CATHOLIC SECONDARY SCHOOLS ASSOCIATION

2006 TRIAL HIGHER SCHOOL CERTIFICATE EXAMINATION

CHEMISTRY – MARKING GUIDELINES

The sample answers indicate features that should be found in a response that receives full marks. For the extended response questions, a set of guidelines is included rather than a sample answer.

Section I
Part A – 15 marks
Questions 1-15 (1 mark each)

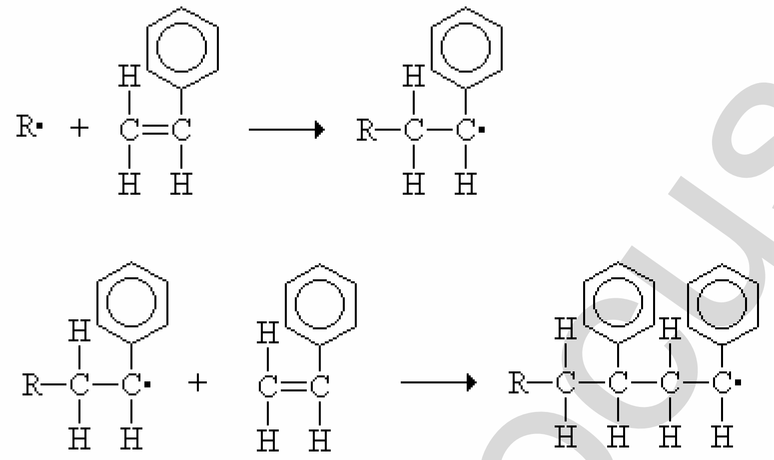
Question	Correct Response	Outcomes Assessed	Targeted Performance Bands
1	B	H8, H9	2-3
2	B	H9, H13	2-3
3	C	H7,H9, H10	4-5
4	B	H6, H8, H13	3-4
5	A	H7, H13	3-4
6	D	H8, H14	4-5
7	D	H8, H10, H13	5-6
8	C	H8, H13	2-3
9	A	H8, H9, H11	3-4
10	C	H6, H9, H10	3-4
11	D	H8, H13	2-3
12	B	H8	2-3
13	D	H6, H7, H8	4-5
14	A	H9, H13	3-4
15	C	H4, H8	3-4

Section I
75 marks

Part B – 60 marks
Question 16
(a) (2 marks)
Outcomes Assessed: H9, H13
Targeted Performance Bands: 3-4

Criteria	Mark
• Identifies structure of styrene AND demonstrates addition polymerisation	2
• Identifies structure of styrene OR demonstrates addition polymerisation	1

Sample Answer
Styrene (the monomer) combines with the free radical initiator R•. This combination in turn pulls an electron out of the double bond of another styrene molecule, to increase the length of the chain. Polystyrene is formed after this process is repeated many times.



(b) (1 mark)
Outcomes Assessed: H9
Targeted Performance Bands: 3-4

Criteria	Mark
• Identifies ONE significant use AND relates that use to a physical property	1

Sample Answer
Many responses possible.
Polystyrene is a very stiff, stable polymer. This makes it suited as a raw material for the production of outdoor furniture.

Question 17

(a) (1 mark)

Outcomes Assessed: H10, H11

Targeted Performance Bands: 2-3

Criteria	Mark
• Identifies the cathode	1

Sample Answer

Student labels the silver electrode as the cathode.

(b) (2 marks)

Outcomes Assessed: H1, H7, H13

Targeted Performance Bands: 3-5

Criteria	Marks
• Explains why the formation of a precipitate makes KCl an inappropriate choice	2
• Identifies the formation of a precipitate	1

Sample Answer

KCl is inappropriate as it reacts with silver ions to form a precipitate. Consequently, chloride ions would not be able to migrate to the oxidation half cell to balance the production of positive copper ions. The precipitate would also remove silver ions from solution therefore preventing them from being reduced at the cathode.

(c) (3 marks)

Outcomes Assessed: H11, H13

Targeted Performance Bands: 2-5

Criteria	Marks
• Evaluates choice by referring to correct half equations and cell voltage calculation	3
• Evaluates choice by referring to partially correct half equations and cell voltage calculations OR • Produces correct half equations and cell voltage calculation	2
• Evaluates choice without using appropriate or correct half equations or providing a cell voltage calculation OR • Identifies a correct half equation OR • Calculates the cell potential	1

Sample Answer

The copper electrode will be oxidised:

$\mathrm{Cu}(s) \rightarrow \mathrm{Cu}^{2+}(aq) + 2e^-$ E° = -0.34 V

and the silver ions in solution at the cathode will be reduced:

$\mathrm{Ag}^+(aq) + e^- \rightarrow \mathrm{Ag}(s)$ E° = 0.80 V

Overall equation:

$\mathrm{Cu}(s) + \mathrm{Ag}^+(aq) \rightarrow \mathrm{Cu}^{2+}(aq) + \mathrm{Ag}(s)$ overall E° = 0.46 V

The selected electrodes and electrolytes are inappropriate for producing a cell voltage between 1.1 and 1.2 V.

Question 18 (2 marks)

Outcomes Assessed: H6, H7, H11

Targeted Performance Bands: 3-4

Criteria	Marks
• Explains the use of a named isotope in terms of its properties	2
• Explains the use OR properties only	1
• Name of isotope only	0

Sample Answer

Many responses possible.

Cobalt-60 is a gamma ray producer. The gamma rays will kill bacteria (by destroying DNA structure), so is used for sterilising in the food canning industry and for sterilising medical supplies such as dressings and bandages. It has a reasonably long half-life (5.3 years), so that the isotope does not need replacing for several years.

Question 19 (2 marks)
(a) (1 mark)
Outcomes Assessed: H10
Targeted Performance Bands: 3-4

Criteria	Mark
• Writes correct nuclear equation	1

Sample Answer

$$^{59}_{27}\mathrm{Co} + ^{1}_{0}\mathrm{n} \longrightarrow ^{60}_{27}\mathrm{Co}$$

(b) (1 mark)
Outcomes Assessed: H7, H13
Targeted Performance Bands: 2-3

Criteria	Mark
• Gives correct explanation	1

Sample Answer
Cyclotrons are required to accelerate positively charged particles towards a positive target. Neutrons have no charge so no such acceleration is required. Thus, a nuclear reactor is appropriate for the production of cobalt-60.

Question 20 (7 marks)
Outcomes Assessed: H1, H3, H5, H13
Targeted Performance Bands: 2-6

Criteria	Marks
• Assesses the potential of ethanol as a replacement for fossil fuels • Explains, using appropriate equations, how ethanol can be used as a source of energy and a source of polymers	6-7
• Assesses the potential of ethanol as a replacement for fossil fuels AND • Explains how ethanol can be used as a source of energy and a source of polymers OR • Explains, using appropriate equations, how ethanol can be used as a source of energy and a source of polymers	4-5
• Outlines some advantages AND disadvantages of the use of ethanol as a source of energy and polymers OR • Describes how ethanol can be used as a source of energy and a source of polymers	2-3
• Outlines a feature of the use of ethanol for energy OR for polymers	1

Sample Answer
Many possible responses.

Ethanol is a potential source of raw material for many of the world's most widely used polymers because it can be dehydrated to form ethylene:

$$C_2H_5OH(l) \xrightarrow{\text{conc } H_2SO_4} C_2H_4(g) + H_2O(l)$$

Ethylene is currently derived from the cracking of alkanes extracted from crude oil and is used as the starting point for the production of some of the world's most important polymer products, including PVC and polystyrene. The dehydration of ethanol to produce ethylene is not currently practised in industry because alkane cracking is more economical, so the adoption of this method of production would increase the price of the final polymer products.

Ethanol has also been used as a fuel for years. As a potential replacement for crude oil based fuels, ethanol has major advantages. Firstly it is renewable, less polluting than petrol, burning cleanly with sufficient oxygen to produce only carbon dioxide and water:

$$C_2H_5OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l)$$

Ethanol is also able to be used in internal combustion engines with minor modifications. Most of the infrastructure used to handle petrol can be used to handle ethanol.

Ethanol is a renewable fuel, but at a high price. Ethanol can be fermented from sugars in a process which uses large amounts of both energy and time.

$$C_6H_{12}O_6\,(aq) \xrightarrow{\text{yeast}} 2CO_2\,(g) + 2C_2H_6O\,(aq)$$

The cycle of photosynthesis and burning of ethanol is neutral with respect to greenhouse gases but the processes of distillation and fertilizer production use large amounts of energy and, for the moment, fossil fuels. Satisfying Australia's entire transport energy demands with ethanol would also require vast amounts of arable land to be given over to sugar cane production at the expense of other farming industries.

Ethanol does have potential as a future source of both energy and polymers, but at a price and only if the problems surrounding the sustainable supply of the raw materials are solved.

Question 21
(a) (i) (1 mark)
Outcomes Assessed: H6
Targeted Performance Bands: 2-3

Criteria	Mark
• Identifies a basic oxide	1

Sample Answer
K_2O *or* CaO

(a) (ii) (1 mark)

Outcomes Assessed: H6

Targeted Performance Bands: 2-3

Criteria	Mark
• Identifies an acidic oxide	1

Sample Answer

SO_2 *or* N_2O_5

(b) (1 mark)

Outcomes Assessed: H8, H10

Targeted Performance Bands: 2-3

Criteria	Mark
• Writes a correct, balanced equation	1

Sample Answer

$SO_2(g) + H_2O(l) \rightarrow H_2SO_3 \Leftrightarrow H^+ + HSO_3^-$

(c) (1 mark)

Outcomes Assessed: H2, H8, H11

Targeted Performance Bands: 3-4

Criteria	Mark
• Defines the term amphoteric	1

Sample Answer

An amphoteric substance will react with both H^+ and OH^- solutions to form a salt and water.

Question 22

(a) (1 mark)

Outcomes Assessed: H9, H13

Targeted Performance Bands: 2-3

Criteria	Mark
• Correctly states an INDUSTRIAL use for a named ester	1

Sample Answer

Ethyl ethanoate – used as a solvent in industry

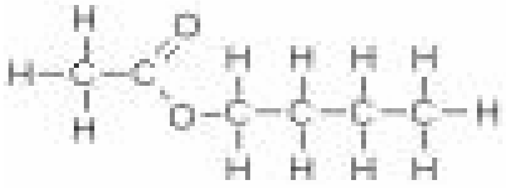
(b) (i) (1mark)

Outcomes Assessed: H9, H13

Targeted Performance Bands: 3-4

Criteria	Mark
• Draws correct structural formula	1

Sample answer



(a)(ii) (1 mark)

Outcomes Assessed: H9, H13

Targeted Performance Bands: 2-3

Criteria	Mark
- Correctly names the ester, OR correctly names ester drawn in part (i)	1

Sample Answer

1-butyl ethanoate

Question 23

(a) (1 mark)

Outcomes Assessed: H8, H13

Targeted Performance Bands: 3-4

Criteria	Mark
- Correctly EXPLAINS why hydrogen sulfide is classified as a WEAK acid	1

Sample Answer

Hydrogen sulfide only PARTIALLY IONISES in water (only a small percentage of the molecules ionise).

(b) (2 marks)

Outcomes Assessed: H8, H13

Targeted Performance Bands: 3-4

Criteria	Marks
- Identifies hydrogen sulfide as a proton donor AND writes an equation to illustrate hydrogen sulfide acting as a Bronsted-Lowry acid	2
- Identifies hydrogen sulfide as a proton donor OR writes an equation to illustrate hydrogen sulfide acting as a Bronsted-Lowry acid	1

Sample Answer

Hydrogen sulfide is a Bronsted-Lowry acid because it donates a proton to a base.

$H_2S(g) + H_2O(l) \Leftrightarrow HS^- + H_3O^+$

(c) (1 mark)

Outcomes Assessed: H8, H13

Targeted Performance Bands: 3-4

Criteria	Mark
- Identifies ONE conjugate acid/base pair	1

Sample Answer

H_2S/HS^- (OR H_3O^+/H_2O).

(d) (i) (2 marks)

Outcomes Assessed: H10

Targeted Performance Bands: 3-5

Criteria	Marks
• Correctly calculates the number of moles of each reactant AND correctly identifies HCl as the reactant in excess	2
• Correctly calculates the number of moles of each reactant	1

Sample Answer

Mole HCl = 0.10 M × 0.050 L = 0.0050 mol
Mole ZnS = 0.11 g ÷ (65.39 + 32.07) g = 0.0011 mol

Mole ratio in balanced equation HCl : ZnS = 2:1
Here HC1 is in excess as ratio is 4.5:1 (HCl in excess by 0.0028 mol)

(d) (ii) (2 marks)

Outcomes Assessed: H10

Targeted Performance Bands: 3-5

Criteria	Marks
• Correctly uses the limiting reagent to calculate the number of moles of H_2S AND correctly calculates the volume of H_2S	2
• Correctly uses the limiting reagent to calculate the number of moles of H_2S	1

Sample Answer

Limiting reagent is ZnS. Mole ratio $ZnS:H_2S$ = 1:1
$\therefore$ mole H_2S = 0.0011 mol
$\therefore$ vol H_2S = 0.0011 × 24.79 = 0.027 L = 27 mL

Question 24

(a) (1 mark)

Outcomes Assessed: H10, H13

Targeted Performance Bands: 3-4

Criteria	Mark
• Correctly calculates the concentration of NaOH	1

Sample Answer

3.0 g ÷ 40 g = 0.075 mol NaOH
0.075 mol ÷ 3.0 L = 0.025 mol L^{-1} (2 significant figures required)

(b) (1 mark)

Outcomes Assessed: H13

Targeted Performance Bands: 3-4

Criteria	Mark
• Correctly calculates the pH	1

Sample Answer

pH = - log 0.026 = 1.59 (Note: Answer must be correct to 2 **decimal places**, as concentration of acid was expressed to 2 **significant figures**.)

(c) (3 marks)

Outcomes Assessed: H7, H11, H12, H13

Targeted Performance Bands: 3-5

Criteria	Marks
• Describes the properties of a primary standard AND evaluates the use of NaOH as a primary standard	3
• Describes the properties of a primary standard AND outlines why NaOH is not a good choice	2
• Describes the properties of a primary standard OR outlines why NaOH is not a good choice	1

Sample Answer

A primary standard needs to be completely soluble in water. It must be obtainable pure and crystalline, it must not react with air and it should have a high molecular mass to minimise errors when weighing accurate amounts of the solid. Sodium hydroxide is not an acceptable primary standard as it readily absorbs water and carbon dioxide from the air. Therefore it is impossible to weigh an exact mass to prepare a primary standard. Considering all these factors, sodium carbonate or oxalic acid are much better choices as primary standards.

Question 25 (4 marks)
Outcomes Assessed: H2, H8, H14
Targeted Performance Bands: 4-6

Criteria	**Marks**
• Writes a balanced equilibrium equation for the Haber process • Explains the impact of changing temperature and pressure on the yield of ammonia • Explains the impact of changing temperature and pressure on the rate of production of ammonia • Identifies the optimum/compromise conditions of temperature and pressure for ammonia production	4
• Writes a balanced equilibrium equation for the Haber process • Explains the impact of changing temperature and pressure on the yield of ammonia • Explains the impact of changing temperature and pressure on the rate of production of ammonia	3
• Writes a balanced equilibrium equation for the Haber process • Explains the impact of changing temperature and pressure on the yield of ammonia OR explains the impact of changing temperature and pressure on the rate of production of ammonia	2
• Identifies an impact of changing temperature on the reaction OR • identifies an impact of changing pressure on the reaction	1

Sample Answer

$N_2(g) + 3H_2(g) \leftrightarrow 2NH_3(g)$ $\Delta H = -92 \text{kJ mol}^{-1}$ (exothermic)

As this is an equilibrium reaction, using Le Chatelier's Principle, we can predict that increasing the temperature would push the reaction to the left, toward the reactants, as the forward reaction is exothermic. Increasing the pressure on an equilibrium mixture of the gases would push the reaction to the right, toward the products, as there are fewer molecules on the RHS. Decreasing temperature and pressure would have the reverse effects.
Thus high pressure and low temperature produce the highest YIELD of ammonia.

Increasing the temperature increases the RATE of reaction. Increasing the pressure also increases the RATE of reaction. (Increasing the temperature and pressure mean more successful collisions as the particles are either moving faster or are closer together.) Hence, high temperature and high pressure produce the fastest RATE OF PRODUCTION of ammonia.

Therefore, the temperature and pressure must be carefully balanced to produce the optimum yield. Thus the reaction should be conducted at high pressure but only at a moderate temperature.

Question 26 (2 marks)
Outcomes Assessed: H7, H8, H9, H16
Targeted Performance Bands: 2-4

Criteria	Marks
• Explains at least ONE problem associated with incomplete combustion and explains how the problem can be reduced	2
• Explains at least ONE problem associated with incomplete combustion OR explains how the problem can be reduced	1

Sample Answer
Incomplete combustion of a fuel results in the production of carbon monoxide (poisonous) and/or carbon (soot – causes visual pollution and medical problems) instead of carbon dioxide. Incomplete combustion also is inefficient in that it does not release as much energy per mole of a fuel and hence wastes fuel resources.
Thus combustion should be monitored to ensure that it is as complete as possible by ensuring that excess oxygen is available.

Question 27 (5 marks)
(a) (1 mark)
Outcomes Assessed: H3, H11.
Targeted Performance Bands: 2-6

Criteria	Mark
• Identifies the appropriate purpose	1

Sample Answer
Standard solutions are required to produce a calibration curve.

(b) (4 marks)
Outcomes Assessed: H3, H4.
Targeted Performance Bands: 2-6

Criteria	Marks
• Assesses the impact of AAS on understanding the effects of one trace element, describing the effects of the element and the advantages of AAS over earlier scientific analytical methods	4
• Describes effects of a named trace element and describes the impact of AAS on the measurement of trace elements	2-3
• Identifies an effect of a named trace element	1

Sample Answer
Lead is a toxic heavy metal. The use of lead was widespread in paints, petrol, batteries, crystal-ware and pesticides. Despite the banning of many of these materials residual lead levels in the environment are still significant. There is no safe level for lead exposure. The National Health & Medical Research Council recommends levels of exposure below 0.1ppm. Lead levels of 0.45ppm produce symptoms such as fatigue, abdominal pain, lethargy and aggressiveness. In severe cases symptoms can escalate to paralysis, fits, vomiting, coma and death.
Prior to the discovery of AAS techniques such minute concentrations could not be accurately measured nor investigated. AAS is an extremely sensitive and accurate technique. AAS has

enabled researchers to monitor lead levels in those affected and to match the level of symptoms to the amount of lead in the body. Monitoring levels in the environment (soil, water air etc) has enabled society to reduce the exposure and risk to life. Therefore AAS has had an enormous impact on our understanding of the effects of lead.

Question 28 (4 marks)
(a) (2 marks)
Outcomes Assessed: H14
Targeted Performance Bands: 3-6

Criteria	Marks
• Identifies more than ONE trend	2
• Identifies ONE trend	1

Sample Answer
The graph shows a general decrease in total ozone at Halley Bay from 1956 to 1993. From 1993 to 1996 the total ozone levels appear to be gradually increasing. From 1996 the levels appear fairly constant.

(b) (2 marks)
Outcomes Assessed: H4
Targeted Performance Bands: 3-5

Criteria	Marks
• Explains ONE method of obtaining data	2
• Describes ONE method of obtaining data	1

Sample Answer
Spectrophotometers are used to measure ozone levels. These spectrophotometers can be ground based, in satellites or carried by helium balloons.
Ground based spectrophotometers measure the intensity of light reaching the surface of the earth. The intensity of light is recorded at a wavelength that ozone absorbs and at a wavelength not absorbed by ozone. By comparing the intensities the total ozone per unit area can be calculated for that location.

Question 29 (5 marks)
(a) (1 mark)
Outcomes Assessed: H2
Targeted Performance Bands: 2-3

Criteria	Mark
• Identifies the correct method	1

Sample Answer
Method B

(b) (1 mark)
Outcomes Assessed: H13, H14
Targeted Performance Bands: 3-4

Criteria	Mark
• Identifies the relationship between ppm and mg/L	1

Sample Answer
17 mg/L = 17 ppm therefore the table indicates < 20 ppm is soft.

(c) (3 marks)
Outcomes Assessed: H2, H11, H2, H14
Targeted Performance Bands: 2-6

Criteria	Marks
• Compares the features and appropriateness of Method A and Method B	3
• Compares the features of Method A and Method B	2
• Identifies a positive or negative feature of either Method A or B	1

Sample Answer
Method A provides a more accurate measure of water hardness than Method B.
Results from Method A could be compared with similar volumetric tests performed anywhere at any time. However, results provided by Method B would not be appropriate for comparisons of water hardness as the concentration and type of detergent and the amount of shaking and width of vial would be difficult to control.
However in situations where a qualitative comparison of water hardness is only required then Method B is faster, more convenient and quite reliable.
Therefore, Method A is appropriate where accuracy and reproducibility are required, whereas Method B would be more appropriate where quick, comparative, inexpensive measurements are needed.

Section II

INDUSTRIAL CHEMISTRY

Question 30 (25 marks)
(a) (i) (1 mark)
Outcomes Assessed: H10
Targeted Performance Bands: 2-3

Criteria	Mark
• Correctly identifies the equilibrium expression	1

Sample Answer

$$K = \frac{[CF_4][CO_2]}{[COF_2]^2}$$

(a) (ii) (3 mark)
Outcomes Assessed: H10
Targeted Performance Bands: 2-5

Criteria	Mark
• Calculates the value of K	3
• Calculates the equilibrium concentrations	2
• Calculates the number of moles of each species at equilibrium	1

Sample Answer

Moles COF_2 initially equilibrium = 0.400
Moles COF_2 at equilibrium = 0.080
Hence moles COF_2 reacting = 0.400 – 0.080 = 0.320
$\therefore$ moles CO_2 at equilibrium = moles CF_4 at equilibrium = 0.160

Equilibrium concentrations are $[COF_2] = 0.080 \div 5.00 = 0.016 \text{ mol L}^{-1}$
$[CO_2] = [CF_4] = 0.16 \div 5.00 = 0.032 \text{ mol L}^{-1}$

$$\therefore K = \frac{0.032 \times 0.032}{0.016^2} = 4$$

(a) (iii) (3 marks)
Outcomes Assessed: H7, H13
Targeted Performance Bands: 3-4

Criteria	Mark
• Correctly identifies the reaction as exothermic, with correct explanation	1

Sample Answer
Increase temperature shifts equilibrium to the left (since more COF_2 is present at equilibrium), therefore the backwards reaction must be endothermic (increase in temperature always favours the endothermic reaction). Therefore the forward reaction (breakdown of COF_2) is exothermic.

(b) (4 marks)

Outcomes Assessed: H7, H8, H10, H13
Targeted Performance Bands: 2-5

Criteria	Marks
- Thorough outline of the steps AND conditions involved including all relevant equations	4
- Sound outline of steps AND conditions involved (including some equations)	3
- Limited outline of steps AND conditions involved OR - Sound outline of steps OR conditions involved	2
- Limited outline of steps OR conditions involved	1

Sample Answer

Liquid sulfur is sprayed into an excess of dry air to form sulfur dioxide:

$S\,(l) + O_2\,(g) \rightarrow SO_2\,(g)$

Using a vanadium (V) oxide catalyst, sulfur dioxide is passed over the catalyst beds at moderate temperatures in order to optimize yield and reaction rate (compromise) and is oxidized to sulfur trioxide.

$2SO_2\,(g) + O_2\,(g) \Leftrightarrow SO_3\,(g)$

The sulfur trioxide is then reacted with sulfuric acid to form oleum, as sulfur trioxide is much more soluble in sulfuric acid than in water.

$SO_3\,(g) + H_2SO_4\,(l) \rightarrow H_2S_2O_7\,(l)$

Oleum is then reacted with water to form sulfuric acid.

$H_2S_2O_7\,(l) + H_2O\,(l) \rightarrow 2H_2SO_4\,(l)$

(c) (i) (4 marks)

Outcomes Assessed: H7, H8, H10, H11, H14
Targeted Performance Bands: 2-6

Criteria	Marks
- Identifies products of electrolysis of dilute AND concentrated NaCl including all equations AND tests to identify products	4
- Identifies products of electrolysis of dilute AND concentrated NaCl including equations OR tests to identify products	3
- Identifies products of electrolysis of dilute OR concentrated NaCl including an equation OR - Identifies products of electrolysis of dilute AND concentrated NaCl	2
- Identifies products of electrolysis of dilute OR concentrated NaCl	1

Sample Answer
The electrolysis of dilute NaCl solution yielded the products of $H_2(g)$ and $O_2(g)$.
Cathode: $H_2O(l) + e^- \Leftrightarrow \frac{1}{2} H_2(g) + OH^-$
Anode: $H_2O(l) \Leftrightarrow \frac{1}{2} O_2(g) + 2H^+ + 2e^-$

The electrolysis of concentrated NaCl solution yielded the products of $H_2(g)$ and $Cl_2(g)$.
Cathode: $H_2O\ (l) + e^- \Leftrightarrow \frac{1}{2} H_2\ (g) + OH^-$
Anode: $2Cl^- \Leftrightarrow Cl_2(g) + 2e^-$

$H_2(g)$ was identified by the pop test, $O_2(g)$ was identified as it re-ignited a glowing splint and $Cl_2(g)$ was identified by its distinct smell and the fact that it decolourised (bleached) indicator paper. Phenolphthalein was also added to the solution which turned pink at the cathode for both reactions to indicate the OH^-.

(c) (ii) (1 mark)
Outcomes Assessed: H7, H8, H10, H11, H14
Targeted Performance Bands: 2-3

Criteria	**Mark**
• Identifies both products	1

Sample answer:
Sodium and chlorine

(d) (5 marks)

Outcomes Assessed: H4, H8, H13

Targeted Performance Bands: 2-6

Criteria	Marks
• Assessment of, AND extensive knowledge of environmental impacts of different classes of detergents and of soaps	4-5
• Comparison of the environmental impacts of soaps and detergents	2-3
• Limited knowledge of the environmental impacts of soaps and detergents	1

Sample Answer

Soap is a cleaning agent made from naturally occurring fats and oils. It is biodegradable and therefore has very little environmental impact. Bacteria are able to break down the structure of soaps in sewage works and in natural waterways.

Because the supply of naturally occurring fats and oils became limited (and necessary for food production), soaps were replaced by synthetic detergents for all but personal hygiene.

The first synthetic detergents produced contained branched hydrocarbon chains which took a long time to break down, resulting in a build-up of detergent in natural waterways. This led to foam developing in rivers and dams and thus posed a problem in terms of pollution to the environment. Foams form a stable film over the surface of water. These foams reduce diffusion between the water and air and hence make the waterways less suitable for aquatic aerobic organisms.

The use of linear chain anionic surfactants in detergents reduced the build up of foam and hence the environmental pollution as these had similar biodegradability to soap.

Non-ionic detergents have been developed for situations where foam is a problem. These detergents do not form a stable layer on the surface of water and hence do not form foam as readily as ionic detergents.

Cationic detergents, at low concentration, are biodegradable. However, at high concentrations they are biocidal, which means they can kill the bacteria which normally break down sewage.

Many laundry detergents contain phosphate-based builders which can lead to significant environmental damage. An increase in phosphate levels in waterways can cause algal blooms and eventually lead to eutrophication. Algal blooms result in anaerobic conditions in waterways and the death of plants and animals. If this process is prolonged or repeated, the river can become marshlands because of the build up of decayed matter from the original waterway.

Hence, soaps have little environmental impact but the use of synthetic detergents has negatively impacted on the environment, depending on the class of detergent used and the level of phosphate in them.

(e) (i) (1 mark)

Outcomes Assessed: H6, H14

Targeted Performance Bands: 2-3

Criteria	Mark
• Correct response giving BOTH raw materials	1

Sample Answer

Limestone (calcium carbonate) and brine (sodium chloride).

(e) (ii) (2 marks)

Outcomes Assessed: H6, H13

Targeted Performance Bands: 3-4

Criteria	Marks
• Correct sequence of equations to form both products	2
• ONE correct equation for ONE step	1

Sample answer:

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

$NH_3\ (aq) + H_2CO_3\ (aq) \Leftrightarrow NH_4^+\ (aq) + HCO_3^-\ (aq)$

Combining these steps, and including the spectator ions

$Na^+\ (aq) + Cl^-\ (aq) + CO_2\ (g) + NH_3\ (aq) + H_2O\ (l) \longrightarrow NaHCO_3\ (s) + NH_4Cl\ (aq)$

(e) (iii) (3 marks)

Outcomes Assessed: H3, H4

Targeted Performance Bands: 4-5

Criteria	Marks
• Identifies the waste and explains the relationship between disposal and location of manufacturing	3
• Identifies waste and identifies the method of disposal OR problems associated with the waste	2
• Identifies the waste only OR gives some correct information linking location with disposal of wastes	1

Sample answer:

The chemical waste product of the Solvay process is calcium chloride. Unless it can be used by other industries (as a drying agent or as an alternative to salt to de-ice roads) it must be disposed of, into water.

Disposal, in diluted form, directly into the ocean is the best solution. The wastes are diluted by the sea water and do not increase significantly the concentrations of calcium or chloride ions. Any residues of sodium carbonate left in the waste do not have significant impact on the pH of sea water because sea water is buffered by the presence of hydrogen carbonate ions.

Solvay plants which are remote from the ocean cannot discharge their wastes into rivers or other inland bodies of water as this would unacceptably increase the concentration of ions, the hardness and the pH of the water. This in turn would impact on the aquatic organism in the water.

Hence Solvay plants are best located in close proximity the ocean, where direct discharge is feasible. If this is not possible then alternate methods of burial of the dried calcium chloride in inland regions must be adopted. This is a more costly method of disposal and leaching of the ions from the waste into waterways is a possibility over time.

SHIPWRECKS, CORROSION AND CONSERVATION

Question 31 (25 marks)
(a) (i) (1 mark)
Outcomes Assessed: H4
Targeted Performance Bands: 2-3

Criteria	Mark
• Identifies the source	1

Sample answer:
Hydrothermal vents in mid-ocean ridges.

(ii) (2 marks)
Outcomes Assessed: H4, H6
Targeted Performance Bands: 2-4

Criteria	Marks
• Describes the formation of salt crystals • Relates the crystal formation to potential damage in the artefacts	2
• Identifies the formation of salt crystals	1

Sample answer:
As the saturated solution evaporates salt crystals form. These crystals can destroy the cellular structure of wooden and leather artefacts, causing splitting, dryness and discolouration. The crystals can damage the outer porous layers of metal artefacts, causing layers to flake and split. The presence of these salt crystals (electrolytes) can result in accelerated corrosion in humid or moist conditions.

(iii) (3 marks)
Outcomes Assessed: H4, H8
Targeted Performance Bands: 4-6

Criteria	Marks
• Describes the electrolysis of a metal artefact, identifying the electrolyte, anode and cathode • Discusses the positive and negative aspects of the process	3
• Describes the electrolysis of a metal artefact OR Describes and discusses a physical process (e.g. soaking and leaching)	2
• Identifies electrolysis as a chemical procedure OR Describes a physical procedure	1

Sample Answer
Electrolysis is a chemical procedure that can be used for the removal of salts, especially chloride ions from an artefact. The artefact is the cathode. It is surrounded by an inert stainless steel mesh (anode) which is immersed in a dilute solution of sodium hydroxide. Chloride is removed from the cathode according to the following reduction equation.
$Fe(OH)Cl\,(s) + 2e^- \rightarrow Fe\,(s) + 2OH^-\,(aq) + Cl^-\,(aq)$
The chloride ions are then attracted to the anode.
This process can take months and can be quite expensive, however it is an effective method of removing ions without causing damage to the artefact if it is performed slowly. It also results in the reduction of Fe^{2+} to iron.

(b) (i) (1 mark)

Outcomes Assessed: H3, H12

Targeted Performance Bands: 2-3

Criteria	Mark
• Identifies the main element	1

Sample Answer

Iron

(ii) (3 marks)

Outcomes Assessed: H2, H11

Targeted Performance Bands: 2-4

Criteria	Marks
• Outlines steps of a valid method that includes a suitable electrolyte, controlled variables, a method of measuring corrosion and repetition	3
• Outlines steps that include a suitable electrolyte and a method of observing corrosion	2
• Identifies a suitable electrolyte OR • Identifies a method for measuring corrosion	1

Sample Answer

Place similarly sized samples of both steels in sea water in 2 identical test tubes. Add 1mL of potassium hexacyanoferrate indicator. Place under identical environmental conditions and monitor the corrosion rate by observing the rate of formation of a blue colour (due to the reaction of the indicator with iron ions) at regular intervals. Repeat.

(iii) (2 marks)

Outcomes Assessed: H3, H5

Targeted Performance Bands: 2-4

Criteria	Marks
• Justifies on the basis of a sound knowledge of the relationship between the added elements and the properties of steels	2
• Identifies an element that limits corrosion	1

Sample Answer

Steel X contains a higher percentage of chromium, molybdenum and nickel. These metals increase the corrosion resistance of the steel. In a marine environment corrosion resistance would be a priority.

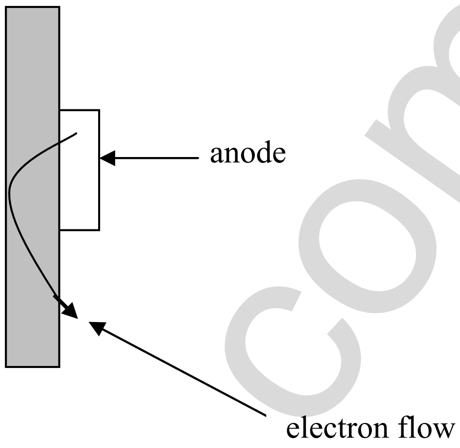
(c) (i) (1 mark)

Outcomes Assessed: H3, H8

Targeted Performance Bands: 3-4

Criteria	Mark
• Labels the correct structure	1

Sample Answer



(ii) (1 mark)

Outcomes Assessed: H3, H8

Targeted Performance Bands: 3-4

Criteria	Mark
• Labels correct electron flow	1

Sample Answer

See above diagram

(iii) (1 mark)

Outcomes Assessed: H8, H13

Targeted Performance Bands: 4-5

Criteria	Mark
• Identifies the correct equation	1

Sample Answer

$$O_2 + 2H_2O + 4e^- \leftrightarrow 4OH^-$$

(d) (6 marks)

Outcomes Assessed: H4, H8, H13

Targeted Performance Bands: 2-6

Criteria	Marks
• Explains the role of bacteria in terms of electron transfer reactions	6
• Describes the action of bacteria on deeply submerged wrecks using electron transfer reactions	4-5
• Describes the action of bacteria on deeply submerged wrecks	2-3
• Identifies the presence of anaerobic bacteria OR sulfate reducing bacteria around wrecks	1

Sample Answer

Cold temperatures and lack of oxygen would suggest that deeply submerged wrecks would corrode slowly. The presence of anaerobic bacteria can, however, accelerate this process. Sulfate reducing bacteria reduce sulfate ions to hydrogensulfide ions according to the following reduction equation:

$SO_4^{2-}(aq) + 5H_2O(l) + 8e^- \rightarrow HS^-(aq) + 9OH^-(aq)$ (Equation 1)

So, despite the absence of oxygen, iron can be oxidised at great depths:

$Fe(s) \rightarrow Fe^{2+}(aq) + 2e^-$ (Equation 2)

Electrons are transferred from the iron to the sulfur. An understanding of this transfer confirms the significant role of the bacteria in the accelerated corrosion of iron.
The formation of rusticles of iron sulfide and iron hydroxide on these submerged wrecks can readily be explained using the above redox equations.
Around wrecks where oxygen is present, due to cold oxygen-rich ocean currents, another type of bacterium is responsible for an unexpected level of corrosion. These bacteria which feed on the organic matter often associated with wrecks, produce hydrogen ions. These hydrogen ions accelerate the reduction of O_2 according to the following equation:

$O_2(g) + 4H^+(aq) + 4e^- \rightarrow 2H_2O(l)$ (Equation 3)

Consequently this accelerates the oxidation of iron as shown in Equation 2 above. The electrons are transferred from the iron to the oxygen, resulting in corrosion of the wreck.

An understanding of electron transfer reactions is essential to the understanding of the unexpected amount of corrosion on deeply submerged wrecks.

(e) (i) (1 mark)

Outcomes Assessed: H12, H14

Targeted Performance Bands 3-4

Criteria	Mark
• Identifies correct relationship	1

Sample Answer

As depth increases solubility increases.

(ii) (3 marks)
Outcomes Assessed: H4, H8, H12
Targeted Performance Bands: 3-5

Criteria	Marks
• Evaluates the relevance of the items • Discusses the relevance of actual oxygen concentration as depth increases	3
• Evaluates the relevance of the items based on a limited understanding of oxygen concentration with depth • Discusses the relevance of inferred oxygen concentration as depth increases	2
• Identifies the relevance of oxygen concentration to the corrosion of metals	1

Sample Answer

The solubility of oxygen versus depth should be relevant to the investigation of corrosion of metals at great depth. Oxygen is usually reduced in the corrosion process so its concentration in lower depths of the ocean is very relevant. However, the relationship inferred from the graph and table is only relevant where a supply of oxygen exists. As the pressure increases with depth in the ocean, the concentration of oxygen does not increase as there is no gaseous oxygen available. Therefore the information in the table and graph are misleading and irrelevant to an investigation designed to predict the rate of corrosion of a metal at great depths.

THE BIOCHEMISTRY OF MOVEMENT

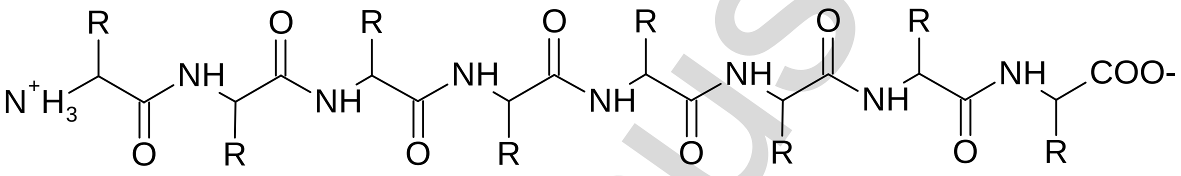
Question 32 (25 marks)
(a) (i) (2 mark)
Outcomes Assessed: H13
Targeted Performance Bands: 3-4

Criteria	Marks
• Description of reaction between amino acids to form peptide bond, including equation or appropriate diagram of peptide bond	2
• Limited knowledge of peptide bond formation	1

Sample Answer
The peptide (amide) bond is formed between two amino acids:

A-COOH + B-NH_2 → A-CO-NH-B + H_2O.

An acid-base reaction occurs between the carboxylic acid group of one amino acid and the amine group of the next. A molecule of water is formed. This reaction happens at each end of the amino acid and a peptide chain is formed. This is the first step in the formation of proteins.



(a) (ii) (2 marks)
Outcomes Assessed: H9, H13
Targeted Performance Bands: 3-5

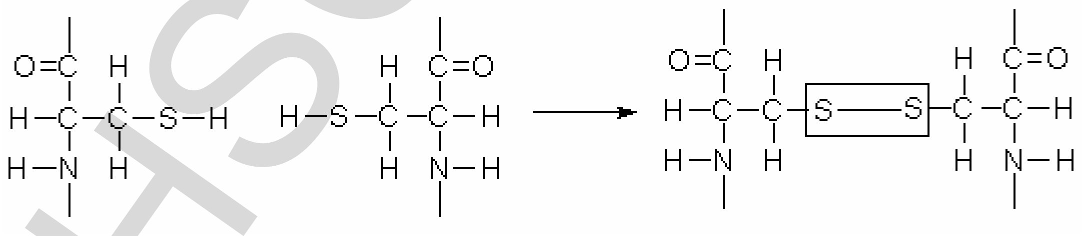
Criteria	Marks
• Identifies amino acid and sketches appropriate diagram of disulfide bond	2
• Identifies amino acid OR sketches appropriate diagram of disulfide bond	1

Sample Answer
Cysteine

Amino acid chain

Another part of same amino acid chain

Disulfide bond S-S linking 2 parts of chain



(a) (iii) (4 marks)

Outcomes Assessed: H6, H9, H13

Targeted Performance Bands: 4-6

Criteria	Marks
• Assessment of the contribution of disulfide bonds • Brief explanation of the role of disulfide bonding in determining shape of protein • Brief description of the THREE other types of forces determining the shape of proteins	4
• Brief explanation of the role of disulfide bonding in determining shape of protein • Brief description of the THREE other types of forces determining shape of proteins	3
• Brief explanation of disulfide bonding • Recognition of the forces determining shape	2
• Limited knowledge of forces determining the shape of proteins	1

Sample Answer

The shape of a protein is due to the structure formed by the chain of amino acids. In many proteins the string of amino acids is wound into a helix. The way this helix folds or coils itself determines the final 3-D shape.

The final 3-D shape is determined by:

- sulfur-sulfur bridges, between TWO cysteine units fairly close together; the –S-H groups of TWO nearby cysteine units are easily oxidized to produce a –S-S- covalent link. The S-S links keep parts of the chain covalently bound to other parts of the chain and hence help to retain the shape of the helix or folded protein.

but also by:

- hydrogen bonding, from the NH group of one peptide link to the O=C group of another peptide link, generally THREE or FOUR amino acid units away.
- ionic attractions (electrostatic forces) between the COO^- and NH_3^+ groups on acidic and basic R groups.
- dispersion forces, between the hydrophobic alkyl groups which tend to be located inside the helix structure, help hold the protein into its 3-D structure.

Assessment. The disulfide bonds do play a role in determining the shape of a protein but are only ONE of the FOUR types of attraction forces which act together to hold the folds or coils together.

(b) (3 marks)

Outcomes Assessed: H6, H9, H13

Targeted Performance Bands: 3-4

Criteria	Marks
• Summary which includes THREE required aspects	3
• Limited summary which includes at least TWO of the THREE required aspects	2
• Some correct information about process	1

Sample Answer

Glycolysis is the conversion of one mole of glucose (the raw material) into 2 moles of pyruvic acid $CH_3 – CO – COOH$ (the end product of glycolysis) by a series of enzyme-catalysed steps. This occurs whether oxygen is present or not.
In the process 2 NAD+ ions are converted to 2 NADH molecules.
Glycolysis also converts 2 moles of ADP to ATP per mole of glucose used. Hence energy is captured and stored in the ATP molecule.

(c) (i) (1 mark)

Outcomes Assessed: H8, H9

Targeted Performance Bands: 2-3

Criteria	Mark
• Correct answer	1

Sample Answer

Muscle cell contractions are caused by Ca^{2+} ions being released when nerve cells stimulate the membranes of skeletal muscle cells.

(c) (ii) (1 mark)

Outcomes Assessed: H8, H9

Targeted Performance Bands: 2-3

Criteria	Mark
• Correct answer	1

Sample Answer

ATP provides the mechanical energy that causes the movement of the filaments in muscles past each other as the contraction occurs.

(d) (8 marks)
Outcomes Assessed: H7, H8, H9
Targeted Performance Bands: 3-6

Criteria	Marks
• Outlines the storage and use of carbohydrates • Outlines the storage and use of TAGs • Compares or contrasts the roles of each • Assesses the importance of each	7-8
• Outlines the storage and use of carbohydrates • Outlines the storage and use of TAGs • Assesses the importance of each	5-6
• Outlines the storage and use of carbohydrates • Outlines the storage and use of TAGs	3-4
• Displays a limited knowledge of the TWO energy sources and makes some correct comparisons of the TWO	2
• Displays a limited knowledge of the TWO energy sources	1

Sample Answer

In animals, carbohydrates are stored as glycogen. Its energy is used in two main ways. The rising blood glucose levels after a meal are controlled through the liver converting excess glucose into glycogen and storing it as granules within the cells that performed the conversion. Between meals, this glycogen is periodically turned back into glucose and released into the blood, to keep blood glucose levels fairly constant. Glycogen granules are also stored in skeletal muscle cells and used by type 2 muscle cells to supply much of the energy for anaerobic respiration during intense use.

TAGs are the major energy storage units in human beings. They are stored in the cells of fat tissue and can be hydrolysed to give fatty acids, which can be transported to cells and broken down into carbon dioxide and water. This process occurs in mitochondria and produces ATP. Per gram, TAGs can provide more than twice the energy of carbohydrates, mainly because of the C atoms in fats exist in a lower oxidation state, and fats are non-polar.

TAGs are used in competition with glucose in aerobic respiration. They produce ATP in greater amounts than carbohydrates but at a slower rate, limited by the rate at which the body's respiratory and circulatory systems can supply oxygen to the mitochondria. Resting muscle gets its energy from glucose and TAGs. During exercise, muscle can obtain its energy aerobically as long as the oxygen supply keeps up. If it doesn't keep up, anaerobic respiration begins to take over, using the carbohydrate granules to provide fast ATP without the consumption of oxygen. Aerobic respiration continues but with less efficiency, producing less ATP and also producing lactic acid.

In summary, carbohydrates are the small store of instant, intense energy; the emergency supply. They can be metabolised quickly without oxygen to produce instant reserves of ATP, but not for long. The liver's entire store of glycogen, for example, can last an average human about 12 hours on its own. TAGs are the body's long term larder. They are the most efficient way to store large amounts of energy, and produce the most ATP when metabolised, although at a much slower rate than glycogen. There is massive variation among fat contents of human bodies but an average healthy human should have enough TAG reserves to last about two months.

(e) (2 marks)
Outcomes Assessed: H6, H9, H11
Targeted Performance Bands: 2-3

Criteria	Marks
• Named enzyme AND TWO factors	2
• Named enzyme OR TWO factors	1

Sample Answer
Many possible responses.
Factors tested: pH and temperature

(f) (2 marks)
Outcomes Assessed: H9, H13
Targeted Performance Bands: 3-4

Criteria	Marks
• Explains when anaerobic respiration occurs AND outlines a problem	2
• Explains when anaerobic respiration occurs OR outlines a problem	1

Sample Answer
Anaerobic respiration occurs when oxygen is absent or the oxygen is being used up too fast in, for example, muscles being used in sprinting, to be replenished fast enough by intake of oxygen during breathing.
A problem associated with anaerobic respiration is the formation of lactic acid in the muscle that prevents the normal contraction of the muscle, causing symptoms of pain and cramp.

THE CHEMISTRY OF ART

Question 33 (25 marks)
(a)(1 mark)
Outcomes Assessed: H6
Targeted Performance Bands: 2-3

Criteria	Mark
• Correct response	1

Sample Answer
Nitrogen

(b) (1 mark)
Outcomes Assessed: H7
Targeted Performance Bands: 3-5

Criteria	Mark
• Correct explanation in terms of energy levels	1

Sample Answer
Removing the first three electrons from boron removes the three that occupy the n=2 energy level therefore requires relatively less energy because of the distance of these energy levels from the nucleus. However, the fourth electron to be removed occupies the n=1 energy level which is closer to the positive nucleus and so this requires much more energy.

(c) (i) (1 mark)
Outcomes Assessed: H6, H7
Targeted Performance Bands: 2-3

Criteria	Mark
• Correctly identifies the flame colours	1

Sample Answer
In a flame test potassium ions give a violet colour and strontium ions give a red colour.

(c) (ii) (2 marks)
Outcomes Assessed: H6, H7, H8
Targeted Performance Bands: 3-5

Criteria	Marks
• A clear description of a distinguishing method including example(s)	2
• A basic description which omits a specific example	1

Sample Answer
A range of responses is possible.
You could show that the metal ions are responsible for the flame colour by using BOTH potassium chloride and strontium chloride OR potassium nitrate and strontium nitrate for testing. In each case where potassium is the cation the flame colour will be violet and in each case where strontium is involved flame colour will be red, showing that the metal ion, not the anion is responsible.

(d) (i) (1 mark)

Outcomes Assessed: H7, H8

Targeted Performance Bands: 3-4

Criteria	Mark
• Both ion and oxidation state correct	1

Sample Answer

The metal ion is Ni^{2+} and its oxidation state is +2.

(d) (ii) (1 mark)

Outcomes Assessed: H6

Targeted Performance Bands: 2-4

Criteria	Mark
• Correct identification of water as the ligand and the bonding through the non-bonding/lone pair of electrons on the oxygen	1

Sample Answer

Each water molecule (the ligand) is bonded to the metal ion through one of the non-bonding/loan pairs of electrons on the oxygen atom.

(d) (iii) (5 marks)

Outcomes Assessed: H2, H6, H7

Targeted Performance Bands: 2-5

Criteria	Marks
• Identification of transition metals. Thorough explanation of electronic configurations of transition metals, including a specific example. Thorough explanation of why compounds are coloured	4-5
• Identification of transition metals. Limited explanation of electronic configurations of transition metals. Limited explanation of why compounds are coloured	2-3
• Identification of transition metals or some correct information about electronic configuration of a specific transition metal ion or some correct information about why compounds are coloured	1

Sample Answer

The transition metals tend to form coloured compounds. It is the partially filled d sub-shells which determine the difference in properties (including colour) of the majority of transition elements when compared with the properties of the main block elements.

Transition elements of the First Transition Series have Atomic Nos. from 21 to 30. Nickel is element 28, and has an electronic configuration of $1s^2$, $2s^2$, $2p^6$, $3s^2$, $3p^6$, $3d^8$, $4s^2$.

The Ni^{2+} ion has no electrons in the 4s sub-shell and the 3d sub-shell is not completely filled.

Transition metal compounds contain ions of those metals, like the hydrated nickel II ion.

Those ions have partially filled 3d energy levels and hence are coloured.

The colour is due to the fact that the different orbitals within the 3d sub-shell are very close in energy and electrons can be excited and jump from the between these levels when visible light falls on the compound. The electrons from a 3d level absorb the energy from visible light, move into a higher energy level. Materials are coloured when part but not all of the visible light passing through the material is absorbed.

(e) (2 marks)

Outcomes Assessed: H3, H4

Targeted Performance Bands: 3-5

Criteria	Marks
• Thorough explanation with example	2
• A sound explanation but without reference to a particular pigment	1

Sample Answer

Metal sulfides and oxide pigments (such as iron oxide) used for paintings, self decoration or burial were insoluble because this gave the advantage of not being easily removed when exposed to rain or ground water. While in hot climates, cosmetics made from insoluble minerals would not dissolve in perspiration. Also the liquid medium that allows the paint to be spread over a surface will dry over time but the insoluble pigment, and therefore the colour, will remain.

(f) (4 marks)

Outcomes Assessed: H1, H2, H7

Targeted Performance Bands: 3-6

Criteria	Marks
• Discussion of merits and limitations, which illustrate thorough understanding of the Bohr model	4
• Discussion of merits and limitations, which illustrate sound understanding of the Bohr model	3
• Outline of some merits and limitations of the model	2
• Outline of some merits OR limitations of the model	1

Sample Answer

The Bohr model of the atom (1913) proposed that the electrons in an atom move around the nucleus in a circular orbit.

Each electron could only have a restricted number of energy values as only orbits of certain radii and particular energy values were permissible. Bohr proposed that an electron was stable only when in one of these energy levels. Electrons could jump from one level to another and Bohr proposed that the electrons falling back into their stable orbits gave out energy equal to the difference in energy between the 2 levels. This energy caused the observed spectral lines. For hydrogen, he calculated the energy values for the electrons in the permissible paths and showed that the frequency of the spectral lines for hydrogen could be explained in terms of his model.

Thus his model was successful in explaining a property of the hydrogen atom. The model thus had merit in that it led to an explanation of spectral lines for hydrogen. It also had merit, it that it offered a simplistic way of visualizing atoms and the properties of electrons around a nucleus. The concept of quantized energy levels, introduced by Bohr, remained an important part of later models.

However, it was limited in that it failed to account for the spectral lines of atoms which had more than 1 electron, and was replaced by a new model called quantum mechanics. As with many models, the limitation can be beneficial to advancement of scientific knowledge, as scientists work to modify or throw out a model if it cannot provide answers for more than a minimal number of examples.

(g) (i) (1 mark)

Outcomes Assessed: H6, H8, H13

Targeted Performance Bands: 2-3

Criteria	Mark
• Correct answer	1

Sample Answer

+7

(g) (i1) (3 marks)

Outcomes Assessed: H6, H8, H11, H13

Targeted Performance Bands: 2-3

Criteria	Marks
• Suitable procedure to show that potassium permanganate is a STRONG oxidising agent • Clear description of procedure • Correct description of observations	3
• TWO of above only	2
• ONE of above only	1

Sample Answer

Many possible responses.

A strong oxidising agent is easily reduced if reacted with even a weak reducing agent (iodide ion).

One **method** of demonstrating this experimentally is as follows.

- Make up a solution of acidified potassium permanganate by mixing approximately 5mL of 0.02M $KMnO_4$ with 5mL of 2.0M H_2SO_4*(aq).*
- Add 1 to 2 mL of this solution to a 0.5M solution of potassium iodide in a test tube.
- Shake the contents well.

Observations. Potassium permanganate solution, $KMnO_4$*(aq)*, is a deep purple colour. When this ion is reduced its colour changes quickly, from purple to brown**.**

(g) (iii) (3 marks)

Outcomes Assessed: H13

Targeted Performance Bands: 3-5

Criteria	Marks
• TWO suitable half equations, balanced overall equation	3
• TWO half equations correctly chosen and written	2
• ONE half equation correctly chosen and written	1

Sample Answer

Half equations

$MnO_4^- + 8H^+ + 5e^- \rightleftharpoons Mn^{2+} + 4H_2O$

$I^- + e^- \rightleftharpoons \frac{1}{2} I_2\,(aq)$

Overall equation

$$MnO_4^- + 8H^+ + 5\,I^- \rightarrow \frac{5}{2}\,I_2\,(aq) + Mn^{2+} + 4H_2O$$

FORENSIC CHEMISTRY

Question 34 (25 marks)
(a) (i) (1 mark)
Outcomes Assessed: H2
Targeted Performance Bands: 2-3

Criteria	Mark
• Correctly identifies site of origin	1

Sample Answer
Site A

(a) (ii)
Outcomes Assessed: H3, H6
Targeted Performance Bands: 4-5

Criteria	Marks
• Correctly identifies of all relevant conditions	2
• Correctly identifies at least TWO relevant conditions	1

Sample Answer
The element must first be ionised (acid) then vapourised (gaseous sample). This sample absorbs energy which excites electrons. As the electrons return to their ground state, energy in the form of light is emitted.

(b) (i) (2 marks)
Outcomes Assessed: H9
Targeted Performance Bands: 2-3

Criteria	Marks
• Outlines an appropriate procedure and describes result	2
• Outlines a correct procedure OR a correct result	1

Sample Answer
Try to burn the sample is air using a Bunsen flame. Organic samples will burn while inorganic samples will not burn but some may char. Carbon dioxide will be formed from organic substances and can be tested with limewater.

(b) (ii) (2 marks)

Outcomes Assessed: H9

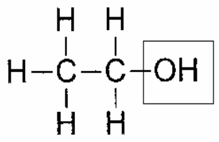
Targeted Performance Bands: 2-4

Criteria	Marks
• Correctly identifies TWO classes, draws TWO correct structural formulae and correctly identifies the functional groups	2
• Correctly identifies ONE class, draws ONE correct structural formula and correctly identifies ONE functional group.	1

Sample Answer

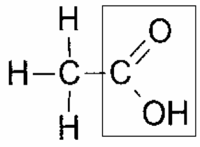
TWO classes of organic compounds are alkanols and alkanoic acids. The functional groups are shown in the rectangles.

Alkanol



e.g. ethanol

Alkanoic acid



e.g. ethanoic acid

(c) (i) (1 mark)

Outcomes Assessed: H4

Targeted Performance Bands: 2-4

Criteria	Mark
• Correctly identifies a situation and example	1

Sample Answer

Destructive testing is a problem where the sample is small and has economic, historical or cultural significance. e.g. artwork, artefacts, valuable jewellery.

(c) (ii) (1 mark)

Outcomes Assessed: H4

Targeted Performance Bands: 2-4

Criteria	Mark
• Correctly identifies a non-destructive method	1

Sample Answer

Examples include mass spectroscopy, electron spectroscopy, atomic force microscopy, scanning tunnelling microscopy.

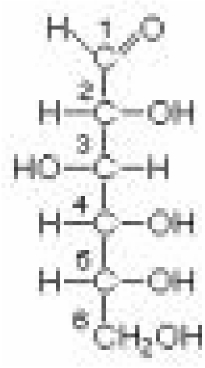
(d) (i) (2 marks)

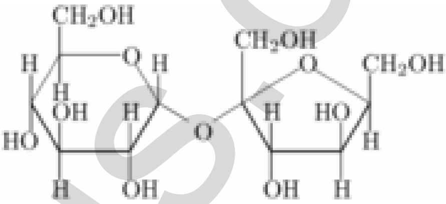
Outcomes Assessed: H9

Targeted Performance Bands: 4-6

Criteria	Marks
• Clear and correct explanation of the oxidation of the carbonyl group to carboxylic acid in a reducing sugar • Correct and complete diagrams to show the difference between reducing and non-reducing sugars	2
• Correct explanation of the oxidation of the carbonyl group to carboxylic acid in a reducing sugar OR • Appropriate diagrams	1

Sample Answer





In a reducing sugar (left, above), the carbonyl group (-C=0) is available to be oxidised to a carboxylic acid, thus ‘reducing’ the reagent. In a non-reducing sugar (right, above) the group is not available.

(d) (ii) (3 marks)

Outcomes Assessed: H13

Targeted Performance Bands: 3-6

Criteria	Marks
• Appropriate reagent identified • Appropriate procedure for named reagent provided including examples of reducing and non-reducing sugars • Appropriate results for distinguishing between reducing or non-reducing sugar included	3
• Appropriate reagent identified • Appropriate procedure for named reagent provided OR • Appropriate results for distinguishing between reducing or non-reducing sugar included	2
• Appropriate reagent identified OR • Appropriate results for distinguishing between reducing or non-reducing sugar included	1

Sample Answer
Benedict’s solution can be used to distinguish between a reducing sugar, such as glucose, and a non-reducing sugar, such as sucrose. Place 2ml (a small amount) of glucose solution and sucrose solution into TWO different test tubes. Add a few drops of Benedict’s solution and warm gently for a few minutes. The glucose solution will go a red-brown colour, the sucrose solution will not change colour.

(Fehling’s solution uses a similar method and gives a similar result; Tollen’s solution is a similar method but gives ‘silver mirror’ coating to the test tube when a reducing sugar is present.)

(e) (i) (2 marks)
Outcomes Assessed: H8, H9
Targeted Performance Bands: 3-4

Criteria	Marks
• Names TWO main groups and gives examples for BOTH groups • Clearly explains function of BOTH groups of proteins	2
• Names TWO groups OR • Explains functions of ONE or TWO groups OR • Names and explains function of ONE group	1

Sample Answer
The TWO groups are:

- fibrous proteins are long tough molecules that provide *structure* for body components, such as hair, skin tendon and cartilage and
- globular proteins are compact and roughly spherical in shape, they are involved in the *functioning* of the organism, such as transporting oxygen (haemoglobin), fighting disease (antibodies), metabolism of nutrients (insulin)

(e) (ii) (4 marks)

Outcomes Assessed: H1, H2, H3

Targeted Performance Bands: 2-6

Criteria	Marks
• Identifies substances separated by electrophoresis • Identifies substances separated by chromatography • Identifies similarities between chromatography and electrophoresis AND • Identifies differences between chromatography and electrophoresis	4
• Identifies substances separated by electrophoresis • Identifies substances separated by chromatography • Identifies similarities between chromatography and electrophoresis OR • Identifies differences between chromatography and electrophoresis	3
• Identifies substances separated by electrophoresis OR • Identifies substances separated by chromatography AND • Identifies similarities between chromatography and electrophoresis OR • Identifies differences between chromatography and electrophoresis	2
• Identifies substances separated by electrophoresis OR • Identifies substances separated by chromatography	1

Sample Answer

Chromatography is used to separate substances based upon their distribution between a mobile phase and a stationary phase (solubility in polar and non-polar substances). There are different types of chromatography eg paper, gas, liquid. Substances such as amino acids and dyes can be separated by chromatography.

Electrophoresis is used to separate substances based on their electrostatic charge and different mobilities. Electrophoresis can be used to separate amino acids and DNA.

Similarities:

- both allow identification of amino acids, leading to identification of protein and its source

Differences:

- Electrophoresis separates fragments on the basis of their charge and size. Chromatography separates fragments on the basis of their different solubilities in polar and non-polar substances
- In electrophoresis, conditions can be easily changed to achieve separation of mixture eg pH. Conditions in chromatography are less easy to vary to improve the result
- Electrophoresis requires more expensive equipment

(f) (5 marks)

Outcomes Assessed: H1, H3, H4

Targeted Performance Bands: 2-6

Criteria	Marks
• Relates the unique nature of individual DNA to the use of DNA analysis in civil and criminal proceedings • Discusses the role of DNA analysis in forensic chemistry by comparing it to another method and referring to points for and against the use of the technique • Identifies possible uses of information that may be obtained by DNA analysis and identifies associated ethical issues	4-5
• Identifies the unique nature of individual DNA and describes at least one use of DNA analysis in civil and criminal proceedings • Identifies possible uses of information obtained by DNA analysis that have associated ethical issues	3
• Identifies the unique nature of individual DNA OR • Identifies a use of DNA analysis in forensic chemistry AND • Identifies possible uses of information obtained by DNA analysis that have associated ethical issues	2
• Identifies the unique nature of individual DNA OR • Identifies a use of DNA analysis in forensic chemistry OR • Identifies possible uses of information obtained by DNA analysis that have associated ethical issues	1

Sample Answer

The DNA that is found in the cells of living and once-living organisms carries the code that allows the organism to live and reproduce. The sections of the DNA that do not code for essential proteins (non-coding regions) are unique for individuals (except identical twins). The regions of non-coding DNA can be separated and mapped by a process called DNA fingerprinting which allows for identification of individuals by comparing samples to determine whether the samples are from the same person, related people or unrelated individuals. Thus DNA analysis can be used to convict people of crime, clear a suspect of a crime or identify relatives, such as in disputed paternity cases or contesting of a will. Previously, fingerprinting and blood typing were used in identification, for which evidence was not always conclusive. DNA is highly accurate and has allowed many people to be convicted of crimes, such as in the case of Stephen James Boney in Wee Waa in 2000. It has also been used to prove the innocence of convicted felons after a number of years. However, DNA analysis is very costly and criminals are now more aware of the risks associated with leaving biological evidence at the scene of a crime. With the increased use of DNA analysis, civil libertarians are concerned that data banks of genetic information may be established. They could create a society in which routine screening was performed. Information about genetic disorders or predisposition to particular diseases would then possibly be available to prospective employers or insurance agencies, creating an ethical issue.