Heinemann
Harcourt Education

Student Number: ……..……..…..

2005
HIGHER SCHOOL CERTIFICATE
Sample Examination Paper

CHEMISTRY

General Instructions

- Reading Time – 5 minutes
- Working Time – Three (3) hours
- Write using blue or black pen
- Write your student number at the top of this page
- A Data Sheet and Periodic Table are provided with this paper

Section I – Core
Attempt ALL questions

Part A 15 multiple choice questions, each worth 1 mark
- Allow about 30 minutes for this section
- Mark your answers on the Answer Sheet provided

Part B Other questions with a total mark value of 60
- Allow about 100 minutes for this section
- Answer this part in the spaces provided

Section II – Options
Attempt ONE question only. Each question is worth 25 marks
- Allow about 50 minutes for this section
- Answer the question in the separate Option Answer Book provided

Directions to school or college

All care has been taken to ensure that this 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 Examination will have a similar content or format.

 Product code: 733914

Section I Core – Part A
15 marks

Attempt ALL Questions
Allow about 30 minutes for this section
Use the multiple choice answer sheet provided

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1 Ethene is a very reactive molecule. The reactivity of this molecule is due to:
- A it being a two carbon organic molecule.
- B the presence of a double covalent bond in the molecule.
- C the reactive C-H bonds present.
- D it being a hydrocarbon molecule.

2 Cellulose is a biopolymer. It is formed:
- A by the polymerisation of α- glucose monomer units.
- B by a process of addition polymerisation.
- C as a long branched chain of monomer units.
- D with the elimination of a water molecule as the pairs of monomers join.

3 Ethanol has a major use as an alternative to petrol. A major advantage of ethanol as a useful alternative fuel is that:
- A it would increase greenhouse gas emissions.
- B it requires large areas of agricultural land to produce.
- C it is an excellent solvent.
- D it can be produced from renewable biomass.

4 The anode in an electrochemical cell is:
- A the site at which oxidation occurs.
- B connected to a salt bridge.
- C the electrode towards which cations migrate.
- D the electrode toward which electrons flow in an external circuit.

5 Ionising radiation is commonly detected by the use of a:
- A particle accelerator.
- B charged electroscope.
- C nuclear reactor.
- D spectrometer.

6 Acids and bases are chemical compounds with characteristic properties. An observable property of acids would be:
- A they turn red litmus blue.
- B they have a soapy feel.
- C they are corrosive liquids.
- D they have a bitter taste.

7 The reaction between carbon dioxide gas and water is an equilibrium reaction

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

What would be the effect on this equilibrium of increasing the concentration of carbon dioxide?

A it would have no effect on the equilibrium.
B the reaction would go to completion.
C it would move the equilibrium to the right.
D it would move the equilibrium to the left.

8 Concentrations of sulfur dioxide and oxides of nitrogen are increased in the atmosphere by a number of human activities. The main human activity that can release both these gases is:

A increased use of fertilisers.
B combustion of fossil fuels.
C industrial extraction of metals from their ores.
D the use of motor vehicles.

9 In the chemical reaction

$$HF(aq) + OH^-(aq) \rightleftharpoons H_2O(l) + F^-(aq)$$

the Bronsted-Lowry acid(s) would be:

A HF and F^-.
B HF and H_2O.
C only HF.
D only OH^-.

10 The purpose of a buffer solution is to:

A allow acids to neutralise bases completely.
B increase the rate of an acid base neutralisation.
C indicate the end point in a titration.
D minimise changes in solution pH upon strong acid or base additions.

11 Which of the following is a TRUE statement about the Haber process for the synthesis of ammonia?

A the yield of ammonia is reduced at higher temperatures.
B the rate of reaction is reduced at higher temperatures.
C the formation of ammonia is an endothermic process.
D use of a catalyst increases the reaction temperature.

12 The technique of atomic absorption spectroscopy is used to:

A measure trace concentrations of metal ions.
B identify anions in a solution.
C identify cations in a solution.
D measure dissolved oxygen levels in water.

13 Which of the following is a TRUE statement about ozone?

A ozone gas is found only in the upper atmosphere.
B ozone reflects ultraviolet radiation.
C ozone is an allotrope of oxygen.
D ozone concentration in the atmosphere is increased by the presence of CFC's.

14 Water hardness can be caused by the presence of which of the following ions?

A chloride ions.
B calcium ions.
C ammonium ions.
D sodium ions.

15 Biochemical oxygen demand in a body of water is a measure of:

A the amount of dissolved oxygen required to respire organic wastes in the water.
B the number of aerobic bacteria in the water.
C the contamination of water with agricultural fertilisers.
D the nitrogen-to-phosphorus ratio (N:P) in the water.

Section I Core – Part B
60 marks

Attempt ALL Questions
Allow about 100 minutes for this section
Write answers in the spaces provided
Show all relevant working in questions involving calculations.

Marks

Question 16 (15 marks)

(a) Write the name of a three carbon alkene and give its structural formula. **2**

(b) (i) Write an equation to show the polymerisation of ethene to polyethylene. **1**

(ii) Low density polyethylene can be formed under high pressures and high temperatures in the presence of an organic peroxide initiator. In contrast, high density polyethylene is formed under low pressure and temperature and uses a catalyst. What is the structural difference between these forms of polythene? **1**

(iii) Name one common use of low density polyethylene. **1**

(c) (i) Write the equation for the reaction of ethene with water to form ethanol. **2**

(ii) What reactions, conditions and catalyst are required in the reaction of ethene with water? **2**

(d) (i) Define molar heat of combustion. **1**

Question 16 (d) cont.

(ii) Write the balanced equation for the combustion of ethanol. **2**

(iii) Calculate the heat of combustion per mole of ethanol from the following experiment. Some ethanol was placed in a spirit burner and the mass of burner plus ethanol determined as 148.2 g. The burner was placed under a container filled with 500 g of water. The temperature of the water was 20.5°C. The burner was lit and the water gently stirred with the thermometer until the temperature of the water had risen by about 30°C. The burner was removed; the final temperature of the water was measured as 52.8°C and the final mass of the burner and ethanol was 125.0 g. (The specific heat capacity of water is 4.2 $JK^{-1}g^{-1}$; in your calculation ignore the heat capacity of the container and any heat losses that may have occurred.) **3**

Question 17 (9 marks)

A galvanic cell was set up as follows. A beaker was set up with a copper wire dipping into a copper(II) sulfate solution. A salt bridge connected this solution to a beaker containing a platinum wire dipping into a chlorine/potassium chloride solution. A wire with inline voltmeter connected the two electrodes. The voltmeter reading showed that the platinum wire was positive with respect to the copper wire.

(a) What are the redox processes occurring at each electrode. **2**

(b) What is the direction of electron flow in the external circuit. **1**

(c) What migration of ions (if any) occurs as current flows. **1**

Question 17 cont.

(d) What is the overall cell reaction? Show state of matter symbols in equation. **2**

(e) Which electrode is the cathode? **1**

(f) Use the concept of oxidation states to show oxidation and reduction were occurring. **2**

Question 18 (13 marks)

(a) A student made up 0.01 $molL^{-1}$ solutions of four acids – A, B, C and D. She measured the pH of the acids and found them to be 4.5, 6.5, 2.1 and 2.7 respectively.

(i) Arrange the acids in order of increasing strength, from weakest to strongest. **2**

(ii) Are any of these acids completely ionised. Explain your answer. **2**

(b) $HClO_4$, perchloric acid, is a strong acid whereas the related, $HClO_2$, chlorous acid is a weak acid. Write ionisation reactions for these acids that reflect the strength of the acid. 2

Question 18 cont.

(c) A series of ten-fold dilutions was carried out on a solution of 0.01 $molL^{-1}$ HNO_3.

(i) What is the minimum concentration of $H^+(aq)$ that can be obtained by successive dilutions of the HNO_3? 1

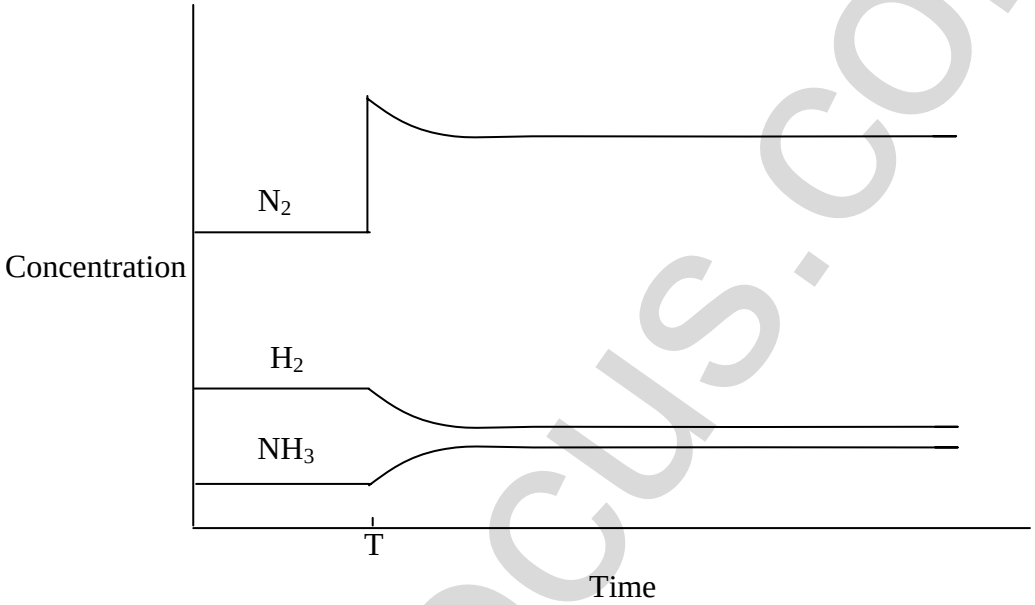
(ii) What is the pH of the solution in (i)? **2**

(d) A volumetric analysis required that a student accurately prepare a 0.1 $molL^{-1}$ solution of pure anhydrous sodium carbonate. Detail the steps required to make the standard solution, including any glassware used. **4**

Question 19 (6 marks)

(a) Write a balanced equation for the equilibrium reaction involving nitrogen, hydrogen and ammonia. **2**

(b) The equilibrium mixture in (a) was subjected to a change at time T. The result of this change is shown in the diagram below.



(i) What was the change made at time T? 1

(ii) Explain why the curves beyond time T have the shapes shown in the diagram – particularly why concentrations increased or decreased. **3**

Question 20 (6 marks)

Chlorofluorocarbons (CFC's) have important effects on the ozone layer.

(a) Why do quite small amounts of CFC's have such very large effects. **2**

(b) What is meant by the term 'ozone hole'? **2**

(c) What will be the consequences of ozone depletion? **2**

Question 21 (5 marks)

(a) Membrane filters are used widely for filtering both drinking water and treated sewage.
What are THREE advantages of membrane filters compared with paper or sand filtration. **3**

(b) Mining and soil erosion are two practices that can have deleterious effects on water quality. State two effects that each of these practices can have on water quality. **2**

Question 22 (6 marks)

You are given the following pairs of substances; each member of the pair is present in an aqueous solution in a separate bottle. Describe simple reactions that could be used to decide which solution contained which substance. Give suitable equations for each reaction involved.

(a) Barium chloride and copper(II) chloride. **3**

(b) Sodium carbonate and sodium sulfate. **3**

End of Section I

Section II Options
25 marks each option

Attempt ONE Question from questions 23–27
Allow about 50 minutes for this section
Answer the questions in a writing booklet. Extra writing booklets are available.
Show all relevant working in questions involving calculations.

Question 23 – INDUSTRIAL CHEMISTRY (25 marks)

(a) A reaction commonly used in industry for the preparation of hydrogen is:

$$CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g)$$

The equilibrium constant is 0.26 at 1200K.

(i) Write the equilibrium expression for the reaction. **2**

(ii) In a particular reaction mixture at 1200K the concentrations were: $[CH_4] = 0.045\ molL^{-1}$, $[H_2O] = 0.24\ molL^{-1}$, $[CO] = 0.063\ molL^{-1}$, $[H_2] = 0.55\ molL^{-1}$
Is the mixture at equilibrium? Show all working. **2**

(b) (i) Write the three equations involved in the Contact process for the industrial synthesis of sulfuric acid from sulfur. **3**

(ii) Why is the above process called the Contact process? **1**

(c) For the industrial production of sodium hydroxide three types of electrolytic cell can be used.

(i) What TWO advantages does the membrane cell have over the diaphragm cell? **2**

(ii) Give ONE reason why the mercury cell is rarely used nowadays. **1**

(iii) Write the half-equations for the electrode reactions in the mercury cell. State which is the cathode reaction and which is the anode reaction. **3**

(d) The process of saponification can be readily performed in a student laboratory.

(i) Outline the experimental method used for saponification. **3**

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

(iii) What is the difference between an anionic and cationic surfactant? Include in your answer one common use of each of these types of surfactant. **3**

(e) (i) What are the raw materials used in the Solvay process for the manufacture of sodium carbonate? **2**

(ii) What is the waste product associated with the Solvay process? **1**

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

(a) Two electrolytic cells, each with platinum electrodes, are connected together in series. The electrolyte in the first cell contains molten sodium chloride and in the second aqueous copper(II) sulfate. Write balanced half-equations for the reactions taking place at the electrodes and note the polarity of the electrode for each reaction. **5**

(b) Outline the contribution of Galvani and Faraday to our understanding of electricity. **2**

(c) (i) Studies of the process of rusting of iron have shown that:
– water is required for the rusting process.
– oxygen is required for the rusting process.
– rusting is accelerated in salt water compared with fresh water.
– impurities in the iron accelerates rusting.
How does rust form? Include in your description the observations above. **6**

(ii) Explain, with an example and relevant equation, what is meant by cathodic protection in relation to rust formation? **3**

(d) Bronze is an alloy of copper (80–90%) and tin (10–20%). In sea water, bronze corrodes slowly to form a chloride and mixed hydroxide layer (and a sulfide coating if certain bacteria are present). Explain how you would best restore a corroded bronze artifact. **3**

(e) The rate at which a substance is formed during electrolysis is dependent on the voltage used and the electrical conductance of the electrolytic cell. What are the THREE factors that affect the conductance of an electrolytic cell? **3**

(f) (i) Why would one predict that deep water conditions in the ocean should slow the corrosion of steel wrecks? **2**

(ii) Despite the expectation that there would be little corrosion at great depths in the ocean, it is observed that considerable rusting of steel occurs. How can this be explained? **1**

Question 25 – THE BIOCHEMISTRY OF MOVEMENT (25 marks)

(a) Actin and myosin are the contractile filaments in skeletal muscle. Describe briefly the structure of skeletal muscle and discuss the process of contraction in skeletal muscle with particular reference to the initiation of muscle cell contraction and role of ATP in contraction. **5**

(b) Glucose and fats are important components in cell metabolism. Both are used as sources of energy for cellular processes.

(i) Outline the process of glycolysis for the production of energy. **3**

(ii) Fat is the most efficient way of storing energy. Outline how fats are oxidised to release energy in cells. **3**

(c) Glycogen is a polysaccharide made up of glucose monomer units. Both these molecules are soluble in water. Explain, with reference to their structure, why these molecules are water soluble. **4**

(d) Proteins are polymeric substances made up of a sequence of amino acids.

(i) Write an equation to show the condensation of two amino acids to form a peptide bond. **2**

(ii) What are four ways in which amino acid chains interact to stabilise tertiary protein structure? **4**

(iii) Proteins can be denatured, particularly by heating. What does denaturation mean and what does it imply in terms of protein structure? **2**

(iv) Almost every reaction in the human body is catalysed by biological proteins. What are these biological proteins called and what structural feature is important to their catalytic function? **2**

Question 26 – THE CHEMISTRY OF ART (25 marks)

(a) (i) The Ancient Egyptians used earth colours and mineral substances as pigments. Malachite and Azurite were two such mineral pigments. What chemical compounds made up these two pigments and what are their colours? **3**

(ii) Canvas, in general, is unsuitable for painting on directly. Why is it unsuitable to paint on directly and how was canvas traditionally prepared for painting? **2**

(b) The colour associated with different elements is related to the excited atomic structure of the element.

(i) Explain the flame colour of an element in terms of excitation of electrons. **3**

(ii) Bohr's model of the atom helps explain the emission spectrum of hydrogen. What is an emission spectrum? **3**

(iii) How can reflectance spectra be used to determine the presence of a particular pigment in a painting? **3**

(c) (i) The successive ionisation energies for aluminium are given below.

ELEMENT	IONISATION ENERGY (kJ/mol)				
	1st	2nd	3rd	4th	5th
Al	584	1823	2751	11584	14837

Explain the variation in the first five ionisation energies for aluminium in terms of its electron configuration. **4**

(ii) Explain why trends in ionisation energy, as in (c)(i), be used to predict the number of electrons in the outermost shell of an atom. **2**

(d) (i) Why is the +2 oxidation state common in the compounds of transition metals? **2**

(ii) Explain why aqueous ions containing transition metals are coloured whereas the aqueous ions of non-transition metals are usually colourless. **3**

Question 27 – FORENSIC CHEMISTRY (25 marks)

(a) (i) Gravimetric analysis of a compound showed that it contained 39.8% carbon, 53.5% oxygen and 6.7% hydrogen. Could this compound be a carbohydrate? Explain your answer. **3**

(ii) Glucose can form the polysaccharide starch. Name the reagent that could be used to test for the presence of starch. **1**

(iii) What is the structural difference between a reducing and non-reducing sugar? **1**

(iv) Describe a test you could use to identify a reducing sugar. **1**

(b) Electrophoresis and paper chromatography are techniques used by the forensic scientist for separation of amino acids.

(i) Each of these separation methods uses different properties of the amino acids for separation. What properties of amino acids are used for each of these separation methods? **2**

(ii) The side chains of amino acids (R, R1 etc) are important in the electrophoretic behaviour of amino acids. Explain the role of side chains in this regard. **4**

(c) Analyse how emission spectra of elements are used as a type of 'fingerprint' for the elements. **4**

(d) Draw a schematic diagram of a mass spectrometer and note, on your diagram, the function of the five main parts. **6**

(e) (i) DNA carries the genetic code in living cells. Name the six compounds that would be formed if a sample of DNA was completely hydrolysed. **2**

(ii) The native DNA molecule is a double stranded helix. Explain how the two strands are held together. **1**

End of Section II

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Section I – Multiple choice

Answer sheet

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

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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 the reactivity of ethene functional group	H9	3–4
2	1	Recall the processes in the formation of the biopolymer cellulose	H9	3–4
3	1	Assess the use of ethanol as an alternative fuel	H5	4–5
4	1	Identify the processes in an electrochemical cell	H7	4–5
5	1	Identify appropriate instrument for detecting ionising radiation	H6	2–4
6	1	Identify the properties of acids	H2	2–3
7	1	Assess the reaction of an equilibrium to concentration changes	H8	4–6
8	1	Identify sources of atmospheric gaseous pollution	H16	2–3
9	1	Recall definition of Bronsted-Lowry acids	H8	3–4
10	1	Recall properties of a buffer solution	H8	2–3
11	1	Analyse the Haber equilibrium process	H7	4–6
12	1	Recall the application of atomic absorption spectroscopy	H3	2–4
13	1	Interpret understanding of ozone layer	H4	2–4
14	1	Assess the contribution of ions to water hardness	H8	2–3
15	1	Recall definition of biochemical oxygen demand	H4	2–3
16 (a)	2	Write structural formula and name alkene	H9	2–4
16 (b)(i)	1	Write polymerisation equation	H9	3–4
16 (b)(ii)	1	Recall structures of polyethylene	H3	2–3
16 (b)(iii)	1	Recall properties of polyethylene	H3	2–3
16 (c)(i)	2	Write equation for formation of ethanol from ethene	H9	2–3
16 (c)(ii)	2	Recall conditions for reaction in 16 ci	H9	2–3
16 (d)(i)	1	Define molar heat of combustion	H13	2–3
16 (d)(ii)	2	Write equation for ethanol combustion	H10	3–4

16 (d)(iii)	3	Calculate heat of combustion per mole	H10	4–5
17 (a)	2	Identify galvanic cell processes	H7	4–6
17 (b)	1	Assess direction of electron flow in galvanic cell	H7	4–5
17 (c)	1	Assess ion flow in galvanic cell	H7	4–5
17 (d)	2	Write overall reaction in galvanic cell	H7	4–6
17 (e)	1	Write cell standard notation	H13	3–4
17 (f)	2	Apply oxidation states to assess cell reaction	H7	2–4
18 (a)(i)	2	Identify acid strength from pH data	H13	2–4
18 (a)(ii)	2	Assess ionisation of acids	H8	2–4
18 (b)	2	Write acid ionisation equations	H8	2–4
18 (c)(i)	1	Identify concentration of diluted acid	H10	4–5
18 (c)(ii)	2	Calculate pH from concentration	H13	3–4
18 (d)	4	Detail laboratory preparation of standard solution	H11	2–4
19 (a)	2	Write equilibrium equation	H10	2–4
19 (b)(i)	1	Interpret equilibrium diagram	H8	5–6
19 (b)(ii)	3	Explain reaction of equilibrium to disturbance	H2	5–6
20 (a)	2	Recall reaction of CFC’s	H1	4–6
20 (b)	2	Explain term ‘ozone hole’	H4	2–3
20 (c)	2	Recall consequences of ozone depletion	H16	2–3
21 (a)	3	Assess use of membrane filters in water purification	H3	3–5
21 (b)	2	Recall pollution effects of mining and soil erosion	H4	2–3
22 (a)	3	Distinguish cations by chemical reactions	H6	4–5
22 (b)	3	Distinguish anions by chemical reaction	H6	4–5

Option Question 23 – Industrial Chemistry

23 (a)(i)	2	Write equilibrium expression	H13	2–4
23 (a)(ii)	2	Assess position of equilibrium from data	H14	3–6
23 (b)(i)	3	Write Contact process equations	H10	3–4
23 (b)(ii)	1	Recall details of Contact process	H8	2–4
23 (c)(i)	2	Recall features of electrolytic cells used in the industrial production of sodium hydroxide	H3	3–5

23 (c)(ii)	1	Explain problems with use of mercury cell	H3	3–4
23 (c)(iii)	3	Write equations for electrode cell reactions	H7	4–6
23 (d)(i)	3	Outline experimental method for saponification	H11	2–4
23 (d)(ii)	2	Explain meaning of surfactant	H13	2–3
23 (d)(iii)	3	Distinguish anionic and cationic surfactants	H13	2–4
23 (e)(i)	2	Recall materials in Solvay process	H7	2–3
23 (e)(ii)	1	Recall reactions in Solvay process	H4	3–4

Option Question 24 – Shipwrecks, Corrosion and Conservation

24 (a)	5	Write half-equations for electrolytic reaction	H7	4–6
24 (b)	2	Recall historical background to understanding of electricity	H1	2–4
24 (c)(i)	6	Discuss features of rust formation	H8	3–6
24 (c)(ii)	3	Explain what is meant by cathodic protection	H3	2–4
24 (d)	3	Describe processes involved in restoration of bronze artifact	H3	2–3
24 (e)	3	Recall factors affecting conductance in an electrolytic cell	H7	2–4
24 (f)(i)	2	Describe expected corrosion conditions in deep ocean	H8	3–5
24 (f)(ii)	1	Explain observations of corrosion in deep ocean	H8	2–4

Option Question 25 – The Biochemistry of Movement

25 (a)	5	Describe structure and contraction of skeletal muscle	H2	3–4
25 (b)(i)	3	Discuss fats as an energy source	H7	3–4
25 (b)(ii)	3	Discuss polysaccharides as an energy source	H7	3–4
25 (c)	4	Explain solubility of glucose and glycogen	H6	4–6
25 (d)(i)	2	Write equation for peptide bond formation	H6	3–4
25 (d)(ii)	4	Recall features of tertiary structure in proteins	H8	3–5
25 (d)(iii)	2	Explain denaturation in terms of protein structure	H8	2–4
25 (d)(iv)	2	Explain structural features of enzymes	H8	2–4

Option Question 26 – The Chemistry of Art

26 (a)(i)	3	Recall colour and structure of pigments	H1	2–3
26 (a)(ii)	2	Recall traditional method of preparation of canvas for painting	H3	2–3
26 (b)(i)	3	Explain flame colour and electron excitation	H6	4–5
26 (b)(ii)	3	Describe Bohr's model of the atom in relation to emission spectrum	H6	5–6
26 (b)(iii)	3	Describe the use of reflectance spectra in identification of pigments	H3	4–6
26 (c)(i)	4	Explain ionisation energies in aluminium	H6	3–5
26 (c)(ii)	2	Describe relation of ionisation energy to electron structure	H6	3–5
26 (d)(i)	2	Discuss oxidation states of transition elements	H6	4–6
26 (d)(ii)	3	Explain colour in transition metal complexes	H3	3–4

Option Question 27 – Forensic Chemistry

27 (a)(i)	3	Relate gravimetric data to structure	H10	4–5
27 (a)(ii)	1	Recall test for cellulose	H3	2–3
27 (a)(iii)	1	Discuss structural difference between sugars	H9	2–4
27 (a)(iv)	1	Recall test for reducing sugar	H9	2–4
27 (b)(i)	2	Discuss features of separation methods for amino acids	H3	3–5
27 (b)(ii)	4	Discuss effect of amino acid side chains on electrophoretic behaviour	H3	4–6
27 (c)	4	Analyse emission spectra as 'fingerprints'	H1	3–5
27 (d)	6	Draw and label a mass spectrometer	H3	2–4
27 (e)(i)	2	Analyse products of DNA hydrolysis	H8	4–6
27 (e)(ii)	1	Explain chemistry of helical structure of DNA	H8	3–5

Marking guidelines

Section I Core – Part A

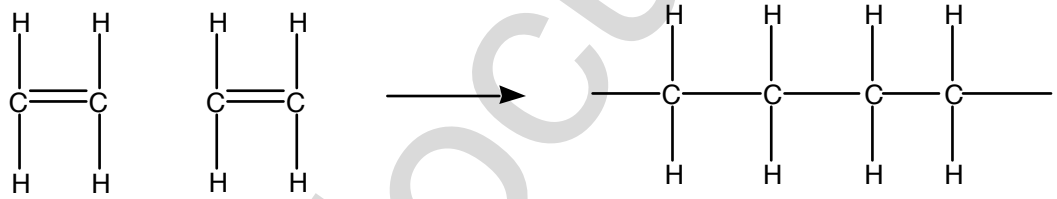
1	B	**2**	D	**3**	D	**4**	A
5	B	**6**	C	**7**	C	**8**	B
9	B	**10**	D	**11**	A	**12**	A
13	C	**14**	B	**15**	A		

Section II Core – Part B

Question 16a
Suggested answer
CH_3CHCH_2 propene

Criteria	Marks
• correct formula.	1
• correct name.	1

Question 16b(i)
Suggested answer



Criteria	Marks
• correct answer.	1

Question 16b(ii)
Suggested answer
High density polyethylene chains are linear whereas there is chain branching in low density polyethylene.

Criteria	Marks
• correct answer.	1

Question 16b(iii)
Suggested answer
Wrapping materials OR carry bags OR squeeze bottles

Criteria	Marks
• any one of the above.	1

Question 16c(i)
Suggested answer
$CH_2CH_2 + H_2O \longrightarrow CH_3CH_2OH$

Criteria	Marks
• correct equation.	2

Question 16c(ii)
Suggested answer
Heat and dilute aqueous sulfuric acid

Criteria	Marks
• both of the conditions above.	2
• one of the conditions above.	1

Question 16d(i)
Suggested answer
Molar heat of combustion of a substance is the heat liberated:
– when one mole of the substance undergoes complete combustion with oxygen.
– at a constant pressure of one atmosphere.

Criteria	Marks
• one mole undergoes complete combustion with oxygen.	1
• condition of one atmosphere constant pressure.	1

Question 16d(ii)
Suggested answer
$CH_3CH_2OH + 3O_2 \longrightarrow 2CO_2 + 3H_2O$

Criteria	Marks
• correct equation.	1
• correct balancing.	1

Question 16d(iii)
Suggested answer
Heat = mass x specific heat x temperature change = 500 × 4.2 × 32.3
= 67830 J
This is the amount of heat produced for (148.2 – 125.0) g, i.e for 23.2 g ethanol
The amount produced for 1 mole (46 g) of ethanol would therefore be 134.5 kJmole^{-1}.

Criteria	Marks
• correct formula and calculation of heat released.	2
• correct calculation per mole.	1

Question 17a
Suggested answer
If the platinum wire was positive, the reaction at the wire is one taking electrons from the external circuit, i.e. reduction. The reaction at the copper electrode is thus oxidation.

Criteria	Marks
• either of the reactions correct.	1
• both of the reactions correct.	2

Question 17b
Suggested answer
From the copper wire to the platinum wire.

Criteria	Marks
• correct answer.	1

Question 17c
Suggested answer
Flow of ions through the salt bridge to preserve electrical neutrality. Negative ions to copper electrode, positive ions to platinum electrode.

Criteria	Marks
• correct answer.	1

Question 17d
Suggested answer
$Cu(s) + Cl_2(aq) \longrightarrow Cu^{2+}(aq) + 2Cl^-(aq)$

Criteria	Marks
• correct overall cell reaction.	1
• correct state symbols.	1

Question 17e
Suggested answer
The cathode is the platinum wire.

Criteria	Marks
• correct answer.	1

Question 17f
Suggested answer
The oxidation state of copper increases from 0 to +2, thus oxidation.
The oxidation state of chlorine decreases from 0 to –1, thus reduction.

Criteria	Marks
• one of the above correct.	1
• both of the above correct.	2

Question 18a(i)
Suggested answer
The order of increasing strength is B, A, D, C.

Criteria	Marks
• all in correct order.	2
• one in incorrect order.	1

Question 18a(ii)
Suggested answer
Acid C is completely ionised. If a 0.1 $molL^{-1}$ acid solution was completely ionised, the $[H^+]$ would be 0.01 $molL^{-1}$, i.e. pH 2.

Criteria	Marks
• correct choice of acid C.	1
• correct explanation.	1

Question 18b
Suggested answer
$HClO_4 \longrightarrow H^+ + ClO_4^-$ $\qquad$ $HClO_2 \rightleftharpoons H^+ + ClO_2^-$

Criteria	Marks
• one correct equation.	1
• both equations correct.	2

Question 18c(i)
Suggested answer
1×10^{-7} $molL^{-1}$

Criteria	Marks
• correct answer.	1

Question 18c(ii)
Suggested answer
$pH = -\log[H^+] = -\log(1 \times 10^{-7}) = 7$

Criteria	Marks
• correct formula for pH.	1
• correct answer.	1

Question 18d
Suggested answer
– Weigh out accurately in a beaker 10.6 g (0.1 mole) of the pure, anhydrous sodium carbonate sample.
– Dissolve the weighed sample in distilled water and transfer all of the dissolved solute to a clean 1L volumetric flask.
– Make the dissolved solute up to 1L with distilled water in the volumetric flask.
– After making up the solution to 1L in the volumetric flask, shake well to ensure uniform mixing of the solute.

Criteria	Marks
• one mark for each of the steps correctly stated.	4

Question 19a
Suggested answer
$N_2 + 3H_2 \rightleftharpoons 2NH_3$

Criteria	Marks
• correct equation.	1
• equation correctly balanced.	1

Question 19b(i)
Suggested answer
The concentration of nitrogen gas is increased in the equilibrium mixture

Criteria	Marks
• correct answer.	1

Question 19b(ii)
Suggested answer
In accord with Le Chatelier's principle, if the equilibrium system is disturbed, then the system will adjust to minimise the disturbance. In this instance, the concentration of nitrogen is changed so the system will adjust to lower the concentration of nitrogen. Thus, the equilibrium will move to the right increasing the concentration of ammonia and reducing the concentration of hydrogen.

Criteria	Marks
• recognition of Le Chatelier's principle.	1
• concentration of nitrogen will be lowered.	1
• concentration of ammonia will increase, concentration of hydrogen will decrease.	1

Question 20a
Suggested answer
The net result of the destruction of ozone by CFC's is that an ozone molecule and an oxygen atom are converted into two oxygen molecules and the reactive chlorine atom (originally produced from reaction of CFC with uv light) is preserved. The reactive chlorine is able to attack another ozone molecule and repeat the process again – a chain reaction.

Criteria	Marks
• regeneration of reactive chlorine atom.	1
• repeated chain reaction.	1

Question 20b
Suggested answer
The ozone hole refers to the continued ozone depletion due to reactions of atmospheric ozone with CFC's and halons

Criteria	Marks
• depletion of atmospheric ozone.	1
• depletion due to ozone reaction with CFC's and halons.	1

Question 20c
Suggested answer
Ozone depletion leads to more uv radiation reaching the earth's surface. This radiation is destructive to cells of living organisms.

Criteria	Marks
• increase in uv radiation reaching earth's surface.	1
• uv radiation destructive to living cells.	1

Question 21a
Suggested answer
Advantages of membrane filters over paper or sand filtration
- membrane filter can filter out much smaller particles
- they are reasonably strong and so can withstand pressure differences across them
- they are quite thin and so liquids can flow rapidly through
- they can be cleaned and reused

Criteria	Marks
• any three of the points above, 1 mark each.	3

Question 21b
Suggested answer
Mining – heavy metal, acid and cyanide run-off from holding ponds.
Soil Erosion – increase in sediment and nutrients in adjacent waterways.

Criteria	Marks
• any two of the effects noted above.	1
• any four of the effects noted above.	2

Question 22a
Suggested answer
The selected reaction must distinguish the cations, barium and copper. Can be distinguished on solubility – add dilute sulfuric acid; barium sulfate is insoluble and copper sulfate is soluble OR add sodium hydroxide; barium hydroxide is soluble and copper hydroxide is insoluble. $Ba^{2+}(aq) + SO_4^{2-}(aq) \longrightarrow BaSO_4(s)$.

Criteria	Marks
• need to distinguish cations, barium and copper.	1
• distinguish on solubility (sulfates OR hydroxides).	1
• suitable ionic equation.	1

Question 22b
Suggested answer
The selected reaction must distinguish the anions, carbonate and sulfate. If hydrochloric acid is added to a solution of each, the one which produces a gas (carbon dioxide) contains the carbonate ion. $Na_2CO_3(s) + 2HCl \longrightarrow 2NaCl + H_2O(l) + CO_2(g)$

Criteria	Marks
• need to distinguish anions, carbonate and sulfate.	1
• distinguish on production of gas a on addition of hydrochloric acid.	1
• correct equation.	1

Question 23 – Industrial Chemistry
Question 23a(i)
Suggested answer
$([CO][H_2]^3)/([CH_4][H_2O])$.

Criteria	Marks
• correct answer.	2

Question 23a(ii)
Suggested answer
Substitution of values in the equilibrium expression gives the value of 0.97. This is not equal to the value of the equilibrium constant of 0.26, so the reaction is not at equilibrium.

Criteria	Marks
• correct answer for substitution into equilibrium expression, 0.97.	1
• correct conclusion.	1

Question 23b(i)
Suggested answer

$$S + O_2(g) \longrightarrow SO_2(g)$$
$$2SO_2(g) + O_2(g) \longrightarrow 2SO_3(g)$$
$$SO_3(g) + H_2O(l) \longrightarrow H_2SO_4(l).$$

Criteria	Marks
• one mark for each correct equation.	3

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

Criteria	Marks
• correct answer.	1

Question 23c(i)
Suggested answer
Two advantages of the membrane cell are: it produces very pure sodium hydroxide; it avoids the use of asbestos.

Criteria	Marks
• one of the above.	1
• both of the above.	2

Question 23c(ii)
Suggested answer
The mercury cell is not commonly used due to the problem of contamination of water systems with mercury residues.

Criteria	Marks
• correct answer.	1

Question 23c(iii)
Suggested answer
Cathode: $Na^+ + e \longrightarrow Na(l)$
Anode: $2Cl^- \longrightarrow Cl_2(g) + 2e$

Criteria	Marks
• correct reduction reaction.	1
• correct oxidation reaction.	1
• correct assignment of electrodes.	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.

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.

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
Anionic surfactants have a hydrophobic tail and a negatively charged hydrophilic, water soluble, anionic head. Cationic surfactants have a hydrophobic tail but the water soluble part is a positively charged N atom. A common use of anionic surfactants is laundry detergents; cationic surfactants are used in fabric softeners.

Criteria	Marks
• correct description of anionic surfactant.	1
• correct description of cationic surfactant.	1
• correct uses for each.	1

Question 23e(i)
Suggested answer
Sodium chloride and calcium carbonate are the raw materials.

Criteria	Marks
• one mark for each correct raw material.	2

Question 23e(ii)
Suggested answer
Calcium chloride.

Criteria	Marks
• correct answer.	1

Question 24 – Shipwrecks, Corrosion and Conservation

Question 24a

Suggested answer

NaCl:	Positive electrode	$2Cl^- \longrightarrow Cl_2 + 2e$
	Negative electrode	$Na^+ + e \longrightarrow Na$
$CuSO_4$:	Positive electrode	$4OH^- \longrightarrow 2H_2O + O_2 + 4e$
	Negative electrode	$Cu^{2+} + 2e \longrightarrow Cu.$

Criteria	Marks
• one mark for each of the four correct equation.	4
• all electrode polarities correct.	1

Question 24b

Suggested answer

Galvani is credited with the first production of an electric current; from two joined different metallic wires with the unjoined ends placed in freshly extracted frog muscle.
Faraday's work related to determining the amount of substance produced to the quantity of electricity passed through an electrolytic cell.

Criteria	Marks
• one mark for each correct.	2

Question 24c(i)

Suggested answer

At locations on the iron, the reaction $Fe \longrightarrow Fe^{2+} + 2e$ occurs. The electrons flow through the iron metal to another site where they reduce oxygen, $O_2 + 2H_2O + 4e \longrightarrow 4OH^-$. The OH^- and Fe^{2+} ions migrate through surface moisture on the iron and combine, $Fe^{2+} + 2OH^- \longrightarrow Fe(OH)_2(s)$. This is oxidised by oxygen to form rust, $Fe_2O_3.xH_2O$.
Water is needed to provide a medium through which the ions can migrate to form $Fe(OH)_2$. Oxygen is needed to form the hydroxide. Migration of ions is faster through salt water because of its greater conductivity. Impurities in iron provide sites for reduction of oxygen to hydroxide.

Criteria	Marks
• correct reactions for formation of rust.	1
• correct formula for rust, $Fe_2O_3.xH_2O$.	1
• correct explanation of each observations of rusting, 1 mark each.	4

Question 24c(ii)
Suggested answer
Cathodic protection refers to the protection of a metal by making it the cathode in the cell. For example coating iron with zinc – the zinc sets up a galvanic cell and any Fe^{2+} formed is converted back to Fe and rust formation is thus prevented.
$Zn(s) + Fe^{2+}(aq) \longrightarrow Zn^{2+}(aq) + Fe(s)$.

Criteria	Marks
• correct idea of cathodic protection.	1
• correct example given.	1
• correct equation showing cathodic protection.	1

Question 24d
Suggested answer
Copper alloys, such as bronze, are usually cleaned by chemical stripping, i.e. dissolving the surface deposits with a chemical solution. The stripped object will need to have residual chloride removed and this is generally done by prolonged soaking in water or sodium hydrogen carbonate solution. Finally, the object is coated with a clear acrylic lacquer to prevent further corrosion.

Criteria	Marks
• chemical stripping; residual chloride removal; coating to prevent further corrosion – one mark each.	3

Question 24e
Suggested answer
– The concentration of ions in the solution.
– The surface area of the electrodes used.
– The distance between electrodes.

Criteria	Marks
• one mark for each correct.	3

Question 24f(i)
Suggested answer
- The low temperatures in deep ocean slows down the chemical reactions involved
- In deep ocean water there is virtually no oxygen present. Oxygen is essential for rusting.

Criteria	Marks
• one mark for each correct.	2

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

Criteria	Marks
• correct answer.	1

Question 25 – The Biochemistry of Movement
Question 25a
Suggested answer
Skeletal muscle tissue is composed of individual muscle cells, the muscle fibres. Each muscle fibre is made up of many cylindrical subunits, the myofibrils. These are rods of the contractile proteins, actin and myosin, that run from one end of the fibre to the other.
Contraction of muscle is triggered by nerve impulses arriving at the muscle cell membrane. The stimulation of the muscle membrane by a nerve impulse releases calcium ions which cause the splitting of ATP to ADP to release energy. A temporary bond is formed with the myosin attaching to the actin molecules and pulling them towards each other, contracting the myofibril and thus the muscle fibre.

Criteria	Marks
• skeletal muscle composed of muscle cells or fibres with each fibre made up of myofibrils.	1
• myofibrils made up of the contractile proteins, actin and myosin.	1
• contraction initiated by nerve impulse with calcium ions released.	1
• ATP is split to ADP with release of energy.	1
• interaction between actin and myosin results in contraction of muscle fibre.	1

Question 25b(i)
Suggested answer
Glycolysis is the process by which the glucose molecule is changed anaerobically to two molecules of lactic acid with the liberation of a small amount of useful energy. The reaction takes place in the cytoplasm of the cell.

Criteria	Marks
• glucose molecule is changed anaerobically.	1
• chemical change of glucose releases energy.	1
• glycolysis takes place in the cell cytoplasm.	1

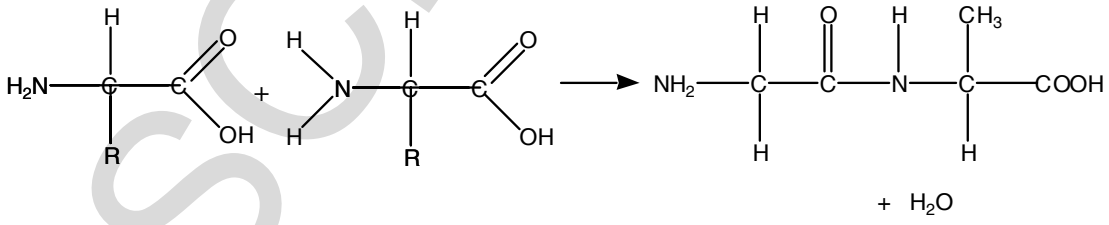
Question 25b(ii)
Suggested answer
Hydrolysis of fat produces glycerol and the fatty acid. These compounds then enter the Krebs cycle where they are oxidised to carbon dioxide and water. The energy released in oxidation is packaged as ATP.

Criteria	Marks
• hydrolysis of fat to glycerol and fatty acids.	1
• products of hydrolysis enter the Krebs cycle.	1
• oxidation to carbon dioxide and water with release of energy to ATP.	1

Question 25c
Suggested answer
Both glycogen and glucose include many hydroxyl groups in their structure. These are polar groups which are strongly attracted to the polar water molecule. Dipole-dipole bonds between the polar groups in the molecules and water results in the solubility of these molecules.

Criteria	Marks
• glycogen and glucose have many hydroxyl groups.	1
• hydroxyl groups are polar.	1
• polar hydroxyl groups attracted to polar water molecules.	1
• dipole-dipole interaction of polar groups results in solubility	1

Question 25d(i)
Suggested answer



Criteria	Marks
• correct and complete equation.	2

Question 25d(ii)
Suggested answer
– Covalent bonding, e.g. disulfide bridges
– Hydrogen bonding between polar groups on the side chain
– Ionic bonds between $–NH_2$ and –COOH groups
– Hydrophobic interactions

Criteria	Marks
• one mark for each correct.	4

Question 25d(iii)
Suggested answer
Denaturation refers to the loss of the three-dimensional structure of proteins. The function of the protein structure is affected since its structure is essential to its proper function.

Criteria	Marks
• loss of three dimensional structure.	1
• structure essential to function.	1

Question 25d(iv)
Suggested answer
Enzymes catalyse biological processes. The structure of enzymes is such that they provide a site (active site) for a specific reaction to take place.

Criteria	Marks
• enzyme.	1
• provide special active site for biological process to take place.	1

Question 26 – The Chemistry of Art
Question 26a(i)
Suggested answer
– Copper(II) carbonate and copper(II) hydroxide.
– Malachite is a bright green pigment.
– Azurite is a blue pigment.

Criteria	Marks
• one mark for each correct answer.	3

Question 26a(ii)
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.

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.

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 spectrum is seen when light from an excited atom is passed through a narrow slit and then a prism. The visible light emitted from the excited atom gives a series of discrete lines separated by black areas. This type of spectrum is called an emission spectrum.

Criteria	Marks
• line spectrum is seen when light from an excited atom is passed through a narrow slit and then a prism.	1
• visible light emitted from the excited atom gives a series of discrete lines separated by black areas.	1
• the spectrum produced is called an emission spectrum.	1

Question 26b(iii)
Suggested answer
A reflectance spectrum can be obtained from the pigments in a painting by shining white light onto the pigment and then analysing the reflected light. The so-called reflectance spectrum can then be compared to those of known pigments and identification made.

Criteria	Marks
• white light is shone onto the pigment.	1
• the reflected light (reflectance spectrum) is analysed.	1
• the reflectance spectrum is compared to those of known pigments and identification made.	1

Question 26c(i)
Suggested answer
The first three electrons removed from aluminium occupy the n = 3 energy level. The fourth and fifth electrons occupy the n = 2 energy level which is closer to the positive nucleus and so requires substantially more energy to remove than those in the further out n = 3 level.

Criteria	Marks
• the first three electrons removed from aluminium occupy the n = 3 energy level.	1
• the fourth and fifth electrons occupy the n = 2 energy level.	1
• n = 3 further out from the influence of the positive nucleus and so less energy required to remove electrons from atom.	1
• n = 2 closer to the influence of the positive nucleus and so more energy required to remove electrons from atom.	1

Question 26c(ii)
Suggested answer
In a table of successive ionisation energies, an obvious jump in ionisation energy indicates a transition to a lower energy level. The number of ionisation steps before this jump predicts the number of electrons in the outermost energy level.

Criteria	Marks
• obvious jump in ionisation energy indicates a transition to a lower energy level.	1
• number of ionisation steps before this jump predicts the number of electrons in the outermost energy level.	1

Question 26d(i)
Suggested answer
The transition metals commonly have two 4s electrons as their outer electons. The loss of these two 4s electrons means that the most common oxidation state will be +2.

Criteria	Marks
• the transition metals commonly have two 4s electrons as their outer electons.	1
• loss of the two 4s electrons means that their the most common oxidation state will be +2.	1

Question 26d(ii)
Suggested answer
Colour in aqueous ions of transition metals results from the ability of these metal ions to absorb quanta of energy and promote electrons to unfilled d-orbitals. The d-orbital absorbed energy is in the visible light range and the colour of the compounds is the complementary colour of the energy absorbed. Aqueous ions of metals, other than transition metals, do not have unfilled d-orbitals so do not produce colours.

Criteria	Marks
• transition metals have the ability to absorb quanta of energy and promote electrons to unfilled d-orbitals.	1
• the absorbed energy is in the visible light range and the colour of the compounds is the complementary colour of the energy absorbed.	1
• aqueous ions of metals, other than transition metals, do not have unfilled d-orbitals so do not produce colours.	1

Question 27 – Forensic Chemistry
Question 27a(i)
Suggested answer
Mole ratio C:O:H = 39.8/12 : 53.3/16 : 6.7/1 = 3.32 : 3.33 : 6.7 = 1 : 1 : 2
Empirical formula is COH_2 which is consistent with the general formula for carbohydrates, $Cx(H_2O)y$, where x and y may be the same or different.

Criteria	Marks
• correct mole ratio calculation.	1
• correct statement of empirical formula.	1
• correct general formula for carbohydrates.	1

Question 27a(ii)
Suggested answer
Starch forms a deep blue complex with iodine.

Criteria	Marks
• correct answer.	1

Question 27a(iii)
Suggested answer
Sugars, that have an OH group attached to the same C as a ring O is attached to, are reducing sugars.

Criteria	Marks
• correct answer.	1

Question 27a(iv)
Suggested answer
Reducing sugars are oxidised by Benedict's solution to form a deep blue solution of copper sulfate in alkaline citrate.

Criteria	Marks
• correct answer.	1

Question 27b(i)
Suggested answer
Electrophoresis separates amino acids on the basis of their size and charge. Chromatography separates them on the basis of their different solubilities in polar and non-polar solvents

Criteria	Marks
• electrophoresis separates on charge and size.	1
• chromatography separates on solubility in polar and non-polar solvents.	1

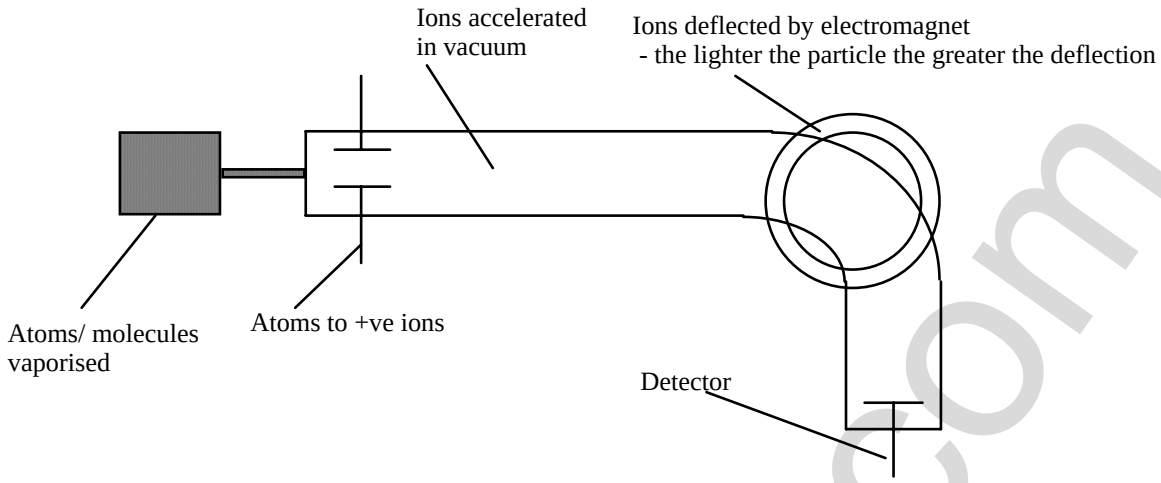
Question 27b(ii)
Suggested answer
For any given amino acid there is a pH at which it exists as an overall neutral molecule. This pH depends on the structure of the amino acid. With an acidic side chain a lower pH is needed to create a neutral molecule; if the side chain is a basic group a higher pH is needed. Since electrophoretic behaviour of amino acids is dependent on charge, the side chain can influence its behaviour at different pH values.

Criteria	Marks
• for any given amino acid there is a pH at which it exists as an overall neutral molecule.	1
• this pH depends on the structure of the amino acid.	1
• an acidic side chain means a lower pH is needed to create a neutral molecule; if the side chain is a basic group a higher pH is needed.	1
• as amino acids's electrophoretic behaviour is dependent on charge, the side chain can influence its behaviour at different pH values.	1

Question 27c
Suggested answer
The emission spectra of elements can be used to identify the elements present in mixtures. A sample to be analysed is heated to vaporise it and excite the electrons. Emissions from the excited sample are passed through a prism to separate the emitted radiation into different wavelengths. A recorder graphs the intensity of light as a function of wavelength. Emission spectra are used as a kind of 'fingerprint' as the spectrum obtained is unique for a particular element.

Criteria	Marks
• sample to be analysed is heated to vaporise it and excite the electrons.	1
• emissions from the excited sample are passed through a prism to separate the emitted radiation into different wavelengths.	1
• recorder graphs the intensity of light as a function of wavelength.	1
• spectrum obtained is unique ('fingerprint') for a particular element.	1

Question 27d
Suggested answer



Criteria	Marks
• correct schematic diagram.	1
• correct notation on diagram, one mark each.	5

Question 27e(i)
Suggested answer
Deoxyribose, adenine, cytosine, guanine, thymine and phosphoric acid.

Criteria	Marks
• four of six correct.	1
• all six correct.	1

Question 27e(ii)
Suggested answer
By hydrogen bonding between the pairs of bases.

Criteria	Marks
• correct answer.	1

