Chemistry 12 Trial Exam 2
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 (minutes)	Marks available
1 Multiple Choice	30	ALL	55	60 (30%)
2 Short Answers	11	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 (60 marks)

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. An element X forms 3 compounds with bromine with formulae XBr_2, XBr_5 and XBr_6. Which one of the following is X?

   (a) C
   (b) Ba
   (c) W
   (d) Rb

2. Which of the following elements has the highest first ionisation energy?

   (a) C
   (b) N
   (c) Aℓ
   (d) Ca

3. Which of the following is the electron configuration of $A\ell^{3+}$?

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

4. Which one of the following ions does not have the electron configuration $1s^2\ 2s^2\ 2p^6$?

   (a) Mg^{2+}
   (b) N^{3-}
   (c) K^+
   (d) F^-

5. The maximum number of electrons that can occupy a 4p energy level is?

   (a) 2
   (b) 6
   (c) 10
   (d) 14

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6. As you move down the elements of group VII of the periodic table, the first ionisation energy

   (a) decreases and their reactivity decreases
   (b) decreases and their reactivity increases
   (c) increases and their reactivity decreases
   (d) increases and their reactivity increases

7. When compared to group 1 metals, transition elements in the same period as the group 1 metal tend to

   (a) have a higher melting temperature and a larger atomic radius
   (b) be harder and have a smaller atomic radius
   (c) be more easily oxidised and display a variety of oxidation states
   (d) have lower ionisation energy and more likely to form complex ions

8. Which one of the following groups contains only oxides that would form a basic solution when mixed with water?

   (a) NO_2, SO_2, $C\ell_2O$
   (b) MgO, $C\ell_2O$, $A\ell_2O_3$
   (c) MgO, CaO, Na_2O
   (d) NO_2, Na_2O, CaO

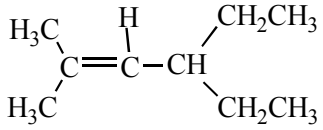
9. An element reacts vigorously with hydrogen to form a molecular substance that is a weak acid and displays hydrogen bonding in the liquid form. The likely identity of the element is

   (a) carbon
   (b) chlorine
   (c) fluorine
   (d) sulfur

10. Which one of the following statements about group 1 elements is true?

   (a) The first ionisation energy increases as the atomic mass increases.
   (b) They become more reactive as the number of electrons they contain increases.
   (c) They all form acidic oxides.
   (d) They all react with chlorine to form molecular substances.

11. What is the correct name for the substance with the structural formula?



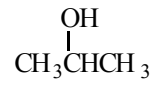
(a) 1,1-dimethyl-3,3-diethyl-1-propene
(b) 1,1-diethyl-3,3-dimethyl-2-propene
(c) 4-ethyl-2-methyl-2-hexene
(d) 3-ethyl-5-methyl-4-hexene

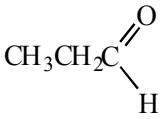
12. Which one of the following compounds can form geometric isomers, that is cis/trans isomers?

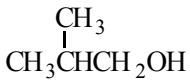
(a) propene
(b) 2-butene
(c) 2-methyl-2-butene
(d) 1-pentene

13. Which formula represents a substance that **cannot** be oxidised to a carboxylic acid?

(a) $CH_3CH_2CH_2OH$

(b) 

(c) 

(d) 

14. The value of the equilibrium constant for the reaction

$2NO_{2(g)} \leftrightarrows N_2O_{4(g)} \quad \Delta H = -57 \text{ kJ mol}^{-1}$

(a) will increase with increasing temperature
(b) will decrease with increasing temperature
(c) will remain the same for any temperature change
(d) will only change if the pressure of the system is changed

15. Hydrogenation is a process used to convert unsaturated hydrocarbons into saturated ones by reaction with hydrogen in the presence of a palladium catalyst at moderate temperature. An example of such a reaction is shown. The reaction is exothermic.

$CH_3CH{=}CH_{2(g)} + H_{2(g)} \leftrightarrows CH_3CH_2CH_{3(g)}$
Propene propane

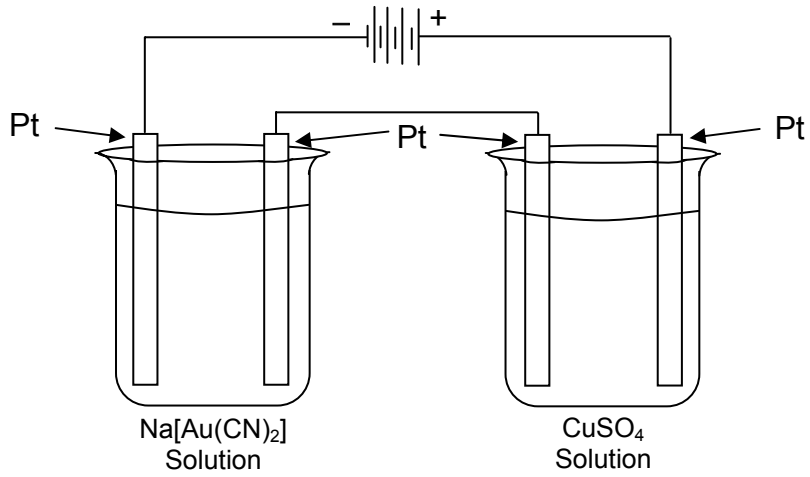
What happens if the temperature is increased from 150 ºC to 250 ºC?

(a) The equilibrium concentration of propane increases.
(b) The equilibrium concentration of hydrogen decreases.
(c) The equilibrium concentrations of all the reactants and product remains unchanged because the rate of the forward and reverse reactions both increase.
(d) The equilibrium concentration of propane decreases.

16. Consider the compounds $A\ell PO_3$, P_2O_5, PH_3, P_2H_4. In which one of the following compounds does phosphorous have the highest oxidation number?

(a) $A\ell PO_3$
(b) P_2O_5
(c) PH_3
(d) P_2H_4

17. A quantity of electricity is passed through the two solutions as shown

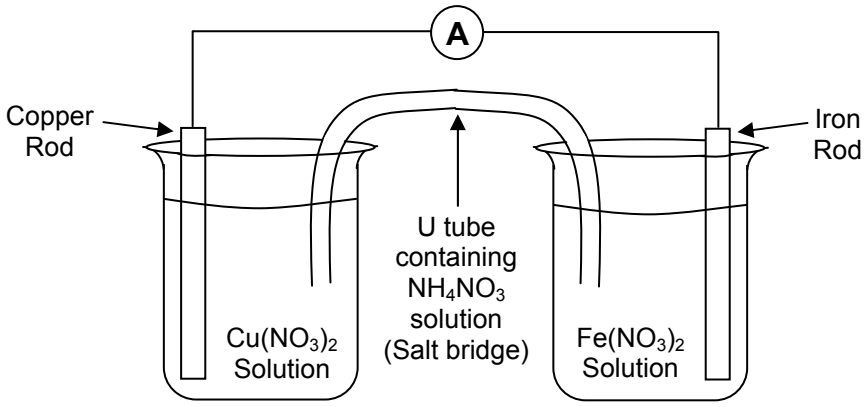


What is the ratio of the number of moles of gold deposited to the number of moles of copper deposited, that is n(Au) : n(Cu)?

(a) 1:1
(b) 1:2
(c) 2:1
(d) 2:3

Question 18 and 19 are both about the following experiment.

Materials and equipment were arranged as in the diagram



18. When the metal electrodes are connected with a metallic conductor, the salt bridge

    (a) enables current to flow between the two half cells by allowing electrons to pass through the salt bridge.

    (b) provides ammonium and nitrate ions to each half cell to maintain a constant pH in each half cell.

    (c) enables current to flow between the two half cells by allowing ions to pass through the salt bridge.

    (d) provides ammonium and nitrate ions for the electrode reactions in each half cell.

19. When the copper and iron rods are connected with a metallic conductor the ammeter indicates that an electric current passes through the conductor. The iron rod will have

    (a) a positive charge on it and the reaction occurring at the iron will be $Fe^{2+} + 2e^- \rightarrow Fe$

    (b) a positive charge on it and the reaction occurring at the iron will be $Fe \rightarrow Fe^{2+} + 2e^-$

    (c) a negative charge on it and the reaction occurring at the iron will be $Fe^{2+} + 2e^- \rightarrow Fe$

    (d) a negative charge on it and the reaction occurring at the iron will be $Fe \rightarrow Fe^{2+} + 2e^-$

20. The following reaction involves chlorine dioxide, $C\ell O_2$.

    $2C\ell O_{2(aq)} + 2OH^-_{(aq)} \rightarrow C\ell O_2^-{}_{(aq)} + C\ell O_3^-{}_{(aq)} + H_2O_{(\ell)}$

    Which one of the following statements is **true** about chlorine dioxide?

    (a) It is acting only as an acid

    (b) It is acting only as a base

    (c) It is acting only as a reducing agent

    (d) It is acting as a reducing agent and as an oxidising agent

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21. Using the standard reduction potential tables predict which one of the following reactions will possibly occur spontaneously.

    (a) $2Cr^{3+} + 3Ni \rightarrow 2Cr + 3Ni^{2+}$

    (b) $2MnO_4^- + 4H_2O + 6Br^- \rightarrow 3Br_2 + 2MnO_2 + 8OH^-$

    (c) $Cr_2O_7^{2-} + 8H^+ + 3C\ell_2 \rightarrow 2Cr^{3+} + 6HC\ell O + H_2O$

    (d) $2H^+ + Sn \rightarrow Sn^{2+} + H_2$

22. When conducting titrations, the pipette is usually washed with the solution being used in it and the conical flask with distilled water. The reason for this is that

    (a) an accurate concentration of the solution must be maintained in both the pipette and the conical flask.

    (b) an accurate number of moles is the only requirement in both the pipette and the conical flask, and accurate concentration is not required in either piece of equipment.

    (c) an accurate concentration must be maintained in the pipette and an accurate number of moles must be maintained in the conical flask.

    (d) an accurate number of moles must be maintained in the pipette and an accurate concentration must be maintained in the conical flask

23. Which one of the following is **false** about a primary standard.

    (a) It must be a pure substance.

    (b) It must be a solution of accurately known concentration.

    (c) It must not react with atmospheric gases.

    (d) It must not release water of crystallisation to the atmosphere

24. Which one of the following is most likely to act as both an acid and a base?

    (a) HS^-

    (b) F^-

    (c) HI

    (d) $C\ell O^-$

25. Which one of the following statements about an acid-base indicator is **false**?

    (a) It is either an acid or a base.

    (b) It must undergo an acid-base reaction.

    (c) It is easily oxidised from one coloured compound to compound of a different colour.

    (d) It has acid-base conjugate forms with different colours.

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26. A student was asked to define a neutral aqueous solution. The four responses given were

A The solution that contains no acidic or basic species

B The solution that contains equal numbers of H^+ and OH^- ions

C The pH of the solution is 7.0

D The concentration of H^+ and OH^- ions is equal

Not all responses were correct. Which combination of statements is always correct?

(a) only A and C

(b) only B and C

(c) only B and D

(d) only C and D

27. The salts $KC\ell$, NH_4NO_3, K_2CO_3, Na_3PO_4, Na_2S and $NaHSO_4$ were dissolved in water. The salts that all produced a basic solution were

(a) NH_4NO_3, $KC\ell$, K_2CO_3

(b) NH_4NO_3, $NaHSO_4$, $KC\ell$

(c) Na_3PO_4, Na_2S, $NaHSO_4$

(d) K_2CO_3, Na_2S, Na_3PO_4

28. Phosphoric acid dissolves in water in any proportion. A large number of species at varying concentration, are found in the resulting solution. Which of the following is the most likely order of increasing concentration of some of the species. The lowest concentration is first and the highest concentration is last

(a) H_3PO_4, H^+, $H_2PO_4^-$, HPO_4^{2-}, PO_4^{3-}

(b) PO_4^{3-}, HPO_4^{2-}, $H_2PO_4^-$, H^+, H_3PO_4

(c) H_3PO_4, $H_2PO_4^-$, HPO_4^-, PO_4^{3-}, H^+

(d) H^+, PO_4^{3-}, HPO_4^{2-}, $H_2PO_4^-$, H_3PO_4

29. Aluminium ore, bauxite, contains mostly $A\ell_2O_3$, Fe_2O_3 and some SiO_2. The reason alumina, pure $A\ell_2O_3$, can be produced by use of hot sodium hydroxide solution is because

(a) $A\ell_2O_3$ is an acid so it dissolves in the sodium hydroxide solution but Fe_2O_3 and SiO_2 do not dissolve.

(b) $A\ell_2O_3$ is a base so it does not dissolve in the sodium hydroxide solution but Fe_2O_3 and SiO_2 both dissolve

(c) $A\ell_2O_3$ is amphoteric so it dissolves in the sodium hydroxide solution but Fe_2O_3 and SiO_2 do not dissolve.

(d) All three substances dissolve in the sodium hydroxide solution but only Fe_2O_3 and SiO_2 precipitate when the solution is cooled.

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30. 25.0 mL of a sodium chloride solution contains 1.26×10^{-3} mol of chloride ions. The concentration of sodium chloride in g L^{-1} is

    (a) 5.04×10^{-2} g L^{-1}
    (b) 1.16 g L^{-1}
    (c) 1.79 g L^{-1}
    (d) 2.95 g L^{-1}

END OF PART I

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PART 2 (70 marks)

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 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) Sodium metal is added to methanol

   Equation: _____

   Observation: _____

   _____

   [3 marks]

   (b) A piece of cobalt metal is added to a solution of copper (II) sulfate

   Equation: _____

   Observation: _____

   _____

   [3 marks]

   (c) Solid sodium sulfite is mixed with a dilute hydrochloric acid solution

   Equation: _____

   Observation: _____

   _____

   [3 marks]

   (d) Iron (III) chloride solution is mixed with sodium sulfide solution

   Equation: _____

   Observation: _____

   _____

   [3 marks]

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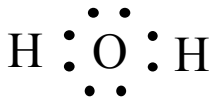
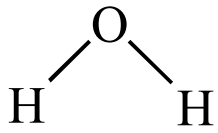
2. For each species listed below draw the structural formula representing all valence electron pairs and draw the shape of the molecule as indicated in the example

Species	Structural formula showing all valence electrons	Draw shape of molecule or ion
Example water H_2O		
silicate ion SiO_3^{2-}		
sulfur dioxide SO_2		
dichloromethane $CH_2C\ell_2$		

[6 marks]

3. Identify by name or formula an example of each of the following

	Description	Name or formula
(a)	A substance used as a solvent for alumina in an electrolytic cell for the production of aluminium.	
(b)	The oxidising agent for gold in the production of the gold cyanide complex from metallic gold.	
(c)	The reducing agent for the iron oxide in the carbon reduction process for the production of iron.	
(d)	A material used to make sacrificial anodes.	
(e)	An element used in the purification of water as a poison for living micro organisms.	
(f)	Mixed with water to make the electrolyte in a lead acid battery	
(g)	A primary standard for an acid base titration.	

[7 marks]

4. Describe a **chemical** test that you could use to distinguish each pair of substances from one another. Describe what you would observe for each of the substances as a result of the test.

Substances	**Describe test**	**Observation for silver nitrate**	**Observation for lead nitrate**
silver nitrate solution and lead nitrate solution			

Substances	**Describe test**	**Observation for sodium sulfide**	**Observation for sodium hydroxide**
solid sodium sulfide and solid sodium hydroxide			

[8 marks]

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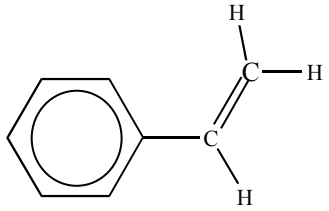
5. A 2.00 mol L^{-1} potassium hydroxide solution is added drop wise to a chromium (III) sulfate solution. Initially a dark green precipitate is produced which then dissolves on further addition of potassium hydroxide solution to produce an intense deep green solution. With the aid of equations explain the observations. You should use at least two equations in your answer.

[6 marks]

6. Draw structural formulas for one ester and one carboxylic acid with the formula $C_3H_6O_2$. Write the IUPAC name for each substance.

[4 marks]

7. (a) Given the monomer below, draw a portion of the polymer that would be produced from it. Your structure should contain a minimum of **three** monomer units.



(b) What type of reaction is involved in this polymerisation process?

_____

(c) Write an equation for a reaction of the same type that may be used to produce ethanol.

_____

[5 marks]

8. The two compounds shown have significantly different melting and boiling points

Compound	**melting point (ºC)**	**Boiling Point (ºC)**
CH_4	–182	–162
$CC\ell_4$	–23	77

With the aid of a diagram describe the type of intermolecular force between these molecules then explain why compound $CC\ell_4$ has the higher melting and boiling points.

[4 marks]

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

Equation	$Ba^{2+}_{(aq)} + S_2O_3^{2-}{}_{(aq)} \leftrightarrows BaS_2O_{3(s)}$
Equilibrium constant expression	
Equation	$4NH_{3(g)} + 5O_{2(g)} \leftrightarrows 6H_2O_{(g)} + 4NO_{(g)}$
Equilibrium constant expression	

[4 marks]

10. The following equilibrium is being studied

$$CO_{(g)} + ZnO_{(s)} \leftrightarrows Zn_{(s)} + CO_{2(g)} \qquad \Delta H \text{ is negative}$$

Some of the equilibrium mixture is placed in each of the three identical sealed containers of fixed volume. After equilibrium has been achieved the changes described in the table were made to the containers. In each case describe what happens to the rate of the forward reaction and what happens to the equilibrium amount of products.

Container	Change made	What happens to the rate of the forward reaction? Write 'increase', 'decrease' or 'no change'	What happens to the equilibrium amount of products? Write 'more products', 'less products' or 'no change'
A	The reaction container is heated.		
B	Some zinc oxide is removed from the container.		
C	A small amount of carbon monoxide is added to the container		

[6 marks]

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11. In the first step of one of the processes used to produce nitric acid, ammonia is heated in air enriched with oxygen. The exothermic reaction may be represented by the equation

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

The reaction is carried out at around 900 ºC and 1 atmosphere pressure in the presence of a catalyst. Explain why these conditions are chosen for this process.

[8 marks]

END OF PART 2

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PART 3 (50 marks)

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.

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1. Some fertilisers are produced by a batch process where the reactants are mixed in stoichiometric quantities so that all of both reactants are used up when the reaction is completed. A research chemist was asked to investigate the production of ammonium sulfate from an ammonia solution of concentration 70.0 g L^{-1} and an 82.0% by mass sulfuric acid solution. The mass of 1.00 L of the 82.0% by mass sulfuric acid solution was found to be 1.59 kg.

   (a) In one experiment the researcher started with 250 mL of the ammonia solution. Calculate the volume of the sulfuric acid solution required to react completely with the ammonia solution.

   [6 marks]

   (b) Calculate the mass of ammonium sulfate produced when the 250 mL of ammonia solution was completely reacted.

   [2 marks]

   (c) Would you expect the solution to be acidic, neutral or basic after the reaction has been completed? Write an equation to justify your answer.

   [2 marks]

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2 A compound extracted from a newly identified bacterium was analysed in order to establish its structure. After purification, analysis showed that it contained only carbon, hydrogen, nitrogen and may also contain oxygen although analysis for this was not carried out. The analysis was conducted as follows.

A 1.573 g sample of the compound was burnt in pure oxygen. The products were passed through cooling coils where the contents were cooled to -10 °C. Ice was formed in the coils which had a mass of 0.7232 g. The remaining products were then passed through a solution of sodium hydroxide where all the carbon dioxide was absorbed. The mass of the solution increased by 3.533 g.

A second sample of the compound of mass 1.363 g was treated so that all the nitrogen was converted to ammonia which was then passed into distilled water where it all dissolved. The solution required 23.67 mL of a 0.4201 mol L^{-1} hydrochloric acid solution for complete neutralisation.

(a) Calculate the empirical formula [6 marks]

(b) To find the structure of the compound further analysis was required. The compound was found to be a monoprotic acid so that when a third sample of the compound of mass 0.01734 g was dissolved in water and titrated with a standardised sodium hydroxide solution of concentration 3.579×10^{-3} mol L^{-1}, it required 35.33 mL of the sodium hydroxide solution to completely neutralised the compound.

Determine the molecular formula. [3 marks]

(c) Further analysis revealed that not only could this compound behave as an acid but it could also behave as a base. It was also found to be aromatic.

Draw a possible structure. [1 mark]

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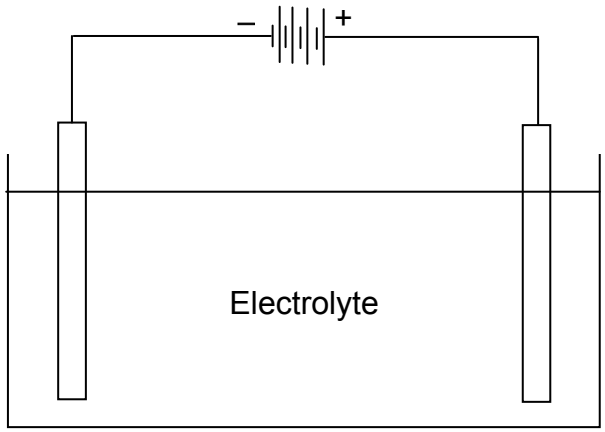
3. Many materials are electroplated with chromium to enhance appearance, reduce corrosion or reduce wear. The electroplating cell can be represented in the diagram.



The electrolyte contains a concentrated solution of chromium (III) sulfate as well as other substances to ensure chromium metal is deposited evenly on the surface of objects. The concentration of the chromium (III) ion remains constant during the electroplating process.

(a) (i) To which electrode, anode or cathode, must the object to be electroplated be attached?

(ii) What is the most likely substance used for the other electrode?

[2 marks]

(b) A large hydraulic piston is electroplated with chromium to stop corrosion and reduce wear. The process takes 20.0 hours to complete at an average current of 3.12 A

(i) Write the half equation for the reactions at the anode and the cathode. Clearly name the electrode where each reaction takes place.

[2 marks]

(ii) Calculate the mass of chromium deposited on the hydraulic piston.

[4 marks]

SEE NEXT PAGE

4. Water for irrigation or for industrial use is often pumped from underground. Occasionally, near areas where the soil contains large amounts of organic matter this water contains significant quantities of arsenic in the form of arsenite ion, AsO_3^{-3}. Before the water is used for irrigation of edible crops, suspect water must be tested to ensure no arsenic is present.

   Analysis of such a water sample was conducted in the following way.

   A 50.0 mL sample of the underground water was measured accurately and placed in a 250 mL volumetric flask. Distilled water was added to the mark. 20.0 mL samples of the dilute water were titrated against standard 2.0732×10^{-5} mol L^{-1} potassium bromate, $KBrO_3$ solution. The results obtained are recorded in the table.

	Rough Trial	Trial 1	Trial 2	Trial 3	Trial 4
Initial reading	1.32	20.16	0.69	19.08	0.02
Final reading	20.16	38.78	19.08	37.86	18.77
volume used					

   The **unbalanced** equation for the reaction that occurs during the titration is

$$BrO_3^- + AsO_3^{3-} \rightarrow Br^- + AsO_4^{3-}$$

   (a) Write balanced half equations and use these to balance the equation for the reaction [3 marks]

   (b) Calculate the concentration of the **arsenite ion** in the underground water expressed in mol L^{-1} [6 marks]

   (c) Calculate the concentration of the **arsenic** in the underground water expressed in parts per million, ppm. The density of the underground water is 1.00 g mL^{-1} [3 marks]

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5. Extraction of nickel from its ore involves a number of chemical processes. Some of those are described in the following.

Many nickel ores contain nickel sulfide. After the ore is crushed and concentrated it is smelted using a process that involves heating the nickel sulfide concentrate in air. This converts some of the nickel sulphide to nickel metal producing a nickel concentrate called nickel matte. The process can be represented by the equation

$$NiS_{(s)} + O_{2(g)} \rightarrow SO_{2(g)} + Ni_{(s)}$$

The nickel matte contains a mixture of NiS, nickel metal and other impurities that don't contain nickel. Pure metal is produced by a refining process that makes use of nickel's ability to form a soluble complex ion with ammonia. In the process the crude nickel matte is dissolved in a solution of ammonia through which oxygen is bubbled. The nickel ammonia complex is formed according to the equations

$$NiS_{(s)} + 2O_{2(g)} + 6NH_{3(aq)} \rightarrow [Ni(NH_3)_6]^{2+}_{(aq)} + SO_4^{2-}{}_{(aq)}$$

and

$$2Ni_{(s)} + O_{2(g)} + 12NH_{3(aq)} + 2H_2O_{(\ell)} \rightarrow 2[Ni(NH_3)_6]^{2+}_{(aq)} + 4OH^-{}_{(aq)}$$

Insoluble impurities are filtered off and soluble impurities are precipitated then filtered off. The pure nickel metal is produced from the solution by reduction of the nickel-ammonia complex at pressures of about 30.0 atmospheres. This process can be represented by the equation

$$[Ni(NH_3)_6]^{2+}_{(aq)} + 3H_{2(g)} \rightarrow Ni_{(s)} + 6NH_4^+{}_{(aq)}$$

Ammonium sulfate which can be used as a fertiliser is a by-product.

(a) (i) If 1.00 tonne of nickel matte requires 877 kL of hydrogen measured at 105 kPa and 28.0 ºC to extract all the nickel, calculate the percentage nickel in the nickel matte. 1.00 tonne = 1.00×10^6 g.

[4 marks]

(ii) When the nickel metal was removed in the reduction process, the remaining solution was concentrated and cooled causing 771 kg of ammonium sulfate to precipitate. This represented 85.0% of the ammonium sulfate in the solution. Calculate the percentage by mass of nickel sulfide in the nickel matte.

[4 marks]

(b) In the smelting process to produce the nickel matte, sulfur dioxide is produced only from the reduction of nickel sulfide. Calculate the mass of sulfur dioxide produced for each 1.00 tonne of nickel matte produced.

[2 marks]

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END OF PART 3

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PART 4 (20 marks)

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. Begin your answer on the lined page following the end of the questions.

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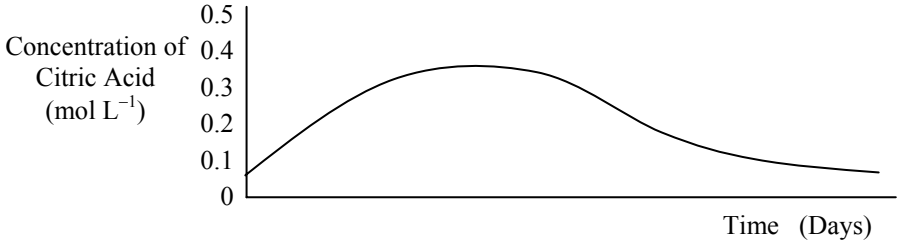
1. Citrus fruits such as oranges contain citric acid, a triprotic acid. The amount of citric acid in the fruit changes as the fruit grows and ripens. A researcher was interested in investigating how the amount of citric acid in oranges changes during the ripening process. He designed an experiment that produced the results in the graph.



Describe a possible experiment the researcher could have used to obtain the results he used to plot the graph. Your answer should explain in detail how the concentration of citric acid was determined. It should include the names and concentration, where appropriate of substances used, details of equipment used and samples of calculations employed.

OR

2. Ethanol can be used as a fuel by burning it in air to produce heat for cooking, heating and heating water. It can also be used as a fuel to operate an internal combustion engine to provide transport, operate machinery and produce electricity. In addition, ethanol may be used as a fuel in a fuel cell which produces electricity as a result of an electrochemical process giving a cell voltage of 1.15 V
The maximum amount of energy available from the combustion of ethanol or from the electrochemical process is 1370 kJ mol^{-1}
Smaller amounts of energy per mole can be obtained from oxidation of ethanol by aqueous oxidising agents such as dichromate ion. This could be the subject of future research.

   (a) Discuss clearly why ethanol can be used as a fuel to produce heat and electricity. Your discussion should include an explanation in terms of the energy changes that occur as reactants proceed to products.

   (b) Describe in detail the chemical process that results in heat being produced by burning ethanol in air and in an internal combustion engine and compare this process with the production of electricity using ethanol in a fuel cell with an acidic electrolyte. The arrangement of components and the chemistry of the fuel cell must be described in detail.

   (c) Design an alternative electrochemical cell using ethanol and an aqueous oxidising agent and give details of the chemistry involved in its operation

END OF QUESTIONS

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