Centre Number

Student Number

CATHOLIC SECONDARY SCHOOLS
ASSOCIATION OF NEW SOUTH WALES

2005
TRIAL HIGHER SCHOOL CERTIFICATE EXAMINATION

Chemistry

Afternoon Session
Friday 5 August 2005

Total marks – 100

Section I Pages 3-20

75 marks
This section has two parts, Part A and Part B

Part A – 15 marks
- Attempt Questions 1-15
- Allow about 30 minutes for this part

Part B – 60 marks
- Attempt Questions 16-29
- Allow about 1 hour and 45 minutes for this part

Section II Pages 21-28

25 marks
- Attempt ONE question from Questions 30-34
- Allow about 45 minutes for this section

General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Write using blue or black pen
- Draw diagrams using pencil
- Board-approved calculators may be used
- Use the Data Sheet and Periodic Table provided
- Use Multiple Choice Answer Sheet provided
- Write your Centre Number and Student Number and the top of this page and page 9

EXAMINERS

Christopher Warren (convenor)	Kincoppal-Rose Bay, Rose Bay
Karen Bertinshaw	Gilroy College, Castle Hill
Philip McIntosh	Mt Carmel College, Varroville
Jo McGrouther	St Vincents College, Potts Point

Sources

Diagrams for Question 32 – Roebuck, C (2000), *Excel HSC Chemistry*, Pascal Press, Sydney, p177

Diagram for Question 34(b) – (Accessed 13/4/05)

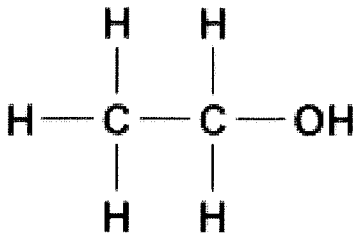
Section I
75 marks

Part A – 15 marks
Attempt Questions 1-15
Allow about 30 minutes for this part

Use the Multiple Choice Answer Sheet provided

---

1 Identify the following compound.



(A) Ethanoic acid

(B) Ethylene

(C) Ethanol

(D) Ethene

2 Which of the following is an alternative source of the compounds presently obtained from the petrochemical industry?

(A) Biomass

(B) Haber process

(C) Photovoltaic cells

(D) Radioisotopes

3 Australians have recently become more aware of the 'hole' in the ozone layer above Antarctica. The reason that we should be concerned is that it will

(A) allow oxygen to escape and we will have to wear oxygen equipment on Antarctic expeditions

(B) expose us to increased levels of ultra violet radiation

(C) cause an increase in ozone levels in the troposphere

(D) expose us to more CFCs

4 In an investigation to compare the pH of a strong acid and a weak acid, which pair of solutions would be most appropriate?

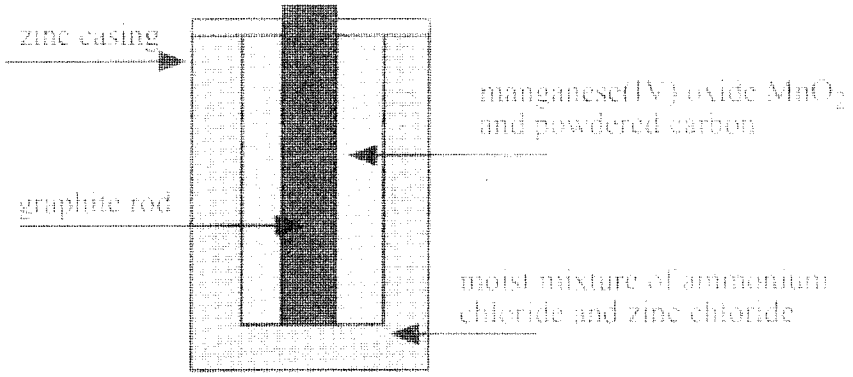
(A) 1.0 $molL^{-1}$ citric acid and 1.0 $molL^{-1}$ acetic acid

(B) 0.10 $molL^{-1}$ acetic acid and 10 $molL^{-1}$ hydrochloric acid

(C) 0.30 $molL^{-1}$ citric acid and 0.10 $molL^{-1}$ hydrochloric acid

(D) 0.10 $molL^{-1}$ acetic acid and 0.10 $molL^{-1}$ hydrochloric acid

5 The diagram below shows a dry cell battery.



Which of the following statements is correct for this dry cell battery?

(A) The manganese(IV) oxide is the electrolyte

(B) The graphite rod is the anode

(C) Graphite is reduced at the cathode

(D) Zinc is oxidised to zinc (II) at the anode

6 A student used a pH meter to measure the acidity of 100mL of 0.1 $molL^{-1}$ HCl. She found that the pH was 1. She then added 900mL of water and tested the pH again.

The value for pH that she obtained for the new concentration was

(A) 10

(B) 2

(C) 1

(D) 0.5

7 The hydrogen for the Haber process can be obtained from the reaction of steam on red-hot coke.

$$H_2O(g) + C(s) \rightleftharpoons CO(g) + H_2(g) \qquad \Delta H = +131 kJ\ mol^{-1}$$

Use Le Chatelier's Principle to predict the conditions required for the efficient production of hydrogen.

(A) High pressure and high temperature

(B) High pressure and low temperature

(C) Low pressure and high temperature

(D) Moderate temperature, high pressure and a catalyst

8 Which pair of equations correctly describes the behaviour of the oxides of lithium and carbon when placed with water?

(A) $Li_2O(s) + H_2O(l) \longrightarrow 2\ LiOH(aq)$

$2\ CO_2(g) + H_2O(l) \longrightarrow HCO_3(aq) + HCO_2(aq)$

(B) $Li_2O(s) + H_2O(l) \longrightarrow 2\ LiOH(aq)$

$CO_2(g) + H_2O(l) \longrightarrow H_2CO_3(aq)$

(C) $2\ Li_2O(s) + H_2O(l) \longrightarrow HLiO_3(aq) + HLiO_2(aq)$

$C_2O(s) + H_2O(l) \longrightarrow 2\ COH(aq)$

(D) $Li_2O(s) + H_2O(l) \longrightarrow HLiO_3(aq) + 2\ HLiO_2(aq)$

$CO(s) + H_2O(l) \longrightarrow C(OH)_2(aq)$

9 Which of the following isotopes is the most unstable?

(A) $^{1}_{1}H$

(B) $^{12}_{6}C$

(C) $^{14}_{7}N$

(D) $^{18}_{8}O$

10 A student tested 4 household substances using indicators. Which of the following results is recorded correctly?

	Substance	Colour with phenolphthalein	Colour with methyl orange
(A)	wine	pink	red
(B)	ammonia cleaner	pink	yellow
(C)	vinegar	red	blue
(D)	bicarbonate of soda	clear	blue

11 A student added a solution of barium nitrate to a solution of lawn fertilizer in order to determine the sulfate content of the fertilizer. The resulting solution was heated and stirred and then filtered. Barium nitrate was then added to the filtrate.

It is true to say that

(A) the barium nitrate is added to the filtrate to determine whether sulfate ions were still present

(B) the solution was heated and stirred to dissolve the fertilizer and the barium nitrate

(C) barium nitrate was added to dissolve the fertiliser

(D) the solution was filtered to remove any impurities in the fertilizer

12 Oysters provide a rich source of zinc, an essential trace element in our diet. The minimum recommended intake for an adult is 12mg per day.

If a sample of oysters was found by AAS to contain an average of 200ppm of zinc per oyster how many oysters would an adult have to eat to reach the minimum recommended daily intake?

(A) 0.2

(B) 1.7

(C) 6

(D) 12

13 The following cathode reaction occurs in the vanadium redox cell.

$$V_2O_5(aq) + 2H^+(aq) + 2e^- \longrightarrow 2VO_2(aq) + H_2O(l)$$

The *oxidation state* of vanadium changes from

(A) +5 to +4

(B) +5 to +2

(C) +2 to +1

(D) +4 to +5

14 Two water samples from a waste water recycling plant were tested for their level of biochemical oxygen demand.

The following results were obtained.

Water sample	***BOD (mg L^{-1})***
1	2
2	16

Using these results, it would be true to conclude that

(A) sample 2 has 8 times the level of dissolved oxygen of sample 1

(B) sample 2 was taken in the final stage of treatment

(C) sample 1 was taken at the beginning of the treatment

(D) sample 1 has the least amount of biodegradable waste in it

15 When the lunar module of Apollo 11 landed on the moon, the fuel used was hydrazine (N_2H_4) and dinitrogen tetroxide(N_2O_4). When these were mixed a spontaneous reaction occurred.

$$2\ N_2H_4(l) + N_2O_4(l) \longrightarrow 3\ N_2(g) + 4\ H_2O(g)$$

What volume of gas would be expelled at, 100kPa and 25°C, for each kilogram of hydrazine used?

(A) 31 L

(B) 109 L

(C) 2707 L

(D) 5414 L

Centre Number

Student Number

Chemistry
Section I (continued)

Part B – 60 marks
Attempt Questions 16-29
Allow about 1 hour and 45 minutes for this part

Answer the questions in the spaces provided.

Show all relevant working in questions involving calculations.

Marks

Question 16 (4 marks)

Poly(vinyl chloride) is an addition polymer which has many everyday uses.

(a) Draw the structural formula for the vinyl chloride monomer. **1**

(b) Define the term *addition polymer*. **1**

.....

.....

.....

(c) Explain ONE use of this polymer in terms of its physical properties. **2**

.....

.....

.....

Question 17 (2 marks) **Marks**

The transuranic element Meitnerium was first detected in Germany in 1982. It existed for five-thousandths of a second. Describe how transuranic elements such as Meitnerium are produced. **2**

.....

.....

.....

.....

.....

Question 18 (2 marks) **Marks**

Describe the uses of ammonia that made Haber's discovery very important at that time in world history. **2**

.....

.....

.....

.....

.....

Question 19 (5 marks) **Marks**

Assess the viability of the use of cellulose from biomass as a substitute for carbon chain structures obtained from petroleum. **5**

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

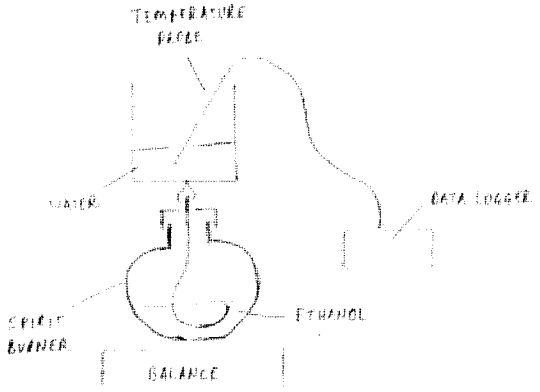
.....

.....

.....

Question 20 (5 marks) **Marks**

A quantity of ethanol was placed in a spirit burner, the wick lit and the energy produced used to heat 100g of water in a beaker. The change in mass of the spirit burner was measured by placing the burner on an electronic balance. The temperature was measured using a probe attached to a data logger. A diagram of the apparatus is shown.



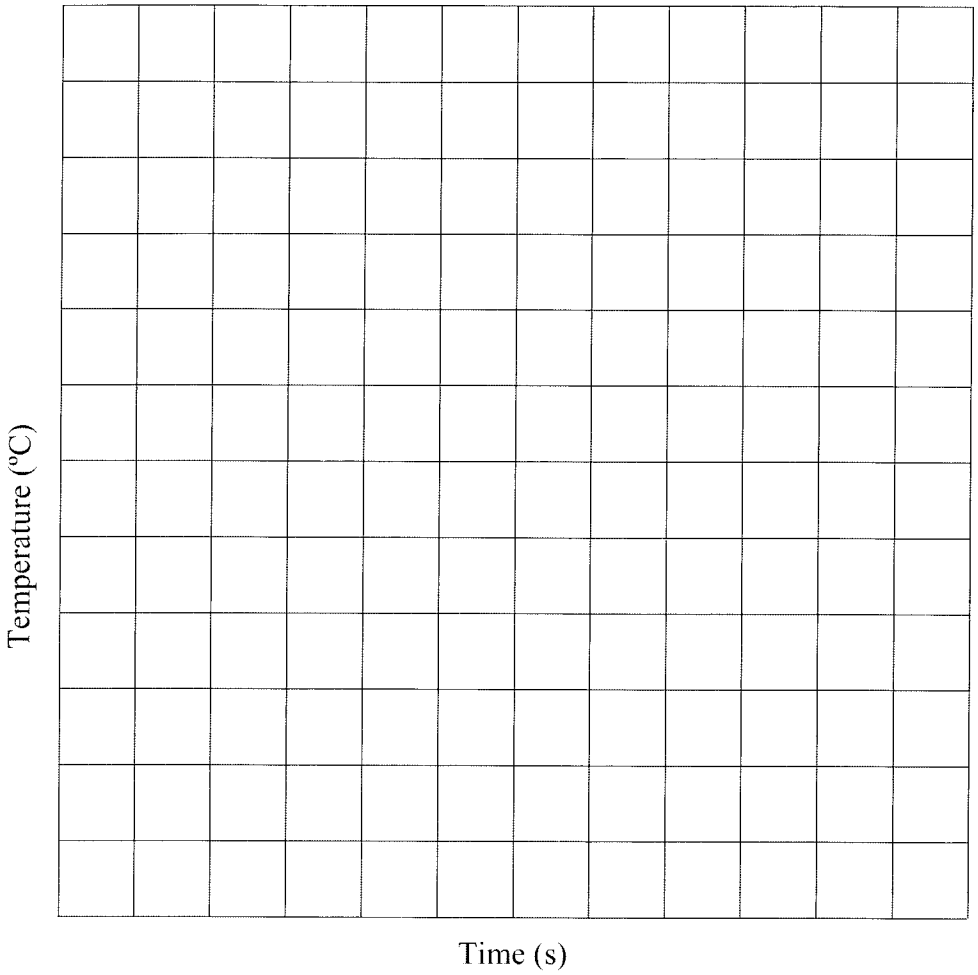
The results are tabulated below.

Time (mins)	Mass of Burner + Alcohol (g)	Temperature (°C)
0	228.3	24
1	227.8	30
2	227.4	37
3	226.9	44
4	226.5	51
5	226.2	58

Question 20 continues on page 13

Question 20 (continued) **Marks**

(a) Draw a graph of temperature v time. Use an appropriate scale. **2**



(b) Calculate the molar heat of combustion of ethanol using these data. **3**

.....

.....

.....

.....

.....

.....

.....

End of Question 20

Question 21 (5 marks) **Marks**

A student constructed an electrochemical cell using nickel, nickel nitrate, silver and silver nitrate. This can be represented by the following chemical shorthand:

$$Ni_{(s)} \mid Ni^{2+}(aq) \parallel Ag^{+}(aq) \mid Ag_{(s)}$$

(a) Draw a diagram of this electrochemical cell and label the following parts: **3**

1. anode and cathode
2. the direction of electron flow

(b) Write half equations for each reaction and calculate the cell potential. **2**

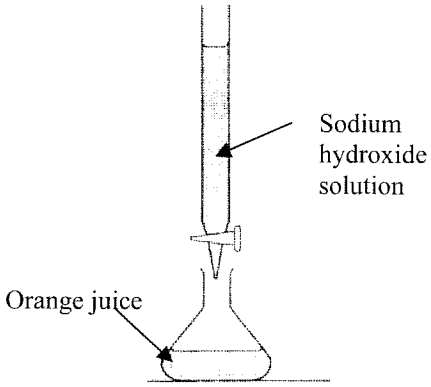
.....

.....

.....

Question 22 (3 marks) **Marks**

To find the citric acid content of some orange juice, a student used the following equipment.



(a) Identify the piece of equipment that holds the sodium hydroxide solution. **1**

.....

(b) Outline the procedure required to rinse this piece of equipment before use. **1**

.....

.....

(c) Identify a potential source of error in this experiment. **1**

.....

.....

Question 23 (3 marks) **Marks**

(a) Identify a practising Australian scientist you have studied during this Chemistry course. **1**

.....

(b) Describe his/her work. **2**

.....

.....

.....

.....

.....

Question 24 (4 marks) **Marks**

Two identical bottles of soda water (carbonated water), one at room temperature (25°C) and one just out of the refrigerator, had their pH determined using a probe and data logger. The results are tabulated below. **4**

Soda Water	pH	Temperature (°C)
Bottle A	5.21	25
Bottle B	4.63	4

Account for the difference in pH in terms of Le Chatelier's principle.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

Question 25 (4 marks) **Marks**

The presence of pairs of chemicals eg CO_3^{2-}/ HCO_3^{1-}, or, $H_2PO_4^{1-}$ / HPO_4^{2-}, in the blood is essential to the proper functioning of the body. Describe the action of these chemical pairs using equations. **4**

.....

.....

.....

.....

.....

.....

Question 26 (7 marks) **Marks**

A 500mL bottle of concentrated sulfuric acid (18 $molL^{-1}$) was dropped in a laboratory accident. Solid sodium hydrogen carbonate ($NaHCO_3$) was used to neutralize the spilled acid.

(a) Justify the choice of the solid sodium hydrogen carbonate to clean up the spill. Include relevant equation(s). **4**

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

(b) Calculate the minimum mass of sodium hydrogen carbonate needed to neutralise the spilled acid completely. **3**

.....

.....

.....

.....

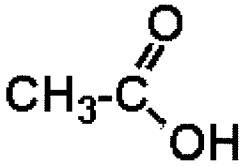
.....

.....

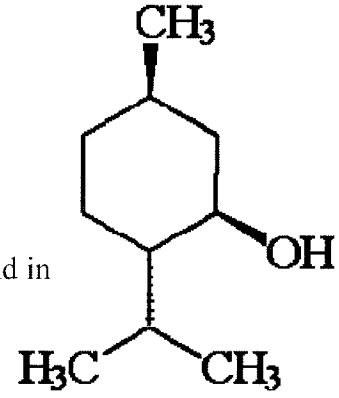
.....

Question 27 (3 marks) **Marks**

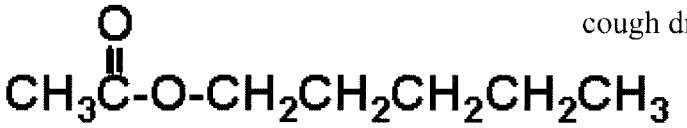
Many organic compounds, other than esters, are responsible for the distinctive aromas or flavours of foods. The following molecules are 'active' ingredients in various foods. Only ONE of these is an ester.



Acetic acid - found in salad dressing



Menthol - found in cough drops



Pentyl ethanoate - found in lollies

(a) Identify the ester. **1**

(b) Outline how this ester could be produced in a school laboratory. **2**

.....

.....

.....

.....

.....

.....

.....

Question 28 (6 marks) **Marks**

(a) Identify your local catchment area. **1**

.....

(b) Outline a chemical test that is carried out to test for a possible named contaminant in a water sample from your local catchment area. **2**

.....

.....

.....

.....

.....

(c) Describe the methods used to purify and sanitise the drinking water supplied from your catchment area. **3**

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

Question 29 (7 marks) **Marks**

Evaluate the effectiveness of the steps taken to alleviate the problems associated with the use of CFCs. 7

Chemistry

Section II

25 marks
Attempt ONE question from Questions 30-34
Allow about 45 minutes for this section

Answer the question in a SEPARATE writing booklet.

Show all relevant working in questions involving calculations.

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

(a) Pressure, volume, concentration and temperature all have an effect on an equilibrium reaction.

(i) Which of these factors will alter the equilibrium constant? **1**

(ii) Compare the effect of an increase in pressure on the following equilibria. **2**

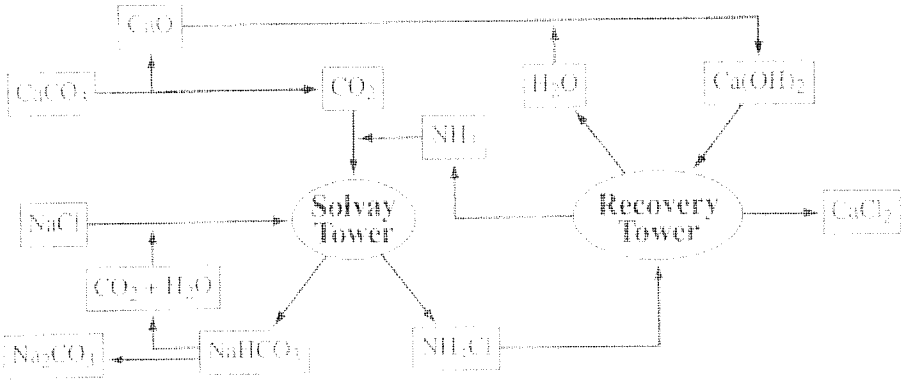
Oxidation of ammonia

$$4\,NH_3(g) + 5O_2(g) \rightleftharpoons 4NO(g) + 6H_2O(g)$$

Production of hydrogen iodide

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$$

(b) The Solvay Process is illustrated below.



(i) Identify the major product of the Solvay Process. **1**

(ii) Choose ONE of the chemical changes that occur in this process and explain the chemistry involved. **3**

(c) Analyse the processes required to manufacture sulfuric acid from Earth materials. **5**

Question 30 continues on page 23

Marks

(d) As part of your study of this Option you performed a first-hand investigation to carry out saponification and test the product.

(i) Describe the procedure you used for this investigation. **3**

(ii) Justify your method of data collection. **3**

(e) Assess the impact on the environment of the developments in technology available to manufacture sodium hydroxide. **7**

End of Question 30

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

(a) Luigi Galvani demonstrated "animal electricity" by making the muscles twitch in a dead frog. Alessandro Volta proposed a different theory about the origins of this electricity.

(i) Identify another scientist who contributed toward our understanding of electrochemistry. **1**

(ii) Compare the theories of Galvani and Volta. **2**

(b) (i) Identify ONE condition at great ocean depths which led to the prediction that shipwrecks would corrode slowly. **1**

(ii) Explain how this condition led to the prediction of a slow rate of corrosion. Support your answer with balanced chemical equations. **3**

(c) With reference to the factors that affect an electrolysis reaction, analyse how an understanding of electrolysis has led to the development of efficient processes that can be applied in the conservation and restoration of marine artefacts. **5**

(d) You were required to perform a first-hand investigation to compare and describe the rate of corrosion of materials in different salt concentrations.

(i) Outline the procedure for your investigation. **2**

(ii) Justify the procedure. **4**

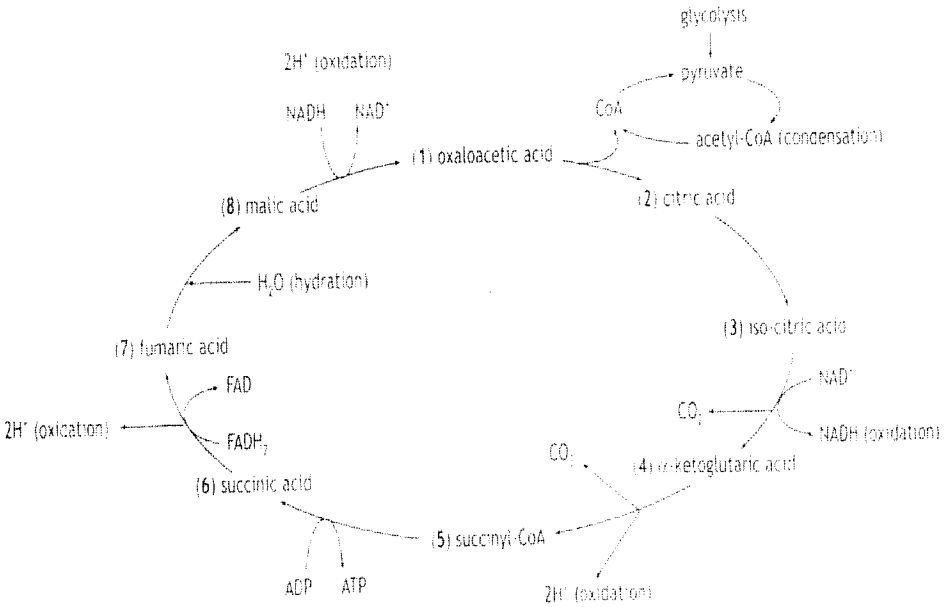
(e) Assess the impact of new materials and the development of corrosion protection systems on the construction of marine going vessels, with a particular emphasis on the 20th Century. **7**

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

(a) (i) Identify the main use of ATP in the body. **1**

(ii) Compare the structure of ATP and ADP. **2**

(b) (i) Identify the name of the process shown below. **1**



(ii) Explain the importance of this process. Use an equation to support your answer. **3**

(c) Analyse the effects of changes in pH and temperature on enzyme activity. **5**

(d) As part of your study of this Option you performed a first-hand investigation to compare the structures of glycogen and glucose.

(i) Draw the structure of glucose. **1**

(ii) Outline the procedure you used for this investigation. **3**

(iii) Justify the choice of materials. **2**

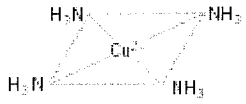
(e) Assess the impact of discoveries in biochemistry on the understanding of the changes that occur in the muscles of a sprinter. **7**

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

(a) Ammonia (NH_3) is an example of a molecule that acts as a ligand.

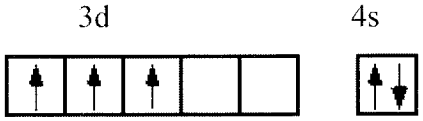
(i) Identify another molecule that can act as a ligand. **1**

(ii) Describe the colour change when the following complex is formed from a Cu^{2+} solution and excess ammonia. **1**



(iii) Write a chemical reaction showing the formation of this complex. **1**

(b) (i) Identify the name of the element with the following electronic configuration. **1**



(ii) Account for TWO different oxidation states of this element. **3**

(c) Analyse the reasons for the position of Manganese in the periodic table in terms of its electron arrangement, ionisation energy and electronegativity. **5**

(d) As part of your study of this Option you performed a first-hand investigation to observe the colour changes of a transition metal in its different oxidation states.

(i) Outline the procedure you used for this investigation. **3**

(ii) Justify the chemicals used. **3**

(e) Assess the impact of technology in analysing the range of pigments used by artists throughout history. **7**

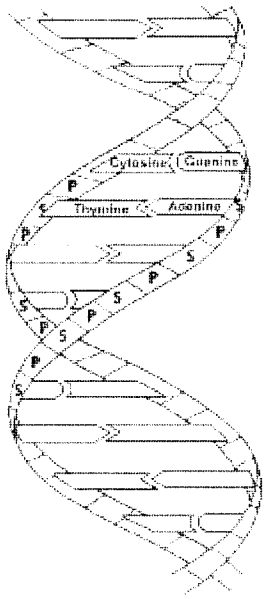
Question 34 – Forensic Chemistry (25 marks) **Marks**

(a) Carbohydrates such as cellulose, starch and glycogen can be used to distinguish between plant and animal materials

(i) Identify the general formula for a carbohydrate. **1**

(ii) Compare the use of carbohydrates by plants and animals. **2**

(b) A section of a DNA molecule is shown below.



(i) Identify the three main components of DNA. **1**

(ii) Explain how DNA is analysed to identify relationships between people. **3**

(c) With reference to a first hand investigation you have carried out, analyse the factors that allow a chemist to use emission spectroscopy to identify an element. **5**

Question 34 continues on page 28

(d) As part of your study of this Option you performed a first-hand investigation to separate a mixture of organic materials.

(i) Outline the procedure you used for this investigation. **3**

(ii) Justify your choice of solvent(s). **3**

(e) Assess the impact of developments in a range of technologies on the ability of chemists to resolve forensic investigations. **7**

End of paper

CATHOLIC SECONDARY SCHOOLS ASSOCIATION
CHEMISTRY DATA SHEET

Avogadro's constant, N_A ..... 6.022×10^{23} mol^{-1}
Volume of 1 mole ideal gas: at 100 kPa and
at 0°C (273 K) ..... 22.71 L
at 25°C (298 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

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

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

THE PERIODIC TABLE

KEY

Atomic Number	Symbol of element	Name of element
79	Au	Gold
Atomic Weight	197.0	

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