2010
Higher School Certificate
Trial Examination

Chemistry

General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Board approved calculators may be used
- Write using black or blue pen
- Draw diagrams using pencil
- A data sheet and a Periodic Table are provided separately
- Write your student number and/or name at the top of every page

Total marks – 100

Section I – Pages 2–16
75 marks
This section has two parts, Part A and Part B

Part A – 20 marks
Attempt Questions 1–20
Allow about 35 minutes for this part

Part B – 55 marks
Attempt Questions 21–31
Allow about 1 hour and 40 minutes for this part

Section II – Pages 17–36
25 marks
Attempt ONE question from Questions 32–36
Allow about 45 minutes for this section

This paper MUST NOT be removed from the examination room

STUDENT NUMBER/NAME: .....

STUDENT NUMBER/NAME: .....

Section I
75 marks

Part A – 20 marks
Attempt Questions 1–20
Allow about 35 minutes for this part

Select the alternative A, B, C or D that best answers the question and indicate your choice with a cross (X) in the appropriate space on the grid below.

	A	B	C	D
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	A	B	C	D
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18				
19				
20				

1. A solution of *bromine water* is suitable to identify which group of compounds?

   (A) Alkanes
   (B) Alkenes
   (C) Alkanols
   (D) Esters

2. *Ethanol* is now widely used as a component of petrol. The molar heat of combustion of ethanol is 1370 kJ mol^{-1} and its density is 0.80 g mL^{-1}.

   What is the heat produced when 1.0 L of ethanol undergoes complete combustion?

   (A) 1370 x 800
   (B) 1370 ÷ 46
   (C) 1370 x 800 ÷ 46
   (D) 1370 x 46 ÷ 800

3. Which reagent oxidises copper metal to copper(II) ions?

   (A) Silver nitrate solution
   (B) Concentrated hydrochloric acid
   (C) Steam
   (D) Zinc sulfate solution

4. For any working *galvanic cell,* which statement is correct concerning the oxidation electrode?

   (A) It is always a metal.
   (B) The polarity is negative.
   (C) Oxygen is required for the reaction.
   (D) Electrons pass from the external circuit into this electrode.

Refer to the following information to answer Questions 5 and 6.

This is an extract from an April 2010 news item, reporting the discovery of a new element.

"In this case, the target was made from berkelium, a radioactive element. It took the Oak Ridge National Laboratory more than a year to process and purify the berkelium used as the cyclotron's target. Researchers at the cyclotron in Dubna then fired beams of calcium ions at the target for 150 days. The haul for all that trouble: six atoms of element 117.

The atoms existed for between 21 and 45 millionths of a second".

5. Which of the following is the main reason that *berkelium* was selected as the target for calcium ions, to create element number 117?

   (A) Berkelium is easy to obtain.
   (B) Berkelium is very stable.
   (C) Berkelium atoms have 97 protons.
   (D) Berkelium has a large atomic radius.

6. To which of the following groups do both berkelium and element 117 belong?

   (A) Alkali metals
   (B) Halogens
   (C) Lanthanides
   (D) Transuranics

7. Bromothymol blue is an *indicator,* changing from yellow to blue with a pH range of 6.0 – 7.6. Bromothymol blue is added to a variety of different solutions. The solutions were made by dissolving samples of the compounds shown in the table below.

   Which alternative below matches the solutions shown with the correct indicator colour?

	NO_2	CaO	$NaCl$	Na_2O
(A)	yellow	blue	green	blue
(B)	blue	blue	green	yellow
(C)	green	yellow	blue	green
(D)	blue	green	blue	yellow

8. Dilute solutions of citric acid and hydrochloric acid are both found to have a pH of 2.0.

Which combination of concentrations, in mol L^{-1}, could explain this observation?

	Citric acid	*Hydrochloric acid*
(A)	0.020	0.020
(B)	0.10	0.010
(C)	2.0	1.0
(D)	0.20	0.020

9. What volume of 0.080 mol L^{-1} potassium hydroxide solution is required to completely neutralise a 20.0 mL volume of 0.050 mol L^{-1} sulfuric acid?

(A) 6.3 mL
(B) 12.5 mL
(C) 20.0 mL
(D) 25.0 mL

10. Which of the following correctly identifies a base and its conjugate acid in the equation below?

$$NH_2^- + HF \rightarrow NH_3 + F^-$$

	Base	*Conjugate acid*
(A)	NH_2^-	NH_3
(B)	HF	F^-
(C)	NH_3	F^-
(D)	F^-	NH_2^-

11. A 0.10 mol L^{-1} solution of acetic (ethanoic) acid has a pH of 2.9. A buffer solution was prepared by adding a salt to a solution of 0.10 mol L^{-1} acetic acid.

Which of the following alternatives correctly identifies the required salt, and the resulting pH of the buffer solution?

(A) Sodium chloride, pH < 2.9
(B) Sodium acetate, pH < 2.9
(C) Sodium acetate, pH > 2.9
(D) Sodium chloride, pH = 7.0

12. A 10.0 mL sample of 0.05 mol L^{-1} HCl solution is diluted to 1.0 L using distilled water.

Which of the following changes would be a result of this dilution?

(A) A decrease in pH by 1 unit
(B) An increase in pH by 1 unit
(C) A decrease in pH by 2 units
(D) An increase in pH by 2 units

13. Which of the following is the best example of *collaboration* between chemists as they collect and analyse data?

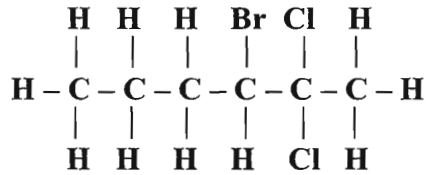
(A) Industrial chemists use computers to predict the properties of polymers based on their reaction to different temperatures and catalysts.
(B) Analytical chemists constantly monitor equipment such as spectrometers to ensure that the required conditions and purity of reactants are maintained.
(C) Environmental chemists evaluate processes proposed by other chemists and jointly discuss any data obtained to maintain high standards of air and water quality in ecosystems.
(D) An organic chemist analyses a fungicide for the presence of a compound that is toxic to fish and carefully prepares a report for relevant authorities to use.

14. A solution is known to contain *either* sodium sulfate or sodium chloride.

Which of the tests below would enable you to identify the substance present?

(A) A yellow flame obtained when a platinum wire is dipped into each solution separately and heated, would indicate the presence of sulfate ions.
(B) Add $Ba(NO_3)_2$ solution. The formation of a white precipitate would indicate the presence of sulfate ions.
(C) Add $Ba(NO_3)_2$ solution. The formation of a white precipitate would indicate the presence of chloride ions.
(D) Add NaOH solution. The formation of a white precipitate would indicate the presence of sulfate ions.

15. What is the correct name for the following compound?



(A) 3-bromo-2,2-dichlorohexane
(B) 2 -dichloro-3-bromohexane
(C) 3-bromo-2-dichlorohexane
(D) 4-bromo-5,5-dichlorohexane

16. Which of the following statements best describes *chlorine* free radicals?

(A) They react with CFCs causing them to release more chlorine gas.
(B) They react with ozone in the stratosphere and convert it to oxygen.
(C) They are mostly formed in the troposphere and filter through to the stratosphere.
(D) They do not directly affect ozone but cause significant amounts of greenhouse gases to form.

17. Which of the following chemicals is currently used as a replacement for chlorofluorocarbons (CFCs)?

(A) Hydrofluorocarbons
(B) Halons
(C) Freons
(D) Esters

18. Which of the following ions causes water to be called 'hard'?

(A) Mg^{2+} and OH^-
(B) NH_4^+ and Ca^{2+}
(C) Mg^{2+} and Ca^{2+}
(D) Na^+ and Cl^-

19. What is a typical use of a microscopic *membrane filter*?

(A) To sanitise town water supplies by adding chlorine
(B) To allow H^+ and OH^- ions to react to form pure water molecules
(C) To remove coagulated solids from waste water
(D) To remove bacteria from contaminated water supplies

20. Which of the following species is capable of forming a coordinate covalent bond with a water molecule?

(A) An ammonium ion
(B) A chloride ion
(C) A hydrogen molecule
(D) A hydrogen ion

Section I (continued)

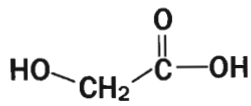
Part B – 55 marks
Attempt Questions 21–31
Allow about 1 hour 40 minutes for this part

Answer the questions in the spaces provided.

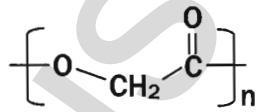
Show all relevant working in questions involving calculations.

Question 21 (5 marks) **Marks**

Polyglycolic acid (PGA) is a polyester which is thermoplastic and biodegradable.
Its chemical structure is based upon glycolic acid and it is used in surgery for self-dissolving sutures ("stitches").



Glycolic Acid



Polyglycolic Acid (PGA)

(a) Identify the *by-product* formed when glycolic acid is polymerised and explain why this polymer is classed as a polyester. **2**

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(b) For surgical use, the polymer is required to have an average molecular mass of at least 60,000. Calculate the average number of units per molecule for this mass. **1**

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(c) Define the term *biodegradable* and suggest a reason, based on its chemistry, why the polymer would dissolve in living tissue. **2**

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Question 22 (5 marks) **Marks**

Biofuels include biomass and other fuels derived by chemical processing of biomass.

(a) Identify ONE biofuel derived from biomass and briefly describe the process by which it is extracted. **2**

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(b) Outline ONE advantage of this biofuel, compared with direct combustion of biomass. **1**

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(c) Describe TWO potential problems associated with the increasing use of biofuels. **2**

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Question 23 (6 marks)

A student is provided with a strip of zirconium metal and asked to measure its *potential difference* against samples of magnesium, nickel and zinc.

(a) Construct a labelled diagram of the apparatus you would use to carry out this investigation. **2**

Question 23 continues on the next page

Question 23 (continued) **Marks**

(b) The table below shows measurements obtained by the student for this investigation.

Metals	*Pot. Diff. (V)*	*Polarity of Zr*
Mg, Zr	**0.7**	+
Ni, Zr	**1.2**	-
Zn, Zr	**0.7**	-

(i) Construct a half-reaction equation for the magnesium electrode in the first cell. **1**

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(ii) Determine the chemical activity of zirconium compared with these three metals. Explain your reasoning. **2**

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(c) Predict the polarity of the zirconium in a similar cell, using copper and zirconium electrodes, and estimate the voltage of this cell. **1**

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Question 24 (4 marks)

Actinium-227 ($_{89}Ac^{227}$) undergoes *radioactive decay* with a mixture of alpha and beta emissions.

(a) Describe the composition of the product nucleus, when Ac^{227} emits a beta particle. **1**

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(b) Given a Geiger counter, outline a procedure by which you could determine the proportions of alpha and beta emissions from a sample of Ac^{227}. **3**

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Question 25 (4 marks) **Marks**

Sulfur dioxide molecules remain in the atmosphere for an average of between 2 and 20 days, while CFC (chlorofluorocarbon) molecules remain in the atmosphere for many decades.

Including relevant equations, explain why there is concern about the industrial emission of both sulfur dioxide and CFCs, given the large difference in times for which they exist in the atmosphere. **4**

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Question 26 (4 marks)

During your study of chemistry you performed analysis of a selected acid by *titration*.

Describe AND justify at least *four* steps you took in performing your analysis, to reduce experimental errors and thus ensure your titration results were valid and reliable. **4**

Step taken	Justification

STUDENT NUMBER/NAME: .....

Question 27 (6 marks) **Marks**

(a) Calculate the volume of CO_2 gas produced (measured at 25°C and 100 kPa), when 5.00 g of $CaCO_3$ is dissolved in excess hydrochloric acid. **2**

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(b) Identify an *amphiprotic* ion formed when compressed carbon dioxide is dissolved in water; and construct an *ionic equation* for the reaction of this ion with dilute potassium hydroxide solution. **2**

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(c) Outline an experiment to measure the *mass* of carbon dioxide in a can of soft drink, and the *volume* of this gas at 25^0C and 100 kPa. **2**

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Question 28 (6 marks) **Marks**

(a) (i) Using *structural* formulae, write a balanced equation for the production of an ester using acetic (ethanoic) acid and 1-propanol. *Name* the ester produced. **2**

(ii) Justify the use of a *catalyst* in the production of this ester. **1**

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(b) The table below shows the boiling points of some organic compounds.

Name	*Molar mass (g mol^{-1})*	*Boiling point (^{o}C)*
Acetic acid	60.1	117.9
1-propanol	60.1	97.2
Ethyl methanoate	60.1	54.2

Explain the *difference* in boiling points between these three compounds. **3**

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Question 29 (5 marks) **Marks**

(a) The production of ammonia from gaseous elements is commonly known as the *Haber process.*

Write a *complete equation* for the Haber process AND explain the impact of a *decrease* in pressure on the system. **3**

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(b) The following table gives data on the percentage yield of ammonia, for various temperatures at a constant pressure of 200 x 10^2 kPa.

Temperature (°C)	*Percentage yield of ammonia*
200	90
300	64
350	51
400	39
500	20

Using this information, predict whether the production of ammonia is an *endothermic* or *exothermic* process. Explain your answer. **2**

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Question 30 (2 marks) **Marks**

The trace element *cobalt*, as the cobalt(II) ion, is vital to human health at a required level of around 0.3 $\mu g\ L^{-1}$ in blood serum.
A solution of cobalt ions can be prepared by dissolving cobalt (II) nitrate in water.
Describe a procedure to prepare a standard solution of cobalt ions, at 1.0 $\mu g\ L^{-1}$ concentration, for atomic absorption spectroscopy. **2**

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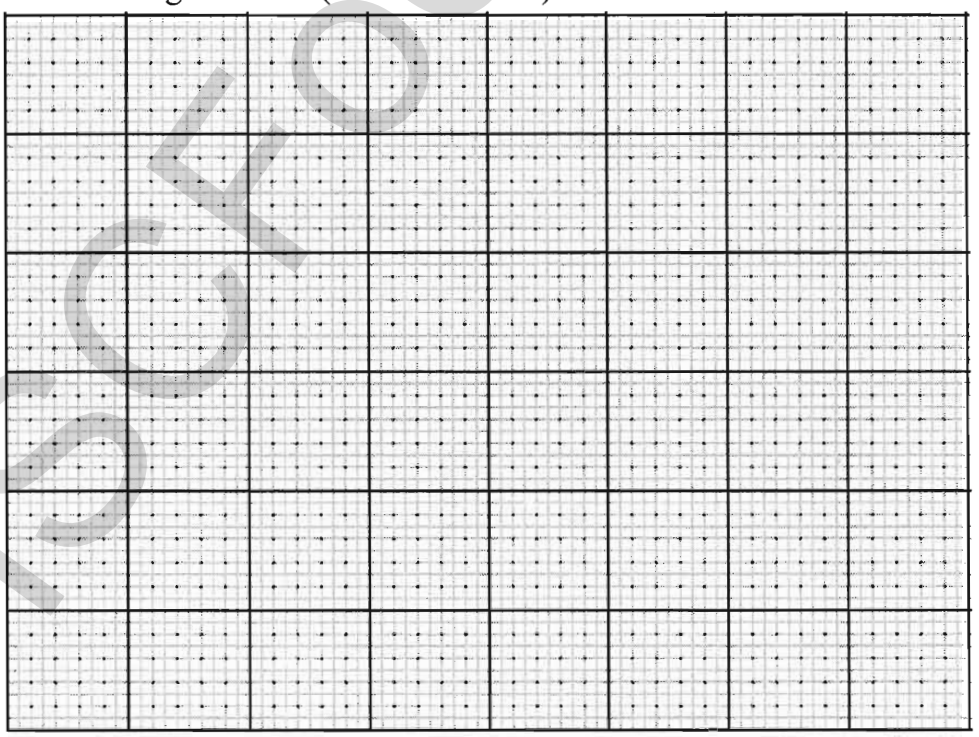
Question 31 (8 marks)

(a) The table below contains measurements of dissolved oxygen and biochemical oxygen demand, for a river into which sewage has been discharged.

Distance downstream (km)	0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0
Dissolved oxygen (ppm)	110	111	110	84	62	33	2	29	56
Biochemical oxygen demand (ppm)	2.0	2.1	2.0	108	78	49	31	18	2.0

Graph BOTH *dissolved oxygen* and *biochemical oxygen demand* versus the distance downstream on the grid below. (Label both axes.) **3**



Question 31 (continued) **Marks**

(b) Estimate the distance downstream at which the sewage was discharged? **1**

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(c) Explain the relationship between *dissolved oxygen* and *biochemical oxygen demand* in this 4 km stretch of river. **2**

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(d) Describe how *biochemical oxygen demand* was measured in samples taken from this river. **2**

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End of Question 31

STUDENT NUMBER/NAME: .....

Section II
Total marks (25)

Attempt ONE question from Questions 32–36
Allow about 45 minutes for this section

Show all relevant working in questions involving calculations.

Question 32 – Industrial Chemistry (25 marks) **Marks**

(a) The Contact Process is named for the reaction in which sulfur dioxide and oxygen are combined to form sulfur trioxide. The reaction typically is carried out with an excess of oxygen, at atmospheric pressure over a vanadium oxide catalyst and heated to 400°C.

Write a brief explanation of how a reaction condition achieves each of effects below:

(i) Accelerates the reaction without affecting the yield. **1**

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(ii) Increases the yield without changing the equilibrium constant. **1**

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(iii) Changes the equilibrium constant. **1**

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(b) Dinitrogen tetroxide (N_2O_4) is an almost colourless liquid which boils at 21°C. In the gaseous state it exists in equilibrium with nitrogen dioxide (NO_2) which is an intensely brown coloured gas.

$$\underset{\text{Colourless}}{N_2O_{4(g)}} \rightleftarrows \underset{\text{Brown}}{2NO_{2(g)}} \quad \Delta H = 58 \text{ kJ mol}^{-1}$$

To study this equilibrium a chemist injects 0.024 mmol of liquid N_2O_4 into a 1.0 L evacuated flask. Using a colorimeter, it is observed that when the flask is heated to 50°C, 50% of the N_2O_4 has decomposed to NO_2.

(i) Determine the equilibrium concentration of each gas at 50°C, and hence calculate the equilibrium constant K_c. under these conditions. **2**

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Question 32 continues on the next page

Question 32 (continued) **Marks**

(ii) The experiment, at 50°C, is repeated starting with 0.040 mol of liquid N_2O_4.
Predict and explain any difference in the extent (%) of dissociation to NO_2. **2**

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(iii) The temperature is raised to 60°C.
Predict and explain the effect on the equilibrium constant (K_c).

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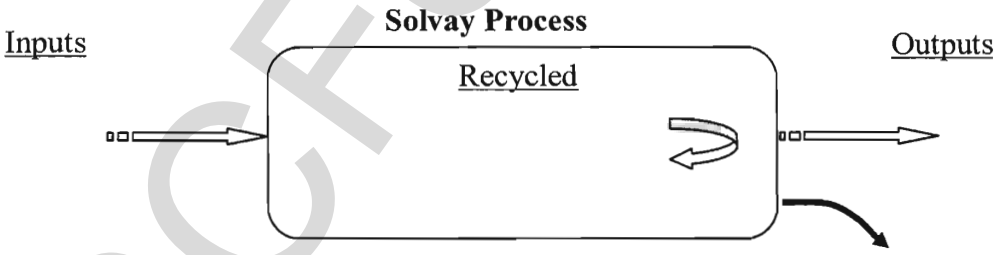
(c) (i) Complete a simple input/output diagram for the Solvay process. **4**

Use arrows and labels to show:

- the input raw materials
- the output product and waste substances
- a substance which is recycled within the process.



(ii) Natural deposits of the main Solvay product have been used for many centuries.

Describe ONE major use of this chemical which continues to the present day. **1**

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Question 32 continues on the next page

Question 32 (continued) **Marks**

(d) You have investigated the range of products available from the electrolysis of sodium chloride using inert electrodes.

(i) Summarise the products obtained using and dilute and concentrated solutions. **2**

Electrolysis Conditions	*Anode Product(s)*	*Cathode Product(s)*
Dilute solution		
Concentrated solution		

(ii) For ONE industrial method outline the electrolytic production of sodium hydroxide. Include an equation. **3**

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(e) During recent oil spills on the Great Barrier Reef, and in the Gulf of Mexico, extensive use was made of dispersants, sprayed onto oil slicks from boats and planes. The key ingredient of these dispersants is a non-ionic surfactant.

Evaluate the use of these substances, with attention to: **6**

- The general structure of non-ionic surfactants and their choice ahead of other surfactants for this application
- The mode of action of the surfactants in dispersing floating oil
- A laboratory procedure to compare the effectiveness of different surfactants

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More space to answer Question 32(e) on the next page

Question 32(e) (continued) **Marks**

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End of Question 32

Question 33 – Shipwrecks, Corrosion and Conservation (25 marks)

Marks

(a) The table below gives the composition of seawater by element by mass.

Element	Percent.	Element	Percent.
Oxygen	85.84	Sulfur	0.091
Hydrogen	10.82	Calcium	0.04
Chlorine	1.94	Potassium	0.04
Sodium	1.08	Bromine	0.0067
Magnesium	0.1292	Carbon	0.0028

(i) Many of these elements exist in seawater as salts. Describe the origins of these salts. **1**

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(ii) Explain why corrosion is more rapid in salt water than fresh water. **2**

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(b) Iron corrodes more rapidly in acidic environments, yet steel building beams are often passivated in 85% phosphoric acid baths prior to painting, to reduce corrosion.

(i) Account for the decrease in the rate of corrosion of iron after phosphoric acid treatment. **1**

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(ii) Assess the relative effectiveness of passivating treatment, as a corrosion preventative measure for steel, compared with other methods. **3**

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Question 33 continues on the next page

Question 33 (continued) **Marks**

(c) Sacrificial anodes may be used to protect the wreck of the World War II M24 Japanese midget submarine sunk off Sydney's northern beaches.

Discuss the nature of sacrificial anodes and explain how they protect steel ships from corrosion. **4**

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(d) In modern cars the water-based coolant circulates through the engine in which aluminium and iron components are bolted together. A corrosion inhibitor is essential as an additive to the coolant, to minimise corrosion.

Outline an experiment you could perform in the laboratory to test the effectiveness of a brand of coolant additive in this situation. **4**

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Question 33 continues on the next page

Question 33 (continued) **Marks**

(e) During your course of study you conducted a first-hand investigation to identify the factors that affect the rate of an electrolysis reaction.

Identify ONE of these factors and, with a suitable diagram, describe an experiment to test the effect of this factor on the rate of electrolysis. **3**

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(f) During the 19th century many ships were wrecked in the Australia's Southern Ocean, some onshore and others far out to sea. These ships were constructed mainly of timber and steel, together with brass and bronze castings.

Assess and evalute the different processes and rates of decay of these shipwrecks at the shoreline and in the deep ocean. **7**

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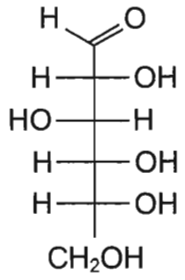
More space to answer Question 33(f) on the next page

Question 33(f) (continued) **Marks**

End of Question 33

Question 34 – The Biochemistry of Movement (25 marks) **Marks**

(a)



(i) Identify the above molecule. **1**

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(ii) Describe the biological significance of this molecule. **4**

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(b) (i) Identify the general formula of fatty acids. **1**

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(ii) Identify how fatty acids are stored in the body. **1**

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Question 34 continues on the next page

Question 34 (continued) **Marks**

(c) (i) Describe the metabolic processes involved in gentle exercise. **6**

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(ii) Identify where TWO of the processes described in (i) take place. **2**

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(d) Outline the roll of the calcium ion in muscle contraction. **3**

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Question 34 continues on the next page

Question 34 (continued) **Marks**

(e) During your study of "The Biochemistry of Movement" you performed a first-hand investigation to observe the effect of changes in pH and temperature on the reaction of a named enzyme.

(i) Describe how the investigation was conducted. **3**

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(ii) Outline the results of the investigation and relate them to the structure of the enzyme. **4**

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End of Question 34

STUDENT NUMBER/NAME: .....

Question 35 – Chemistry of Art (25 marks) **Marks**

(a) (i) Identify the ion that produces a violet (lilac) flame in a flame test. **1**

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(ii) Explain how a colour is produced in the flame. **2**

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(b) Describe how infra-red light can be used to analyse and identify pigments. **3**

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Question 35 continues in the next page

Question 35 (continued) **Marks**

(c) Below is a table showing the successive ionisation energies for four elements.

Element	*1st Ionisation Energy (kJ/mol)*	*2nd Ionisation Energy (kJ/mol)*	*3rd Ionisation Energy (kJ/mol)*	*4th Ionisation Energy (kJ/mol)*
P	736	1450	7740	10500
Q	577	1820	2740	11600
R	498	4560	6910	9540
S	590	1145	4910	6474

(i) Predict the number of valence electrons for elements P and Q. **1**

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(ii) Explain why successive ionisation energies always increase. **2**

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(d) (i) Describe how you performed a first-hand investigation to demonstrate the oxidising strength of $KMnO_4$.

Include observations from ONE of the reactions. **3**

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Question 35 continues in the next page

Question 35 (continued) **Marks**

(ii) Using half-equations, account for the changes in the oxidation state for the permanganate ion and TWO of the other substances tested. **3**

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(e) Models are often used to show the structure of complex ions.

Outline some reasons, including specific examples, why such models are useful. **3**

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Question 35 continues in the next page

Question 35 (continued) **Marks**

(f) Ancient cultures, such as early Egyptian and Roman, used a variety of pigments for cosmetic purposes.

Describe, using examples and chemical formulas, the type of pigments used and assess the potential health risk associated with their use. **7**

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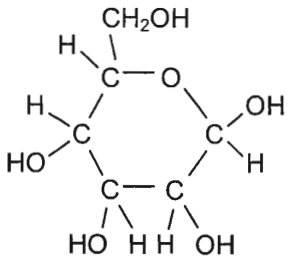
End of Question 35

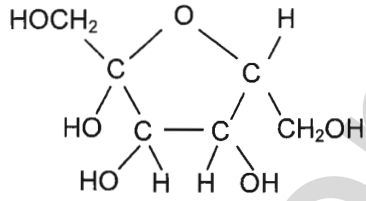
STUDENT NUMBER/NAME: .....

Question 36 – Forensic Chemistry (25 marks) **Marks**

(a) The ring structures of the carbohydrates glucose and fructose are shown below



glucose



fructose

(i) Explain why each of these is classified as a carbohydrate. **1**

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(ii) Using molecular formulas, write an equation to show the formation of sucrose from glucose and fructose. **1**

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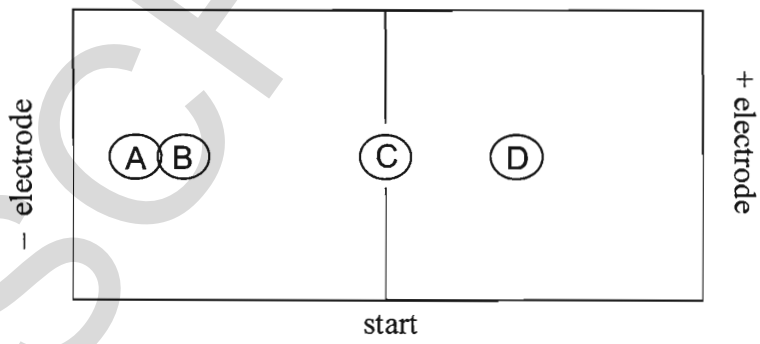
(b) Electrophoresis was carried out on a mixture of four amino acids labelled A, B, C and D. The electrolytic solution was buffered at pH 6.0 and the developed result of the process is illustrated below.



(i) Identify the functional groups present in all amino acids. **1**

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Question 36 continues on the next page

Question 36 (continued) **Marks**

(ii) Explain how amino acids A and B have been separated in this process. **2**

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(iii) Explain the property difference that results in the separation of amino acids C and D. **2**

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(c) (i) Outline the structure of DNA. **2**

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(ii) Identify the percentage match between the DNA profiles of identical twin sisters and the profiles of non-identical twin sisters. **1**

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Question 36 continues on the next page

Question 36 (continued) **Marks**

(iii) Outline precautions that are necessary to ensure accuracy and prevent contamination of DNA samples used for forensic analysis. **2**

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(d) During your practical work you performed a number of first-hand investigations that involved carrying out tests to distinguish between different substances.

(i) Outline the procedure you used to perform a distinguishing test for proteins, and describe the results obtained. **3**

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(ii) Describe another distinguishing test you carried out, including precautions you took to minimise identified hazards. **3**

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Question 36 continues on the next page

Question 36 (continued) **Marks**

(e) Assess the roles of both gas-liquid chromatography and mass spectroscopy in modern forensic investigations. **7**

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DATA SHEET

Avogadro constant, N_A ..... 6.022×10^{23} mol^{-1}

Volume of 1 mole ideal gas: at 100 kPa and

at 0°C (273.15 K) ..... 22.71 L

at 25°C (298.15 K) ..... 24.79 L

Ionisation constant for water at 25°C (298.15 K), K_w ..... 1.0×10^{-14}

Specific heat capacity of water ..... 4.18×10^3 J kg^{-1} K^{-1}

Some useful formulae

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

Some standard potentials

$K^+ + e^-$	$\rightleftharpoons$	$K(s)$	–2.94 V
$Ba^{2+} + 2e^-$	$\rightleftharpoons$	$Ba(s)$	–2.91 V
$Ca^{2+} + 2e^-$	$\rightleftharpoons$	$Ca(s)$	–2.87 V
$Na^+ + e^-$	$\rightleftharpoons$	$Na(s)$	–2.71 V
$Mg^{2+} + 2e^-$	$\rightleftharpoons$	$Mg(s)$	–2.36 V
$Al^{3+} + 3e^-$	$\rightleftharpoons$	$Al(s)$	–1.68 V
$Mn^{2+} + 2e^-$	$\rightleftharpoons$	$Mn(s)$	–1.18 V
$H_2O + e^-$	$\rightleftharpoons$	$\frac{1}{2}H_2(g) + OH^-$	–0.83 V
$Zn^{2+} + 2e^-$	$\rightleftharpoons$	$Zn(s)$	–0.76 V
$Fe^{2+} + 2e^-$	$\rightleftharpoons$	$Fe(s)$	–0.44 V
$Ni^{2+} + 2e^-$	$\rightleftharpoons$	$Ni(s)$	–0.24 V
$Sn^{2+} + 2e^-$	$\rightleftharpoons$	$Sn(s)$	–0.14 V
$Pb^{2+} + 2e^-$	$\rightleftharpoons$	$Pb(s)$	–0.13 V
$H^+ + e^-$	$\rightleftharpoons$	$\frac{1}{2}H_2(g)$	0.00 V
$SO_4^{2-} + 4H^+ + 2e^-$	$\rightleftharpoons$	$SO_2(aq) + 2H_2O$	0.16 V
$Cu^{2+} + 2e^-$	$\rightleftharpoons$	$Cu(s)$	0.34 V
$\frac{1}{2}O_2(g) + H_2O + 2e^-$	$\rightleftharpoons$	$2OH^-$	0.40 V
$Cu^+ + e^-$	$\rightleftharpoons$	$Cu(s)$	0.52 V
$\frac{1}{2}I_2(s) + e^-$	$\rightleftharpoons$	I^-	0.54 V
$\frac{1}{2}I_2(aq) + e^-$	$\rightleftharpoons$	I^-	0.62 V
$Fe^{3+} + e^-$	$\rightleftharpoons$	Fe^{2+}	0.77 V
$Ag^+ + e^-$	$\rightleftharpoons$	$Ag(s)$	0.80 V
$\frac{1}{2}Br_2(l) + e^-$	$\rightleftharpoons$	Br^-	1.08 V
$\frac{1}{2}Br_2(aq) + e^-$	$\rightleftharpoons$	Br^-	1.10 V
$\frac{1}{2}O_2(g) + 2H^+ + 2e^-$	$\rightleftharpoons$	H_2O	1.23 V
$\frac{1}{2}Cl_2(g) + e^-$	$\rightleftharpoons$	Cl^-	1.36 V
$\frac{1}{2}Cr_2O_7^{2-} + 7H^+ + 3e^-$	$\rightleftharpoons$	$Cr^{3+} + \frac{7}{2}H_2O$	1.36 V
$\frac{1}{2}Cl_2(aq) + e^-$	$\rightleftharpoons$	Cl^-	1.40 V
$MnO_4^- + 8H^+ + 5e^-$	$\rightleftharpoons$	$Mn^{2+} + 4H_2O$	1.51 V
$\frac{1}{2}F_2(g) + e^-$	$\rightleftharpoons$	F^-	2.89 V

Aylward and Findlay, *SI Chemical Data* (5th Edition) is the principal source of data for this examination paper. Some data may have been modified for examination purposes.

PERIODIC TABLE OF THE ELEMENTS

KEY

1 H 1.008 Hydrogen																	2 He 4.003 Helium
3 Li 6.941 Lithium	4 Be 9.012 Beryllium											5 B 10.81 Boron	6 C 12.01 Carbon	7 N 14.01 Nitrogen	8 O 16.00 Oxygen	9 F 19.00 Fluorine	10 Ne 20.18 Neon
11 Na 22.99 Sodium	12 Mg 24.31 Magnesium											13 Al 26.98 Aluminium	14 Si 28.09 Silicon	15 P 30.97 Phosphorus	16 S 32.07 Sulfur	17 Cl 35.45 Chlorine	18 Ar 39.95 Argon
19 K 39.10 Potassium	20 Ca 40.08 Calcium	21 Sc 44.96 Scandium	22 Ti 47.87 Titanium	23 V 50.94 Vanadium	24 Cr 52.00 Chromium	25 Mn 54.94 Manganese	26 Fe 55.85 Iron	27 Co 58.93 Cobalt	28 Ni 58.69 Nickel	29 Cu 63.55 Copper	30 Zn 65.41 Zinc	31 Ga 69.72 Gallium	32 Ge 72.64 Germanium	33 As 74.92 Arsenic	34 Se 78.96 Selenium	35 Br 79.90 Bromine	36 Kr 83.80 Krypton
37 Rb 85.47 Rubidium	38 Sr 87.62 Strontium	39 Y 88.91 Yttrium	40 Zr 91.22 Zirconium	41 Nb 92.91 Niobium	42 Mo 95.94 Molybdenum	43 Tc [97.91] Technetium	44 Ru 101.1 Ruthenium	45 Rh 102.9 Rhodium	46 Pd 106.4 Palladium	47 Ag 107.9 Silver	48 Cd 112.4 Cadmium	49 In 114.8 Indium	50 Sn 118.7 Tin	51 Sb 121.8 Antimony	52 Te 127.6 Tellurium	53 I 126.9 Iodine	54 Xe 131.3 Xenon
55 Cs 132.9 Caesium	56 Ba 137.3 Barium	57–71 Lanthanoids	72 Hf 178.5 Hafnium	73 Ta 180.9 Tantalum	74 W 183.8 Tungsten	75 Re 186.2 Rhenium	76 Os 190.2 Osmium	77 Ir 192.2 Iridium	78 Pt 195.1 Platinum	79 Au 197.0 Gold	80 Hg 200.6 Mercury	81 Tl 204.4 Thallium	82 Pb 207.2 Lead	83 Bi 209.0 Bismuth	84 Po [209.0] Polonium	85 At [210.0] Astatine	86 Rn [222.0] Radon
87 Fr [223] Francium	88 Ra [226] Radium	89–103 Actinoids	104 Rf [261] Rutherfordium	105 Db [262] Dubnium	106 Sg [266] Seaborgium	107 Bh [264] Bohrium	108 Hs [277] Hassium	109 Mt [268] Meitnerium	110 Ds [271] Darmstadtium	111 Rg [272] Roentgenium							

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

Lanthanoids

57 La 138.9 Lanthanum	58 Ce 140.1 Cerium	59 Pr 140.9 Praseodymium	60 Nd 144.2 Neodymium	61 Pm [145] Promethium	62 Sm 150.4 Samarium	63 Eu 152.0 Europium	64 Gd 157.3 Gadolinium	65 Tb 158.9 Terbium	66 Dy 162.5 Dysprosium	67 Ho 164.9 Holmium	68 Er 167.3 Erbium	69 Tm 168.9 Thulium	70 Yb 173.0 Ytterbium	71 Lu 175.0 Lutetium

Actinoids

89 Ac [227] Actinium	90 Th 232.0 Thorium	91 Pa 231.0 Protactinium	92 U 238.0 Uranium	93 Np [237] Neptunium	94 Pu [244] Plutonium	95 Am [243] Americium	96 Cm [247] Curium	97 Bk [247] Berkelium	98 Cf [251] Californium	99 Es [252] Einsteinium	100 Fm [257] Fermium	101 Md [258] Mendelevium	102 No [259] Nobelium	103 Lr [262] Lawrencium

For elements that have no stable or long-lived nuclides, the mass number of the nuclide with the longest confirmed half-life is listed between square brackets.
The International Union of Pure and Applied Chemistry Periodic Table of the Elements (October 2005 version) is the principal source of data. Some data may have been modified.

NSW INDEPENDENT TRIAL EXAMS – 2010
CHEMISTRY TRIAL HSC EXAMINATION
MARKING GUIDELINES

Section I – Part A

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
B	C	A	B	C	D	A	B	D	A	C	D	C	B	A	B	A	C	D	D

Section I – Part B

Question 21(a)

Criteria	Mark
• Identifies the secondary reaction product. (*1 mark*) • Relates the molecular linkage to the name of the polymer. (*1 mark*)	2

Answer may include:

- Water is the by-product of the polymerisation reaction.
- The monomer units are linked by an ester group (-COO-), so the polymer is a polyester.

Question 21(b)

Criteria	Mark
• Calculates the molecular mass of the glycolate unit. • Calculates the number of units for this molecular mass.	1

Answer may include: Molecular mass of glycolate unit $C_2H_2O_2 = 58$. For a molecular mass of 60 000 approximately 1000 (1035) monomer units are present in each polymer molecule.

Question 21(c)

Criteria	Mark
• Defines the term *biodegradable*. (*1 mark*) • Relates conditions in the body to the reversibility of the esterification reaction. (*1 mark*)	2

Answer may include:

- A biodegradable substance is one which is chemically broken down to harmless molecules by natural processes in the environment.
- Esterification is a reversible reaction. Body fluids provide a high concentration of water, and possibly catalysts, for depolymerisation to glycolic acid.

Question 22(a)

Criteria	Mark
• Identifies a biofuel from processing of biomass. (*1 mark*) • Describes the reaction converting biomass to this fuel. (*1 mark*)	2

Answer may include:

- Ethanol is a fuel which can be produced from biomass.
- Ethanol is produced by fermentation of sugars from biomass under anaerobic conditions.

  OR
- Methane is a fuel which can be produced from biomass.
- Methane is produced by bacterial fermentation (or digestion) of biomass under anaerobic conditions.

Question 22(b)

Criteria	Mark
Describes an advantage of the nominated biofuel against biomass.	1

Answer may include: Ethanol is a chemically stable liquid which can be delivered in pipes. Biomass is mostly solid, unstable, and is more difficult and expensive to deliver.

OR

Methane is a chemically stable gas which can be delivered in pipes. Biomass is mostly solid, unstable, and is more difficult and expensive to deliver.

Question 22(c)

Criteria	Mark
• Identifies and describes TWO problems associated with widespread biofuel use.	2

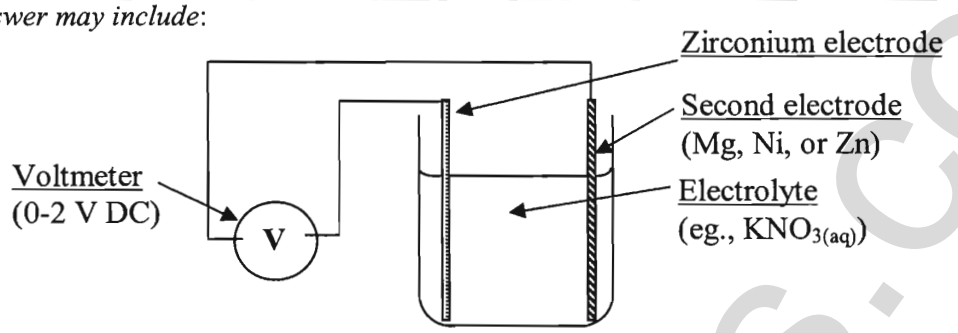
Answer may include:

- The production of biofuels requires soil, water and fertilisers, putting pressure on these limited resources.
- Biofuels compete with food production, reducing food supply and possibly increasing food prices.
- Biofuel production is itself an energy-intensive process requiring energy for cultivation, harvesting and transport.

Question 23(a)

Criteria	Mark
• Constructs a diagram of a suitable galvanic cell.	1
• Correctly labels the main cell components.	1

Answer may include:



(A two compartment cell, with a salt bridge may also be used).

Question 23(b)(i)

Criteria	Mark
Writes the balanced half-reaction equation.	1

Answer may include: $Mg_{(s)} \rightarrow Mg^{2+} + 2e^-$

Question 23(b)(ii)

Criteria	Mark
• Identifies the activity of zirconium relative to the other metals.	1
• Relates the activity of zirconium to the observed cell voltages	1

Answer may include:

- Zirconium is less active than magnesium but more active than zinc and nickel.
- In the cell with magnesium, magnesium is the anode, showing that it is more reactive than zirconium. In the other two cells zirconium is the anode, so it is more active than these metals. (Can also explain in terms of polarity and/or tendency to form cations).

Question 23(c)

Criteria	Mark
Uses the redox table to predict an approximate voltage and polarity.	1

Answer may include:

- (Copper has a voltage of +1.1 V against zinc, which itself is +0.7 V against zirconium.)
- The voltage of the zirconium/copper cell will be about 1.8 V, copper being positive.

Question 24(a)

Criteria	Mark
Identifies the atomic and mass number of the daughter nucleus.	1

Answer may include: The product nucleus will consist of 90 protons and 137 neutrons.

Question 24(b)

Criteria	Mark
• Identifies a property by which the radiations may be separated. (*1 mark*) • Describes a procedure using this property to measure each component. (*2 marks*)	3

Answer may include:

- Alpha radiation is blocked by a layer of aluminium foil, while beta is transmitted.
- Set the Geiger counter a fixed distance from the actinium source. Measure the total activity, then the activity with a sheet of alfoil interposed. The remnant activity is beta radiation, and the difference is the alpha component.
- (A strong magnet could also be used to separate the components of a thin beam of the radiation).

Question 25

Criteria	Mark
• Describes the removal of sulfur dioxide by rainwater.	1
• Explains problems caused by acid rain, from sulfur dioxide emissions.	1
• Relates the long residence time of CFC to their reaching the stratosphere.	1
• Describes the ozone-destroying role of CFC's and identfies reasons for concern.	1

Answer may include: SO_2 is released into the atmosphere during the burning of fossil fuels and the smelting of metal ores. In the lower atmosphere, this gas can cause health issues such as breathing difficulties in people. It remains in the atmosphere for only a relatively short time as it readily dissolves in rainwater forming acid rain.

$$SO_{2\,(g)} + H_2O_{\,(l)} \rightarrow H_2SO_{3\,(aq)}$$

This process, which relatively quickly, removes the gas from the atmosphere, results in major environmental damage, lowering the pH of natural waterways and soil, also corroding metal and stone structures.

CFC's are insoluble in water and very stable, hence are not washed out of the air or broken down by sunlight. Their long residence time allows these gases to slowly diffuse into the upper layers of the atmosphere. In these upper layers, the CFC's are broken down by UV light producing chlorine free radicals which in turn catalyse breakdown of ozone.

$$\text{e.g. } CCl_2F_{2\,(g)} \rightarrow CClF_{2\,(g)} + Cl_{\,(g)}$$

$$Cl_{\,(g)} + O_{3\,(g)} \rightarrow OCl_{\,(g)} + O_{2\,(g)}$$

The ClO free radical is capable of reacting with O free radicals present, reforming the Cl free radical and so continuing further destruction of ozone.

$$OCl_{\,(g)} + O_{\,(g)} \rightarrow Cl_{\,(g)} + O_{2\,(g)}$$

The destruction of the ozone layer exposes living organisms at ground level to dangerous UV radiation that is normally absorbed by the ozone layer.

Question 26

Criteria	Mark
Identifies and justifies FOUR measures taken to ensure accuracy of the titration result.	4

Answer may include: Any four of the below, or other valid measures. Titration was used to estimate the acid content in vinegar.

Steps taken	Justification
The burette was given a final rinse with diluted vinegar solution	To ensure the concentration of the diluted vinegar was unaltered when placed in the burette
The pipette was given a final rinse with the standardised NaOH solution	To ensure the concentration of the standardised NaOH solution was unaltered when placed in the pipette
The conical flask was given a final rinse with distilled water	To ensure the flask was clean and that only the correct number of moles of NaOH was present when delivered by the pipette
The NaOH was standardised against a primary standard solution prior to use	To ensure the concentration of the NaOH solution was accurately known as NaOH solutions are unstable in air
Phenolphthalein indicator was used	The range of this indicator is above pH 7 which matches the pH of the equivalence point of this weak acid strong base titration
The titration was repeated and an average titre used to perform the calculations	To increase the reliability of the results
White paper was placed under the conical flask	So that the colour change of the indicator could be more easily seen

Question 27(a)

Criteria	Mark
• Uses reaction stoichiometry to calculate the molar quantity of $CO_{2\,(g)}$. (*1 mark*) • Converts moles of gas to a volume under standard conditions. (*1 mark*)	2

Answer may include:

$CaCO_3 + 2\,HCl \rightleftharpoons CaCl_2 + CO_{2\,(g)} + H_2O_{(l)}$

$n = m / M = 5.00\ g / 100.09\ g\ mol^{-1} = 0.0500\ mol\ CaCO_3$

$1\ mol\ CO_2 / 1\ mol\ CaCO_3 \times 0.0500\ mol\ CaCO_3 = 0.0500\ mol\ CO_2$

$n = V / MV .\quad V = n \times MV = 0.0500\ mol\ CO_2 \times 24.79\ L\ mol^{-1} = 1.24\ L\ CO_2\ gas$

Question 27(b)

Criteria	Mark
• Identifies HCO_3^- as the amphiprotic species. (*1 mark*) • Constructs an ionic equation for the reaction with OH^- ion. (*1 mark*)	2

Answer may include: The amphiprotic ion is the hydrogen carbonate ion HCO_3^-.

Equation: $HCO_3^- + OH^- \rightleftharpoons CO_3^{2-} + H_2O$

Question 27(c)

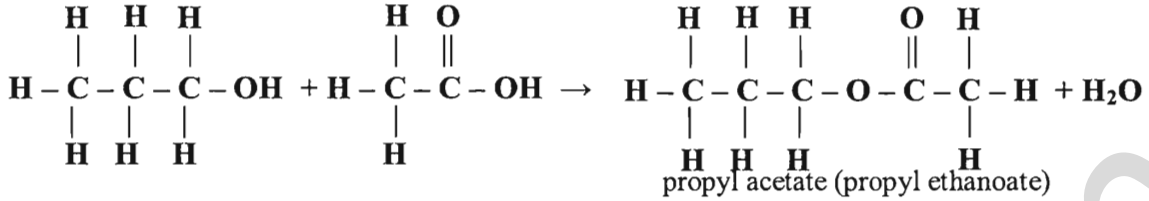
Criteria	Mark
• Describes a procedure for removing CO_2 from a measured volume of drink. (*1 mark*) • Outlines measurements and basis for calculating mass and volume of CO_2. (*1 mark*)	2

Answer may include: The can's mass is measured, then it is opened and warmed to about 40°C and the mass monitored until it remains constant. The mass loss is assumed to be equal to the mass of CO_2. The volume is calculated as the no of moles x molar volume = n x 24.79 L

Question 28(a)(i)

Criteria	Mark
• Constructs structural formulas for 1-propanol and acetic acid. (*1 mark*) • Constructs a structural formula and assigns a systematic name for propyl acetate. (*1 mark*)	2

Answer may include:



propyl acetate (propyl ethanoate)

Question 28(a)(ii)

Criteria	Mark
Explains the need for catalysis in esterification.	1

Answer may include: Esterification is a slow reaction which involves breaking bonds in the acid and alcohol. Without a catalyst the reaction would require a very long time to reach equilibrium.

Question 28(b)

Criteria	Mark
• Relates the boiling point of a substance to the strength of its intermolecular forces. (*1 mark*) • Identifies that polarity and hydrogen bonding are significant forces between molecules. (*1 mark*) • Correctly ascribes the differences in these substances to variations in polarity and hydrogen bonding. (*1 mark*)	3

Answer may include:

- The boiling point of a substance is determined by the strength of its intermolecular forces. The stronger the forces, the higher the boiling point.
- Ethyl methanoate has lower polarity than acetic acid and 1-propanol and so has weaker dipole-dipole attractions between molecules.
- Acetic acid and 1-propanol also contain -OH groups and so can also establish hydrogen bonding between molecules, giving them higher boiling points.
- The more extensive hydrogen bonding in acetic acid gives it a higher boiling point than 1-propanol.

Question 29(a)

Criteria	Mark
• Correctly writes a complete and balanced equation for the Haber process and explains the impact of a decrease in pressure on the system. • Explains this impact.	3

Answer may include:

- $3H_{2(g)} + N_{2(g)} \rightarrow 2NH_{3(g)}$ (*1 mark*)
- A decrease in pressure would cause this equilibrium to shift to the side with more particles (the left side). Hence, more hydrogen and nitrogen would be formed. (*1 mark*)
- Based on Le Chatelier's Principle, this occurs because the decrease in pressure is counteracted by an increase in the overall number of particles on the left (4) compared to the right (2). (*1 mark*)

Question 29(b)

Criteria	Mark
• Using the information provided, correctly predicts whether the production of ammonia is an endothermic or exothermic process. • Explains answer given.	2

Answer may include: Exothermic (*1 mark*) – as the temperature increases the percentage yield decreases. This indicates that less of the product forms and therefore that the equilibrium has shifted to the left. Le Chatelier's principle suggests that this shift counteracts the temperature increase. Therefore the shift to the left must be in the endothermic direction. Consequently, the reaction as written is exothermic. (*1 mark*)

Question 30

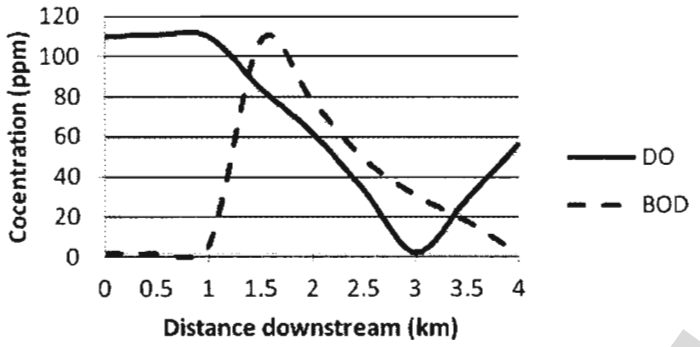
Criteria	Mark
• Describes a procedure for preparing a standard solution of cobalt(II) ion.	1
• Describes a stepwise dilution procedure to obtain the required concentration.	1

Answer may include:

- 1.00 g of cobalt(II) ion is present in 1/58.9 = 0.0170 mol of cobalt nitrate. A standard 1.00 g L^{-1} solution of cobalt(II) ion is prepared by dissolving 0.0170 mol (3.11 g) of the cobalt(II) nitrate into 100 mL of solution. (*1 mark*)
- A 10.0 ml volume of this solution, measured with a pipette, is diluted to 1.00L in a volumetric flask. This dilution is repeated twice to produce a concentration of 1.00 μg L^{-1} (*1 mark*)

Question 31(a)

Criteria	Mark
• DO and BOD lines plotted correctly and labelled (or with a key). (*2 marks*)	3
• Both axes correctly labelled as shown below (including units). (*1 mark*)	



Question 31(b)

Criteria	Mark
Correctly states the distance downstream that the sewage discharged.	1

Answer may include: 1 to 1.5 km. (*1 mark*)

Question 31(c)

Criteria	Mark
Accurately explains the relationship between DO and BOD in the 4 km stretch of stream.	2

Answer may include:

- DO refers to the amount of dissolved oxygen in the water. BOD is the biochemical oxygen demand. It is a measure of how much oxygen is consumed by the decay of organic matter present in the water. (*1 mark*)
- At zero kms dissolved oxygen is at a normally high level and BOD is low – very little organic matter is present. Sewage is discharged into the downstream river. Almost immediately, dissolved oxygen decreases and BOD increases due to the sudden increase in the concentration of organic matter. At 3 km DO reaches its lowest level but the organic matter is becoming less concentrated. From this point onward DO rises as oxygen demand continues to decrease. (*1 mark*)

Question 31(d)

Criteria	Mark
Accurately describes how BOD was measured in samples taken from the stream.	2

Answer may include:

- A sample of water is taken and its oxygen concentration is measured at a given temperature by using a colorimeter, an oxygen meter or by titration. (*1 mark*)
- The sample is sealed and kept out of the light at the given temperature for 5 days. The oxygen concentration of the sample is measured again. The BOD is the difference between the first and second measurements. (*1 mark*)

Section II- Options

Question 32 – Industrial Chemistry

Question 32(a)(i)

Criteria	Mark
Identifies and explains the role of a catalyst.	1

Answer may include: A catalyst accelerates both the forward and reverse reactions equally, and has no effect on the equilibrium yield.

Question 32(a)(ii)

Criteria	Mark
Identifies and explains the role of increased concentration of a reactant.	1

Answer may include: Excess oxygen forces the equilibrium to the right, increasing the yield, with no change in the equilibrium constant.

Question 32(a)(iii)

Criteria	Mark
Identifies the effect of temperature on the equilibrium constant.	1

Answer may include: Increasing the temperature results in a decrease in the equilibrium constant, as the forward reaction is exothermic.

Question 32(b)(i)

Criteria	Mark
Calculates the equilibrium concentration of each gas. Calculates the equilibrium constant	1 1

Answer may include: As each molecule of N_2O_4 produces two molecules of NO_2, the equilibrium concentrations are:

$$[N_2O_4] = 0.012 \text{ mol } L^{-1} \quad [NO_2] = 0.024 \text{ mol } L^{-1}$$

$$\text{and } K_c = [NO_2]^2 / [N_2O_4] = 0.024 \times 0.024/0.012 = 0.048$$

Question 32(b)(ii)

Criteria	Mark
• Identifies that the change increases the pressure in the system which shifts to the left. (*1 mark*) • Uses Le Chatelier's Principle to explain the equilibrium shift. (*1 mark*)	2

Answer may include: The increased gas concentration results in higher gas pressure in the container, and the equilibrium shifts to the left, so that more than 50% of the $[N_2O_4]$ remains at equilibrium.

Question 32(b)(iii)

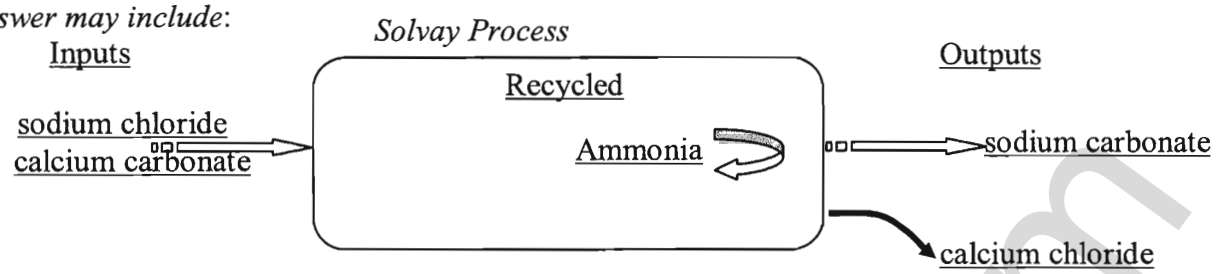
Criteria	Mark
• States that the equilibrium constant increases. (*1 mark*) • Explains the effect of temperature on the equilibrium constant. (*1 mark*)	2

Answer may include: At 60°C the value of K_c is higher than at 50°C. The forward reaction is endothermic. Le Chatelier's Principle holds that the equilibrium will shift to absorb heat when the temperature is raised, increasing the equilibrium constant.

Question 32(c)(i)

Criteria	Mark
• Identifies the two main raw materials. (*1 mark*) • Identifies the main product. (*1 mark*) • Identifies the main waste substance. (*1 mark*) • Identifies a recycled substance. (*1 mark*)	4

Answer may include:



Question 32(c)(ii)

Criteria	Mark
Describes a major industrial use of sodium carbonate.	1

Answer may include: Sodium carbonate is a major input material for making glass. (Sodium carbonate has also been used as a water softener and in soap-making, in place of sodium hydroxide.)

Question 32(d)(i)

Criteria	Mark
• Identifies change in anode products with concentration. (*1 mark*) • Identifies cathode products. (*1 mark*)	2

Answer may include:

Electrolysis Conditions	*Anode Product(s)*	*Cathode Product(s)*
Dilute solution	Oxygen gas and hydrogen ions	Hydrogen gas and hydroxide ions
Concentrated solution	Chlorine gas	Hydrogen gas and hydroxide ions

Question 32(d)(ii)

Criteria	Mark
• Describes a the operation of a cell for the manufacture of sodium hydroxide	2
• Constructs an equation for the overall cell reaction, or the half- reactions.	1

Answer may include: Sodium hydroxide is produced from sodium chloride solution in a membrane cell using a steel cathode and carbon anode. At the anode chloride ions are oxidised to chlorine gas. As the solution passes through the membrane water is redcued to hydrogen and hydroxide ions on the steel cathode, leaving a solution of sodium hydroxide.

$Cl^- + H_2O \rightleftharpoons \frac{1}{2}Cl_{2(g)} + OH^- + \frac{1}{2}H_{2(g)}$

OR

Cathode: $+ e^- \rightleftharpoons OH^- + \frac{1}{2}H_{2(g)}$

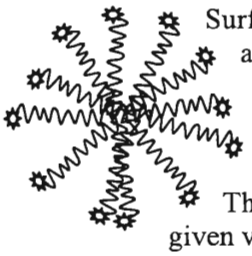
Anode: $Cl^- \rightleftharpoons \frac{1}{2}Cl_{2(g)} + e^-$

Question 32(e)(i)

Criteria	Mark
• Describes the structure of non-ionic surfactants. (*1 marks*) • Justifies the selection of non-ionics in this application. (*1 mark*) • Describes the mode of action of surfactants in oil dispersal. (*2 marks*) • Outlines a practical procedure for assessing surfactants. (*2 marks*)	6

Answer may include: Surfactants consist of molecules with a long non-polar chain (the "tail") which is hydrophobic. The chain terminates in a strongly polar group (the "head") which is strongly hydrophilic, often capable of hydrogen bonding with water. Non-ionic surfactants have non-ionising heads, unlike ionic surfactants which ionise to produce positive or negatively charged surfactant molecules. The polar head of non-ionic surfactants usually carries hydroxyl (OH) groups, for example in a sugar (glycoside) unit.

Non-ionic surfactants are a suitable choice for oil slick dispersal as they are more stable in marine conditions and less harmful to the natural environment. Ocean water contains a complex mixture of cations and anions, including sodium, calcium, magnesium, chloride, sulfate, and carbonate ions. Ionic surfactants are likely to react with one or more of these ions, perhaps forming insoluble substances which reduces their effectiveness and adds to the pollution problem. Organisms such as plankton are also adversely affected by surfactants and this harm is reduced when a non-ionic surfactant is used. When non-ionics break down the main products are harmless substances such as sugars and fatty acids.



Surfactants act on oil slicks by first reducing the surface tension of the water layer, allowing easier mixing with oil. Surfactant molecules then form micelles, which are clusters of molecules with non-polar interiors and a surface covered with the polar head groups. Oil dissolves into the interior of the micelles and so the slick is dispersed within the water layer.

The effectiveness of a surfactant can be tested by adding a measured quantity to a given volume of seawater. Mineral oil is then added, drop-wise with shaking, until the added oil is no longer dispersed. The dispersing power is measured by the volume of oil dispersed by the surfactant mixture.

Question 33 – Shipwrecks, Corrosion and Conservation

Question 33(a)(i)

Criteria	Mark
Correctly identifies at least ONE major source of salts.	1

Answer may include: Leachate from terrestrial environments washing into the sea; salts dissolving into water as it passes through hydrothermal vents in the ocean.

Question 33(a)(ii)

Criteria	Mark
Describes the electrolytic action of salt in promoting corrosion.	2

Answer may include: Salt is an electrolyte and provides ion migration between the anodic site of corrosion and the cathodic surface. Chloride ions also destabilise oxide coats that tend to passivate the metal.

Question 33(b)(i)

Criteria	Mark
Describes the passivating action of phosphoric acid.	1

Answer may include: Phosphoric acid passivates the steel by reacting with the iron to produce an impervious layer of insoluble iron phosphate. The stable iron phosphate shields the underlying steel from the oxidising agent, reducing corrosion.

Question 33(b)(ii)

Criteria	Mark
• Assesses the passivating action and limitations of phosphoric acid treatment.	1
• Compares effectiveness of this method with two other methods.	2

Answer may include (3 or more of the following points):

- On a corrosion protection scale from 1 to 5 where 1 offers no protection, phosphate coating would rate from 2 – 3.
- The stability of the iron phosphate and its formation by chemical reaction with the surface makes this method more effective than other barriers such as greases, oil based products and paint.
- It is less effective than any form of active protection e.g. sacrificial anode protection, galvanising or impressed current cathodic protection.
- It is very effective for use on land where the coating can be further stabilised by paint. Sheds and protected areas will give protection in excess of twenty years.
- It is not effective for steel to be submerged in water and even less in sea water where the protection would be measured in months.
- Phosphoric acid treatment offers no protection if the phosphate barrier is broken.

Question 33(c)

Criteria	Mark
• Describes and explains the action of sacrificial anodes. (*2 marks*)	4
• Explains the application of this method in protecting underwater wrecks. (*2 marks*)	

Answer may include: Sacrificial anodes are metals, such as zinc or magnesium, that are more active (more easily oxidised) than the metal to be protected from corrosion i.e. they give up electrons to the oxidising agent more readily than the metal being protected.

Sacrificial anodes are preferentially oxidised and are 'sacrificed' (corroded) in preference to the metal being protected, in this case the submarine

Sacrificial Anode reaction: $M \rightarrow M^{2+} + 2e^-$

Cathode (submarine) reactions: $Fe^{2+} + 2e^- \rightarrow Fe$ $2H_2O + 2e^- \rightarrow 2OH^- + H_2$

Sacrificial anodes protect steel ships in two ways:

i. By giving electrons to the oxidising agent before the iron in the steel i.e. preventing the steel ship giving up electons i.e. corroding.
ii. By setting the potential for the 'anti corrosion' half reaction:
$Fe^{2+} + 2e^- \rightarrow Fe$

Oxidation occurs on the sacrificial anode and reduction occurs at the cathode (steel ship) so any corrosion of the iron would be reversed.

Question 33(d)

Criteria	Mark
• Describes a suitable experiment to compare corrosion rates with and without coolant. (*3 marks*)	4
• Explains how results would be observed and interpreted. (*1 mark*)	

Answer may include:

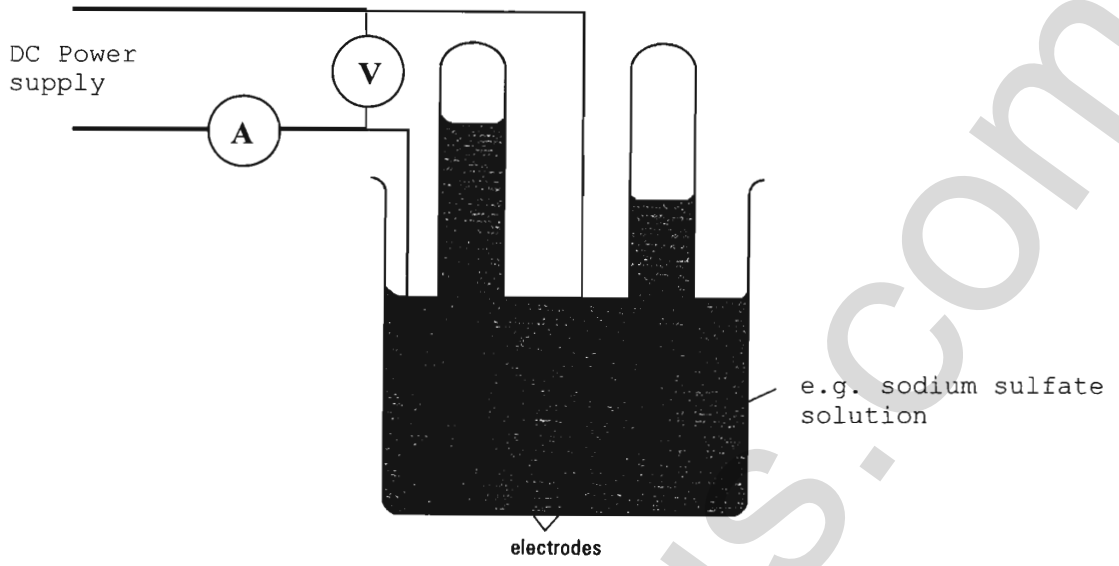
- In this situation it is mainly the more active element, aluminium, which requires protection as aluminium will provide anodic protection to the iron.
- Strips of aluminium metal are wound around three iron nails, ensuring contact between the metals and exposure to the surrounding liquid.
- The metals are placed in petri dishes or test tubes. One is immersed in distilled water, a second in tap water and the third in tap water to which coolant has been added to the concentration given on the label. Coolant solution is also used to cover a separate strip of aluminium in another dish. Each vessel is covered to reduce evaporation.
- The vessels are observed weekly over an extended period to observe the extent of any corrosion of aluminium. Corroded aluminium will be pitted and surrounded by a white deposit of aluminium oxide.
- If the coolant is effective there will be less or no corrosion of aluminium in coolant solution compared with water.

Question 33(e)

Criteria	Mark
• Draw or describe equipment suitable for this purpose. (*1 mark*) Identify a factor to be investigated with this equipment and a method of measuring the rate of reaction. (*1 mark*)" • Describe an experiment to investigate the effect of this variable. (*1 mark*)	3

Answer may include:

Electrolysis of an aqueous solution with inert electrodes:



Suitable variables are concentration of the electrolyte, electrode area, and applied voltage. The rate of electrolysis may be measured by the volume of gas produced in a given time or the current passing through the cell.

Question 33(f)

Criteria	Mark
• Describes and compares corrosive conditions at the shoreline and in the deep ocean. (*2 marks*) • Describes and compares the decay processes of wood, steel, and brass/bronze in different situations. *(3 marks)* • Discusses the roles of oxygen, water, salt and organisms in decay and corrosion. *(2 marks)*	7

Answer may include: The ocean is a hostile environment for materials such as wood and steel. Aided by water and the electrolytic action of salt, oxygen acts rapidly to convert steel to rust and supports a range of organisms which consume wood as food, oxidising it to carbon dioxide and water. For this reason shoreline wrecks have a short lifetime and the original structure often is visible only as pillars of rust.

$$Fe_{(s)} \text{ ®-→←} Fe^{2+} + 2e^- \text{ and } \tfrac{1}{2} O_{(2)} + H_2O + 2e^- \text{ ®-→←} 2OH^-$$

Iron(II) ion is further oxidised to iron(III) and forms a precipitate of iron(III) oxide, or rust.

$$2Fe^{2+} + \tfrac{1}{2}O_{(2)} + 4OH^- \text{ ®-→←} Fe_2O_{3(s)} + 2H_2O$$

The process is a galvanic one in which seawater acts as the electrolyte.

Question 33(f) continues on the next page

In the deep ocean, conditions can be very different, with much lower temperatures and an almost total lack of oxygen. Both wood and steel are preserved for much longer under these conditions. The low temperature slows all chemical processes and the lack of oxygen prevents rusting of steel and the growth of wood-consuming organisms. However steel is not immune from corrosion, even under these conditions. Anaerobic bacteria obtain energy through the reduction of sulfate ions to sulfide ions, producing hydrogen sulfide which is a weak acid. The deep ocean, with its high pressure, also dissolves more carbon dioxide, contributing to increased acidity.

While the pH of seawater is usually a little over 8 the pH in these regions can be 5 or less. As a result iron is slowly dissolved and converted to insoluble iron sulfide.

$$Fe_{(s)} + 2H^+ \text{ ®⟶⟵ } Fe^{2+} + H_{(2)} \text{ and } Fe^{2+} + S^{2-} \text{ ®⟶⟵ } FeS_{(s)}$$

This is also a galvanic corrosion process. Sulfide deposits provide a cathode surface just as rust does in shoreline conditions.

Brass and bronze are passivating alloys which corrode much more slowly than steel and can survive for many centuries. Often they are the sole remnants of wrecks.

Question 34 – The Biochemistry of Movement

Question 34(a)(i)

Criteria	Mark
Correctly identifies the molecule.	1

Answer may include: Glucose or D-Glucose.

Question 34(a)(ii)

Criteria	Mark
Provides a comprehensive description of the significance of glucose.	4
Provides a description of the significance of glucose.	3
Provides some relevant information.	1 – 2

Answer may include: Glucose is:

- Used in the production of energy in the form of ATP;
- Used by the body in both aerobic and anaerobic respiration to produce ATP;
- Stored in the liver as glycogen and is used to maintain blood sugar levels;
- Stored in skeletal muscle as glycogen and is used when rapid delivery of energy is required.

Question 34(b)(i)

Criteria	Mark
Identifies the general formula of fatty acids.	1

Answer may include: $CH_3(CH_2)_nCOOH$

Question 34(b)(ii)

Criteria	Mark
Identifies how fatty acids are stored.	1

Answer may include: Fatty acids are stored as esters of glycerol known as triacylglycerols.

Question 34(c)(i)

Criteria	Mark
Provides a comprehensive description of the metabolic processes involved in gentle exercise.	5 – 6
Provides a description of the metabolic processes involved in gentle exercise.	3 – 4
Provides some relevant information.	1 – 2

Answer may include:

- Gentle exercise utilises glycolysis whereby, through several enzymatic reactions, pyruvate is produced.
- Acetyl-CoA is produced from the pyruvate created from glycolysis.
- Gentle exercise utilises aerobic respiration as there is sufficient oxygen present.
- The acetyl-CoA enters the TCA and is oxidised to CO_2 while NAD is reduced to NADH.
- The TCA is an 8-step process involving 8 different enzymes.
- The energy yield from one whole glucose molecule (2 pyruvate molecules) is 6 NADH, 2 FADH, and 2 ATP.
- Oxidative phosphorylation then takes place via the electron transport chain. The chain establishes a proton gradient across the membrane by oxidizing the NADH from the TCA.
- ATP is synthesised from ADP by an enzyme and the electron is accepted by exogenous oxygen. The process produces a further 24 ATP.

Question 34(c)(ii)

Criteria	Mark
Correctly identifies where TWO of the processes take place.	2
Correctly identifies where ONE of the processes takes place.	1

Answer may include:

- Glycolysis occurs in the cytoplasm.
- TCA occurs in the matrix of the mitochondrion.
- Oxidative phosphorylation occurs in the inner mitochondrial membrane.

Question 34(d)

Criteria	Mark
Provides an accurate outline of the role of the calcium ion in muscle contraction.	3
Provides some relevant information.	1 – 2

Answer may include:

- Motor neurons stimulate muscle cells by releasing acetylcholine.
- This triggers the release of ionic calcium from the cells sarcoplasmic reticulum.
- This interacts with the protein troponin.
- Calcium bound troponin changes conformation and causes tropomyosin to move.
- This exposes the myosin binding sites on the actin fillament.

Question 34(e)(i)

Criteria	Mark
Provides a comprehensive description of how the investigation was conducted.	3
Provides an outline of the investigation.	2
Provides some relevant information.	1

Answer will vary but should address: suitable equipment; appropriate method (control of variables, using a control, safety and risk assessment); etc.

Question 34(e)(ii)

Criteria	Mark
• Provides an accurate outline of the results. • Effectively relates the results to the structure of the enzyme.	4
• Provides an outline of the results. • Relates the results to the structure of the enzyme.	2 – 3
Provides some relevant information.	1

Answer will vary but students should outline the results they obtained and attempt to relate them to the primary, secondary and/or tertiary structure of the enzyme.

For example: changes in activity of the enzyme related to the change in folding of the protein. pH changes effect the ionic bonds and hydrogen bonds of the protein. Increase in temperature increases the activity of the enzyme until the temperature causes the enzyme to become denatured. Then all activity is lost.

- Primary structure – amino acid sequence;
- Secondary structure – regular sub-structures i.e. alpha helices, beta pleated sheet;
- Tertiary structure – spatial arrangement of the secondary structure.

Question 35 – Chemistry of Art

Question 35(a)(i)

Criteria	Mark
Identifies the ion that produces a violet (lilac) flame in a flame test.	1

Answer may include: Potassium ion.

Question 35(a)(ii)

Criteria	Mark
Explains how a colour is produced in the flame.	2

Answer may include: Flame supplies energy to atoms. One or more of their higher energy (outer-shell) electrons become excited (absorb energy). These excited electrons can move to a higher energy level. The unstable electrons drop back to lower energy levels and release (emit) the energy they previously absorbed in the form of photons (packets) of light. The colour of light emitted depends on the energy of the photons emitted.

Question 35(b)

Criteria	Mark
Describes how infra-red light can be used to analyse and identify pigments.	3

Answer may include: I-R has been used to identify pigments and minerals and analyse binders and coatings. The Getty museum uses I-R as one of the first steps in materials analysis. I-R radiation can show up charcoal underdrawings and cause some pigments to change colour e.g. ZnO turns from white to yellow and red Cu_2O changes to black CuO. FTIR (Fourier Transform) technology combines a microscope and IR spectrometer. It can obtain a spectrum of pigments that can then be compared to a known pigment spectrum in a computerised database, for identification purposes. It is micro-destructive, simple and fast and is often used in conjunction with other techniques e.g. chromatography, x-ray.

Question 35(c)(i)

Criteria	Mark
Predicts the number of valence electrons for elements P and Q.	1

Answer may include: P –2; Q –3.

Question 35(c)(ii)

Criteria	Mark
Explains why successive ionisation energies always increase.	2

Answer may include: As each electron is removed, the effective nuclear charge increases. The positively charged nucleus exerts a stronger attraction on the remaining electrons hence more energy is needed to remove the next electron

Question 35(d)(i)

Criteria	Mark
Student describes how they performed a first-hand investigation to demonstrate the oxidising strength of $KMnO_4$, including observations from ONE of the reactions.	3

Answer may include:

- A 20 mL solution of 0.02M $KMnO_4$ was prepared and acidified using sulfuric acid.
- 2 test-tubes were obtained and 1 mL of 0.1M FAS (Fe^{2+}) placed in #1 and 1 mL of 0.05M KI in #2.
- $KMnO_4$ was added dropwise to each and any colour changes observed.
- The tests were repeated and results compared with other student groups.

Observation: The FAS was a very pale green solution. The $KMnO_4$ (dark purple solution) decolourised when added and the resulting solution became very pale yellow

Question 35(d)(ii)

Criteria	Mark
Using half-equations, the student accounts for the changes in the oxidation state for the permanganate ion and TWO of the other substances tested.	3

Answer may include:

½ eq: $MnO_4^-(aq) + 8H^+(aq) + 5e^- \longrightarrow Mn^{2+}(aq) + 4H_2O(l)$
Ox. State: +7 +2 (reduction)

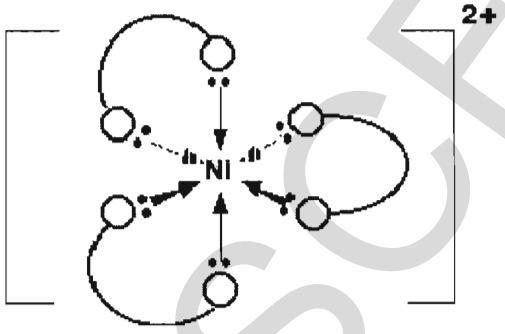
½ eq: $Fe^{2+}(aq) \longrightarrow Fe^{3+}(aq) + e^-$
Ox. State: +2 +3 (oxidation)

½ eq: $2I^-(aq) \longrightarrow I_2(aq) + 2e^-$
Ox. State: -1 0 (oxidation)

Question 35(e)

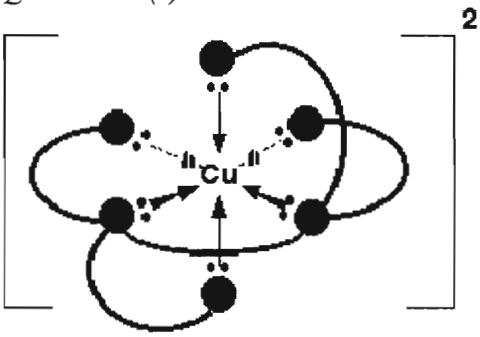
Criteria	Mark
Outlines some reasons, including specific examples, why models used to show the structure of complex ions, are useful.	3

Answer may include: Models are important because they allow us to visualise the geometries of the complex ions. They allow us to see how monodentate ligands attach e.g. Linear ions – $[Ag(NH_3)_2]^+$, Square Planar – $[Pt(NH_3)_4]^{2+}$, Tetrahedral – $[Zn(NH_3)_4]^{2+}$, Octahedral – $[Co(NH_3)_6]^{3+}$.
Models are especially useful when envisaging how polydentate ligands or chelating ligands attach to the central ion. It is important to be able to visualise how each ligand can occupy more than one position in the coordination sphere e.g. Ethylenediamine (en) is bidentate and attaches to the central atom at two points.



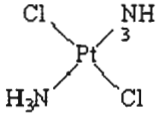
Making a model of the hexadentate EDTA demonstrates how one of these can attach to the central ion in 6 positions.

Question 35(e) continues on the next page

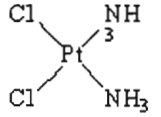


the [Cu(EDTA)]$^{2-}$ ion

Models can also demonstrate the various forms of isomerism that are characteristic of coordination compounds.



trans - $Pt(NH_3)_2Cl_2$



cis - $Pt(NH_3)_2Cl_2$

Question 35(f)

Criteria	Mark
Describes, using examples and chemical formulas, the type of pigments used in ancient cultures and assesses the potential health risk associated with their use.	7

Answer may include: Egyptians used many colourful pigments for self-decoration. Egyptian eye make-up was prepared by grinding the pigments on a stone slab. It was then used as a powder on a base of ointment. Examples of pigments used include malachite (green copper carbonate $CuCO_3.Cu(OH)_2$) and azurite (another form of copper carbonate but is blue $2CuCO_3.\ Cu(OH)_2$) as eye shadow, galena (black lead sulphide PbS) to darken eyebrows, kohl (black antimony sulphide Sb_2S_3) to darken eyelids and outline eyes. Orpiment (rich yellow – sulphide of arsenic As_2O_3) as an eye shadow. Red ochre (Fe_2O_3) to colour lips and cheeks.

Ancient Greeks used similar pigments as well as others such as cinnabar (a naturally occurring form of red mercury (II) sulfide HgS) ground and used as rouge and lipstick. They also mixed white lead (lead carbonate) with fat, oil or egg white, called ceruse, used to make the face appear pale. White lead was one of the first artificially prepared pigments.

Some of the pigments contained toxic metals and were hazardous to health. Lead, arsenic and mercury are particularly poisonous.

The major risk from inorganic mercury occurs through ingestion and if cinnabar was used on the lips there would be a high risk of this occurring. Acute oral exposure to inorganic mercury compounds has been known to produce a metallic taste in the mouth, nausea, vomiting, and severe abdominal pain. The primary effect from chronic exposure to inorganic mercury is kidney damage. Arsenic affects many parts of the body including the skin, liver, heart and lungs. It can cause conditions such as cancer, jaundice, cirrhosis, diabetes and depigmentation of the skin. If lead was actually eaten, death could be a possibility. As the lead compounds were used as cosmetics, it is more likely that the lead would enter their bloodstream and cause the effects listed below:

- Reproductive difficulties,
- High blood pressure,
- Digestive problems,
- Disorders of the nervous system,
- Memory loss and concentration problems,
- Muscle and joint pain.

Although not all pigments were hazardous to health, there were those used that certainly would pose health risks. The risk of being affected was increased by the fact that cosmetics could enter the body relatively easily through the mouth and eyes or by being absorbed by the skin.

Question 36 – Forensic Chemistry

Question 36(a)(i)

Criteria	Mark
Identifies the general formula of a carbohydrate and relates it to these compounds.	1

Answer may include: Fructose and glucose, each with a formula of $C_6H_{12}O_6$ or $C_6(H_20)_6$, matches the general formula for a carbohydrate $C_x(H_2O)_y$

Question 36(a)(ii)

Criteria	Mark
Constructs a balanced molecular equation.	1

Answer may include: $C_6H_{12}O_6 + C_6H_{12}O_6 \text{ ®⟶⟵ } C_{12}H_{22}O_{11} + H_2O$

Question 36(b)(i)

Criteria	Mark
Identifies the functional groups in any amino acid.	1

Answer may include: The amine functional group ($-NH_2$) and the carboxylic acid functional group (-COOH).

Question 36(b)(ii)

Criteria	Mark
• Relates the movement of acids to electric charge and molecular mass. (*1 mark*) • Explains that both have a positive charge but B has a higher molecular mass. (*1 mark*)	2

Answer may include: The amino acids A and B both have a positive charge and so are attracted towards the negative electrode. B has a higher molecular mass than A and so has moved towards the electrode at a slower speed, separating it from A.

Question 36(b)(iii)

Criteria	Mark
• Describes the amphiprotic properties of amino acids and their consequent range of charges. (*1 mark*) • Explains that one acid is at its neutral point while the other is negative. (*1 mark*)	1 1

Answer may include: The amine group is a weak base and so can accept a proton gaining a positive charge. The carboxylic acid group is a weak acid and so can donate a proton gaining a negative charge. The isoelectric point is the pH at which the amino acid exists as a neutral zwitterion – with one end positive and the other end negative. Amino acid C has not moved from the start position and so must be a neutral zwitterion at pH 6. Amino acid D has moved towards the positive electrode and so must exist as a negative ion at pH 6 meaning its isoelectric point is less than pH 6.

Question 36(c)(i)

Criteria	Mark
• Describes the helical structure of DNA. (*1 mark*) • Identifies the structural (molecular) units of DNA and their arrangement. (*1 mark*)	2

Answer may include: DNA exists as a double helix – 2 strands intertwined connected by hydrogen bonds between bases. Each strand consists of a backbone of sugar molecules, each joined together by a phosphate unit. Attached to each sugar unit is one of four base units – adenine, guanine, cytosine or thymine.

Question 36(c)(ii)

Criteria	Mark
Identifies the match percentage for each pair.	1

Answer may include: Identical twin sisters – 100% match, non-twin sisters – 50% match.

Question 36(c)(iii)

Criteria	Mark
Describes at least TWO situations and relates them to the required precautions.	2

Answer may include: To ensure accurate results, precautions must be taken to prevent the possible contamination of analysis samples.

- At the crime scene – the scene needs to be isolated to exclude unauthorised people (friends, relatives, sightseers, reporters, etc) and animals.
- In the collection of samples to be removed from the scene – strict guidelines must be followed in the collection, handling, storing and transportation of any samples required for laboratory analysis.
- In the laboratory – a clean, well-maintained laboratory is essential and strict guidelines must be followed in the handling and treatment of any samples being analysed

Question 36(d)(i)

Criteria	Mark
• Identifies a suitable test. (*1 mark*) • Describes the test procedure. (*1 mark*) • Describes a positive result for the test. (*1 mark*)	3

Answer may include:

- The Biuret test was used to identify the presence of proteins.
- About 5 mL of water, a sugar solution and a protein solution were placed in three separate test tubes. An equal volume of 2 mol L^{-1} NaOH solution followed by 5 drops of 0.1 mol L^{-1} $CuSO_4$ solution was then added to test tube, shaking the mixture between drops.
- No colour change was observed in the test tubes containing water and the sugar solution.
- The protein solution reacted to change the colour from a light blue to a dark purple colour.

Question 36(d)(ii)

Criteria	Mark
• Identifies a suitable test and describes the test procedure. (*1 mark*)	1
• Outlines precautions to minimise hazards. (*2 marks*)	2

Answer may include: Benedict's solution was used to distinguish between glucose, a reducing sugar, and sucrose, a non-reducing sugar. A few millilitres of glucose and sucrose solutions were placed in separate test tubes. 10 drops of Benedict's solution was added to each test tube. The mixtures were warmed in a hot water bath. The glucose reacted resulting in the Benedict's solution changing from blue to orange. The sucrose did not cause a colour change as it did not react.

Benedict's solution is a corrosive and potentially toxic substance so contact with the skin was avoided. Precautions used included using gloves and caution to minimise the risk of skin contact and use of only small amounts of reactants to minimise the impact of waste disposal.

Question 36(e)

Criteria	Mark
• Identifies and contrasts the information available through the techniques of gas-liquid chromatography (GLC) and mass spectrometry. • Describes the procedure for each technique, including sample preparation and detection methods. • Describes uses of each technique in forensic investigations. • Assesses the roles of both techniques.	7

Answer may include: Gas-liquid chromatography (GLC) and mass spectrometry are very important and widely used techniques in modern forensic investigations. They are usually used together as mass spectrometers require very pure compounds for analysis and GLC is able to separate mixtures to provide these pure samples. This analysis technique is extremely sensitive and so can be used to analyse very small samples. It also identifies compounds, unlike AAS and AES which mainly identifies the elements present.

Question 36(e) continues on the next page

Question 36(e) continued

Applications of GLC and mass spectrometry include detecting drugs in urine samples provided by athletes, alcohol in blood samples, the presence of accelerants in fire investigations, explosives on airport luggage and a range of environmental analyses. GLC has the disadvantage in that many substances tested are sensitive to heat, and so will be decomposed when vapourised and therefore will not arrive at the detector intact for identification. Organic explosives and some drugs are examples of such heat sensitive molecules. In these circumstances high pressure liquid chromatography can be used.

GLC involves pumping a gas (the mobile phase) through a column packed with particles of an inert solid, on which is a microscopic layer of liquid (the stationary phase). The sample to be analysed is vapourised and injected into the column where it is carried through by the carrier gas, usually an inert gas such as helium or nitrogen. The column is coiled up to fit inside an oven and the whole process is performed at high temperature. The different components of the sample separate depending on their interaction with the stationary phase. As the components exit the column they are detected electronically. The recorder attached to the detector produces a graph showing a series of peaks and their retention times. Each peak corresponds to a separate component in the sample mixture. If a data base of information is available, the retention time under defined conditions can be used to identify each component. The area under each peak is proportional to the amount of that component in the sample. By passing a number of standard samples of known concentration through the column and comparing them to the unknown sample, the amount in this sample can be determined.

However on its own GLC cannot positively identify the components of a mixture. Different substances may have the same retention time. For this reason the use of mass spectrometry is often combined with GLC. As the separated components individually emerge from the gas chromatograph they are analysed by the mass spectrometer. It is highly unlikely that two different substances will give the same results in both a gas chromatograph and a mass spectrograph.

Mass spectrometers identify substances on the basis of the mass of the positive ions formed when a sample is bombarded by high energy electrons. A stream of high energy electrons causes the sample molecules to break into fragments and lose electrons, resulting in a positive charge. These fragments are accelerated by electric fields and then passed into a magnetic field. The radius of the curved path taken in the magnetic field depends on the charge/mass ratio of the fragments, so allowing the different fragments to separate and be identified. The mass spectra of different compounds are unique. If a data bank of mass spectra is available, the mass spectrum produced by a compound being analysed can be compared with those in the data bank and if a match is obtained, the sample can be identified. If no match is found, some useful information about the compound can be deduced.

NSW INDEPENDENT TRIAL EXAMS – 2010
CHEMISTRY TRIAL HSC EXAMINATION
MAPPING GRID

Question	Marks	Content	Syllabus Outcomes	Target performance bands
1	1	9.2.1	8, 9	2-3
2	1	9.2.3	7, 10	4-5
3	1	9.2.4	6, 8	3-4
4	1	9.2.4	6, 7	3-4
5	1	9.2.5	3, 6	4-5
6	1	9.1, 9.2	1, 4	2-3
7	1	9.3.1 , 9.3.2	6, 8	4-5
8	1	9.3.3	8, 10	3-4
9	1	9.3.4	10	3-4
10	1	9.2.4	6, 8	3-4
11	1	9.3.2, 9.3.3, 9.3.4	8	4-5
12	1	9.3.3	8	3-4
13	1	9.4.1	2, 4, 14	2-3
14	1	9.4.3	8	3-4
15	1	9.4.4	6	3-4
16	1	9.4.4	4, 8	2-3
17	1	9.4.4	6, 8	3-4
18	1	9.4.5	8	2-3
19	1	9.4.5	4	3-4
20	1	9.3.4, 9.4.4	6, 8	4-5
21(a)	2	9.2.1, 9.3.5	8, 9	3-5
21(b)	1	9.2.1	9, 10	2-3
21(c)	2	9.2.2, 9.3.5	3, 9	4-6
22(a)	2	9.2.2	7, 9	3-4
22(b)	1	9.2.3, 9.2.3	4, 7, 9	2-4
22(c)	2	9.1, 9.2.2	4, 5, 9	3-5
23(a)	2	9.1, 9.2.4	7, 8, 11	3-4
23(b)(i)	1	9.2.4	6, 8	2-3
23(b)(ii)	2	9.1, 9.2.4	8, 14	3-5
23(c)	1	9.1, 9.24	8, 12, 14	4-5
24(a)	1	9.2.5	6	2-3
24(b)	3	9.1, 9.2.5	6, 11, 12	3-5
25	4	9.3.2 , 9.4.4	3, 4, 5, 6, 7, 8	2-6
26	4	9.1 , 9.3.4	3, 8, 11, 12	3-5
27(a)	2	9.3.2	2, 6, 8	2-5
27(b)	2	9.3.4	6, 8	3-4
27(c)	2	9.1, 9.3.2	8, 11,12	3-5
28(a)(i)	2	9.2.5	9	2-4
28(a)(ii)	1	9.1, 9.2.5	9, 11, 12	2-3
28(b)	3	9.2.5	6, 7, 9	3-6
29(a)	3	9.4.2	8	2-5
29(b)	2	9.4.2	7, 8	3-5
30	2	9.1, 9.4.3	8, 11, 12	3-5
31(a)	3	9.1, 9.4.5	13	2-4
31(b)	1	9.4.5	8, 9, 13, 14	2-3
31(c)	2	9.4.5	8, 9, 13, 14	2-5
31(d)	2	9.4.5.	8, 9, 11, 12	3-5
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Options:

32(a)(i)	1	9.5.3	7, 8	3-4
32(a)(ii)	1	9.5.3	8, 10	3-4
32(a)(iii)	1	9.5.3	7, 8	3-4
32(b)(i)	2	9.5.2	8, 10	3-5
32(b)(ii)	2	9.5.2	7, 8, 10	3-4
32(b)(iii)	2	9.5.2	8, 10	3-4
32(c)(i)	4	9.5.6	3, 4, 8	3-4
32(c)(ii)	1	9.5.6	4	2-3
32(d)(i)	2	9.5.4	7, 8	3-5
32(d)(ii)	2	9.5.4	7, 8	3-4
32(e)	7	9.5.5	3, 4	2-6
	25			
33(a)(i)	1	9.6.1	4, 8	2-3
33(a)(ii)	2	9.6.1, 9.6.2	8	3-5
33(b)(i)	1	9.6.4	8	3-6
33(b)(ii)	3	9.6.4	4, 6, 8	3-5
33(c)	4	9.6.4	3, 4, 6, 7, 8	3-6
33(d)	4	9.1, 9.6.4	3, 6, 8	3-6
33(e)	3	9.1, 9.6.3	2, 7, 8, 11, 12	2-4
33(f)	7	9.6.5, 9.6.6	3, 4, 7, 8	2-6
	25			
34(a)(i)	1	9.7.2	6, 9	2-3
34(a)(ii)	4	9.7.1, 9.7.2, 9.7.7	4, 6, 9	2-5
34(b)(i)	1	9.7.3	6, 8, 9	2-3
34(b)(ii)	1	9.7.3	4, 6, 8, 9	3-4
34(c)(i)	6	9.7.8	4, 6, 7, 8 9	2-6
34(c)(ii)	2	9.7.8	8	3-4
34(d)	3	9.7.5	4, 6, 7, 8	3-5
34(e)(i)	3	9.7.4	11, 12, 13	2-4
34(e)(ii)	4	9.7.4	12, 13, 14	3-5
	25			
35(a)(i)	1	9.8.2	6	2-3
35(a)(ii)	2	9.8.2	6, 7	3-5
35(b)	3	9.8.2	3, 4, 7, 8	4-6
35(c)(i)	1	9.8.3	6, 7	3-4
35(c)(ii)	2	9.8.3	6, 7, 8	3-5
35(d)(i)	3	9.1, 9.8.4	6, 8, 11	2-4
35(d)(ii)	3	9.1, 9.8.4	6, 8, 13	3-5
35(e)	3	9.8.5	2, 6,8	3-6
35(f)	7	9.8.1	1, 3, 4, 6, 8	2-6
	25			
36(a) i)	1	9.9.2	6, 9	2-3
36(a) ii)	1	9.9.2	6, 9	3-4
36(b) i)	1	9.9.3	9	2-3
36(b) ii)	2	9.9.3	3, 6, 7, 9	3-4
36(b) iii)	2	9.9.3	3, 6, 7, 9	3-5
36(c) i)	2	9.9.4	6, 9	3-4
36(c) ii)	1	9.9.4	5	2-3
36(c) iii)	2	9.9.1, 9.9.4	3, 4, 5	2-4
36(d) i)	3	9.9.3	4, 8, 11, 12	2-4
36(d) ii)	3	9.9.1, 9.9.2	4, 8, 9, 11, 12	2-4
36(e)	7	9.9.5	3, 4, 6, 7, 8	2-6
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