CATHOLIC SECONDARY SCHOOLS ASSOCIATION

2004 TRIAL HIGHER SCHOOL CERTIFICATE EXAMINATION

CHEMISTRY – MARKING GUIDELINES

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

Question	Correct Response	Outcomes Assessed	Targeted Performance Bands
1	B	H9	2 – 3
2	A	H9, H14	4 – 5
3	D	H7	3 – 4
4	C	H9, H10, H14	4 – 5
5	A	H7, H9	5 – 6
6	D	H4	3 – 4
7	B	H6	2 – 3
8	C	H10, H12, H14	4 – 5
9	B	H1, H12	4 – 5
10	A	H14	5 – 6
11	B	H4, H9	2 – 3
12	A	H4, H6	3 – 4
13	D	H3, H4	3 – 4
14	C	H3, H6	2 – 3
15	D	H8, H12	4 – 5

Section I
75 marks

Part B – 60 marks
Question 16
(a) (1 mark)
Outcomes Assessed: H8, H9
Targeted Performance Bands: 2-3

Criteria	Mark
• Identifies the substance	1

Sample answer
Water

(b) (2 marks)
Outcomes Assessed: H6, H14
Targeted Performance Bands: 3-4

Criteria	Marks
• Describes ethanol's ability to hydrogen bond with water and its ability to interact with non-polar pentane	2
• Describes ethanol's ability to hydrogen bond with water OR • Describes ethanol's ability to interact with non-polar pentane OR • Gives general description concerning 'like dissolves like'	1

Sample answer
Ethanol can hydrogen bond with water as both contain –OH groups; the non-polar end of the ethanol is able to interact via dispersion forces with non-polar pentane. Thus, ethanol dissolves in both polar water and non-polar pentane.

Question 17
(a) (1 mark)
Outcomes Assessed: H6
Targeted Performance Bands: 3-4

Criteria	Mark
• Correctly identifies the particle	1

Sample answer
An electron OR ${}^{0}_{-1}e$

(b) (2 marks)
Outcomes Assessed: H4, H13
Targeted Performance Bands: 3-5

Criteria	Marks
• Describes a process for detecting beta radiation using its effects	2
• Identifies equipment used to detect the radiation	1

Sample answer
In a Geiger tube the radiation passes through a tube consisting of a cathode and an anode and filled with gas, ionising the gas as it does so. The gas ions are detected as they hit the electrodes.

Question 18 (4 marks)
Outcomes Assessed: H4, H5, H13
Targeted Performance Bands: 2-5

Criteria	Marks
• Identifies a biopolymer AND • Gives an impact on society OR the environment AND • Makes an assessment of the impact of the use of the biopolymer AND • Displays a thorough knowledge	4
• Identifies a biopolymer AND • Provides a statement of impact on the environment OR society AND • Gives an assessment	3
• Identifies a biopolymer AND • Provides general statement of impact on the environment OR society	2
• Identifies a biopolymer	1

Sample answer
'Biopol' is a high molecular weight linear biopolymer which can be melt spun into fibres. Biocompatibility and biodegradability makes these polyhydroxybutyrate (PHB) fibres ideally suited for surgical use; sutures made from PHB are slowly degraded by the body's enzymes. Biopol is also used in conventional plastics applications such as shampoo bottles. The price of the biopolymer is still considered too high for many fibre applications but ultimately Biopol might be produced by plants. The producers are experimenting with a genetically engineered variety of canola which can synthesise Biopol. In time, as the cost of production decreases, the use of Biopol may dramatically increase. It does pollute the environment, or a body, as it decays. It can be engineered for body-compatible uses because as a fibre it is less susceptible to insect damage.

Question 19 (3 marks)
Outcomes Assessed: H2
Targeted Performance Bands: 3-5

Criteria	Marks
• Identifies at least TWO standard conditions and explains their necessity	3
• Identifies at least ONE standard condition and explains its necessity	2
• Identifies at least ONE standard condition OR • Explains necessity for standard conditions	1

Sample answer
The standard conditions are: all solutions have a concentration of 1 mol/L; any gases have a pressure of 1 atm; the temperature is 25°C (298K); the comparison half-cell is a hydrogen half-cell. It is necessary to choose a standard set of conditions for an electrochemical reaction so that comparisons can be made and cell differences determined.

Question 20
(a) (1 mark)
Outcomes Assessed: H10
Targeted Performance Bands: 3-4

Criteria	Mark
• Equation is complete and correctly balanced (states not required)	1

Sample answer
$2\ C_2H_5OH + 6\ O_2 \rightarrow 4\ CO_2 + 6\ H_2O$

(b) (6 marks)
Outcomes Assessed: H2, H7, H11, H14
Targeted Performance Bands: 2-6

Criteria	Marks
• Outlines, thoroughly, a procedure for determining the heat of combustion of an alkanol AND • Justifies the procedure used	5-6
• Outlines a procedure for determining the heat of combustion of an alkanol AND attempts to justify the procedure used OR • Outlines, thoroughly, a procedure for determining the heat of combustion of an alkanol	3-4
• Outlines a procedure for determining the heat of combustion of an alkanol	1-2

Sample answer
20 – 30 mL of ethanol is placed in a spirit burner and weighed with its lid on. 50 mL of water is then placed in a conical flask and clamped just above the height of the flame from the spirit burner. The temperature of the water is recorded and the spirit burner is lit. The water is stirred and the temperature is checked. After the water has increased by about 10°C, the lid is placed on the spirit burner to smother the flame. The spirit burner is re-weighed. The water is stirred and the water is checked until it does not rise any further. The final temperature is then recorded. The Law of Conservation of Energy and the data collected in the experiment is used to determine the Heat of Combustion of the Ethanol. Since this is a quantitative experiment, all measurements must be accurate therefore an electronic balance is used – measures to 0.01 g. One of the major sources of error in this experiment is the loss of heat to the surroundings – this is minimized by clamping the flask just above the flame height and using a flask that has a relatively small opening.

3 marks for method
3 marks for justification

Question 21
(a) (2 marks)
Outcomes Assessed: H9
Targeted Performance Bands: 3-4

Criteria	Marks
• ALL chemicals correct	2
• At least ONE chemical correct	1

Sample answer
Ethanol, butanoic acid, concentrated sulfuric acid

(b) (2 marks)
Outcomes Assessed: H3
Targeted Performance Bands: 2-4

Criteria	Marks
• Identifies an ester AND • Outlines a use of this ester	2
• Identifies an ester OR • Outlines a use esters	1

Sample answer
Ethyl ethanoate is used as the solvent in nail polish remover.

Question 22
(a) (1 mark)
Outcomes Assessed: H13
Targeted Performance Bands: 4-5

Criteria	Mark
• Correct equation including states and equilibrium arrows	1

Sample answer

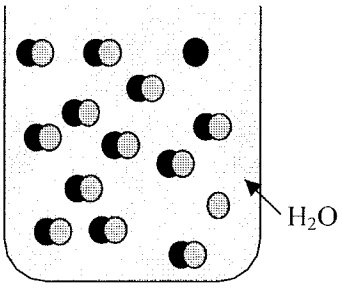
$CH_3COOH(aq) + H_2O(l) \rightleftharpoons CH_3COO^-(aq) + H_3O^+(aq)$ OR

$CH_3COOH(aq) \rightleftharpoons CH_3COO^-(aq) + H^+(aq)$

(b) (2 marks)
Outcomes Assessed: H13
Targeted Performance Bands: 4-5

Criteria	Marks
• Diagram including both intact molecules and ions in solution	2
• Diagram showing ions in solution	1

Sample answer



● H_3O^+ or H^+ (hydronium)

○ CH_3COO^- (acetate)

◐ CH_3COOH (acetic acid)

Question 23 (3 marks)
Outcomes Assessed: H10, H12, H14
Targeted Performance Bands: 3-5

Criteria	Marks
• Correct value and units, showing working. (3 sig figs)	3
• Correct value with units but no working OR • Correct value with working but missing/incorrect units OR • Correctly calculates TWO steps	2
• Correct answer, no units, no working OR • Calculates ONE step correctly	1

Sample answer

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

mass of S = 0.01% x 1.00×10^{10} g = 1×10^6 g

moles of S = 1×10^6 g/32.07

= 3.12×10^4 mol

moles of SO_2 = moles of S

volume = moles of SO_2 x 24.79 = 7.73×10^5 L

answer sheet out by factor of 10.

Question 24 (4 marks)
Outcomes Assessed: H12, H14
Targeted Performance Bands: 3-5

Criteria	Marks
• Correct answer with working	4
• Working correct but with error in ONE step	3
• Working correct but with error in TWO steps OR • Correct answer, no working	2
• ONE step correct	1

Sample answer

For H_2SO_4:

volume = 30 mL = 0.030 L

n= c x v = 0.100 x 0.03 = 3×10^{-3} mol

$H_2SO_4 + 2\ NaOH \rightarrow H_2SO_4 + 2\ H_2O$

For NaOH:

volume = 0.0200 L

n = 6×10^{-3} mol

c = n/v = 6×10^{-3} mol/ 0.02 = 0.300 $molL^{-1}$

Question 25 (6 marks)
Outcomes Assessed: H1, H2, H13
Targeted Performance Bands: 2-6

Criteria	Marks
• Demonstrates a thorough knowledge of different acid base theories, using equations and formula where appropriate	5-6
• Demonstrates a sound knowledge of THREE acid base AND • Relates H_2SO_4 to these theories	3-4
• Demonstrates a limited knowledge of at least TWO acid base theories	1-2

Sample answer
Lavoisier claimed that all acids contain oxygen. Sulfuric acid (H_2SO_4) contains oxygen.
Davy stated that active metals would displace hydrogen gas from acids. Magnesium will displace hydrogen from sulfuric acid.

$$H_2SO_4(aq) + Mg(s) \rightarrow MgSO_4(aq) + H_2(g)$$

Arrhenius stated that acids will produce hydrogen ions in solution and could neutralise bases

$$H_2SO_4(aq) \rightarrow 2\ H^+(aq) + SO_4^{2-}(aq)$$

$$2\ NaOH(aq) + H_2SO_4(aq) \rightarrow 2\ H_2O(l) + Na_2SO_4(aq)$$

Brönsted-Lowry stated that acids are capable of donating a proton to a solvent, e.g. water.

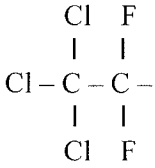
$$H_2SO_4(aq) + H_2O(l) \rightarrow H_3O^+(aq) + HSO_4^-(aq)$$

some (1-2) using equations 1
using multiple equations 1

Question 26
(a) (1 mark)
Outcomes Assessed: H9, H13
Targeted Performance Bands: 2-3

Criteria	Mark
• Correctly names AND draws a CFC	1

Sample answer



1, 1, 1-trichloro 2, 2, 2-trifluoroethane

(b) (2 marks)
Outcomes Assessed: H4
Targeted Performance Bands: 2-4

Criteria	Marks
• Correctly identifies a suitable alternative to a CFC AND • Accounts for its use	2
• Correctly identifies a suitable alternative to a CFC OR • States why CFC's are being replaced	1

Sample answer
Hydrofluorocarbons, like 1,1,1,2–tetrafluoroethane are now replacing CFC's in refrigeration and air conditioning units as they contain no Cl atoms which cause destruction of the ozone layer.

(c) (3 marks)
Outcomes Assessed: H5, H13
Targeted Performance Bands: 3-5

Criteria	Marks
• Describes how information about changing atmospheric ozone concentrations are obtained	3
• Identifies that changing atmospheric ozone concentrations are obtained spectroscopically	2
• Identifies that changing atmospheric ozone concentrations are obtained from satellites	1

Sample answer
Ozone levels are measured by satellites spectroscopically. The Total Ozone Measuring Spectrometer (TOMS) measure the total amount of ozone between the Earth's surface and the top of the atmosphere. The CSIRO also takes measurements of components of the atmosphere at one of its research bases in Tasmania.

Question 27
(a) (1 mark)
Outcomes Assessed: H3
Targeted Performance Bands: 2-3

Criteria	Mark
• Correctly identifies an industrial use of ammonia	1

Sample answer
Production of fertilisers

(b) (1 mark)
Outcomes Assessed: H7
Targeted Performance Bands: 3-4

Criteria	Mark
• Identifies the production of ammonia as exothermic	1

Sample answer
Exothermic

(c) (3 marks)
Outcomes Assessed: H3, H8
Targeted Performance Bands: 3-5

Criteria	Marks
• Identifies a catalyst for the Haber process AND • Explains why it is used	3
• Identifies a catalyst for the Haber process AND • Explains why it is used OR • Identifies a catalyst for the Haber process AND describes the function of a catalyst	2
• Identifies a catalyst for the Haber process OR • Describes the function of a catalyst	1

Sample answer
Catalyst is Fe_3O_4 with small quantities of K_2O and Al_2O_3. The catalyst lowers the activation energy, hence more molecules have sufficient energy for successful collisions and hence there is a greater likelihood of the reaction proceeding.

(d) (3 marks)
Outcomes Assessed: H1, H3, H4, H13
Targeted Performance Bands: 3-5

Criteria	Marks
• Relates the production of ammonia to the production of fertilisers AND explosives during World War I AND • Relates the significance of the production of fertilisers AND ammonia to the historical events occurring at that time	3
• Relates the production of ammonia to the production of fertilisers OR explosives during World War I AND • Identifies the significance of the production of fertilisers OR ammonia to the historical events occurring at that time	2
• Relates the production of ammonia to the production of fertilisers OR explosives during World War I	1

Sample answer
Germany's supply of nitrates came from Chile. This was blocked with the outbreak of World War I. Therefore, Haber's process was a means of producing ammonia which was a raw material in fertilisers and also used in the manufacture of explosives. This was important in prolonging the German war effort.

Question 28 (6 marks)
Outcomes Assessed: H3, H4, H6, H13, H14
Targeted Performance Bands: 2-6

Criteria	Marks
• Demonstrates an extensive knowledge of the use of AAS AND • Assesses its impact on society AND the environment	4-5
• Demonstrates a thorough knowledge of the use of AAS AND • Assesses its impact on society OR the environment	3
• Demonstrates a basic knowledge of the use of AAS AND • Describes its impact on society OR the environment	2
• Identifies a use of AAS	1

Sample answer
AAS can be used due to its sensitivity to detect trace elements in soils and plants. This can provide crucial evidence when dealing with soil or pasture deficiencies. AAS can identify the particular trace element that needs to be added, thus leading to improved animal health and more efficient agriculture which is of tremendous importance to society as it provides food sources where previously no pasture or crop would grow.

For example: cobalt deficiencies in pasture can cause animals to decline in condition and the pasture cannot be efficiently used. Molybdenum and zinc deficiencies can result in certain crops failing.

The use of AAS in pollution control can also lead to improved environmental monitoring which has obvious positive benefits for society and the environment. AAS can detect very small concentrations of metals, particularly heavy metals like Pb, Hg and Cd, in the environment before those concentrations are high enough to cause significant damage to the environment. It is quick, easy and accurate which means it can be used routinely to monitor/detect harmful metals in food, water and effluent.

Question 29 – Industrial Chemistry (25 marks)

(a) (i) (1 mark)
Outcomes Assessed: H7
Targeted Performance Bands: 2-3

Criteria	Mark
• Correct definition for electrolysis	1

Sample answer
Electrolysis is the chemical separation of compounds using electricity. Electrical energy is converted into chemical potential energy.

(a) (ii) (3 marks)
Outcomes Assessed: H3, H13
Targeted Performance Bands: 2-4

Criteria	Marks
• Explains how the technology has led to improvements	3
• Relates a technology to an improvement	2
• Identifies a technology or an improvement	1

Sample answer
The development of membrane technology that has allowed the production to be safer as mercury is no longer used and has also improved the purity of the NaOH produced because the diffusion of NaCl has been reduced.

(b) (i) (1 mark)
Outcomes Assessed: H12
Targeted Performance Bands: 2-3

Criteria	Mark
• Correctly balanced equation for the equilibrium reaction in the catalytic converter	1

Sample answer
$2\ SO_2(g) + O_2(g) \rightleftharpoons 2\ SO_3(g)$

(b) (ii) (2 marks)
Outcomes Assessed: H10, H12, H14
Targeted Performance Bands: 2-4

Criteria	Marks
• Correct response consistent with equation in (b)(i)	2
• Substitutes correctly into incorrect expression OR • Expression consistent with equation in (b)(i)	1

Sample answer

$$K = \frac{[SO_3]^2}{[SO_2]^2[O_2]} = \frac{4^2}{2^2 \times 1} = \frac{16}{4} = 4$$

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

Criteria	Marks
• Explains at least TWO safety precautions	3
• Explains ONE safety precaution	2
• Identifies a safety precaution	1

Sample answer
When transporting sulfuric acid, it must be stored away from water because it will generate a large amount of heat and cannot be transported with reducing agents because it is a strong oxidising agent. It must be transported in steel containers as it will react to form an insoluble iron sulfate on the walls of the container, to prevent further attack.

(c) (i) (2 marks)
Outcomes Assessed: H11
Targeted Performance Bands: 2-4

Criteria	Marks
• Identifies that mass loss needs to be attributed to both products	2
• Identifies that there will be a mass loss	1

Sample answer
Weigh the contents of the flask before heating and after heating. The mass loss will be due to the removal of ammonia and water vapour. The amount of ammonia produced could be calculated stoichiometrically.

(c) (ii) (2 marks)
Outcomes Assessed: H8
Targeted Performance Bands: 3-6

Criteria	Marks
• Relates colour change to the presence of ammonia	2
• Identifies solution turns pink OR • Identifies that ammonia is alkaline	1

Sample answer
The colour will change from clear to pink as ammonia forms a basic solution in water.

(d) (4 marks)

Outcomes Assessed: H4, H8, H12

Targeted Performance Bands: 2-5

Criteria	Marks
• Recommends detergent B AND • Justifies choice by relating a range of ingredients and effects	4
• Recommends detergent B AND • Justifies choice by considering a range of ingredients and effects OR • Justifies choice by relating one ingredient and its effect	3
• Recommends detergent B AND • Justifies choice by considering a range of ingredients OR effects	2
• Recommends a detergent. • Justifies decision by considering an ingredient or effect	1

Sample answer

Detergent B is the most environmentally friendly detergent. It has no added phosphate so it will not lead to eutrophication of water ways. Being non-ionic, it will not produce a lot of foam in the water and being straight-chained it will be biodegradable. Detergent A is the least environmentally friendly because being anionic, it will produce lots of lathering, the phosphorous will lead to eutrophication and the detergent has branched chains, so will not decompose easily in the environment.

(e) (7 marks)

Outcomes Assessed: H2, H8, H13

Targeted Performance Bands: 2-6

Criteria	Marks
• Describes features of the model AND • Discusses the advantages/disadvantages of the model	6-7
• Describes features of the model OR • Outlines features of the model AND identifies an advantage and a disadvantage of the model	4-5
• Outlines features of the model AND • Identifies an advantage OR a disadvantage of the model	3
• Outlines a model used	1-2

Sample answer

The equilibrium reaction $H_2(g)+I_2(g) \rightleftharpoons 2HI(g)$ can be modelled using a molecular model kit and a bag. Put 8 H_2 molecules and 8 I_2 molecules in a bag. Draw out two molecules at random to simulate a collision between the molecules. If the molecules are H_2 and I_2, they are separated to form 2 HI molecules. If the two molecules are both HI, the molecules are separated to form a H_2 and an I_2 molecule. Other combinations are returned to the bag without reaction. This is repeated 50 times (to reach equilibrium)and the molecules are counted. The results from a number of groups were collated to calculate average equilibrium concentrations of each species. To model the effect of a change of concentration, 4 more H_2 molecules are added to the equilibrium mixture, then 20 more collisions carried out and the equilibrium concentrations counted again. This simulation gives an increased number of HI molecules in the new equilbrium mixture.

The benefits of this model are that the simulation is easy to carry out, the concentrations are easy to calculate and the accuracy can be easily improved by using a number of groups. The concepts of equilibrium as forward and reverse reactions occurring simultaneously and that reactions are caused by collisions are clearly observed. The results of the experiment are supported by theory.

The limitations of this model are that it is time consuming and requires a lot of molecular models. It requires several assumptions that are not necessarily true: all collisions between reactant molecules will be successful and that the equilibrium has been reached after the number of collisions chosen.

Question 30 – Shipwrecks, Corrosion and Conservation (25 marks)

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

Criteria	Mark
• Identifies a negative ion in the ocean	1

Sample answer
Chloride ion

(a) (ii) (3 marks)
Outcomes Assessed: H8
Targeted Performance Bands: 2-4

Criteria	Marks
• Clearly relates the presence of salts in artifacts to the potential damage if dried immediately	2-3
• Indicates that salts need to be removed before drying the artifact	1

Sample answer
If marine artefacts are allowed to dry prior to the removal of the salts, like NaCl, from the artefact, the salts cause considerable damage to the artefact. The presence of salts causes discolouration, distortion and the growth of crystals can cause the destruction of some artefacts. The presence of salts also accelerates possible further corrosion of the artefact. So the salts need to be removed before the artefact is allowed to dry.

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

Criteria	Mark
• Correctly identifies the TWO main metals in steel	1

Sample answer
Iron and carbon

(b) (ii) (2 marks)
Outcomes Assessed: H8, H13
Targeted Performance Bands: 2-4

Criteria	Marks
• Demonstrates a sound knowledge of the process of rusting	2
• Identifies rust as a corrosion product OR • Identifies rust as an oxide of iron iron oxides form in presence of $O_2 + H_2O$ (1)	1

Sample answer
Steel rusts as the iron in steel reacts spontaneously in an oxidation/reduction reaction with water and oxygen in the environment to form hydrated iron oxides e.g.

$Fe \rightarrow Fe^{2+} + 2e$ 0.44V

$2H_2O + O_2 + 4e \rightarrow 4OH^-$ 0.40V

(b) (iii) (3 marks)
Outcomes Assessed: H6, H13, H14
Targeted Performance Bands: 3-5

Criteria	Marks
• Demonstrates a thorough understanding of the relationship between the composition and properties of steel	2-3
• States a property of steel OR • Identifies a steel additive	1

Sample answer
The percentage of carbon in steel can have a dramatic effect on its properties. Steels with high percentages of C eg 3-4% C, are hard and brittle and corrode rapidly. Mild steel which contains less than 0.2% C is soft and malleable. The addition of other metals like 10-15% Cr and 4-22% Ni to steel can produce stainless steel which is hard but very resistant to corrosion. Other metals like 5% molybdenum can make steel stronger and heat resistant.

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

Criteria	Marks
• Demonstrates a thorough knowledge of the procedure for a factor that affects the RATE of electrolysis	2
• Identifies a factor that affects the rate of electrolysis	1

Sample answer
1. Weigh 2 similarly shaped, clean, dry graphite electrodes
2. Set up two 250mL beakers with the previously weighed electrodes attached by leads to the negative terminal of a transformer
3. Attach a graphite electrode to each positive terminal
4. To the first beaker add 200ml of 0.1 $molL^{-1}$ $CuSO_4$
5. To the second beaker add 200 mL of 2 $molL^{-1}$ $CuSO_4$
6. Label the beakers
7. Adjust the voltage to 2V on each transformer
8. Allow current to run for 5 minutes for each beaker
9. Carefully transfer negative electrodes to a previously weighed and labelled petri dish and place in an oven overnight to dry
10. Reweigh electrodes to constant mass

(c) (ii) (2 marks)
Outcomes Assessed: H12, H13
Targeted Performance Bands: 3-6

Criteria	Marks
• Demonstrates a thorough description of the observations	2
• Demonstrates a sound description of the observations	1

Sample answer
When reweighed the negative electrode in the 2 $molL^{-1}$ $CuSO_4$ showed a slightly higher mass gain than that of the negative electrode in the 0.1 $molL^{-1}$ $CuSO_4$ indicating that in the higher concentration solution more $Cu_{(s)}$ was deposited in the same time.

(d) (4 marks)

Outcomes Assessed: H6, H8, H11, H12, H14

Targeted Performance Bands: 2-6

Criteria	Marks
• Evaluates the procedure, giving supporting evidence for said judgement and relates this to the purpose of the investigation	3-4
• Relates the procedure to the purpose of the investigation OR • Explains the use of scratched samples	1-2

Sample answer

The student has planned the investigation well. The student has used her knowledge of what factors affect the rate of corrosion of iron to control variables e.g. shape and thus surface area of the samples used are identical. The concentration of the HCl is kept constant etc. This, together with using multiple set ups of identical samples e.g. 5 painted nails, is designed to improve the reliability of the results. The student has also used their knowledge that different types of coatings work in different ways e.g. as physical barrier or as cathodic protection, to design an experiment that differentiates between the coatings. By scratching the coatings and leaving them intact the comparison of their effectiveness under different conditions is achieved. This allows for better discrimination between the coatings in terms of their effectiveness.

(e) (7 marks)

Outcomes Assessed: H3, H4, H6, H8, H13, H14

Targeted Performance Bands: 2-6

Criteria	Marks
• Demonstrates an extensive knowledge and understanding of the process of cathodic protection and its use in marine and wet terrestrial environments AND • Discusses the impact of its use on society and the environment	6-7
• Demonstrates a thorough knowledge and understanding of the process of cathodic protection AND • Describes how its application affects society OR the environment	4-5
• Demonstrates a sound knowledge and understanding of the process of cathodic protection	2-3
• Identifies an application of cathodic protection OR • Defines cathodic protection	1

Sample answer

The use of cathodic protection in which a metal is protected by making it the cathode in a galvanic cell, has had a significant positive impact on society and the environment. Cathodic protection is a more efficient and effective method than physical protection methods such as painting, tin plating etc. This means that the metal being protected will last longer in a corrosive environment, like marine or wet terrestrial environments. This method also works when the coating is damaged and so is more effective in real life situations. This method thus extends the working life of the metal object. Galvanizing is one form of cathodic protection. In this case, iron is coated with a thin layer of zinc. The zinc being a better reductant is oxidized at the anode, $Zn_{(s)} \rightarrow Zn^{2+} + 2e$ 0.76V, and the iron is forced to become the cathode and is protected. This method will work until all the Zn has oxidized so it protects the iron longer than other methods. This is of benefit to society as we don't have to replace the iron as often with newly refined iron. This means less energy and less valuable resources (iron ore) are used. This is a saving to society and better for the environment – less mining, less use of fossil fuels for energy production and in refining, etc. Sacrificial anodes are another form of cathodic protection eg zinc blocks are attached to the steel hull of ships. The Zn, once again, being more easily oxidized, acts as the anode. $Zn \rightarrow Zn^{2+} + Ze$ 0.76V and the iron in the hull acts as the cathode. Thus, the hull is protected from corrosion. This method is also used for buried steel pipelines. The zinc can be easily replaced without digging up the entire pipeline which would be inconvenient and environmentally damaging as it would cause accelerated soil erosion etc. Ships can also have their zinc blocks replaced without the necessity of dry docking them and taking them out of action as would happen with painting for example. In addition, the paints used were toxic to marine life and hence, sacrificial anodes are less polluting and less expensive in the long term.

Question 31 – Biochemistry of Movement (25 marks)

(a) (i) (1 mark)
Outcomes Assessed: H6, H8
Targeted Performance Bands: 2-3

Criteria	Mark
• Correctly identifies the class of compounds to which molecule A belongs	1

Sample answer
Fatty acid

(a) (ii) (3 marks)
Outcomes Assessed: H6, H7
Targeted Performance Bands: 2-4

Criteria	Marks
• Identifies the polar part molecule A AND • Explains the intermolecular forces between water and this part of molecule A	3
• Identifies the polar part of molecule A AND • Identifies the intermolecular forces between water and this part of molecule A	2
• Identifies the polar part of molecule A	1

Sample answer
The CO group in the COOH is attracted to the water molecule because water is a polar molecule as is the CO as electrons are drawn from the carbon atom towards the O giving the CO a small negative charge and attracting it to the positive end of the water molecule.

(b) (i) (1 mark)
Outcomes Assessed: H9
Targeted Performance Bands: 2-3

Criteria	Mark
• Correctly identifies the alcohol	1

Sample answer
1,2,3-propanetriol

(b) (ii) (2 marks)
Outcomes Assessed: H7, H9
Targeted Performance Bands: 2-4

Criteria	Marks
• States/shows that carbon chains are broken into TWO carbon molecules – acetyl Coenzyme A AND a carbon molecule that is TWO carbons shorter than the original molecule AND • Indicates that the reaction continues until all is converted to acetyl Coenzyme A	2
• States / shows that carbon chains are broken into TWO carbon molecules OR • Names ONE of the products as acetyl Coenzyme A	1

Sample answer
The long carbon chains of fatty acids are broken in stages into 2 – carbon molecules that are attached to a carrier called coenzyme A, so the product of each stage is acetyl Co A and a chain shorter by two carbons.

(b) (iii) (3 marks)
Outcomes Assessed: H7, H9, H14
Targeted Performance Bands: 3-5

Criteria	Marks
• Compares TAGS and glycogen as stores of energy for human metabolism AND • Assesses the importance of TAGS and glycogen as stores of energy for human metabolism	3
• Compares TAGS and glycogen as stores of energy for human metabolism	2
• Describes TAGS OR glycogen as stores of energy for human metabolism	1

Sample answer
TAGs or fats store energy very efficiently in the body because they are hydrophobic. The body can store between 9000 g to 14 000 g of fats and these stores are important as long term stores of energy that can be converted to acetyl CoA and so produce ATP in the respiratory cycle.

Glycogen is a polymer of glucose. It is stored for a limited time in the liver and muscles, and the body cannot store more than about 200g. It is a problem because it is stored bonded with water, making glycogen an inefficient storage molecule compared to fats. Glycogen is important because while glucose, fats and proteins can be respired/used to produce ATP by most body cells, only glucose can cross the blood/brain barrier and enter the brain cells.

(c) (i) (1 mark)
Outcomes Assessed: H9
Targeted Performance Bands: 2-3

Criteria	Mark
• Identifies an enzyme AND its substrate	1

Sample answer
The protein in milk is broken down by the enzyme rennin.

(c) (ii) (3 marks)
Outcomes Assessed: H7, H9, H11, H14
Targeted Performance Bands: 3-6

Criteria	Marks
• Assesses the validity AND accuracy for their investigation	3
• Assesses the validity OR accuracy for their investigation	2
• Identifies a factor that affects the validity OR accuracy of their investigation	1

Sample answer
Accuracy relates to measurements, and in this experiment it would be difficult to make the temperatures right on target. However, the thermometer should be read to avoid parallax error, and a mercury thermometer would be preferable as alcohol thermometers tend to be inaccurate due to the alcohol thread separating. Also the method of assessing the degree of setting needs to be discussed, deciding whether or not the milk has separated into curds may need discussion by all of the team for each test tube for consistency. Validity relates to control of variables, in this experiment the elimination of any other cause of curd formation. The milk needs to be fresh, all from one container, as do the junket tablets, and the test tubes must be totally clean.

(d) (4 marks)
Outcomes Assessed: H7, H8, H12, H13, H14
Targeted Performance Bands: 2-6

Criteria	Marks
• Discusses the importance of the PDH (Pyruvate dehydrogenase) complex in its inhibition of the conversion of pyruvate to acetyl CoA AND • Relates the importance of this inhibition to a body's needs in prolonged gentle exercise	4
• Discusses the importance of the PDH (Pyruvate dehydrogenase) complex in its inhibition of the conversion of pyruvate to acetyl CoA	3
• Identifies that the production of acetyl CoA inhibits the action of PDH	2
• Identifies the purpose of pyruvate	1

Sample answer
During light exercise skeletal muscle uses blood glucose for a while. However, our brains are dependent on glucose, and as blood glucose levels fall the insulin levels fall, mobilizing the body to begin using breaking down fats stored in adipose tissue into fatty acids as a source of acetyl CoA. The acetyl Co A build up causes the inhibition of PDH. PDH is the enzyme that converts the pyruvate derived from glycolysis into acetyl CoA. Acetyl CoA derived from the fatty acids then enters the TCA cycle and then the oxidative chain, providing the ATP for muscle cells.

The result of this inhibition in muscles means that the limited fuel glucose is not used for muscle respiration, and brain function is not impaired.

(e) (7 marks)
Outcomes Assessed: H3, H7, H8, H12, H13, H14
Targeted Performance Bands: 2-6

Criteria	Marks
• Extensive understanding of the role of NADH and $FADH_2$ in the human respiratory chain AND • Evaluates the importance of NADH and $FADH_2$	6-7
• Extensive understanding of the role of NADH and $FADH_2$ in the human respiratory chain OR • Thorough understanding of the role of NADH and $FADH_2$ in the human respiratory chain AND • Evaluates the importance of NADH or $FADH_2$	4-5
• Basic understanding of the role of NADH and $FADH_2$ in the human respiratory chain	2-3
• Limited understanding of the role of NADH or $FADH_2$ in the human respiratory chain	1

Sample answer
Whether the fuel used to provide ATP for the cells is glucose or fatty acids, the different sections of the respiratory cycle operate to remove the H atoms from the fuels and to generate NADH and $FADH_2$. The purpose of these molecules is to transport hydrogen to the electron transport chain, a series of protein embedded in the inner matrix of the mitochondria.

$NADH \rightarrow NAD + H+$

The electron transport chain is the point of respiration where oxygen is actually used. The enzymes of the electron transport chain pass electrons and hydrogen along to oxygen atoms in a series of steps, and this is coupled to the production of ATP. The hydrogen atoms losing electrons become H^+ (protons) and the protons are pumped out of mitochondria. They can only re-enter the mitochondria if ADP is available. The entry of the H^+ ions into the mitonchondria allows the formation of ATP. ATP is not stored in the cell, it must be constantly produced by the addition of a phosphate group to the ADP molelcule. The process of ATP formation and fuel oxidation are coupled, one cannot occur without the other. Each NADH molecule allows the production of 3 ATP molecules. And each $FADH_2$ molecule allows the production of 2 ATP molecules. The total ATP produced from the oxidation of NADH and $FADH_2$ is 34. This is added to the 2ATP from glycolysis making the total 36 ATP.

$ADP + P0_4 \rightarrow ATP$

The final products are ATP and the formation of water.

Question 32 – Chemistry of Art (25 marks)

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

Criteria	Mark
• Correctly identifies an ancient cosmetic pigment	1

Sample answer
Cinnabar/vermilion (mercury(II) sulfide)

(a) (ii) (3 marks)
Outcomes Assessed: H4
Targeted Performance Bands: 2-4

Criteria	Marks
• Links named chemical component of cosmetic pigment with specific effect on health	3
• Links cosmetic with a general health risk OR • Links chemical with specific health risk OR • Links chemical with general health risk	2
• Identifies a general health risk	1

Sample answer
Cinnabar was a red cosmetic used as a lipstick and rouge. It is mercury(II) sulfide and the mercury is a heavy metal poison that gives symptoms of seizures, nerve degeneration, kidney disease and skin irritation.

(b) (i) (1 mark)
Outcomes Assessed: H12, H13
Targeted Performance Bands: 2-3

Criteria	Mark
• Correctly identifies the element	1

Sample answer
Vanadium

(b) (ii) (2 marks)
Outcomes Assessed: H7
Targeted Performance Bands: 2-4

Criteria	Marks
• Correctly describes the difference between the 1s and 2s/2p subshells and the slight difference between the 2s and 2p subshells	2
• Correctly describes the difference between the 1s and 2s/2p subshells OR • Correctly describes the slight difference between the 2s and 2p subshells	1

Sample answer
The 1s subshell has a lower energy level than the 2s and 2p subshells. The 2p subshell has a slightly higher energy than the 2s subshell.

(b) (iii) (3 marks)
Outcomes Assessed: H13, H14
Targeted Performance Bands: 3-5

Criteria	Marks
• Accurately describes the Pauli principle and Hund's rule and links these appropriately to filling of orbitals	3
• Accurately describes the Pauli principle and Hund's rule OR • Accurately describes the Pauli principle and links this to filling of orbitals OR • Accurately describes Hund's rule and links this to filling of orbitals	2
• Accurately describes the Pauli principle OR • Accurately describes Hund's rule	1

Sample answer
The Pauli exclusion principle states that an orbital can only hold a maximum of two electrons and Hund's rule says that if two or more orbitals with the same energy are available, one electron goes into each orbital until all are half full and only then does a second electron fill an orbital. By following these rules it is possible to correctly position electrons into their orbitals and so produce an electron configuration for vanadium.

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

Criteria	Mark
• Correctly identifies the transition metal	1

Sample answer
Manganese

(c) (ii) (3 marks)
Outcomes Assessed: H6, H12, H13, H14
Targeted Performance Bands: 3-6

Criteria	Marks
• Links different filling arrangement of orbitals for different ions of the transition metal and hence different energies able to be absorbed, to different oxidation states and to different colours	3
• Links simply different colours to different electron arrangements	2
• Attributes different colours to different oxidation states	1

Sample answer
Since each ion of a transition metal in a different oxidation state has different arrangement of filled and unfilled 3d and 4s orbitals, then they will have different energies they can absorb from the range of visible light, so this will give them different colours. This explains why manganese changes its colour from purple to colourless as it moves from an oxidation state of +7 to +2.

(d) (4 marks)
Outcomes Assessed: H6, H13, H14
Targeted Performance Bands: 2-5

Criteria	Marks
• Makes thorough reference to lone pairs of electrons used to co-ordinately covalently bond and chelate the ligands to the central metal ion	4
• Identifies coordinate covalent bonding through lone pairs of electrons between oxalate ions and metal ions	3
• Identifies coordinate covalent bonding	2
• Identifies covalent bonding	1

Sample answer
Each oxalate ion has two sets of lone pair electrons available for bonding. Three oxalate ions coordinately covalently bond with each of these pairs to the central chromium ion which has empty d-orbitals which can accept these pairs of electrons. The oxalate ions are known as chelating ligands.

(e) (7 marks)
Outcomes Assessed: H1, H2, H4, H7, H13
Targeted Performance Bands: 2-6

Criteria	Marks
• Describes Bohr's model with reference to energy levels, gives at least one merit of the model and at least ONE limitation, assesses the importance of the model	6-7
• Describes Bohr's model, gives a merit or a limitation and gives a simple assessment	4-5
• Describes Bohr's model and gives a simplistic discussion of importance	2-3
• Describes a simple shell model of the atom with little detail of energies	1

Sample answer
The Bohr model of the atom described the orbit of electrons around the atom as being at fixed radii and energy. The electrons could absorb energy in fixed quanta and move to a higher energy level and then emit these quanta of energy when they fell back to a lower energy level. This model was very useful in explaining the line spectrum of hydrogen, and it supplied the notion of quanta of energy able to be absorbed and emitted, but it was not useful for explaining the atomic spectra of atoms other than hydrogen. Nor could it explain the different intensities of spectral lines, the fact that some spectral lines actually consist of a number of very fine close lines, or the splitting of such spectral lines in magnetic fields. The model was useful in providing the groundwork on which to base further theories of quantum mechanics.

Question 33 – Forensic Chemistry (25 marks)

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

Criteria	Mark
• Correctly identifies ONE major functional group of an amino acid	1

Sample answer
Amine group OR carboxylic acid group

(a) (ii) (3 marks)
Outcomes Assessed: H6, H9, H13, H14
Targeted Performance Bands: 2-4

Criteria	Marks
• Identifies that a peptide bond is formed AND • Relates its formation to the condensation polymerisation reaction that is repeated many times to form polypeptide chains	3
• Identifies that a peptide bond is formed AND • Relates its formation to condensation polymerisation reaction	2
• Identifies that a peptide bond is formed	1

Sample answer
The amine group of one amino acid undergoes a condensation polymerisation reaction with the carboxylic acid group of another amino acid releasing a water molecule. Since amino acids have two functional groups, this process can be repeated many times to form a polypeptide chain (protein).

(b) (i) (1 mark)
Outcomes Assessed: H12
Targeted Performance Bands: 2-3

Criteria	Mark
• Correctly identifies ONE trace element present in the lawn food	1

Sample answer
Calcium

(b) (ii) (2 marks)
Outcomes Assessed: H3, H6, H13
Targeted Performance Bands: 2-4

Criteria	Marks
• Describes, using a specific example, the use of line emission spectra by the forensic chemist	2
• Describes the use of line emission spectra by the forensic chemist	1

Sample answer
Each element has its own specific spectrum, therefore the forensic chemist can analyse two soil samples and by comparing the spectra, they can determine if they are both from the same site.

(b) (iii) (3 marks)
Outcomes Assessed: H6, H13, H14
Targeted Performance Bands: 3-5

Criteria	Marks
• Explains why each element produces its own signature spectrum	3
• Describes spectra as the result of electrons moving from a higher to a lower energy level	2
• Identifies that spectra are related to energy levels in the atom	1

Sample answer
As excited electrons move to lower energy levels they emit particular amounts of energy. This corresponds to particular wavelengths. Since each element has its own particular energy "gaps" between the various energy levels, each also has its own unique corresponding wavelengths.

(c) (i) (1 mark)
Outcomes Assessed: H9, H12
Targeted Performance Bands: 2-3

Criteria	Mark
• Identifies ONE relevant safety precaution	1

Sample answer
Perform the experiment in a well-ventilated area.

(c) (ii) (3 marks)
Outcomes Assessed: H12, H14
Targeted Performance Bands: 3-6

Criteria	Marks
• Accounts for observations AND • Names all products formed	3
• Accounts for some observations AND • Names at least ONE product formed	2
• Describes at least ONE observation OR • Names at least ONE product formed	1

Sample answer
Both alkenes and primary alkanols decolourise potassium permanganate. The cyclohexene undergoes an addition reaction to form cyclohexane-1,2-diol. The 1-propanol is oxidised to form propanoic acid, while the permanganate is reduced.
The cyclohexene decolourises bromine water as it undergoes an addition reaction to form 1,2-dibromocyclohexane whereas the 1-propanol does not react with the bromine water.

(d) (4 marks)
Outcomes Assessed: H3, H6, H13
Targeted Performance Bands: 2-6

Criteria	Marks
• Thoroughly compares GC and HPLC, including similarities and differences.	4
• Compares GC and HPLC, including at least one similarity and difference OR • Thoroughly describes either GC or HPLC	3
• Briefly describes either GC or HPLC	2
• Briefly outlines chromatography	1

Sample answer
Both involve a mobile phase passing over a stationary phase. The sample passes through a column. As it does so it separates into its components since they travel through the column at different rates, thus reaching the detector at different times. By comparing the detection times with standards, the components of the mixture can be identified. GC is the most sensitive of the chromatographic techniques, however it is only useful if the mixture can be vapourised. Hence it is only useful for mixtures that contain low boiling point liquids that are easily vapourised. In HPLC, however, the mixture that passes through the column remains as a liquid, hence it is useful for mixtures that contain less volatile liquids, i.e. higher boiling points.

(e) (7 marks)
Outcomes Assessed: H3, H4, H5, H6, H9, H13
Targeted Performance Bands: 2-6

Criteria	Marks
• Discusses how the process of electrophoresis assists the forensic chemist in analysing DNA	6-7
• Describes the process of electrophoresis AND • Describes how the analysis of DNA assists the forensic chemist	4-5
• Describes the process of electrophoresis OR • Describes how the analysis of DNA assists the forensic chemist	2-3
• Identifies that electrophoresis produces bands	1

Sample answer
DNA is extracted from a sample of blood or body tissues then cut into fragments. The fragments are charged so they will move through an applied electric field. The fragments are separated according to the speed with which they move through the carrier medium. Larger fragments of DNA move faster hence a band structure is produced. The forensic chemist uses this technique to compare samples at crime scenes with victims and suspects. Comparison with the victim allows, by elimination, the perpetrator's DNA to be determined. This is then compared to suspects. It can be used to eliminate suspects as well as convicting suspects.