



TERTIARY ENTRANCE EXAMINATION, 2000

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

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	12	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

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

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

At the end of the examination, check that your Student Identification Label and your Student Number (in figures and words) have been placed in the spaces provided on the front cover of this 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.

- Which one of the following electron configurations represents an element that forms a monoatomic ion with a charge of -2 ?
 - $1s^22s^2$
 - $1s^22s^22p^2$
 - $1s^22s^22p^4$
 - $1s^22s^22p^6$
- 5.0 mL of CH_4 , 5.0 mL of C_2H_4 , and 25.0 mL of O_2 are mixed. All three gas volumes are measured at 25°C and 1.00 atm. The mixture is ignited. What volume of O_2 (at 25°C and 1.00 atm) is consumed in the combustion?
 - 10.0 mL
 - 15.0 mL
 - 20.0 mL
 - 25.0 mL
- Which one of the following mixtures of salts will dissolve in water to produce a clear colourless solution?
 - cadmium sulfate, potassium chloride, sodium carbonate
 - calcium nitrate, nickel sulfate, potassium carbonate
 - calcium nitrate, potassium bromide, sodium chloride
 - calcium nitrate, potassium carbonate, sodium chloride
- In the graphite crystal lattice, what is the number of nearest covalently bonded neighbours for each carbon atom?
 - 3
 - 4
 - 5
 - 6

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5. Which one of the following statements is true?
- (a) H_2O has a greater molecular polarity (dipole moment) than H_2S .
 - (b) H_2O is polar, but H_2S is non-polar.
 - (c) The molecules H_2S and H_2O are both linear.
 - (d) The molecules H_2S and H_2O both have zero molecular polarity (dipole moment).

6. The table below gives information about three pure solids designated X, Y and Z.

	X	Y	Z
Approximate melting point ($^{\circ}\text{C}$)	800	3500	1500
Electrical conductivity in the solid state	nil	moderate	high
Electrical conductivity in the liquid (melted) state	high	cannot be easily tested	high

Which of the following describes the bonding present in the three substances?

	X	Y	Z
(a)	covalent molecular	covalent network	ionic
(b)	ionic	covalent network	metallic
(c)	ionic	metallic	metallic
(d)	covalent molecular	metallic	ionic

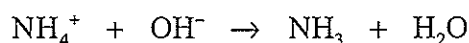
7. Which one of the following statements about graphite and diamond is true?
- (a) They have the same crystal lattice structure.
 - (b) They have the same degree of hardness.
 - (c) They have the same electrical conductivity.
 - (d) They can undergo the same chemical reactions.

8. In which one of the following does hydrogen act as an oxidising agent?
- (a) $\text{C}_2\text{H}_4 + \text{H}_2 \rightarrow \text{C}_2\text{H}_6$
 - (b) $\text{Cl}_2 + \text{H}_2 \rightarrow 2 \text{HCl}$
 - (c) $3 \text{N}_2 + 2 \text{H}_2 \rightarrow 2 \text{NH}_3$
 - (d) $2 \text{Na} + \text{H}_2 \rightarrow 2 \text{NaH}$
9. In which one of the following does the underlined element have an oxidation state of +5?
- (a) $\underline{\text{C}}\text{O}_3^{2-}$
 - (b) $\underline{\text{Cl}}\text{O}_3^-$
 - (c) $\underline{\text{Mn}}\text{O}_4^-$
 - (d) $\underline{\text{S}}\text{O}_3^{2-}$
10. In which of the following compounds is the underlined element in its highest oxidation state?
- (a) $\text{K}\underline{\text{F}}$
 - (b) $\text{K}\underline{\text{N}}\text{O}_2$
 - (c) $\text{K}_2\underline{\text{Mn}}\text{O}_4$
 - (d) $\text{K}_2\underline{\text{S}}\text{O}_3$
11. Which one of the following solutions would oxidise Br^- in 1 mol L^{-1} NaBr?
- (a) a solution containing Fe^{3+} and dilute H_2SO_4
 - (b) a solution containing H_2O_2 and dilute H_2SO_4
 - (c) a solution containing Sn^{4+} and dilute H_2SO_4
 - (d) dilute nitric acid solution

12. When an electric current is passed through 1 mol L⁻¹ KI solution between two platinum electrodes, which one of the following half-reactions occurs at the anode?

- (a) $2 \text{H}_2\text{O} \rightarrow \text{O}_2 + 4 \text{H}^+ + 4 \text{e}^-$
- (b) $2 \text{I}^- \rightarrow \text{I}_2 + 2 \text{e}^-$
- (c) $2 \text{H}_2\text{O} + 2 \text{e}^- \rightarrow \text{H}_2 + 2 \text{OH}^-$
- (d) $\text{K}^+ + \text{e}^- \rightarrow \text{K}$

13. For the reaction described by the following equation:



which one of the following statements is correct?

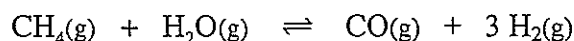
- (a) NH_4^+ is behaving as an acid.
 - (b) NH_4^+ is behaving as a base.
 - (c) NH_4^+ is oxidised.
 - (d) NH_4^+ is reduced.
14. The pH of 0.050 mol L⁻¹ solution of hydrogen cyanide is 6.40. What percentage of the hydrogen cyanide in this solution has ionised?
- (a) $4.0 \times 10^{-7} \%$
 - (b) $8.0 \times 10^{-6} \%$
 - (c) $4.0 \times 10^{-5} \%$
 - (d) $8.0 \times 10^{-4} \%$
15. Which one of the following correctly defines an acid according to the Brønsted-Lowry theory?
- (a) accepts H^+ ions in water
 - (b) forms H^+ ions in water
 - (c) H^+ acceptor
 - (d) H^+ donor

16. A chemist carries out a titration and records the following values in the report book.

Final reading (mL)	11.6	22.00	32.41	42.07	11.47	
Initial reading (mL)	0.20	11.60	22.00	32.41	1.05	

What titration value should the chemist use in a subsequent calculation?

- (a) 10.22
(b) 10.41
(c) 10.46
(d) none of these
17. Which of the following best explains the way in which a catalyst increases the rate of a reaction?
- (a) A catalyst increases the rate of the forward reaction but not the reverse reaction: hence the overall rate is increased.
(b) A catalyst provides additional energy to the particles: hence a greater fraction of collisions is effective.
(c) A catalyst provides an alternative reaction pathway with a lower activation energy: hence a greater fraction of collisions is effective.
(d) A catalyst provides an alternative reaction pathway with a lower heat of reaction: hence less energy is needed for the particles to react.
18. Consider the following endothermic reaction for the production of hydrogen gas in a rigid container:

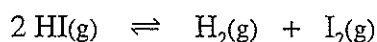


Which of the following would increase the **final yield** of hydrogen gas?

- (a) adding a catalyst
(b) adding inert argon gas
(c) increasing the pressure
(d) increasing the temperature

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Use the following information to answer Questions 19 to 21 which concern the reaction:



In the absence of a catalyst, the activation energy for the forward reaction is 183 kJ mol^{-1} and the activation energy for the reverse reaction is 157 kJ mol^{-1} .

In the presence of a platinum catalyst the activation energy for the forward reaction is 58 kJ mol^{-1} .

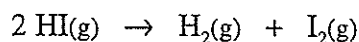
19. What is ΔH for the reaction



in the absence of a catalyst?

- (a) -26 kJ mol^{-1}
- (b) $+26 \text{ kJ mol}^{-1}$
- (c) -84 kJ mol^{-1}
- (d) $+84 \text{ kJ mol}^{-1}$

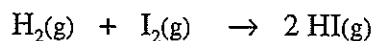
20. What is ΔH for the reaction



in the presence of a platinum catalyst?

- (a) -26 kJ mol^{-1}
- (b) $+26 \text{ kJ mol}^{-1}$
- (c) -84 kJ mol^{-1}
- (d) $+84 \text{ kJ mol}^{-1}$

21. Which one of the following statements about the reaction



in the presence of a platinum catalyst is true?

- (a) The activation energy is 32 kJ mol^{-1} .
- (b) The activation energy is 99 kJ mol^{-1} .
- (c) The activation energy is 157 kJ mol^{-1} .
- (d) The activation energy cannot be known without further experiment.

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22. Which one of the following statements about the value of an equilibrium constant is **false**?
- (a) It indicates how quickly the reaction is likely to proceed.
 - (b) It indicates the relative proportions of products to reactants at equilibrium.
 - (c) The value is dependent on the temperature.
 - (d) The value is independent of any catalysts present.
23. A single organic compound has at least one correct name—how many of the following names are correct?
- 4-chlorohexane
 - 3,3-dimethyl-3-hexene
 - *cis*-3-ethyl-3-hexene
 - *cis*-1-hexene
 - 2-pentanal
 - 2-pentanol
- (a) 1
 - (b) 2
 - (c) 3
 - (d) 4
24. Which one of the following compounds will react (in the presence of a concentrated sulfuric acid catalyst) with its own oxidation product to give a sweet-smelling liquid?
- (a) propanal
 - (b) 1-propanol
 - (c) 2-propanol
 - (d) propanone

25. When a compound is shaken with a solution of bromine in water, the red-brown colour of the bromine **rapidly** disappears. Which one of the following could the compound be?
- (a) 2-bromopropane
 - (b) cyclohexane
 - (c) 2-methylbutane
 - (d) 1-pentene
26. Which one of the following solutions could be used to distinguish between 2-methyl-2-propanol [(CH₃)₃COH] and butanoic acid [CH₃CH₂CH₂COOH]?
- (a) a solution of bromine in water
 - (b) a solution containing sulfuric acid and potassium dichromate
 - (c) dilute hydrochloric acid
 - (d) sodium hydrogencarbonate solution
27. During discharge of the lead-acid accumulator, a white solid builds up on the grids inside the battery. What is this substance?
- (a) Pb
 - (b) PbO₂
 - (c) Pb(OH)₂
 - (d) PbSO₄
28. In the extraction of aluminium from bauxite, cryolite (Na₃AlF₆) is added during one of the steps. What is the main purpose of the cryolite?
- (a) to act as seed crystals for the precipitation of alumina from a concentrated solution
 - (b) to act as a solvent to dissolve the alumina in preference to impurities in the bauxite ore
 - (c) to act as a solvent and therefore depress the melting point of the alumina
 - (d) to provide a source of aluminium in the electrolysis step

29. When the following pairs of substances react together, hydrogen is evolved in three cases. In which one reaction is hydrogen **not** evolved?
- (a) acetic acid (ethanoic acid) and sodium metal
 - (b) concentrated nitric acid and copper metal
 - (c) ethanol and sodium metal
 - (d) lithium metal and water
30. Which one of the following is a reaction of aluminium hydroxide?
- (a) It fumes in the presence of hydrochloric acid because volatile aluminium chloride is produced.
 - (b) It reacts with dilute sulfuric acid to give a white precipitate of aluminium sulfate.
 - (c) It reacts with dilute hydrochloric acid to give a white precipitate of aluminium chloride.
 - (d) It reacts with sodium hydroxide solution to give a solution containing tetrahydroxoaluminate ion, $Al(OH)_4^-$.

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) Solid sodium hydroxide is added to dilute hydrochloric acid.

Equation _____

Observation _____

[3 marks]

- (b) Dilute ammonia solution is added to sodium hydroxide solution.

Equation _____

Observation _____

[3 marks]

- (c) Sodium hydroxide solution is added to a solution of propanoic acid.

Equation _____

Observation _____

[3 marks]

- (d) Dilute sulfuric acid is added to a solution of potassium chromate.

Equation _____

Observation _____

[3 marks]

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2. For each species listed in the table below

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

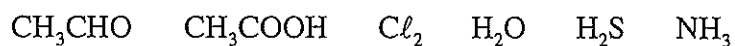
[for example, water $\text{H}:\ddot{\text{O}}:\text{H}$ or $\text{H}-\ddot{\text{O}}-\text{H}$ or $\text{H}-\ddot{\text{O}}-\text{H}$ and so on]

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

Species	Structural formula (showing all valence shell electrons)	Shape (sketch or name)
Dinitrogen monoxide, NNO		
Difluorochlorine(I) cation, ClF_2^+		

[6 marks]

3. Place each of the following substances in the appropriate column based on the most significant type of intermolecular force present.



Hydrogen bonding	Dipole-dipole interactions	Dispersion forces

[4 marks]

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

Description	Name or Formula
A salt that dissolves in water to give an acidic solution	
A gas that dissolves in water to give an acidic solution	
A compound containing three carbon atoms and two oxygen atoms	
A compound that has a geometric (<i>cis/trans</i>) isomer	
A cyclic alkene	
A secondary alcohol	
An element that is a liquid at room temperature	

[7 marks]

5. Answer the following questions about primary standards used in volumetric analysis.

What are two characteristics of a primary standard?
Why is a primary standard often required for use in volumetric analysis?

[3 marks]

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

What is done	Observation	Equation
A colourless odourless liquid is added to a green solid.	The green solid dissolves, and a colourless, odourless gas bubbles off, leaving a green solution.	

What is done	Observation	Equation
An excess of a solution with a pH of about 9 is added to a blue solution.	At first a light blue precipitate forms.	
	Then the light blue precipitate dissolves and a deep blue solution forms.	

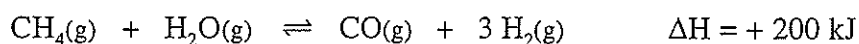
[6 marks]

7. At 95°C pure water has $K_w = 4.8 \times 10^{-13}$. This corresponds to a pH of 6.2.

Explain why the pH of pure water at 95°C is not equal to 7.0.
Is water at 95°C acidic, or is it neutral? Explain your answer.

[4 marks]

8. The following equilibrium is being investigated:



Four identical sealed boxes are set up at 300°C and 1.00 atm, each containing the equilibrium mixture. Each of the boxes is treated as described below, and time allowed for a new equilibrium to be established. In each case describe the change between the original equilibrium and the new equilibrium.

	What happens to the total pressure? Write 'increase', 'decrease' or 'no change'.	What happens to the partial pressure of CO? Write 'increase', 'decrease' or 'no change'.	What happens to the equilibrium position? Write 'move to the right', 'move to the left' or 'no change'.
The system is heated above 300°C.			
More CH ₄ (g) (at 300°C) is injected into the box.			
Ne(g) (at 300°C) is injected into the box.			
The volume of the box is halved.			

[8 marks]

9. Write the equilibrium constant expression for each of the following:

Equation	$\text{Fe}(\text{H}_2\text{O})_5\text{NCS}^{2+}(\text{aq}) + \text{H}_2\text{O}(\ell) \rightleftharpoons \text{Fe}(\text{H}_2\text{O})_6^{3+}(\text{aq}) + \text{NCS}^-(\text{aq})$
Equilibrium constant expression	

Equation	$2 \text{NOCl}(\text{g}) \rightleftharpoons 2 \text{NO}(\text{g}) + \text{Cl}_2(\text{g})$
Equilibrium constant expression	

[4 marks]

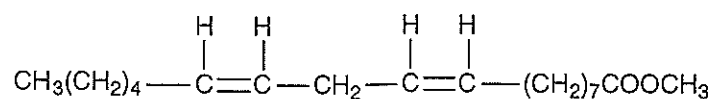
10. This question asks you to predict properties of elements from their positions in the Periodic Table. The symbols of eight elements are shown in the outline of the Periodic Table below. Answer the following questions about these eight elements.

	Be																Ne	
														As		Br		
	Rb							Rh							Te			
	Ra																	

- (a) Write the symbol of the element with the highest electronegativity. _____
- (b) Write the formula of the hydride of Te. _____
- (c) Write the symbol of the element with the lowest first ionisation energy. _____
- (d) Write the formula of the oxygen-containing acid of Te with Te in its highest oxidation state. _____
- (e) Write the symbol of the element which can be the central atom in a complex ion. _____
- (f) Write the formula for the sulfate of Rb. _____
- (g) Write the formula for a basic oxide of one of the elements. _____

[7 marks]

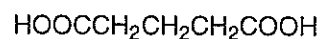
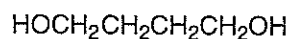
11. (a) The structural formula for the methyl ester of linoleic acid is shown below:



Draw the structural formulae of all organic species formed when the above compound is boiled with NaOH solution.

[2 marks]

- (b) The structural formulae for 1,4-butanediol and 1,5-pentanedioic acid are shown below:



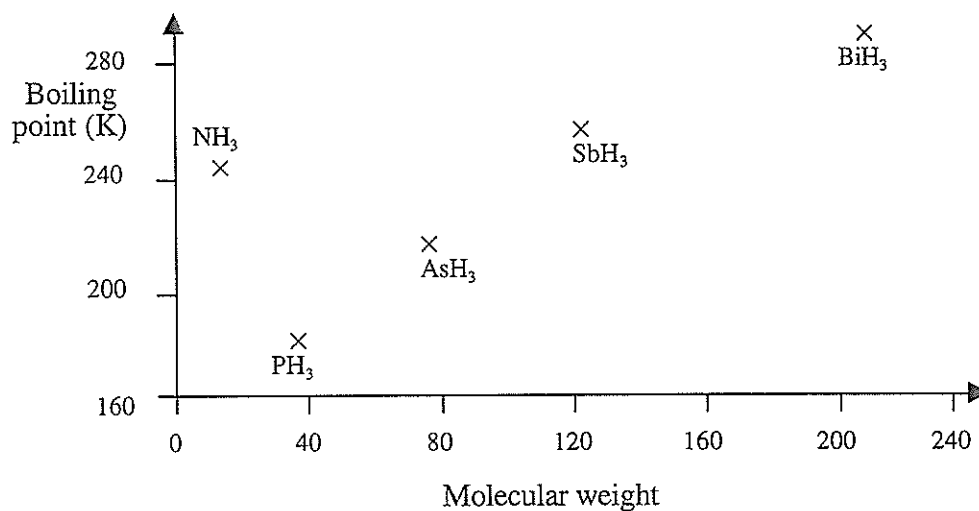
When 1,4-butanediol and 1,5-pentanedioic acid react, a polymer is formed. Draw enough of the structural formula to show the structure of the polymer.

[2 marks]

State the type of polymerisation involved in this reaction.

[1 mark]

12. The boiling points of the hydrides of the Group V elements are shown in the graph below.



- (a) Account for the trend in boiling point from PH₃ to BiH₃.

[2 marks]

- (b) Account for the relatively high boiling point of NH₃.

[2 marks]

END OF PART 2

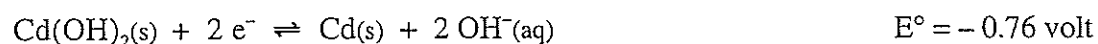
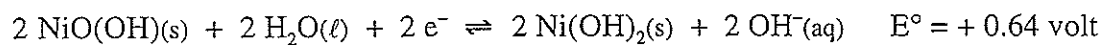
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2. A pure substance 'A' is a colourless liquid boiling at 229°C and contains carbon, hydrogen, silicon and oxygen.

When 1.0640 g of 'A' was burnt in a current of dry oxygen, 1.462 g of carbon dioxide and 0.894 g of water were produced. The solid which remained consisted of 0.832 g of silicon dioxide.

- (a) Calculate the empirical formula of 'A'. [8 marks]
- (b) At 150°C and 2.0 kPa pressure, 0.0138 g of 'A' evaporated to occupy a volume of 67 mL. Calculate the molecular weight of 'A'. [3 marks]
- (c) What is the molecular formula of 'A'? [2 marks]
- (d) A nuclear magnetic resonance spectrum for 'A' showed all the hydrogen atoms to be in methyl groups. Suggest a structural formula for 'A'. [2 marks]

3. A nickel-cadmium (Nicad) battery uses the following half-reactions with a basic electrolyte solution.

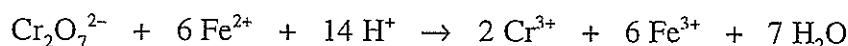


- (a) Write the overall equation for the cell reaction. [1 mark]
- (b) What is the voltage of the cell? [1 mark]
- (c) In a Nicad battery, what mass of NiO(OH) cathode would correspond to a 1.420 g Cd anode? [3 marks]
- (d) The battery requires recharging after 95% of the Cd has been consumed. Calculate the charge (in coulombs) produced by 95% of the Cd. [3 marks]
- (e) A mobile phone draws 0.150 ampere of current. For how many hours can the phone be used before the battery needs to be recharged? [2 marks]
- (f) Nicad batteries can be recharged many times, but eventually wear out and must be discarded. What is one problem associated with disposing of old Nicad batteries? [1 mark]

4. In a method for volumetric determination of ethanol in wine, the ethanol ($\text{CH}_3\text{CH}_2\text{OH}$) is first distilled from a basic solution of the wine.

The distilled $\text{CH}_3\text{CH}_2\text{OH}$ solution is then treated with an excess of a solution containing dilute H_2SO_4 and $\text{K}_2\text{Cr}_2\text{O}_7$. The mixture is then placed in a water bath at 60°C for 30 minutes to ensure complete oxidation to CH_3COOH .

A redox indicator (N-phenylanthranilic acid) is then added and the amount of excess $\text{K}_2\text{Cr}_2\text{O}_7$ is determined by titration with a standard solution containing Fe^{2+} ion. The equation for this reaction is:

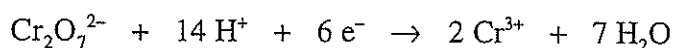
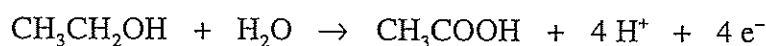


From this the amount of $\text{Cr}_2\text{O}_7^{2-}$ ion that combined with the $\text{CH}_3\text{CH}_2\text{OH}$, and hence the amount of $\text{CH}_3\text{CH}_2\text{OH}$ in the sample, can be calculated.

The following results were obtained for a 1.00 mL sample of wine analysed as above.

Volume of $0.1005 \text{ mol L}^{-1} \text{K}_2\text{Cr}_2\text{O}_7$ added to the distillate:	25.00 mL
Volume of $0.3005 \text{ mol L}^{-1} \text{Fe}^{2+}$ required to titrate the excess $\text{K}_2\text{Cr}_2\text{O}_7$:	23.55 mL

The half-equations for the oxidation of ethanol and the reduction of $\text{Cr}_2\text{O}_7^{2-}$ are :



- (a) Combine these two half-equations to obtain an equation for the oxidation of $\text{CH}_3\text{CH}_2\text{OH}$ to CH_3COOH by a solution containing dilute H_2SO_4 and $\text{K}_2\text{Cr}_2\text{O}_7$.
[2 marks]
- (b) Calculate the amount (in mole) of $\text{K}_2\text{Cr}_2\text{O}_7$ added to the $\text{CH}_3\text{CH}_2\text{OH}$.
[1 mark]
- (c) Calculate the amount (in mole) of $\text{K}_2\text{Cr}_2\text{O}_7$ in excess.
[2 marks]
- (d) Calculate the amount (in mole) of $\text{K}_2\text{Cr}_2\text{O}_7$ that combined with the $\text{CH}_3\text{CH}_2\text{OH}$.
[1 mark]
- (e) Calculate the concentration of $\text{CH}_3\text{CH}_2\text{OH}$ in gram per 100 mL in the wine.
[3 marks]

5. A damp mixture of potassium iodide and potassium sulfate was dissolved in water and made up to 250.00 mL. 25.00 mL of this solution was treated with an excess of barium nitrate until no further precipitate formed. The solid was filtered and washed. It was then dried to a constant weight of 0.218 g.

(a) Write the equation for the reaction that produced the precipitate.

[1 mark]

(b) Calculate the mass of the compound in the damp mixture that produced the precipitate.

[3 marks]

A second 25.00 mL of the solution was treated with an excess of lead nitrate solution until no further precipitate formed. The solid was filtered and washed. It was then dried to a constant weight of 0.607 g.

(c) Write the equations for the two reactions that produced the precipitate.

[2 marks]

(d) Calculate the mass of the second compound in the damp mixture.

[4 marks]

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 page 32.

1. An industrial method for the manufacture of nitric acid is the Ostwald Process, and the reactions involved are described as follows:

Stage	Description	Equation	ΔH (kJ)
1	NH ₃ and O ₂ are heated together at 800°C in the presence of a platinum catalyst.	$4 \text{NH}_3(\text{g}) + 5 \text{O}_2(\text{g}) \rightarrow 4 \text{NO}(\text{g}) + 6 \text{H}_2\text{O}(\text{g})$	-908
2	O ₂ is added to the NO from Stage 1.	$2 \text{NO}(\text{g}) + \text{O}_2(\text{g}) \rightarrow 2 \text{NO}_2(\text{g})$	-114
3	The NO ₂ from Stage 2 is bubbled through water.	$2 \text{NO}_2(\text{g}) + \text{H}_2\text{O}(\ell) \rightarrow \text{HNO}_2(\text{aq}) + \text{H}^+(\text{aq}) + \text{NO}_3^-(\text{aq})$	-106
4	The HNO ₂ /HNO ₃ mixture from Stage 3 is heated to produce concentrated nitric acid. [The NO is recycled into Stage 2.]	$3 \text{HNO}_2(\text{aq}) \rightarrow \text{H}^+(\text{aq}) + \text{NO}_3^-(\text{aq}) + \text{H}_2\text{O}(\ell) + 2 \text{NO}(\text{g})$	+44

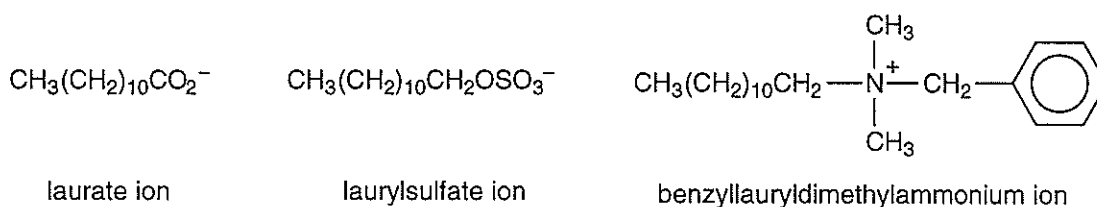
Each stage can be summarised by a reaction diagram showing initial state, transition state and final state. Sketch such a reaction diagram for each stage. Use your diagrams and your knowledge of rate and equilibrium principles to explain why the conditions have been chosen for each stage in the process.

OR

2. Discuss corrosion in metals: its causes, and its minimisation and prevention.

OR

3. The species listed below are active ingredients in soaps or detergents.



Attractive forces hold molecules and ions together both in pure substances and in mixtures. Discuss the attractive forces associated with the above three species. Explain their interaction with both polar and non-polar solvents. Describe how the species act as cleansing agents. Discuss why detergents such as sodium laurylsulfate and benzyl lauryldimethylammonium chloride are preferable to soaps such as sodium laurate when used in water which may be acidic or contain dissolved salts.

END OF QUESTIONS

SEE NEXT PAGE

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