2004
Higher School Certificate
Trial Examination

Chemistry

General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Board approved calculators may be used
- Write using black or blue pen
- Draw diagrams using pencil
- A Data Sheet and Periodic Table are provided at the back of this paper
- Write your student number and/or name at the top of every page

Total Marks – 100

Section I
Total marks (75)
This section has two parts, Part A and Part B

Part A
Total marks (15)
Attempt questions 1 – 15
Allow about 30 minutes for this part

Part B
Total marks (60)
Attempt questions 16 – 29
Allow about 1 hour 45 minutes for this part

Section II (Page 19)
Total marks (25)
Attempt ONE question from Questions 30-34
Allow about 45 minutes for this section

This paper MUST NOT be removed from the examination room

STUDENT NUMBER/NAME: .....

STUDENT NUMBER/NAME: .....

Section I

Total marks (75)

Part A

Total marks (15)
Attempt questions 1 – 15
Allow about 30 minutes for this part

Select the alternative A, B, C or D that best answers the question and indicate your choice with a cross (X) in the appropriate space on the grid below.

	A	B	C	D
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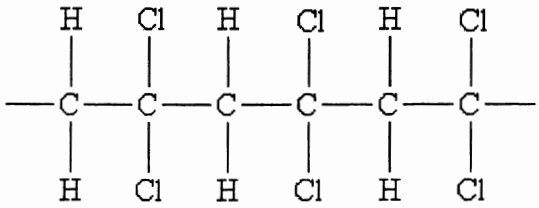
STUDENT NUMBER/NAME: .....

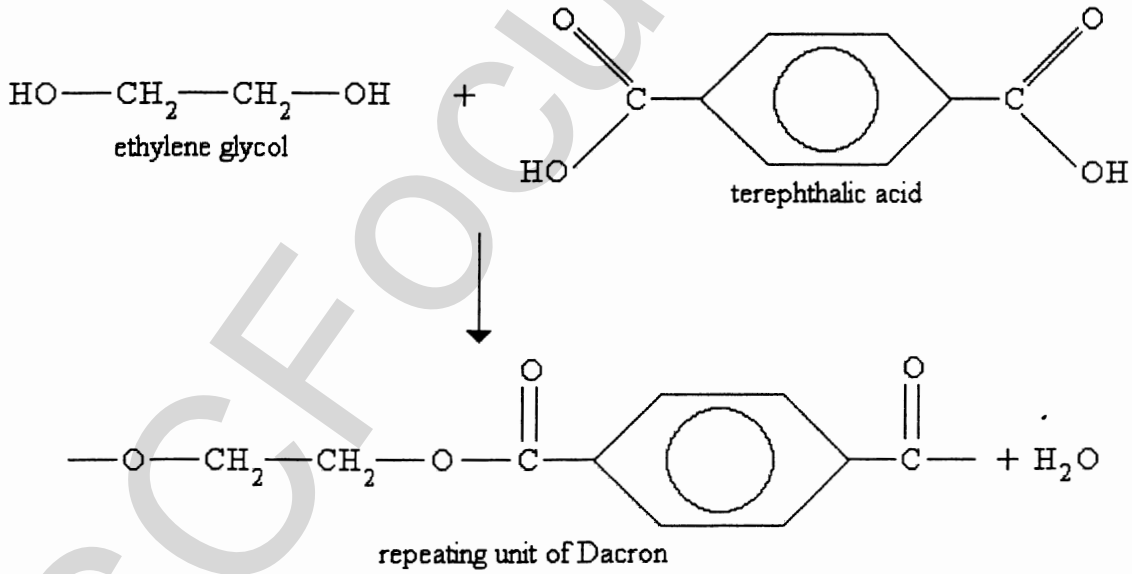
1. Saran is a polymer used to make packaging film and seat covers. Shown below is a representation of a Saran chain.



Which of the following is the monomer from which Saran is made?

(A) 1,1-dichloroethane
(B) 1,2-dichloroethane
(C) 1,1-dichloroethene
(D) 1,2-dichloroethene

2. When ethylene glycol is reacted with terephthalic acid a polyester (Dacron) is formed. The reaction is represented below. What type of reaction is this?



(A) addition polymerisation
(B) condensation polymerisation
(C) substitution
(D) dehydration

3. When a lead strip is placed a solution of silver nitrate the lead becomes coated with greyish furry growth. Which is the correct interpretation of the observation?

(A) Lead from solution has deposited on the original lead.
(B) Silver has deposited on the lead.
(C) The lead has reacted with the water which has caused a deposit similar to rust.
(D) Lead nitrate has formed a precipitate.

4. Water hardness is used to describe water that contains significant amounts of specific ions. Hard water will not lather easily with soaps. These ions are:

(A) Na^+ and Cl^- ions
(B) NH_4^+ and OH^- ions
(C) Hg^{2+} and Pb^{2+} ions
(D) Mg^{2+} and Ca^{2+} ions

5. The table below lists some physical and chemical properties of four different carbon compounds.

Compound	Boiling point (°C)	Reactivity in bromine water	Solubility in Water
W	-89	unreactive	insoluble
X	-104	reactive	insoluble
Y	78	unreactive	soluble
Z	138	unreactive	slightly soluble

Which alternative best identifies compounds W, X, Y and Z ?

	W	X	Y	Z
(A)	C_2H_6	C_2H_4	C_2H_5OH	$C_5H_{11}OH$
(B)	C_2H_4	C_2H_6	$C_5H_{11}OH$	C_2H_5OH
(C)	$C_5H_{11}OH$	C_2H_5OH	C_2H_4	C_2H_6
(D)	$C_5H_{11}OH$	C_2H_4	C_2H_5OH	C_2H_6

6. Heart pacemakers are often powered by lithium-silver chromate button cells. The overall cell reaction is:

$$2\ Li_{(s)} + Ag_2Cr_2O_{4\,(s)} \rightarrow Li_2Cr_2O_{4\,(s)} + 2\ Ag_{(s)}$$

What is the anode in this cell ?

(A) $Ag_{(s)}$
(B) $Li_{(s)}$
(C) Ag^+
(D) $Cr_2O_4^{2-}$

7. Which of the following statements identifies the conjugate base of the acid HNO_3?

(A) NaOH is the conjugate base of the acid HNO_3
(B) OH^- is the conjugate base of the acid HNO_3
(C) NO_3 is the conjugate base of the acid HNO_3
(D) NO_3^- is the conjugate base of the acid HNO_3

8. The table shows the colours of three indicators at different hydrogen ion concentrations.

[HCl] mol L^{-1}	10^{-2}	10^{-4}	10^{-6}
Methyl Orange	red	orange	yellow
Bromothymol Blue	yellow	yellow	green
Phenol Red	yellow	red	red

What is the pH of a solution that showed the following indicator colours?

Methyl Orange	Yellow
Bromothymol Blue	Green
Phenol Red	Red

(A) 2
(B) 4
(C) 6
(D) 8

9. What is a correct name for the compound with the molecular formula CH_2O_2?

(A) ethanoic acid
(B) ethanol
(C) methanol
(D) methanoic acid

10. Identify the pH at the neutralisation point when sodium hydroxide is neutralised by hydrochloric acid.

(A) pH = 0
(B) pH = 7
(C) pH > 7
(D) pH < 7

11. Nitrogen dioxide, NO_2, a brown gas and dinitrogen tetroxide, N_2O_4, a colourless gas are in equilibrium according to the equation-:

$$2NO_{2\,(g)} \rightleftharpoons N_2O_{4\,(g)}$$

If a sealed tube of the gases is placed in an ice-water bath the colour fades from brown to almost colourless. Which conclusion is correct?

(A) The forward reaction is exothermic
(B) The reverse reaction is exothermic
(C) The pressure has increased.
(D) The pressure has not changed

12. Identify the compound in the atmosphere which reacts with chlorofluorocarbons (CFC's).

(A) water
(B) carbon monoxide
(C) ozone
(D) carbon dioxide

13. Sulfuric acid reacts with pyrosulfuric acid according to the equation-:

$$H_2SO_{4\,(l)} + H_2S_2O_{7\,(l)} \rightleftharpoons H_3SO_4^{+}{}_{(l)} + HS_2O_7^{-}{}_{(l)}$$

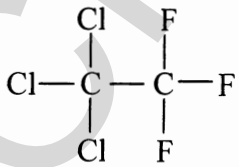
Identify a method of increasing the concentration of $H_3SO_4^{+}$ in the mixture at equilibrium.

(A) increase the pressure on the system
(B) add H_2SO_4
(C) add a catalyst
(D) add $HS_2O_7^{-}$

14. Select the molecule from below that possesses a coordinate covalent bond.

(A) carbon dioxide
(B) water
(C) ozone
(D) oxygen

15. What is the correct systematic name of this compound?



(A) 1,1,1,2,2,2-chlorofluoroethane
(B) 1,1,1-trifluoro - 2,2,2-trichloromethane
(C) 1,1,1,2,2,2-chlorofluoromethane
(D) 1,1,1-trichloro - 2,2,2-trifluoroethane

Section I – continued

Part B

Total marks (60)
Attempt questions 16 – 29
Allow about 1 hour 45 minutes for this part

Answer the questions in the spaces provided

Show all relevant working in questions involving calculations.

Question 16 (4 marks) **Marks**

Ethane can be cracked to form ethene and hydrogen at 850°C.
The reaction is strongly endothermic.

(a) Construct the equation for this reaction. **1**

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(b) Justify the use of a high temperature for this reaction. **1**

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(c) Describe what is observed when ethane and ethene gases are bubbled separately through bromine water. **2**

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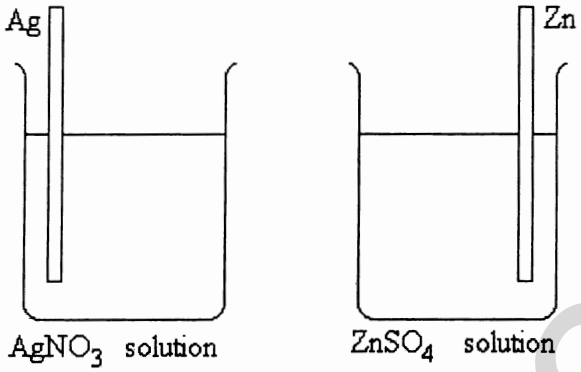
STUDENT NUMBER/NAME: .....

Question 17 (5 marks) **Marks**

Two beakers are set up as follows:



(a) One the diagram include additional components needed to obtain an electric current from this arrangement. **1**

(b) Label on the diagram:- **2**

(i) the cathode and anode
(ii) the direction of electron movement

(c) Construct the equation for the cell reaction **1**

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(d) Determine the cell voltage under standard conditions. **1**

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STUDENT NUMBER/NAME: .....

Question 18 (4 marks) **Marks**

Cellulose is a naturally occurring *condensation polymer* that makes up a major proportion of biomass. Its structure is represented below.

$$-O-C_6H_{10}O_4-O-C_6H_{10}O_4-O-C_6H_{10}O_4-O-C_6H_{10}O_4-O-C_6H_{10}O_4-O-$$

(a) Identify the monomer from which cellulose forms. **1**

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(b) Explain what is meant by the term *condensation*. **1**

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(c) Using an example to illustrate your answer, explain how the formation of an *addition polymer* is different to the formation of a condensation polymer. **2**

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Question 19 (3 marks) **Marks**

A student designed an experiment to investigate the displacement of metals from solution. She placed an iron nail into one test tube containing some dilute copper sulfate solution and a piece of copper wire into a separate test tube containing some dilute iron (II) sulfate solution. Her observations are recorded in the table below.

test tube	metal	solution	Observations
1	iron	copper sulfate	A red/brown deposit appeared on the nail. The blue colour of the solution faded.
2	copper	iron (II) sulfate	No changes were observed.

(a) Write an ionic equation for the reaction occurring in test tube 1. **1**

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(b) Referring to the Table of Standard Potentials explain the recorded observations. **2**

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Question 20 (4 marks)

During your practical work you performed a first-hand investigation to carry out the fermentation of glucose.

(a) With the aid of a relevant equation, explain any changes in mass observed during this fermentation process. **2**

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(b) Justify the conditions under which this fermentation was carried out. **2**

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STUDENT NUMBER/NAME: .....

Question 21 (5 marks) **Marks**

Low sulfur diesel fuels used in coal mining must have a sulfur content of less than 0.05% sulfur by mass.

(a) Calculate the volume of sulfur dioxide at 25°C and 100 kPa produced by burning 1.0 kg of low (0.05%) sulfur diesel. **2**

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(b) Discuss the impact on the environment of using high sulfur fuels. **3**

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Question 22 (4 marks) **Marks**

The phosphate buffer system operates in the internal fluid of all cells. This buffer system is represented by the chemical equation below:

$$H_2PO_4^- \rightleftharpoons H^+ + HPO_4^{2-}$$

(a) Define the term 'buffer' and identify the key components of any buffer system. **2**

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(b) Using relevant equations explain what happens if: **2**

(i) H^+ ions are added to this system.

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(ii) OH^- ions are added to this system.

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STUDENT NUMBER/NAME: .....

Question 23 (5 marks) **Marks**

A student used indicator paper to estimate the pH of three different acids, to the nearest integer value. Each acid was at a concentration of 0.10 mol L^{-1} in aqueous solution. The table below records these measurements:

Acid	pH
acetic	3
citric	2
hydrochloric	1

(a) Compare the hydrogen ion concentrations in these three solutions. **2**

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(b) Account for the differences in these values. **3**

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STUDENT NUMBER/NAME: .....

Question 24 (6 marks) **Marks**

A bottle of vinegar is labelled *4.0% w/v* (4.0 g per 100 mL of solution) acetic acid (ethanoic acid).

(a) Describe the laboratory procedure you would use to verify this concentration. **3**

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(b) Calculate the volume of 0.118 mol L^{-1} NaOH required to neutralise the acid in 5.0 mL of this vinegar. **3**

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STUDENT NUMBER/NAME: .....

Question 25 (6 marks) **Marks**

(a) Identify the steps you followed in performing a first hand investigation to measure the sulfate content of lawn fertiliser. **3**

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(b) Describe how you calculated the percentage of sulfate in the fertiliser including relevant equations in your answer. **3**

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Question 26 (2 marks)

(a) Identify ONE factor that can affect water quality. **1**

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(b) Describe how this factor will affect the quality of water in a freshwater lake. **1**

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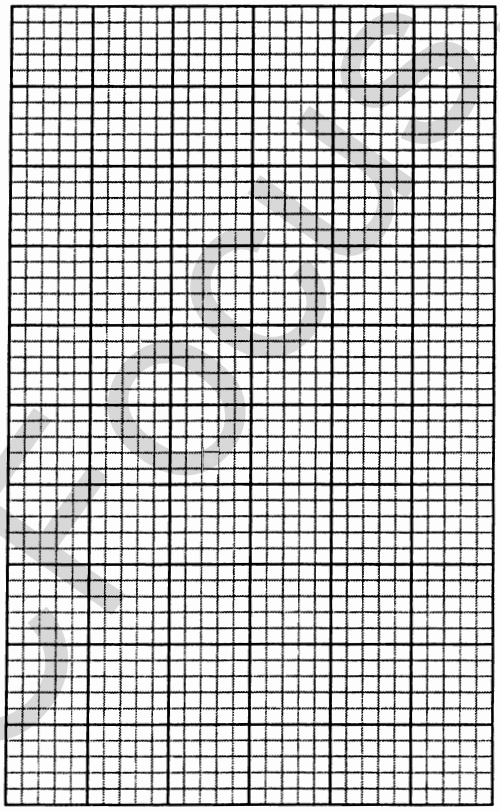
STUDENT NUMBER/NAME: .....

Question 27 (4 marks) **Marks**

A sample of river water was analysed for nickel using Atomic Absorption Spectroscopy (AAS).
A 25mL sample was diluted to 250mL with distilled water, and measured with the AAS instrument. An average absorbance reading of 0.350 was obtained, for the diluted sample. The results for a set of nickel standards is included in the table below.

Standard nickel concentration $g.mL^{-1}$	Absorbance
2.0×10^{-6}	0.134
4.0×10^{-6}	0.272
6.0×10^{-6}	0.416

(a) Construct a calibration graph for the standard nickel solutions. **2**



(b) Using the graph, determine the concentration of nickel in the original sample of river water. **2**

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Question 28 (3 marks) **Marks**

When ammonia reacts with hydrochloric acid, the ammonium ion is formed.

(a) Draw an electron dot formula for the ammonium ion. **1**

(b) Explain the term "coordinate covalent bond" using this example. **2**

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Question 29 (5 marks)

The table below shows the percentage yield of ammonia using the Haber process at a pressure of 30 MPa.

Temperature (Kelvin)	Percentage yield of ammonia
200	94
300	66
400	44
500	22
600	9

(a) Use the table values to predict whether the production of ammonia is endothermic or exothermic. Justify your answer. **2**

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(b) Predict how an increase in temperature would affect the rate of production of ammonia. **1**

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(c) Identify and explain the effect of increased pressure on the production of ammonia. **2**

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End of Section I

STUDENT NUMBER/NAME: .....

Section II

Total marks (25)

Attempt ONE question from Questions 30 – 34
Allow about 45 minutes for this part

Answer the question in a separate writing booklet. Extra writing booklets are available.

STUDENT NUMBER/NAME: .....

Question 30 – Industrial Chemistry (25 marks) **Marks**

(a) 0.100 mole of iodine, I_2, and 0.100 mole of I^- (in the form of KI) is added to water to make 1 L of solution. In this solution the following equilibrium is established at 25°C.

$$I_2 + I^- \Leftrightarrow I_3^-$$

(i) Write an expression for the equilibrium constant. **1**

(ii) At equilibrium the solution contains 2.0×10^{-2} mole each of iodine and iodide ion, and 8.0×10^{-2} mole of the I_3^- ion. Calculate the value of the equilibrium constant for this reaction at 25°C. **2**

(iii) Describe the effect on the equilibrium state and the value of the equilibrium constant, of adding some potassium iodide crystals. **2**

(iv) If the solution is cooled in an ice bath the equilibrium constant decreases. What conclusion can be made concerning the energy of reaction? **1**

(b) Predict and explain the different products of the electrolysis of molten sodium chloride and a concentrated solution of sodium chloride. **4**

(c) During your course you performed a first hand investigation to carry out a chemical step involved in the Solvay process for the production of sodium carbonate. Describe the chemical step and the results obtained and relate them to the sequence of steps used in the commercial production of sodium carbonate. **4**

(d) Describe the steps and chemistry involved in the commercial production of sulfuric acid. In your answer analyse the process to predict ways in which the output of sulfuric acid is maximised. **5**

(e) Explain how the effect of hard water on the action of early soaps led to the development of new synthetic cleaning agents and associated environmental problems. **6**

End of Question 30

STUDENT NUMBER/NAME: .....

Question 31 – Shipwrecks, Corrosion and Conservation (25 marks) **Marks**

(a) Cadmium and zinc are often used as protective coats to prevent corrosion of mild steel.

(i) Explain why zinc is a passivating metal. **1**

(ii) Account for the difference in corrosion when zinc and cadmium plated steels are cut or drilled **3**

(b) You have carried out a first hand investigation to compare the effectiveness of different protections used to coat iron and thus prevent corrosion. Describe and explain the results of the experimental procedure used in the investigation. **5**

(c) Chloride ions are removed from steel artefacts using an alkaline electrolytic cell.

(i) Construct a diagram to show how chloride ions could be removed from a steel cannon, clearly labelling the anode and cathode, and identifying the half reaction at the anode. **3**

(ii) Justify the use of sodium hydroxide solution as the electrolyte for this procedure. **2**

(d) (i) Contrast the corrosion of metal shipwrecks at great depth with those wrecked in shallow water **3**

(ii) Describe the action of sulfate reducing bacteria around deep ocean wrecks. **2**

(e) Outline and analyse the impact of Volta, Davy and Faraday on our understanding of electron transfer reactions. **6**

End of Question 31

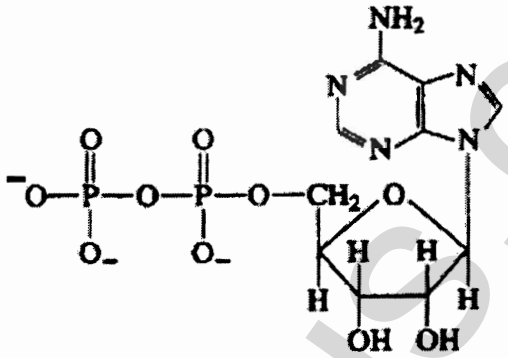
STUDENT NUMBER/NAME: .....

Question 32 – Biochemistry of Movement (25 marks) **Marks**

(a) (i) State the general formula for a carbohydrate, and demonstrate that glucose matches this formula. **2**

(ii) Describe how glycogen is produced from glucose and identify sites of glycogen storage in the body **2**

(b) Adenosine diphosphate (ADP) has the structure:



(i) Describe the process, involving NADH, which converts ADP to ATP. **2**

(ii) Explain the role of ATP in muscle action. **2**

(c) With reference to a named example describe the general structure of enzymes. Explain why the shape of an enzyme is essential for its function. **5**

(d) (i) Construct a structural formula for glycerol. **1**

(ii) Explain the solubility of glycerol in water. **2**

(iii) Demonstrate the role of glycerol in storing fatty acids and account for the hydrophobic properties the stored substances. **3**

(e) Compare the respiratory pathways and products in the action of Type 1 and Type 2 muscle cells. **6**

End of Question 32

Question 33 – Chemistry of Art (25 marks) **Marks**

(a) Identify the chemical composition of two minerals used in cosmetics in ancient culture and assess the potential health risks associated with their use. **3**

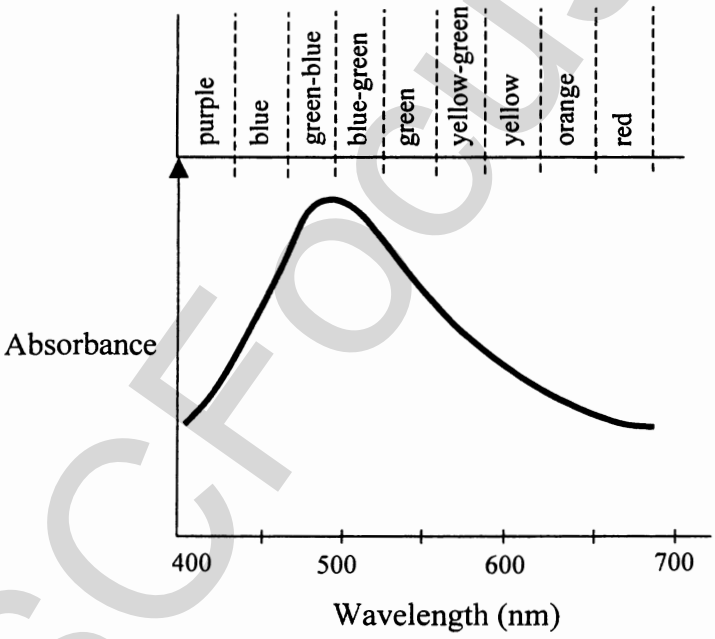
(b) The study of spectra has enabled scientists to develop new technologies in the study of pigments.

(i) Outline the differences between line emission spectra and absorption spectra. **2**

(ii) How did Bohr explain spectral lines in the emission spectra? **2**

(iii) The diagram below shows an absorption spectrum for the hydrated titanium(III) ion in graphical form.

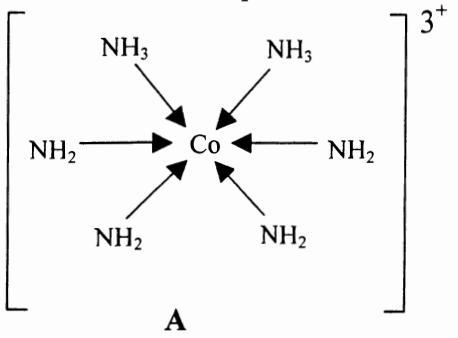
Predict the colour of this ion. Give a reason for your answer. **2**



Question 33 continues on the next page

Question 33 continued **Marks**

(c) Examine the two complex ions shown below.



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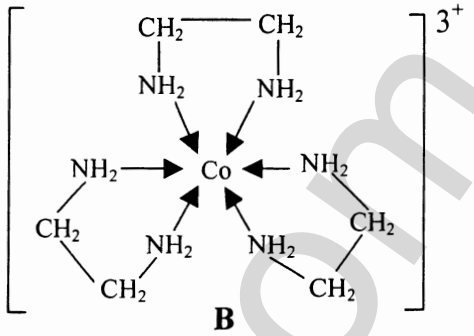

B

(i) Write the ground state electronic configuration of the cobalt atom in terms of sub-shells. **1**

(ii) By referring to the two complex ions discuss the following in relation to modelling the structure of complex ions. **4**

- ligands
- chelation
- nature of the coordinate bonds.

(d) The table below shows the successive ionisation energies for the sodium atom.

Ionisation	Ionisation energy ($kJmol^{-1}$)
1st	502
2nd	4 569
3rd	6 919
4th	9 550
5th	13 356
6th	16 616
7th	20 121
8th	25 497
9th	28 941
10th	141 373
11th	159 086

(i) Write an equation to show the first ionisation for sodium. **1**

(ii) Explain how the trend in successive ionisation energies provides information about the electronic structure of the sodium atom. **3**

(e) (i) Define the term transition element. **1**

(ii) Analyse why transition metal compounds are able to be extensively used in pigments in paints and to colour glass, enamel and ceramics. Supplement your answer with specific examples. **6**

End of Question 33

STUDENT NUMBER/NAME: .....

Question 34 – Forensic Chemistry (25 marks) **Marks**

(a) (i) Distinguish between organic and inorganic compounds. **1**

(ii) Alkanes, alkenes, alkanols and alkanoic acids are different classes of organic (or carbon) compounds. Describe a sequence of tests that could be used to distinguish between any THREE of these classes of compounds. **3**

(b) Sucrose is an example of a carbohydrate that is classified as both a ***disaccharide*** and a ***non-reducing sugar***.

(i) Explain what is meant by the term "disaccharide". **1**

(ii) Describe the chemical difference between reducing and non-reducing sugars. **3**

(c) Discuss the use of line emission spectra to identify the presence of elements and explain how such information can assist in the analysis of the origins of a soil sample **5**

(d) Improvements in computer technology have increased the use of stored data banks of information for use in forensic analysis.

(i) Describe how a data bank is useful for a forensic chemist performing analyses using a mass spectrometer. **2**

(ii) Discuss issues associated with the maintenance of data banks of DNA. **4**

(e) Evaluate the use of electrophoresis in identifying the amino acids present in a mixture. **6**

End of Question 34

End of Paper

Chemistry

DATA SHEET

Avogadro constant, N_A ..... 6.022×10^{23} mol^{-1}

Volume of 1 mole ideal gas: at 100 kPa and

at 0°C (273.15 K) ..... 22.71 L

at 25°C (298.15 K) ..... 24.79 L

Ionisation constant for water at 25°C (298.15 K), K_w ..... 1.0×10^{-14}

Specific heat capacity of water ..... 4.18×10^3 J kg^{-1} K^{-1}

Some useful formulae

$$pH = -\log_{10}[H^+] \qquad \Delta H = -m\,C\,\Delta T$$

Some standard potentials

$K^+ + e^-$	$\rightleftharpoons$	$K(s)$	–2.94 V
$Ba^{2+} + 2e^-$	$\rightleftharpoons$	$Ba(s)$	–2.91 V
$Ca^{2+} + 2e^-$	$\rightleftharpoons$	$Ca(s)$	–2.87 V
$Na^+ + e^-$	$\rightleftharpoons$	$Na(s)$	–2.71 V
$Mg^{2+} + 2e^-$	$\rightleftharpoons$	$Mg(s)$	–2.36 V
$Al^{3+} + 3e^-$	$\rightleftharpoons$	$Al(s)$	–1.68 V
$Mn^{2+} + 2e^-$	$\rightleftharpoons$	$Mn(s)$	–1.18 V
$H_2O + e^-$	$\rightleftharpoons$	$\frac{1}{2}H_2(g) + OH^-$	–0.83 V
$Zn^{2+} + 2e^-$	$\rightleftharpoons$	$Zn(s)$	–0.76 V
$Fe^{2+} + 2e^-$	$\rightleftharpoons$	$Fe(s)$	–0.44 V
$Ni^{2+} + 2e^-$	$\rightleftharpoons$	$Ni(s)$	–0.24 V
$Sn^{2+} + 2e^-$	$\rightleftharpoons$	$Sn(s)$	–0.14 V
$Pb^{2+} + 2e^-$	$\rightleftharpoons$	$Pb(s)$	–0.13 V
$H^+ + e^-$	$\rightleftharpoons$	$\frac{1}{2}H_2(g)$	0.00 V
$SO_4^{2-} + 4H^+ + 2e^-$	$\rightleftharpoons$	$SO_2(aq) + 2H_2O$	0.16 V
$Cu^{2+} + 2e^-$	$\rightleftharpoons$	$Cu(s)$	0.34 V
$\frac{1}{2}O_2(g) + H_2O + 2e^-$	$\rightleftharpoons$	$2OH^-$	0.40 V
$Cu^+ + e^-$	$\rightleftharpoons$	$Cu(s)$	0.52 V
$\frac{1}{2}I_2(s) + e^-$	$\rightleftharpoons$	I^-	0.54 V
$\frac{1}{2}I_2(aq) + e^-$	$\rightleftharpoons$	I^-	0.62 V
$Fe^{3+} + e^-$	$\rightleftharpoons$	Fe^{2+}	0.77 V
$Ag^+ + e^-$	$\rightleftharpoons$	$Ag(s)$	0.80 V
$\frac{1}{2}Br_2(l) + e^-$	$\rightleftharpoons$	Br^-	1.08 V
$\frac{1}{2}Br_2(aq) + e^-$	$\rightleftharpoons$	Br^-	1.10 V
$\frac{1}{2}O_2(g) + 2H^+ + 2e^-$	$\rightleftharpoons$	H_2O	1.23 V
$\frac{1}{2}Cl_2(g) + e^-$	$\rightleftharpoons$	Cl^-	1.36 V
$\frac{1}{2}Cr_2O_7^{2-} + 7H^+ + 3e^-$	$\rightleftharpoons$	$Cr^{3+} + \frac{7}{2}H_2O$	1.36 V
$\frac{1}{2}Cl_2(aq) + e^-$	$\rightleftharpoons$	Cl^-	1.40 V
$MnO_4^- + 8H^+ + 5e^-$	$\rightleftharpoons$	$Mn^{2+} + 4H_2O$	1.51 V
$\frac{1}{2}F_2(g) + e^-$	$\rightleftharpoons$	F^-	2.89 V

Aylward and Findlay, *SI Chemical Data* (5th Edition) is the principal source of data for this examination paper. Some data may have been modified for examination purposes.

PERIODIC TABLE OF THE ELEMENTS

KEY

1 H 1.008 Hydrogen																	2 He 4.003 Helium
3 Li 6.941 Lithium	4 Be 9.012 Beryllium											5 B 10.81 Boron	6 C 12.01 Carbon	7 N 14.01 Nitrogen	8 O 16.00 Oxygen	9 F 19.00 Fluorine	10 Ne 20.18 Neon
11 Na 22.99 Sodium	12 Mg 24.31 Magnesium											13 Al 26.98 Aluminium	14 Si 28.09 Silicon	15 P 30.97 Phosphorus	16 S 32.07 Sulfur	17 Cl 35.45 Chlorine	18 Ar 39.95 Argon
19 K 39.10 Potassium	20 Ca 40.08 Calcium	21 Sc 44.96 Scandium	22 Ti 47.87 Titanium	23 V 50.94 Vanadium	24 Cr 52.00 Chromium	25 Mn 54.94 Manganese	26 Fe 55.85 Iron	27 Co 58.93 Cobalt	28 Ni 58.69 Nickel	29 Cu 63.55 Copper	30 Zn 65.39 Zinc	31 Ga 69.72 Gallium	32 Ge 72.61 Germanium	33 As 74.92 Arsenic	34 Se 78.96 Selenium	35 Br 79.90 Bromine	36 Kr 83.80 Krypton
37 Rb 85.47 Rubidium	38 Sr 87.62 Strontium	39 Y 88.91 Yttrium	40 Zr 91.22 Zirconium	41 Nb 92.91 Niobium	42 Mo 95.94 Molybdenum	43 Tc [98.91] Technetium	44 Ru 101.1 Ruthenium	45 Rh 102.9 Rhodium	46 Pd 106.4 Palladium	47 Ag 107.9 Silver	48 Cd 112.4 Cadmium	49 In 114.8 Indium	50 Sn 118.7 Tin	51 Sb 121.8 Antimony	52 Te 127.6 Tellurium	53 I 126.9 Iodine	54 Xe 131.3 Xenon
55 Cs 132.9 Caesium	56 Ba 137.3 Barium	57–71 Lanthanides	72 Hf 178.5 Hafnium	73 Ta 180.9 Tantalum	74 W 183.8 Tungsten	75 Re 186.2 Rhenium	76 Os 190.2 Osmium	77 Ir 192.2 Iridium	78 Pt 195.1 Platinum	79 Au 197.0 Gold	80 Hg 200.6 Mercury	81 Tl 204.4 Thallium	82 Pb 207.2 Lead	83 Bi 209.0 Bismuth	84 Po [210.0] Polonium	85 At [210.0] Astatine	86 Rn [222.0] Radon
87 Fr [223.0] Francium	88 Ra [226.0] Radium	89–103 Actinides	104 Rf [261.1] Rutherfordium	105 Db [262.1] Dubnium	106 Sg [263.1] Seaborgium	107 Bh [264.1] Bohrium	108 Hs [265.1] Hassium	109 Mt [268] Meitnerium	110 Uun — Ununnilium	111 Uuu — Unununium	112 Uub — Ununbium	113	114 Uuq — Ununquadium	115	116 Uuh — Ununhexium	117	118 Uuo — Ununoctium

Lanthanides

57 La 138.9 Lanthanum	58 Ce 140.1 Cerium	59 Pr 140.9 Praseodymium	60 Nd 144.2 Neodymium	61 Pm [146.9] Promethium	62 Sm 150.4 Samarium	63 Eu 152.0 Europium	64 Gd 157.3 Gadolinium	65 Tb 158.9 Terbium	66 Dy 162.5 Dysprosium	67 Ho 164.9 Holmium	68 Er 167.3 Erbium	69 Tm 168.9 Thulium	70 Yb 173.0 Ytterbium	71 Lu 175.0 Lutetium

Actinides

89 Ac [227.0] Actinium	90 Th 232.0 Thorium	91 Pa 231.0 Protactinium	92 U 238.0 Uranium	93 Np [237.0] Neptunium	94 Pu [239.1] Plutonium	95 Am [241.1] Americium	96 Cm [244.1] Curium	97 Bk [249.1] Berkelium	98 Cf [252.1] Californium	99 Es [252.1] Einsteinium	100 Fm [257.1] Fermium	101 Md [258.1] Mendelevium	102 No [259.1] Nobelium	103 Lr [262.1] Lawrencium

Where the atomic weight is not known, the relative atomic mass of the most common radioactive isotope is shown in brackets.
The atomic weights of Np and Tc are given for the isotopes ^{237}Np and ^{99}Tc.