IONA PRESENTATION COLLEGE

Year 12 Chemistry

Semester Two Examination, 2003

Student Name : _____

Part	Mark	
1	/60	
2	/70	
3	/50	
4	/20	
Total	/200	%

TIME ALLOWED FOR THIS PAPER

READING TIME: 10 MINUTES
WORKING TIME FOR PAPER: 3HOURS

MATERIAL REQUIRED/RECOMMENDED FOR THIS PAPER

TO BE PROVIDED BY THE SUPERVISOR

This Question Paper/Answer Booklet
Separate Multiple Choice Answer Sheet
Chemistry/Data Sheet (inside front cover of this Question/Answer booklet)

TO BE PROVIDED BY THE CANDIDATE

Standard Items: Pens, pencils, eraser or correction fluid, ruler
Special Items: Calculators satisfying the conditions set by the Curriculum Council and a 2B, B or HB pencil for the separate Multiple Choice Answer Sheet.

IMPORTANT NOTE TO CANDIDATES

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

Part	Format	No. of Questions Set	No. of Questions to be Attempted	Marks Allocated	Recommended Time (Approx) /Minutes
1.	Multiple choice	30	ALL	60 (30%)	55
2.	Short answers	11	ALL	70 (35%)	60
3.	Calculations	5	ALL	50 (25%)	45
4.	Extended answers	2	1	20 (10%)	20

Total marks for paper = 200 (100%)

INSTRUCTIONS TO CANDIDATES

Reading Time: The examiners recommend that candidates spend the reading time mainly reading the Instructions to Candidates and Parts 2, 3 and 4.

Part 1 — Multiple Choice

Answer **ALL** questions, using a pen, on the separate Multiple Choice Answer Sheet.

If you consider that two or more of the alternative responses are correct, choose the one you think is best. If you think you know an answer, mark it even if you are not certain you are correct. Marks will **not** be deducted for incorrect answers.

FEEL FREE TO WRITE OR DO WORKING ON THE QUESTION PAPER; many students who score high marks in the Multiple Choice Section do this.

Parts 2, 3 and 4

Use a ballpoint or ink pen. **Do not** answer in pencil. Write your answers in this Question/Answer Booklet.

Questions containing specific instructions to show working should be answered with a complete, logical, clear sequence of reasoning showing how the final answer was arrived at; correct answers which do not show working will not be awarded full marks.

CHEMICAL EQUATIONS

For full marks, chemical equations should refer only to those species consumed in the reaction and the new species produced. These species may be **ions** [for example $Ag^+(aq)$], **molecules** [for example NH_3,(g), NH_3(aq), $CH_3COOH(l)$, CH_3COOH(aq)] or **solids** [for example $BaSO_4$(s), Cu(s), Na_2CO_3(s)].

PART 1 (60 marks = 30% of paper)

Answer ALL questions in Part 1 on the separate Multiple Choice Answer Sheet provided, using a 2B, B or HB pencil. Each question in this part is worth 2 marks.

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1. Which of these atoms is a metal that is in group three of the periodic table?

   (a) $1s^2 2s^2 2p^3$

   (b) $1s^2 2s^2 2p^6 3s^2$

   (c) $1s^2 2s^2 2p^6 3s^2 3p^1$

   (d) $1s^2 2s^2 2p^1$

2. The first five ionisation energies of an element are as follows:

1^{st}	793 kJ mol^{-1}
2^{nd}	1583 kJ mol^{-1}
3^{rd}	3238 kJ mol^{-1}
4^{th}	4362 kJ mol^{-1}
5^{th}	16098 kJ mol^{-1}

   The element is most likely to be:

   (a) H

   (b) Ca

   (c) Si

   (d) C*l*

3. The molecules formed by combining atoms with the atomic numbers of 7 and 9 will be:

   (a) Pyramidal and polar.

   (b) Pyramidal and non-polar.

   (c) Trigonal planar and polar.

   (d) Trigonal planar and non-polar.

4. In which of the following mixtures would the only intermolecular forces be dispersion forces?

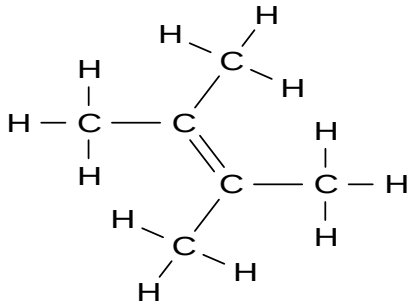
   (a) Hydrogen chloride and benzene.

   (b) Octane and water.

   (c) Ethanol and Propanol.

   (d) Tetrachloromethane and Pentane.

5. What is the correct IUPAC name for the following compound?



   (a) 1,2-dimethyl *cis*-2-butene

   (b) *cis*-2,3-dimethyl-1-butene

   (c) 2,3-dimethyl-2-butene

   (d) 2,3-methyl-1-butene

6. Which formula represents a molecule that can act as a monomer in an addition polymerisation reaction?

   (a) $CH_3CH_2CH_2CH_3$

   (b) $H_2CC(CH_3)_2$

   (c) $CH_3CH_2CH_3$

   (d) $CH_3CH_2CH_2OH$

7. Which of the following pairs of compounds would form propyl ethanoate when warmed with sulfuric acid?

   (a) CH_3CH_2COOH and CH_3CH_2OH

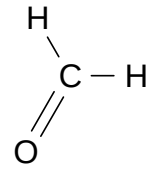
   (b) CH_3CH_2OH and $CH_3CH_2CH_2OH$

   (c) CH_3COOH and $CH_3CH_2CH_2OH$

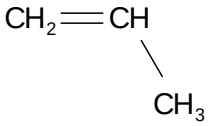
   (d) CH_3OH and CH_3COOH

8. Which of the following molecules are planar?

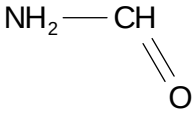
I



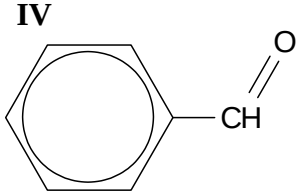
II



III



IV



(a) **I**, **II** and **IV** only

(b) **II** and **III** only

(c) **I** and **III** only

(d) **I** and **IV** only

9. What is the concentration in parts per million of a solution of 0.0100 mol L^{-1} $NaOH_{(aq)}$ (molar mass (NaOH) = 40.00 g mol^{-1} and density of solution = 1.00 g mL)

(a) 4.0×10^{2} ppm

(b) 2.5×10^{3} ppm

(c) 4.0×10^{3} ppm

(d) 1.0×10^{-2} ppm

10. Which of the following pairs of solutions would form a green precipitate when mixed?

(a) iron(III) nitrate and sodium hydroxide

(b) ammonium nitrate and chromium chloride

(c) copper(II) chloride and potassium nitrate

(d) nickel(II) sulfate and sodium carbonate

11. Surfactants, or wetting agents, are used to remove grease and dirt from surfaces. Which of the following substances will not act as a surfactant?

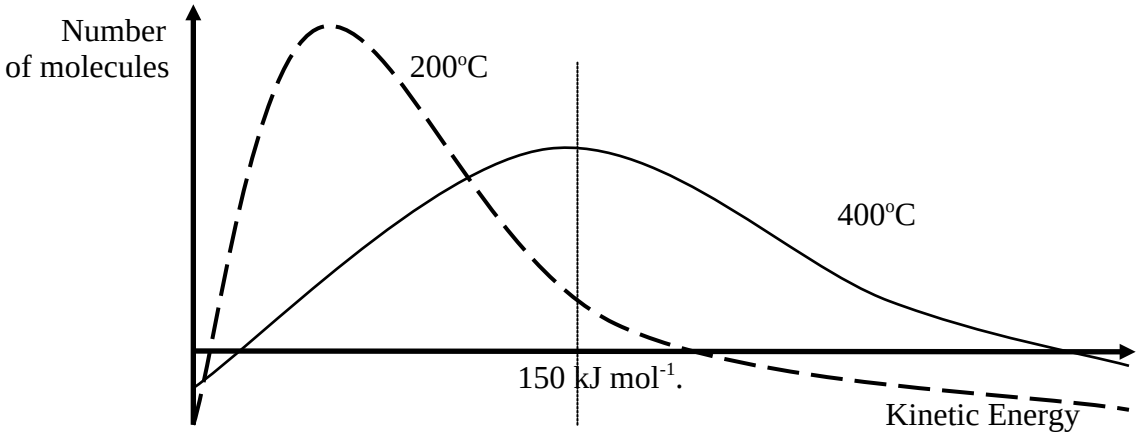
(a) $CH_3(CH_2)_{16}CO_2K$

(b) $CH_3(CH_2)_{16}CO_2H$

(c) $CH_3(CH_2)_{12}C_6H_4SO_3Na$

(a) $CH_3(CH_2)_{14}CO_2Na$

12. The graph shows the distribution of kinetic energy of molecules in a fixed quantity of gas at 200°C and 400°C involved in a reaction that has an activation energy of 150 kJ mol^{-1}.



Which of the following statements about the graph is **false**?

(a) The average kinetic energy of the particles is greater at 400°C than at 200°C.

(b) The total area under each graph should be equal.

(c) The reaction will not occur at 200°C.

(d) Some molecules at 200°C will have higher velocities than some at 400°C.

13. Copper metal is dissolved in concentrated nitric acid to form a blue solution. When aqueous ammonia solution is added a pale blue precipitate forms initially which is replaced by a deep blue solution.The copper species goes through the following changes:

(a) $Cu_{(s)} \longrightarrow Cu^{+}_{(aq)} \longrightarrow Cu(OH)_{2(s)} \longrightarrow [Cu(NH_4)_3]^{-}_{(aq)}$

(b) $Cu_{(s)} \longrightarrow Cu^{2+}_{(aq)} \longrightarrow Cu(OH)_{2(s)} \longrightarrow [Cu(NH_3)_4]^{++}_{(aq)}$

(c) $Cu_{(s)} \longrightarrow Cu(NO_3)_{2(aq)} \longrightarrow Cu(NH_4)_{2(aq)} \longrightarrow [Cu(NH_3)_4]^{++}_{(aq)}$

(d) $Cu_{(s)} \longrightarrow Cu^{2+}_{(aq)} \longrightarrow Cu^{2+}_{(s)} \longrightarrow [Cu(NH_3)_4]_{(s)}$

14. →

(a) 0.064 mol L^{-1}

(b) 0.150 mol L^{-1}

(c) 0.032 mol L^{-1}

(d) 0.015 mol L^{-1}

15. In the titration of hydrochloric acid (in burette) and sodium carbonate solution (in flask), which would be correct indicator to use and what would be the colour change at the end point?

	Indicator	Colour Change
(a)	Phenolphthalein	Pink to colourless
(b)	Methyl orange	Orange to yellow
(c)	Methyl orange	Yellow to red
(d)	Phenolphthalein	Colourless to pink

16. In which of the following compounds does chlorine have an oxidation state of +3 ?

(a) PCl_3

(b) $Mg(ClO_2)_2$

(c) $HClO_3$

(d) CH_3Cl

17. The following question relates to this process:

$$HSO_4^-(aq) + H_2O(l) \rightleftharpoons OH^-(aq) + H_2SO_4(aq)$$

Which of the following statements is false?

(a) The water is acting as an acid.

(b) The hydroxide ion is the conjugate base of water.

(c) HSO_4^- is the conjugate acid of H_2SO_4.

(d) H_2SO_4 can donate a proton to OH^-.

18. Which one of the following redox reactions will not occur spontaneously?

(a) $2Br^-(l) + H_2O_2(aq) + 2H^+(aq) \longrightarrow Br_2(l) + 2H_2O(l)$

(b) $Sn^{4+}(aq) + 2Ag(s) \longrightarrow Sn^{2+}(aq) + 2Ag^+(aq)$

(c) $Br_2(l) + 2I^-(aq) \longrightarrow I_2(aq) + 2Br^-(aq)$

(d) $2Cu^+(aq) + Fe(s) \longrightarrow 2Cu(s) + Fe^{2+}(aq)$

19. During the electrolysis of purified bauxite, what mass of pure aluminium would be deposited when 1000 moles of electrons are passed through the electrolytic cell? [$A_r(Al) = 27.0$]

(a) 9.0 kg

(b) 3.0 kg

(c) 27.0 kg

(d) 81.0 kg

20. Which one of the following correctly arranges 1.0 mol L^{-1} solutions of the substances in the order of increasing pH?

(a) H_3PO_4 H_2SO_4 CH_3COONa CH_3COOH NH_4CH_3COO

(b) H_2SO_4 H_3PO_4 CH_3COOH NH_4CH_3COO CH_3COONa

(c) H_2SO_4 H_3PO_4 CH_3COOH CH_3COONa NH_4CH_3COO

(d) H_3PO_4 H_2SO_4 NH_4CH_3COO CH_3COOH CH_3COONa

21. The discharging reactions occurring in a lead-acid accumulator cell are as follows:

Cathode: $PbO_{2(s)} + 4H^{+}_{(aq)} + SO_4^{2-}{}_{(aq)} + 2e^- \longrightarrow PbSO_{4(s)} + 2H_2O_{(l)}$

Anode: $Pb_{(s)} + SO_4^{2-}{}_{(aq)} \longrightarrow PbSO_{4(s)} + 2e^-$

Which of the following statements regarding the discharging process are correct?

I The pH in the cell will increase.
II The mass of the anode will decrease.
III Lead is both oxidised and reduced in the process.
IV Hydrogen is reduced.

(a) **I** and **III** only

(b) **II**, **III** and **IV** only

(c) **II** and **III** only

(d) **I** and **II** only

22. Which of these correctly show the trends in Electronegativity, First Ionisation Energy and Strength as a Reducing Agent as you go down the elements in group two of the periodic table from Be to Ra ?

	Electronegativity	First Ionisation Energy	Reducing Strength
(a)	Decreases	Decreases	Decreases
(b)	Decreases	Increases	Increases
(c)	Increases	Decreases	Decreases
(d)	Decreases	Decreases	Increases

23. The 2nd Ionisation energy of magnesium is the energy required per mole for the following process:

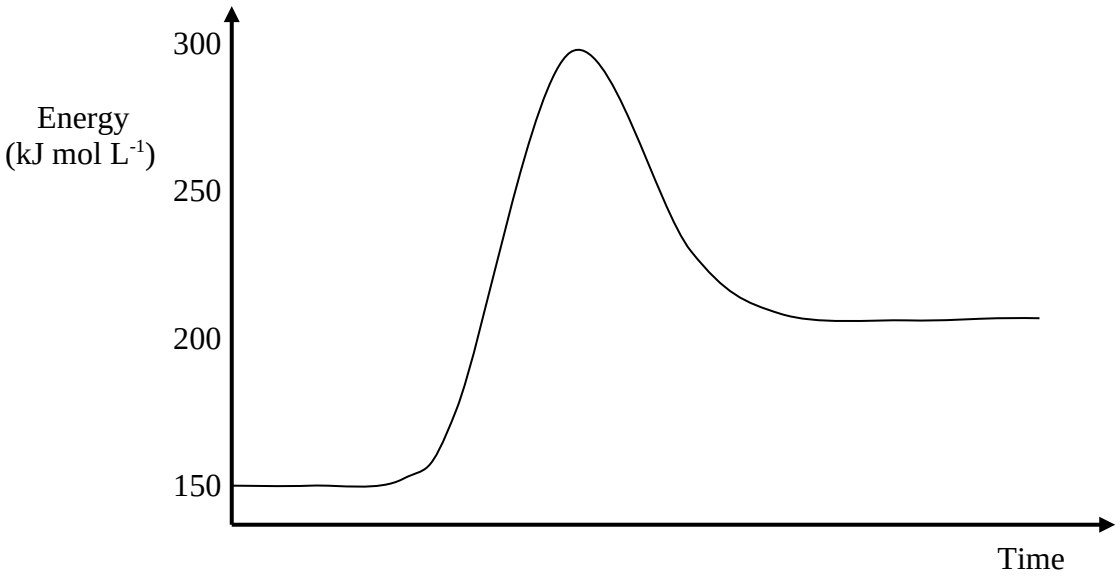
(a) $Mg_{(g)} \longrightarrow Mg^{2+}_{(g)} + 2e^-$

(b) $Mg^{+}_{(s)} \longrightarrow Mg^{2+}_{(aq)} + e^-$

(c) $Mg^{+}_{(g)} \longrightarrow Mg^{2+}_{(g)} + e^-$

(d) $Mg_{(g)} \longrightarrow Mg^{+}_{(g)} + e^-$

24. An energy profile diagram for a chemical reaction is shown below.



The reaction is:

(a) Exothermic with an activation energy of +100 kJ mol L^{-1}

(b) Endothermic with an activation energy of +150 kJ mol L^{-1}

(c) Exothermic with an of enthalpy change +50 kJ mol L^{-1}

(d) Endothermic with an enthalpy change of +200 kJ mol L^{-1}

25. In which of the following substances would hydrogen bonding occur?

I HF **II** NH_3 **III** H_2 **IV** HC*l*

(a) **I** and **III** only

(b) **II**, **III** and **IV** only

(c) **II** and **III** only

(d) **I** and **II** only

26. Graphite conducts electricity because:

(a) It is a covalent network solid.

(b) It contains positive ions.

(c) It has a layer structure.

(d) It contains delocalised electrons.

27. The following statements are about atomic orbitals:

I Each orbital can accommodate a maximum of 2 electrons.

II Electrons in the 3s orbital have less energy than electrons in a 2p orbital.

III There are 3 p-orbitals in each principal energy level.

Which statements are false?

(a) **I** only

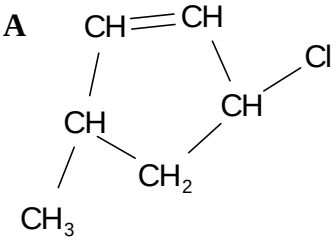
(b) **I**, **II** and **III**

(c) **II** and **III** only

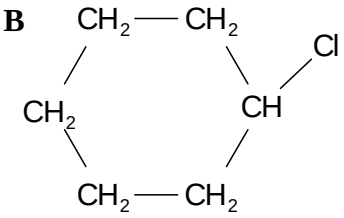
(d) **II** only

28. Which of the following structures is an isomer of 2-chloro-3-methyl-1-pentene?

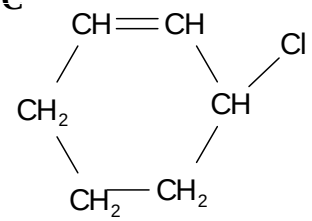
A



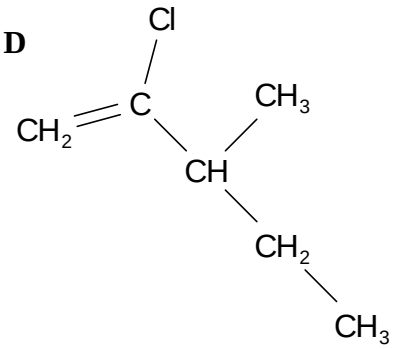
B



C



D



(a) **A**

(b) **B**

(c) **C**

(d) **D**

29. The atomic number of manganese is 25. The electron configuration of the Mn^{4+} ion could be:

(a) $1s^2 2s^2 2p^6 3s^2 3p^6 3d^3$

(b) $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^3$

(c) $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^9$

(d) $1s^2 2s^2 2p^6 3s^2 3p^6 3d^5$

30. The correct equation for the reaction of ammonia solution with silver(I) oxide is as follows:

(a) $8NH_{3(aq)} + Ag_2O_{(s)} + OH^-_{(aq)} \longrightarrow 2[Ag(NH_3)_4]^+_{(aq)} + H_2O_{(l)}$

(b) $NH_{3(aq)} + 2AgO_{(s)} + 3H_2O_{(l)} \longrightarrow NH_4^+{}_{(aq)} + 5OH^-_{(aq)} + 2Ag^+_{(aq)}$

(c) $2NH_{3(aq)} + AgO_{(s)} \longrightarrow [Ag(NH_3)_2]^-_{(aq)} + O^{2-}_{(aq)}$

(d) $4NH_{3(aq)} + Ag_2O_{(s)} + H_2O_{(l)} \longrightarrow 2[Ag(NH_3)_2]^+_{(aq)} + 2OH^-_{(aq)}$

END OF PART 1

PART 2 (70 marks = 35% of paper)

Answer ALL questions in Part 2 in the spaces provided below.

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1. Write equations for any reactions that occur in the following procedures. If no reaction occurs write 'no reaction'

   In each case describe **in full** what you would observe, including any
   - colours
   - odours
   - precipitates (give the colour)
   - gases evolved (give the colour or describe as colourless).

   If no change is observed, you should state this.

   (a) 5 mol L^{-1} sodium hydroxide solution is added to zinc hydroxide and warmed.

   Equation _____

   Observation _____

   _____

   [3 marks]

   (b) Dilute sodium hydroxide is added dropwise to copper (II) nitrate solution.

   Equation _____

   Observation _____

   _____

   [3 marks]

   (c) Sodium metal is added to ethanol.

   Equation _____

   Observation _____

   _____

   [3 marks]

   (d) Hydrogen peroxide solution is added to sodium bromide solution..

   Equation _____

   Observation _____

   _____

   [3 marks]

2. Complete the table below by choosing one of the aqueous solutions **A-I** from the following list that match the description. (You can use each substance more than once)

A 2.0 mol L^{-1} $HCl_{(aq)}$

B 1.0 mol L^{-1} $NH_4Cl_{(aq)}$

C 1.0 mol L^{-1} $Au(NO_3)_{3(aq)}$

D 0.1 mol L^{-1} $H_2C_2O_{4(aq)}$

E 1.0 mol L^{-1} $Na_2CO_{3(aq)}$

F 0.1 mol L^{-1} $Br_{2(aq)}$

G 0.01mol L^{-1} $HCl_{(aq)}$

H 0.02 mol L^{-1} $NaOH_{(aq)}$

I 1.0 mol L^{-1} $Fe(NO_3)_2$

Description	**Solution** (state letter)
Will have a pH of 2.0.	
Will decolourise when added to C_2H_2.	
Can oxidise bromide ions to bromine.	
Will form a precipitate when added to a solution of $BaCl_2$.	
Will become a red/brown colour when left in air.	
Can reduce Sn^{2+} to tin metal but not Mg^{2+} to magnesium metal.	
Contains a salt of a weak acid.	
Will go pink when a few drops of phenolphthalein are added.	

[8 marks]

3. Calculate the pH of a solution containing 25.0 mL of 2.0 mol L^{-1} sodium hydroxide and 49.5 mL of 1.0 mol L^{-1} hydrochloric acid.

[4 marks]

4. The overall reaction occurring in a dry cell can be shown as follows:

$$Zn_{(s)} + 2NH_4^{+}{}_{(aq)} + 2MnO_{2(s)} \longrightarrow Zn^{2+}{}_{(aq)} + Mn_2O_{3(s)} + H_2O_{(l)} + 2NH_{3(aq)}$$

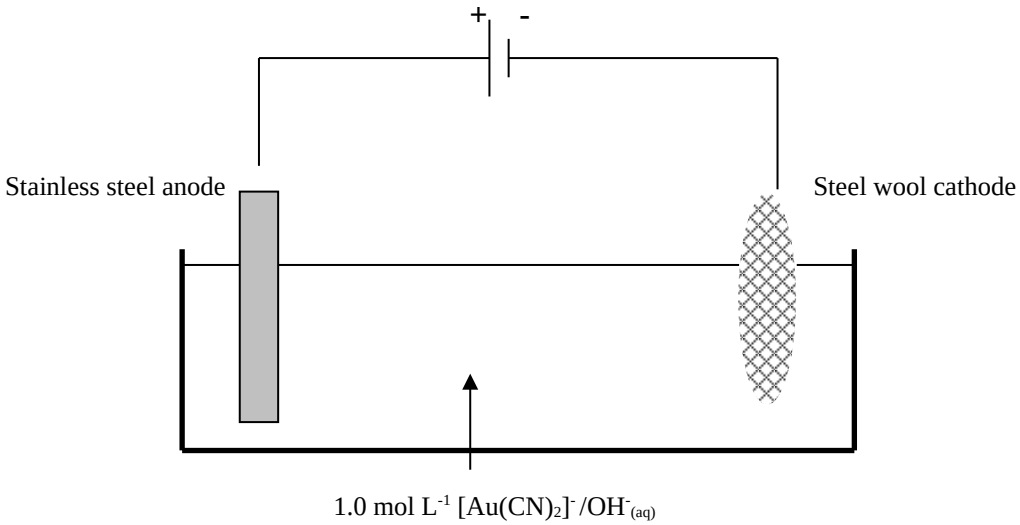
(a) Explain the role of zinc in the cell.

[2 marks]

(b) Explain the role of the ammonium ions in the cell.

[2 marks]

5. The following diagram shows the final stage in the extraction of Gold.



(a) Using half equations from your data sheet, complete the following table for this process:

Anode half-equation:
Cathode half-equation:
Overall equation:

[3 marks]

(b) Calculate the minimum voltage required for this process to occur.

[1 marks]

(c) Explain why **stainless** steel is required for the anode.

[2 marks]

6. (a) Write the equilibrium constant expression for the following reaction.

$$Cr_2O_7^{2-}{}_{(aq)} + H_2O_{(l)} \rightleftharpoons 2CrO_4^{2-}{}_{(aq)} + 2H^+{}_{(l)}$$

[2 marks]

(b) With reference to the following equilibrium:

$$OH^-{}_{(aq)} + H^+{}_{(aq)} \rightleftharpoons H_2O_{(l)}$$

and the system in (a), explain why a solution of dichromate ions becomes a lighter orange when alkali is added.

[3 marks]

7. This question is about how imposed changes affect the following reaction at equilibrium.

$$CaCO_{3(s)} + 179\ kJ \rightleftharpoons CO_{2(g)} + CaO_{(s)}$$

Complete the table by predicting the initial effect on the rate of the forward and reverse reactions and the position of equilibrium once it has been re-established.

Imposed change	**Forward reaction** Faster, slower or no change	**Reverse reaction** Faster, slower or no change	**Effect on equilibrium position** to right, to left, or no change
Reduce temperature			
Reduce pressure			
Increase surface area of the $CaCO_3$			

[9 marks]

8. For each species listed in the table below draw an electron dot diagram to show the bonding, sketch the shape, and state the polarity of the species.

Species	Electron dot diagram	Shape (sketch)	Polarity (polar or non-polar)
BF_3			
HCO_3^-			

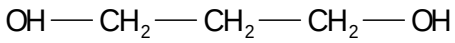
[6 marks]

9. Explain, using a diagram and equations, why the corrosion of iron on the hull of a boat can be reduced by the attachment of pieces of zinc metal at positions along the hull.

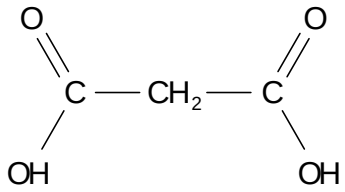
[4 marks]

10. The two compounds below were reacted together in the presence of concentrated sulphuric acid.

A



B



(a) Draw the structure of the product.

[2 marks]

(b) Name the other product in the reaction.

[1 marks]

(c) Suggest a reason for the presence of the sulphuric acid.

[1 mark]

(d) What reagents could be used to convert **A** into **B**?

[2 marks]

11. Explain how you could distinguish between the following pairs of compounds using chemical tests.

	Compounds	Description of Test	Observations
(a)	$PbCl_{2(s)}$		with $PbCl_{2(s)}$
	$KCl_{(s)}$		with $KCl_{(s)}$
(b)	$CH_3CO_2C_2H_5$		with $CH_3CO_2C_2H_5$
	$C_3H_7CO_2H$		with $C_3H_7CO_2H$
(c)	1-pentanol		with 1-pentanol
	2-ethyl-2-propanol		with 2-ethyl-2-propanol

[6 marks]

END OF PART 2

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PART 3 (50 marks = 25% of the paper)

Answer ALL questions in Part 3. The calculations are to be set out in detail in this Question/Answer Booklet. Marks will be allocated for correct answers and clear setting out, even if you cannot complete the problem. When questions are divided into sections, clearly distinguish each section using (a), (b) and so on. Express your final numerical answers to three (3) significant figures where appropriate, and provide units where applicable. Information which may be necessary for solving the problems is located on the separate Chemistry Data Sheet. Show clear reasoning: if you don't, you will lose marks.

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1. Titratable acidity is a measure of the concentration of all available hydrogen ions that can be neutralised by a base. It is an important measurement in the analysis of many foods including milk and wine.

   In the wine industry titratable acidity is recorded as: g(Tartaric Acid)/100 ml sample.
   Tartaric acid has the molecular formula of $C_4H_6O_6$ and is a **diprotic acid.**
   The following experiment was carried out:

   Procedure:
   Pipette 5.00 mL of wine into flask. Add approximately 100 mL distilled water and a few drops of phenolphthalein. Titrate against 0.100 M NaOH.

   Results

Burette readings (mL)	Titrations			
	1	2	3	4
Final volume	6.50	11.40	17.25	23.25
Initial volume	0.00	5.50	11.30	17.25
Titre				

   (a) Complete the table and calculate the titration volume.

   [2 marks]

   (b) Calculate the concentration of available hydrogen ions in the original sample of wine in $molL^{-1.}$.

   [3 marks]

   (c) Assuming this acidity was caused solely by tartaric acid, convert this to the concentration as grams of tartaric acid per 100 mL sample of wine.

   [3 marks]

   (d) Suggest a difficulty that may arise if red wine is used in this experiment.

   [1 marks]

   _____

   _____

   _____

2. An Organic Ester underwent hydrolysis to produce a monoprotic carboxylic Acid **X** and a secondary alcohol **Y** that has an empirical formula of $C_4H_{10}O$.

A 17.50 g sample of pure **X**, when combusted produced 44.15g of carbon dioxide and 7.750g of water.

Y was oxidised with potassium dichromate as follows:

$$3Y_{(l)} + Cr_2O_7^{2-}{}_{(aq)} + 8H^+_{(aq)} \longrightarrow 3Z_{(l)} + 2Cr^{3+}_{(aq)} + 7H_2O_{(l)}$$

44.88mL of 0.500 $molL^{-1}$ potassium dichromate was required to oxidise 4.99g of **Y**.

(a) Calculate the empirical formula of **X**

[4 marks]

(b) Calculate the Molar Mass of **Y** from the reaction with potassium dichromate

[3 marks]

(c) Draw possible structures of **X** and **Y**

[2 marks]

(d) Draw and name the original Ester.

[2 marks]

3. Chromium plating is often used to improve the appearance and corrosion protection of metallic objects. Inert electrodes are used to electrolyse an acidified solution of sodium dichromate and the equations involved are as follows:

Cathode: $Cr_2O_7^{2-}{}_{(aq)} + 14H^+{}_{(aq)} + 12e^- \longrightarrow 2Cr_{(s)} + 7H_2O_{(l)}$

Anode: $2H_2O_{(l)} \longrightarrow O_{2(g)} + 4H^+{}_{(aq)} + 4e^-$

Overall: $Cr_2O_7^{2-}{}_{(aq)} + 2H^+{}_{(aq)} \longrightarrow 2Cr_{(s)} + H_2O_{(l)} + 3O_{2(g)}$

Because chromium metal is not used as the anode, chromium salts have to be added periodically to the electrolytic cell.

A steel object is made the cathode, and a current of 2.50 Amps is passed through a tank containing 5.00 L of 1.00 mol L^{-1} sodium dichromate. The original pH of the solution is 2.00.

(a) For how many minutes will the current need to flow to deposit 2.50 g of chromium metal on the steel object?

[4 marks]

(b) What would be the pH of the solution after this time.(assume volume is maintained at 5.00 Litres)

[4 marks]

(c) What mass of solid sodium dichromate would be needed to be added to the solution to replace the used dichromate ions?

[3 marks]

(d) Suggest a reason why chromium is not used as the anode in the process.

[1 marks]

4. A sample of hydrated iron(II) sulfate $FeSO_4.xH_2O$ was analysed to calculate the value of x.

A solution of potassium permanganate was standardised by reacting it with 0.200 mol L^{-1} oxalic acid ($H_2C_2O_4$). 29.07 mL of the oxalic acid reacted with 22.15 mL of the potassium permanganate.

13.45 g of the hydrated solid was dissolved in approximately 40 mL of distilled water and the solution made up to 250 mL. 20 mL samples of this solution where titrated against the standardised potassium permanganate solution and 7.37 mL was required for complete reaction.

The relevant half equations are:

$$H_2C_2O_{4(aq)} \longrightarrow CO_{2(g)} + 2H^+_{(aq)} + 2e^-$$

$$MnO_4^-{}_{(aq)} + 8H^+_{(aq)} + 5e^- \longrightarrow Mn^{2+}_{(aq)} + 4H_2O_{(l)}$$

$$Fe^{2+}_{(aq)} \longrightarrow Fe^{3+}_{(aq)} + e^-$$

(a) Write equation for the standardisation reaction and calculate the concentration of the standardised potassium permanganate solution.

[4 marks]

(b) Write equation for the titration reaction and calculate the number of moles of Fe^{2+} ions in the original solid sample.

[4 marks]

(c) Calculate the value of *x*.

[4 marks]

5. Standard unleaded petrol has an Octane Number of 92 which means it burns in a similar way to a test sample of 92% (by mass) 2,2,4-trimethylpentane (C_8H_{18}) and 8% heptane (C_7H_{16}).

45.0g of this test sample was completely combusted in 130 L oxygen at 25°C and 100 kPa. The equations for the combustion's are as follows:

$$2C_8H_{18(l)} + 25O_{2(g)} \longrightarrow 16CO_{2(g)} + 18H_2O_{(g)}$$

$$C_7H_{16(l)} + 11O_{2(g)} \longrightarrow 7CO_{2(g)} + 8H_2O_{(g)}$$

(a) Calculate the masses of each compound in the test sample.

[1 mark]

(b) Calculate the volume of oxygen (at **S.T.P.**) remaining after the complete combustion.

[5 marks]

END OF PART 3

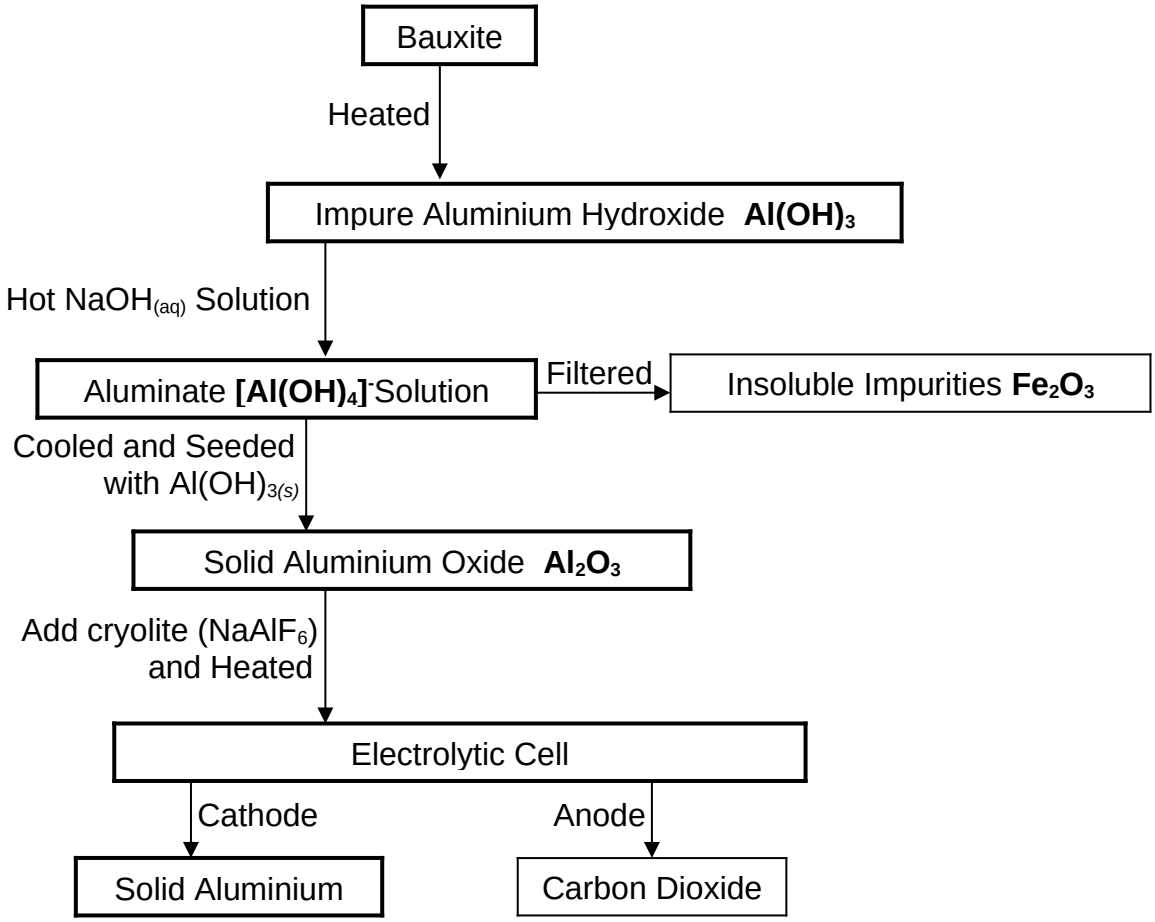
PART 4 (20 marks = 10% of paper)

Answer ONE of the following extended answer questions. Where applicable use equations, diagrams and illustrative examples of the chemistry you are describing.

Marks are awarded principally for the relevant chemical content of your answer, and also for coherence and clarity of expression. Your answer should be presented in about 1½ to 2 pages on the lined paper after the questions.

EITHER:

1. The following is an outline of the production of Aluminium from Bauxite.



Using one example from this process and one example of your choice, explain the meaning of each of the following terms. Discuss clearly how the concepts are used both in the production of Aluminium and in your chosen example.

(a) Amphoteric Nature
(b) Complex Ion
(c) Precipitation
(d) Electrolytic Reduction

OR:

2. The following is a summary of the Production of Nitric Acid.

Production of Nitric Acid

The first stage produces nitric acid which has concentrations ranging from 30% to 70%. This is then converted into high-strength nitric acid that contains more than 90 % nitric acid.

1. Ammonia Oxidation

A 1:9 ammonia/air mixture is oxidised at a temperature of 1380 °C to 1470 °C as it passes through a catalytic convertor, according to the following reaction:

$$4NH_{3(g)} + 5O_{2(g)} \rightleftharpoons 4NO_{(g)} + 6H_2O_{(g)}$$

The most commonly used catalyst is made of 90% platinum and 10% rhodium gauze constructed from squares of fine wire. Under these conditions the oxidation of ammonia to nitric oxide (NO) proceeds in an exothermic reaction with a range of 93-98% yield. Higher catalyst temperatures increase NO production.

2. Nitric Oxide Oxidation

The nitric oxide formed during the ammonia oxidation must be oxidised. The gases are cooled to 100 °C or less at pressures up to 8 atm. The nitric oxide reacts non-catalytically with residual oxygen to form nitrogen dioxide (NO_2)

$$2NO_{(g)} + O_{2(g)} \rightleftharpoons 2NO_{2(g)}$$

This slow, homogeneous reaction is highly temperature and pressure dependent. Operating at low temperatures and high pressures promotes maximum production of NO_2 within a minimum reaction time.

3. Absorption

An exothermic reaction occurs between NO_2 and steam as follows:

$$3NO_{2(g)} + H_2O_{(g)} \rightleftharpoons 2HNO_{3(g)} + NO_{(g)}$$

A secondary air stream is introduced into the column to re-oxidise the NO that is formed in the Reaction. This secondary air also removes NO from the product acid. The acid concentration can vary from 30% to 70% nitric acid.

4. High-Strength Nitric Acid Production

Concentrated nitric acid can be obtained by concentrating the weak nitric acid using extractive distillation. Normal distillation cannot be used due to strong intermolecular attractions between Nitric Acid and Water. The distillation must be carried out in the presence of a dehydrating agent. Concentrated sulfuric acid is most commonly used for this purpose. Concentrated nitric acid leaves the top of the column as 99% vapour which is then condensed.

Explain the Chemistry behind the design of the process at each stage. You can use the concepts of Stoichiometry, Rate of Reaction, Dynamic Equilibrium and Intermolecular Bonding. Include how the process maximises the final yield of Nitric Acid.

END OF QUESTIONS

SEE NEXT PAGE

SEE NEXT PAGE

END OF EXAM