Centre Number

Student Number

CATHOLIC SECONDARY SCHOOLS
ASSOCIATION OF NEW SOUTH WALES

2010
TRIAL HIGHER SCHOOL CERTIFICATE EXAMINATION

Chemistry

Morning Session
Friday, 6 August 2010

Total marks – 100

General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Write using black or blue pen
- Draw diagrams using pencil
- Board-approved calculators may be used
- Use the Data Sheet and Periodic Table provided
- Use the Multiple Choice Answer Sheet provided
- Write your Centre Number and Student Number at the top of this page and page 13

Section I Pages 2–26

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 21–33
- Allow about 1 hour and 40 minutes for this part

Section II Pages 30–38

25 marks
- Attempt ONE question from Questions 34–38
- Allow about 45 minutes for this section

Disclaimer
Every effort has been made to prepare these 'Trial' Higher School Certificate Examinations in accordance with the Board of Studies documents, *Principles for Setting HSC Examinations in a Standards-Referenced Framework* (BOS Bulletin, Vol 8, No 9, Nov/Dec 1999), and *Principles for Developing Marking Guidelines for Examinations in a Standards Referenced Framework* (BOS Bulletin, Vol 9, No 3, May 2000). No guarantee or warranty is made or implied that the 'Trial' Examination papers mirror in every respect the actual HSC Examination question paper in any or all courses to be examined. These papers do not constitute 'advice' nor can they be construed as authoritative interpretations of Board of Studies intentions. The CSSA accepts no liability for any reliance, use or purpose related to these 'Trial' question papers. Advice on HSC examination issues is only to be obtained from the NSW Board of Studies.

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Section I
75 marks

Part A – 20 marks
Attempt Questions 1-20
Allow about 40 minutes for this part

Use the Multiple Choice Answer Sheet provided.

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1 Which of the following is the best description of cellulose?

(A) A condensation polymer made from ethylene monomers

(B) A condensation polymer made from glucose monomers

(C) An addition polymer made from ethylene monomers

(D) An addition polymer made from glucose monomers

2 In an experiment 6.0 g of propan-1-ol underwent complete combustion to produce carbon dioxide and water.

What volume of carbon dioxide was produced at 25°C and 100 kPa?

(A) 2.5 L

(B) 3.4 L

(C) 3.8 L

(D) 7.4 L

3 The fuel E10 consists of 10% ethanol blended with petrol consisting mainly of octane.

Which of the following statements best explains the solubility of ethanol in petrol?

(A) Ethanol undergoes hydrogen bonding with petrol which increases its solubility.

(B) Ethanol contains a polar –OH group improving its solubility in hydrocarbons.

(C) Ethanol and petrol are both non-polar molecules and soluble in each other.

(D) Ethanol contains a short hydrocarbon chain which allows it to be soluble in petrol.

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4 The lithium iodide solid-state battery has specific applications such as in cardiac pacemakers, due to its long life span.

The reactions of this battery are shown below:

$Li\ (s) \rightarrow Li^+ + e^-$

$\frac{1}{2}\ I_2\ (s) + e^- \rightarrow I^-$

Which of the following is correct for the chemistry at the anode of the lithium iodide cell?

(A) The oxidation state of lithium increases.

(B) The oxidation state of lithium decreases.

(C) The oxidation state of iodine increases.

(D) The oxidation state of iodine decreases.

5 The molar heat of combustion of ethanol is 1367 kJ mol^{-1}.

Assuming no heat losses to the surroundings, what mass of ethanol must be combusted to raise the temperature of 0.250 kg of water from 20.0°C to 60.0°C?

(A) 1.41×10^{-3} g

(B) 2.11×10^{-3} g

(C) 1.41 g

(D) 2.11 g

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6 Bromine water, $Br_2(aq)$, is a reddish solution which can be used to distinguish between saturated and unsaturated hydrocarbons.

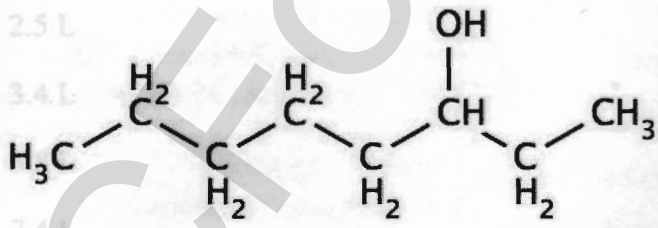
In a darkened laboratory, a student placed 5 mL of hexane into a test tube and 5 mL of hex-1-ene into another test tube. Three drops of bromine water were added to both test tubes. After shaking the test tubes, the student immediately recorded his observations.

Test Tube	*Observation*
1	The reddish colour faded rapidly
2	A coloured layer remained

Which of the following would best represent the species present in test tubes 1 and 2 immediately after the reaction?

	Test Tube 1	*Test Tube 2*
(A)	C_6H_{14}, Br_2	C_6H_{12}, $C_6H_{12}Br_2$
(B)	C_6H_{14}, Br_2, H_2O	C_6H_{12}, $C_6H_{12}Br_2$, H_2O
(C)	$C_6H_{12}Br_2$	C_6H_{14}, Br_2
(D)	C_6H_{12}, $C_6H_{12}Br_2$, H_2O	C_6H_{14}, H_2O, Br_2

7 What is the systematic name for the following compound?



(A) Heptan-5-ol

(B) Heptan-3-ol

(C) Octan-5-ol

(D) Octan-3-ol

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8 Samples of 0.1 mol L^{-1} hydrochloric acid and 0.1 mol L^{-1} acetic acid were tested. The hydrochloric acid was found to have a lower pH than the acetic acid.

Which of the following best explains this observation?

(A) The hydrochloric acid is more concentrated than the acetic acid.

(B) The acetic acid produces more hydronium ions than the hydrochloric acid.

(C) Hydrochloric acid ionises to a greater extent than acetic acid.

(D) An error occurred during the testing as the two acids should have the same pH.

9 The mass ratio of alcohol to organic acid reacted in an esterification process is 1:1.

The ester produced could be

(A) ethyl ethanoate.

(B) butyl propanoate.

(C) propyl butanoate.

(D) ethyl propanoate.

10 The pH of pure water at 25°C is 7, whereas the pH of unpolluted rainwater is close to 6.

Which of the following substances contributes most to this difference in pH?

(A) CO_2

(B) SO_2

(C) NO_2

(D) O_3

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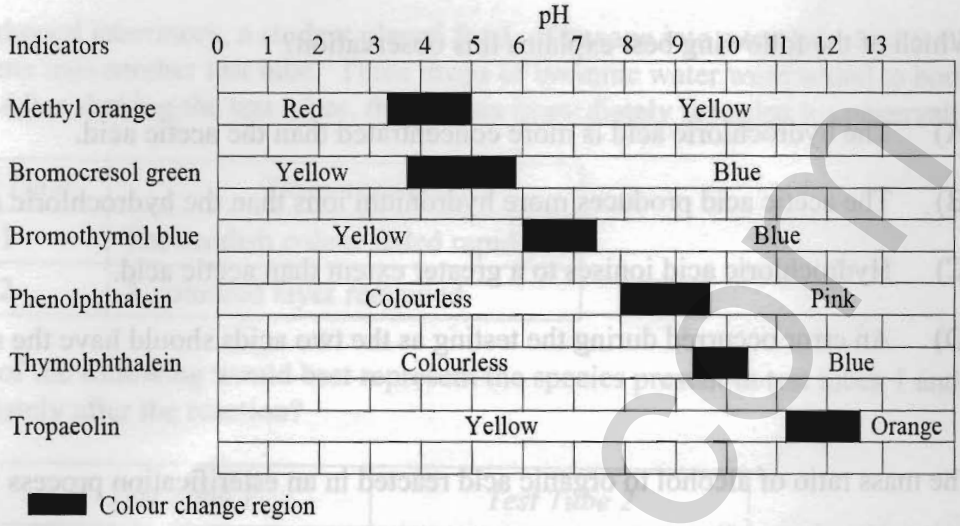
11 The chart below shows the pH colour change ranges for various indicators.



The pH ranges of common household substances are shown below.

Household substance	*pH range*
Orange juice	3-4
Milk	6-7
Baking soda solution	10-11
Liquid ammonia	12-13

A substance was tested with the following indicators. The results are shown below.

Indicator	*Colour*
Methyl orange	Yellow
Bromocresol green	Blue
Phenolphthalein	Colourless
Thymolphthalein	Colourless

The substance is most likely to be

(A) orange juice.

(B) milk.

(C) baking soda solution.

(D) liquid ammonia.

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12 A student pipetted 25.0 mL of a sodium hydroxide solution into a conical flask, added a few drops of phenolphthalein indicator and titrated this with a 0.015 mol L^{-1} solution of hydrochloric acid. The volume of hydrochloric acid required was 11.55 mL.

What is the concentration of sodium hydroxide (expressed to the correct number of significant figures)?

(A) 6.930×10^{-3} mol L^{-1}

(B) 6.93×10^{-3} mol L^{-1}

(C) 6.9×10^{-3} mol L^{-1}

(D) 7×10^{-3} mol L^{-1}

13 Which of the following is classified as the conjugate base of water?

(A) OH^-

(B) H_3O^+

(C) O^-

(D) O^{2-}

14 The synthesis of ammonia is a reversible reaction that can reach equilibrium.

Why does the industrial process to produce ammonia NOT reach equilibrium?

(A) The reaction is extremely slow.

(B) There is insufficient ammonia produced.

(C) The addition of a catalyst changes the rate of the reaction.

(D) The system is not closed as reactants and products are added and removed.

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15 A lawn fertiliser lists the sulfate content as 38.5% (w/w).

What mass of barium sulfate precipitate would be expected to form if a 1.50 g sample of the fertiliser were analysed by reacting the sample with excess barium nitrate solution?

(A) 0.238 g

(B) 0.578 g

(C) 1.40 g

(D) 3.64 g

16 In order to determine the possible cations in a sample of water, a student followed the following procedure.

	Method	*Observation*
Step 1	Excess hydrochloric acid was added to a portion of the sample.	A white precipitate formed, which did not darken when left exposed to UV light.
Step 2	The precipitate from Step 1 was filtered off and the filtrate retained.	
Step 3	Dilute sulfuric acid was added to some of the filtrate from Step 2.	No precipitate formed.
Step 4	Excess sodium hydroxide was added to some of the filtrate from Step 2.	A precipitate formed, which turned yellowish on standing for several hours.

The cations in the sample are likely to be

(A) Pb^{2+} and Fe^{2+}

(B) Fe^{2+} and Ag^{+}

(C) Na^{+} and Pb^{2+}

(D) Ag^{+} and Na^{+}

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17 Hardness of natural water sources results from

(A) increasing the acidity of a body of water.

(B) the presence of excessive concentrations of calcium and magnesium ions.

(C) the presence of iron-based minerals from rocks.

(D) the presence of excessive concentrations of phosphate and nitrate ions.

18 Black smoke emitted from the exhaust of a motor cycle is most likely caused by

(A) excessive heat energy in the combustion chamber.

(B) excessive build up of carbon dioxide in the combustion chamber.

(C) insufficient oxygen present in the combustion chamber.

(D) insufficient fuel present in the combustion chamber.

19 What flame colour is produced by calcium ions in a flame test?

(A) Red

(B) Blue

(C) Green

(D) Yellow

20 Which alternative best fits the properties of gaseous oxygen and the oxygen free radical?

	Gaseous oxygen		*Oxygen free radical*	
(A)	more reactive	monatomic	less reactive	molecular
(B)	less reactive	molecular	more reactive	monatomic
(C)	less reactive	monatomic	more reactive	molecular
(D)	more reactive	molecular	less reactive	monatomic

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Chemistry

Centre Number

Student Number

Section I (continued)

Part B – 55 marks
Attempt Questions 21-33
Allow about 1 hour and 35 minutes for this part

Answer the questions in the spaces provided. These spaces provide guidance for the expected length of response.

Show all relevant working in questions involving calculations.

Question 21 (3 marks)

The production of artificial elements neptunium and curium can be summarised by the following equations:

$$^{238}_{92}\text{U} + {}^{1}_{0}\text{n} \rightarrow {}^{239}_{92}\text{U} \rightarrow {}^{239}_{93}\text{Np} + X$$

$$^{239}_{94}\text{Pu} + {}^{4}_{2}\text{He} \rightarrow {}^{242}_{96}\text{Cm} + Y$$

(a) Identify particle *X* and particle *Y*. **1**

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(b) Compare these methods of production of neptunium and curium. **2**

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Question 22 (5 marks)

Ethanol is readily available from renewable sources such as glucose or it may be produced using industrial methods from non-renewable sources.

A student conducted an investigation to produce ethanol from glucose. The graph shows the total volume of gas produced from the reaction vessel over 8 days. The reaction was conducted at 25°C and 100 kPa.

(a) Identify the process used to produce ethanol from glucose. **1**

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(b) Calculate the mass of glucose that reacted over the 8 days. **3**

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(c) Write an equation for the production of ethanol from a non-renewable source and include a catalyst in your equation. **1**

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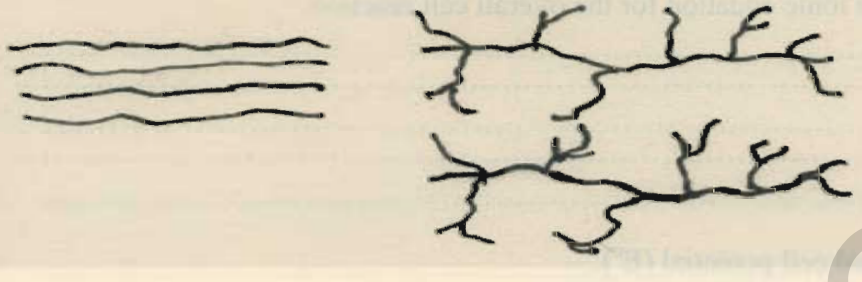
Question 23 (4 marks)

Models are used in the study of Chemistry to aid our understanding. The diagram shows two different models of the polymer, polyethylene, constructed by a student.

Model A Model B



Some properties of two forms of polyethylene, known as HDPE and LDPE, are shown in the table. **4**

Property	*HDPE*	*LDPE*
Melting Point (^{o}C)	~ 135	~ 115
Solubility in water	insoluble	insoluble
Flexibility	low	high

Evaluate the effectiveness of the TWO models to explain the properties of HDPE and LDPE shown in the table.

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Question 24 (6 marks)

A student constructed a galvanic cell using two half-cells. One half-cell consisted of a zinc electrode in a zinc sulfate solution. The other half-cell consisted of an aluminium electrode and a solution of aluminium sulfate. A voltmeter and a salt bridge were also used in the cell.

(a) Write a balanced net ionic equation for the overall cell reaction. **1**

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(b) Calculate the standard cell potential (E°). **1**

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(c) The student was told to decrease the cell potential by replacing the reduction half-cell with a different metal cathode and an appropriate solution. **1**

Identify a suitable replacement cathode and solution.

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Question 24 continues on page 17

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Question 24 (continued)

(d) "Oxidation-reduction reactions are increasingly important as a source of energy". **3**

Discuss this statement.

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End of Question 24

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Question 25 (3 marks)

Nitrogen (N_2) is very stable and forms 78% of the Earth's atmosphere. When lightning occurs, some of the nitrogen is oxidised and a number of products may form. Some of these are shown in the table below.

Name	*Formula*
dinitrogen monoxide	N_2O
nitrogen monoxide	NO
nitrogen dioxide	NO_2

(a) Write appropriate equations to show the formation of nitrogen dioxide from nitrogen and oxygen. **2**

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(b) Identify a problem associated with the presence of oxides of nitrogen in the atmosphere. **1**

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Question 26 (2 marks)

As part of your course an investigation was performed to identify the pH of a range of salt solutions. **2**

Identify whether ammonium chloride (NH_4Cl) is an acidic, basic or neutral salt and explain your answer, using an appropriate equation.

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Question 27 (3 marks)

A small sample of calcium was reacted with 100.0 mL of water in a beaker. The resulting solution was found to contain hydroxide ions at a concentration of 3.16×10^{-2} mol L^{-1}.

(a) Write a balanced equation for the reaction of calcium with water. **1**

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(b) Determine the volume of the gas formed during this reaction (assume at 25°C and 100 kPa). **2**

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Question 28 (3 marks)

Buffer solutions are important in natural systems.

(a) Explain why a mixture of sodium chloride and hydrochloric acid cannot form a buffer solution. **2**

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(b) Account for the importance of buffer solutions in natural systems. **1**

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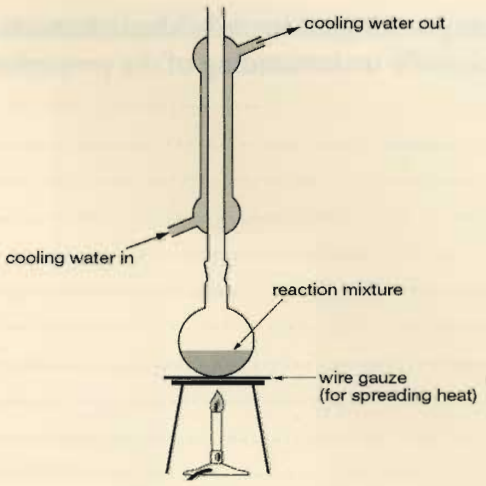
Question 29 (5 marks)

The diagram shows the apparatus used in a school laboratory to produce the ester, methyl propanoate.



(a) Name the chemicals used to produce methyl propanoate. **1**

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(b) Identify the contents of the flask after refluxing for 30 minutes. **2**

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(c) Justify your answer to part (b) above. **2**

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Question 30 (4 marks)

Our understanding of scientific concepts has developed, over time, as the result of the work of scientists, both individually and in collaboration.

(a) With reference to the ideas put forward by individual chemists over two centuries, analyse the changes in scientific understanding of the properties of acids. **3**

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(b) Use an example to identify a benefit of collaboration between chemists in the 21st century. **1**

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Question 31 (6 marks)

Some elements, referred to as trace elements, exist in the environment in very low concentrations which can only be measured in parts per million.

(a) Describe an appropriate technique for measuring these low concentrations. **2**

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(b) Assess the impact of the process described in part (a) on the understanding of the effects of a named trace element. **4**

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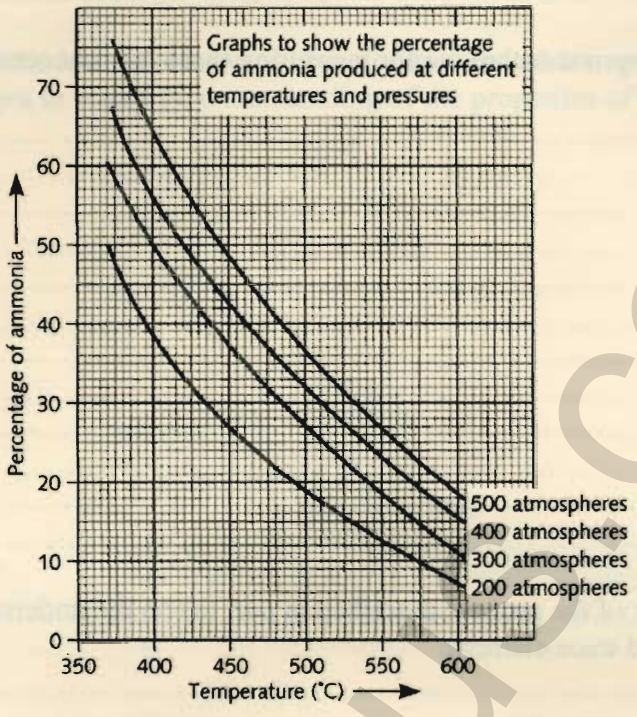
Question 32 (6 marks)

A student located the following graphs whilst investigating the Haber process.



(a) Write a balanced chemical equation for the synthesis of ammonia. **1**

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(b) According to the graphs, which conditions will produce the greatest percentage of ammonia? **1**

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Question 32 continues on page 25

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Question 32 (continued)

(c) Upon further investigation the student discovered the industrial synthesis of ammonia was usually carried out at approximately $450^{o}C$ and 2×10^{4} kPa. **4**

With reference to the graphs on page 24 and using your knowledge of the Haber process, explain why these conditions are chosen.

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End of Question 32

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Question 33 (5 marks)

According to the Australian Government's Bureau of Meteorology, "*overwhelming scientific evidence accumulated over more than two decades of study ... has shown that human-made chemicals are responsible for the observed depletion in the ozone layer over Antarctica.*"

Assess the validity of this statement in terms of the scientific evidence gathered and the role of human-made chemicals.

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Chemistry

Section II

25 marks
Attempt ONE question from Questions 34–38
Allow about 45 minutes for this section

Answer the question in a SEPARATE writing booklet.

Show all relevant working in questions involving calculations.

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Question 34 – Industrial Chemistry (25 marks)

(a) Electrolysis is an important industrial process.

(i) Define *electrolysis*. **1**

(ii) Compare the reaction products from the electrolysis of molten sodium chloride and concentrated aqueous sodium chloride. **2**

(b) The reaction of methane with water vapour is shown below:

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

In one experiment, 1.00 mol of pure methane was reacted with 2.00 mol of water vapour in a 10.0 L sealed flask. When equilibrium was established at 1400K, 0.046 mol of methane were in the flask.

(i) How many moles of each of H_2O, CO and H_2 were in the flask at equilibrium? **3**

(ii) Calculate the value for the equilibrium constant for the reaction, as represented in the equation, at 1400K. **2**

(iii) In another experiment, the values of the equilibrium constant (K) at 1200K and 1600K were determined and found to be 3.20 and 5.90 respectively. **2**

Is this reaction exothermic or endothermic? Explain.

(c) (i) Compare the structures of soap, anionic detergents and cationic detergents. **3**

(ii) Identify a different use for each of the above and outline how the identified use is related to the structure or properties of the surfactant. **3**

(d) During your studies a first-hand investigation was performed using sulfuric acid acting as a dehydrating agent.

(i) Describe the reaction and the observations as the experiment was carried out. **2**

(ii) Identify any safety precautions taken because of the properties of sulfuric acid. **1**

(iii) Write a balanced equation for the above reaction. **1**

(e) Evaluate how environmental issues are addressed in the Solvay process. **5**

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Question 35 – Shipwrecks, Corrosion and Conservation (25 marks)

(a) (i) Identify the oxidation-reduction reaction from the list below. **1**

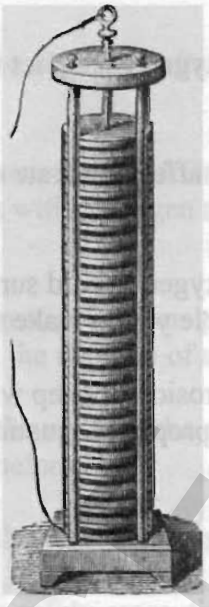
Reaction 1
zinc chloride *(aq)* + lead nitrate *(aq)* → zinc nitrate *(aq)* + lead chloride *(s)*

Reaction 2
hydrochloric acid *(aq)* + sodium hydroxide *(aq)* → sodium chloride *(aq)* + water *(l)*

Reaction 3
zinc *(s)* + copper sulfate *(aq)* → zinc sulfate (*aq)* + copper *(s)*

(ii) Explain your selection in part (i). **2**

(b) This image is of a Voltaic Pile.



(i) Identify the scientist who invented this device. **1**

(ii) Explain why the Voltaic Pile was considered to be the first battery. **2**

Question 35 continues on page 32

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(c) During your course, an investigation was carried out to identify the factors that affect the rate of an electrolysis reaction.

(i) What is an electrolysis reaction? **1**

(ii) For ONE of the factors in the investigation, produce a labelled diagram of the apparatus. Clearly indicate the independent variable and controlled variables. **3**

(iii) Outline how electrolysis can be used to prevent corrosion. **1**

(d) "The salvage, conservation and restoration of objects from wrecks require careful planning and an understanding of the behaviour of chemicals." **6**

Analyse this statement.

(e) The solubility and therefore the concentration of oxygen gas affect the rate of corrosion in marine environments.

(i) Explain why the concentration of oxygen gas affects the rate of corrosion. Use an appropriate equation in your response. **2**

(ii) Qualitatively predict the level of dissolved oxygen in cold surface waters of the Southern Ocean. Discuss factors that enable you to make this prediction. **3**

(iii) Describe the role of anaerobic bacteria in corrosion of deep wrecks where there is little dissolved oxygen. Include an appropriate equation in your response. **3**

End of Question 35

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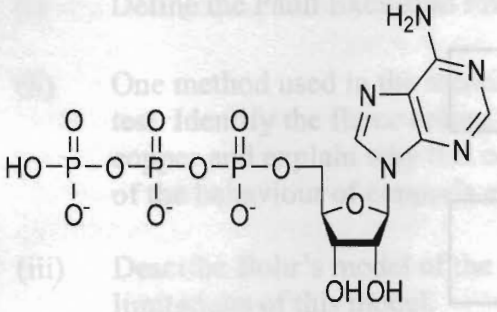
Question 36 – The Biochemistry of Movement (25 marks)

(a)  **2**

Identify the molecule above and the site of most of its production in the cell.

(b) Using a named example of an enzyme, explain why the enzyme's binding site is substrate specific. **2**

(c) As a foodstuff, a significant fraction of our caloric intake is triacylglycerol (TAGs). **6**

Assess the importance of TAGs as an energy dense store for humans and compare TAGs with glycogen as a source of energy.

(d) A first hand investigation was performed to observe the effect of changes in temperature on the reaction of a named enzyme.

(i) Identify the name of the enzyme and the group of compounds to which the enzyme belongs. **2**

(ii) Explain the results obtained and discuss the conclusions reached. **3**

(iii) Identify a safety precaution associated with the experimental procedure. **1**

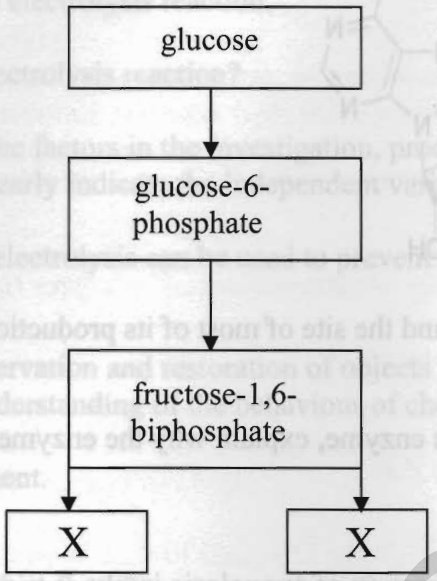
(e) (i) Describe the generalised structure of a skeletal muscle cell. **2**

(ii) "Active fish such as marlin and tuna have a much darker meat than less active fish like flounder and flathead." **3**

Discuss this statement, taking into account the types of muscle used by these fish.

Question 36 continues on page 34

(f)



The flow chart above represents glycolysis, which is the first stage of cellular respiration.

(i) Two molecules of a compound X are produced as the end product of this process. Identify both the common name and the systematic name of this compound. **1**

(ii) What is the net result in terms of energy released by the above process? **1**

(iii) Under normal aerobic conditions molecule X becomes the starting point for the tricarboxylic acid cycle. During vigorous exercise not enough oxygen is available to complete this cycle. **2**

Describe the alternate pathway available to molecule X in anaerobic conditions. Include an appropriate equation.

End of Question 36

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Question 37 – The Chemistry of Art (25 marks)

(a) (i) Define the Pauli Exclusion Principle. **1**

(ii) One method used in the identification of copper compounds is a flame test. Identify the flame colour typically associated with the presence of copper and explain why this colour reliably identifies the element in terms of the behaviour of copper's electrons. **2**

(iii) Describe Bohr's model of the hydrogen atom and discuss the merits and limitations of this model. **5**

(b) Early Egyptian and Roman civilisations experimented extensively with pigments. One of the most common uses of the pigments they discovered or developed was as an additive in cosmetics. **2**

Identify the chemical composition of ONE named cosmetic used by an ancient civilisation and describe the potential threat to the health of those who used this cosmetic.

(c) An experiment was performed to investigate the oxidising strength of potassium permanganate ($KMnO_4$).

(i) One of the variables kept constant in this experiment was the concentration of the species to be oxidised. Explain why controlling the concentration is essential to the validity of the results. **2**

(ii) Manganese acts as an oxidising agent in many compounds, three of which are $KMnO_4$, $MnCl_2$ and MnO_2. Account for the difference in the oxidising strengths of $KMnO_4$ and $MnCl_2$ and predict where the oxidising strength of MnO_2 would lie compared with the other two compounds, giving a reason for your prediction. **3**

Question 37 continues on page 36

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(d) When outlining the reason for a permanganate ion solution's purple colour, a teacher found the following explanation on the internet. **4**

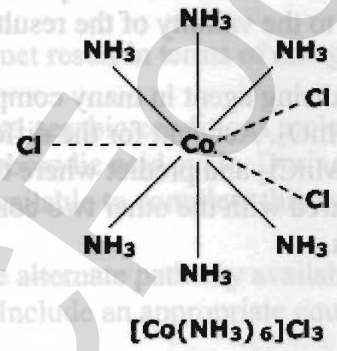
1. White light containing all visible wavelengths shines upon the permanganate ion.
2. One or more wavelengths of light corresponding to the purple colour are absorbed by ground state electrons, enabling them to jump to a higher energy level.
3. These electrons return to their ground state, emitting the same purple wavelengths of light.
4. The emitted purple light enters our eyes and we see the permanganate solution as purple.

The teacher said the explanation was wrong. Write an alternative step by step explanation that correctly describes how the behaviour of light and the electrons in the permanganate ion lead to the solution's purple appearance.

(e) (i) Write appropriate electron configurations for the ions V^{5+} and Fe^{3+}. **2**

(ii) Relate the stability of each ion to its electron configuration. **2**

(f) The diagram below represents $[Co(NH_3)_6]Cl_3$. **2**



Describe the bonding within the complex ion in this salt.

End of Question 37

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Question 38 – Forensic Chemistry (25 marks)

(a) Describe a significant difference between organic and inorganic compounds. **1**

(b) Outline a series of tests that could be used to distinguish between unsaturated hydrocarbons, alkanols and alkanoic acids. Include in your answer any safety precautions that should be used. **4**

(c) (i) Identify the three elements found in carbohydrates. **1**

(ii) Compare the condensation reactions between glucose molecules to form a polysaccharide and between amino acid molecules to form proteins. **3**

(d) Explain why a range of solvents can be used to separate different mixtures when performing chromatography. **2**

(e) Justify the uses of DNA analyses in forensic chemistry. **5**

Question 38 continues on page 38

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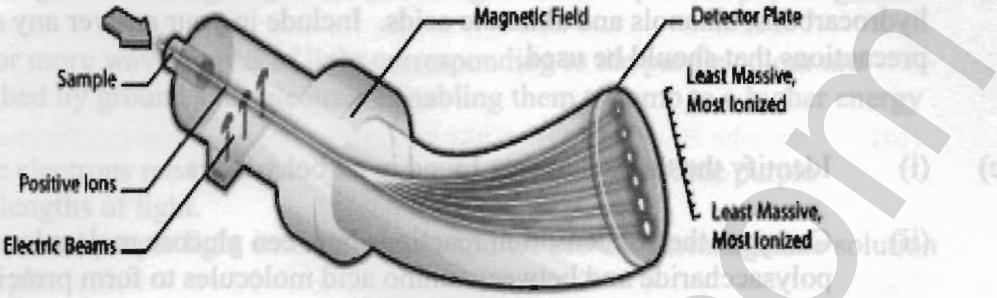
(f) A schematic diagram of a mass spectrometer is shown below.



(i) Describe how a mass spectrometer operates. **2**

(ii) Account for the use of mass spectrometry in forensic chemistry. **3**

(g) Discuss the importance of the use of line emission spectra in determining the origins of a mixture. **4**

End of Question 38

End of Paper

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PERIODIC TABLE OF THE ELEMENTS

KEY

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

1 H 1.008 Hydrogen																	2 He 4.003 Helium
3 Li 6.941 Lithium	4 Be 9.012 Beryllium											5 B 10.81 Boron	6 C 12.01 Carbon	7 N 14.01 Nitrogen	8 O 16.00 Oxygen	9 F 19.00 Fluorine	10 Ne 20.18 Neon
11 Na 22.99 Sodium	12 Mg 24.31 Magnesium											13 Al 26.98 Aluminium	14 Si 28.09 Silicon	15 P 30.97 Phosphorus	16 S 32.07 Sulfur	17 Cl 35.45 Chlorine	18 Ar 39.95 Argon
19 K 39.10 Potassium	20 Ca 40.08 Calcium	21 Sc 44.96 Scandium	22 Ti 47.87 Titanium	23 V 50.94 Vanadium	24 Cr 52.00 Chromium	25 Mn 54.94 Manganese	26 Fe 55.85 Iron	27 Co 58.93 Cobalt	28 Ni 58.69 Nickel	29 Cu 63.55 Copper	30 Zn 65.41 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] Astutine	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							

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.

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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.