ARC Academic Resources Centre

Harcourt Education

Student Number: ……..……..…

2006

HIGHER SCHOOL CERTIFICATE

Sample Examination Paper

CHEMISTRY

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
- A data sheet and Periodic Table are provided with this paper
- Write your student number at the top of this page

Total Marks – 100

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

Part B – 60 marks
- Attempt Questions 16–22
- Allow about 1 hour and 45 minutes for this part

Section II
25 marks
- Attempt ONE question from Questions 23–27
- Allow about 45 minutes for this section

Directions to school or college

To ensure maximum confidentiality and security, examination papers used for trial examinations must NOT be removed from the examination room or used with students for revision purposes until Monday 4 September 2006.

All care has been taken to ensure that this sample examination paper is error free and that it follows the style, format and material content of the current NSW syllabus. Candidates are advised that the authors of this examination paper cannot in any way guarantee that the actual Board of Studies Examination will have a similar content or format.

 Product code:734844

Section I
75 marks

Allow about 2 hours and 15 minutes for this section

This section has TWO parts

Part A – 15 marks Questions 1–15
Part B – 60 marks Questions 16–22

Part A
15 marks

Select the alternative A, B, C, or D that best answers the question. Fill in the response sheet clearly.

1	**X**			

If you think you have made a mistake, blank out the incorrect answer and fill in the new answer.

1	**X**			**X**

If you change your mind and have crossed out what you consider to be the correct answer, then indicate the correct answer by writing the word *correct* and drawing an arrow.

1	X			X

Correct

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 Which of the following is present in an alkene hydrocarbon?

A branched carbon chain
B C to C double bond
C monomer group
D hydroxyl group on the terminal C atom

2 Which of the following is a condensation polymer?

A cellulose
B polypropylene
C teflon
D PVC

3 Which of the following statements correctly describes a redox reaction?

A The oxidation half-reaction and the reduction half-reaction occur simultaneously.
B The oxidation half-reaction occurs before the reduction half reaction.
C The oxidation half-reaction occurs after the reduction half-reaction.
D The oxidation half-reaction occurs spontaneously but the reduction half-reaction does not.

4 Which of the substances listed below functions as the electrolyte in a lead-acid automobile battery?

A PbO_2
B $PbSO_4$
C H_2SO_4
D H_2O

5 Of the following statements, which would predict that a particular isotope of an element is radioactive?

A The atomic number of the element is 15 and its neutron to proton ratio is equal to about 1.
B The atomic number of the element is 50 and its neutron to proton ratio is equal to about 1.3.
C The atomic number of the element is 80 and its neutron to proton ratio is less than 1.
D The atomic number of the element is greater than 83.

6 The radioactive isotope cobalt-60 is used in the treatment of cancer. Which property of the isotope makes it useful for this purpose?

A Disintegrates by β-emission
B Produces γ–rays that can penetrate deeply into body tissues
C Is a radioactive isotope that has a half life of only a few hours
D Emits radiation that will kill cancer cells and not harm normal cells

7 The hydronium ion concentration (in $molL^{-1}$) of some common substances is given in the Table below

$[H_3O^+]$	Substance
10^{-9}	baking soda
10^{-5}	black coffee
10^{-8}	sea water
10^{-11}	laundry detergent
10^{-6}	milk
10^{-13}	chlorine bleach
10^{-4}	soda water

Of the substances listed which of the following are acidic?

A soda water and chlorine bleach
B milk and laundry detergent
C sea water and baking soda
D black coffee and milk

8 In the equilibrium

$$N_2H_5^+(aq) + SCN^-(aq) \rightleftharpoons HSCN(aq) + N_2H_4(aq)$$

A $N_2H_5^+$ acts as a acid
B SCN^- acts as a acid
C HSCN acts as a base
D N_2H_4 acts as a acid

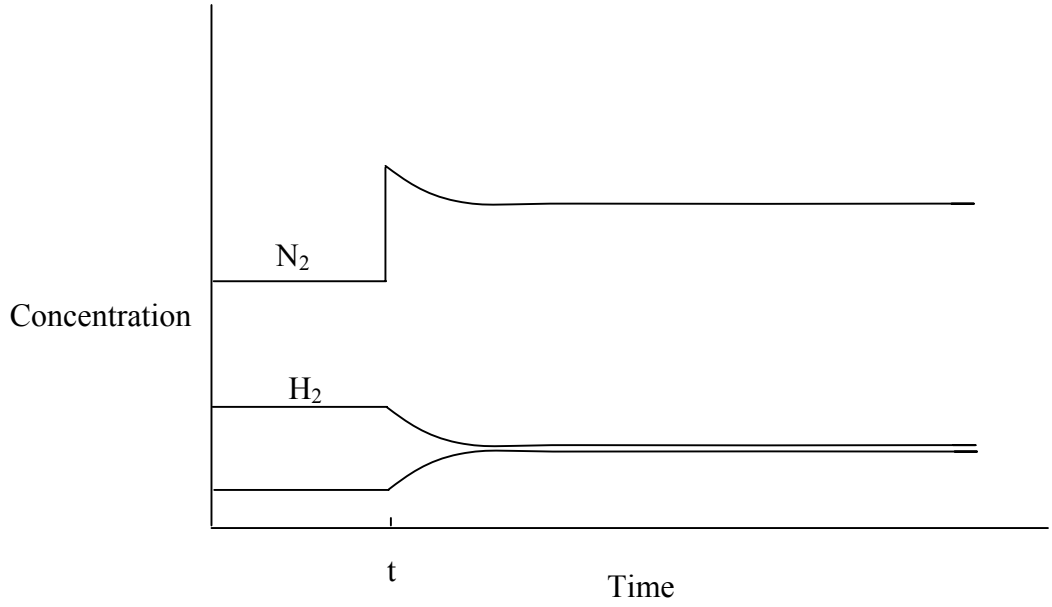
9 Which statement best describes a weak acid solution?

A There are no neutral acid molecules present.
B Only a fraction of the acid molecules is ionised.
C All acid present is ionised to hydrogen ions.
D The total concentration of acid molecules present is high.

10 In the process of esterification the reactant alcohol and acid mixture is refluxed. What is the purpose of refluxing the mixture?

A Speed up the reaction
B Prevent the loss of alcohol as the reactant mixture is heated
C Remove the water produced as a product of the reaction
D Force the reaction to come to equilibrium

11 An equilibrium mixture between nitrogen, hydrogen and ammonia was subjected to a change at time t. The result of this change is shown in the diagram below.



What was the change made to the equilibrium mixture at time t?

A The pressure in the equilibrium mixture of nitrogen and hydrogen was decreased.
B The temperature of the reaction mixture was raised.
C The concentration of nitrogen gas in the equilibrium mixture was increased.
D The volume of the reaction vessel was increased.

12 The technique of atomic absorption spectroscopy (AAS) is widely used. For which of the following measurements would AAS be used?

A concentration of ozone in the upper atmosphere
B amount of dissolved oxygen in a water sample
C phosphate concentration in water quality analysis
D concentration of metal ions in solution

13 Which is a simple test that can be used to test for the presence of carbonate ions in water?

A volatilising the solution in a flame
B addition of silver nitrate to the solution
C addition of a weak acid to the solution
D addition of ammonia to the solution

14 Oxygen and ozone differ in their molecular structure and bonding. The difference in bonding structure is reflected in different properties. How can the two molecules be distinguished?

A a difference in reactivity
B the colour of the gases at room temperature
C the presence of covalent bonds in one but not the other

D oxygen having a higher boiling point than ozone

15 Which of the following halogen-containing compounds is NOT a source of ozone-destroying atoms in the stratosphere?

A CCl_4
B CH_2FCF_3
C CCl_2F_2
D $CBrClF_2$

Section I (continued)

Part B – 60 marks
Attempt Questions 16–22
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 (14 marks)

(a) (i) The reaction of ethylene with water is an important industrial process. Write a balanced equation for this reaction. **1**

(ii) Give the experimental conditions required for the reaction in (i). **1**

(b) (i) Three commercially significant monomers used in the manufacture of polymers are given in the Table below. Write the structure of each of these monomers and give the names of the polymers formed from each of these monomers. **3**

Monomer	Structure of Monomer	Name of Polymer
ethylene		
chloroethylene		
phenylethylene		

(ii) Each of the polymers in (i) are called addition polymers. What does the term imply in regard to the polymerisation process? **2**

(iii) What types of intermolecular forces would you expect between the polymers formed from ethylene? **1**

Marks

Question 16 cont.

(c) (i) Define the term 'biopolymer'. **1**

(ii) What is the major chemical component of biomass? **1**

(d) Ethanol has been proposed as an alternative fuel. Give TWO advantages and TWO disadvantages of its use as a fuel. **4**

Question 17 (11 marks)

(a) (i) From the Table of Standard Potentials, select TWO metals that will reduce hydrogen ions to hydrogen gas. **1**

(ii) Using one of the metals in part (i) write oxidation and reduction half reactions for the reaction which occurs. **2**

(iii) Write a balanced overall cell equation for the redox reaction. **1**

Marks

Question 17 cont.

(b) (i) Sketch and label a diagram showing the structure of a silver oxide 'button' cell. Mark in your diagram the positive and negative terminals of the cell. **5**

(ii) Write the balanced overall cell reaction for the silver oxide 'button' cell. **2**

Question 18 (8 marks)

A student wished to determine the percentage of calcium carbonate present in a shell found at the beach. The clean dry shell, which weighed 1.306 g, was placed in a small beaker and 10 mL of 5 $molL^{-1}$ of hydrochloric acid was added. When the shell had completely dissolved, the resulting solution was transferred to a volumetric flask and the volume made up to 25 mL with distilled water. A 10 mL sample from this solution required 11.2 mL of 1 $molL^{-1}$ sodium hydroxide for complete neutralisation.
All working, for parts (b) to (e) of this question, should be shown.

(a) Write a balanced equation for the reaction of calcium carbonate with hydrochloric acid. **1**

(b) Calculate the number of moles of NaOH present in the 11.2 mL of 1 $molL^{-1}$ NaOH solution. **1**

(c) How many moles of acid remained in the beaker after the reaction with the shell (before the dilution was made)? **2**

Marks

Question 18 cont.

(d) How many moles of acid reacted with the shell? **1**

(e) What mass of calcium carbonate was present in the shell? **2**

(f) What was the percentage of calcium carbonate in the shell? **1**

Question 19 (8 marks)

$$A(g) + B(g) \rightleftharpoons X(g)$$

When two gases, A and B, are reacted, partial conversion to product X occurs according to the equation above. The following data provide information about the percentage composition of the gaseous mixture at equilibrium under various conditions.

At constant pressure:

Temperature (°C)	100	200	300	400	500
Percentage of X in the mixture	50	35	23	14	8

At constant temperature:

Pressure (MPa)	5	10	15	20	25
Percentage of X in the mixture	12	18	25	34	44

(a) From the above data, is the formation of X from A and B endothermic or exothermic? Briefly explain your answer. **2**

Marks

Question 19 cont.

(b) From the data above, does the volume increase, decrease or remain the same when A and B react to form X? Explain your answer. **2**

(c) State qualitatively what combination of temperature and pressure conditions (i.e. high or low) would give the highest percentage of X at equilibrium. **2**

Temperature: _____

Pressure: _____

(d) Suggest a means of increasing the amount of product in this reaction other than by altering the temperature or pressure. Explain your answer. **2**

Marks

Question 20 (10 marks)

(a) (i) Define acids and bases according to the Bronsted-Lowry theory. **2**

(ii) In the following two reactions, state whether HCO_3^- behaves as an acid or a base. Explain your answer in each case.

1. $H_2CO_3(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + HCO_3^-(aq)$
2. $HCO_3^-(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + CO_3^{2-}(aq)$ **2**

(b) The pH of a 0.001 $molL^{-1}$ solution of hydrochloric acid and the pH of a 0.056 $molL^{-1}$ of ethanoic acid is 3.

(i) Compare the concentration of each acid. Explain your answer. **2**

(ii) Compare the strength of each acid. Explain your answer. **2**

(iii) Compare the hydrogen ion concentration in the solutions of each acid. Explain your answer. **2**

Marks

Question 21 (4 marks)

(a) Write the formula for ozone and note the type of bond(s) found in the molecule. **2**

(b) Explain why ozone in the stratosphere is beneficial to humans. **2**

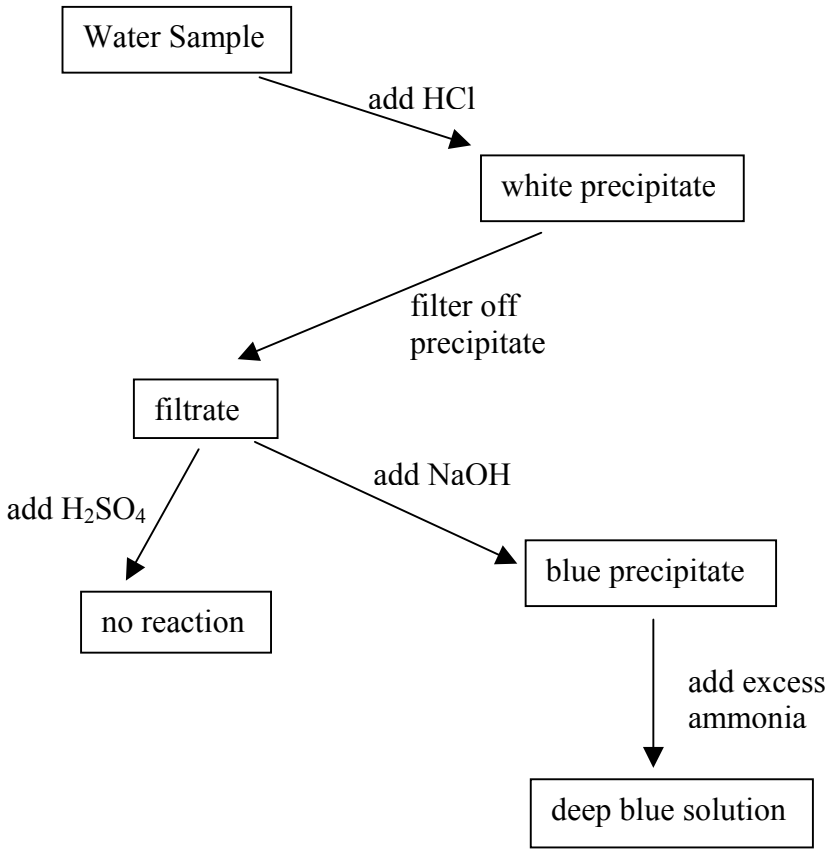
Question 22 (5 marks)

(a) It was suspected that the water in a river was being contaminated by sewage. What test(s) would you use to check for sewage pollution downstream from the point of suspected discharge? Explain what answer you would expect from the test(s) if the water was indeed polluted by sewage. **2**

Marks

Question 22 cont.

(b) A chemist performed the tests shown in the flow chart below to determine the cation(s) present in a water sample.



(i) What cation(s) is/are present in the solution? **1**

(ii) Write balanced chemical equations for the FIRST TWO reactions in the flow chart sequence. **2**

End of Section I

Section II – 25 marks

Attempt ONE question from Questions 23–27
Allow about 45 minutes for this section

Answer the questions in a writing booklet. Extra writing booklets are available.
Show all relevant working in questions involving calculations.

Marks

Question 23 – INDUSTRIAL CHEMISTRY (25 marks)

(a) N_2O_4, a colourless gas, and NO_2, a brown gas, exist in equilibrium as follows

$$2NO_2(g) \rightleftharpoons N_2O_4(g)$$

A closed container at 25°C is charged with NO_2 and N_2O_4 at partial pressures of 0.56 atm and 0.51 atm respectively. At equilibrium the partial pressure of N_2O_4 is found to be 0.54 atm.

(i) Write the equilibrium expression for the reaction. **1**

(ii) What is the value of Kp for the equilibrium? **3**

(b) Sulfuric acid is one of the world's most widely used chemicals. It is produced industrially by the so called Contact Process. Sulfur dioxide, air and water are the main feedstocks in its production.

(i) Why is the production process called the Contact Process? **1**

(ii) The sulfur dioxide for the Contact Process is usually obtained from the combustion of sulfur. Write a balanced equation for the combustion of sulfur. **1**

(iii) What reaction conditions will maximise the yield of sulfur trioxide in the Contact Process? **3**

(iv) Sulfuric acid is an oxidising agent. Describe, with a balanced equation, sulfuric acid being used in the oxidation of copper(II) metal. **2**

(v) What are the safety precautions necessary for the transport and storage of concentrated (98%) sulfuric acid? Explain the reasons for the precautions you specify. **3**

(c) The process for the manufacture of sodium carbonate is called the Solvay Process.

(i) The first stage of the Solvay Process involves the saturation of concentrated NaCl with NH_3 and the bubbling of CO_2 through this solution to produce $NaHCO_3$. What volume of carbon dioxide (measured at RTP) is required per tonne of sodium hydrogen carbonate produced by the Solvay Process? **3**

(ii) What is the only waste product in the Solvay Process and how can this waste be disposed of from plants remote from oceans or waterways? **2**

(d) (i) Describe how a saponification reaction can be carried out in the school laboratory. **3**

(ii) Soaps are often called surfactants or 'surface active agents'. Explain. **2**

(iii) What is the major environmental concern with the use of washing powders and liquids? **1**

Marks

Question 24 – SHIPWRECKS, CORROSION and CONSERVATION (25 marks)

(a) (i) The electrodes in an electrolytic cell are given the names anode and cathode. What processes occur at the surface of these electrodes in electrolysis? **2**

(ii) List three factors that can affect the products that are formed in an electrolysis reaction. **3**

(iii) Describe the major achievement of Michael Faraday in the field of electrochemistry. **1**

(b) (i) How does the solubility of a gas in water change with change in temperature, a change in pressure and a change in salinity? **3**

(ii) Outline an experiment you have performed to compare the effect of varying salinity on the rate of corrosion of a material. **3**

(c) (i) Describe the mechanism of corrosion of iron. **4**

(ii) How is the galvanic corrosion of iron affected by pH? **1**

(iii) Explain how coating the surface of iron with zinc can offer protection from corrosion. Include in your explanation the equation that describes this protection. **4**

(iv) From the oxygen and temperature conditions in the deep ocean it would be predicted that the rate of corrosion of a sunken iron ship would be fairly slow. However, from observation of wrecks it is found that corrosion is more extensive than expected. Explain this observation. **1**

(d) The first stage of restoration of ancient wooden ships raised from the ocean floor is spraying with fresh water. This stage of restoration can often last for many years. Explain the purpose of this prolonged exposure to water and describe what would have happened if this procedure had not been carried out as a first stage of restoration. **3**

Marks

Question 25 – THE BIOCHEMISTRY OF MOVEMENT (25 marks)

(a) (i) Even though the general formula for glucose, galactose and fructose is $C_6H_{12}O_6$ the molecules are structurally different. What are the differences in structure? **3**

(ii) Cellulose and starch are both polymers of glucose. They are found, however, to have different properties. Explain. **2**

(b) The Table below shows some characteristics of saturated fatty acids.

Name of Acid	Formula	Melting Point (°C)
lauric acid	$CH_3(CH_2)_{10}COOH$	44
palmitic acid	$CH_3(CH_2)_{14}COOH$	63
stearic acid	$CH_3(CH_2)_{16}COOH$	70

Explain the trend in melting point of these fatty acids. **2**

(c) (i) Amino acids are the building blocks of protein molecules. Write the general formula for an amino acid and identify and name the functional groups present. **2**

(ii) Proteins can be denatured, particularly by heating. What does the term 'denaturation' mean? **2**

(d) (i) Adenosine triphosphate (ATP) is sometimes known as the 'energy currency' of the cell. Explain. **2**

(ii) In what organelle of the cell are the enzymes and electron carriers associated with cellular respiration found? **1**

(e) (i) What are the four major proteins found in muscle and to what structures within muscle do these proteins contribute? **3**

(ii) State an important structural difference between Type 1 and Type 2 muscle cells. **1**

(iii) Compare the primary fuel usage for metabolism by athletes in sprint events with that of athletes in endurance events. **3**

(iv) Explain the relationship between production of lactic acid and impairment of muscle function. **3**

(v) What is the IUPAC name for lactic acid? **1**

Marks

Question 26 – THE CHEMISTRY OF ART (25 marks)

(a) How is a canvas prepared for painting before the application of pigments? **2**

(b) (i) The flame test is regularly used to identify metals in solution. Discuss the theory behind the test. **3**

(ii) What is meant by the term 'line absorption spectra' and why is it important in the conservation of art? **3**

(c) What are the fundamental ideas in the Bohr theory of the atom? What are the limitations of the Bohr theory? **3**

(d) How are X-rays used in art conservation? **3**

(e) (i) What is the electronegativity of an atom and what are the trends in electronegativity across a Period and down a Group in the Periodic Table? **3**

(ii) Discuss the principal factors that influence the ionisation energy of an atom. **3**

(f) (i) Compare the electron configuration of the transition elements with that of the main Group elements. **2**

(ii) Name two properties of transition metal ions that can be largely explained by the presence of partially filled d shells. **3**

Marks

Question 27 – FORENSIC CHEMISTRY (25 marks)

(a) (i) The first step in determining the structure of a protein is to hydrolyse the bonds between the amino acids. Describe how electrophoresis can be used to separate and identify the amino acids. **4**

(ii) How can DNA be used to identify relationships between individuals? **2**

(iii) Briefly discuss any ethical issues associated with the maintenance of data banks of DNA. **2**

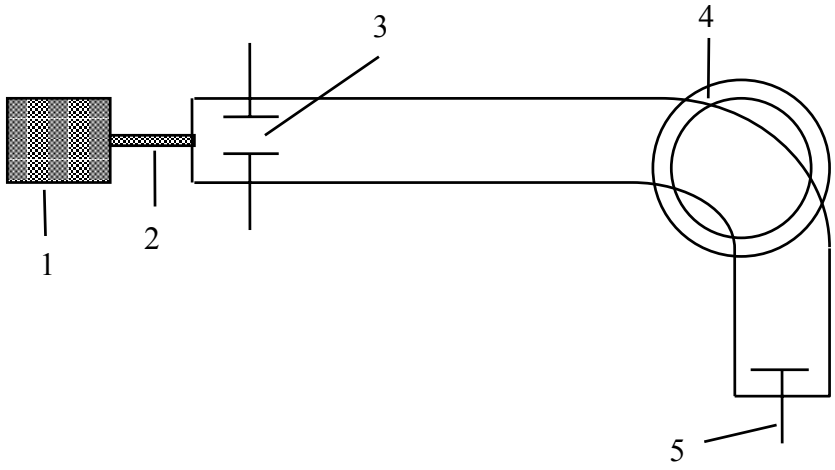
(b) Describe the structure of a nucleic acid, using the genetic material deoxyribonucleic acid (DNA) as an example. **5**

(c) One of the monosaccharides from which sucrose is formed is ∝-glucose.

(i) What is meant by the term 'monosaccharide'? **3**

(ii) Name the other monosaccharide (apart from ∝-glucose) from which sucrose is formed. **1**

(d) Below is a schematic diagram of a mass spectrometer. What are the functions of the numbered parts of the spectrometer? **5**



(e) In what way have the various methods of spectroscopy contributed to forensic science? Give one example. **3**

End of Section II

Section I – Multiple choice

Answer sheet

	A	B	C	D
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				

This page has been intentionally left blank

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

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

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

PERIODIC TABLE OF THE ELEMENTS

KEY

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

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.

Mapping grid

Core Questions

Question	Mark	Content	Outcome	Band
1	1	Recall character of alkenes	H9	2–3
2	1	Recall the processes in the formation of the polymers	H9	3–4
3	1	Identify the processes in a redox reaction	H7	4–5
4	1	Recall function of lead-acid battery	H7	2–3
5	1	Predict atomic basis of radioactivity	H6	4–5
6	1	Assess use of radioisotopes in medicine	H4	3–4
7	1	Relate hydronium ion concentration to acidity	H9	4–5
8	1	Recall definition of Bronsted-Lowry theory	H8	2–3
9	1	Identify basis of definition of weak acid	H8	3–4
10	1	Recall experimental steps in esterification reaction	H9	2–3
11	1	Interpret graphical information with respect to equilibrium reaction	H14	4–6
12	1	Recall the application of atomic absorption spectroscopy	H3	2–4
13	1	Recall test for anions in solution	H8	2–4
14	1	Recall differences between oxygen and ozone	H7	3–4
15	1	Identify structural feature of ozone destroying molecules	H4	3–4
16 a i	1	Write equation for reaction of ethylene and water	H9	3–4
16 a ii	1	Give experimental conditions for reaction of ethylene with water	H9	2–3
16 b i	3	Write structures of monomers and the name of their polymers	H9	2–4
16 b ii	2	Recall features of addition polymerisation reactions	H9	3–4
16 b iii	1	Name intermolecular forces in polymer	H9	3–4
16 c i	1	Define the term ‘biopolymer’	H9	2–3
16 c ii	1	State major chemical component of biomass	H9	2–3
16 d	4	Assess ethanol as an alternative fuel	H3	3–4

Question	Mark	Content	Outcome	Band
17 a i	1	Interpret Table of Standard Potentials	H7	4–5
17 a ii	2	Write oxidation and reduction half reactions	H7	4–6
17 a iii	1	Write balanced cell reaction	H7	4–5
17 b i	5	Sketch and label silver oxide ‘button’ cell	H3	3–4
17 b ii	2	Write cell reaction for ‘button’ cell	H7	4–5
18 a	1	Write balanced equation	H10	3–4
18 b	1	Calculate moles present in solution	H10	2–4
18 c	2	Calculate moles remaining after reaction	H10	2–4
18 d	1	Calculate moles of acid reacted	H10	3–4
18 e	2	Calculate initial mass from neutralisation data	H10	4–5
18 f	1	Calculate percentage composition	H10	3–4
19 a	2	Predict reaction from data	H14	5–6
19 b	2	Interpret equilibrium data	H14	5–6
19 c	2	State effect of reaction conditions on equilibrium	H8	4–5
19 d	2	Suggest manipulation of equilibrium to increase product	H8	4–5
20 a i	2	Recall Bronsted-Lowry definition	H8	2–3
20 a ii	2	State behaviour of species in terms of Bronsted-Lowry definition	H8	3–4
20 b i	2	Compare concentrations of acids	H7	3–4
20 b ii	2	Compare strengths of acids	H7	3–4
20 b iii	2	Compare hydrogen concentrations in acid solutions	H7	3–5
21 a	2	Write formula and note bonding types	H6	3–4
21 b	2	Explain importance of ozone layer to human health	H4	3–4
22 a	2	Select suitable test for water pollution	H11	4–5
22 b i	1	Interpret data on cation testing	H11	5–6
22 b ii	2	Write chemical equations	H10	4–5
23 a i	1	Write equilibrium expression	H13	3–4
23 a ii	3	Calculate value of equilibrium constant	H10	3–4
23 b i	1	Recall detail of Contact Process	H8	2–3
23 b ii	1	Write equation for combustion of sulfur	H10	3–4

Question	Mark	Content	Outcome	Band
23 b iii	3	Recall conditions that maximise yield in Contact Process	H8	2–3
23 b iv	2	Write equation for sulfuric acid acting as an oxidising agent	H7	3–4
23 b v	3	Specify safety precautions in transport and storage of concentrated sulfuric acid	H4	2–3
23 c i	3	Calculate gas production in stage of Solvay Process	H10	5–6
23 c ii	2	Recall issues with waste from Solvay Process	H4	3–4
23 d i	3	Describe detail of saponification experiment	H9	2–3
23 d ii	2	Recall features of surfactants	H9	3–4
23 d iii	1	Recall environmental concern related to use of washing powders and detergents	H4	2–3
24 a i	2	Recall process associated with electrolytic cell	H7	3–4
24 a ii	3	Note factors affecting electrolytic reactions	H7	3–4
24 a iii	1	Describe contribution of a scientist to electrochemistry	H2	2–3
24 b i	3	Recall characteristics of solubility of gases	H8	3–4
24 b ii	3	Outline experiment on rate of corrosion	H11	4–5
24 c i	4	Detail mechanism of corrosion of iron	H8	5–6
24 c ii	1	Recall effect of pH on corrosion	H8	3–4
24 c iii	4	Explain how iron can be protected from corrosion by zinc coating	H3	4–5
24 c iv	1	Explain observation of corrosion in deep ocean	H3	3–4
24 d	3	Explain wooden ship restoration processes	H3	3–4
25 a i	3	Explain structural differences in carbohydrates	H9	4–5
25 a ii	2	Relate properties of polymers to structure	H9	3–4
25 b	2	Explain trends in fatty acid melting points	H8	3–4
25 c i	2	Write general formula and note functional groups in amino acids	H9	3–4
25 c ii	2	Explain meaning of protein denaturation	H9	3–4
25 d i	2	Describe function of ATP	H9	3–4
25 d ii	1	Locate cell respiration in cellular organelle	H8	2–3

Chemistry HSC 2006

Question	Mark	Content	Outcome	Band
25 e i	3	Name major muscle proteins	H8	2–3
25 e ii	1	Recall structural difference between muscle types	H8	3–4
25 e iii	3	Discuss fuels used in muscle	H7	5–6
25 e iv	3	Relate lactic acid accumulation to muscle function	H7	4–5
25 e v	1	Give IUPAC name of lactic acid	H9	3–4
26 a	2	Recall method of preparation of canvas for painting	H1	2–3
26 b i	3	Explain flame tests for metals	H6	4–5
26 b ii	3	Relate atomic spectra to art conservation	H3	4–5
26 c	3	Discuss Bohr's model of the atom	H6	5–6
26 d	3	Relate X-rays to art conservation	H3	4–5
26 e i	4	Describe electronegativity of elements to position in Periodic Table	H6	3–5
26 e ii	2	Discuss factors that influence ionisation energy of atoms	H6	5–6
26 f i	2	Compare electron configuration of transition elements with main element Groups	H6	3–4
26 f ii	3	Relate properties of transition elements to electron structure	H6	4–5
27 a i	4	Describe use of electrophoretic techniques in identification of amino acids	H3	3–4
27 a ii	2	Describe forensic use of DNA in identifying relationships between individuals	H3	3–4
27 a iii	2	Examine ethical issues related to maintenance of DNA banks	H4	3–4
27 b	5	Describe structure of DNA	H9	2–4
27 c i	3	Describe meaning of term 'monosaccharide'	H9	2–3
27 c ii	1	Recall structure of sucrose	H9	2–3
27 d	5	Describe function of parts of mass spectrometer	H4	3–4
27 e	3	Describe use of spectroscopy in forensic science	H3	3–5

Marking guidelines

Section I – Part A

1	B	**2**	A	**3**	A	**4**	C
5	D	**6**	B	**7**	D	**8**	A
9	B	**10**	B	**11**	C	**12**	D
13	C	**14**	A	**15**	B		

Section I – Part B

Question 16a(i)
Suggested answer

$$C_2H_4 + H_2O \longrightarrow CH_3CH_2OH$$

Marking guidelines

Criteria	Marks
• correct balanced equation	1

Question 16a(ii)
Suggested answer
Phosphoric acid catalyst, temperature 300°C

Marking guidelines

Criteria	Marks
• correct conditions for reaction (accept catalyst and heat)	1

Question 16b(i)
Suggested answer

Monomer	Structure of Monomer	Name of Polymer
ethylene	CH_2CH_2	polyethylene
chloroethylene	CH_2CHCl	polyvinylchloride (or PVC)
phenylethylene	$CH_2C(C_6H_6)H$	polystyrene

Marking guidelines

Criteria	Marks
• correct structure of monomer and name of polymer (1 mark each)	3 total

Question 16b(ii)
Suggested answer
The polymer forms by monomers bonding together without the loss of any atoms.

Marking guidelines

Criteria	Marks
• monomers bond	1
• no loss of any atoms when bonds are formed	1

Question 16b(iii)
Suggested answer
Dispersion forces

Marking guidelines

Criteria	Marks
• dispersion (or Van der Waal forces)	1

Question 16c(i)
Suggested answer
Biopolymers are polymers that are totally, or in large part, made by living organisms.

Marking guidelines

Criteria	Marks
• polymers totally or largely made by living organisms	1

Question 16c(ii)
Suggested answer
Cellulose

Marking guidelines

Criteria	Marks
• cellulose	1

Question 16d
Suggested answer
Advantages – a renewable resource; potential to reduce greenhouse gas emissions
Disadvantages – large areas of agricultural land required to grow suitable crops; disposal of waste products from fermentation processes

Marking guidelines

Criteria	Marks
• Advantage – renewable resource	1
• Advantage – potential reduction of greenhouse gases	1
• Disadvantage – crops for production require large area of agricultural land	1
• Disadvantage – disposal of fermentation waste products	1

Question 17a(i)
Suggested answer
Any TWO of Mg, Al, Zn, Fe, Ni, Sn or Pb

Marking guidelines

Criteria	Marks
• any TWO of Mg, Al, Zn, Fe, Ni, Sn or Pb	1

Question 17a(ii)
Suggested answer
e.g. Oxidation half reaction $Mg \longrightarrow Mg^{2+} + 2e$
Reduction half reaction $2H^+ + 2e \longrightarrow H_2$

Marking guidelines

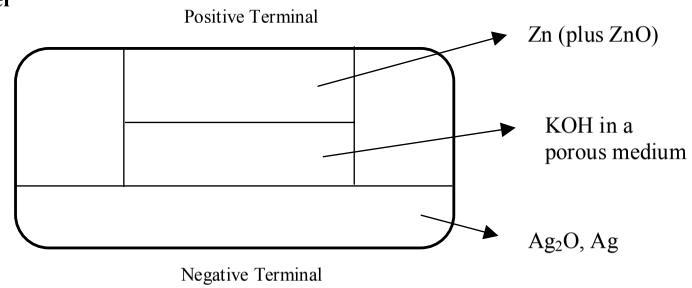
Criteria	Marks
• oxidation half reaction appropriate to metal chosen	1
• reduction half reaction $2H^+ + 2e \longrightarrow H_2$	1

Question 17a(iii)
Suggested answer
e.g. Redox cell reaction $Mg + 2H^+ \longrightarrow Mg^{2+} + H_2$

Marking guidelines

Criteria	Marks
• correct combination of half cell reactions to overall redox cell reaction (depending on metal chosen)	1

Question 17b(i)
Suggested answer



Marking guidelines

Criteria	Marks
• correct schematic sketch of cell	1
• correct labelling of electrodes and electrolyte (1 mark each)	3 total
• correct labelling of terminals	1

Question 17b(ii)
Suggested answer
$Zn(s) + Ag_2O(s) \longrightarrow ZnO(s) + 2Ag(s)$

Marking guidelines

Criteria	Marks
• correct formula of reactants and products	1
• balanced equation	1

Question 18a
Suggested answer
$CaCO_3 + 2HCl \longrightarrow CaCl_2 + H_2O + CO_2$

Marking guidelines

Criteria	Marks
• correct balanced equation	1

Question 18b
Suggested answer
1000 mL has 1 mole NaOH, thus 11.2 mL has ((11.2/1000) × 1) moles = **1.12×10^{-2} moles**

Marking guidelines

Criteria	Marks
• correct working and result	1

Question 18c
Suggested answer
Since the mole ratio for reaction NaOH with HCl is 1:1, the amount of HCl reacted is 1.12×10^{-2} moles.
Thus, amount of HCl in beaker after reaction with shell, and before dilution to 25 mL, is $(25/10) \times 1.12 \times 10^{-2} =$ **2.8×10^{-2} moles**.

Marking guidelines

Criteria	Marks
• correct calculation of amount of HCl reacted	1
• correct result for undiluted acid	1

Question 18d
Suggested answer
Original amount HCl reacted, 10 mL of 5 $molL^{-1}$, is (10/1000) × 50 = 0.05 moles
Thus amount reacted with shell = 0.05 – 0.028 = 0.022 or **2.2×10^{-2} moles**

Marking guidelines

Criteria	Marks
• correct calculation of moles reacted with shell	1

Question 18e
Suggested answer
From equation in (a), 1 mole $CaCO_3$ reacts with 2 moles of HCl, thus number of moles of $CaCO_3$ reacting with HCl is 0.022/2 or 0.011 moles.
1 mole of $CaCO_3$ has mass of 100 g, thus 0.011 moles has a mass of 0.011 × 100 = **1.10 g**.

Marking guidelines

Criteria	Marks
• correct calculation of number of moles $CaCO_3$ reacting	1
• correct conversion of moles to mass	1

Question 18f
Suggested answer
(mass of $CaCO_3$/mass of shell) × 100% = (1.10/1.306) × 100% = **84.2%**

Marking guidelines

Criteria	Marks
• correct calculation of percentage mass	1

Question 19a
Suggested answer
From information given, at constant pressure, an increase in temperature causes the equilibrium yield of product to decrease, i.e. the equilibrium system is changing in favour of the reactants. According to Le Chatelier's Principle, if reaction is exothermic, equilibrium will change to reduce the temperature, i.e. in backward direction reducing the yield of product.

Marking guidelines

Criteria	Marks
• reaction is exothermic	1
• increase in temperature causes the equilibrium yield of product to decrease	1

Question 19b
Suggested answer
From information given, at constant temperature, the percentage of product in the equilibrium vessel increases, i.e. the equilibrium system is changing in the favour of the product. According to Le Chatelier's Principle, the equilibrium system reacts to the change by decreasing its volume, i.e. in forward direction in favour of the product. Since 2 moles of gaseous reactants produces 1 mole of gaseous product, volume is reduced by the reaction going in the forward direction.

Marking guidelines

Criteria	Marks
• volume decreases	1
• at constant temperature, the percentage of product in the equilibrium vessel increases – since 2 moles of gaseous reactants produces 1 mole of gaseous product, the system is reacting to the change by decreasing its volume	1

Question 19c
Suggested answer
Low temperature; High pressure

Marking guidelines

Criteria	Marks
• low temperature	1
• high pressure	1

Question 19d
Suggested answer
According to Le Chatelier's Principle if an equilibrium is disturbed it will change to minimise the disturbance. To move the reaction to the right, i.e. to increase product, EITHER the concentration of reactants could be increased OR the concentration of product decreased by removing it from the equilibrium system.

Marking guidelines

Criteria	Marks
• statement of Le Chatelier's Principle	1
• EITHER increase concentration of reactants OR decrease concentration of product	1

Question 20a(i)
Suggested answer
An acid is a substance, that in solution, tends to donate protons, and a base is a substance that tends to accept protons.

Marking guidelines

Criteria	Marks
• acid is a proton donor	1
• base is a proton acceptor	1

Question 20a(ii)
Suggested answer
In the first reaction, HCO_3^- is acting as a base as it accepts H^+ to form H_2CO_3; in the second reaction, HCO_3^- is acting as an acid as it donated a proton to form CO_3^{2-}.

Marking guidelines

Criteria	Marks
• HCO_3^- is acting as a base as it accepts H^+ to form H_2CO_3	1
• HCO_3^- is acting as an acid as it donated a proton to form CO_3^{2-}	1

Question 20b(i)
Suggested answer
The concentration of an acid refers to the amount of solute in a volume of solution, thus hydrochloric acid is less concentrated.

Marking guidelines

Criteria	Marks
• hydrochloric acid is less concentrated	1
• concentration of an acid refers to the amount of solute in a volume of solution	1

Question 20b(ii)
Suggested answer
The strength of an acid refers to the degree of ionisation on dissociation in solution. Ethanoic is less ionised in solution and thus is the weaker acid.

Marking guidelines

Criteria	Marks
• ethanoic acid is the weaker acid	1
• strength of an acid refers to the degree of ionisation on dissociation in solution	1

Question 20b(iii)
Suggested answer
Since the pH, which is a measure of hydrogen ion concentration, of each acid is the same, the hydrogen ion concentration in solution must be the same.

Criteria	Marks
• the hydrogen ion concentration of each acid in solution is the same	1
• the pH, which is a measure of hydrogen ion concentration, is the same	1

Question 21a
Suggested answer
O_3; covalent and co-ordinate covalent bonds

Marking guidelines

Criteria	Marks
• O_3	1
• covalent and co-ordinate covalent bonds	1

Question 21b
Suggested answer
Ozone in the stratosphere absorbs much of the harmful UV rays from the sun. The UV rays absorbed can cause problems such as skin cancer and eye cataracts.

Marking guidelines

Criteria	Marks
• ozone absorbs much of the harmful UV rays from the sun	1
• UV rays absorbed can cause problems such as skin cancer and eye cataracts	1

Question 22a
Suggested answer
The main problems expected from sewage discharge would be disease-causing microorganisms and oxygen-demanding wastes. Thus water suspected to be contaminated by sewage would be tested for coliform bacteria counts and for biochemical oxygen demand (BOD). Both these indicators would have increased values compared to clean water.

Marking guidelines

Criteria	Marks
• water suspected to be contaminated by sewage would be tested for coliform bacteria counts and for biochemical oxygen demand	1
• increased values compared to clean water	1

Question 22b(i)
Suggested answer
Pb^{2+} (white precipitate with HCl) and Cu^{2+} (blue precipitate with OH^- which dissolves in NH_3)

Marking guidelines

Criteria	Marks
• Pb^{2+} and Cu^{2+}	1

Question 22b(ii)
Suggested answer

$Pb^{2+} + SO_4^{2-} \longrightarrow PbSO_4$ $\quad\quad$ $Cu^{2+} + 2OH^- \longrightarrow Cu(OH)_2$

Marking guidelines

Criteria	Marks
• $Pb^{2+} + SO_4^{2-} \longrightarrow PbSO_4$	1
• $Cu^{2+} + 2OH^- \longrightarrow Cu(OH)_2$	1

Section II
Question 23 – Industrial Chemistry
Question 23a(i)
Suggested answer
$Kp = p(N_2O_4)/p^2(NO_2)$

Marking guidelines

Criteria	Marks
• correct answer	1

Question 23a(ii)
Suggested answer
Change in pressure of N_2O_4 = 0.54 atm – 0.51 atm = 0.03 atm
Change in pressure of NO_2 = -(0.03 atm N_2O_4)(2 mol NO_2/1 mol N_2O_4) = -0.06 atm
Thus, equilibrium pressure of NO_2 = 0.56 atm + (-0.06 atm) = 0.50 atm
Now, $Kp = p(N_2O_4)/p^2(NO_2) = 0.54/(0.50)^2 =$ **2.2**

Marking guidelines

Criteria	Marks
• correct calculation of change in pressure that occurs at equilibrium	1
• correct calculation of equilibrium pressure of NO_2	1
• correct calculation of Kp	1

Question 23b(i)
Suggested answer
The process is called the Contact process because SO_2 and O_2 gases must come in contact with a catalyst.

Marking guidelines

Criteria	Marks
• correct answer	1

Question 23b(ii)
Suggested answer

$$S(s) + O_2(g) \longrightarrow SO_2(g)$$

Marking guidelines

Criteria	Marks
• correct equation	1

Question 23b(iii)
Suggested answer
Moderate temperatures (400–500°C)
Catalyst – vanadium(v) oxide
Pressures of 1–2 atm

Marking guidelines

Criteria	Marks
• moderate temperatures (400–500°C)	1
• catalyst – vanadium(v) oxide	1
• pressures of 1–2 atm	1

Question 23b(iv)
Suggested answer
Sulfuric acid can be used to oxidise copper to copper ions.

$$Cu + 2H_2SO_4 \longrightarrow CuSO_4 + SO_2 + 2H_2O$$

Marking guidelines

Criteria	Marks
• correct equation	1
• correct balancing of equation	1

Question 23b(v)
Suggested answer
Concentrated (98%) sulfuric acid can be safely stored or transported in steel containers. Care must be taken to avoid contamination of the acid with water, because water could set off a vigorous reaction between acid and a steel container.

Marking guidelines

Criteria	Marks
• can be safely stored or transported in steel containers	1
• avoid contamination of the acid with water	1
• water could set off a vigorous reaction between acid and a steel container	1

Question 23c(i)
Suggested answer
The equation for the reaction of carbon dioxide in the production of sodium hydrogen carbonate is:

$$NaCl + CO_2 + NH_3 + H_2O \longrightarrow NaHCO_3 + NH_4Cl$$

From equation, 1 mole CO_2 produces 1 mole $NaHCO_3$
or 24.5 L of CO_2 produces 84 g of $NaHCO_3$
thus amount required to produce 10^6 g (1 tonne) is $(24.5/84) \times 10^6 = \mathbf{2.9 \times 10^5\ L}$

Marking guidelines

Criteria	Marks
• correct equation	1
• 24.5 L of CO_2 produces 84 g of $NaHCO_3$	1
• correct calculation of amount of CO_2 required	1

Question 23c(ii)
Suggested answer
The major issue is the disposal of the calcium chloride waste. Evaporation to dryness and disposal in a suitable burial site is an acceptable method of disposal.

Marking guidelines

Criteria	Marks
• calcium chloride waste	1
• evaporation to dryness and disposal in a suitable burial site	1

Question 23d(i)
Suggested answer
There are three main steps in a saponification reaction:
- Place the oil and alkali solution in a large beaker and heat for 30–60 minutes
- Add salt to precipitate the soap
- Filter and wash the soap

Marking guidelines

Criteria	Marks
• one mark for each correct step	3

Question 23d(ii)
Suggested answer
Surfactants are 'surface active' because they are able to alter the surface properties of water. Surfactants lower the surface tension of water so the water is more readily able to 'solubilise' oil or dirt particles and so move them off skin or fabric.

Marking guidelines

Criteria	Marks
• alter surface properties/ lower surface tension of water	1
• 'solubilise' oil or dirt particles so they can be removed from surfaces	1

Question 23d(iii)
Suggested answer
Phosphate pollution from 'builders' normally present in washing powders and detergents.

Marking guidelines

Criteria	Marks
• phosphate pollution.	1

Question 24 – Shipwrecks, Corrosion and Conservation
Question 24a(i)
Suggested answer
Oxidation occurs at the anode (the positive electrode in an electrolytic cell), and reduction occurs at the cathode (the negative electrode in an electrolytic cell).

Marking guidelines

Criteria	Marks
• oxidation occurs at the anode (the positive electrode in an electrolytic cell)	1
• reduction occurs at the cathode (the negative electrode in an electrolytic cell)	1

Question 24a(ii)
Suggested answer
The nature of the electrolyte.
The nature of the electrodes.
The concentration of ions present.

Marking guidelines

Criteria	Marks
• the nature of the electrolyte	1
• the nature of the electrodes	1
• the concentration of ions present	1

Question 24a(iii)
Suggested answer
Michael Faraday's work related to determining the amount of substance produced relative to the quantity of electricity passed through an electrolytic cell.

Marking guidelines

Criteria	Marks
• amount of substance produced relative to the quantity of electricity passed through an electrolytic cell	1

Question 24b(i)
Suggested answer
The solubility of a gas changes as follows:
- decreased temperature increases solubility
- increased pressure increases solubility
- increased salinity decreases solubility

Marking guidelines

Criteria	Marks
• decreased temperature increases solubility	1
• increased pressure increases solubility	1
• increased salinity decreases solubility	1

Question 24b(ii)
Suggested answer
Make up solutions of various salinities, e.g. fresh water, sea water and dilutions of sea water with fresh water.
Place steel nails in each of the test solutions.
Qualitatively/visually observe the amount of rust forming over extended periods of time and record and report results appropriately.

Marking guidelines

Criteria	Marks
• make up solutions of various salinities	1
• place steel nails in each of the test solutions	1
• qualitatively/visually observe the amount of rust forming over extended periods of time	1

Question 24c(i)
Suggested answer
Iron and steel rust in the presence of oxygen and moisture. It is a galvanic process where iron(II) ions are formed by oxidation of iron, and hydroxide ions are formed by the reduction of oxygen in the presence of water. The products of the redox process result in the formation of iron(II) hydroxide; the iron(III) oxide (rust) is then formed from the oxidation of the hydroxide.

Marking guidelines

Criteria	Marks
• iron and steel rust in the presence of oxygen and moisture	1
• a galvanic process where iron(II) ions are formed by oxidation of iron, and hydroxide ions are formed by the reduction of oxygen in the presence of water	1
• the products of the redox process result in the formation of iron(II) hydroxide	1
• the iron(III) oxide (rust) is then formed from the oxidation of the hydroxide	1

Question 24c(ii)
Suggested answer
Galvanic corrosion occurs more rapidly in slightly acidic solutions.

Marking guidelines

Criteria	Marks
• occurs more rapidly in slightly acidic solutions	1

Question 24c(iii)
Suggested answer
Galvanising means the covering of the iron surface with a thin layer of a more reactive metal such as zinc. Instead of the iron(II) ions combining with hydroxide ions to start the formation of rust, zinc ions (formed by a galvanic reaction with iron(II) ions) preferentially react with the hydroxide ions to form zinc hydroxide (some of which is converted to zinc carbonate). These zinc compounds form an impervious layer over any exposed iron.

$$Zn + Fe^{2+} \longrightarrow Zn^{2+} + Fe$$

Marking guidelines

Criteria	Marks
• instead of the iron(II) ions combining with hydroxide ions to start the formation of rust, zinc ions preferentially react	1
• the zinc ions react with hydroxide ions to form zinc hydroxide	1
• the zinc compounds form an impervious layer over any exposed iron	1
• $Zn + Fe^{2+} \longrightarrow Zn^{2+} + Fe$	1

Question 24c(iv)
Suggested answer
Certain anaerobic bacteria can create conditions that cause corrosion in deep ocean water.

Marking guidelines

Criteria	Marks
• anaerobic bacteria can create conditions that cause corrosion in deep ocean water	1

Question 24d
Suggested answer
The extensive washing with fresh water removes salt from the wood. If salts were not washed out, crystals of salt would form as the wood dries out. These growing crystals would crack the wood.

Marking guidelines

Criteria	Marks
• extensive washing with fresh water removes salt from the wood	1
• if not washed crystals of salt would form as the wood dries out	1
• growing crystals would crack the wood	1

Question 25 – The Biochemistry of Movement
Question 25a(i)
Suggested answer
Glucose and galactose are six carbon sugars while fructose is a five carbon sugar. The difference between glucose and galactose is the orientation of the hydroxyl group on one of the carbon atoms.

Marking guidelines

Criteria	Marks
• glucose and galactose are six carbon sugars	1
• fructose is a five carbon sugar	1
• difference between glucose and galactose is the orientation of the hydroxyl group on one of the carbon atoms	1

Question 25a(ii)
Suggested answer
The glucose linkages are different in the two polymers resulting in a different orientation of those glucose molecules.

Marking guidelines

Criteria	Marks
• glucose linkages are different	1
• different orientation of the glucose molecules	1

Question 25b
Suggested answer
These three fats have an increasing number of carbon atoms and thus increased molar mass and increased intermolecular attraction. Increased intermolecular attraction is the prime reason for increasing melting point.

Marking guidelines

Criteria	Marks
• increasing number of carbon atoms and thus increased molar mass and increased intermolecular attraction	1
• increased intermolecular attraction results in increased melting points	1

Question 25c(i)
Suggested answer
General formula of amino acids is $H_2NCH(R)COOH$, where R is a carbon-containing side chain. The functional groups are the amine group (H_2N) and the carboxyl group (COOH).

Marking guidelines

Criteria	Marks
• general formula of amino acids is $H_2NCH(R)COOH$	1
• functional groups are the amine group (H_2N) and the carboxyl group (COOH)	1

Question 25c(ii)
Suggested answer
Functional proteins have a complex three dimensional shape. If this three dimensional shape is destroyed (by heating) the protein no longer will function as it should and is described as having been denatured.

Marking guidelines

Criteria	Marks
• functional proteins have a complex three dimensional shape	1
• if the three dimensional shape is destroyed (by heating) the protein no longer will be functional and is described as having been denatured	1

Question 25d(i)
Suggested answer
In cellular respiration the energy produced by the oxidation of carbon compounds is stored as ATP. The energy stored in ATP can then be released to provide energy for various aspects of cellular function.

Marking guidelines

Criteria	Marks
• in cellular respiration the energy produced by the oxidation of carbon compounds is stored as ATP	1
• energy stored in ATP can then be released to provide energy for various aspects of cellular function	1

Question 25d(ii)
Suggested answer
Mitochondrion.

Marking guidelines

Criteria	Marks
• mitochondrion	1

Question 25e(i)
Suggested answer
Myosin, actin, tropomysin and troponin. These proteins contribute to the structure of the thick and thin filaments in skeletal muscle.

Marking guidelines

Criteria	Marks
• myosin, actin, tropomysin and troponin	2
• the structure of the thick and thin filaments in skeletal muscle	1

Question 25e(ii)
Suggested answer
The Type 1 muscle cells contain fewer contractile filaments than do Type 2 cells.

Marking guidelines

Criteria	Marks
• fewer contractile filaments in Type 1 cells	1

Question 25e(iii)
Suggested answer
In long distance endurance running most of the energy required comes from the aerobic metabolism of carbohydrates, fats and protein. During an endurance run, as the demand for oxygen for aerobic respiration rises, anaerobic respiration is required to support the extra requirement for energy. The muscles of athletes that compete in short sprint events use anaerobic respiration because it provides high levels of energy at a rapid rate.

Marking guidelines

Criteria	Marks
• in long distance running most of the energy required is from the aerobic metabolism of carbohydrates, fats and protein	1
• in an endurance run, as the demand for oxygen for aerobic respiration rises, anaerobic respiration is required to supply energy	1
• in short sprint events use anaerobic respiration because it provides high levels of energy at a rapid rate	1

Question 25e(iv)
Suggested answer
In muscle cells, during bursts of extra hard work, amount of oxygen available to the muscle is insufficient and lactic acid is produced as the product of anaerobic respiration. The muscles accumulate what is known as oxygen debt by producing lactic acid from glucose. The accumulated lactic acid causes the sensation of muscle fatigue.

Marking guidelines

Criteria	Marks
• amount of oxygen available to the muscle is insufficient and lactic acid is produced as the product of anaerobic respiration	1
• muscles accumulate what is known as oxygen debt by producing lactic acid	1
• accumulated lactic acid causes the sensation of muscle fatigue	1

Question 25e(v)
Suggested answer
2-hydroxypropanoic acid.

Marking guidelines

Criteria	Marks
• 2-hydroxypropanoic acid	1

Question 26 – The Chemistry of Art
Question 26a
Suggested answer
Canvas is generally unsuitable for painting on directly since it is too rough and adsorbent. It is prepared for painting with layers of ground or priming.

Marking guidelines

Criteria	Marks
• canvas is rough and adsorbent	1
• prepared for painting with layers of ground or priming	1

Question 26b(i)
Suggested answer
The distinctive colours of some metal ions can be used to identify their presence in compounds using a flame test. When excited in a flame an electron jumps to a higher energy level. It then falls back to a lower energy state emitting a photon of radiation that is exactly equal to the difference in energy between the two levels in the atom. For some of these emissions the energy released is in the visible spectrum and so can be seen as visible light.

Marking guidelines

Criteria	Marks
• when excited an electron can jump to a higher energy level	1
• electron falls back to lower energy state emitting a photon of radiation	1
• if energy released is in the visible spectrum it can be seen as visible light	1

Question 26b(ii)
Suggested answer
A line absorption spectrum results when light is passed through a substance in the vapour phase with the resulting spectrum observed as a pattern of dark lines across a continuous spectrum. These spectra are used to identify different components of pigments, media and varnishes. Knowledge of the pigments, media and varnishes in a painting allow conservators to decide which products and techniques will be used in the restoration or conservation of a painting.

Marking guidelines

Criteria	Marks
• line absorption spectrum results when light is passed through a substance in the vapour phase and the resulting spectrum is observed as a pattern of dark lines across a continuous spectrum	1
• spectra are used to identify different components of pigments, media and varnishes	1
• allow conservators decide which products and techniques will be used in the restoration or conservation of a painting	1

Question 26c
Suggested answer
Bohr proposed, when studying the line spectrum of hydrogen, that in a hydrogen atom the electron moves around the nucleus in orbits without radiating energy. Only orbits of certain energy are allowed. Electrons can jump from one orbital to another by absorbing or emitting energy of a particular quantum amount. Bohr's model was limited in that it could not successfully explain the atomic spectra of elements other than hydrogen.

Marking guidelines

Criteria	Marks
• Bohr proposed that in a hydrogen atom the electron moves around the nucleus in orbits without radiating energy	1
• only orbits of certain energy are allowed and electrons can jump from one orbital to another by absorbing or emitting energy of a particular quantum amount	1
• Bohr's model was limited in that it could not successfully explain the atomic spectra of elements other than hydrogen	1

Question 26d
Suggested answer
X-ray diffraction is used in the chemistry of art. The diffraction pattern of X-rays seen from a painting is analysed for identification by comparison with patterns of known pigments. The information gained about pigments in a painting can be used for conservation or restoration of the artwork being studied.

Marking guidelines

Criteria	Marks
• the diffraction pattern of X-rays seen from a painting is analysed	1
• X-rays patterns seen from a painting is used for identification by comparison with patterns of known pigments	1
• information gained about pigments in a painting can be used for conservation or restoration	1

Question 26e(i)
Suggested answer
Electronegativity of an atom is a measure of its ability to attract electrons to itself. As you move from left to right across a Period, the trend in electronegativity is to increase; down a Group the electronegativity tends to decrease.

Marking guidelines

Criteria	Marks
• electronegativity of an atom is a measure of its ability to attract electrons to itself	1
• electronegativity increases from left to right across a Period	1
• down a Group the electronegativity tends to decrease	1

Question 26e(ii)
Suggested answer
Ionisation energy is influenced by the increasing number of protons (positive charge) in the nucleus as you go from left to right across a Period in the Periodic Table. As you go down a Group the ionisation energy is influenced by the distance of the outer electrons from the nucleus and the number of electron shells shielding outer electrons.

Marking guidelines

Criteria	Marks
• influenced by the increasing number of protons (positive charge) in the nucleus as you go from left to right across a Period	1
• down a Group the ionisation energy is influenced by the distance of the outer electrons from the nucleus	1
• down a Group the ionisation energy is influenced by the number of electron shells shielding outer electrons	1

Question 26f(i)
Suggested answer
The transition elements have electron configurations that include the filling of d-block orbitals. The other elements in the main groups of the Periodic Table have either empty or filled d-block orbitals.

Marking guidelines

Criteria	Marks
• transition elements have electron configurations that include the filling of d-block orbitals	1
• elements in the main groups of the Periodic Table have either empty or filled d-block orbitals	1

Question 26f(ii)
Suggested answer
The presence of partially filled d-orbitals in transition elements accounts for:
- often more than one stable oxidation state
- magnetic properties
- compound colours of metal ions

Marking guidelines

Criteria	Marks
• any two properties correct	2
• any one property correct	1

Question 27 – Forensic Chemistry
Question 27a(i)
Suggested answer
Electrophoresis involves separating the amino acids by exposing them to an electrical field. Negatively charged amino acids will move toward the positive electrode and those with a positive charge toward the negative electrode. Once the amino acids are localised in the electrophoresis gel, with a reagent such as ninhydrin, the distance moved is characteristic and can be used to identify the amino acid.

Marking guidelines

Criteria	Marks
• electrophoresis involves separating the amino acids by exposing them to an electrical field	1
• negatively charged amino acids will move toward the positive electrode and those with a positive charge toward the negative electrode	1
• amino acids are localised in the electrophoresis gel with a reagent such as ninhydrin	1
• the distance moved is characteristic of and can be used to identify the amino acid	1

Question 27a(ii)
Suggested answer
Because of the similarity of the human species, much of the genetic material (DNA) is similar. The uniqueness of a person's DNA comes from the so called non-coding bits of their DNA. If people are related then these non-coding bits of DNA show some similarity. People who are not related have very little of their non-coding DNA in common.

Marking guidelines

Criteria	Marks
• much of the genetic material (DNA) is similar – the uniqueness of a person's DNA comes from the so called non-coding bits of their DNA	1
• if people are related then these non-coding bits of DNA show some similarity	1

Question 27a(iii)
Suggested answer
If data banks of DNA samples exist, analysis of the DNA could give information about a person that would be an invasion of their privacy. Routine screening of such DNA, for example, could give access to information about genetic disorders.

Marking guidelines

Criteria	Marks
• analysis of the DNA could give information about a person that would be an invasion of their privacy	1
• routine screening of such DNA, for example, could give access to information about genetic disorders	1

Question 27b
Suggested answer
The DNA (deoxyribonucleic acid) molecule is a polymeric chain of nucleotides. Nucleotides consist of three components – a phosphate group, a pentose sugar group and a nitrogenous base. In DNA there are four possible nitrogenous bases that may be part of a nucleotide, split into two groups, the purines and the pyrimidines. Purines are double ringed structures and consist of the bases adenine and guanine, the pyrimidines have a single ringed structure and consist of cytosine and thymine. The sugar part of the nucleotide in DNA is deoxyribose. The DNA polymeric chain of nucleotides is formed by condensation reactions.
DNA in genetic material consists of two strands of nucleic acid that interact through hydrogen bonds between opposing bases to form a double helical structure. In the structure, adenine and thymine are present in the helix opposite each other, as are cytosine and guanine.

Marking guidelines

Criteria	Marks
• DNA molecule is a polymeric chain of nucleotides	1
• nucleotides consist of three components: a phosphate group, a pentose sugar group and a nitrogenous base	1
• purine bases are double ringed structures and consist of the bases adenine and guanine, the pyrimidine bases have a single ringed structure and consist of cytosine and thymine	1
• sugar part of the nucleotide in DNA is deoxyribose	1
• DNA genetic material consists of two strands of nucleic acid that interact through hydrogen bonds between opposing bases to form a double helical structure	1

Question 27c(i)
Suggested answer
Monosaccharides are carbohydrates that cannot be hydrolysed into two or more simpler sugars. The features of a monsaccharide are one carbonyl group and at least two hydroxyl groups. They have the empirical fromula CH_2O.

Marking guidelines

Criteria	Marks
• they cannot be hydrolysed into two or more simpler sugars	1
• they have one carbonyl group and at least two hydroxyl groups	1
• empirical fromula CH_2O	1

Question 27c(ii)
Suggested answer
Fructose.

Marking guidelines

Criteria	Marks
• fructose	1

Question 27d
Suggested answer
1. Atoms/molecules vaporised and ionised
2. Ions collimated into a fine beam
3. Ions accelerated in vacuum
4. Ions deflected by electromagnet
5. Ions detected

Marking guidelines

Criteria	Marks
• atoms/molecules vaporised and ionised	1
• ions collimated into a fine beam	1
• ions accelerated in vacuum	1
• ions deflected by electromagnet	1
• ions detected	1

Question 27e
Suggested answer
Spectroscopic methods permit routine and relatively simple ways of identifying inorganic and organic substances. They have been particularly useful in that the analyses can be performed on very small samples, much less than required by classical chemical analysis. An example of their use is in the monitoring of the environment and policing environmental legislation.

Marking guidelines

Criteria	Marks
• permit routine and relatively simple ways of identifying inorganic and organic substances	1
• analyses can be performed on very small samples	1
• monitoring of the environment (OR other suitable example)	1