Chemistry 12 Trial Exam 1
Final

Semester 2 Examination,

Question/Answer Booklet

CHEMISTRY

NAME: _____

CLASS: _____

Time allowed for this paper

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

Material required/recommended for this paper

To be provided by the supervisor

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

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

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 PAPER

Part	Number of questions available	Number of questions to be attempted	Suggested working time	Marks available
1 Multiple Choice	30	ALL	55	60 (30%)
2 Short Answers	9	ALL	60	70 (35%)
3 Calculations	5	ALL	45	50 (25%)
4 Extended Answers	2	1	20	20 (10%)
			Total marks	**200 (100%**

Instructions to candidates

2. Answer the questions according to the following instructions:

   Part 1 Answer **all** questions, using 2B, B or HB pencil, on the separate Multiple Choice Answer Sheet. Do **not** use a ballpoint or ink pen.

   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.

   Part 2, 3 and 4 Write your answers in the space provided in this Question/Answer Booklet. A blue or black ball point or ink pen should be used.

   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.

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

4. **Chemical equations**
   For full marks, chemical equations should refer only to those species consumed in the reaction and new species produced. These species may be **ions** [for example $Ag^{+}_{(aq)}$], **molecules** [for example $NH_{3(g)}$, $NH_{3(aq)}$, $CH_3COOH_{(\ell)}$, $CH_3COOH_{(aq)}$] or **solids** [for example $BaSO_{4(s)}$, $Cu_{(s)}$ $Na_2CO_{3(s)}$].

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PART 1

Answer ALL questions in Part 1 on the Separate Multiple Choice Answer Sheet provided.
This part is worth 60 marks, 2 marks per question.

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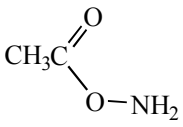
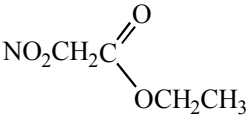
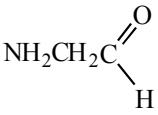
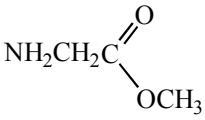
1. Which formula represents a compound which is both an amine and an ester?

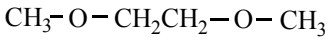
(a) 

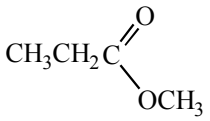
(b) 

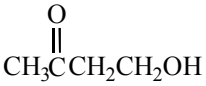
(c) 

(d) 

2. Which of the 3 compounds are structural isomers of ethyl ethonoate?

1. 

2. 

3. 

(a) 2 and 3 only
(b) 1 and 2 only.
(c) 1 and 3 only.
(d) 2 only.

3. Which one of the following is a possible product of the oxidation of $CH_3CH_2CHOHCH_3$?

(a) $CH_3CH_2\overset{\overset{O^-}{|}}{C}HCH_3$

(b) $CH_3CH_2\overset{\overset{O}{\|}}{C}CH_3$

(c) CH_3CH_2COOH

(d) $CH_3CH_2COOCH_3$

4. The activated complex formed during a reaction

(a) has lower energy than the products.
(b) involves bonds to the catalyst in a catalysed reaction.
(c) only forms if the reaction is exothermic.
(d) when formed always decomposes to products.

5. Which one of the following processes is exothermic?

(a) $Li_{(g)} \rightarrow Li^+_{(g)} + e^-$
(b) $H_{2(g)} \rightarrow 2H_{(g)}$
(c) $H_2O_{(\ell)} \rightarrow H_2O_{(s)}$
(d) $NaC\ell_{(s)} \rightarrow Na^+_{(\ell)} + C\ell^-_{(\ell)}$

6. Which one of the following statements correctly describes the situation in a reaction mixture that has achieved chemical equilibrium?

(a) the concentrations of reactants and products are equal.
(b) all chemical reactions have stopped as all reactants have been converted to products.
(c) the speed of reactant particles and product particles are equal.
(d) reactant species are being formed at the same rate as they are being used up.

7. Consider the following reaction at equilibrium

$$2CO_{(g)} + O_{2(g)} \leftrightarrows 2CO_{2(g)} \quad \Delta H = -566 \text{ kJ mol}^{-1}$$

Which one of the following changes will increase the concentration of $CO_{2(g)}$ when the equilibrium is re-established?

(a) increasing the temperature at constant pressure
(b) increasing the pressure at constant temperature
(c) decreasing the concentration of $O_{2(g)}$ at constant temperature and pressure
(d) adding a catalyst for the reaction $2CO_{(g)} + O_{2(g)} \rightarrow 2CO_{2(g)}$

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8. Which one of the following reagents, when mixed with solid ammonium chloride and heated will produce large quantities of ammonia?

   (a) a solution of barium hydroxide
   (b) dilute sulfuric acid
   (c) a solution containing ammonium dichromate and dilute hydrochloric acid
   (d) water

9. In an experiment a student reacted 1.00 g of each of the following carbonates with excess dilute hydrochloric acid and collected the gas at 20 ^{o}C and 101 kPa in each case. Which carbonate produced the greatest volume of gas?

   (a) Na_2CO_3
   (b) K_2CO_3
   (c) $MgCO_3$
   (d) $CaCO_3$

10. An element A has a valence electron configuration of s^2p^1 and element B has a valence electron configuration of s^2p^4. Which of the following is the most likely formula of a compound formed between A and B?

   (a) AB_3
   (b) A_2B_3
   (c) A_3B_2
   (d) AB

11. For the elements across the third row of the periodic table, going from left to right, the trends in the atomic radius and the metallic character is best described by which one of the following?

   (a) Atomic radius decreases and metallic character increases
   (b) Atomic radius decreases and metallic character decreases
   (c) Atomic radius increases and metallic character increases
   (d) Atomic radius increases and metallic character decreases

12. Which underlined element has the highest oxidation state?

   (a) $K_2Cr_2\underline{O}_4$
   (b) $\underline{N}I_3$
   (c) $K_2\underline{C}O_3$
   (d) $\underline{Cr}^{3+}$

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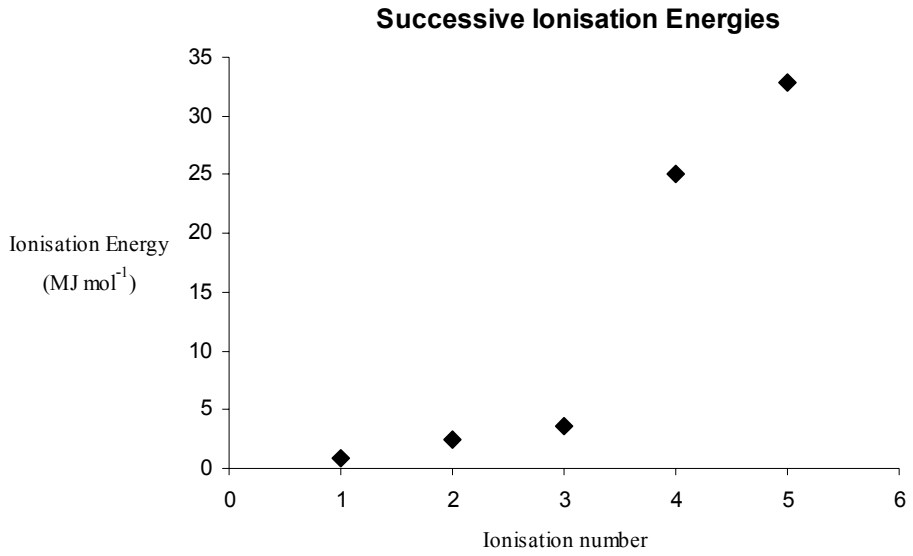
13. An element has the first five successive ionisation energies as shown on the graph.



Which one of the following is it?

(a) Calcium
(b) Carbon
(c) Nitrogen
(d) Boron

Questions 14 and 15 refer the following experiment. An electric current is passed through an electrolysis cell containing a mixture of NaCℓ, KBr and $NiSO_4$. All solutions were present at a concentration of 1 mol L^{-1} and the electrodes were both made from carbon.

14. Which one of the following elements is produced at the cathode?

(a) $Ni_{(s)}$
(b) $H_{2(g)}$
(c) $K_{(s)}$
(d) $O_{2(g)}$

15. Which one of the following elements is produced at the anode?

(a) $Br_{2(aq)}$
(b) $C\ell_{2(g)}$
(c) $Ni_{(s)}$
(d) $O_{2(g)}$

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16. An electrochemical cell is set up using two standard half cells based on the reaction

$$2Fe^{3+}_{(aq)} + Co_{(s)} \rightarrow 2Fe^{2+}_{(aq)} + Co^{2+}_{(aq)}$$

The cell potential for this cell is

(a) 1.21 V
(b) 1.05 V
(c) 0.49 V
(d) 0.33 V

17. The concentration of hydrogen peroxide solution can be found by titrating with a standardised solution of potassium permanganate. In such an experiment 20 mL of 2.00 mol L^{-1} sulfuric acid is added to 20.00 mL of a diluted solution of hydrogen peroxide in a 250 mL conical flask. Potassium permanganate solution is added from a burette until the first permanent pink colour remains in the conical flask. Which one of the following will cause an error?

(a) rinsing the burette with distilled water then with a little of the permanganate solution then filling it with the permanganate solution
(b) rinsing the pipette with distilled water then with a little of the hydrogen peroxide solution then using it to measure out the 20.00 mL of hydrogen peroxide solution
(c) rinsing the conical flask with distilled water then with a little of the hydrogen peroxide solution before adding the 20.00 mL of hydrogen peroxide and sulfuric acid solution
(d) washing down the sides of the conical flask with distilled water from time to time during the titration

18. What is the maximum number of unpaired electrons in any of the elements in the 4th row of the periodic table?

(a) 3
(b) 5
(c) 6
(d) 10

19. Which one of the following is the correct formula for the complex ion formed from one Copper(II) ion and six chloride ions?

(a) $[CuC\ell_6]^{4-}$
(b) $[CuC\ell_6]^{2-}$
(c) $[CuC\ell_6]^{2+}$
(d) $[CuC\ell_6]^{4+}$

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20. Which of the following are properties of transition elements?

    1. they often form coloured compounds
    2. they often form complex ions
    3. they are all oxidising agents
    4. they are all good electrical conductors
    5. they are all amphoteric

    (a) 1, 2 and 3 only
    (b) 1, 2 and 4 only
    (c) 1, 2, 3 and 4 only
    (d) 1, 2, 4 and 5 only

21. In which one of the following are only ionic bonds broken during the process of melting?

    (a) $H_2O_{(s)}$
    (b) $CsC\ell_{(s)}$
    (c) $OC\ell_{2(s)}$
    (d) $SiC_{(s)}$

22. In which one of the following substances is dipole - dipole attraction the main intermolecular force?

    (a) Beryllium dichloride
    (b) Nitrogen trichloride
    (c) Carbon tetrachloride
    (d) Boron trichloride

23. A gardener needs a fertiliser solution containing ions that will supply nitrogen, phosphorous and potassium to his vegetables. Which one of the following mixtures of solids will completely dissolve to give the require solution?

    (a) $KC\ell$ $Ca(NO_3)_2$ Na_3PO_4
    (b) K_2CO_3 K_3PO_4 $Ba(NO_3)_2$
    (c) NH_4NO_3 Na_3PO_4 $Ca(NO_3)_2$
    (d) $KC\ell$ Na_3PO_4 $(NH_4)_2SO_4$

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24. Which one of the following statements about the trends down group V in the periodic table is true?

    (a) The oxides become more acidic
    (b) The electronegativity decreases
    (c) Metallic character decreases
    (d) The first ionisation energy increases

25. Which of the following reactions are part of the process for the production of aluminium metal from bauxite?

    1. $A\ell_2O_3 + 3CO \rightarrow 2A\ell + 3CO_2$
    2. $A\ell(OH)_4^- \rightarrow A\ell(OH)_3 + OH^-$
    3. $CO_2 + C \rightarrow CO$
    4. $C + 2O^{2-} \rightarrow CO_2 + 4e^-$
    5. $A\ell^{3+} + 3e^- \rightarrow A\ell$

    (a) 1 , 4 and 5 only
    (b) 1 , 2 and 3 only
    (c) 2 , 4 and 5 only
    (d) 1 , 2 , 4 and 5 only

26. Gold is produced by the carbon in pulp process. Which one of the following steps is part of this process?

    (a) oxidation with oxygen, concentration using activated carbon, electrolytic reduction
    (b) oxidation with oxygen, concentration using activated carbon, reduction using carbon
    (c) carbon reduction, dissolving in CN^- solution, precipitating on cathode in an electrolysis cell
    (d) oxidation with CN^-, concentration using activated carbon, electrolysis using an iron cathode

27. Which one of the following can act as a Brønsted-Lowry base but not a Brønsted - Lowry acid?

    (a) HCO_3^-
    (b) H_2SO_4
    (c) HSO_4^-
    (d) SO_4^{2-}

28. Which one of the following statements about a 5.00×10^{-8} mol L^{-1} H^+ is correct?

    (a) The pH is 5.8
    (b) The pH is a little less than 7
    (c) The pH is 7.3
    (d) The pH is 8.5

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29. A student measures the pH of four solutions all with a concentration of 1.0×10^{-2} mol L^{-1}. The table summarises the results.

Solution N^{o}	Solution Content	pH
1	CH_3COOH	3.4
2	H_2SO_4	1.9
3	CH_3COONa	6.5
4	NH_3	10.6

Which experimental result must be incorrect?

(a) Solution 1
(b) Solution 2
(c) Solution 3
(d) Solution 4

30. In volumetric analysis a primary standard is best described as

(a) a solution of known concentration
(b) a solid that can be used to make a solution of known concentration
(c) a solution that has been standardised
(d) a solution that can be used to standardise another solution

END OF PART I

PART 2

Answer ALL questions in Part 2 in the spaces provided below. This part is worth 70 marks (35% of the total).

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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 observe, including any
   * colours
   * odours
   * precipitates (give the colour)
   * gases evolved (give the colour or describe as colourless)

   If a reaction occurs but the change is not visible, you should state this.

   (a) Iron(II) sulfate solution is added to potassium phosphate solution.

   Equation: _____

   Observation: _____

   _____

   [3 marks]

   (b) A piece of silver metal is dropped into concentrated nitric acid.

   Equation: _____

   Observation: _____

   _____

   [3 marks]

   (c) Chlorine gas is bubbled through a solution of sodium iodide.

   Equation: _____

   Observation: _____

   _____

   [3 marks]

   (d) A dilute solution of potassium dichromate is added to a mixture of methanal and dilute sulfuric acid.

   Equation: _____

   Observation: _____

   _____

   [3 marks]

2. For each species listed in the table below

   (a) draw the structural formula, including all valence electron pairs represented as ⁚ .

   For example water 

   (b) Draw the shape of each species

   (c) indicate the polarity of each species. Write 'nonpolar' or 'polar'

Species	**Structural formula (Showing all valence electrons)**	**Draw shape (include all atoms)**	**Polarity (non Polar or Polar)**
Iodate ion IO_3^-			
Metasilicate ion SiO_3^{2-}			
Selenium disulfide SeS_2			

[12 marks]

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3. Write the name and formula of an example of each of the following.

Description	Name	Formula
A metal that will react with a dilute acid and a dilute base		
A molecular compound that dissolves in water to form a weak acid.		
A monomer, containing 3 carbon atoms, used to prepare an addition polymer.		
A molecule that can become a ligand in a complex ion.		
A covalent network substance that conducts electricity in the solid state.		
A molecule containing 4 carbon atoms that reacts with a bromine solution resulting in a colourless solution.		
A non metallic element that exhibits in its compounds oxidation states that include -2 and +6		

[14 marks]

4. Some powdered magnesium is sprinkled into fluorine gas.

(a) Write the equation for the reaction

[1 mark]

(b) Would you expect this reaction to be slow or fast? Clearly explain your answer.

[3 marks]

5. A student carried out a reaction between a 1.00 mol L^{-1} sodium hydroxide solution and a 1.00 mol L^{-1} hydrochloric acid solution. The only observation made was that there was a small increase in temperature in the reaction vessel.

   (a) Write an equation for this reaction and indicate whether it is exothermic or endothermic by writing "Heat" as either a reactant or product.

   [2 marks]

   (b) The equilibrium constant for water is usually quoted for a temperature of 25 ^{o}C. Explain why stating a temperature is important?

   [1 mark]

   (c) Would you expect the pH of pure water at 80 ^{o}C to be equal to, greater than or less than 7.00 ? Explain how you arrived at your answer.

   [3 marks]

6. Aqueous solutions of salts can be acidic, basic or neutral. For each of the following

(a) Write the name or formula of the salt.
(b) Write an equation to show how the solution becomes acidic or basic.

Solution	**Name or formula of salt**	**Equation**
Produces an acidic solution		
Produces a basic solution		

[6 marks]

7. Write the equilibrium constant expression for each of the following.

Equation	$Zn_{(s)} + 2NH_4^+{}_{(aq)} + 2MnO_{2(s)} \leftrightarrows Zn^{2+}{}_{(aq)} + Mn_2O_{3(s)} + H_2O_{(\ell)} + 2NH_{3(aq)}$
Equilibrium constant expression	

Equation	$2SO_{2(g)} + O_{2(g)} \leftrightarrows 2SO_{3(g)}$
Equilibrium constant expression	

[4 marks]

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8. Describe one chemical test you could use to distinguish between the following pairs of substances. You must describe the test and what you observe happening to each substance.

Substances	**Describe the Test**	**Observation for Magnesium nitrate solution**	**Observation for Zinc nitrate Solution**
Magnesium nitrate solution and Zinc nitrate solution			

[3 marks]

Substances	**Describe the Test**	**Observation for methyl-2-propanol**	**Observation for 1-propanol**
methyl-2-propanol and 1-propanol			

[3 marks]

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9. Consider the equilibrium

$$\text{Energy} + \underset{\text{YELLOW}}{[Fe(H_2O)_6]^{3+}(aq)} + 6CN^-(aq) \leftrightarrows \underset{\text{RED}}{[Fe(CN)_6]^{3-}(aq)} + 6H_2O(\ell)$$

An equilibrium mixture is produced by dissolving iron(III) sulfate in water then adding a concentrated solution of sodium cyanide until the solution colour is orange, that is a mixture of yellow and red. The solution is divided into three parts and placed into 3 separate test tubes. Each test tube was treated as described in the table.

(a) Write the observation for each treatment.

(b) Write an explanation in terms of changes in reaction rates for each observation [A statement such as 'no change' or 'nc' , 'favours forward reaction' or '$\rightarrow$' or 'favours reverse reaction' or '$\leftarrow$' is not a sufficient explanation].

Test tube	**Experiment**	**Observation**	**Explanation**
1	A little concentrated sodium cyanide solution is added		
2	The solution is warmed		
3	A little water is added		

[6 marks]

END OF PART 2

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PART 3

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 equations 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. This part carries 50 marks (25% of the total).

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1. Commercial lithium ion cells have a positive electrode made from cobalt(IV) oxide in which lithium is trapped as lithium metal, $CoO_2.Li$. The negative electrode is made from highly crystallised graphite containing lithium ions, C.Li. The electrolyte is a highly polar organic solvent into which the lithium ions easily dissolve, so allowing lithium ions to move away from the electrode where they are produced. These cells are rechargeable.

   During charging, the electrode reactions can be represented by

   $$CoO_2.Li \rightarrow CoO_2 + Li^+ + e^-$$
   and $$C + Li^+ + e^- \rightarrow C.Li$$

   The cell can maintain a maximum discharge current of 133 mA for 2.00 hours at a voltage of 3.70 V

   (a) (i) Write an equation for the process that occurs at the anode during discharge.

   (ii) Write an equation for the process that occurs at the cathode during discharge.

   (iii) Write an equation for the overall process that occurs in the cell as it is being used to operate a mobile phone.

   [3 marks]

   (b) Calculate the change in mass of lithium metal in the positive electrode during a period of 45.0 minutes while the cell is operating at its maximum discharge current. Indicate whether this is an increase or decrease in mass of lithium metal.

   [5 marks]

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2. Many compounds of gold are unstable. One exception seems to be gold(III) oxide, Au_2O_3. It is however a powerful oxidising agent. If powdered Au_2O_3 is shaken with hydrogen iodide gas, HI, gold(I) iodide, AuI, and iodine are formed. The reaction proceeds according to the following unbalanced equation.

$$Au_2O_{3(s)} + HI_{(g)} \rightarrow AuI_{(s)} + I_{2(s)} + H_2O_{(\ell)}$$

In an experiment to investigate the properties of gold(I) iodide, a research assistant shook 25.7 g of gold(III) oxide with 4.92 L of hydrogen iodide gas in a rigid, sealed container at 45.0 ^{o}C and 116 kPa until the reaction was completed.

(a) Balance the equation.

[1 mark]

(b) Calculate the mass of each of the 5 substances (reactants and products) in the reaction vessel after the completion of the reaction.

[9 marks]

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3. An analytical chemist received a sample of cassiterite which contains mostly tin(IV) oxide, the rest being quartz, SiO_2.

   He analysed the sample using the following procedure.

   The sample was crushed then ground to a powder. 2.562 g of the powdered sample was mixed with 2 mol L^{-1} sulfuric acid and heated to 90 ^oC for two hours. The resulting mixture was filtered then mixed with excess pure zinc powder to ensure all the tin(IV) ions were reduced to tin(II) ions.

   The resulting solution was then made up to 250.0 mL in a volumetric flask.

   20.00 mL samples of the diluted solution were mixed with 20 mL of 2 mol L^{-1} sulfuric acid in a conical flask then titrated with a standardised solution of potassium permanganate of concentration 0.0192 mol L^{-1}.

   The results he obtained are record in the table.

	Rough trial	**Trial 1**	**Trial 2**	**Trial 3**	**Trial 4**
1st reading (mL)	1.35	25.53	2.04	25.90	1.78
2nd reading (mL)	25.53	48.98	25.90	49.42	25.34
Amount used (mL)					

   (a) Write the equation for the reaction of the powdered cassiterite and sulfuric acid.
   [1 mark]

   (b) Write an equation for the reaction that occurs in the conical flask during the titration.
   [2 marks]

   (c) Calculate the percentage by mass of tin in the cassiterite sample.
   [6 marks]

SEE NEXT PAGE

4. An organic compound used in the manufacture of complex experimental pesticides contains carbon, hydrogen, nitrogen and sulfur only.

   A 3.127 g sample of the compound was burnt completely in excess pure oxygen. At 100 ^{o}C all the products were gases and had a total mass of 12.56 g. Analysis of the gaseous mixture indicated that there were 5 gases present. They were identified as water, carbon dioxide, nitrogen dioxide, sulfur dioxide and oxygen.

   The gas mixture was passed through silica gel which absorbs water. The mass of the remaining gases was found to be 11.518 g. These remaining gases were then cooled in an ice bath. The nitrogen dioxide condensed to a liquid and was removed. The mass of the remaining gases was 10.454 g.

   The sulfur dioxide was converted to sulfate ion by shaking the remaining gas mixture with chlorine water. Excess barium chloride solution was then added. The resulting precipitate of barium sulfate was filtered, dried and found to have a mass of 5.398 g.

   (a) Determine the empirical formula.

   [7 marks]

   (b) Another 2.372 g sample of the compound was vaporised and found to have a volume of 415.5 mL at 103.6 kPa and 22.0 ^{o}C. Calculate the molecular mass and determine the molecular formula of the compound.

   [3 marks]

   (c) Further tests indicate that this is an aromatic compound containing a benzene ring. Draw a possible structure for this compound.

   [1 mark]

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5. Titanium(IV) oxide, TiO_2, is used extensively as a pigment in paints, paper and plastics. Before it can be used, however, it must be extracted from its ore and purified.

In the chloride process, synthetic rutile (impure titanium(IV) oxide) is refined in a 2 step process at temperatures of around 950 ^oC. A major impurity in synthetic rutile is iron(II) oxide.

Step 1: Chlorination

In the chlorinator powdered carbon is burnt in oxygen to produce carbon monoxide which then reacts with powdered titanium(IV) oxide and chlorine to produce titanium tetrachloride, $TiC\ell_4$

$$2C_{(s)} + O_{2(g)} \rightarrow 2CO_{(g)}$$

$$TiO_{2(s)} + 2CO_{(g)} + 2C\ell_{2(g)} \rightarrow TiC\ell_{4(g)} + 2CO_{2(g)}$$

The iron(II) oxide present in the synthetic rutile also reacts with the carbon monoxide and chlorine to produce iron(II) chloride, $FeC\ell_2$

$$FeO_{(s)} + CO_{(g)} + C\ell_{2(g)} \rightarrow FeC\ell_{2(s)} + CO_{2(g)}$$

Step 2: Oxidation

In the oxidiser, toluene, $C_6H_5CH_3$ is burnt in oxygen to produce heat and the titanium tetrachloride reacts with oxygen to produced titanium(IV) oxide and chlorine. The chlorine produced is recycled and used again in the chlorinator (Step I)

$$C_6H_5CH_{3(g)} + 9O_{2(g)} \rightarrow 7CO_{2(g)} + 4H_2O_{(g)} + \text{Heat}$$

$$TiC\ell_{4(g)} + O_{2(g)} \rightarrow TiO_{2(s)} + 2C\ell_{2(g)}$$

Water produced from the burning of toluene also reacts with the titanium tetrachloride to produce hydrogen chloride and titanium(IV) oxide.

$$TiC\ell_{4(g)} + 2H_2O_{(g)} \rightarrow TiO_{2(s)} + 4HC\ell_{(g)}$$

Because of the reaction between chlorine and iron(II) oxide in Step 1 and some chlorine ending up as hydrogen chloride in Step 2, some chlorine is lost because both $FeC\ell_2$ and $HC\ell$ are waste products and are discarded.

(a) Calculate the total mass of chlorine converted to $FeC\ell_2$ and $HC\ell$ for each tonne (1000 kg) of synthetic rutile refined if the percentage by mass of FeO in synthetic rutile is 5.00%. To refine 1.00 tonne of synthetic rutile 35.0 kg of toluene is burnt.

[7 marks]

(b) What percentage of chlorine used in the process is lost, that is, ends up in the waste products $FeC\ell_2$ and $HC\ell$?

[5 marks]

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PART 4

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 for the relevant chemical content of your answer, but you will lose marks if what you write is unclear or lacks coherence. Your answer should be presented in about 1½ - 2 pages, and should be written in the space beginning on page 29
This part carries 20 marks (10% of the total).

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1. Ocean going fishing vessels are often made from iron. They operate in an environment that is ideal for accelerated corrosion. In its construction, equipment such as fittings winches and motors need to be bolted to the vessel. This equipment is often made from alloys such as stainless steel and brass that contain metals such as nickel, chromium and copper.

   (a) Clearly outline details of how the process of corrosion occurs on the iron fishing vessel and indicate, giving reasons, where corrosion is likely to be most severe.

   (b) Discuss what manufacturers of these fishing vessels could do to reduce the amount of corrosion during the operation of the vessel and in each case explain how corrosion would be reduced.

OR

2. Concentrated 12.0 mol L^{-1} hydrochloric acid has a hydrogen ion concentration of 12.0 mol L^{-1} where as 12.0 mol L^{-1} phosphoric acid has a hydrogen ion concentration of around 0.008 mol L^{-1}. This difference in hydrogen ion concentration accounts for some of the differences in their chemical properties and hence the uses to which these acids are put. Some uses are similar, for example both acids are used to remove rust from the surface of iron. Hydrochloric acid is used to remove rust from iron in preparation for galvanising and phosphoric acid is used to remove rust from iron prior to painting. If the iron treated with hydrochloric acid, washed with water and left in air even for a short time it rapidly turns brown where as if iron treated with phosphoric acid is left in air there is no appearance of any brown material on its surface, but after about a day when it dries, a dark coloured coating becomes apparent.

   A second example of where hydrochloric acid is used extensively is to remove hardened mortar from bricks. Hardened mortar consists of sand stuck together mostly by crystals of calcium and magnesium hydroxides and some calcium and magnesium carbonates. The cleaning process involves application of concentrated hydrochloric acid, then washing it off with water.

   Phosphoric acid cannot be used for removing hardened mortar from bricks.

   (a) Explain fully why the hydrogen ion concentration of the acids is different even though the concentration of both acids is 12.0 mol L^{-1}.

   (b) Fully discuss the chemistry involved in the two examples of the uses of these acids described above. Your discussion should include an explanation of the similarities and differences in the chemistry for each acid when used to remove rust, and an explanation of why hydrochloric acid can be used and phosphoric acid cannot be used to remove hardened mortar.

END OF QUESTIONS

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