



TERTIARY ENTRANCE EXAMINATION, 1996

QUESTION/ANSWER BOOKLET

CHEMISTRY

Please place your student identification label in this box

SEA 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 Secondary Education Authority 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	13	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 SEA Student Number is on your Question/Answer Booklet and on your separate Multiple Choice Answer Sheet.

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 $\text{BaSO}_4(\text{s})$, $\text{Cu}(\text{s})$, $\text{Na}_2\text{CO}_3(\text{s})$].

SEE NEXT PAGE

PART 1

Answer ALL questions in Part 1 on the separate Multiple Choice Answer Sheet provided, using a 2B, B or HB pencil. This part carries 60 marks—2 marks for each question (30% of the total).

1. An element has the first five successive ionisation energies

0.6 1.2 4.9 6.5 8.2 MJ mol⁻¹ .

Which one of the following is it?

- (a) aluminium
 - (b) argon
 - (c) calcium
 - (d) carbon
 - (e) sodium
2. In which one of the following is there no covalent bond?
- (a) diamond
 - (b) sodium fluoride
 - (c) sodium sulfate
 - (d) sulfur dioxide
 - (e) sulfur trioxide
3. Which one of the following molecules is bent (non-linear)?
- (a) BeF₂
 - (b) C₂H₂
 - (c) CO₂
 - (d) HCN
 - (e) H₂Se

4. Which of the following **best** explains why metals conduct electricity?
- (a) All metals are strongly electronegative.
 - (b) In a metal crystal lattice, the metal atoms are not bonded strongly to each other.
 - (c) Metal atoms have two electrons in their valence shells and these are easily removed.
 - (d) Metals are in the bottom left hand region of the Periodic Table.
 - (e) The valence electrons of a metal do not belong to a particular atom but to the crystal or liquid as a whole.
5. Which of the following **best** explains why water has a lower boiling-point than sodium chloride?
- (a) The bonding in water is weaker than the bonding in sodium chloride.
 - (b) The covalent bonds in water are weaker than the ionic bonds in sodium chloride.
 - (c) The van der Waals forces between water molecules are weaker than the ionic bonds in sodium chloride.
 - (d) The molecular weight of water (18.02) is lower than the molecular weight of sodium chloride (58.44).
 - (e) A mole of water occupies a smaller volume (18.02 mL) than a mole of sodium chloride (27.01 mL).
6. Which of the following is least soluble in water?
- (a) $\text{CH}_3\text{CH}_2\text{OH}$
 - (b) $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{OH}$
 - (c) CH_3COCH_3
 - (d) $\text{HOCH}_2\text{CHOHCH}_2\text{OH}$
 - (e) $\text{HOCH}_2\text{CH}_2\text{OH}$

7. A stock solution contains 1.00 g L^{-1} copper (as Cu^{2+}). What volume of this solution must be diluted to 50.0 mL to give a solution containing 5.00 mg L^{-1} copper?
- (a) 0.100 mL
(b) 0.250 mL
(c) 1.00 mL
(d) 2.50 mL
(e) 10.0 mL
8. Which one of the following statements about trends in the elements of Periodic Group IV is **false**?
- (a) Bonding in the elements tends to change from covalent to metallic going down the group.
(b) Electrical conductivity in the elements tends to rise going down the group.
(c) The melting point of the chlorides of the elements tends to fall going down the group.
(d) The melting point of the elements tends to fall going down the group.
(e) The oxides of the elements tend to become more basic going down the group.
9. Which one of the following **best** describes what happens when magnesium chloride solution is added to dilute nitric acid?
- (a) $\text{MgCl}_2 + 2 \text{HNO}_3 \rightarrow \text{Mg}(\text{NO}_3)_2 + 2 \text{HCl}$
(b) $\text{Mg}^{2+} + 2 \text{NO}_3^- \rightarrow \text{Mg}(\text{NO}_3)_2$
(c) $\text{H}^+ + \text{Cl}^- \rightarrow 2 \text{HCl}$
(d) $\text{Cl}^- + \text{HNO}_3 \rightarrow \text{HCl} + \text{NO}_3^-$
(e) There is no reaction.
10. The following pairs of substances are mixed. In which one of these will there be no visible reaction?
- (a) barium hydroxide solution and dilute sulfuric acid
(b) bromine water (a solution of bromine in water) and cyclohexene
(c) chlorine water (a solution of chlorine in water) and sodium iodide solution
(d) dilute hydrochloric acid and sodium hydroxide solution
(e) dilute sulfuric acid and potassium chromate solution

11. Each of the following examples is a set of three water-solutions. In which one of the sets could all three solutions be distinguished from one another by colour alone?
- barium bromide, barium chloride, barium nitrate
 - lead nitrate, mercury(II) chloride, zinc sulfate
 - magnesium nitrate, manganese nitrate, silver nitrate
 - nickel nitrate, nickel sulfate, tetraamminenickel(II) sulfate
 - sodium chromate, sodium dichromate, sodium sulfate
12. A chemist wishes to make a fertiliser solution containing ions that will act as a source of nitrogen, phosphorus and potassium. Which one of the following mixtures will completely dissolve to give such a solution?
- $\text{Ca}(\text{NO}_3)_2$ KCl Na_3PO_4
 - $\text{Ca}(\text{NO}_3)_2$ K_2CO_3 $(\text{NH}_4)_2\text{HPO}_4$
 - $\text{Ca}(\text{NO}_3)_2$ K_3PO_4 $(\text{NH}_4)_2\text{HPO}_4$
 - $\text{Ca}_3(\text{PO}_4)_2$ KCl NaNO_3
 - $(\text{NH}_4)_2\text{HPO}_4$ NaNO_3 K_2CO_3
13. Which one of the following oxides dissolves in water to give a strongly basic solution?
- sodium oxide
 - magnesium oxide
 - aluminium oxide
 - sulfur dioxide
 - sulfur trioxide
14. A chemist carries out a titration and records the following figures in her report book.

Final reading (mL)	23	22.53	22.59	22.01	22.37	
Initial reading (mL)	0.02	1.07	1.15	1.56	0.89	

What titration figure should she use in her subsequent calculation?

- 21.208 mL
- 21.21 mL
- 21.46 mL
- 21.56 mL
- 21.562 mL

15. Solid sodium carbonate is added to deionised water at pH 7.00. Which one of the following statements is correct?
- (a) The pH decreases because of the reaction of CO_3^{2-} with water.
 - (b) The pH decreases because of the reaction of Na^+ with water.
 - (c) The pH increases because of the loss of carbon dioxide.
 - (d) The pH increases because of the reaction of CO_3^{2-} with water.
 - (e) The pH increases because of the reaction of Na^+ with water.
16. Which one of the following species acts as an acid when ammonia gas is passed into a water solution of sodium chloride?
- (a) Cl^-
 - (b) H_2O
 - (c) Na^+
 - (d) NH_3
 - (e) None of these species, since no acid/base reaction occurs.
17. A 0.100 mol L^{-1} acetic acid (ethanoic acid) solution is 1.34% ionised. What is the pH of the solution?
- (a) 0.34
 - (b) 0.87
 - (c) 1.00
 - (d) 1.34
 - (e) 2.87

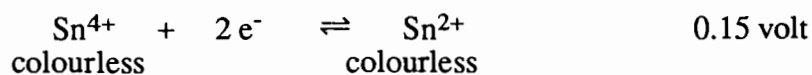
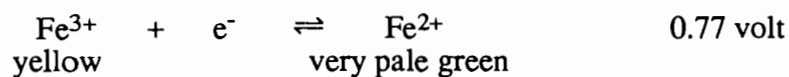
18. A series of four NaOH solutions with different concentrations was prepared, and tested with the indicator Brilliant Cresyl Blue. The results are set out below.

pH	Colour with Brilliant Cresyl Blue
10.0	blue
11.0	green
12.0	yellow
13.0	yellow

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

Unknown solution	Colour with Brilliant Cresyl Blue
A	blue
B	yellow

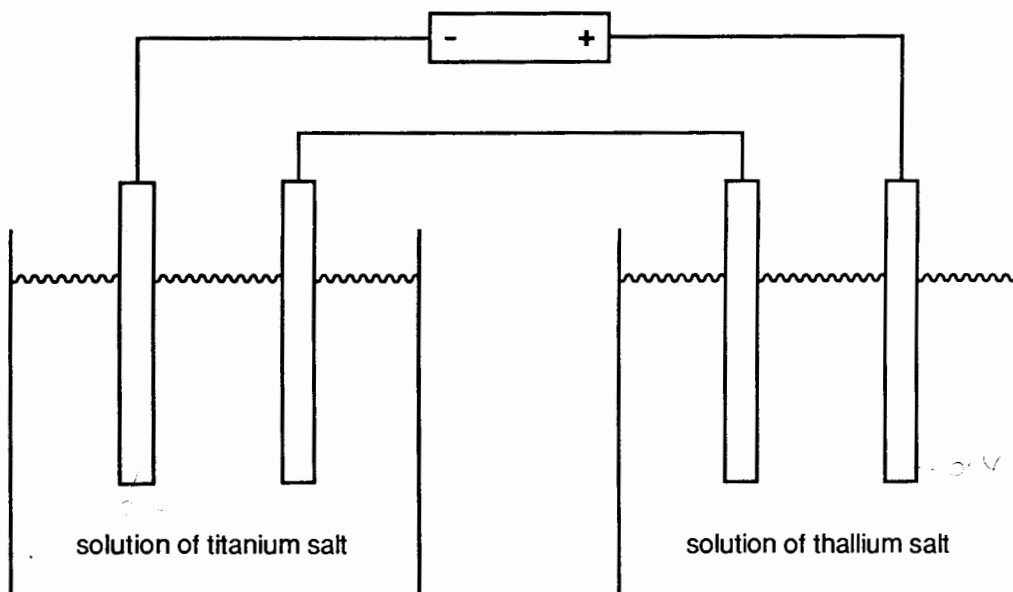
- (a) The pH of A is 10, and the pH of B is 12.
- (b) The pH of A is 10, and the pH of B is between 12 and 13.
- (c) The pH of A is 10, and the pH of B is 12 or more.
- (d) The pH of A is 10 or less, and the pH of B is between 12 and 13.
- (e) The pH of A is 10 or less, and the pH of B is 12 or more.
19. Standard Reduction Potentials for the iron(III)/iron(II) couple and the tin(IV)/tin(II) couple are given below, along with the colours of the ions.



In which one of the following experiments would you observe a colour change?

- (a) Iron(II) chloride solution is added to tin(II) chloride solution.
- (b) Iron(II) chloride solution is added to tin(IV) chloride solution.
- (c) Iron(III) chloride solution is added to tin(II) chloride solution.
- (d) Iron(III) chloride solution is added to tin(IV) chloride solution.
- (e) In none of the experiments is a colour change observed.

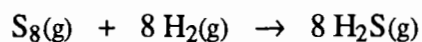
20. One solution contains a titanium (Ti) salt, and a second solution contains a thallium (Tl) salt. When a quantity of electricity is passed through the two solutions as shown in the diagram below, 0.20 mol of Ti is deposited on one cathode and 0.40 mol of Tl on the other cathode.



Which of the following conclusions can be drawn from these observations **alone**?

- I Both the Ti and the Tl ions are positively charged.
- II The charge on the Ti ion is double that on the Tl ion.
- III The Ti ion has a 2+ charge.
- IV The Tl ion has a 1+ charge.

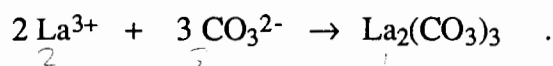
- (a) I and II only
 - (b) II only
 - (c) II, III and IV only
 - (d) All of I, II, III and IV
 - (d) None of I, II, III and IV
21. At 500°C sulfur vapour reacts with hydrogen gas as follows.



When 1.0 L of sulfur vapour (at 500°C and 1.00 atm) reacts with excess hydrogen gas what volume of hydrogen sulfide (measured at 500°C and 1.00 atm) is produced?

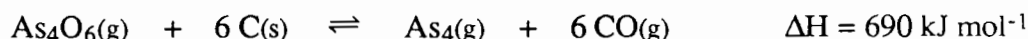
- (a) 1.0 L
- (b) 8.0 L
- (c) 9.0 L
- (d) 17.0 L
- (e) None of these

22. Lanthanum carbonate is insoluble, and precipitates according to the equation



A solution containing 0.600 mol of lanthanum nitrate is added to a solution containing 0.600 mol of sodium carbonate. How much lanthanum carbonate is precipitated?

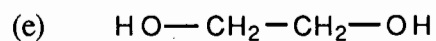
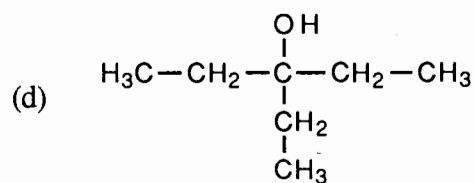
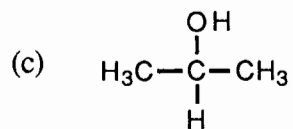
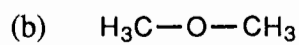
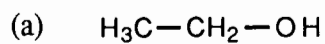
- (a) 0.20 mol
 - (b) 0.30 mol
 - (c) 0.50 mol
 - (d) 0.60 mol
 - (e) 1.20 mol
23. The element arsenic is obtained from its ores by first allowing the arsenic-containing ore to react with oxygen to form As_4O_6 . The As_4O_6 is then reduced at 750°C using coke as follows.



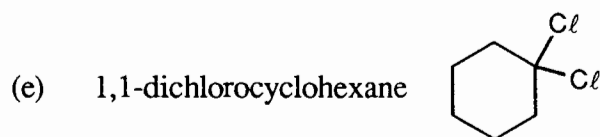
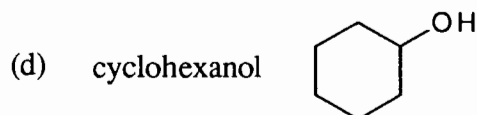
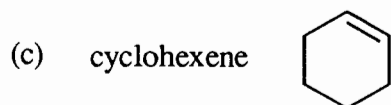
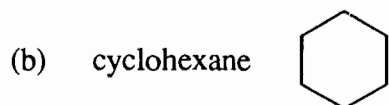
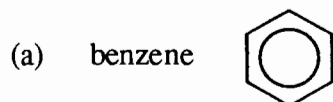
For this equilibrium process, which one of the following statements is correct?

- (a) The equilibrium constant $K = \frac{[\text{As}_4][\text{CO}]^6}{[\text{As}_4\text{O}_6][\text{C}]^6}$
- (b) The equilibrium yield of As_4 could be increased by decreasing the temperature of the system.
- (c) The equilibrium yield of As_4 could be increased by grinding the coke before reaction.
- (d) The equilibrium yield of As_4 could be increased by reducing the pressure in the reaction vessel.
- (e) The equilibrium yield of As_4 could be increased by using a suitable catalyst.

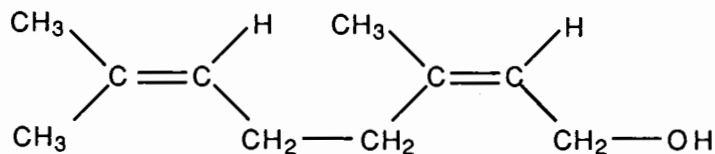
24. Which one of the following is a secondary alcohol?



25. When an organic compound was treated with chlorine in the presence of ultraviolet light, a major reaction product was chlorocyclohexane. Which one of the following was the original organic compound?



26. The following is the structural formula for the natural oil geraniol.



Which one of the following statements about geraniol is **false**?

- (a) *Cis/trans* isomerism can occur about each of the double bonds.
 (b) It is an alcohol.
 (c) It will decolourise a water-solution containing potassium permanganate and sulfuric acid.
 (d) It will decolourise bromine water.
 (e) With controlled oxidation, the $-\text{CH}_2\text{OH}$ group of geraniol can be converted into $-\text{COOH}$.

27. Which one of the following is **not** used in sulfuric acid manufacture?

- (a) $\text{H}_2 + \text{S} + 2 \text{O}_2 \rightarrow \text{H}_2\text{SO}_4$
 (b) $4 \text{FeS}_2 + 11 \text{O}_2 \rightarrow 2 \text{Fe}_2\text{O}_3 + 8 \text{SO}_2$
 (c) $\text{S} + \text{O}_2 \rightarrow \text{SO}_2$
 (d) $2 \text{SO}_2 + \text{O}_2 \rightarrow 2 \text{SO}_3$
 (e) $\text{SO}_3 + \text{H}_2\text{SO}_4 \rightarrow \text{H}_2\text{S}_2\text{O}_7$

28. There are several general industrial methods for obtaining metals. Which of the following is **not** one of these? In other words, which one of the following statements is **false**?

	Industrial process	Examples
(a)	A molten salt of a very reactive metal can be electrolysed to produce the metal.	$\text{Al}_2\text{O}_3(\ell)$ to give Al $\text{NaCl}(\ell)$ to give Na
(b)	A solution of a salt of a moderately reactive metal can be electrolysed to produce the metal.	$\text{Ni}^{2+}(\text{aq})$ to give Ni $\text{Sn}^{2+}(\text{aq})$ to give Sn
(c)	A sulfide ore of a moderately reactive metal can be roasted in air to produce sulfur dioxide and the metal.	$\text{MnS}(\text{s})$ to give Mn $\text{PbS}(\text{s})$ to give Pb
(d)	An oxide ore of a moderately reactive metal can be heated with carbon to produce a carbon oxide and the metal.	$\text{Fe}_3\text{O}_4(\text{s})$ to give Fe $\text{SnO}_2(\text{s})$ to give Sn
(e)	The least reactive metals occur free in nature and they are obtained by methods which involve separating the metal from rock and sand.	Au Pt

29. Blister copper may contain iron, cobalt, nickel, zinc, silver, platinum and gold as impurities. When blister copper is refined by electrolysis, what happens to the cobalt and the platinum impurities?
- (a) Both the cobalt and the platinum finish up as ions in the electrolyte solution.
 - (b) Both the cobalt and the platinum fall to the bottom of the electrolysis vessel as part of the anode mud.
 - (c) Both the cobalt and the platinum remain in the blister copper anode which becomes increasingly impure.
 - (d) The cobalt finishes up as Co^{2+} in the electrolyte solution and the platinum falls to the bottom.
 - (e) The cobalt falls to the bottom and the platinum finishes up as Pt^{2+} in the electrolyte solution.
30. The Carbon-in-Pulp Process for the extraction of gold is operated at a pH between 9.2 and 10.5. Which one of the following chemicals is used to control the pH?
- (a) activated carbon
 - (b) calcium hydroxide
 - (c) oxygen
 - (d) sodium cyanide
 - (e) water

END OF PART 1

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PART 2

Answer ALL questions in Part 2 in the spaces provided below. This part carries 70 marks (35% of the total).

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 a reaction occurs but the change is not visible, you should state this.

- (a) Dilute hydrochloric acid is added to silver nitrate solution.

Equation _____

Observation _____

[3 marks]

- (b) Dilute sulfuric acid is added to nickel carbonate.

Equation _____

Observation _____

[3 marks]

- (c) A piece of copper foil is dropped into concentrated nitric acid.

Equation _____

Observation _____

[3 marks]

- (d) A small piece of sodium is added to ethanol.

Equation _____

Observation _____

[3 marks]

2. Write a structural formula to give an example of each of the following.

A polar molecule that contains at least one polar bond	
A polar molecule that contains at least one non-polar bond	
A non-polar molecule that contains at least one non-polar bond	
A non-polar molecule that contains at least one polar bond	

[4 marks]

3. Draw a structural formula for each of the following species, 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]

Methanethiol, CH_3SH	Nitrite ion, ONO^- (or NO_2^-)
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[4 marks]

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

(a) A calcium atom _____

(b) An oxide ion _____

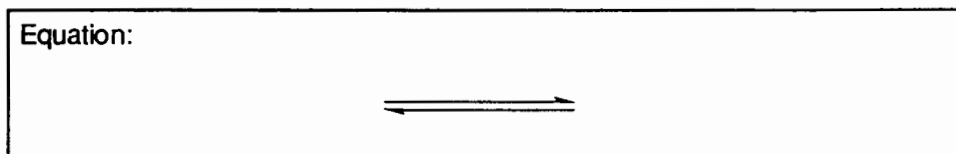
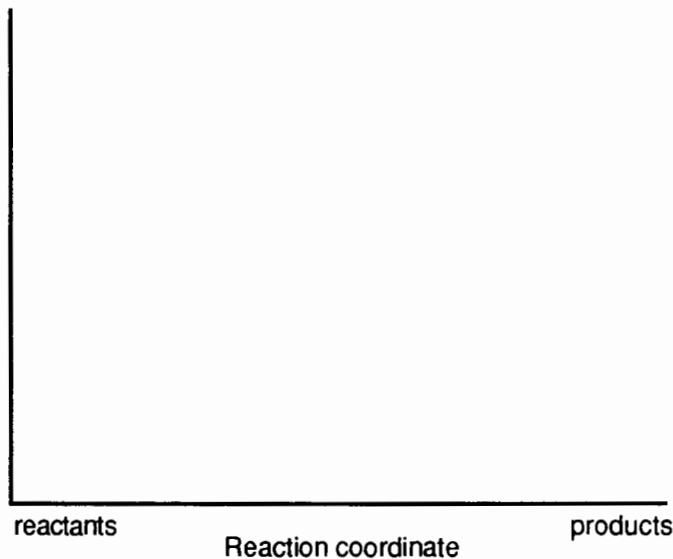
[2 marks]

5. For each of the following pairs of compounds, describe a chemical test to distinguish between them. Give all steps, but equations are not required.

	Your chemical test. Describe fully	What you would observe in each case
Cu(NO ₃) ₂ and CuSO ₄		with Cu(NO ₃) ₂
		with CuSO ₄
MgCl ₂ and ZnCl ₂		with MgCl ₂
		with ZnCl ₂
CH ₃ CH ₂ OH and CH ₃ COOH		with CH ₃ CH ₂ OH
		with CH ₃ COOH

[6 marks]

6. In the thermite process, a finely-ground mixture of aluminium powder and iron(III) oxide can react to produce white-hot molten iron. This mixture has first to be ignited with burning magnesium.
- On the axes below, draw a potential energy diagram for the reaction between aluminium and iron(III) oxide.
 - Label the vertical coordinate.
 - In the box below, write the equation for this reaction.



[4 marks]

7. Work out the equation for the reaction that occurs when propan-2-ol is warmed with a water-solution containing potassium dichromate and sulfuric acid.

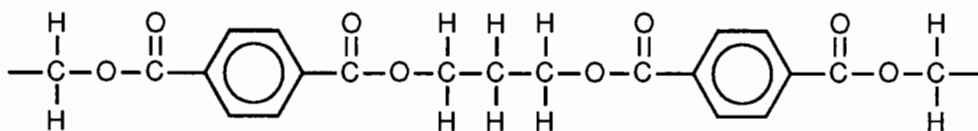
Oxidation half-equation
Reduction half-equation
Redox equation

[5 marks]

8. Draw structural formulae for and name all isomers of molecular formula C_3H_5Cl .

Structures	Names
[5 marks]	[3 marks]

9. The following is part of the structure of a polymer.



Draw a structural formula for each of the monomers needed to produce the polymer.

[2 marks]

10. An amine may be regarded as an alkyl-substituted ammonia. Butylamine (1-butanamine, $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{NH}_2$) is a liquid with a low boiling-point and a strong ammonia-like fishy stink.

When a sample of butylamine is shaken with excess 0.1 mol L^{-1} hydrochloric acid the resulting solution has no odour. What has happened to the butylamine molecules?

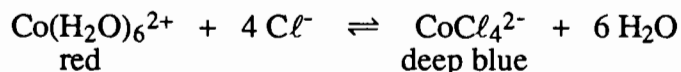
Why was the odour lost?

When a little 0.1 mol L^{-1} sodium hydroxide is shaken with the resulting mixture the strong fishy stink returns. Why is this?

Why was **excess** dilute hydrochloric acid needed to get rid of the odour, but only **a little** sodium hydroxide solution needed to bring it back?

[4 marks]

11. When cobalt chloride is dissolved in dilute hydrochloric acid the following equilibrium is set up.



Both the red ion and the deep blue ion are present in the reaction mixture which is therefore purple. Three test-tubes are set up, each containing some of the equilibrium mixture. Each of the tubes is treated as described below. In each case state how the equilibrium will shift, and what will be observed.

What is done	How the equilibrium shifts. Write '→', '←', or 'no change'	What is observed. Give the complete observation
A little concentrated hydrochloric acid is added to the first tube		
A little silver nitrate solution is added to the second tube		
A little concentrated cobalt nitrate solution is added to the third tube		

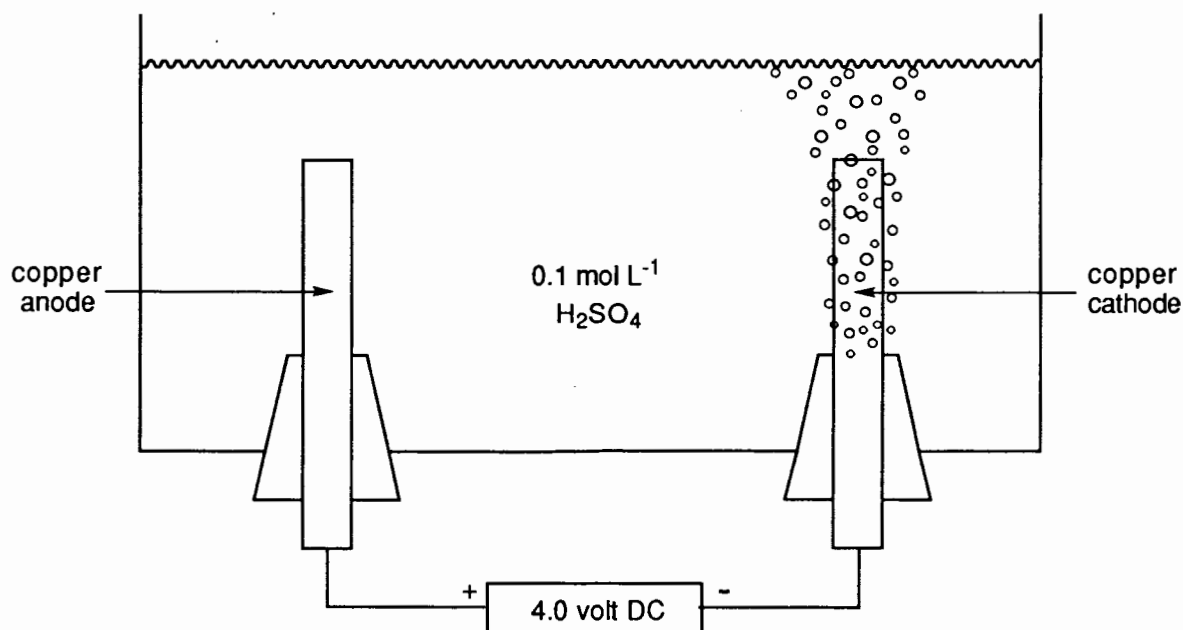
[8 marks]

12. Explain the following.

	Explanation
Finely-chopped pieces of wood ignite faster than large lumps of wood.	
Nitrogen reacts faster with hydrogen when a high pressure is used.	
Sulfur dioxide reacts faster with oxygen when a suitable catalyst is used.	

[6 marks]

13. A student is asked to demonstrate that water is made from the elements hydrogen and oxygen. He decides to set up the following apparatus.



To his surprise a colourless gas is liberated from the cathode as expected, but no gas is liberated from the anode!

Write the equation for the reaction occurring at the cathode.

Write the equation for the reaction actually occurring at the anode.

Describe how this anode reaction could be observed?

How should the student modify the apparatus so that the intended demonstration is successful?

Write the equation for the intended anode reaction.

[5 marks]

END OF PART 2

SEE PAGE 22

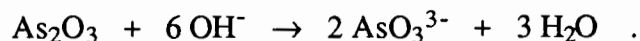
PART 3

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. This part carries 50 marks (25% of the total).

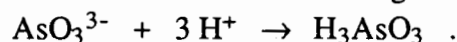
1. A pure substance 'A' is a colourless liquid which boils at 57°C and has a strong odour. 'A' burns readily in air leaving no ash, and qualitative analysis shows that nitrogen, sulfur, and the halogens are absent. It may thus be concluded that 'A' contains the elements carbon and hydrogen, and possibly oxygen.
- (a) In an experiment, 0.6047 g of 'A' is burnt in a current of dry air, and 1.078 g of carbon dioxide and 0.441 g of water are produced. Calculate the empirical formula of 'A'. [5 marks]
- (b) At 100°C and 1.00 atm pressure, 0.1367 g of 'A' evaporates to occupy a volume of 57 mL. Calculate the molecular weight of 'A'. [4 marks]
- (c) What is the molecular formula of 'A'? [1 mark]
- (d) A nuclear magnetic resonance spectrum of 'A' indicates that all the H atoms in 'A' are in methyl groups. Draw the structural formula for 'A'. [1 mark]

2. Cerium(IV) ion is an important industrial oxidising agent, but no cerium(IV) compound is a primary standard. Cerium(IV) solutions can be standardised as follows:

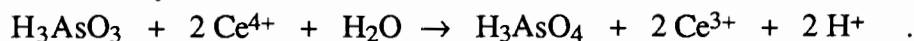
The primary standard arsenic(III) oxide is dissolved in sodium hydroxide solution which converts it to arsenite ion:



Dilute sulfuric acid is then added to give arsenious acid:



The arsenious acid is then titrated with cerium(IV) sulfate solution, using osmium tetroxide as catalyst and ferroin as indicator:



A 0.2476 g sample of arsenic(III) oxide is treated as described above, and ultimately when the sample is titrated, it requires 46.34 mL of unknown cerium(IV) sulfate solution.

- (a) Use the above equations to work out how many moles of cerium(IV) ion will react with the arsenious acid produced from 1 mole of arsenic(III) oxide. [3 marks]
- (b) Use this value to calculate the concentration of the $\text{Ce}(\text{SO}_4)_2$ solution. [5 marks]

Lined writing area consisting of horizontal lines for text entry.

3. A brand of toilet cleaner claims on the label to contain
Sodium hydrogensulfate NaHSO_4 , 410 g/kg.

A chemist wishes to verify this claim by carrying out a volumetric analysis, using a standard solution of $0.04343 \text{ mol L}^{-1}$ sodium hydroxide.

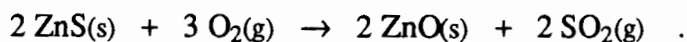
- (a) She decides to make a solution of the toilet cleaner in a 500.0 mL volumetric flask that will give a titre of 20.00 mL when titrated against 20.00 mL of the sodium hydroxide solution. Assume that the claimed contents of the cleaner are correct, and calculate the mass of the cleaner she should take to make the 500.0 mL of solution.

[5 marks]

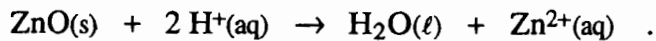
- (b) By incredible good fortune she weighs out exactly the mass of cleaner she has calculated in part (a). Using phenolphthalein as indicator, she then finds that a titre of 18.00 mL of the cleaner solution is needed for reaction with 20.00 mL of the sodium hydroxide solution. What is the actual concentration of the cleaner in g/kg of sodium hydrogensulfate?

[2 marks]

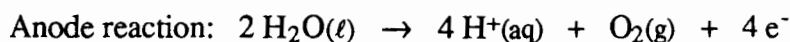
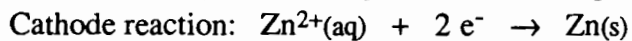
4. Zinc metal is obtained from the ore zinc blende. Zinc blende is mainly zinc sulfide, ZnS . The ore is concentrated by flotation and then heated in air, which converts the zinc sulfide into zinc oxide:



The zinc oxide is then dissolved in dilute sulfuric acid:



An electric current is passed through the solution to produce the pure metal.



- (a) A current of 12.50 ampere is passed through a solution containing zinc ion for 7.50 hours. Calculate

(i) the theoretical mass of zinc deposited at the cathode, and

[5 marks]

(ii) the theoretical volume of dry oxygen (at 1.00 atm and 25°C) produced at the anode.

[2 marks]

- (b) A 503 kg sample of zinc blende ore is treated, and 213 kg of zinc metal obtained. If the flotation process is 89% efficient, and the electrolysis step is 92% efficient, calculate the percentage by mass of zinc sulfide in the ore.

[5 marks]

5. Copper sulfate is dissolved in water, and treated with excess concentrated ammonia solution until the initial precipitate of copper hydroxide dissolves to yield a deep blue solution. When ethanol is added to the solution deep blue crystals precipitate. The isolated crystals smell of ammonia, and are presumably a complex salt with formula $\text{Cu}(\text{NH}_3)_x\text{SO}_4 \cdot y\text{H}_2\text{O}$.
- (a) 1.0087 g of the complex salt is heated at 300°C to constant weight, and the white anhydrous copper(II) sulfate which remains weighs 0.652 g. Calculate the molecular weight of the complex salt. [3 marks]
- (b) 1.4009 g of the complex salt is heated at 300°C and the ammonia so produced passed into water and made up to 250.0 mL in a volumetric flask. 20.00 mL portions of the ammonia solution are titrated with $0.09880 \text{ mol L}^{-1}$ hydrochloric acid using methyl orange as indicator. The average titre is 18.33 mL. Calculate the number of moles of ammonia in the 1.4009 g sample of the complex. [4 marks]
- (c) Use your molecular weight from part (a) and your answer to part (b) to calculate the value of x in the formula $\text{Cu}(\text{NH}_3)_x\text{SO}_4 \cdot y\text{H}_2\text{O}$. [3 marks]
- (d) Calculate the value of y , and write the full formula for the complex salt. [2 marks]
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PART 4

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, and should be written in the space beginning on page 33. This part carries 20 marks (10% of the total).

1. *Why substances dissolve.*

Discuss this topic, illustrating your answer with examples.

OR

2. Chemists use concepts to help them predict which reactions occur.

Explain, with examples, how the concepts of

* proton-transfer, and

* electron-transfer

are used in this way.

OR

3. Describe the chemistry of the transition metals; choose your examples so that they illustrate the general principles you are discussing.

END OF QUESTIONS

SEE PAGE 33