



TERTIARY ENTRANCE EXAMINATION, 1998

QUESTION/ANSWER BOOKLET

CHEMISTRY

Please place your student identification label in this box

STUDENT NUMBER - In figures

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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	14	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 $\text{Ag}^+(\text{aq})$], **molecules** [for example $\text{NH}_3(\text{g})$, $\text{NH}_3(\text{aq})$, $\text{CH}_3\text{COOH}(\text{l})$, $\text{CH}_3\text{COOH}(\text{aq})$] or **solids** [for example $\text{BaSO}_4(\text{s})$, $\text{Cu}(\text{s})$, $\text{Na}_2\text{CO}_3(\text{s})$].

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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. Enough water is added to 5.0 mL of 4.0 mol L⁻¹ HCl to make 50.0 mL of solution. Which one of the following gives the number of moles of Cl⁻ present in the 50.0 mL of solution?
- (a) 0.0010 mol
 - (b) 0.020 mol
 - (c) 0.050 mol
 - (d) 0.40 mol
 - (e) 0.50 mol
2. Sodium tungstate dihydrate has the formula Na₂WO₄·2H₂O. What is the charge on the tungstate ion?
- (a) 2-
 - (b) 1-
 - (c) 1+
 - (d) 2+
 - (e) 6+
3. 0.50 mol of a certain metal reacts with excess hydrochloric acid to produce 0.50 mol of hydrogen gas. What is the charge on the metal ion produced in this reaction?
- (a) 1+
 - (b) 2+
 - (c) 3+
 - (d) 4+
 - (e) 5+

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4. In which one of the following pairs could the two substances be distinguished from each other solely by visual observation of their reaction with dilute sulfuric acid?
- (a) aluminium metal and manganese metal
 - (b) caesium hydroxide solution and sodium hydroxide solution
 - (c) carbon dioxide gas and oxygen gas
 - (d) lead(II) nitrate solution and sodium nitrate solution
 - (e) solid magnesium hydroxide and solid sodium hydroxide
5. Each of three gas jars contains a sample of a pure gaseous substance. Given the colour of each gas, which one of the following sets is possible?

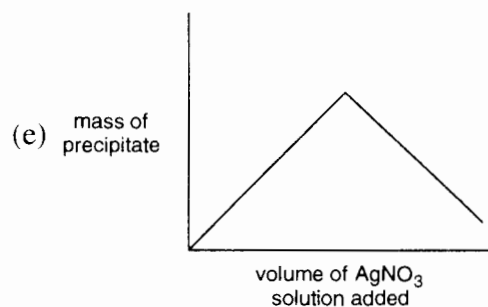
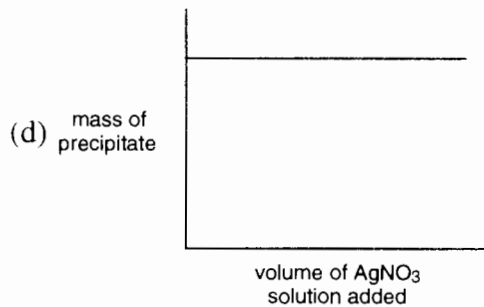
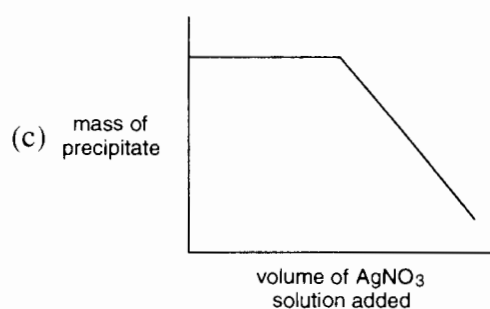
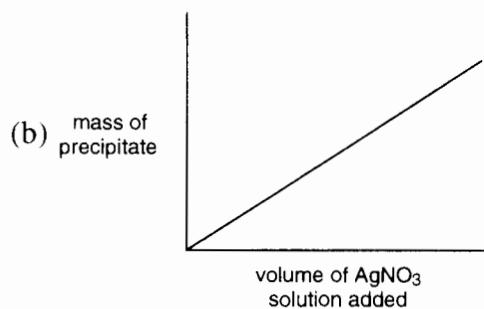
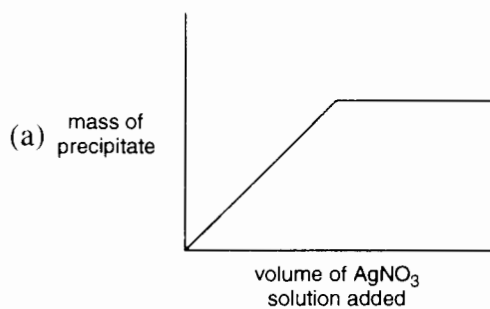
	Gas 1 colourless	Gas 2 colourless	Gas 3 brown
(a)	CO	H ₂	SO ₂
(b)	CO ₂	Cl ₂	NO ₂
(c)	H ₂	CO ₂	Br ₂ vapour
(d)	N ₂	NO ₂	Br ₂ vapour
(e)	O ₂	NO ₂	Cl ₂

6. An element X has ions XO_3^{2-} and XO_4^{2-} . Which one of the following is X?
- (a) chlorine
 - (b) nitrogen
 - (c) phosphorus
 - (d) silicon
 - (e) sulfur

7. Which one of the following does **not** contain delocalised electrons?
- (a) acetate (ethanoate) ion
 - (b) benzene
 - (c) copper
 - (d) diamond
 - (e) graphite
8. Which one of the following electron configurations represents an element that forms a monoatomic ion with a charge of 3- ?
- (a) $1s^2 2s^2 2p^6 3s^2 3p^1$
 - (b) $1s^2 2s^2 2p^6 3s^2 3p^3$
 - (c) $1s^2 2s^2 2p^6 3s^2 3p^6 3d^1 4s^2$
 - (d) $1s^2 2s^2 2p^6 3s^2 3p^6 3d^3 4s^2$
 - (e) $1s^2 2s^2 2p^6 3s^2 3p^6 3d^7 4s^2$
9. Two atoms X and Y have electron configurations shown below.
- X: $1s^2 2s^2 2p^6 3s^2 3p^2$ Y: $1s^2 2s^2 2p^6 3s^2 3p^5$
- Which one of the following formulae is most likely for the product when X and Y combine?
- (a) covalent, with formula XY_4
 - (b) covalent, with formula X_2Y_5
 - (c) ionic, with formula XY_2
 - (d) ionic, with formula X_2Y_5
 - (e) ionic, with formula X_2Y

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10. Molecules of COCl_2 and SO_3 are both trigonal planar (triangular planar). Which one of the following statements is true?
- (a) Both COCl_2 and SO_3 are non-polar.
 - (b) Both COCl_2 and SO_3 are polar.
 - (c) COCl_2 is non-polar whereas SO_3 is polar.
 - (d) SO_3 is non-polar whereas COCl_2 is polar.
 - (e) Because both COCl_2 and SO_3 contain a double bond the concept of polarity is not applicable to these molecules.
11. Excess silver nitrate solution is added to a sample of sodium chloride solution while the mixture is constantly stirred. Which of the following graphs best represents the amount of precipitate formed?

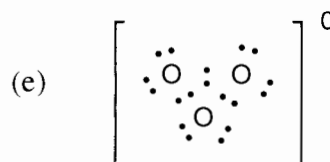
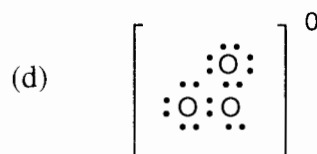
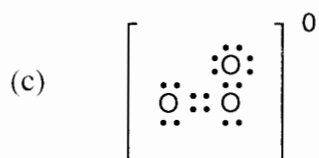
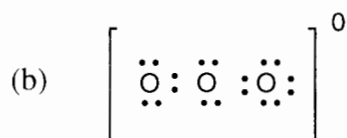


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Questions 12 and 13 concern the forms of oxygen. Data which may be helpful are given in the table below.

Name	Formula	Colour of liquid	Melting-point (°C)	Boiling-point (°C)	Density of liquid (g mL ⁻¹)	Dipole moment (10 ⁻³⁰ C m)
Dioxygen or oxygen	O ₂	pale blue	-219	-183	1.1	0
Trioxxygen or ozone	O ₃	deep blue	-193	-111	1.6	1.8
Nitrogen trifluoride	NF ₃	colourless	-207	-129	1.5	0.8

12. Which one of the following would best represent the electron-dot structure of ozone?

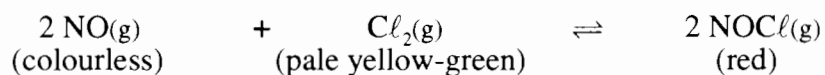


13. Equal masses of oxygen and ozone at -190°C are shaken together. When the system settles, what is seen?

- (a) A deep blue liquid layer below a pale blue liquid layer
- (b) A pale blue liquid layer below a deep blue liquid layer
- (c) A deep blue solid below a pale blue liquid
- (d) A deep blue solid floating on a pale blue liquid
- (e) A homogeneous mid-blue liquid

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14. Consider the following system at equilibrium.



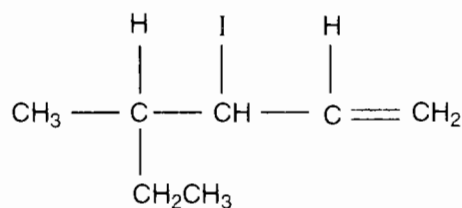
External pressure is applied to halve the volume. Which one of the following occurs?

- (a) The equilibrium shifts to the right, and the final colour is darker than the original.
- (b) The equilibrium shifts to the right, and the final colour is paler than the original.
- (c) The equilibrium shifts to the left, and the final colour is darker than the original.
- (d) The equilibrium shifts to the left, and the final colour is paler than the original.
- (e) There is no shift in equilibrium, and the final colour is darker than the original.
15. What is the pH of $1.5 \times 10^{-4} \text{ mol L}^{-1} \text{ Ca(OH)}_2$, assuming that Ca(OH)_2 is completely dissociated in a water-solution?
- (a) 3.5
- (b) 3.8
- (c) 4.2
- (d) 10.2
- (e) 10.5
16. Which one of the following would cause the percentage ionisation of a weak acid to decrease?
- (a) addition of a strong acid
- (b) addition of a strong base
- (c) addition of a weak base
- (d) dilution with water
- (e) none of the above

17. Which of the following descriptions best distinguishes a weak acid from a strong acid?
- (a) All organic acids are weak acids and all inorganic acids are strong acids.
 - (b) A solution of a weak acid has more hydroxide ions than hydrogen ions.
 - (c) A solution of a weak acid contains its own molecules.
 - (d) A weak acid is obtained by diluting a strong acid.
 - (e) The acidic hydrogen atom of a weak acid is more weakly bonded to the rest of the molecule.
18. Which one of the following sets contains an acidic, an amphoteric and a basic oxide?
- (a) Al_2O_3 MgO Na_2O
 - (b) Al_2O_3 MgO P_4O_{10}
 - (c) Al_2O_3 P_4O_{10} CO_2
 - (d) MgO Na_2O SO_3
 - (e) MgO P_4O_{10} SO_3
19. A nitric acid solution is to be standardised using $0.09937 \text{ mol L}^{-1}$ potassium hydroxide. Which of the following indicators would be suitable?
- I methyl orange (changes colour around pH 4)
 - II bromothymol blue (changes colour around pH 7)
 - III phenolphthalein (changes colour around pH 9)
- (a) I only
 - (b) II only
 - (c) III only
 - (d) I and III only
 - (e) all of I, II and III

20. Which of the following responses has both of the underlined elements in the same oxidation state?
- (a) CO₂ and KNO₃
 - (b) HF and NaH
 - (c) H₂SO₄ and PCl₅
 - (d) K₂Cr₄ and NH₄V₃
 - (e) KMn₄ and NaCl₄
21. A chromium-containing compound is reduced to chromium metal (in one or more steps). A total of 0.090 mole of electrons is involved in the reduction and 0.0150 mole of chromium metal is obtained. Which one of the following could have been the original compound?
- (a) CrCl₂
 - (b) CrCl₃
 - (c) CrF₄
 - (d) CrF₅
 - (e) Na₂Cr₂O₇
22. Which one of the following cannot be used as an acid in a potassium permanganate titration because it reacts with the permanganate?
- (a) CH₃COOH
 - (b) HCl
 - (c) HNO₃
 - (d) H₃PO₄
 - (e) H₂SO₄
23. Which one of the following pairs of compounds is a pair of isomers?
- (a) benzene and cyclohexane
 - (b) 1-butene and cyclobutane
 - (c) dichloromethane and trichloromethane
 - (d) 2,3-dimethylbutane and pentane
 - (e) hexane and methylcyclopentane

24. What is the systematic name for the following?



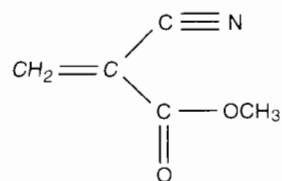
- (a) 2-ethyl-3-iodo-2-methyl-4-pentene
 (b) 2-ethyl-3-iodo-5-methyl-4-hexene
 (c) 4-ethyl-3-iodo-4-methyl-1-pentene
 (d) 3-iodo-4,4-dimethyl-1-hexene
 (e) 3-iodo-4-methyl-1-hexene
25. A food chemist wants to create the odour of pineapples for a product. An ester with this odour has the formula $\text{CH}_3\text{CH}_2\text{COOCH}_2\text{CH}_3$. Which of the following pairs of reactants, with a suitable catalyst, would produce this ester?
- (a) $\text{CH}_3\text{CH}_2\text{COOH}$ and $\text{CH}_3\text{CH}_2\text{OH}$
 (b) $\text{CH}_3\text{CH}_2\text{COOH}$ and CH_3COOH
 (c) $\text{CH}_3\text{CH}_2\text{OH}$ and $\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$
 (d) CH_3COOH and $\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$
 (e) $\text{CH}_3\text{CH}_2\text{CH}_2\text{COOH}$ and $\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$
26. The following molecule belongs to two classes of compounds. Which are they?



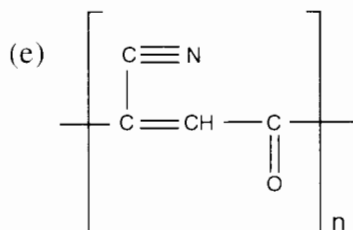
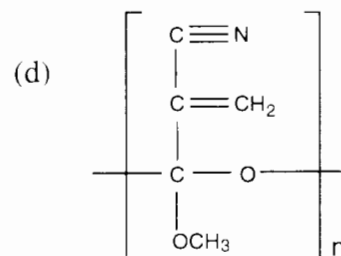
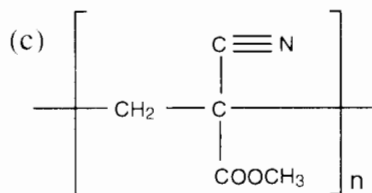
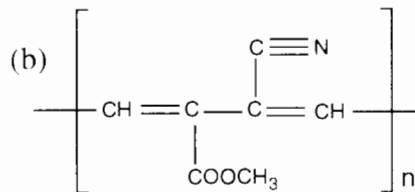
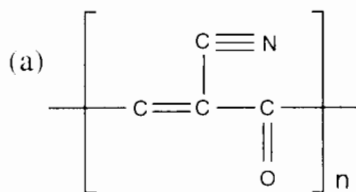
- (a) an aldehyde and a ketone
 (b) an aldehyde and a primary alcohol
 (c) an aldehyde and a secondary alcohol
 (d) a ketone and a primary alcohol
 (e) a ketone and a secondary alcohol

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27. The active ingredient in "superglue" is the compound:



Which one of the following represents the polymer which is formed when the glue sets?



28. Which one of the following statements is true?

- (a) Galvanised iron will corrode rapidly if the zinc coating is scratched.
- (b) If a steel wharf is connected to the positive terminal of a lead accumulator this will help prevent corrosion of the wharf.
- (c) If sodium chloride is used as an antifreeze in a car radiator, the radiator will corrode more rapidly than if 1,2-ethanediol is used.
- (d) The oxide layer on a piece of iron will prevent further corrosion by electrically insulating the iron.
- (e) Zinc can be used as a sacrificial anode to protect aluminium.

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29. During an industrial electrolysis to obtain aluminium, both hydrogen fluoride and carbon monoxide may be evolved as undesirable side-products. Which of the following are the sources of these gases?

	Source of carbon monoxide	Source of hydrogen fluoride
(a)	the anode	the bauxite in the electrolyte
(b)	the anode	the cryolite in the electrolyte
(c)	the bauxite in the electrolyte	the bauxite in the electrolyte
(d)	the cathode lining	the bauxite in the electrolyte
(e)	the cathode lining	the cryolite in the electrolyte

30. The commercial production of ammonia using the Haber Process involves an exothermic reaction between nitrogen gas and hydrogen gas. Which one of the following statements is true?
- (a) Continual removal of the ammonia formed will increase the rate at which the hydrogen gas and nitrogen gas react.
 - (b) High temperature and high pressure each increase the rate of formation of ammonia.
 - (c) Removal of the catalyst will affect both forward and reverse reactions and thus make no appreciable difference to the rate of production of ammonia.
 - (d) The rate of production of ammonia will be greater at low temperature than at high temperature.
 - (e) The rate of production of ammonia will be lower at high pressure than at low pressure.

END OF PART 1

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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) Sodium hydroxide pellets are shaken with dilute hydrochloric acid.

Equation _____

Observation _____

[3 marks]

- (b) Ethyl propanoate is boiled with sodium hydroxide solution.

Equation _____

Observation _____

[3 marks]

- (c) Iron(III) nitrate solution is added slowly to sodium bromide solution.

Equation _____

Observation _____

[3 marks]

- (d) Mercury(I) nitrate solution is added to potassium bromide solution.

Equation _____

Observation _____

[3 marks]

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

(a) a magnesium atom _____

(b) a sulfide ion _____

[2 marks]

3. For each molecule listed in the table below

(a) draw the structural formula, representing **all** valence shell electron pairs either as : or as —

[for example, water $\text{H} : \ddot{\text{O}} : \text{H}$ or $\text{H} - \ddot{\text{O}} - \text{H}$ or $\text{H} - \ddot{\text{O}} - \text{H}$ and so on]

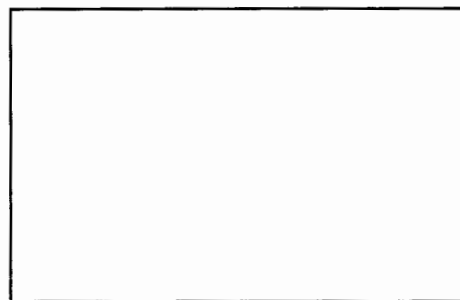
(b) indicate the shape of each molecule by either a sketch or a name

Species	Structural formula (showing all valence shell electrons)	Shape (sketch or name)
chlorate ion, ClO_3^-		
methanal, H_2CO		
nitronium ion, ONO^+ (or NO_2^+)		

[6 marks]

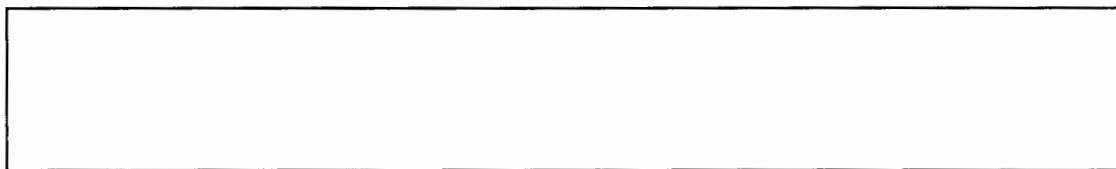
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4. Sodium amide has the formula NaNH_2 . Draw the structural formula for the amide ion; show bonding-pairs and lone-pairs.



[1 mark]

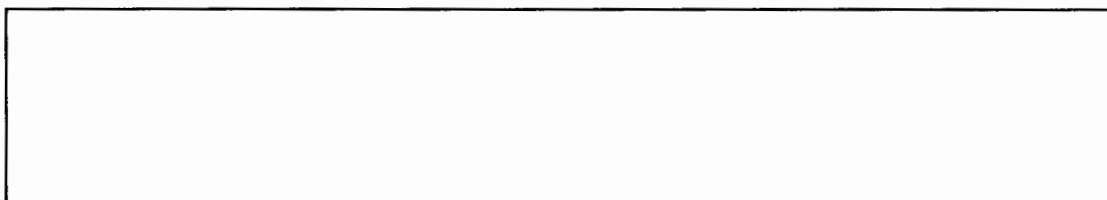
When sodium amide is added to water, the white solid dissolves in a vigorous reaction, ammonia is evolved and the resulting solution is strongly basic. Write the equation for the reaction that has occurred.



[2 marks]

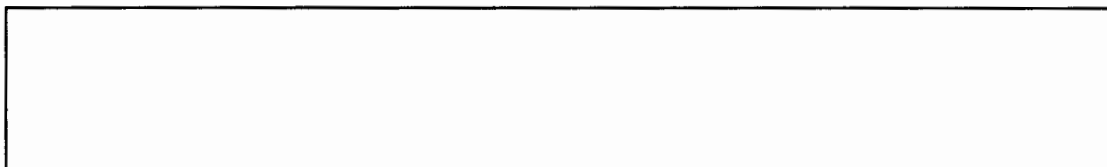
5. When dilute hydrogen peroxide is added to black manganese dioxide powder there is vigorous bubbling.

What has happened to the hydrogen peroxide?



[1 mark]

What has happened to the manganese dioxide?



[1 mark]

Give the name or formula of the gas produced.



[1 marks]

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6. When a solution of NaCl is added to a solution of AgNO_3 a white precipitate is formed. Write the formula of the white precipitate.

[1 mark]

When a solution of NaI is added to a solution of AgNO_3 a yellow precipitate is formed. Write the formula of the yellow precipitate.

[1 mark]

When dilute NH_3 solution is added to each mixture, the white precipitate dissolves but the yellow precipitate does not. Write the equation for the reaction of the white precipitate with the dilute NH_3 .

[2 marks]

When a salt is described as insoluble it usually means that less than 0.01 mol of the salt dissolves per litre. However, in this insoluble region there is a wide range of solubility. On the basis of the above experiments, what can you say about the relative water-solubilities of the white and yellow solids?

[1 mark]

7. For each of the following pairs of compounds, state which compound has the higher boiling-point and indicate the type of van der Waals force (dispersion, dipole-dipole, hydrogen-bonding) responsible for the difference between the boiling-points. [One example has been done for you]

Pair of compounds	Higher boiling compound	Intermolecular force responsible for difference
F_2 and Cl_2	Cl_2	dispersion force
CH_3CH_2OH and CH_3CH_2F		
CH_3CH_2OH and $CH_3CH_2CH_2OH$		
Br_2 and ICl		

[3 marks]

8. When a solution containing potassium dichromate ($K_2Cr_2O_7$) and sulfuric acid is added to a solution of tellurium(IV) oxide (TeO_2), the mixture turns deep green which indicates that chromium(III) ions are produced. Every reduction must be accompanied by oxidation, so the TeO_2 must have been oxidised. The only known higher oxidation state for Te is +VI, so presumably an ion similar to SO_4^{2-} is produced. Work out the equation for the overall reaction that has occurred.

Oxidation half-equation
.....
Reduction half-equation
Redox equation

[5 marks]

SEE NEXT PAGE

9. One of the contaminants in river water caused by run-off from superphosphate is the sulfate ion. To analyse for sulfate ion in the river water, the solution is first acidified (to prevent the phosphate ion from reacting in the next step); barium chloride solution is then added and the precipitated barium sulfate weighed.

To write the equation for the precipitation reaction, is it necessary to know the formula of superphosphate? Give a reason for your answer.

[2 marks]

Write the equation for the precipitation reaction.

[2 marks]

Why does acidifying prevent precipitation of barium phosphate but not barium sulfate?

[2 marks]

Both hydrochloric acid and sulfuric acid are available for acidifying the test solution. Which would you choose and why?

[2 marks]

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10. Gold metal is quite inert to oxygen. However, in the presence of oxygen and potassium cyanide solution the following equilibrium is set up.



The reaction is exothermic.

In each case state how the equilibrium will shift.

What is done	How the equilibrium shifts. Write '→', '←', or 'no change'
More gold powder is added to the system.	
The pressure of the oxygen is increased.	
The temperature of the system is increased.	

[3 marks]

The above equilibrium is a crucial part of both the old gold/cyanide process and the modern Carbon-in-Pulp process. What is the function of the carbon in the CIP process?

[1 mark]

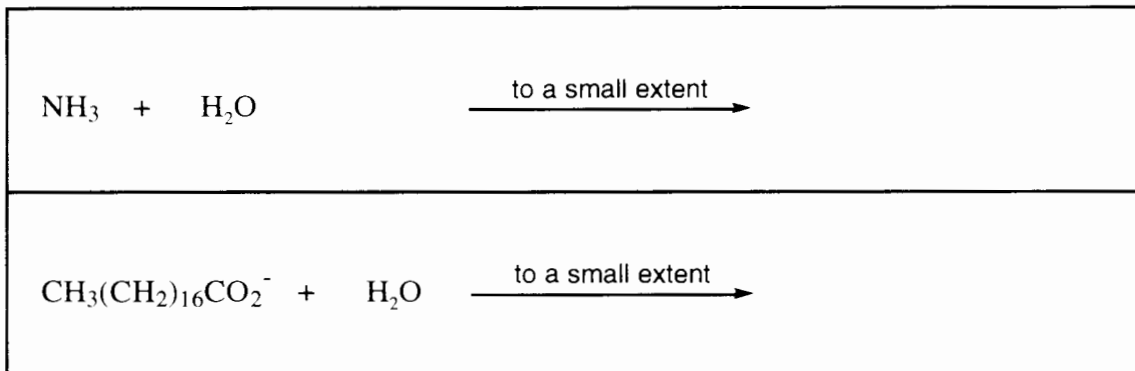
The CIP extraction is carried out at pH 10. If the pH is lowered, the above equilibrium favours the formation of the $\text{Au}(\text{CN})_2^{-}$ complex. Give two reasons why the oxidation of the gold is not carried out in acid solution, say pH 4.

Give a chemical reason:
Give a practical reason:

[2 marks]

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11. The active ingredients in two common cleaning agents are ammonia and octadecanoate ion (stearate ion). Both of the species work, in part, by reacting to a small extent with water to make the solution basic. Complete the equations to show the reactions that make the solutions slightly basic.



[2 marks]

Octadecanoate ion also dissolves grease in a way that ammonia does not. How does the ion do this?

[1 mark]

Ammonia solution is appropriate for cleaning floors, but generally sodium octadecanoate solution is not. Suggest one reason for this.

[1 mark]

Sodium octadecanoate solution is appropriate for cleaning one's body in a bath or shower, but generally ammonia solution is not. Suggest one reason for this.

[1 mark]

12. Not all solutions of salts are neutral. Complete the following table stating whether the following solutions are acidic ($\text{pH} < 7$), neutral ($\text{pH} = 7$) or basic ($\text{pH} > 7$).

Solute (0.1 mol L^{-1})	pH of solution Write 'acidic', 'neutral', or 'basic'
NH_4Cl	
Na_2CO_3	
NaCl	
KCH_3CO_2	

[4 marks]

13. Classify each of the substances in the table below as one of the following:

- aldehyde
- alkane
- alkene
- alkyne
- amine
- carboxylic acid
- ester
- haloalkane
- ketone
- primary alcohol
- secondary alcohol
- tertiary alcohol

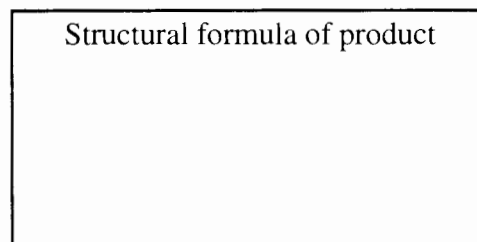
Compound	Class	Compound	Class
$(\text{CH}_3)_2\text{CHCH}(\text{CH}_3)_2$		$\text{CH}_3\text{CHBrCH}_3$	
$\text{CH}_3\text{CH}(\text{OH})\text{CH}_3$		$\text{CH}_3\text{COCH}_2\text{CH}_3$	
$\text{CH}_3\text{CH}(\text{NH}_2)\text{CH}_3$		$\text{CH}_3\text{CH}_2\text{OOCCH}_3$	
HCOCH_3		HCOOCH_3	

[4 marks]

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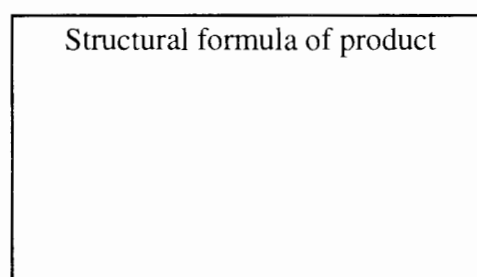
14. Draw the structural formula for the organic product formed in each of the following experiments.

- (a) A small amount of sodium is added to 1-propanol.



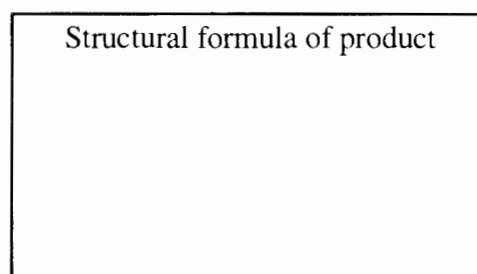
[1 mark]

- (b) 2-Propanol is warmed with a water-solution containing potassium dichromate and sulfuric acid.



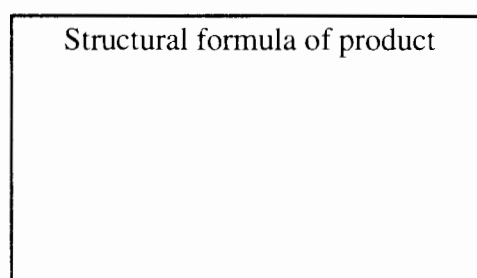
[1 mark]

- (c) Hydrogen bromide gas is bubbled into cyclohexene.



[1 mark]

- (d) Butanoic acid is added to dilute sodium hydroxide solution.



[1 mark]

END OF PART 2

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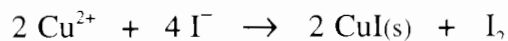
PART 3 (50 marks = 25% of paper)

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.

- 1 Copper(II) sulfate may be converted into copper(II) chloride by treatment of a copper(II) sulfate solution with the calculated quantity of barium chloride solution, removing the precipitate and evaporating the filtrate. A 2.136 g sample of copper(II) sulfate pentahydrate was converted into copper(II) chloride by this procedure.
- (a) Calculate the mass of barium chloride dihydrate that must be dissolved in water and added quantitatively to the copper(II) sulfate solution in order to bring about this conversion. Show your working. [4 marks]
- (b) Calculate the mass of the precipitate. Show your working. [2 marks]
- (c) The solution is then evaporated until the crystals just begin to form. The mixture is then allowed to cool and the blue-green crystals filtered off, washed with a little water and allowed to dry. In the experiment 0.785 g of pure copper(II) chloride dihydrate was obtained. Calculate the percentage yield. Show your working. [3 marks]
- (d) If the solution were evaporated to dryness you might get a 100% yield of copper(II) chloride dihydrate. Suggest one reason why this is not done in practice. [1 mark]
- (e) Another method of bringing about this conversion is to add the copper(II) sulfate solution to sodium carbonate solution. The precipitate is then filtered, washed with water, and dissolved in dilute hydrochloric acid. When the resulting solution is filtered and evaporated, copper(II) chloride dihydrate is obtained. Is it necessary to weigh the sodium carbonate accurately to prepare this solution? Explain your answer. [2 marks]
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3. A copper sulfide ore was analysed by iodometry in the following way. The ore was finely crushed and a representative sample of 6.056 g was brought into solution with a mixture of concentrated hydrochloric acid and concentrated nitric acid. The excess hydrochloric and nitric acids were removed by heating with a little concentrated sulfuric acid. The remaining solution was quantitatively transferred into a 250.0 mL volumetric flask and the solution made up to the mark with water.

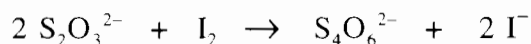
25.00 mL portions of the above solution were each treated as follows. Sodium acetate was added to bring the pH to 4. Then an excess of potassium iodide solution was added, and iodine was liberated according to the following equation.



Each portion was titrated with 0.05103 mol L⁻¹ sodium thiosulfate (Na₂S₂O₃) using starch indicator (which was added towards the end of the titration). The following figures were obtained.

Final reading (mL)	17	16.5	15.68	15.12	16.28	
Initial reading (mL)	0.22	1.10	0.66	0.06	1.24	

The equation for the reaction of iodine with sodium thiosulfate is as follows:



Starch is blue in the presence of I₂. The end-point is taken to be the loss of all blue colour.

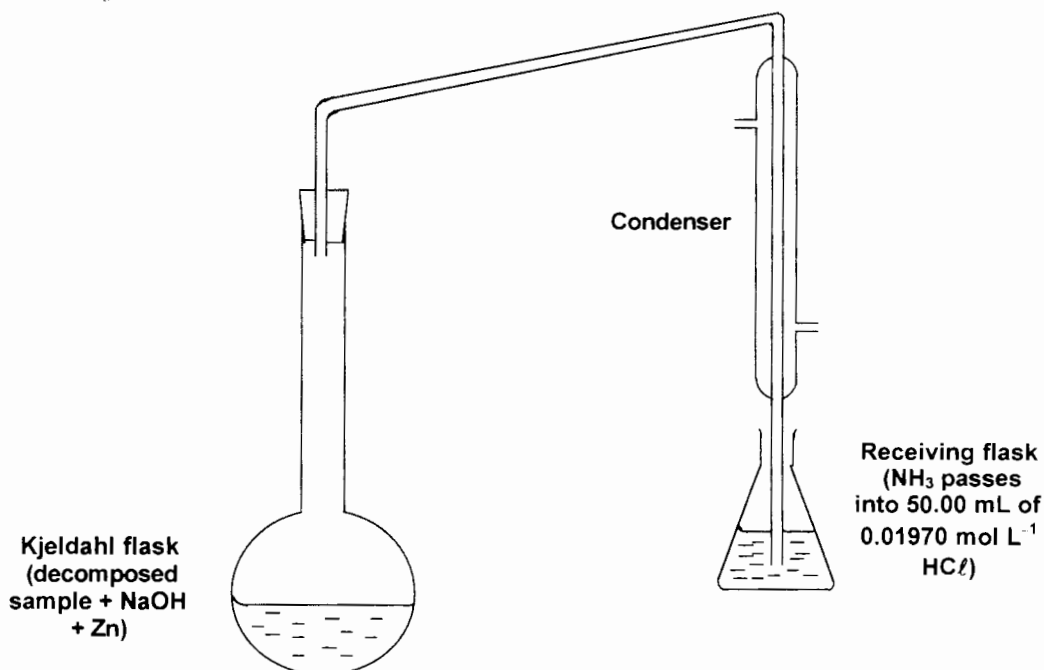
- (a) (i) How many moles of iodine are liberated from one mole of copper(II) ion?
[1 mark]
- (ii) How many moles of thiosulfate ion are required for one mole of iodine?
[1 mark]
- (iii) How many moles of thiosulfate ion are required for one mole of copper(II) ion?
[1 mark]
- (b) What titration volume should you use in the calculation? Show your working.
[1 mark]
- (c) Calculate the percentage by mass of copper in the ore. Show your working.
[5 marks]

4. The Kjeldahl method is used to analyse for nitrogen in an organic substance. The substance is treated with concentrated H_2SO_4 , using anhydrous CuSO_4 as a catalyst; all nitrogen is converted into NH_4^+ ion.

The mixture is then treated with excess OH^- to convert the NH_4^+ ion into NH_3 . The NH_3 is boiled off and absorbed in an excess of dilute HCl .

In a Kjeldahl determination 1.2540 g of dried pet food was heated for an hour with concentrated H_2SO_4 and anhydrous CuSO_4 (together with K_2SO_4 to raise the boiling-point of the reaction mixture).

On cooling the reaction mixture, Zn pieces and an excess of concentrated NaOH solution were added and the flask quickly attached to a distillation apparatus as shown below. The mixture was gently boiled to drive the NH_3 into the receiving flask. (The Zn dissolves to give $\text{Zn}(\text{OH})_4^{2-}$ and H_2 gas; the H_2 gas helps sweep out all the NH_3 .) The NH_3 was distilled into 50.00 mL of $0.01970 \text{ mol L}^{-1} \text{ HCl}$.



- (a) Calculate the original number of moles of H^+ in the solution in the receiving flask before any NH_3 was absorbed. Show your working. [1 mark]
- (b) After the NH_3 had been absorbed by the HCl solution, the excess HCl was titrated with $0.1000 \text{ mol L}^{-1} \text{ NaOH}$ (in the burette). Methyl orange was used as indicator; 5.62 mL of NaOH solution was needed for the colour change. Calculate the number of moles of H^+ in this solution after the absorption of the NH_3 . Show your working. [2 marks]
- (c) Calculate the number of moles of NH_3 absorbed by the HCl solution, and hence the percentage by mass of nitrogen in the 1.2540 g of dried pet food. Show your working. [5 marks]
- (d) During the decomposition of the pet food (with H_2SO_4 , CuSO_4 and K_2SO_4) there is no stopper on the flask. Why is nitrogen not lost? [1 mark]

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 1½ - 2 pages. Begin your essay on the next page.

1. The following table gives some data about several elements in the fourth row of the Periodic Table.

Element	Melting-point (°C)	First ionisation energy (MJ mol ⁻¹)	Electrical conductivity κ (MS m ⁻¹)	Chloride and its melting-point (°C)
potassium K	63	0.43	14	KCl 770
chromium Cr	1857	0.66	8	CrCl ₃ 1150
germanium Ge	937	0.77	10 ⁻⁶	GeCl ₄ - 50
bromine Br	-7	1.15	10 ⁻¹⁶	BrCl - 66

Discuss the bonding in these elements and in their chlorides, and so account for the way in which the values relate to the structure of the elements and their chlorides at the atomic level.

OR

2. In an electrochemical cell, a chemical reaction is used to generate an electric current. In an electrolytic cell, an electric current is used to generate a chemical reaction. Compare and contrast the two processes. Include diagrams and examples.

OR

3. Discuss isomerism.

END OF QUESTIONS

SEE NEXT PAGE