Year 12

Chemistry 2001

Name: .....

Teacher: .....

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 corrector fluid, ruler

Special Items: Calculators satisfying the conditions set by the Curriculum Council and a 2B 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.

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STRUCTURE OF THE PAPER

Part	Format	No. of questions set	No. of questions to attempt	Marks allocated	Recommended time (approx.) in minutes
1	Multiple choice	30	ALL	60 (30%)	55
2	Short answers	9	ALL	70 (35%)	60
3	Calculations	5	ALL	50 (25%)	45
4	Extended answers	2	1	20 (10%)	20

Total marks for paper = 200 (100%)

INSTRUCTIONS TO CANDIDATES

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

Part 1 : Multiple Choice

Answer **ALL** questions, using a 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.

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 you have written your name 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%)

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. A molecule is linear, non-polar and triatomic.
Which of the following molecules fits the above description?

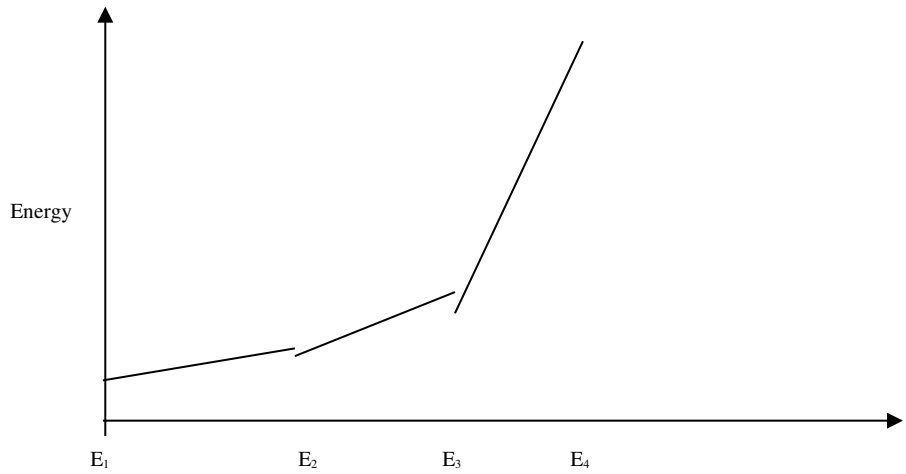
(a) CO_2

(b) HCl

(c) BCl_3

(d) NH_3

2. The pattern of successive ionisation energies E_1, E_2, E_3 and E_4 (in kJ mol $^{-1}$) of element X is shown in the graph below.



Which of the following is the most likely formula for the oxide of element X?

(a) XO

(b) X_2O

(c) X_2O_3

(d) XO_2

SEE NEXT PAGE

3. A white crystalline substance has a melting point of 2000 °C and does not conduct electricity in either the solid or molten phase. Which of the following substances is it most likely to be?

   (a) A covalent network substance

   (b) An ionic substance

   (c) A metallic substance

   (d) A covalent molecular substance

4. A groundwater sample was found to contain 20.0 milligrams (2.00×10^{-2} g) of dissolved iron per litre of solution. Assuming that one litre of the groundwater weighs 1.00 kg, which of the following gives the correct concentration of iron in the sample?

   (a) 2.00 ppm (parts per million)
   (b) 2.00×10^{-2} mol L^{-1}
   (c) 20.0 ppm
   (d) 0.200 g per 100 g

5. Which of the following 1.0 mol L^{-1} solutions when mixed, will produce a coloured precipitate?

   (a) $Ca(NO_3)_2$ (aq) and $Pb(NO_3)_2$(aq)
   (b) K_2CrO_4(aq) and $Pb(NO_3)_2$(aq)
   (c) $Cu(NO_3)_2$(aq) and Na_2SO_4(aq)
   (d) K_2SO_4(aq) and Na_3PO_4(aq)

6. Which of the following lists shows the four substances in the correct <u>ascending</u> order of their boiling points?

   (a) He, CH_3CH_2OH, Cl_2, CH_3OH
   (b) Cl_2, CH_3CH_2OH, He, CH_3OH
   (c) He, Cl_2, CH_3OH, CH_3CH_2OH
   (d) Cl_2, He, CH_3CH_2OH, CH_3OH

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7. It is known that a 1.00 mol L^{-1} solution of the weak acid HBr is exactly 5.00% dissociated into ions. The pH of this solution is nearest to which of the following?

   (a) 0.05

   (b) 1.30

   (c) 2.60

   (d) 5.00

8. In the acid-base titration between 1.00 mol L^{-1} aqueous sodium carbonate solution and 1.00 mol L^{-1} hydrochloric acid solution using methyl orange indicator, which of the following statements is correct?

   (a) The reaction produces carbon dioxide gas.

   (b) The change in pH around the equivalence point is so small that a distinct colour change of the methyl orange indicator is not obtained.

   (c) The end point of this reaction will occur at a pH greater than 7.

   (d) The equivalence point will be reached when equal volumes of the two solutions have been combined.

9. In an investigation, 10.0 mL of carbon monoxide gas is mixed with 10.0 mL of oxygen gas, both volumes being measured at the same temperature and pressure. The gas mixture is then ignited to produce carbon dioxide gas. When the original temperature is restored which of the following is true?

   (a) No excess oxygen gas remains.

   (b) 5.00 ml of excess oxygen gas remains.

   (c) 15.0 mL of carbon dioxide gas is produced.

   (d) A total volume of 20.0 mL of gas mixture is produced.

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10. Which of the following lists the elements in decreasing order of their first ionization energies?

(a) oxygen, sulfur, selenium, tellurium

(b) hydrogen, fluorine, chlorine, bromine

(c) sodium, magnesium, aluminium, phosphorus

(d) krypton, argon, neon, helium

11. Which of the following types of reactions of aluminium is not generally characteristic of most metals ?

(a) $2Al^{3+}(aq) + 3CO_3^{2-}(aq) \rightarrow Al_2(CO_3)_3(s)$
(b) $Al(OH)_3(s) + OH^-(aq) \rightarrow Al(OH)_4^-(aq)$
(c) $Al^{3+}(l) + 3e^- \rightarrow Al(l)$
(d) $2Al(s) + 3Cu^{2+}(aq) \rightarrow 2Al^{3+}(aq) + 3Cu(s)$

12. Which of the following species contains sulfur in its highest oxidation state?

(a) $S_8(s)$
(b) $Na_2S_2O_3(s)$
(c) $H_2SO_4(aq)$
(d) $SO_2(g)$

13. A solution of 1.0 mol L^{-1} potassium sulfate is electrolysed using inert electrodes. Which of the following gives the correct anode reaction?

(a) $SO_4^{2-}(aq) \rightarrow SO_2(g) + O_2(g) + 2e^-$
(b) $e^- + K^+(aq) \rightarrow K(s)$
(c) $H_2SO_3(aq) + H_2O(l) \rightarrow SO_4^{2-}(aq) + 4H^+(aq) + 2e^-$
(d) $2H_2O(l) \rightarrow O_2(g) + 4H^+(aq) + 4e^-$

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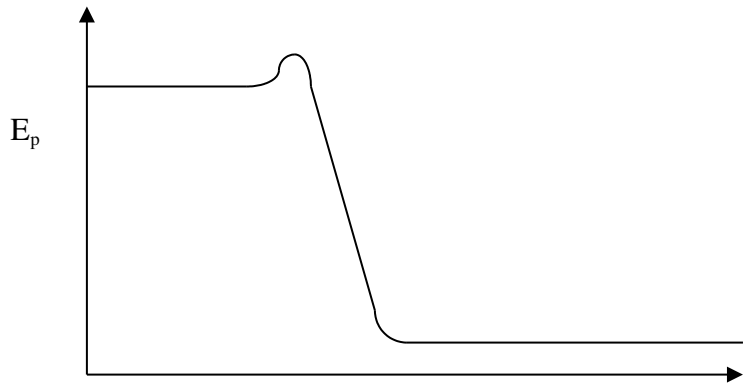
14. An oxidizing agent was able to convert aqueous iron (II) ions to iron (III) ions, but was not able to react with aqueous chloride ions. Which of the following could it have been?

(a) $NO_2(g) + H_2O(l)$
(b) $Br_2(l)$
(c) Acidified potassium permanganate solution
(d) Hot 1.0 mol L^{-1} oxalic acid solution (HOOCCOOH(aq))

15.



A chemist drew the above graph to represent the potential energy profile of a chemical reaction. Which of the following statements is consistent with the above graph?

(a) The reaction is endothermic, and has a relatively small value of ΔH.
(b) The reaction is exothermic with a relatively large activation energy.
(c) The graph represents an energy storing reaction in which molecules of low potential energy are converted into molecules of high potential energy.
(d) The reaction is exothermic with a relatively small activation energy and a relatively high value of ΔH.

16. In which of the following will there be little or no visible reaction?
(a) A clean strip of copper metal is placed into a silver nitrate solution.
(b) Solutions of sodium fluoride and potassium chloride are mixed together.
(c) Bromine water and ethanol are shaken together.
(d) Sodium metal is dropped into a beaker of distilled water.

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17. Which of the following illustrates the redox reaction known as disproportionation?

(a) $2Cu^{+}(aq) \rightarrow Cu^{2+}(aq) + Cu(s)$
(b) $2KClO_3(s) \rightarrow 2KCl(s) + 3O_2(g)$
(c) $2Al(s) + 2OH^{-}(aq) + 6H_2O(l) \rightarrow 2Al(OH)_4^{-}(aq) + 3H_2(g)$
(d) $SO_4^{2-}(aq) + 2H^{+}(aq) + 2e^{-} \rightarrow SO_3^{2-}(aq) + H_2O(l)$

18. On the basis of E^o values from the Standard SRP Table, which of the following 1.0 mol L^{-1} solutions is not stable due to a predicted redox reaction between the dissolved ions?

(a) Mercury(II) chloride
(b) Mercury(I) sulfate
(c) Copper (II) iodide
(d) Iron(III) iodide

19. When a potassium permanganate solution is reduced to solid manganese(IV) oxide, which of the following gives the correct **change** in the oxidation number of the managanese?

(a) -3
(b) -1
(c) 0
(d) +4

20. Which of the following molecules contains exactly one carbon-carbon double bond?

(a) $CH_3CHCHOH$
(b) CH_3CH_2COOH
(c) CH_3CH_2CCH
(d) $CH_2CCHCH_2CH_3$

21. Which of the following names is inconsistent with the IUPAC system of nomenclature?

(a) 1,1,1- trichloro-2-methyl-2-propanol
(b) 1,3-dichloropropanone
(c) 1,2,3 trichloropropane
(d) 1,1-dichloro-1,2- difluoropropanamine

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22. Propanoic acid reacts with 1-butanol in the presence of sulfuric acid catalyst. Which of the following is a correct organic product of the above reaction?

    (a) $CH_3(CH_2)_6SO_4$
    (b) $CH_3CH_2COO(CH_2)_3CH_3$
    (c) $HCOO(CH_2)_5CH_3$
    (d) $CH_3(CH_2)_4COCH_3$

23. The repeating section of a condensation polymer is represented below:

    --$O(CH_2)_3OCOCOO$--

    Which of the following pairs of monomers is most likely to produced the above section of polymer?

    (a) $CH_3(CH_2)_2COOH$ and CH_3CH_2OH
    (b) $HO(CH_2)_3OH$ and HOOCCOOH
    (c) $HO(CH_2)_3OH$ and HOOC(CH2)2COOH
    (d) CH_3COCH_3 and $CH_3(CH_2)_3CO(CH_2)_2CH_3$

24. Which of the following statements about molecules is incorrect?

    (a) A molecule which has polar bonds within it is not necessarily a polar molecule.
    (b) Pairs of electrons in the outer shell of a covalently bonded atom repel as far away as possible.
    (c) The molecules CH_4 and CCl_4 are polar but $CHCl_3$ and CH_3Cl molecules are non-polar.
    (d) Oxygen atoms in molecules generally have two bond pairs of electrons and two lone pairs of electrons.

25. Which of the following statements about the periodic table of the elements is correct?

    (a) The elements are arranged in the table in increasing order of their atomic masses.
    (b) Electronegativity decreases from left to right across the first three rows of the table.
    (c) Elements in the same column of the table have the same total number of electrons.
    (d) Atoms of Group I elements tend to form monopositive (+1) ions by losing one electron.

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26. Which of the following pairs of molecules represent isomers?

(a) butyl pentanoate and methyl octanoate
(b) 2-chloropropane and 1,1-dichloropropane
(c) pentene and pentyne
(d) cyclohexane and hexane

27. Which of the following molecules is least soluble in water?

(a) propanol
(b) propanoic acid
(c) 2-chloropropane
(e) 1,2,3-propanetriol

28. Element X is a transition metal. Which of the following properties of X most specifically identifies it as a transition metal?

(a) X has common oxidation numbers of +3, +6 and +2.
(b) X has a shiny silvery appearance when its surface is freshly cut.
(c) X forms X^{3+} ions and is an amphoteric metal.
(d) X is a good conductor of electricity in both the solid and molten phases.

29. An organic compound has the empirical formula CH_2 and it is found that 10.0 grams of its vapour at STP occupies 5.30 litres. Which of the following is the correct molecular formula of the hydrocarbon?

(a) C_3H_6
(b) C_5H_{10}
(c) C_8H_{16}
(d) $C_{10}H_{20}$

30. Chlorine gas reacts with 2-pentene to produce which of the following?

(a) 2-chloropentene
(b) 2,3-dichloropentane
(c) 2-chloropentane and hydrogen chloride
(e) 2,2-dichloropentyne

END OF PART ONE

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PART 2 (70 marks = 35%)

Answer each of the following questions in the space provided.

1. Give fully balanced equations for the reactions which occur in the following experiments. Use net **ionic equations** where appropriate. In each case describe observations such as colour changes, precipitate formation (give the colour), or gas evolution (give the colour or describe as colourless) resulting from the chemical reaction.

a) An ammonium chloride solution is added to solid calcium hydroxide and gently warmed.

Equation: .....

Observation.....

.....

[3]

b) A small piece of sodium metal is dropped into 2-propanol.

Equation.....

Observation: .....

[3]

c) Excess potassium hydroxide solution is added to dilute chromium(III)chloride solution.

Equation:.....

Observation: .....

.

[3]

d) 2-methyl-2-propanol is shaken with an acidified potassium dichromate solution.

Equation: .....

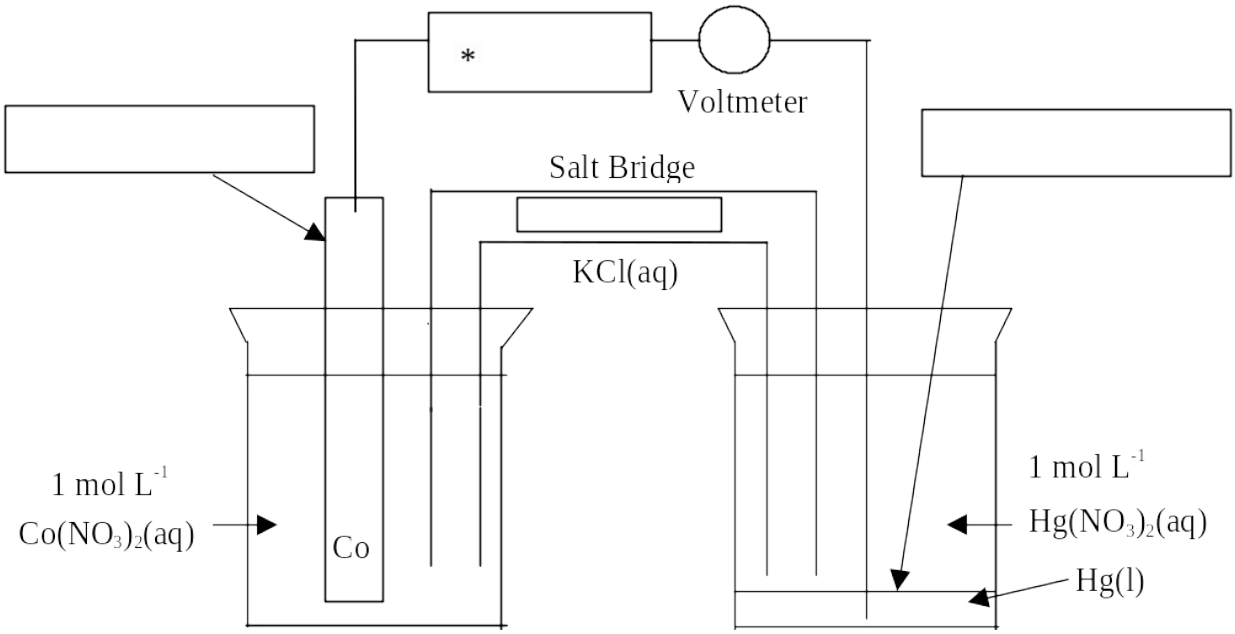
Observation: .....

.

[3]

SEE NEXT PAGE

2. A demonstration electrochemical cell is made by assembling two half cells consisting of beakers with cobalt metal in contact with cobalt(II) nitrate solution and a layer of pure liquid mercury in contact with mercury(II) nitrate. The half cells are joined as shown in the diagram.



(a) **<u>In the boxes</u>** provided on the above diagram:

(i) Label the ANODE. [1]

(ii) Label the CATHODE. [1]

(iii) Draw an arrow to indicate the direction of electron flow in the external circuit. (*) [1]

(iv) Draw an arrow to indicate the direction of flow of the chloride ions through the salt bridge. [1]

(b) Write balanced equations for the:

(i) ANODE REACTION.....[2]

(ii) CATHODE REACTION.....[2]

(c) The expected reading on the voltmeter is .....volts. [1]

3. Four white crystalline substances in identical unmarked jars need to be identified. The substances are barium nitrate, magnesium chloride, sodium nitrate and zinc carbonate. Complete the following table giving a relevant distinguishing **chemical** test which will enable you to correctly identify each substance. Give the accompanying observation and your conclusion. Equations are unnecessary.

Test	Observation	Conclusion
1. To a little of each of the four samples, add …… …… ……	…… …… …… ……	…… …… …… ……
2. To a little of each of the three remaining samples add water to dissolve, then…… …… ……	…… …… …… ……	…… …… …… ……
3. To a little of the two remaining samples add water to dissolve, then…… …… ……	…… …… …… ……	…… …… …… ……

[9]

4. Write the balanced half equations for the reaction between copper metal and **concentrated** nitric acid. Then show the overall balanced equation.

oxidation.....

.[2]

reduction.....…
[2]

SEE NEXT PAGE

overall equation.....
[1]

SEE NEXT PAGE

5. Complete the following table. Draw the semistructural formula where the name is given, or name the compound whose semistructural formula is drawn.

IUPAC NAME	SEMI-STRUCTURAL FORMULA
a) 3,4-dibromo-cyclohexene	
b) 3-chloro-4,4-dimethyl-2-pentanone	
c)	$CH_2Cl(CH_2)_3COOH$

[6]

6. Write a chemical equation which is consistent with the observation in each of the following procedures.

What is done	Observation	Equation
Two colourless liquids are combined and heated gently with sulfuric acid.	A sweet fruity smell is detected.	
A clear liquid is added to a black powder.	Bubbles of an odourless, colourless gas are given off vigorously.	
A pale green liquid is added to a deep purple liquid.	The colour of the liquid changes from purple to very pale yellow-brown.	

[6]

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7. Consider the equilibrium reaction between hydrogen chloride gas and oxygen gas using a suitable catalyst:

$4HCl(g) + O_2(g) \quad 2H_2O(g) + 2Cl_2(g) \quad \Delta H = -280 \text{ kJ mol}^{-1}$

Complete the table below by:

(a) indicating the change in the **amount** of hydrogen chloride gas (write either "more", "less" or "unchanged") after each of the following changes to conditions at equilibrium have been made.
(b) giving also a brief **reason** for your choice based on accepted chemical principles.

Change imposed on the system	Effect on **amount** of HCl(g) present
1. The temperature of the system is raised.	(a)……..……. (b) Reason…….. …… ……..……
2. The pressure of the system is doubled by halving the volume of the reaction vessel.	(a)…….. (b) Reason……..…… ……..…… ……..……
3. The surface area of the **catalyst** is increased	(a)…….…….. (b) Reason……..…… …… ……

[9]

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8. Explain fully why SO_2 molecules are bent but CO_2 molecules are linear. Indicate also whether the molecule is polar or non-polar and give a full reason.

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[6]

9. In the spaces below, draw and name four of the isomers of $C_3H_4Cl_2$

Structural formula of isomer	IUPAC name of isomer

[8]

END OF PART 2

SEE NEXT PAGE

PART 3 (50 marks = 25%)

Answer **ALL** the 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 of a partial answer, even if you cannot complete the problem. Numerical answers **MUST** be corrected to three (3) significant figures and appropriate units must be provided. Information necessary for the solution of the problem is located in your Chemical Data Sheet.

1. A sample of impure calcium carbonate weighing 0.2450 g is dissolved in 100 mL of standardized 0.0905 mol L^{-1} hydrochloric acid solution. After the reaction is complete, it is found that the excess acid required 17.0 mL of 0.250 mol L^{-1} sodium hydroxide solution for complete neutralization using phenolphthalein indicator. Find the percentage of calcium carbonate in the sample.

[6]

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2. A textile company uses a solution of sodium hypochlorite to bleach sheets. An industrial chemist employed by the company is asked to investigate the change in the concentration of the bleaching solution after sheets have been soaked in this solution for a time of 2 hours. The original solution is known to contain 30.0 g of sodium hypochlorite per litre of solution. [The bleaching process slowly reduces hypochlorite ions to chloride ions while at the same time changing double bonds in the sheet fibres into single bonds - an oxidation process]. The chemist removes a sample of the bleaching solution after two hours of bleaching and tests it with sodium thiosulfate solution to determine the final concentration of hypochlorite ions. The redox reaction between hypochlorite ion and thiosulfate ion in an acidified solution may be represented as follows:

$$OCl^-(aq) + 2S_2O_3^{2-}(aq) + 2H^+(aq) \rightarrow S_4O_6^{2-}(aq) + Cl^-(aq) + H_2O(l)$$

Using a starch-iodine indicator to moderate the equivalence point of the reaction, it is found that an average of 47.5 mL of 0.250 mol L^{-1} sodium thiosulfate solution is needed to react with 20.0 mL samples of the final bleaching solution.

(a) Calculate the concentration of sodium hypochlorite in mol L^{-1} in the original bleaching solution. [2]

(b) Calculate, from the given redox reaction, the concentration of hypochlorite ions in the final bleaching solution. [8]

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3. It is found by discharge testing that a fully charged lead-acid accumulator (car battery) is able to supply an average current of 2.00 amperes for 35.0 hours.

(a) Calculate the minimum mass of lead which is needed in each cell of the battery to produce this amount of charge. [Hint: electrical charge in coulombs = amperes x seconds]
The half equations for each cell of the battery are :

Anode: $Pb(s) + SO_4^{2-}(aq) \rightarrow PbSO_4(s) + 2e^-$
Cathode: $PbO_2(s) + 4H^+(aq) + SO_4^{2-}(aq) + 2e^- \rightarrow PbSO_4(s) + 2H_2O(l)$

[6]

(b) Determine the minimum volume of 12.0 mol L^{-1} sulfuric acid which each cell of the battery needs to produce the above amount of electrical charge.

[4]

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4. An organic compound containing only carbon, hydrogen and nitrogen was analysed as follows:

   (i) A sample of the compound of mass 2.435 g was burnt in oxygen gas under such conditions as to convert all the carbon it contained into carbon dioxide gas, and all the hydrogen it contained was converted into water. The masses of carbon dioxide and water were, respectively, 4.753 g and 3.405 g.

   (ii) When vaporized in the absence of air, a further 2.435 g sample of the compound was found to occupy 1.321 L at 25°C and 101.3 kPa.

   (a) From the data in (i), calculate the empirical formula of the compound. [8]

   (b) From the data in (ii), calculate the molecular formula of the compound [4]

   (c) Given that the compound is an amine, draw a structural formula for the compound and give it a systematic name. [2]

SEE NEXT PAGE

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5. In the manufacture of sulfuric acid, liquid sulfur is burned in air to produce sulfur dioxide. The sulfur dioxide is then catalytically converted into sulfur trioxide and then to fuming sulfuric acid, $H_2S_2O_7$, by adding the sulfur trioxide to pure sulfuric acid.
Finally, sulfuric acid is produced by adding a stoichiometric amount of water to the fuming sulfuric acid.

The reactions are:

$$S_8(l) + 8O_2(g) \rightarrow 8SO_2(g)$$
$$2SO_2(g) + O_2(g) \rightarrow 2SO_3(g)$$
$$SO_3(g) + H_2SO_4(aq) \rightarrow H_2S_2O_7(aq)$$
$$H_2O(l) + H_2S_2O_7(aq) \rightarrow 2H_2SO_4$$

Assume that each reaction stage proceeds fully to the right and that 100% recovery is made.

(a) Given that the liquid sulfur is 98.0% by mass pure, and that the impurity does not react, find the mass of liquid sulfur needed to produce 1.00 tonne of sulfuric acid. [4]
Do not include the sulfuric acid used in the third reaction above. [1 tonne = 10^6 g.]

(b) Calculate the volume of oxygen gas measured at 350°C and 98.0 kPa needed to produce the above amount of sulfuric acid. [4]

(c) Find the mass of water required in the production of 1.00 tonne of sulfuric acid. [2]

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PART 4 (20 marks = 10%)

Answer **ONE** of the following essay-type questions. Where applicable use equations, diagrams and illustrative examples of the chemistry you are describing. Marks are awarded principally for the relevant chemical content of your essay, but some marks can also be gained for clarity in arranging a reasonable amount of material in essay form. Your answer should be presented in about 1.5 - 2 pages.

1. Discuss the nature and importance of Van der Waal's (VDW) forces in Chemistry. You should clearly indicate the links between types of VDW forces (ie. hydrogen bonding, dipole-dipole forces and dispersion forces) and the effects they have on **two** physical properties of the molecular substances which have these forces. Give examples.

OR

2. Compare and contrast the reactions involved in the chemical purification and extraction reactions for gold and iron. In what way are the differences in the properties of these two metals evident in the use of the metals in everyday life?

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END OF PAPER

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