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CATHOLIC SECONDARY SCHOOLS ASSOCIATION OF NSW

2011 TRIAL HIGHER SCHOOL CERTIFICATE EXAMINATION

CHEMISTRY – MARKING GUIDELINES

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

Section I
Part A – 20 marks

Questions 1–20 (1 mark each)

Question	Correct Response	Outcomes Assessed	Targeted Performance Bands
1	C	H4, H9	2-3
2	D	H8, H9	3-4
3	D	H9	2-3
4	A	H9, H10,H12	5-6
5	A	H7, H8	3-4
6	C	H7	2-3
7	D	H3, H4	2-3
8	C	H14	4-5
9	A	H10	4-5
10	B	H10	5-6
11	A	H8	2-3
12	D	H8	3-4
13	C	H8H9	3-4
14	B	H3, H7	3-4
15	B	H8, H14	2-3
16	C	H12	3-4
17	B	H8, H12	2-3
18	A	H4	3-4
19	D	H4, H5, H9	3-4
20	B	H4	2-3

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Section I
Part B – 55 marks

Question 21 (3 marks)
Outcomes Assessed: H6, H9
Targeted Performance Bands: 2–4

Criteria	Marks
• Identifies the correct compound • Relates the compound's ability as a solvent to its polar and non polar regions • Links the polar and non polar regions to the ability to dissolve both polar and non polar substances • Provides some comparison between the chosen compound and the other TWO	3
• Identifies the correct compound • Relates the compound's ability as a solvent to its polar and non polar regions • Links the polar and non polar regions to the ability to dissolve both polar and non polar substances OR provides some comparison between the chosen compound and the other TWO	2
• Identifies the correct compound • Relates the compound's ability as a solvent to its polar and non polar regions	1

Sample answer:
Compound B has the ability to dissolve the greatest variety of substances. Compound A is non-polar and can thus only dissolve non polar substances because it lacks the attraction necessary to separate molecules of polar substances. Compound C is very polar and will thus only dissolve polar substances because it is more attracted to itself than to non-polar solutes. Compound B has a polar section (the O-H bond) which will attract and be attracted to polar solutes, allowing them to mix. It also has a non-polar section (the CH_3-CH_2 section) which will be mutually attracted to non-polar solutes enabling them to separate from each other and also mix with compound B.

Question 22 (5 marks)
Outcomes Assessed: H3, H4
Targeted Performance Bands: 2–5

Criteria	Marks
• Thoroughly compares the chemistry (including equations) and the impact on society of TWO appropriate galvanic cells	5
• Thoroughly compares the chemistry and the impact on society of TWO appropriate galvanic cells OR • Compares the chemistry (including equations) and the impact on society of TWO appropriate galvanic cells	4
• Compares the chemistry and the impact on society of TWO appropriate galvanic cells	3
• Correctly identifies a chemical aspect AND an impact on society of either cell	2
• Correctly identifies a chemical aspect OR • Correctly identifies an impact on society of either cell	1

Sample answer:
The DRY Cell has been in use since 1866 and has remained the most common and reliable sources of portable electric power for electrical devices. The BUTTON cell was developed for smaller electrical devices that required smaller cells with stable voltages during the lifetime of its operation.

Dry Cell: Anode reaction: $Zn(s) \rightarrow Zn^{2+}(aq) + 2\ e^-$
Cathode Reaction: $NH_4^+(aq) + MnO_2(s) + e^- \rightarrow NH_3(aq) + MnO(OH)(s)$

BUTTON Cell: Anode reaction: $Zn(s) \rightarrow Zn^{2+}(aq) + 2\ e^-$
Cathode reaction: $Ag_2O(s) + H_2O(l) + 2e^- \rightarrow 2Ag(s) + 2OH^-(aq)$

In terms of their chemistry they are **similar** in a number of aspects:
- both cells are non rechargeable
- zinc is the anode in both cells both utilise electrolyte pastes
- both have inert graphite as a component of the cathode

But they **differ** in a number of aspects
- the electrolyte paste in the dry cell is acidic whilst it is alkaline in the button cell
- the button cell produces a slightly higher voltage than the dry cell
- the anode is powdered in the button cell and not in the dry cell

In terms of their impact on society they are **similar** in they both allow small electric devices to be easily powered. Whereas they differ because the dry cell can only be used in low drain appliances like torches, calculators and toys that do not require high current, whilst the button cell is widely used in watches, cameras, hearing aids or in appliances that require a small battery that produces a stable voltage over a longer period of time.

Question 23 (5 marks)
(a) (2 marks)
Outcomes Assessed: H6, H8
Targeted Performance Bands: 2–3

Criteria	Marks
• Identifies elements A and B	2
• Identifies element A or B	1

Sample answer:
Element A - Krypton
Element B – Barium

(b) (3 marks)
Outcomes Assessed: H3, H4
Targeted Performance Bands: 2–5

Criteria	Marks
• Analyses thoroughly the problems associated with the use of a radioisotope in a named application	3
• Describes problems associated with the use of a radioisotope	2
• States a problem associated with the use of radioisotopes	1

Sample answer:
Exposure:
The use of radioisotopes in medicine poses a range of problems. It is essential to control the amount of exposure to radioactive material as this can result in long lasting detrimental effects to the human body. Radioisotopes are often used in medical diagnoses as tracers that are injected into the body. They are used in this way because the radioactive isotopes have the same chemical properties as non-radioactive forms. Therefore isotopes with a short half life are used so that the radiation is not present in the tissues for a prolonged length of time that may cause damage to healthy tissues. If a radioisotope is used to irradiate cancerous tissue it is essential to target specific cancerous cells and not expose large amounts of the body to the harmful rays that could cause further damage.
Waste:
Radioactive wastes from the production of medical radioisotopes, like all others, must be safely stored for long periods of time (often hundreds of thousands of years). It must be disposed of carefully often in stable underground geological structures where it cannot contaminate ground water supplies and is far enough away from organisms. Synroc is a waste storage material developed in Australia at ANSTO which allows the waste to be carefully stored under these conditions.

Question 24 (5 marks)
(a) (1 mark)
Outcomes Assessed: H12, H14
Targeted Performance Bands: 2–3

Criteria	Mark
• Calculates number of moles per litre of octane	1

Sample answer:

$density_{octane}$= 703g/L
M_{octane} = 114.224g/mol
c_{octane} = 703g/L / 114.224g/mol
= 6.16 mol/L (3 sig fig)

(b) (2 marks)
Outcomes Assessed: H12, H14
Targeted Performance Bands: 2–4

Criteria	Marks
• Calculates the amount of energy released with correct units and significant figures	2
• Calculates the amount of energy released	1

Sample answer:
ΔH = 6.155 mol/L x 5470 kJ/mol Check for "follow-on" error
= 33666 kJ/L
= 33700 kJ/L (3 sig fig)

(c) (2 marks)
Outcomes Assessed: H12, H14
Targeted Performance Bands: 4–6

Criteria	Marks
• Calculates the distance travelled on 1L of ethanol	2
• Calculates amount of energy released by 1 litre of ethanol	1

Sample answer:
Using octane 33700kJ of energy takes the car 10km. Check for "follow-on" error

$density_{ethanol}$ = 789 g/L
M_{octane} = 46.068 g/mol
$c_{ethanol}$ = 789 g/L / 46.068 g/mol
= 17.13 mol/L
ΔH = 17.13 mol/L x 1367 kJ/mol
= 23412 kJ/L
= 23400 kJ/L (3 sig fig)
Distance travelled using ethanol = 23400/33700 x 10km = 6.94km

Question 25 (6 marks)

(a) (1 mark)

Outcomes Assessed: H12

Targeted Performance Bands: 2–3

Criteria	Mark
• Correctly determines the pH of the solution correct to THREE decimal places	1

Sample answer:

$pH = -\log[3.02 \times 10^{-4}] = 3.520$

(b) (2 marks)

Outcomes Assessed: H10

Targeted Performance Bands: 2–4

Criteria	Marks
• Calculate a volume of distilled water required	2
• Calculates the final volume of the diluted solution	1

Sample answer:

Initial concentration (c_1) = 3.02×10^{-4} mol L^{-1}

Initial volume (V_1) = 0.375 L

Final concentration (c_2) = 2.51×10^{-4} mol L^{-1}

Final volume (V_2) = ?

$c_1V_1 = c_2V_2$

$(3.02 \times 10^{-4})(0.375) = (2.51 \times 10^{-4})(v_2)$

$V_2 = 0.451$ L

Volume of distilled water to be added = 0.451 L – 0.375 L = 0.076 L or 76 mL

(c) (3 marks)

Outcomes Assessed: H8

Targeted Performance Bands: 3–4

Criteria	Marks
• Clearly explains the change in CO_2 solubility using Le Chatelier's Principle AND includes an equation	3
• Clearly explains the change in CO_2 solubility using Le Chatelier's Principle OR • Identifies an increase in CO_2 solubility AND includes an equation	2
• Identifies an increase in CO_2 solubility	1

Sample answer:

The change in the equilibrium within the soft drink bottle can be best explained using the following equations:

$CO_2\,(g) \Leftrightarrow CO_2\,(aq)$

$CO_2\,(aq) + H_2O\,(l) \Leftrightarrow H_2CO_3\,(aq) \Leftrightarrow 2H^+\,(aq) + CO_3^{2-}\,(aq)$

Any base added to this equilibrium system would react with the carbonic acid (H_2CO_3) present. According to Le Chatelier's principle, the system will try to minimise the disturbance, ie the removal of the carbonic acid. To minimise this disturbance the equilibrium will shift to the right and CO_2 (g) will dissolve to form more H_2CO_3.
Therefore, the solubility of carbon dioxide in water would be increased by the addition of a base.

Question 26 (4 marks)
(a) (2 marks)
Outcomes Assessed: H10
Targeted Performance Bands: 2–4

Criteria	Marks
• Calculates the concentration of potassium hydrogen phthalate	2
• Calculates the number of moles of potassium hydrogen phthalate	1

Sample answer:

M = 204.22g/mol
m = 5.1025g
n = ?

$n = m/M = 5.1025g \ / \ 204.22g/mol = 2.499 \times 10^{-2} mol$

v = 0.10000L

$c = n/v = 2.499 \times 10^{-2} mol / 0.10000 \ L = 0.2499 mol \ L^{-1}$

(b) (2 marks)
Outcomes Assessed: H11
Targeted Performance Bands: 2–4

Criteria	Marks
• Identifies TWO characteristics of a primary standard and explains why NaOH is not appropriate	2
• Identifies TWO characteristics of a primary standard OR • Identifies reasons why NaOH is not appropriate	1

Sample answer:
A primary standard such as potassium hydrogen phthalate would have the following characteristics:

- solid with a high molecular weight (making weighing more accurate and minimising the significance of any errors)
- extremely pure (to ensure that the final solution is a high purity)
- stable (to ensure that it does not absorb water from air which would make weighing inaccurate)
- high solubility in water (allowing the solid to be fully and easily dissolved.)

Sodium hydroxide is a solid with a high solubility. However, it is not stable in air, readily absorbing water. The sample weighed out would produce a solution of lower concentration than expected. It also has a relatively low molecular mass, making weighing less accurate.

Question 27 (3 marks)
Outcomes Assessed: H4, H8
Targeted Performance Bands: 2–4

Criteria	Marks
• Identifies any element that could form an acidic oxide AND • Describes the formation of an acidic substance from this element through a natural process including ONE equation AND • Explains how the acidic substance can cause an increase in acidity in the environment	3
• Identifies any element that could form an acidic oxide AND describes the formation of an acidic substance from this element through a natural process including ONE equation OR • Describes the formation of an acidic substance from this element through a natural process including ONE equation AND explains how the acidic substance can cause an increase in acidity in the environment OR • Identifies any element that could form an acidic oxide AND explains how the acidic substance can cause an increase in acidity in the environment	2
• Identifies any element that could form an acidic oxide OR • Describes the formation of an acidic substance from this element through a natural process including ONE equation OR • Explains how the acidic substance can cause an increase in acidity in the environment	1

Sample answer:
Non-metal elements tend to form acidic oxides. For example, sulfur, nitrogen and carbon would produce oxides that are acidic.
Sulfur is readily produced from natural sources such as volcanoes. The sulfur that is released combines with oxygen in the atmosphere to produce sulfur dioxide (SO_2) and sulfur trioxide (SO_3).
Sulfur dioxide dissolves in water droplets in the atmosphere to form sulfurous acid and sulfuric acid.

$SO_2(g) + H_2O(l) \rightarrow H_2SO_3(aq)$ and $SO_3(g) + H_2O(l) \rightarrow H_2SO_4(aq)$

These acids are washed out of the atmosphere in the form of acid rain which contributes to the increased acidity of waterways which can harm aquatic life and damage plants.

Question 28 (6 marks)

(a) (i)(1 mark)

Outcomes Assessed: H9

Targeted Performance Bands: 2–4

Criteria	Mark
• Identifies 1-butanol	1

Sample answer:

1-butanol

(b) (2 marks)

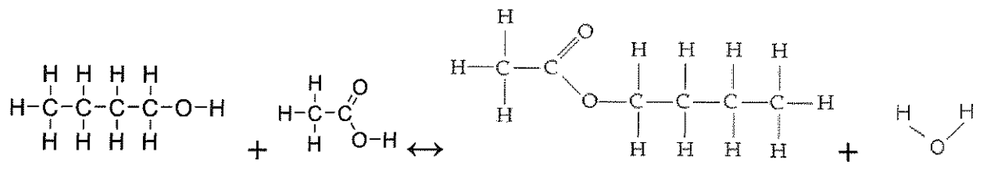
Outcomes Assessed: H8, H9, H13

Targeted Performance Bands: 2–4

Criteria	Marks
• Draws structural formulae for 1-butanol and ethanoic acid (semi-structural acceptable) • Draws structural formulae for butyl ethanoate, showing correct ester linkage	2
• Draws structural formulae for 1-butanol and ethanoic acid (semi-structural acceptable) OR • Draws structural formulae for butyl ethanoate	1

Sample answer:

The reagents used in the experiment are 1-butanol and ethanoic acid.



(c) (1 mark)

Outcomes Assessed: H8, H11

Targeted Performance Bands: 3–4

Criteria	Mark
• Outlines reflux as a process which speeds up the rate of the reaction whilst preventing the loss of reactants	1

Sample answer:

Refluxing heats the mixture and thus allows this slow reaction to proceed at a much faster rate, while preventing the loss of volatile reagents and products.

(d) (2 marks)

Outcomes Assessed: H9

Targeted Performance Bands: 2–4

Criteria	Marks
• Identifies TWO hazards and an appropriate step to minimise each hazard.	2
• Identifies ONE hazard and an appropriate step to minimise the hazard. OR • Identifies TWO hazards OR TWO steps to minimise hazards.	1

Sample answer:

Many possible

eg

Any acid is corrosive. Lab coats and goggles should be worn when using acids to protect the skin and eyes.

Reagents are flammable, heating mats or water baths should be used instead of a naked flame to minimise risk of fire.

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Question 29 (5 marks)
Outcomes Assessed: H4, H8
Targeted Performance Bands: 2–5

Criteria	Marks
• Identifies some uses of ammonia • Describes the equilibrium reaction involved in producing ammonia With reference to le Chatelier, explains the effect of changing conditions of temperature and pressure on equilibrium during Haber process • Identifies the use of an iron/iron oxide catalyst in the Haber process • Outlines how the Haber process contributed to German war effort • Assesses the accuracy of the statement	5
• Identifies some uses of ammonia • Describes the equilibrium reaction involved in producing ammonia Explains the effect of changing conditions of temperature and pressure on equilibrium during Haber process • Identifies the use of an iron/iron oxide catalyst in the Haber process • Outlines how the Haber process contributed to German war effort	4
• Identifies some uses of ammonia • Briefly describes the equilibrium reaction involved in producing ammonia • Describes the effect of changing conditions of temperature and/or pressure on equilibrium during Haber process OR • Outlines how the Haber process contributed to German war effort	3
• Identifies a use of ammonia • Lists the effect of changing conditions of temperature and/or pressure on equilibrium during Haber process OR outlines how the Haber process contributed to German war effort OR • Identifies some uses of ammonia • Briefly describes the equilibrium reaction involved in producing ammonia OR • Lists the effect of changing conditions of temperature and/or pressure on equilibrium during Haber process OR • Outlines how the Haber process contributed to German war effort • Briefly describes the equilibrium reaction involved in producing ammonia	2
• Briefly describes the equilibrium reaction involved in producing ammonia OR • Outlines how the Haber process contributed to German war effort OR • Identifies a use of ammonia	1

Sample answer:
The synthesis of ammonia occurs as a reversible exothermic reaction. Equilibrium is reached when the rate of the forward reaction equals the rate of the reverse reaction.

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

In 1884 Le Chatelier demonstrated that changing the conditions in a system at equilibrium will cause the established equilibrium to shift in a way that will minimise the change. Haber used this principle to develop a process for efficiently producing ammonia at a time of great need for the German people.

In the early 1900's, much of the world's fertiliser was mined in Chile, a long way from Europe. It would be advantageous to convert this readily available nitrogen in the atmosphere to usable compounds for agriculture and industry, cheaply and on a large scale. Haber developed this process.

When the British cut off supplies of nitrate from Chile, Germany used the process to make explosives in World War I and after, as well as produce fertilisers for their crops. This lengthened the war.

Haber recognised that increasing the temperature would allow the reaction to proceed more rapidly thus reaching equilibrium faster. However, as the reaction was exothermic, increasing the temperature also caused the equilibrium to shift to the left, reducing the yield of ammonia. Haber overcame this problem by introducing a finely ground iron/iron oxide catalyst to increase the rate of the reaction whilst maintaining the lower temperatures required to favour ammonia production.

Increasing the pressure also favoured the production of ammonia because two molecules of gaseous ammonia occupy a smaller volume than the four molecules of gaseous reactants. High pressure also increases the reaction rate because the gas molecules are closer and at higher concentrations.

Thus, the Haber Process is a balance between temperature and pressure and the catalyst was used to maximise production, increase efficiency and minimize costs.

The development of the Haber process was an important scientific contributions in the early 1900's demonstrating a greater understanding of chemical equilibrium and also having an enormous impact on the course of World War 1. The statement is therefore accurate.

Question 30 (4 marks)
Outcomes Assessed: H5, H12
Targeted Performance Bands: 2–6

Criteria	Marks
• Outlines methods used to collect data and analyses the graph thoroughly to describe changes in the size of the ozone hole	4
• Outlines methods used to collect data and analyses the graph to describe changes in the size of the ozone hole	3
• Identifies a method for collecting data and describes trends in the graph OR • Analyses the graph to describe changes in the size of the ozone hole	2
• Identifies a method for collecting data OR identifies a trend in the graph	1

Sample answer:
Data in the graph would be gathered and compiled from a range of sources including the following:

- The Dobson Spectrophotometer measures the relative intensities pairs of wavelengths in the Huggins ozone band.
- In addition to the ground based spectrophotometers, monitoring also uses satellite data eg the Tiros Operational Vertical Scanner (TOVS). These data come from the NOAA polar orbiting satellites.
- Ozone sondes are balloon-borne instruments that continuously estimate ozone concentration as they ascend into the atmosphere. The transmitted information is received by a ground station.

The graphs do not provide sufficient information to justify any conclusions about the trend in the size of the ozone hole. Scientists are hopeful that the hole is shrinking and the graphs for 1998, 2009 and 2010 indicate this is possibly true. However, the lines showing the maximum and minimum from 2000 to 2009 indicate that within the last decade the hole has been smaller than in 2010 and larger than in 1998, thus refuting the existence of a constant decline in size. More data will be required for years to come to determine whether there is a genuine decrease in the size of the hole.

Question 31 (2 marks)
Outcomes Assessed: H3, H11
Targeted Performance Bands: 3–4

Criteria	Marks
• Explains in terms of cost and the usefulness of identifying the metals to be tested	2
• Explains in terms of cost OR the usefulness of identifying the metals to be tested	1

Sample answer:
AAS is an expensive technique which requires the use of appropriate lamps that produce wavelengths of light appropriate to the metal being analysed. Therefore it would be appropriate to employ cheaper qualitative methods to determine whether or not an element is present in a sample before using AAS.

Question 32 (7 marks)
(a) (1 mark)
Outcomes Assessed: H13
Targeted Performance Bands: 2–3

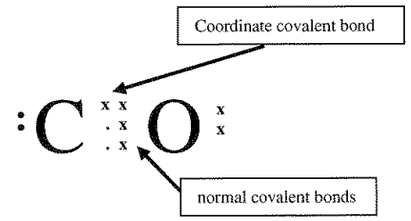
Criteria	Mark
• Identifies correctly	1

Sample answer:
carbon monoxide

(b) (2 marks)
Outcomes Assessed: H6, H13
Targeted Performance Bands: 2–5

Criteria	Marks
• Describes the formation of the bond using a correctly drawn Lewis electron dot structure	2
• Describes the formation of a coordinate covalent bond OR • Presents a correctly drawn Lewis electron dot structure for CO	1

Sample answer:



CO contains a triple bond formed from 2 normal covalent bonds (ie carbon and oxygen each contribute an electron to the shared pair) and a coordinate covalent bond where both shared electrons are contributed by the oxygen atom.

(c) (4 marks)
Outcomes Assessed: H4,H12, H14
Targeted Performance Bands: 2–6

Criteria	Marks
• Assesses by - calculating the concentration of CO in the garage - comparing the concentration to the quoted value - assessing the risk	4
• Assesses with a minor calculation error OR • Compares the correctly calculated value with the quoted value	3
• Assesses with a significant calculation error OR • Calculates the concentration of CO in the garage	2
• Completes ONE step of the required calculation OR • Assesses risk using incorrect data	1

Sample answer:
mass of C forming CO = 2% of 1kg = 20g
moles of C = 20g/12.01g/mol
= 1.67mol
moles of CO = 1.67mol
volume of CO = 1.67mol x 24.79L/mol
= 41.3L
Concentration of CO = 41.3L /50 000L (as $1m^3$=1000L)
= 0.0825L/100L (v/v)
= 825ppm
=800ppm (1 sig fig)
This calculated concentration exceeds the quoted value of 650ppm significantly and as such would pose an extreme risk of coma or death to anyone entering the garage for even a brief amount of time.

Section II

Question 33 – Industrial Chemistry (25 marks)
(a) (i) (1 mark)
Outcomes Assessed: H4
Targeted Performance Bands: 2–3

Criteria	Mark
• Names the Solvay process	1

Sample answer:
Solvay process

(a) (ii) (3 marks)
Outcomes Assessed: H4
Targeted Performance Bands: 3–5

Criteria	Marks
• Coherently describes steps in the production of sodium carbonate • Demonstrates understanding of chemistry by using appropriate terminology and equations	3
• Describes steps in the production of sodium carbonate including relevant equations	2
• Describes steps in the production of sodium carbonate	1

Sample answer:
The production of sodium carbonate using the Solvay process first requires that calcium carbonate is heated in a kiln to form carbon dioxide & calcium oxide.

$CaCO_3(s) \rightarrow CO_2(g) + CaO(s)$

Ammonia is dissolved in the purified brine (NaCl) and the carbon dioxide is dissolved in this solution to produce sodium hydrogen carbonate.

$NaCl(aq) + NH_3(g) + H_2O(l) + CO_2(g) \rightarrow NH_4Cl(aq) + NaHCO_3(aq)$

The sodium hydrogen carbonate is washed, dried and used to make sodium carbonate by heating it to about 300°C, causing it to decompose into sodium carbonate and carbon dioxide. Sodium carbonate is removed and sold.

$2NaHCO_3(s) \rightarrow Na_2CO_3(s) + CO_2(g) + H_2O(l)$

(b) (4 marks)
Outcomes Assessed: H3, H5
Targeted Performance Bands: 3–5

Criteria	Marks
• Names the natural product • Provides characteristics or features of replacement materials and/or current research for replacement materials • Provides characteristics and features of at least TWO issues associated with shrinking world supplies of the natural product	4
• Names the natural product • Identifies replacement materials and/or current research for replacement materials • Provides characteristics and features of ONE issue associated with shrinking world supplies of the natural product	3
• Name the natural product • Identifies replacement materials and/or current research for replacement materials OR • Provides characteristics and features of ONE issue associated with shrinking world supplies of the natural product	2
• Names the natural product • Identifies an issue associated with shrinking world supplies of the natural product OR • Identifies a replacement material or steps being taken in research	1

Sample answer:
Many possible

eg A natural product is one that is used with little or no modification. Raw rubber is an addition polymer that is also a natural product. Raw rubber is obtained from the sap of the rubber tree and is a very useful natural product. It is used in balls, shoes, tyres and as elastic bands. In the early 20th century demand for rubber outstripped supply. The supply of rubber was limited as rubber trees could only produce a certain amount of rubber each year. In addition, this production was mainly from Asia. As the demand for rubber grew, new alternatives needed to be produced. This situation became crucial during the first and second world wars. Rubber was needed for tyres for military vehicles and the limited supply of rubber greatly influenced the war. In the second world war, the Japanese had control of rubber producing areas which resulted in other nations needing scientists to develop synthetic rubber. Another issue that caused the rising demand for rubber was that the automobile industry was growing and car manufacturers needed rubber. Steps to solve the limited supply of rubber involved the development of synthetic rubbers. In the 1950s SBR (styrene butadiene rubber) was formed.
Synthetic rubber improved the properties of natural rubber as the rubber was vulcanised. Short sulfur chains formed crosslinks between polymer chains. This improved the properties of synthetic rubber, making it more durable, more resistant to chemical attack and stronger. Synthetic rubber has allowed the production of rubber to meet demand and maintain a low cost. New developments to rubber involve the use of non-petrochemicals as the cost of petroleum products has increased.

(c) (i) (3 marks)
Outcomes Assessed: H8, H13
Targeted Performance Bands: 2–4

. must incl. volumes / conc

Criteria	Marks
• Outlines, in a logical manner, the steps taken to perform the experiment • Describes conditions which were changed in qualitative analysis of the reaction	2
• Includes most appropriate steps OR • Identifies observations that were made	1

Sample answer:
Many Possible

eg
NOTE: Any shift in equilibrium can be easily observed by changes in colour.
1. Use a fresh solution of dilute $CoCl_2$ add distilled water dropwise (until a violet/maroon colour is observed).
2. Place 2mL of solution into 6 test tubes labelled 1, 2, 3, 4, 5 and 6
3. Keep test tube 1 as a control, place test tube 2 into a beaker of hot water (over 90°C) and test tube 3 into a beaker of crushed ice. Record your observations
4. Add 10mL of water to test tube 4 and 10mL of ethanol to test tube 5 (to remove water). Record your observations.
6. Add 2mL of concentrated HCl to test tube 6. Record you observations.

(c) (ii) (1 mark)
Outcomes Assessed: H10
Targeted Performance Bands: 4–6

Criteria	Mark
• Uses correct equilibrium reaction appropriate for experiment described in question above	1

Sample answer:
Many Possible

$[Co(H_2O)_6]^{2+}(aq) + 4Cl^-(aq) \leftrightarrow [CoCl_4]^{2-}(aq) + 6H_2O(l)$
violet/maroon blue

(c) (iii) (2 marks)
Outcomes Assessed: H7, H8
Targeted Performance Bands: 4–6

Criteria	Marks
• Clearly explains effects of changing at least TWO conditions on the equilibrium	2
• Clearly explains effects of changing ONE condition on the equilibrium OR • Identifies TWO conditions on the equilibrium	1

Sample answer:
Many Possible – must relate to experiment described in b(i)

eg
When the temperature was increased the equilibrium shifted to the right because the forward reaction is endothermic and a blue colour was observed.

When water was added there was a greater concentration of water and the equilibrium shifted to the left and became more pink in colour. The addition of ethanol removes water and the equilibrium shifts to the right to minimise the disturbance, becoming more blue in colour.

When HCl(aq) is added to the equilibrium, more Cl^- ions are added, shifting the equilibrium to the right and so the solution becomes more blue in colour.

(d) (i) (1 mark)
Outcomes Assessed: H10
Targeted Performance Bands: 2–4

Criteria	Mark
• Correctly writes an expression for the equilibrium constant	1

Sample answer:

$$K = \frac{[CO][H_2O]}{[CO_2][H_2]}$$

(d) (ii) (3 marks)
Outcomes Assessed: H10
Targeted Performance Bands: 3–6

Criteria	Marks
• Correctly calculates the value of K	3
• Calculates the number of moles of each substance at equilibrium AND substitutes these value into the equilibrium expression OR • Calculates K with one error	2
• Calculates the number of moles of each substance at equilibrium OR • Substitutes the initil mole value into the equilibrium expression	1

Sample answer:
Calculate the number of moles of each species at equilibrium

	$CO_2(g)$	+ $H_2(g)$	↔ $CO(g)$	+ $H_2O(g)$
Initially	0.2000	0.1000	0.0000	0.0000
At equilibrium	0.1908	0.0908	0.0092	0.0092

Calculate molar concentrations for each species

$[CO_2] = 0.1908\text{mol } CO_2/2.00\text{ L} = 0.0954\text{mol L}^{-1}$
$[H_2] = 0.0908\text{mol } H_2/2.00\text{L} = 0\ .0454\text{mol L}^{-1}$
$[CO] = 0.0092\text{mol CO}/2.00\text{L} = 0.0046\text{mol L}^{-1}$
$[H_2O] = 0.0092\text{mol } H_2O/2.00\text{L} = 0.0046\text{mol L}^{-1}$

Substitute each concentration into the equilibrium expression and calculate the value of the equilibrium constant.

$$K = \frac{[0.0046][0.0046]}{[0.0954][0.0454]} = 0.0049$$

(e) (2 marks)
Outcomes Assessed: H3, H7
Targeted Performance Bands: 2–6

Criteria	Marks
• Accounts for the action of soap due to the hydrophobic tails and hydrophilic head of the soap • Response appropriately refers to diagram	2
• Accounts for the action of soap due to the hydrophobic tails and hydrophilic head of the soap	1

Sample answer:
Soaps dissolve in water, dissociating into an anion and a cation. The anion consists of a nonpolar hydrophobic tail, indicated in the diagram by the short straight lines. The tails strongly attract the non-polar grease molecules via dispersion forces. The anion also has a hydrophilic head which is polar, shown as the circles, which readily dissolve in water due to dipole-dipole interactions. An oil in water emulsion results (the micelles in the diagram) and as the water is agitated the grease is carried away with it.

(f) (6 marks)
Outcomes Assessed: H3, H5
Targeted Performance Bands: 2–6

Criteria	Marks
• Provides a clear assessment statement based on criteria provided • Describes at least THREE uses of sulfuric acid • Outlines production steps in the manufacture of H_2SO_4 • Describes safety issues associated with the use of H_2SO_4 • Uses appropriate chemical equations	6
• Lists at least THREE uses of sulfuric acid • Describes production steps in the manufacture of H_2SO_4 • Describes safety issues associated with the use of H_2SO_4 • Uses appropriate chemical equations	4-5
• Lists uses of sulfuric acid • Identifies production steps in the manufacture of H_2SO_4 OR uses an appropriate chemical equation • Describes a safety issue associated with the use of H_2SO_4	2-3
• Lists a use of sulfuric acid OR • Identifies a production steps in the manufacture of H_2SO_4 OR uses an appropriate chemical equation OR • Describes a safety issue associated with the use of H_2SO_4	1

Sample answer:
The industrial production of sulfuric acid involves the combustion of sulfur (or metal sulfide ore e.g. PbS) to form sulfur dioxide.

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

$$2PbS(s) + 3O_2(g) \rightarrow PbO(s) + 2SO_2(g)$$

Sulfur dioxide may also be released form metal sulfide smelters which may be used directly to make sulfuric acid. The sulfur dioxide is then passed over vanadium pentoxide or platinum catalyst, at 450°C to produce sulfur trioxide. This process takes place in a catalytic converter.

$$2SO_2(g) + O_2(g) \rightarrow 2SO_3(g)$$

Absorption towers are then used to dissolve sulfur trioxide in sulphuric acid to form oleum, then the oleum is dissolved in water to form sulfuric acid.

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

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

Gaseous sulfur trioxide cannot be added directly to water as the reaction is very exothermic and would cause the acid to vaporise and form a dangerous mist. Also SO_2 contributes to the formation of acid rain and is now strictly controlled by government regulations.

Acidification of natural waterways and soils must considered when considering the location of industrial plants that produce or use sulfuric acid as this may affect the local flora and fauna. Disposal of waste should be carefully monitored on a regular basis.

When using acids, it should be remembered that they are corrosive and thus goggles, protective clothing and gloves should always be used when working with sulfuric acid. Acid should always be added in small amounts to water (not water to acid) when diluting as ionisation of sulfuric acid is vigorous and exothermic. Concentrated sulfuric acid can be transported and stored in iron containers, as it is molecular and does not readily react with iron. However, dilute sulfuric acid is stored in glass containers as it reacts with metal, increased issues where glass may be broken. The lid must be kept tightly sealed, as sulfuric acid absorbs water from the atmosphere.

Assessment: Sulfuric acid is one of the most important industrial chemicals as more of it is made each year than any other manufactured chemical. It has such a wide variety of uses, including playing some part in the production of nearly all manufactured goods. The major use of sulfuric acid is in the production of fertilizers, e.g., superphosphate of lime and ammonium sulfate. It is widely used in the manufacture of chemicals, e.g., in making hydrochloric acid, nitric acid, sulfate salts, synthetic detergents, dyes and pigments, explosives, and drugs. It is used in petroleum refining to wash impurities out of gasoline and other refinery products. Sulfuric acid is used in processing metals, e.g., in pickling (cleaning) iron and steel before plating them with tin or zinc. Rayon is made with sulfuric acid. It serves as the electrolyte in the lead-acid storage battery commonly used in motor vehicles.

Question 34 – Shipwrecks, Corrosion and Conservation (25 marks)

(a) (i) (1 mark)

Outcomes Assessed: H8

Targeted Performance Bands: 2–3

Criteria	Mark
• Defines an electrolyte	1

Sample answer:

An electrolyte is a substance that contains freely moving ions which can conduct an electric current.

(a) (ii) (2 marks)

Outcomes Assessed: H4

Targeted Performance Bands: 2–4

Criteria	Marks
• Explains why the oceans have more ions than non-marine waters and hence are better electrolytes	2
• Compares the ion concentration of the ocean and non-marine waters	1

Sample answer:

The ocean is a better electrolyte as it contains a larger concentration of ions. These ions are leached from terrestrial environments and from hydrothermal vents in mid-ocean ridges. Ions that are present in fresh water sources do not accumulate as they are flushed regularly and ultimately end up in the oceans.

(b) (7 marks)

Outcomes Assessed: H3, H8

Targeted Performance Bands: 2–6

Criteria	Marks
• Evaluates by – identifying the factors that affect the rate of an electrolysis reaction – discussing the electrolysis of an iron artefact with respect to some of these factors and efficiency and minimisation of harm to the artefact – describing the accuracy of the statement	7
• Evaluates by doing most of the above	5-6
• Discusses aspects of the electrolysis of artefacts with respect to efficiency and harm minimisation OR factors that affect the rate	3-4
• Identifies features of the electrolysis of an iron artefact OR • Identifies factors that affect the rate of an electrolysis reaction	1-2

Sample answer:

The factors that affect the rate of an electrolysis reaction are
- distance between the electrodes
- concentration of the electrolyte
- size of the electrodes
- voltage

When treating an iron artefact using electrolysis there are three considerations
- the rate of reaction can cause excessive bubbling that may result in outer layers of the corroded iron sloughing off
- artefacts are three dimensional and the rate will be faster on surfaces closer to the anode and slower on more distant surfaces
- electrolysis is a slow and expensive process

Considering all these issues the process can be carried out efficiently and without harm to the artefact. A low voltage will enable the chloride ions to be expelled from the outer layers and the iron ions to be reduced back to elemental iron hence restoring the artefact. A high voltage would result in vigorous bubbles that may abrade the outer layers before they can be reduced. The artefact should be placed within a steel mesh cage anode so that all sides of the three-dimensional object can be equally distant from the anode and hence reduced at a similar rate. The steel is inert and will not corrode and the mesh allows for the free movement of ions to prevent polarisation. This strategy also ensures that the long and expensive process is not prolonged and is thus carried out efficiently.
The statement is accurate as without a good understanding of the factors that affect the rate of an electrolysis reaction the iron artefact could be damaged, the process could be uneven and require additional time thus reducing efficiency and increasing costs.

(c) (i) (2 marks)

Outcomes Assessed: H5

Targeted Performance Bands: 2–3

Criteria	Marks
• Identifies an alloy and TWO constituent elements correctly	2
• Identifies an alloy	1

Sample answer:

Marine grade stainless steel contains iron and chromium.

(c) (ii) (1 mark)

Outcomes Assessed: H5, H8

Targeted Performance Bands: 2–3

Criteria	Mark
• Outlines correctly	1

Sample answer:

The reaction of the alloy to the presence of chloride ions is an important consideration for marine alloys.

(c) (iii) (4 marks)
Outcomes Assessed: H11, H12
Targeted Performance Bands: 2–5

Criteria	Marks
• Describes an investigation that includes THREE alloys, a suitable electrolyte, repetition, controlled variables and a method for comparing the rates of corrosion	4
• Describes an investigation that includes most of the above	3
• Outlines basic features of an investigation	2
• Identifies a feature of an appropriate investigation	1

Sample answer:
Identically sized, clean samples of mild steel, stainless steel and marine grade stainless steel were placed (not touching) in a large petri dish. Phenolphthalein and potassium hexacyanoferrate indicators were added to a warm agar solution made from seawater. The alloy samples were covered with the mixture. When the agar was set the dish was covered with a lid and inverted. This process was repeated three times. The dishes were placed in the same environment and photographed and observed each morning for five days. The change of colour of the two indicators was compared and the alloys that were slowest at producing Prussian Blue, which indicated oxidation of iron, were considered to be most suitable for a marine environment.

(d) (3 marks)
Outcomes Assessed: H8, H12
Targeted Performance Bands: 3–5

Criteria	Marks
• Explains using BOTH appropriate half-equations and standard potentials	3
• Explains using ONE appropriate half-equation and standard potential • Identifies BOTH appropriate half-equations and standard potentials	2
• Explains without using half-equations OR • Identifies ONE appropriate half equation and standard potential	1

Sample answer:
When iron oxidises the corresponding reduction equation is:

$$\tfrac{1}{2}\,O_2(g) + H_2O(l) + 2e^- \rightarrow 2OH^-(aq) \qquad 0.40V$$

In acidic conditions the reduction equation becomes:

$$\tfrac{1}{2}\,O_2(g) + 2H^+(aq) + 2e^- \rightarrow H_2O(l) \qquad 1.23V$$

Thus, as the higher reduction potential of the second half-equation implies, the corrosion of iron will be accelerated in even mildly acidic conditions.

(e) (i) (2 marks)
Outcomes Assessed: H7, H12, H13
Targeted Performance Bands: 2–4

Criteria	Marks
• Explains using TWO appropriate half-equations and standard potentials and comparing the oxidation potential of Fe and Cu.	2
• Explains using TWO appropriate half-equations OR standard potentials and comparing the oxidation potential of Fe and Cu.	1

Sample answer:
Iron is a stronger reductant than copper so the iron will be oxidised forcing the copper to act as a cathode.

$$Fe(s) \rightarrow Fe^{2+} + 2e^- \qquad 0.44V$$
$$Cu(s) \rightarrow Cu^{2+} + 2e^- \qquad -0.34V$$

(e) (ii) (1 mark)
Outcomes Assessed: H3
Targeted Performance Bands: 2–3

Criteria	Mark
• Identifies correctly	1

Sample answer:
Cathodic protection

(e) (iii) (2 marks)
Outcomes Assessed: H1, H4, H8
Targeted Performance Bands: 3–4

Criteria	Marks
• Explains the growth of marine organisms	2
• Identifies a reason for the growth of marine organisms	1

Sample answer:
Whilst the copper hulls were corroding they were protected from biofouling. The corrosion product of copper was probably responsible. The copper ions were toxic and formed a layer that was easily dislodged in the water, resulting in constant removal of any organisms. Davy's method prevented this corrosion which then allowed the organisms to attach and grow on the hull.

Question 35 – The Biochemistry of Movement (25 marks)

(a) (i) (1 mark)

Outcomes Assessed: H9, H13

Targeted Performance Bands: 2–3

Criteria	Mark
• Correct answer	1

Sample answer:

Fatty Acids

(a) (ii) (2 marks)

Outcomes Assessed: H9

Targeted Performance Bands: 2–3

Criteria	Marks
• Identifies BOTH sub classes of fatty acid	2
• Identifies ONE sub classes of fatty acid	1

Sample answer:

A: Saturated fatty acid

B: Unsaturated fatty acid

(b) (2 marks)

Outcomes Assessed: H9, H12, H13

Targeted Performance Bands: 4–6

Criteria	Marks
• Calculates correct answer	2
• Uses correct steps with incorrect answer OR • Calculates correct answer with incorrect units	1

Sample answer:

1 mol of glucose produces 38 mol ATP

180g of glucose produces 38 mol ATP

Rate of metabolism = 0.0015 ATP/g/minute

= 0.0015 x 1000g x 12min37sec (12.61666)

=18.925 mol ATP

Since 1 mol of glucose (or 180g) is required to metabolise 38ATP molecules

Glucose required = (18.926/38) x 180g = 89.65g

(c) (i) (3 marks)

Outcomes Assessed: H1, H12, H13

Targeted Performance Bands: 2–4

Criteria	Marks
• Outlines a logical sequence for the procedure used in the investigation, quantities, substances and equipment specified	3
• Outlines a logical sequence for the procedure used in the investigation	2
• Outlines some steps for the procedure used in the investigation	1

Sample answer:

Procedure

- 6 test tubes were filled with 25 mL of milk and numbered 1 to 6.
- A junket tablet (with enzyme rennin) was crushed and dissolved in 30 mL of water.
- 5 mL of enzyme solution was added to each test tube.
  - Test tube 1 was warmed to 37°C.
  - Test tube 2 was heated to 60°C in a hot water bath.
  - Test tube 3 was placed in crushed ice.
  - 10 mL of 1 mol L^{-1} NaOH was added to test tube 4.
  - 10 mL of 1 mol L^{-1} HCl was added to test tube 5.
  - 10 mL of 5 mol L^{-1} HCl was added to test tube 6.
- The observations were recorded for each test tube.

(c) (ii) (2 marks)

Outcomes Assessed: H11

Targeted Performance Bands: 2–3

Criteria	Marks
• Outlines at least TWO hazards and precautions taken for the experiment	2
• Outlines ONE hazard and precaution taken for the experiment	1

Sample answer:

When handling acids and bases you need to use safety glasses and gloves to protect your skin and eyes as acids and bases are corrosive. When disposing of acids and bases you need to first neutralise the sample then dispose of down the sink using plenty of running water.

(c) (iii) (1 mark)

Outcomes Assessed: H1, H14

Targeted Performance Bands: 3–4

Criteria	Mark
• Outlines an appropriate conclusion	1

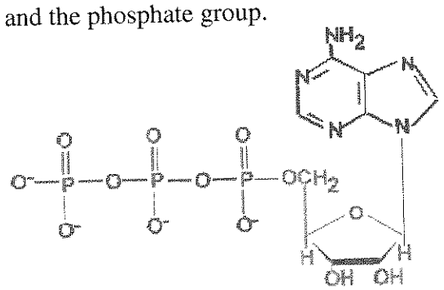
Sample answer:

The optimum conditions for the functioning of the enzyme rennin, which cause milk to coagulate, are 37°C and approximately 1 mol L^{-1} HCl acidic conditions. If the temperature or pH fluctuates from this fairly specific band the enzyme will denature and not function effectively.

(d) (6 marks)
Outcomes Assessed: H3, H8, H9, H13, H14
Targeted Performance Bands: 4–6

Criteria	Marks
• Demonstrates a thorough knowledge of ATP and its role in muscle contraction • Includes chemical structure of ATP • Demonstrates coherence and logical progression and includes correct use of scientific principles and ideas	5-6
• Demonstrates a sound knowledge of ATP and its role in muscle contraction • Communicates some scientific principles and ideas in a clear manner	3-4
• Demonstrates a basic knowledge of ATP and its role in muscle contraction • Communicates ideas in a basic form using general scientific terms	2
• Demonstrates a limited knowledge of ATP and its role in muscle contraction • Communicates simple ideas	1

Sample answer:
When compounds like glucose are metabolized in organisms, the energy released is captured and stored in the molecule ATP (adenosine triphosphate). ATP molecules exist in every living cell and play an important role in a biochemical pathway.
The structure of ATP is a molecule consists of a nitrogen base (adenine), a five carbon sugar and the phosphate group.



ATP actually contains 3 phosphate groups (thus TRIphosphate). The third phosphate can be removed by a hydrolysis reaction leaving the ADP (adenosine diphosphate) molecule and a phosphate molecule. During this reaction the highly exothermic reaction releases large amounts of chemical energy which can be utilized by organisms for energetic activities. It is possible to remove another phosphate group from AMP (adenosine monophosphate) to release further energy.

ATP plays an important role in muscle contraction. Initially muscle contractions are triggered by nervous impulses arriving at the cell membrane of a muscle cell. The contraction of muscle cells occur when a specific protein called an actin filament slides past the myosin filament. For this to occur specific enzymes are required that control the ATP molecule hydrolyzing to ADP releasing energy that is necessary for the muscle contraction to occur. At the same time calcium ions are released which also aid in the splitting of ATP into ADP and the subsequent interaction between actin and myosin.

(e) (i) (2 marks)
Outcomes Assessed: H9
Targeted Performance Bands: 3–4

Criteria	Marks
• Outlines ONE similarity AND ONE difference between the molecules	2
• Outlines ONE similarity OR ONE difference between the molecules	1

Sample answer:
Similarity: Both glucose and glycogen consist of the glucose monomer of formula $C_6H_{12}O_6$

Difference: Glucose is a small molecule consisting of just $C_6H_{12}O_6$ whilst glycogen is a molecule that consists of thousands of glucose monomers joined together by glycosidic bonds

e) (ii) (2 marks)
Outcomes Assessed: H9
Targeted Performance Bands: 3–4

Criteria	Marks
• Identifies exposed OH molecules and their role in hydrogen bonding	2
• Identifies OH molecules OR hydrogen bonding as reasons for solubility	1

Sample answer:
Both glucose and glycogen demonstrate high solubility in water. Both molecules possess many OH functional groups which are exposed outward enabling them to form hydrogen bonds with water molecules.

(e) (iii) (4 mark)
Outcomes Assessed: H7, H9
Targeted Performance Bands: 4–6

Criteria	Marks
• Outlines thoroughly the process of lactic acid formation and removal. • Uses correct terminology, biochemical principles and ideas	4
• Outlines to a high standard the process of lactic acid formation	3
• Outlines the removal of lactic acid AND • Outlines some areas of the formation of lactic acid	2
• Outlines the removal of lactic acid OR • Outlines some part of the formation of lactic acid	1

Sample answer:
Glycogen is converted to lactic acid via the following pathway:

Glycogen $\xrightarrow[\text{Hydrolysis}]{}$ glucose $\xrightarrow[\text{glycolosis}]{}$ pyruvic acid $\rightarrow$ lactic acid

(requires ADP → ATP)

Once creatine phosphate stores are depleted and exercise of high intensity continues, muscles generate energy for ATP re-synthesis by the lactic acid method shown above. The system is anaerobic; enzymes are needed for the conversion of glycogen to glucose and glycolysis results in the formation of pyruvic acid. When insufficient oxygen is present, the body has no time to deliver oxygen to the muscles to react with the increasing amount of pyruvic acid and lactic acid is therefore produced. This increase in lactic acid lowers the pH of muscle and renders them incapable of functioning efficiently causing fatigue and soreness. Eventually the lactic acid diffuses to the liver where it is re-synthesised to pyruvic acid which is further metabolised to carbon dioxide and water with the generation of molecules of ATP.

Question 36 – The Chemistry of Art (25 marks)
(a) (i) (2 marks)
Outcomes Assessed: H1
Targeted Performance Bands: 2–3

Criteria	Marks
• Identifies a pigment used AND • Describes the chemical composition of the identified pigment	2
• Identifies a pigment used OR • Describes the chemical composition of the identified pigment	1

Sample answer:
Traditional Aboriginal art used ochre pigments such as red ochre. The ochre was composed of anhydrous iron oxide (Fe_2O_3).

Other pigments used include ochre's of various other colours (yellow, brown), charcoal, kaolin, chalk, gypsum

(a) (ii) (2 marks)
Outcomes Assessed: H1, H6
Targeted Performance Bands: 3–4

Criteria	Marks
• Relates the need for an insoluble pigment to the application on a surface by a user and relates the effect of a soluble pigment to the difficulty of applying the pigment to a surface	2
• Relates the need for an insoluble pigment to the application on a surface OR • Relates the effect of a soluble pigment to the difficulty of applying a pigment to a surface	1

Sample answer:
To apply the pigment in the form of paint, the coloured pigment must be carried in a liquid medium. This allows it to be spread over the surface to which it is to be applied. The pigment remains insoluble so that it can be seen and as the medium dries, the colour remains. If the pigment is soluble, then the painter would be applying a solution that was too pale to seen on the surface.

(b) (i) (2 marks)
Outcomes Assessed: H11, H13
Targeted Performance Bands: 2–3

Criteria	Marks
• Describes a valid method and identifies the flame colour	2
• Identifies basic steps in an appropriate method OR • Identifies the flame colour	1

Sample answer:
A platinum wire is thoroughly cleaned. A small sample of a potassium compound such as KCl is adhered to the end of the wire and the powder is placed in a non-luminous Bunsen burner flame. The flame colour for potassium is violet (or lilac).

(b) (ii) (3 marks)
Outcomes Assessed: H6, H7, H8
Targeted Performance Bands: 3–5

Criteria	Marks
• Clearly demonstrates the relationship between the heat energy and excited state AND • Identifies the release of a photon of radiation as the energy is released from the atom AND • Relates the colour produced to part of the visible spectrum	3
• Any TWO of the above	2
• Any ONE of the above	1

Sample answer:
Emission spectra are caused by excited atoms emitting light. This light is caused by the atoms of the element being heated in the Bunsen flame which supplies the additional energy required to move the electrons to a higher energy level. This is termed an excited state. When the electron returns to a lower energy level a photon of radiation is released and in the case of potassium, this light falls with the visible spectrum range and is seen as purple light.

(b) (iii) (1 mark)
Outcomes assessed: H11
Targeted Performance Bands: 2–3

Criteria	Mark
• Identifies a valid safety precaution and explains how the precaution reduces a risk	1

Sample answer:
Flame testing involves the use of naked flames. Safety glasses, gloves and laboratory coats should be worn to reduce the risk of getting material in the eye and burns to the skin from hot apparatus.

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

Criteria	Mark
• Identifies the electron configuration of the aluminium atom	1

Sample answer:
Aluminium has an electron configuration of $1s^2$, $2s^2$, $2p^6$, $3s^2$, $3p^1$.

(c) (ii) (2 marks)
Outcomes Assessed: H13
Targeted Performance Bands: 2–4

Criteria	Marks
• Distinguishes between the terms ionisation energy and electronegativity	2
• Defines ionisation energy OR • Defines electronegativity	1

Sample answer:
The ionisation energy of an atom is the energy required to remove an electron from an atom. This will lead to a positive ion being formed. Electronegativity refers to an atoms ability to attract an electron. This will lead to an atom becoming more negative if an electron is attracted towards it.

(c) (iii) (2 marks)
Outcomes Assessed: H6
Targeted Performance Bands: 3–5

Criteria	Marks
• Relates the pattern of ionisation energies to the electron configuration	2
• Describes a partially correct relationship between aluminium's electron configuration and the pattern of ionisation energies	1

Sample answer:
Aluminium has 3 electrons in its outer (valency) energy level. These electrons are arranged with two in the 3s and one in a 3p orbital. As each of these electrons is removed, more energy is needed to remove the next electron because of the increasing positive charge on the species formed.
Once the first three electrons have been removed, removing the fourth takes a much greater amount of energy, as the next electron will be removed from a 2p orbital, which is much closer to and therefore more tightly held by the nucleus.

(d) (i) (2 marks)
Outcomes Assessed: H6, H13
Targeted Performance Band: 3–5

Criteria	Marks
• Demonstrates the feature of all ligands is the presence of a lone pair • Provides detail on the nature of the bonding between the metal and the ligand	2
• Demonstrates the feature of all ligands is the presence of a lone pair OR • Provides detail on the nature of the bonding between the metal and the ligand	1

Sample answer:
A ligand is able to form a coordinate covalent bond between an anion (Cl^-) or molecule (H_2O) due to the presence of a lone pair of electrons on the anion or an atom within the molecule. They act as Lewis bases and donate an electron pair and the metal (Co) acts as a Lewis acid and accepts an electron pair from the ion or molecule.
Only atoms that have a lone pair could form coordinate covalent bonds and therefore act as a ligand in a coordination complex.

(d) (ii) (2 marks)
Outcomes Assessed: H6, H8
Targeted Performance Band: 3–5

Criteria	Marks
• Relates the colour to change to a variation in ligands bonded to the metal • Identifies the oxidation state of the metal	2
• Relates the colour to change to a variation in ligands bonded to the metal OR • Identifies the oxidation state of the metal	1

Sample answer:
The colour of a transitional metal complex may be due to the oxidation state of the transition metal, the type of metal present and the ligands bonding to the metal.
In all three cobalt complexes the oxidation state of cobalt is +2. Therefore, the colour change that occurs in this reaction is primarily due to the additional H_2O ligands that would be available to bond to cobalt in the presence in the presence of water. Initially the chloride ligands are replaced by four water ligands. With the addition of more water ligands (in a wet environment), a colour change is observed due to variations in the separation of the d-orbitals.

Please turn over

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(e) (6 marks)
Outcomes Assessed: H6, H13, H14
Targeted Performance Band: 3–6

Criteria	Marks
• Analyses the contribution of Bohr and Pauli • Explains THREE limitations and/or benefits to the models/ideas provided by the Scientists and relates the limitations and/or benefits to experimental observations • Demonstrates a link between the work of Bohr and Pauli	6
• Explains THREE limitations and/or benefits to the models/ideas provided by the Scientists • Relates the limitations and/or benefits to experimental observations • Demonstrates a link between the work of Bohr and Pauli	5
• Explains TWO limitations and/or benefits to the models/ideas provided by the Scientists • Relates the limitations and/or benefits to experimental observations • Demonstrates a link between the work of Bohr and Pauli	4
• Identifies TWO limitations and/or benefits to the models/ideas provided by the Scientists AND relates the limitations and/or benefits to experimental observations OR • Demonstrates a link between the work of Bohr and Pauli	3
• Identifies TWO limitations and/or benefits to the models/ideas provided by the Scientists	2
• Identifies ONE limitation and/or benefit to the models/ideas provided by the Scientists	1

Sample answer:
Bohr and Pauli developed their ideas and models of the atom to describe the experimental observations of emission spectra.
The emission spectra for different atoms indicated that each had a different internal structure. Bohr's model of the hydrogen atom proposed that electrons could exist in fixed radii and energy levels. When energy was supplied they could move to higher energy levels and would emit energy when the electrons returned to lower energy levels. This adequately explained the line emission spectra produced and therefore was highly effective.
Some limitations of the Bohr model were that it did not explain the line emission spectra of atoms with more electrons than hydrogen, where the frequencies observed did not agree with the predications. Furthermore, his model could not explain the existence of different intensities in the lines of the emission spectra and the closer examination of single lines that were actually two closely separated lines (a doublet).

Pauli's idea was highly effective in explaining this limitation of the Bohr model. Electrons can exist not in fixed radii from the nucleus but more accurately, in subshells each containing different orbital. He proposed that an electron orbital can hold two electrons and each of these must have an opposite spin. Two opposite spins result in a doublet in the line emission spectra and his idea effectively explained a limitation of the Bohr model and improved on our understanding of electron behaviour.
Analysis: Bohr's model of the atom was useful in explaining the line emission spectra for the hydrogen atom but failed for other atoms and when the spectrum was examined more closely, limitation were noted. Pauli's idea was highly effective in correcting inadequacies in the Bohr model and further improved our understanding of electron behaviour.

Question 37 – Forensic Chemistry (25 marks)

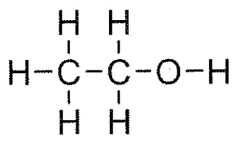
(a) (3 marks)

Outcomes Assessed: H9

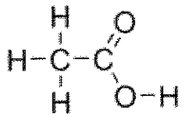
Targeted Performance Bands: 2–4

Criteria	Marks
• Draws THREE diagrams that correctly identify THREE classes of carbon compounds • Identifies appropriate tests to distinguish between the classes of compounds • Explains that the functional groups react with specific reagents, allowing for identification	3
• Draws THREE diagrams that correctly identify THREE classes of carbon compounds • Identifies appropriate tests to distinguish between the classes of compounds OR • Explains that the functional groups react with specific reagents, allowing for identification	2
• Draws THREE diagrams that correctly identify THREE classes of carbon compounds OR • Identifies appropriate tests to distinguish between the classes of compounds OR • Describes that the functional groups react with specific reagents, allowing for identification	1

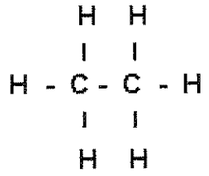
Sample answer:



alkanol (ethanol)



alkanoic acid (ethanoic acid)



hydrocarbon (ethane)

(Note : examples of tests will vary dependent on whether the identified hydrocarbon is an alkane, alkene or alkyne)
Alkanols can be identified simply by adding dilute permanganate solution (or bromine water) which will change the colour of the permanganate (or decolourise the bromine), (also occurs with alkenes). Or dry the sample using calcium chloride and add a small piece of sodium, bubbles of colourless gas (H_2) will form if the sample is an alkanol.
Alkanoic acids can be identified by adding drops of sodium carbonate, bubbles of colourless gas (CO_2) will form if the sample is an alkanoic acid.
Alkanes can be identified if the previous tests are negative, can be confirmed by adding bromine solution in UV light and the bromine will slowly decolourise if an alkane is present.

The specific reagents will react with the functional group of the carbon compound to give a positive reaction where the compound is present.

(b) (i) (1 mark)

Outcomes Assessed: H9

Targeted Performance Bands: 2–3

Criteria	Mark
• Describes the presence of either a –CHO or –CO-CH_2OH on the reducing sugar that is absent on a non-reducing sugar	1

Sample answer:

A reducing sugar, in its open chain form, has either a –CHO or –CO-CH_2OH group that can be easily oxidised to a carboxylic acid, thus reducing other reagents. A non-reducing sugar cannot convert to an open ring structure and does not have an –OH attached to the same carbon that is also attached to a ring O atom.

(b) (ii) (2 marks)

Outcomes Assessed: H9

Targeted Performance Bands: 3–4

Criteria	Marks
• Outlines that a reducing sugar can be identified with Benedict's solution (blue), Fehling's solution (blue) or Tollen's reagent • Outlines that starch can be identified with iodine solution • States the expected positive result for the named reagents	2
• Outlines a reducing sugar can be identified with Benedict's solution (blue), Fehling's solution (blue) or Tollen's reagent • Outlines that starch can be identified with iodine solution	1

Sample answer:

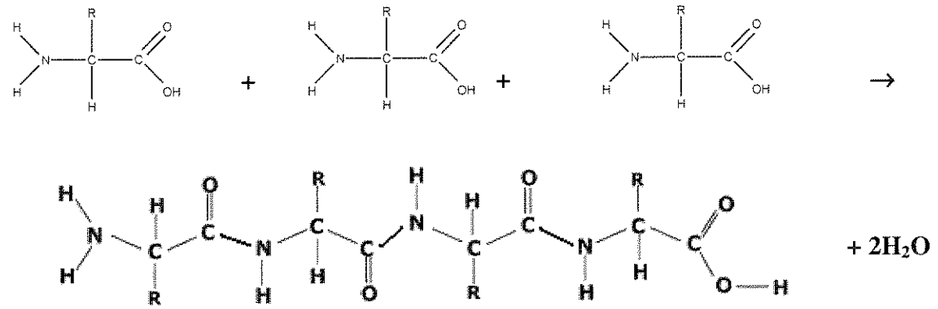
Reducing sugars can be identified using:
Benedict's solution (blue) - on gentle heating with reducing sugar, reagent will form a reddish brown precipitate, no reaction with starch.
Fehling's solution (blue) - on gentle heating with reducing sugar, reagent will form a reddish brown precipitate, no reaction with starch.
Tollen's reagent (colourless solution) – on gentle heating with reducing sugar, metallic silver (as black precipitate or shiny mirror on walls of clean test tube) will form, no reaction with starch.

Starch can be identified by using drops of yellow-brown iodine solution which, when added to starch, will form a blue-purple complex. Iodine will not change colour in the presence of a reducing sugar.

(c) (i) (1 mark)
Outcomes Assessed: H9
Targeted Performance Bands: 3–4

Criteria	Mark
• Draws the general formula of at least ONE amino acid and a polypeptide sequence showing the formation of a peptide bond	1

Sample answer:



(c) (ii) (2 marks)
Outcomes Assessed: H8
Targeted Performance Bands: 2–4

Criteria	Marks
• Identifies that enzymes break proteins at specific arrangements of amino acids • Explains that if the amino acid sequence is known, specific enzymes can be used to break the protein into desired pieces, without breaking it into individual amino acids	2
• Identifies that enzymes break proteins at specific arrangements of amino acids OR • States that specific enzymes can be used to break the protein into desired pieces, without breaking it into individual amino acids	1

Sample answer:
Enzymes are biological catalysts with highly specific active sites. Some, such as trypsin, act to break a peptide bond by hydrolysis at a specific sequence of amino acids. Thus, if the amino acid sequence is known, a specific enzyme or enzymes can be used to break the protein into pieces of a specific size, without breaking it into individual amino acids.

(c) (iii) (4 marks)
Outcomes Assessed: H13
Targeted Performance Bands: 2–5

Criteria	Marks
• Clearly details procedures used in a logical method, identifying the use of either chromatography or electrophoresis • Names the reagent used to visualise the position of the amino acid or protein fragments	4
• Clearly outlines method • Names the reagent used to visualise the position of the amino acid or protein fragments	3
• Outlines method	2
• Includes some appropriate steps but not in the correct sequence	1

Sample answer:
Either separation by chromatography or electrophoresis is acceptable.
eg Separation by chromatography.

1. Cut a suitable length of chromatography paper.
2. Using 3 different pipettes, place a drop of each amino acid (controls), and the mixture at the appropriate positions marked at the bottom of the paper.
3. In a fume cupboard or well ventilated area of the lab, pour a small amount of chromatography solvent (butanol/ethanoic acid) into the glass chamber (to about 1 cm depth). Place on the lid to allow the atmosphere to become saturated with vapour.
5. Attach the paper to the lid, and then place the lid on. The paper should not touch the sides of the chamber. The solvent should touch the lower part of the paper but not cover the drops of samples.
6. When the solvent nears the top of the paper, remove the paper from the apparatus, and use a pencil to mark the position of the solvent front. Place the chromatograms into an oven at about 45 C to dry.
7. Either in a fume cupboard or or well ventilated area, spray ninhydrin dissolved in acetone evenly over the paper.
8. Return the chromatograms to the oven to develop the colour. Spots should be visible as purplish smears on the paper.

(d) (2 marks)
Outcomes Assessed: H
Targeted Performance Bands: 2–4

Criteria	Marks
• Identifies that non-coding regions are unique to individuals • Explains that uniqueness of non-coding regions makes the analysis highly accurate	2
• Identifies that non-coding regions are unique to individuals	1

Sample answer:
DNA carries two forms of information; genetic coding and non-coding information. The pattern of non-coding information that is used in DNA identification of individuals and family members by comparison of samples. The genetic coding portion of a person's DNA is very similar to another and is not used to specifically and uniquely identify a person. It can however be used to identify the species of organism. Non-coding information is carried on the series of bases which separate the genetic coding information. This "junk DNA" sequence is unique to an individual as the structure is developed from both the parents of the individual (about half from each parent). Only identical twins have identical DNA and therefore identical base sequences. Therefore DNA analysis has a high degree of accuracy.

(e) (4 marks)
Outcomes Assessed: H3, H4
Targeted Performance Bands: 4–5

Criteria	Marks
• Identifies TWO different forms of DNA databanks • Compares DNA databanks to other forms of personal profiles (eg fingerprints, dental and medical records) • Outlines ethical issues • Indicates benefits/advantages of DNA databanks • Indicates problems/disadvantages of DNA databanks	4
• Describes a DNA databank as storage of personal information • Lists ethical issues • Indicates benefits/advantages of DNA databanks • Indicates problems/disadvantages of DNA databanks	3
• Identifies DNA databank • Indicates benefits/advantages of DNA databanks OR • Indicates problems/disadvantages of DNA databanks	2
• Indicates benefit/advantage of DNA databanks • Indicates problem/disadvantage of DNA databanks	1

Sample answer:
The collection and storage of personal profiles, such as fingerprints, blood types, dental and medical records, have provided the positive identification of countless individuals. However, the similar collection and storage of DNA information in a data bank has been subject to much controversy as the information stored may provide other information about individuals, not just their identity. DNA information can be stored in a data bank by two methods. Firstly, the collection and storage of actual DNA, as DNA is a highly stable molecule if kept under the right conditions. The second method only stores the results of DNA analysis (profile). Benefits of the use of DNA data banks include the identification of individuals responsible for major crimes, the identification of individuals who have been incorrectly suspected of committing a crime, or the identification of individuals who cannot be identified by other means (eg after fires or bombs). Problems of DNA data banks arise due to a large number of ethical concerns, including the invasion of privacy in collecting specimens from suspects and access of information, potential for genetic discrimination by government, insurers, employers, schools, banks etc if DNA analysis provides information about genetic disease, and the problems of storage of biological samples.

(f) (6 marks)

Outcomes Assessed: H3, H4

Targeted Performance Bands: 2–6

Criteria	Marks
• Defines the terms destructive and non-destructive testing • Compares destructive and non-destructive testing • Provides named examples of modern analytical techniques and the types of analysis performed • Provides advantages AND disadvantages of destructive techniques • Provides advantages AND disadvantages of non-destructive techniques • Assesses the value of modern techniques based on criteria	6
• Defines the terms destructive and non-destructive testing • Provides named examples of modern analysis techniques and the types of analysis performed • Provides advantages AND disadvantages of destructive techniques OR • Identifies advantages AND disadvantages of non-destructive techniques • Assesses the value of non-destructive techniques	5
• Defines the term "non-destructive testing" • Provides named examples of non-destructive analysis techniques • Provides advantages OR disadvantages of destructive techniques AND • Identifies advantages OR disadvantages of non-destructive techniques	4
• Defines the term "non-destructive testing" • Provides a named example of non-destructive analysis techniques • Identifies an advantage AND a disadvantage of non-destructive techniques	3
• Provides a named example of non-destructive analysis techniques • Identifies an advantage AND a disadvantage of non-destructive techniques	1-2

Sample answer:

Techniques used in analysis of samples for forensic reasons can be classified as non-destructive and destructive techniques.

Non-destructive techniques do not alter the sample in any way. Examples include optical methods (naked eye, light microscopy, photography eg, comparing damage to car paint and car bodies after accidents) and spectroscopic techniques (ultra-violet, Fourier transform infrared, X-ray fluorescence). A significant advantage of non-destructive testing is that the samples in their original form and the analysis may be completed with fewer transfers of the sample from location to location, increasing the risk of contamination. However, the cost and location of the equipment, expertise required to perform the analysis and the restrictions of the information available using these techniques may limit the usefulness of these techniques.

Techniques are considered destructive in forensic science if they modify the sample in some way and the original sample is not longer available for re-analysis. Destructive techniques include chemical reactions (screening tests for explosives, drugs, blood, DNA analysis eg for identifying suspects), spectroscopic techniques (mass spectrometry eg for analysis to determine compounds or elements present) and analytical separation (thin layer chromatography, gas-liquid chromatography, high performance liquid chromatography eg for blood or urine analysis for athletes) and electron microscopy eg scanning EM for car paint analysis. An advantage of modern destructive techniques is that small samples can be used to achieve extremely accurate results which are difficult to refute. However the major disadvantage of destructive is that performing the analysis alters the sample, but if the sample is large enough it is not necessarily relevant. The cost and location of the equipment and expertise required to perform the analysis are also limitations.

All possible non-destructive techniques should be performed on a sample prior to the use of destructive technique. The integrity of a sample in its original form is paramount in a criminal trial because if the original sample is not altered in any way it can be re-analysed and results reproduced by an independent analyst. Modern analysis techniques are extremely useful in forensic chemistry. They allow for highly accurate results to be collected and analysed to be used in legal argument. Even though there is some risk of convicting a person based on "planted evidence" or arguments that the analysis is flawed in some way, the sensitivity of the techniques add significant value in forensic investigations.