CHEMISTRY

Please place your student identification label in this box

STUDENT NUMBER -   In figures

In words

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 (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

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 THE 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	3	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

Use a 2B, B or HB pencil to answer 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.

Parts 2, 3 and 4

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

At the end of the examination make sure that your Student Number is on your Question/Answer Booklet and on your separate Multiple Choice Answer Sheet.

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 $BaSO_4(s)$, $Cu(s)$, $Na_2CO_3(s)$].

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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.

1. Which one of the following atoms in its ground state has the greatest number of valence electrons?

   (a) $A\ell$

   (b) P

   (c) S

   (d) Si

2. Two atoms, X and Y, have valence shell electron configurations of s^2p^4 and s^2. Which of the following would be the expected nature of a compound formed between X and Y?

   (a) covalent network

   (b) covalent molecular

   (c) ionic

   (d) molecular gas

3. Which one of the following structural features is common to both diamond and graphite?

   (a) covalent bonds between carbon atoms

   (b) delocalised electrons

   (c) dipole/dipole interactions

   (d) each carbon atom is bonded to four other carbon atoms

4. Which one of the following does **not** consist of planar molecules?

   (a) benzene

   (b) boron trichloride

   (c) methanal

   (d) propene

SEE NEXT PAGE

5.   When potassium chlorate ($KC\ell O_3$) is heated at its melting point, it disproportionates into potassium perchlorate ($KC\ell O_4$), potassium chloride and oxygen. How many moles of $KC\ell O_4$ be produced from 1.0 mole of $KC\ell O_3$?

   (a)   0.50

   (b)   0.75

   (c)   0.80

   (d)   1.0

6.   A 0.0250 mole sample of a chloride of an element Z was dissolved in dilute nitric acid and the solution made up to 500 mL with distilled water. 12.5 mL of this solution was required to react with 25.00 mL of 0.100 mol L^{-1} $AgNO_3$ solution. What is the likely formula of the chloride?

   (a) $Z_2C\ell$

   (b) $ZC\ell$

   (c) $ZC\ell_2$

   (d) $ZC\ell_4$

7.   Which one of the following best explains why solid copper conducts electricity?

   (a)   Copper(II) ions move to the cathode when a current is passed.

   (b)   The crystal lattice breaks down on applying a potential difference.

   (c)   The atoms of copper become ionised when a current is passed.

   (d)   The bonding electrons in the crystal lattice move when a potential difference is applied.

8.   Which one of the following alloys can be cleaned using sodium hydroxide solution, without either of the component metals dissolving?

   (a)   aluminium and copper

   (b)   aluminium and zinc

   (c)   copper and magnesium

   (d)   magnesium and zinc

SEE NEXT PAGE

9.   A certain element has the following first four ionisation energies (in MJ mol^{-1})

$$0.58 \quad 1.8 \quad 2.7 \quad 12$$

Which one of the following could this element be?

     (a)   Aℓ

     (b)   Cℓ

     (c)   Mg

     (d)   P

10.   A solid has a melting point of 1440°C. The solid conducts heat and electricity. It does not dissolve in water or cyclohexane. Which one of the following describes the bonding between the atoms in the solid?

     (a)   both covalent and dipole/dipole

     (b)   covalent

     (c)   ionic

     (d)   metallic

11.   A small increase in temperature can produce a relatively large increase in the rate of a chemical reaction. Which one of the following statements best explains this?

     (a)   At a higher temperature there is a large increase in the proportion of reactant particles with sufficient energy to form the activated complex.

     (b)   The activation energy for a reaction gets lower as the temperature gets higher.

     (c)   The extra energy orients the molecules for a reaction.

     (d)   The increase in temperature strengthens the bonds in the products so that it is easier for the new compound to form.

12. Which one of the following statements about the salt bridge in an electrochemical cell is correct?

    (a) Any soluble ionic compound can be used because its solution will be an electrical conductor.

    (b) A salt is chosen whose component ions are not readily oxidised or reduced.

    (c) Compounds containing highly charged positive ions such as Al^{3+} are not used because the highly charged ions tend to prevent electrons from flowing freely.

    (d) Salt bridges are made dilute so that anions and cations can move through them without excessive resistance.

13. The reaction of coal with steam in a vessel at constant volume produces a mixture of hydrogen and carbon monoxide gases.

    $$C_{(graphite)} + H_2O_{(g)} \rightarrow H_{2(g)} + CO_{(g)} \qquad \Delta H = +131 \text{ kJ mol}^{-1}$$
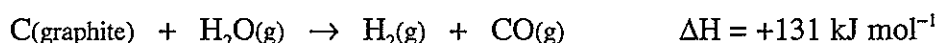
    Which one of the following changes would slow down the **rate** of reaction?

    (a) decreasing the pressure of the steam

    (b) grinding up the coal

    (c) injecting CO gas into the reaction vessel

    (d) raising the temperature of the steam

14. Ethyne can be converted into ethanal according to the following equation:

    $$C_2H_{2(g)} + H_2O_{(g)} \rightarrow CH_3CHO_{(g)} \qquad \Delta H = +128 \text{ kJ mol}^{-1}$$

    Which one of the following changes would increase the **yield** of ethanal?

    (a) adding a catalyst

    (b) increasing the pressure of the steam

    (c) increasing the volume

    (d) lowering the temperature

15. Which of the following best describes the equivalence point in an acid-base titration?

    (a) the point at which chemical equilibrium is reached and no further reaction will occur

    (b) the point at which equal moles of reactants have been mixed

    (c) the point at which the indicator changes colour

    (d) the point at which the stoichiometric amount of reactant has been added

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16.   Which one of the following correctly arranges 0.1 mol L^{-1} solutions of the substances in order of increasing pH (more basic)?

(a)   NaOH CH_3COOH NH_3 $HC\ell$

(b) CH_3COOH $HC\ell$ NaOH NH_3

(c) $HC\ell$ CH_3COOH NH_3 NaOH

(d) $HC\ell$ NH_3 CH_3COOH NaOH

17.   A series of four $HC\ell$ solutions with different concentrations was prepared, and tested with the indicator Methyl Yellow. The results are set out below.

pH	Colour with Methyl Yellow
1	red
2	red
3	orange
4	yellow

On the basis of the above experiment, what can you conclude about the pH of two unknown solutions which, when tested with Methyl Yellow, gave the following results?

Unknown solution	Colour with Methyl Yellow
A	red
B	yellow

(a)   The pH of A is between 1 and 2, and the pH of B is 4.

(b)   The pH of A is between 1 and 2, and the pH of B is 4 or more.

(c)   The pH of A is 1 or 2, and the pH of B is 4.

(d)   The pH of A is 2 or less, and the pH of B is 4 or more.

18.   Which one of the following species is the strongest reducing agent?

(a)   Ar

(b) Ca^{2+}

(c) $C\ell^-$

(d) K^+

19.   In which one of the following species does chlorine exhibit the highest oxidation number?

   (a) $C\ell_2$

   (b) $C\ell_2O$

   (c) $HC\ell O_3$

   (d) $PC\ell_3$

20.   Which of the following will most readily cause a warm solution containing both potassium dichromate and sulfuric acid to change colour?

   (a) CH_3CH_2OH

   (b) CH_3COOH

   (c) $CH_3COCH_2CH_3$

   (d) $(CH_3)_3OH$

21.   During electrolysis, which of the following would affect the mass of an element formed?

           I   The current used

           II   The time during which electrolysis takes place

           III   The charge on the ion of the element being deposited

   (a)   I and II only

   (b)   II and III only

   (c)   III only

   (d)   All of I, II and III

22.   When 5 moles of electrons are passed through a molten aluminium salt what is the maximum mass of aluminium formed at the cathode?

   (a)   5.4 g

   (b)   27 g

   (c)   45 g

   (d)   81 g

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23.   For complete oxidation to carbon dioxide and water, 1 mole of an organic compound requires 3 moles of oxygen gas. Which one of the following could the compound be?

   (a)   acetic acid (ethanoic acid)

   (b)   ethanal

   (c)   ethane

   (d)   ethanol

24.   Which one of the following gases readily decolourises bromine water?

   (a)   carbon dioxide

   (b)   ethane

   (c)   ethene

   (d)   hydrogen chloride

25.   Which one of the following structures will exhibit geometrical (*cis-trans*) isomerism?

   (a) $CH_3CBr=CCl_2$

   (b) $CH_2=CH-CH_2-CH=CH_2$

   (c) $CH_2=C(CH_3)_2$

   (d) $C_6H_5CH=CHCOOH$

26.   How many esters are there with the molecular formula $C_4H_8O_2$?

   (a)   1

   (b)   2

   (c)   3

   (d)   4

SEE NEXT PAGE

27. Which of the following statements about ethene, C_2H_4, are correct?

      I   It undergoes substitution reactions rather than addition reactions.

      II   It can form a polymer.

(a) I only

(b) II only

(c) Both I and II

(d) Neither I nor II

28. A small amount of an alcohol RCH_2OH is shaken with an excess of a warm solution containing both sodium dichromate and sulfuric acid until reaction ceases. Which functional group is present in the product?

(a) $-CO-C-$

(b) $-CO-H$

(c) $-CO-O-H$

(d) $-CO-O-C$

29. In the electrolytic reduction of alumina to aluminium by the Hall-Heroult process, what is the purpose of mixing cryolite (Na_3AlF_6) with the alumina?

(a) It allows a molten phase to be maintained at a lower temperature.

(b) It lowers the solubility of aluminium metal.

(c) The cryolite contains aluminium in a more active form.

(d) The fluoride ion catalyses the process.

SEE NEXT PAGE

30. Although aluminium is a strong reducing agent and is situated near the bottom of the Standard Reduction Potential table, aluminium does not corrode appreciably under normal conditions. Which of the following statements best explains why this is so?

    (a)   Aluminium contains delocalised electrons in its lattice structure.

    (b)   Aluminium forms a thin protective coating of aluminium oxide.

    (c)   Aluminium is an amphoteric metal.

    (d)   Aluminium is usually alloyed with other metals to prevent corrosion.

END OF PART 1

PART 2   (70 marks = 35% of paper)

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

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) Lead(II) nitrate solution is added to rubidium iodide solution.

Equation_____

Observation_____

_____

[3 marks]

(b) Ammonium nitrate solution is warmed with sodium hydroxide solution.

Equation_____

Observation_____

_____

[3 marks]

(c) Aluminium hydroxide is shaken with sodium hydroxide solution.

Equation_____

Observation_____

_____

[3 marks]

(d) Potassium carbonate is added to an excess of dilute sulfuric acid.

Equation_____

Observation_____

_____

[3 marks]

SEE NEXT PAGE

2.   The electron configuration of a lithium atom is $1s^2\,2s^1$. Using the same notation, give the electron configuration of

(a)   an aluminium ion $A\ell^{3+}$ _____

(b)   a magnesium atom   Mg _____

<div align="right">[2 marks]</div>

3.   For each species listed in the table below
(a)   draw the structural formula,
      representing **all** valence shell electron pairs either as : or as —

[for example, water   H : Ö : H   or   H—Ö—H   or   H—Ö—H   and so on]

(b)   indicate the shape of each species by either a sketch or a name

Species	Structural formula (showing all valence shell electrons)	Shape (sketch or name)
carbon disulfide, CS_2		
phosphorus trichloride, $PC\ell_3$		
azide ion, [NNN]⁻ (or N_3^-)		

<div align="right">[6 marks]</div>

SEE NEXT PAGE

4. Consider 0.1 mol L^{-1} solutions of

- sodium hydroxide
- ammonium chloride
- sulfuric acid, and
- acetic acid (ethanoic acid).

(a) Which solution would have the lowest electrical conductivity? Explain your answer.

(b) Which solution would have the highest pH? Explain your answer.

(c) Which solution would have the highest concentration of ions? Explain your answer.

[6 marks]

5. Distilled water, which has been exposed to air, has a pH of about 5. When it is boiled and then cooled, the pH has changed to 7. The pH of the distilled water prepared in this way then slowly falls back to about 5. Explain with the aid of equations the role of carbon dioxide in these observations.

[3 marks]

SEE NEXT PAGE

6.   For each of the following pairs, describe a chemical test that will distinguish between the two substances. State the distinguishing observations; if there is no visible reaction write "nvr". If there is a chemical reaction, write the equation.

		What you would do	What you would observe	Chemical equation (where there is one)
$AgNO_3$ solution and $NaNO_3$ solution			with $AgNO_3$ solution	with $AgNO_3$ solution
			with $NaNO_3$ solution	with $NaNO_3$ solution
Ar gas and CO_2 gas			with Ar	with Ar
			with CO_2	with CO_2

[10 marks]

SEE NEXT PAGE

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

Description	Name or Formula
A positively charged complex ion	
The main commercial component of bauxite	
An organic compound which reacts with a solution containing sodium dichromate and sulfuric acid to give a ketone	
An amine with two carbon atoms	
The active ingredient in lime water	
An ion which can undergo a disproportionation reaction	
A gas which forms a basic solution in water	
A primary standard suitable for a redox titration	

[8 marks]

8.   A solution containing potassium permanganate and sulfuric acid is warmed with methanol: the purple colour in the solution disappears, and colourless odourless carbon dioxide gas bubbles off. Write the equation for the reaction that has occurred.

Oxidation half-equation

Reduction half-equation

Redox equation

[5 marks]

SEE NEXT PAGE

9.   In the table, draw the structural formulae of all isomeric alcohols of molecular formula $C_4H_{10}O$. Name each alcohol, and identify each as primary (1°), secondary (2°) or tertiary (3°). You may not need all the rows in the table.

Structure	Name	1°, 2°, or 3°

[10 marks]

SEE NEXT PAGE

10. Here is a diagram of an electrochemical cell at 25°C.
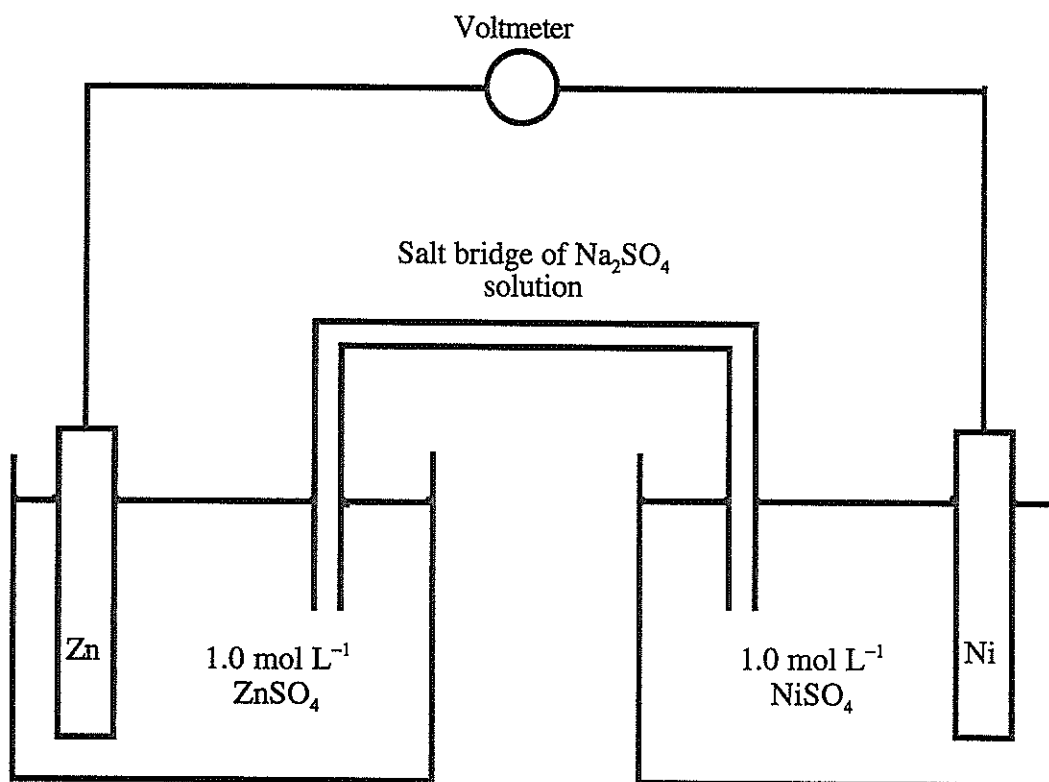
(a) Write the half-equation for the reaction occurring at the cathode.

_____

[2 marks]

(b) Draw an arrow on the diagram to illustrate the flow of electrons in the external circuit.

[1 mark]

(c) What is the reading on the voltmeter?

_____

[2 marks]

SEE NEXT PAGE

11. Arrange the following compounds (all of similar molecular weight) in order of decreasing boiling point. In the table write "1" for the compound with the highest boiling point, down to "5" for the compound with the lowest boiling point.

Compound	Boiling points in order (1 = highest, 5 = lowest)
$CH_3CH_2CH_2CH_2CH_2CH_3$	
$CH_3CH_2CH_2COOH$	
$CH_3CH_2CH_2CH_2(CH_3)_2$	
$CH_3CH_2CH_2CH_2CH_2OH$	
$CH_3CH_2CH_2CH_2CHO$	

[3 marks]

END OF PART 2

SEE NEXT PAGE

PART 3   (50 marks = 25% of 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 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.   An unknown organic compound 'A' melts sharply at 53°C and is therefore assumed to be pure. At 1.00 atm 'A' decomposes above 100°C before it boils.   Its empirical formula is determined to be CH_2O.

(a)   When 0.0033 g of 'A' is vaporised on a steam bath at 100°C and 0.0026 atm it occupies 460 mL. Calculate the molecular weight of 'A'. Show your working.

[5 marks]

(b)   It is difficult to measure gas volumes accurately at such high temperatures and very low pressures. Nevertheless the inaccurate value you calculate for a molecular weight still enables you to establish the molecular formula. What is the molecular formula for 'A'?

[2 marks]

(c)   When 'A' is dissolved in water the solution is quite acidic. Therefore 'A' must be a carboxylic acid. When the solution is titrated with sodium hydroxide solution the titration curve of this solution shows that 'A' is a monoprotic acid. When 1 mole of 'A' is treated with excess sodium, 1 mole of H_2 is produced. Besides the carboxylic acid, what other functional group is present in 'A'?

[1 mark]

(d)   Draw one of the two possible structural formulae for 'A'.

[1 mark]

SEE NEXT PAGE

2.   A concentrated solution of sodium chloride, when electrolysed, will produce hydrogen
      and chlorine gases according to the following half-equations:

$$2\,C\ell^- \rightarrow C\ell_2 + 2\,e^-$$

$$2\,H_2O + 2\,e^- \rightarrow 2\,OH^- + H_2$$

A pilot model is built to test the design of a new commercial production plant for
chlorine which uses inert electrodes. The model must produce 5.00×10^2 L of chlorine
gas at 10°C and 1.00 atm during 24.0 hours of operation. The electrolysis vat contains
1.00×10^3 L of the $NaC\ell$ solution.

CALCULATIONS ASSUMING 100% EFFICIENCY OF THE PROCESS

(a)   How many moles of chlorine gas are produced in the 24.0 hours?

[2 marks]

(b)   Calculate the current.

[3 marks]

(c)   Assume there is no appreciable change in the volume of the solution during the
       electrolysis, and so calculate the concentration of the hydroxide ion in the
       solution at the end of the 24.0 hours.

[2 marks]

(d)   The solution is recycled. What volume of hydrogen chloride gas at 25°C and
       1.00 atm should be passed into the mixture to restore the original $NaC\ell$
       concentration?

[3 marks]

CALCULATION INCORPORATING INEFFICIENCY

(e)   Like many electrolysis processes this is not 100% efficient, and at the anode
       10% of the current produces oxygen.

$$2\,H_2O \rightarrow O_2 + 4\,H^+ + 4\,e^-$$

Calculate the current actually needed to achieve the required amount of chlorine.

[2 marks]

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SEE NEXT PAGE

3.   Quicklime [CaO] deteriorates on standing in air by absorbing water vapour to give calcium hydroxide [Ca(OH)$_2$], and carbon dioxide to give calcium carbonate [CaCO$_3$]. The absorption of these gases can be analysed by the technique of "thermogravimetry". In this form of analysis, a sample is placed on a balance in a chamber in which the temperature is made to rise steadily, and the mass is monitored.

At 330°C calcium hydroxide loses water to give calcium oxide; calcium carbonate is stable until 530°C when it decomposes to give calcium oxide and carbon dioxide.

A 52.7 mg sample of Builder's Quicklime was analysed by thermogravimetry. At 400°C the mass had fallen to 48.5 mg, and at 600°C the mass had fallen again until steady at 45.3 mg.

(a)   (i)   Write an equation for the decomposition of calcium hydroxide to give calcium oxide and water.

       (ii)   Write an equation for the decomposition of calcium carbonate to give calcium oxide and carbon dioxide.

                                                                        [2 marks]

(b)   (i)   Calculate the percentage by mass of the original pure quicklime which had absorbed water to give calcium hydroxide

       (ii)   Calculate the percentage by mass of the original pure quicklime which had absorbed carbon dioxide to give calcium carbonate.

                                                                        [6 marks]

[Since the final mass was 45.3 mg, the mass of CaO before it absorbed H$_2$O and CO$_2$ must have been 45.3 mg.]

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4.   Sodium sulfite (Na_2SO_3) can be used as a preservative in hamburgers. In an experiment to determine the amount of Na_2SO_3 in a sample of hamburger, the following steps were followed.

Step 1:   1.00 kg of minced meat was boiled with an excess of dilute sulfuric acid.

$$Na_2SO_3 + 2H^+ \rightarrow SO_2 + H_2O + 2Na^+$$

Step 2:   The sulfur dioxide gas released was completely absorbed in an excess of sodium hydroxide solution.

$$SO_2 + 2OH^- \rightarrow SO_3^{2-} + H_2O$$

Step 3:   The resulting solution was acidified with excess dilute sulfuric acid and titrated with 0.02023 mol L^{-1} potassium permanganate. 30.08 mL of the potassium permanganate solution were required to reach the end-point.

$$5SO_3^{2-} + 2MnO_4^- + 6H^+ \rightarrow 5SO_4^{2-} + 2Mn^{2+} + 3H_2O$$

(a)   How many moles of SO_3^{2-} are required to react completely with 1 mole of MnO_4^-?

[2 marks]

(b)   Calculate the number of moles of Na_2SO_3 present in 1.00 kg of hamburger meat.

[5 marks]

(c)   Government chemists often express the amount of Na_2SO_3 in meats as parts per million (ppm) [1 ppm = 1 mg Na_2SO_3 in 1 kg of meat]. Express the amount of Na_2SO_3 in the 1.00 kg meat sample in parts per million.

[2 marks]

(d)   In step 1, why must the dilute sulfuric acid be in excess?

[1 mark]

(e)   In step 3, what colour change in the reaction vessel would you observe at the end-point?

[1 mark]

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**SEE NEXT PAGE**

5.   In a method for volumetric determination of sulfate ion, the SO_4^{2-} ion is precipitated as $PbSO_4$ by the addition of Pb^{2+}. The $PbSO_4$ is then analysed for Pb and the number of moles of SO_4^{2-} ion is equal to the number of moles of Pb^{2+} in the precipitate.

The amount of lead is determined by titration using a compound symbolised as H_4Y. [This compound is actually called 1,2-diaminoethane-N,N,N′,N′-tetraethanoic acid.]

A known amount of H_4Y is added to the precipitate, bringing it into solution.

$$PbSO_4(s) \;+\; H_4Y \;\rightarrow\; PbY^{2-}(aq) \;+\; SO_4^{2-} \;+\; 4\,H^+$$
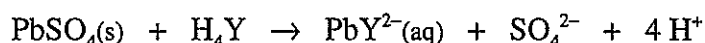
Then the amount of excess H_4Y is determined by titration with standard lead nitrate.

$$Pb^{2+} \;+\; H_4Y \;\rightarrow\; PbY^{2-}(aq) \;+\; 4\,H^+$$
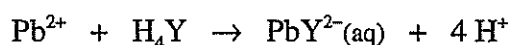
From this, the amount of Pb^{2+} in the $PbSO_4$, and hence the amount of SO_4^{2-} ion in the sample, can be calculated.

The following results were obtained for a sample of ground water analysed as above.

Volume of ground water sample:	10.00 L
Volume of 0.1000 mol L^{-1} H_4Y added to the precipitate:	25.00 mL
Volume of 0.1000 mol L^{-1} $Pb(NO_3)_2$ required to titrate excess H_4Y:	8.26 mL

(a)   Calculate the total number of moles of H_4Y added to the precipitate.

[2 marks]

(b)   Calculate the number of moles of H_4Y in excess.

[2 marks]

(c)   Calculate the number of moles of H_4Y that combined with the $PbSO_4$.

[2 marks]

(d)   Calculate the concentration of the SO_4^{2-} ion in the ground water.

[3 marks]

(e)   Suggest a source of sulfate in the groundwater resulting from agricultural activity.

[1 mark]

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END OF PART 3

SEE NEXT PAGE

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 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 $1^1/_2$ - 2 pages. Begin your essay on the next page.

1.   Explain and distinguish between the Arrhenius and Lowry-Brønsted models of acid-base behaviour. In your discussion refer to the behaviour of

- water
- hydrogen chloride
- sodium hydroxide
- a salt that is neutral in water
- a salt that is acidic in water, and
- a salt that is basic in water.

Be careful with your use of the symbols $\rightarrow$ and $\rightleftharpoons$.

OR

2.   Alkanes are sometimes called paraffins. This comes from the Latin "parum affinis" which means "little affinity" and indicates that these hydrocarbons are unreactive. Organic compounds with multiple bonds or functional groups are much more reactive. Discuss with examples.

OR

3.   The Haber process is commonly used as an example of the application of the principles of equilibrium. With reference to **other** examples (industrial or otherwise) discuss the nature and consequence of chemical equilibrium. [In your essay do NOT deal with the Haber Process]

END OF QUESTIONS

SEE NEXT PAGE

END OF PAPER