- (a) 5-bromo -3- hexanamine.
(b) 2-bromo - 4 -hexanamine
(c) 5-bromo - 5 - methyl - 3 - pentanamine
(d) 1-bromo-1-methyl - 3 - pentanamine

End of Section One

See next page

Section Two: Short answer 35% (70 Marks)

This section has **11** questions. Answer **all** questions. Write your answers in the space 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.

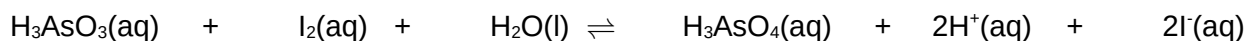
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Suggested working time for this section is 60 minutes.

Question 26**(4 marks)**

When a brown iodine solution and a colourless arsenious acid solution are mixed, the brown colour of the iodine fades noticeably as the following reaction occurs:



- (a) Predict whether the following changes will increase, decrease or have no effect on the equilibrium yield of the reaction.

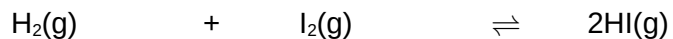
Change	Effect
Adding dilute nitric acid	
Adding sodium hydroxide solution	
Adding silver nitrate solution	

- (b) Write the equilibrium constant expression for the above reaction.

Equilibrium constant expression	
---------------------------------	--

Question 27**(4 marks)**

Consider the following equilibrium system:



- (a) When the equilibrium system is heated the position of the equilibrium shifts to favour the formation of the products. Is the forward reaction exothermic or endothermic? (1 mark)

- (b) Predict whether the following changes will increase, decrease or have no effect on the rate of attainment of equilibrium. (3 marks)

Change	Effect
Increasing the temperature	
Increasing the volume of the system	
Adding a catalyst	

Question 28**(4 marks)**

- (a) Would a solution of sodium phosphate be acidic, neutral or basic? (1 mark)

- (b) Explain your answer to (a) using an equation. (3 marks)

Question 29**(6 marks)**

Carbonic acid (H_2CO_3) is present in blood and acts as a buffer.

- (a) Write an equation for the reaction between carbonic acid and water. (2 marks)
- (b) Blood needs a constant pH of 7.4. Draw the structure (either carbonic acid or hydrogen carbonate ion) that would predominate if the equilibrium constant at this pH is very small. (1 mark)



- (c) After exercise the concentration of H^+ in the bloodstream increases. Explain, using an equation and the principles of equilibrium, how a solution of carbonic acid and the hydrogen carbonate ion may act to counteract the increase in concentration of H^+ . (2 marks)

- (d) What would be the concentration of H^+ at pH 7.4? (1 mark)

Question 30**(4 marks)****See next page**

Explain why ethanol is very soluble in water but virtually insoluble in a solvent such as paraffin.
(Note "like dissolves like" is a statement not an explanation)

Question 31**(6 marks)**

Consider the following reactions and complete the tables that follow.

- (a) An excess of 2-propanol is oxidised by acidified KMnO_4 (3 marks)

Observations	
Structural formula of organic product Show all atoms	
Name of organic product	

- (b) Methanoic acid reacts with 1-butanol in the presence of H_2SO_4 (3 marks)

Observations	
Structural formula of organic product Show all atoms	
Name of organic product	

See next page

Question 32

(12 marks)

For each species listed on the table below, draw the structural formula, representing all valence electron pairs either as : or as — and state or draw the shape of the molecule **and** state the polarity of the molecule.

(for example, water $\text{H}:\ddot{\text{O}}:\text{H}$ or $\text{H}-\ddot{\text{O}}-\text{H}$ or $\text{H}-\ddot{\text{O}}-\text{H}$ bent polar)

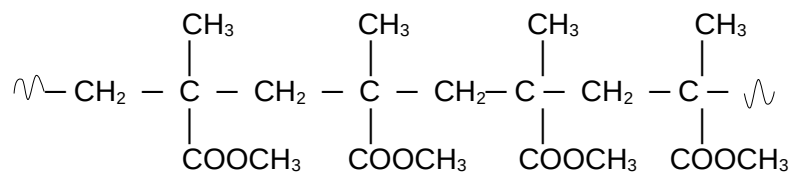
Species	Structure (showing all valence shell electrons)	Shape (sketch or name)	Polarity of molecule (polar or non-polar)
Silicon hydride SiH_4			
Hydrogen cyanide HCN			
Sulfite ion SO_3^{2-}			
Boron trifluoride BF_3			

Question 33

(4 marks)

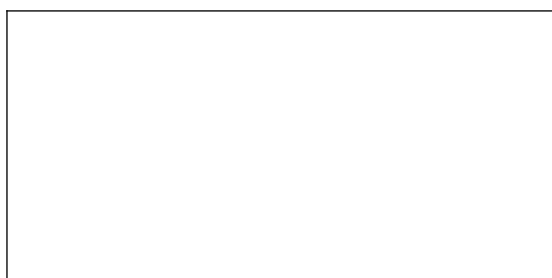
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PMMA, a polymer used in the manufacture of lightweight spectacle lenses, has the structural formula shown below:



- (a) On the structural formula above, identify the repeating unit. (1 mark)
- (b) Draw the structural formula of the monomer from which PMMA is produced. (1 mark)

Monomer



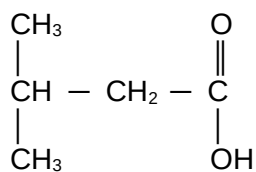
- (c) Name the type of polymerisation from which PMMA is produced. (1 mark)

-
- (d) Name the functional group in PMMA (1 mark)
-

Question 34

(6 marks)

Compounds similar to that shown below are responsible for the odour of some cheeses.



- (a) State the systematic (IUPAC) name of the compound shown above. (1 mark)

- (b) This compound can be produced by the oxidation of an alcohol with acidified potassium permanganate solution.

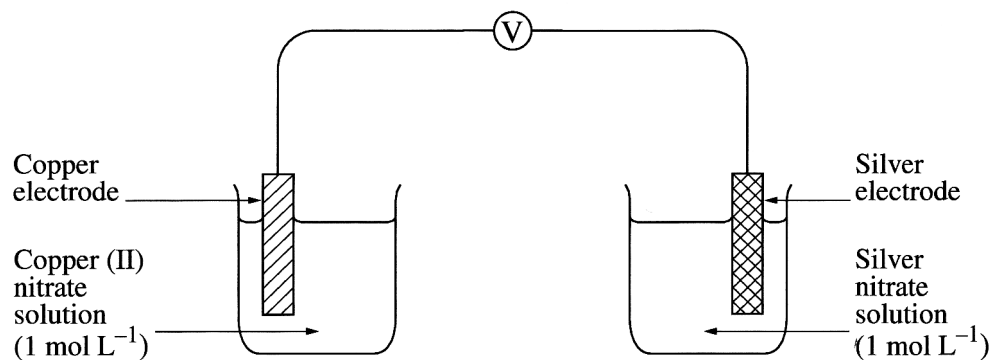
Write the half equation for the oxidation of this alcohol to the compound shown above. (2 marks)

- (c) Write the half equation for the reduction of the acidified permanganate ion (MnO_4^-) and hence write the overall redox equation for the reaction. (3 marks)

Question 35

(7 marks)

An electrochemical cell was made by connecting two half-cells. One half-cell was made by putting a copper electrode in a copper (II) nitrate solution. The other half cell was made by putting a silver electrode in a silver nitrate solution. The electrodes were connected to a voltmeter as shown in the diagram.



(a) Complete the above diagram by (4 marks)

- (i) drawing and labelling a suitable salt bridge
- (ii) labelling the cathode
- (iii) labelling the direction of electron flow
- (iv) labelling the direction of anion flow in the salt bridge

(b) Write the balanced anode and cathode reactions. (2 marks)

- (i) Anode

- (ii) Cathode

(c) What would be the initial voltage in the above cell under standard conditions? (1 mark)

Question 36

(13 marks)

The metal tin, Sn(s), is often used to surface coat steel cans to protect them from corrosion.

- (a) In terms of the mechanisms of corrosion, explain how this protective coating works. (3 marks)

- (b) Once the coating is scratched and the steel is exposed, corrosion actually occurs more rapidly than if the tin were not there. In terms of corrosion mechanisms, explain why this occurs. (3 marks)

- (c) A second alternative for the protection of steel is to galvanise with zinc. Give a chemical reason, with equation, why zinc galvanising is not used to protect steel food cans from corrosion. (3 marks)

- (d) During the 1960s an American automobile manufacturer produced cars with an **aluminium** water pump directly attached to a cast **iron** engine. There were subsequently, a lot of complaints about leaking water pumps.

Discuss possible electrochemical reasons for this. Diagrams and equations may help your answer. (4 marks)

End of Section Two

Section Three: Extended answer

40% (80 Marks)

This section contains **six (6)** questions. You must answer **all** questions. Write your answers in the space 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 for this section is 70 minutes.

Question 37

(15 marks)

Baking powder consists of a mixture of potassium hydrogen tartrate, $\text{KHC}_4\text{H}_4\text{O}_6(\text{s})$, and sodium hydrogen carbonate, $\text{NaHCO}_3(\text{s})$. It is used in cooking to make cakes rise. It works because the substances react in the presence of water to form $\text{CO}_2(\text{g})$. As the $\text{CO}_2(\text{g})$ tries to escape from the cake mixture it causes the mixture to rise. The equation for the reaction is:



- (a) A container of baking powder purchased from a supermarket contains 150 g of sodium hydrogen carbonate and 350 g of potassium hydrogen tartrate. Which reagent is the limiting reagent in the container? (Show your working) (4 marks)

- (b) Calculate the amount of the reagent in excess (in grams). (3 marks)

See next page

- (c) What volume of carbon dioxide would be released from the 500 g of baking powder at 105 kPa and 180°C? (3 marks)

- (d) Calculate the amount of each reagent needed to make exactly 500 g of baking powder so that neither reagent is in excess (the exact stoichiometric ratio). Quote your answers to 3 significant figures. (5 marks)

Question 38

(12 marks)

A student was given the job of determining the sulphuric acid content in car battery acid. This was done by titrating a solution of this car battery acid with a standardised sodium hydroxide solution (NaOH) of pH 13.3. The following procedure was followed:

Step 1: 10.0 mL of car battery acid was dissolved in water and made up to 500.0 mL of solution.

Step 2: A burette was filled with this solution and was used to titrate a 20.00 mL sample of the NaOH using a suitable indicator.

Step 3: Titrations were repeated until a consistent end point was obtained.

The student's results were as follows:

Final reading (mL)	20.60	19.65	20.75	20.80	19.05
Initial reading (mL)	4.50	3.80	5.25	5.00	3.20
Titration volume (mL)					

- (a) Complete the table and determine the average titre value for the NaOH solution. (1 mark)

Average Titre:

- (b) Write an equation for the reaction. (1 mark)

.....

- (c) Name a suitable indicator for the titration and explain your choice of indicator. (4 marks)

(d) Calculate the concentration of the sulfuric acid in the original car battery acid in moles per litre. (6 marks)

[illegible]

Question 39

(17 marks)

2.31g of an organic compound containing C, H and O was burnt in excess oxygen. 5.51 g of carbon dioxide and 2.81 g of water was formed.

- (a) Determine the empirical formula of the organic compound. (7 marks)

- (b) If compound X has a molar mass of 74.1 g mol^{-1} , determine the molecular formula of the compound. (2 marks)

- (c) When compound X is oxidised by an acidified potassium permanganate solution, compound Y is the only product. After isolating and purifying it, compound Y was shown to have acidic properties.

Draw and name two possible structures of compound X

(4 marks)

Structure	Structure
Name	Name

Draw and name two possible structures of compound Y.

(4 marks)

Structure	Structure
Name	Name

Question 40

(16 marks)

A soluble fertiliser contains phosphorus in the form of phosphate ions (PO_4^{3-}). To determine the PO_4^{3-} content by gravimetric analysis, 6.15 g of the fertiliser powder was completely dissolved in water to make a volume of 250.0 mL. A 20.00 mL volume of this solution was pipetted into a conical flask and the PO_4^{3-} ions in the solution were precipitated as MgNH_4PO_4 . The precipitate was filtered, washed with water and then converted by heating into $\text{Mg}_2\text{P}_2\text{O}_7$. The mass of $\text{Mg}_2\text{P}_2\text{O}_7$ was 0.0364 g.

- (a) Calculate the percentage of phosphate ions (PO_4^{3-}) by mass in the fertiliser. (6 marks)

- (b) Several actions which could occur during this analytical procedure are listed below (A-D). For each action, indicate the likely effect on the calculated percentage of phosphate ions in the fertiliser by placing a tick in the appropriate box. (5 marks)

Action	Calculated result would be too low	No effect on calculated result	Calculated result would be too high
A. All of the MgNH_4PO_4 was not precipitated.			
B. All of the fertiliser did not dissolve.			
C. The conical flask had been previously washed with water but not dried.			
D. The MgNH_4PO_4 precipitate was not washed with water.			

See next page

In the case of action **C** above, explain your reasoning for the answer you have given.

- (c) Common fertilisers are called NPK fertilisers as they contain the major plant nutrients nitrogen, phosphorus and potassium. The relative amounts of these nutrients in a typical fertiliser are 20.0 %:20.0 %:10.0 % by mass respectively. How much potassium nitrate (KNO_3) would be needed in a 50.0 kg of fertiliser to give a fertiliser containing 10.0 % of potassium by weight?

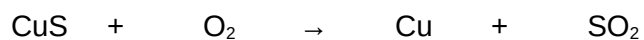
(3 marks)

- (d) What would be **two** advantages of using potassium nitrate as a fertiliser? (2 marks)

Question 41

(10 marks)

Copper is produced in a series of reactions from chalcopyrite (CuFeS_2) which are summarised below:



- (a) The copper produced is called blister copper and is approximately 98% pure copper. What mass of chalcopyrite is needed to produce 1 tonne of blister copper? (5 marks)

- (b) What volume of sulfur dioxide would be evolved at 1500°C and 150 kPa in producing 1 tonne of blister copper? (4 marks)

See next page

(c) What environmental problems may the sulfur dioxide produced cause? (1 mark)

(10 marks)

[illegible]

End of questions

[illegible]

[illegible]

Additional working space

[illegible]

Additional working space

[illegible]

Additional working space

[illegible]

