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Year 12 Chemistry 2004

Name: .....

Teacher: .....

Time allowed for this paper

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

Materials 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: A 2B, B or HB pencil for the separate Multiple Choice Answer Sheet and calculators satisfying the conditions set by the Curriculum Council for this subject.

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 this paper

Part	Format	No. of Questions Set	Number of Questions to be Attempted	Marks available	Suggested working time (minutes)
1	Multiple choice	30	All	60 (30%)	55
2	Short answers	12	All	70 (35%)	60
3	Calculations	5	All	50 (25%)	45
4	Extended answers	2	1	20 (10%)	20
			Total marks	200 (100%)	

Instructions to candidates

1. The rules for the conduct of Tertiary Entrance Examinations are detailed in the booklet *TEE Handbook.* Sitting this examination implies that you agree to abide by these rules.

2. Answer the questions according to the following instructions:

Part 1 Answer **all** questions, using a 2B, B or HB pencil, on the separate Multiple Choice Answer Sheet. Do **not** use a ball point 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 Write your answers in the spaces 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 for such questions which do not show working will not be awarded full marks.

3. The examiners recommend that you spend your 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 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)

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. Element X has the outer shell electron configuration s^2p^1. Element Y has the outer shell electron configuration s^2p^3. The most likely formula of the compound formed by X and Y is which of the following?

   (a) XY

   (b) XY_2

   (c) X_2Y

   (d) X_2Y_3

2. Which of the following rows contains three correct formulae for the named ions?

	dichromate ion	dihydrogenphosphate ion	oxalate ion
(a)	CrO_2^-	$H(PO_4)_2^-$	O_2^-
(b)	$Cr_2O_7^{2-}$	$H_2PO_4^-$	$C_2O_4^{2-}$
(c)	$Cr_2O_3^{2-}$	HPO_4^{2-}	O_2^{2-}
(d)	CrO_2^{2-}	HPO_3^{2-}	$HCOO^-$

3. An element has the electronic configuration $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^5$.
   In which group and period of the Periodic Table is the element located?

   (a) Group III, period 4

   (b) Group V, period 4

   (c) Group IV, period 1

   (d) Group VII, period 3

4. Which one of the following has only dispersion forces between its molecules in the liquid phase?

   (a) CO_2

   (b) NH_3

   (c) C_2H_5OH

   (d) H_2O

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5. Which of the following molecules has a double bond?

(a) $BeCl_2$

(b) $CH_3(CH_2)_3CH_3$

(c) HCOOH

(d) $CH_3CHBrCH_3$

6. The unusual electrical conductivity of graphite (a form of pure carbon) is best explained by which of the following?

(a) Carbon atoms are free to move between the layers in graphite, carrying their charge with them.

(b) Carbon atoms form three covalent bonds with neighbouring atoms in graphite, leaving one valence electron for conductivity.

(c) Carbon atoms in graphite form charged molecules which move under the influence of an applied electrical field.

(d) Carbon has only dispersion forces between atoms in graphite, so the four valence electrons are free to move throughout the structure.

7. Which of the following substances have both covalent and ionic bonding within them?

(a) CsF (s)

(b) C_2H_5Cl (l)

(c) $Ca_3(PO_4)_2$ (s)

(d) HF (g)

8. A 10.0 L sample of air at 25.0^oC weighing 11.80 g was collected from a busy city intersection, and was found to contain 0.230 mg of lead. The concentration of lead in the air is which of the following?

(a) 0.0230 ppm (parts per million)

(b) 1.18 ppm

(c) 19.5 ppm

(d) 51.3 ppm

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9. 20.0 mL of 0.100 mol L^{-1} calcium chloride solution is added to 80.0 mL of 0.0500 mol L^{-1} silver nitrate solution.
The concentrations of ions in the **final 100.0 mL** of solution is correctly shown by which of the following?

	$[Ca^{2+}(aq)]$	$[NO_3^-(aq)]$	$[Ag^+(aq)]$
(a)	1.00×10^{-2} mol L^{-1}	2.00×10^{-2} mol L^{-1}	2.00×10^{-2} mol L^{-1}
(b)	2.00×10^{-2} mol L^{-1}	4.00×10^{-2} mol L^{-1}	zero moles per litre
(c)	2.00×10^{-2} mol L^{-1}	8.00×10^{-2} mol L^{-1}	1.00×10^{-2} mol L^{-1}
(d)	4.00×10^{-2} mol L^{-1}	8.00×10^{-2} mol L^{-1}	zero moles per litre

10. A chemist added 20.0 mL of concentrated sulfuric acid to 100.0 mL of 0.100 mol L^{-1} lead nitrate solution in a 500 mL beaker. Which one of the following does **not** occur in the beaker as a result of the mixing of the two liquids?

(a) Solid lead(II) sulfate is precipitated.

(b) A rise in temperature of the liquid contents of the beaker is observed.

(c) The reaction: $H^+ (aq) + OH^- (aq) \rightarrow H_2O (l)$ occurs.

(d) The pH of the solution in the 500 mL beaker is lowered.

11. Which of the lists below indicate the boiling points of the compounds in either ascending or descending order?

(a) H_2O, H_2Se, H_2S

(b) NH_3, PH_3, AsH_3

(c) CH_4, C_3H_8, C_2H_6

(d) C_3H_8, CH_3CH_2COOH, CH_3COCH_3

12. Solutions of lithium carbonate, sodium chloride and ammonium sulfate have their pH tested. Which of the following is the correct classification from the test?

	$Li_2CO_3(aq)$	$NaCl(aq)$	$(NH_4)_2SO_4(aq)$
(a)	acidic	neutral	basic
(b)	basic	neutral	acidic
(c)	neutral	acidic	basic
(d)	neutral	acidic	neutral

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13. When 1.0 mol L^{-1} solutions of the following are mixed, which combinations will result in the formation of precipitates?

(1) $Ba(NO_3)_2$ and HCl

(2) $Ca(NO_3)_2$ and Na_2CO_3

(3) $Cu(NO_3)_2$ and KOH

(4) $Zn(NO_3)_2$ and **limited** $NH_3(aq)$

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

14. Which of the following best describes the shape and polarity of a molecule whose formula is CF_4 ?

(a) tetrahedral, non polar
(b) pyramidal, polar
(c) pyramidal, non polar
(d) tetrahedral, polar

15. Silicon dioxide has a much higher melting point than carbon dioxide. Which of the following best explains this difference?

(a) Silicon dioxide is a larger molecule than carbon dioxide, so the dispersion forces between its molecules are greater than those between carbon dioxide molecules.

(b) The double bonds within silicon dioxide molecules are stronger than the double bonds within carbon dioxide molecules.

(c) Silicon atoms in silicon dioxide are each bonded to four oxygen atoms to produce an extended covalent bonding arrangement, whereas carbon dioxide forms discrete molecules.

(d) Silicon dioxide molecules are polar and have stronger dipole - dipole interactions, whereas carbon dioxide molecules are non-polar and have only weak dispersion forces between them.

16. A compound has the empirical formula CH_2O. If 3.50 g of the gaseous compound

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occupied 436 mL at STP, which of the following is the molecular formula of the compound?

(a) CH_2O

(b) $C_3H_6O_3$

(c) $C_4H_8O_4$

(d) $C_6H_{12}O_6$

17. Which of the following statements about oxidising and reducing agents is false?

(a) Hydrogen peroxide solution is capable of spontaneous self oxidation - reduction.

(b) Group I metals are good reducing agents.

(c) Acidified potassium permanganate solution can oxidise oxalic acid solution to carbon dioxide and water.

(d) Copper metal will not react with a dilute silver nitrate solution.

18. 3 - hexanone can be prepared from which of the following lists of substances?

(a) 3-hexanoic acid and 3-hexanol

(b) 3-hexanol and acidified potassium permanganate solution

(c) 3-hexylhexanoate and 3-hexanol

(d) 3-hexanoic acid and acidified potassium dichromate solution

19. Which of the following is true for an exothermic reaction?

(a) The product molecules have higher potential energy than the reactant molecules.

(b) In an exothermic reaction, more chemical bonds or stronger chemical bonds are present in the reactant molecules than in the product molecules.

(c) A decrease in the enthalpy of the system occurs.

(d) Exothermic reactions have a higher activation energy for the forward reaction than endothermic reactions have.

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20. Which of the following reactions represent disproportionation (self oxidation - reduction)?

I $2CrO_4^{2-}(aq) + H^+(aq) \rightarrow Cr_2O_7^{2-}(aq) + OH^-(aq)$

II $3I_2(s) + 6OH^-(aq) \rightarrow 5I^-(aq) + IO_3^-(aq) + 3H_2O(l)$

III $Zn(s) + 2H^+(aq) \rightarrow Zn^{2+}(aq) + H_2(g)$

IV $2Cu^+(aq) \rightarrow Cu(s) + Cu^{2+}(aq)$

(a) I only

(b) II and IV only

(c) III only

(d) IV only

21. In which of the following examples is the underlined substance acting as a base?

(a) $\underline{NH_3}\ (aq) + H_2O\ (l) \rightarrow NH_4^+\ (aq) + OH^-\ (aq)$

(b) $\underline{H_2O}\ (l) + O^{2-}\ (aq) \rightarrow 2OH^-\ (aq)$

(c) $\underline{2K}(s) + 2H_2O\ (l) \rightarrow 2K^+\ (aq) + 2OH^-\ (aq) + H_2\ (g)$

(d) $\underline{H_2O}\ (l) + CO_3^{2-}\ (aq) \rightarrow OH^-\ (aq) + HCO_3^-\ (aq)$

22. In which one of the following species is the oxidation number of manganese lower than it is in the other three compounds?

(a) K_2MnO_4

(b) Mn_2O_3

(c) $NaMnO_4$

(d) MnO_2

23. For the titration between dilute ethanoic acid (in a burette) and standardised sodium hydroxide in a conical flask, which of the following procedures is incorrect?

(a) Prior to adding the acid to the burette, rinse the burette with distilled water and then a small portion of the acid solution.

(b) Pipette out 20.00 mL aliquots of the sodium hydroxide solution into three separate conical flasks which have each been rinsed with distilled water.

(c) Rinse the pipette with the standardised sodium hydroxide solution before transferring the first aliquot to the conical flask.

(d) Add a few drops of methyl orange indicator to the acid in the burette.

Questions 24 and 25 refer to the energy profile diagram for the reaction between hydrogen gas and iodine vapour producing hydrogen iodide gas.

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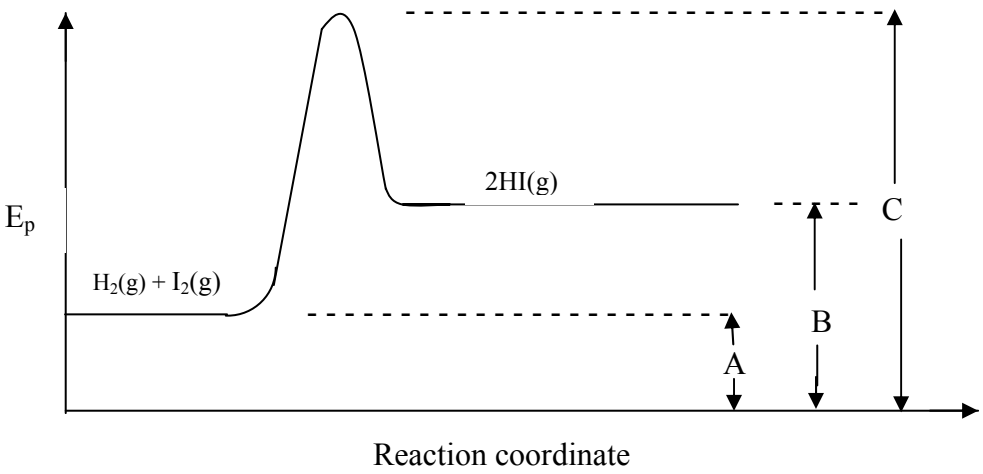

24. For the reaction $H_2(g) + I_2(g) \rightarrow 2HI(g)$, which of the following is true?

(a) It is an endothermic reaction with ΔH = (**B - A**)

(b) It is an exothermic reaction with ΔH = (**C - A**)

(c) It is an exothermic reaction with ΔH = (**A - B**)

(d) It is an endothermic reaction with ΔH = **B**

25. The activation energy for the reaction $2HI(g) \rightarrow H_2(g) + I_2(g)$ is indicated on the graph by which of the following?

(a) (**A** + **B**)

(b) (**B - A**)

(c) (**C - B**)

(d) (**B + C**)

26. A student requires a solution of pH = 4 for an experiment.
Which of the following procedures will yield such a solution?

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(a) Add 50 mL of a solution of pH = 2 to 50 mL of a solution of pH = 6.

(b) Add 95 mL of distilled water to 5 mL of 0.1 mol L^{-1} HCl(aq).

(c) Add 50 mL of 0.1 mol L^{-1} NaOH to 25 mL of 0.1 mol L^{-1} HCl(aq).

(d) Add 1.0 mL of 0.01 mol L^{-1} HCl(aq) to 99 mL of distilled water.

27. According to the Standard Reduction Potential Table, which of the following partially completed half reactions is able to oxidise Cu^{+}(aq) to Cu^{2+}(aq), but is not able to oxidise aqueous iodide ions to solid iodine?

(a) $Cr_2O_7^{2-}(aq) + 14H^{+}(aq) + 6e^{-}$

(b) $O_2(g) + 2H_2O(l) + 4e^{-}$

(c) $S(s) + 2H^{+}(aq) + 2e^{-}$

(d) $H_2(g) + 2OH^{-}(aq)$

28. What is the systematic name for the compound

```
CH3COCHCH3 ?
      |
      CH2
      |
      CH3
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(a) 3 - methyl - 2 - pentanone

(b) 2 - ethyl - 3 - butanone

(c) 2 - hydroxy - 3 - ethylbutane

(d) 3 - methylpentanoate

29. The repeating section of a condensation polymer molecule is shown below:

$$-OC(CH_2)_2COO(CH_2)_3O-$$

Which of the following correctly indicates the monomers which reacted to form the polymer?

(a) $HOOC(CH_2)_2COOH$ and $HO(CH_2)_3OH$

(b) $OH(CH_2)_3COOH$ and $OH(CH_2)_2COOH$

(c) $HOOC(CH_2)_3COOH$ and $HO(CH_2)_2OH$

(d) $CH_3COOCH_2CH_3$ and CH_3COOCH_3

30. The number of isomers of dichloropropene is which of the following?

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(a) three

(b) four

(c) five

(d) seven

END OF PART 1

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PART 2 (70 marks)

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

1. Give fully balanced equations for the reactions which occur (if at all) in the following experiments.
Use **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) Propanal is shaken vigorously with a dilute solution of acidified potassium dichromate.

Oxidation : .....

Reduction : .....

Equation : .....

Observation : .....

.....

[4 marks]

(b) Concentrated ammonia solution is added to solid zinc hydroxide.

Equation : .....

Observation : .....

.....

[3 marks]

(c) Copper metal is placed in a solution of lead nitrate.

Equation : .....

Observation : .....

.....

[3 marks]

(d) A solution of ammonium nitrate is added to a solution of potassium hydroxide.

Equation : .....

Observation : .....

.....

[3 marks]

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2. For each of the following substances give the **chemical** formula of **one** raw material which is permanently consumed in the manufacture or purification of that substance.

Substance	Raw material consumed
Aluminium	
Sulfuric acid	
Hydrochloric acid	
Iron	

[4 marks]

3. (a) Write the name of an addition polymer.

..... [1 mark]

(b) Write the name and draw the structure of the monomer used to produce the polymer in (a).

Name : ..... Structure:

[3 marks]

4. Write an equation for the reaction which occurs at the cathode of a lead-acid accumulator when it is supplying an electric current.

Equation : .....

[2 marks]

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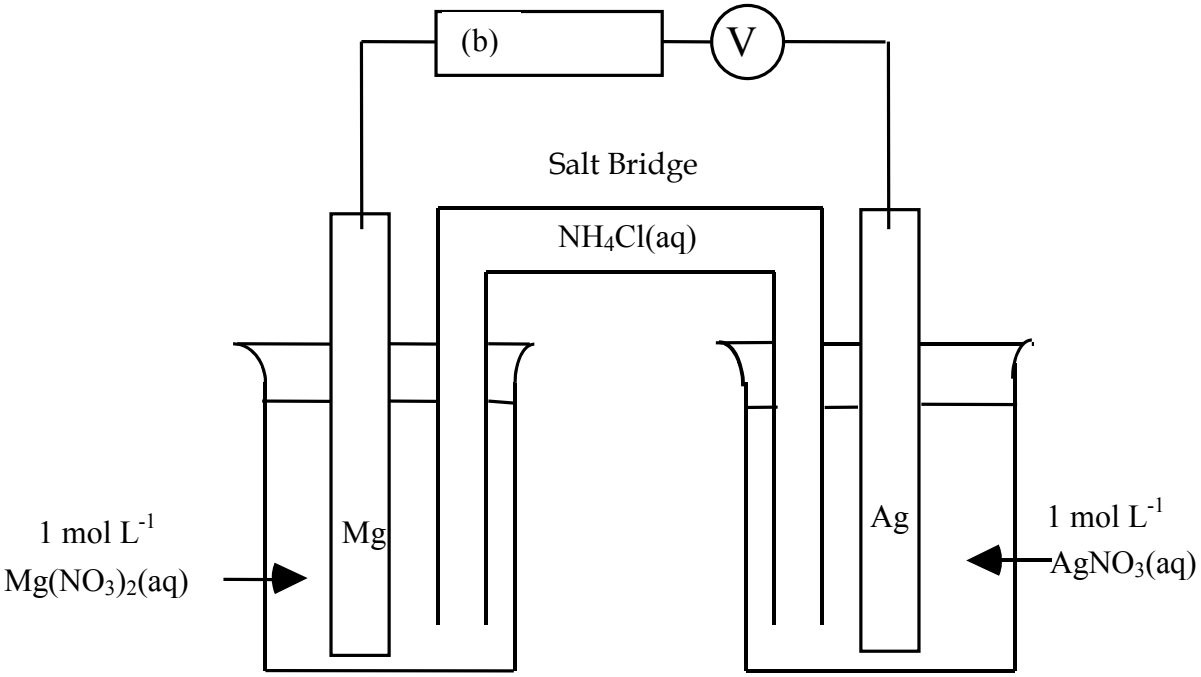
5. Below is a diagram of an electrochemical cell.



(a) Write a half equation to show the reaction at the **anode** of the cell.

.....

[2 marks]

(b) Draw an arrow **in the box** provided on the diagram to indicate the flow of electrons in the external circuit. [1 mark]

(c) Give the formula of one ion that will move from the Mg/Mg^{2+} half cell towards the Ag/Ag^{+} half cell through the salt bridge.

..... [1 mark]

(d) Under standard conditions, what would be the maximum reading on the voltmeter in the external circuit?

.....volts [2 marks]

(e) Several connected strips of magnesium and silver are used in the half-cells instead of just one strip. What would be the specific advantage of this cell over the one shown above?

Answer : .....

.....

[2 marks]

6. For the species below, draw the structural formula, representing all valence shell electron pairs

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either as : or — [For example, water H : Ö : H or H— O— H and so on]

methanol

a chlorite ion ClO_2^-

[6 marks]

7. Complete the following table.

I.U.P.A.C. NAME	SEMI-STRUCTURAL FORMULA
(a) 2-iodo-3-methyl-2-pentanol	
(b) 2-pentyne	
(c)	$CH_3CH_2CH_2CH_2ONa$
(d)	$CH_3COCH_2CH_2CH_2CH_2CH_3$
(e) methyl propanoate	

[5 marks]

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8. Yellow iron(III) ions and colourless thiocyanate ions establish equilibrium in aqueous solution as shown in the equation below:

$$Fe^{3+}(aq) + SCN^{-}(aq) \rightleftharpoons FeSCN^{2+}(aq)$$

The iron(III) thiocyanate complex ion shown on the right hand side of the equation is dark red.

With reference to the above, certain changes are then imposed on the system at equilibrium. Clearly state what you would observe after each change is made and apply Le Chatelier's Principle to account for each observation in the spaces allocated below.

(a) Some concentrated colourless sodium thiocyanate solution is added.

Observation : .....

[1 mark]

Explanation : .....

.....

.....

.....

[3 marks]

(b) A small amount of concentrated potassium nitrate solution is added.

Observation : .....

[1 mark]

Explanation : .....

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[3 marks]

9. Both aluminium metal and aluminium hydroxide are amphoteric.
Explain what is meant by the term “amphoteric” and write balanced equations which illustrate the amphoteric nature of either one.

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[6 marks]

10. Using carefully drawn diagrams, thoroughly explain the difference in shape and polarity between BF_3 molecules and PF_3 molecules.

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[6 marks]

11. Consider the electrolysis of molten potassium iodide and 1.0 mol L^{-1} potassium iodide solution.
Write the equations for the anode and cathode reactions in each case.

(a)

KI(l)
Anode:
Cathode:

(b)

KI(aq)
Anode:
Cathode:

[4 marks]

12. Explain the difference between the terms "electronegativity" and "ionisation energy".

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[4 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. A sample of 5.318 g of a chlorofluorocarbon (a compound containing carbon, fluorine and chlorine only) was analysed as follows:

   All the carbon in the sample was converted into carbon dioxide gas, and all its chlorine was converted into hydrochloric acid. The carbon dioxide weighed 1.703 g, and the hydrochloric acid formed required 56.6 mL of 2.052 mol L^{-1} ammonia solution for complete neutralisation.

   A second sample of the same chlorofluorocarbon of mass 1.542 g occupied 0.2516 L at S.T.P.

   (a) Determine the empirical formula of the compound. [8 marks]

   (b) Determine the molecular formula of the compound. [2 marks]

   (c) Name and draw a possible structure of the compound. [2 marks]

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2. An analytical chemist was contracted by a mining company to determine the percentage of nickel in an ore which was known to be mainly hydrated nickel(II) carbonate of formula $NiCO_3.\mathbf{x}H_2O$. The chemist took a 5.750 g sample of the ore and heated it strongly to drive off all the water of crystallisation. The dry anhydrous powder (nickel carbonate + impurities) remaining weighed 4.164 g. This powder was then dissolved in excess nitric acid. The resulting solution was then diluted to 1.00 L by the addition of distilled water, and was then electrolysed with inert electrodes until the mass of the cathode finally remained constant, indicating that all the nickel in the solution had been deposited at the cathode. The gain in mass of the cathode was 1.707 g.

   From the above information, calculate:

   (a) The value of **x** (ie. determine the formula of the hydrated nickel carbonate).[8 marks]

   (b) The percentage of hydrated nickel carbonate in the ore. [2 marks]

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3. The "volume strength" of hydrogen peroxide solution is defined as the number of litres of oxygen gas obtainable at STP from the decomposition of exactly 1.00 L of the hydrogen peroxide solution according to the equation:

$$2H_2O_2(aq) \rightarrow 2H_2O(l) + O_2(g)$$

An analytical chemist is required to determine both the concentration and the volume strength of a commercial hydrogen peroxide solution. She takes 10.00 mL of the concentrated hydrogen peroxide solution and dilutes it to 250.0 mL in a volumetric flask. She then pipettes a 20.00 mL sample of the diluted solution into 50.00 mL of acidified potassium permanganate solution of concentration 0.0740 mol L^{-1}. After the redox reaction is complete, the final solution is still purple, indicating the presence of excess permanganate ions. The chemist then adds from a burette, a standardised oxalic acid solution of concentration 0.245 mol L^{-1} and finds that 18.75 mL of the oxalic acid solution is required to consume the excess permanganate ions.

(a) Determine the concentration of the original hydrogen peroxide solution in mol L^{-1}. [10 marks]

(b) Determine the volume strength of the original hydrogen peroxide solution. [2 marks]

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4. Chromium metal occurs mainly as the green mineral chromite, $Fe_2O_3.Cr_2O_3$.

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It is extracted from chromite by heating the mineral in air with sodium carbonate to form sodium chromate according to the following balanced equation:

$$2Fe_2O_3.Cr_2O_3 + 4Na_2CO_3 + 3O_2(g) \rightarrow 2Fe_2O_3 + 4Na_2CrO_4(s) + 4CO_2(g)$$

(a) Calculate the mass of sodium carbonate needed to react with 1.00 tonne of chromite. [Hint: 1 tonne = 10^3 kg or 10^6 g.] [5 marks]

(b) What volume of oxygen gas measured at 30.0°C and 98.0 kPa pressure is required for the reaction in (a) above? [5 marks]

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5. In a laboratory experiment to prepare highly insoluble mercury(I) bromide, a student added

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150.0 mL of 0.0502 mol L^{-1} mercury(I) nitrate solution to 250.0 mL of 0.0203 mol L^{-1} potassium bromide solution.

Determine the theoretical mass of mercury(I) bromide the student would obtain.

[6 marks]

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PART 4 (20 marks)

SEE NEXT PAGE

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Answer **ONE** of the following two extended answer questions.
Marks are awarded for the relevant chemical content of your answer, and also for coherence and clarity of expression. Where applicable, use equations, diagrams and illustrative examples of the chemistry you are describing.

Your answer should be presented in about 1.5 to 2 pages. Commence your answer on page 29.

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1. The extraction of metals from their ores and their subsequent refining or purification is of vital importance in today's economy. Discuss aluminium and gold as two such metals by **comparing** and **contrasting** the types of chemical reactions which are used in both their extraction and refining.

OR

2. Compare and contrast the structure and the related properties of **covalent molecular and covalent network** substances. You should clearly indicate what constitutes the basic unit of these substances, and how properties such as hardness, conductivity, melting and boiling point are related to the structure and the forces within these two types of substances. Appropriate examples should be given.

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