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HSC Trial Examination 2005

Chemistry

This paper must be kept under strict security and may only be used on or after the morning of Friday 5 August, 2005 as specified in the NEAP Examination Timetable.

General Instructions

Reading time 5 minutes.

Working time 3 hours.

Board-approved calculators may be used.

Write using blue or black pen.

Draw diagrams using pencil.

A data sheet and Periodic Table are provided at the back of this paper.

Total Marks 100

Section I Pages 2–16

Total marks 75

This section has two parts, Part A and Part B

Part A – 15 marks
Attempt Questions 1–15.
Allow about 30 minutes for this part.

Part B – 60 marks
Attempt Questions 16–27.
Allow about 1 hour and 45 minutes for this part.

Section II Pages 17–24

Total marks 25

Attempt ONE question from Questions 28–32.
Allow about 45 minutes for this section.

Students are advised that this is a trial examination only and cannot in any way guarantee the content or the format of the 2005 Chemistry HSC Trial Examination.

Section I

Total marks 75

Part A

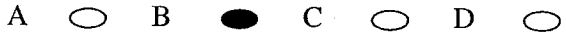
Total marks 15
Attempt Questions 1–15.
Allow about 30 minutes for this part.

Use the multiple-choice answer sheet.
Select the alternative A, B, C, or D that best answers the question. Fill in the response oval completely.

Sample:

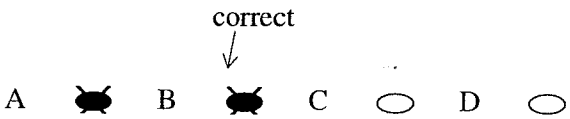
2 + 4 =

(A) 2
(B) 6
(C) 8
(D) 9



If you think you have made a mistake, put a cross through the incorrect answer and fill in the new answer.

If you change your mind and have crossed out what you consider to be the correct answer, then indicate this by writing the word *correct* and draw an arrow as follows:



1. Which of the following equations shows the greatest change in oxidation state for the reduction of the reactant?

   (A) $Fe \rightarrow Fe^{3+} + 3e^-$

   (B) $Fe + 3e^- \rightarrow Fe^{3+}$

   (C) $Fe^{3+} + e^- \rightarrow Fe^{2+}$

   (D) $Fe^{2+} + 2e^- \rightarrow Fe$

2. A 285.3 g bottle of soda water was decarbonated by adding 14.7 g of salt to it. The final mass was 296 g. The volume of gas formed at 25°C and 100 kPa was

   (A) 2.22 L

   (B) 2.06 L

   (C) 2.25 L

   (D) 2.04 L

3. A hydrochloric acid solution has a pH of 4. In comparison, a citric acid solution of the same pH must have

   (A) the same proportion of molecules ionising.

   (B) a higher concentration of acid molecules.

   (C) a lower concentration of acid molecules.

   (D) a higher concentration of hydrogen ions.

4. Which of the following correctly identifies the amphiprotic species with both its conjugate acid and its conjugate base?

	Conjugate acid	*Amphiprotic species*	*Conjugate base*
(A)	HCO_3^-	H_2CO_3	CO_3^{2-}
(B)	NH_4^+	NH_3	NH_2^-
(C)	OH^-	H_2O	H_3O^+
(D)	H_2SO_4	SO_4^{2-}	HSO_4^-

5. When an indicator is used in an acid base titration, its colour change

   (A) always identifies the equivalence point.

   (B) only occurs at a pH of 7.

   (C) needs to correspond to that point when the moles of acid and base present in the mixture are identical.

   (D) needs to correspond to that point when the moles of acid and base present in the mixture correspond to the molar ratio of the balanced equation.

6. Metallic zinc, copper and solutions of their ions were used to produce a galvanic cell. Which of the following correctly summarises the cell produced?

	Anode	*Cathode*	*Species Oxidised*	*Species Reduced*
(A)	zinc	copper	copper ions	zinc
(B)	zinc	copper	zinc ions	copper
(C)	copper	zinc	zinc ions	copper
(D)	copper	zinc	copper ions	zinc

7. A transuranic element is produced when
   (A) nuclei with 92 protons break up into smaller atoms.
   (B) a small nucleus is forced into a large nucleus so that the total number of protons becomes greater than 92.
   (C) more than 92 hydrogen nuclei are forced together to make a single nucleus.
   (D) two nuclei containing at least 47 protons are forced together to form a single nucleus.

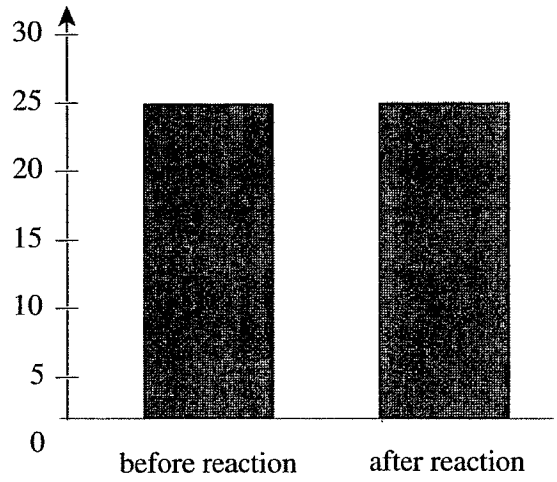
8. Ammonia can be synthesised from its component gases in an equilibrium process.
   Which of the following changes to the system would increase the yield of ammonia?
   (A) Decreasing the pressure of system.
   (B) Decreasing the temperature of the system.
   (C) Decreasing the concentration of both reactants.
   (D) Using an iron-iron oxide catalyst.

9. Some reaction processes are:
   I condensation, II equilibrium, III polymerisation, IV acid/base, V addition.

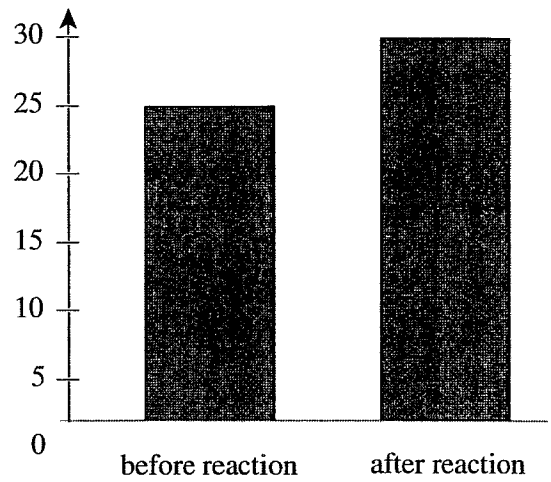
   The reaction $CH_3OH + CH_3COOH \rightleftharpoons CH_3COOCH_3 + H_2O$ is an example of:
   (A) I only.
   (B) I and II.
   (C) II and V.
   (D) I and IV.

10. A student reacts equal amounts of 5 M sodium hydroxide solution, $NaOH_{(aq)}$ and 5 M hydrochloric acid solution, $HCl_{(aq)}$ at room temperature. The column graph that correctly compares the temperature of the solutions before they were reacted and once the reaction is completed is

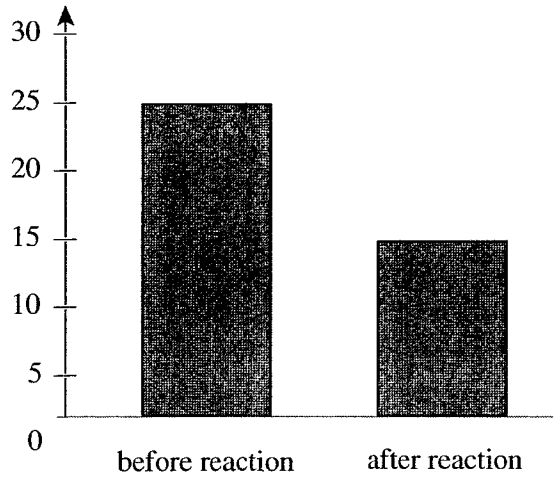
(A)



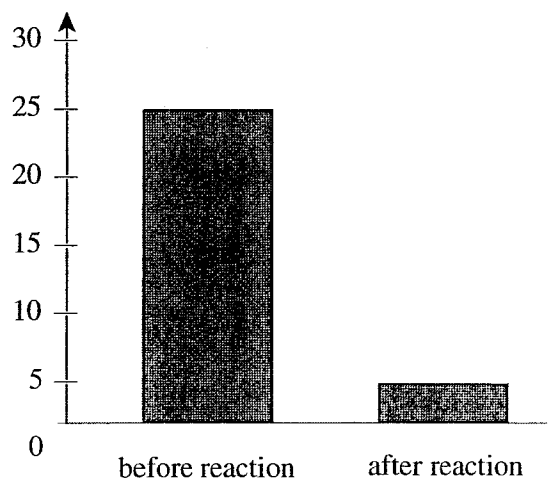
(B)



(C)



(D)



11. A student was attempting to detect the presence of calcium ions in a solution containing nitrate ions and only one other cation. Which of the following could be used as a positive test for calcium ions?

(A) A red flame is produced when a fine mist of the solution is sprayed into a Bunsen flame.

(B) A yellow-green flame is produced when a fine mist of the solution is sprayed into a Bunsen flame.

(C) A white calcium chloride precipitate is produced after the addition of hydrochloric acid.

(D) A small amount of white ammonium chloride precipitate is produced after the addition of ammonia.

12. Which of the following haloalkanes represent isomers?

(A) dichlorodifluoromethane; dichlorodibromomethane.

(B) 2-fluoro-3-methylbutane; 1-fluoropentane.

(C) 2-fluoro-3-methylpentane; 2,2-difluoro-3-methylpentane.

(D) 1-fluoro-2-pentene; 1-fluoro-2-methylpentane.

13. Which of the following steps in the purification and sanitisation of mass water supplies could be regarded as a physical process?

(A) flocculation
(B) filtration
(C) chlorination
(D) softening of hard water

14. The correctly balanced equation for the burning of octane in insufficient oxygen is

(A) $2C_8H_{18(l)} + 17O_{2(g)} \rightarrow 8CO_{2(g)} + 9H_2O_{(l)}$
(B) $C_8H_{18(l)} + 17/2O_{2(g)} \rightarrow 8CO_{2(g)} + 9H_2O_{(l)}$
(C) $C_8H_{18(l)} + 5O_{2(g)} \rightarrow 7C_{(s)} + CO_{(g)} + 9H_2O_{(l)}$
(D) $C_8H_{18(l)} + 8O_{2(g)} \rightarrow 7CO_{(g)} + CO_{2(g)} + 9H_2O_{(l)}$

15. Read the following statements and choose the correct response.

(A) To dilute a concentrated acid, water should carefully be added to the acid.
(B) To dilute a concentrated acid, the acid should carefully be added to water.
(C) A spill of strong sulfuric acid on a laboratory bench top should be neutralised by adding dilute sodium hydroxide to it.
(D) A spill of strong sulfuric acid on a laboratory bench top should be neutralised by adding concentrated sodium hydroxide to it.

Part B

Total marks 60
Attempt Questions 16–27.
Allow about 1 hour and 45 minutes for this part.

Answer Part B questions in the spaces provided.
Show all relevant working in questions that require calculations.

Marks

Question 16 (4 marks)

The table shows the solubility of different materials in ethanol and water.

Chemical	*Solubility in ethanol*	*Solubility in water*
Sodium chloride	High	High
Heptanol	High	Low

Use the results from the above table to analyse the solvent ability of ethanol and water. **4**

Question 17 (4 marks) **Marks**

(a) Briefly describe two chemical processes encountered in this course that use a catalyst. **2**

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(b) Identify the features of the catalysts that make them useful for the process. **2**

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Marks

Question 18 (5 marks)

Draw the electrochemical cell:

$$C_{(s)}| Fe^{2+}, Fe^{3+} || Cu^{2+}, Cu_{(s)}$$

Label the anode and cathode and write the redox half equations and full equation to determine the voltage produced by the cell. **5**

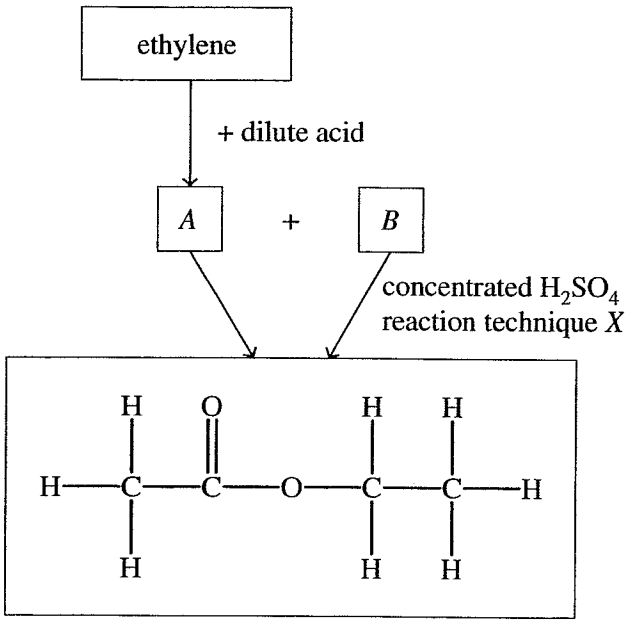
Question 19 (3 marks)

Outline the difference between destructive and non-destructive testing in chemistry, giving an appropriate example of each. **3**

Question 20 (4 marks)

Marks

The following flow chart shows a series of reactions using mainly carbon based compounds.



(a) Identify the formula of compound *A* by writing a balanced equation that describes its production, as shown in the flow chart. **1**

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(b) Name compound *B*. **1**

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(c) Reaction technique *X* is needed to prevent the loss of volatile reactants and products. Identify two safety procedures needed when performing this technique and explain why they are necessary. **2**

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Marks

Question 21 (8 marks)

For a named biopolymer:

(a) Describe how it is made. **2**

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(b) Give a use of the biopolymer and explain why it is useful in terms of its properties. **2**

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(c) Compare the named biopolymer and polyethylene in terms of uses and environmental effect. **4**

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Question 22 (3 marks) **Marks**

Which of the following show(s) coordinate bonding? Justify your choice. **3**

O_3, NH_4^+, H_2O

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Question 23 (4 marks)

Use Le Chatelier's Principle to relate the increase in burning fossil fuels to a possible increase in the acidity of the oceans. **4**

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Marks

Question 24 (7 marks)

A solution of vinegar was titrated against 0.22 mol L^{-1} NaOH to determine its concentration. The 50.00 mL sample of vinegar was diluted to 500.0 mL and 20.00 mL aliquots of the diluted solution were titrated with phenolphthalein as the indicator. The results of the titration are shown:

Run	Rough	1	2	3
Volume of NaOH used (mL)	23.50	23.10	23.00	22.90

(a) Justify the use of phenolphthalein as the indicator. **2**

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(b) Calculate the concentration of the vinegar. **3**

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(c) Describe an alternative method of determining the equivalent point of this titration. **2**

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Marks

Question 25 (6 marks)

Ammonia can be synthesised in an industrial process which was developed by German chemist, Fritz Haber, in 1912. The development of the Haber process paved the way for large-scale production of mass quantities of ammonia.

(a) Write a balanced chemical equation to show the Haber process. **1**

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(b) Identify and describe one industrial use of ammonia. **1**

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(c) Evaluate the significance of the development of the Haber process at that time in world history. **4**

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Marks

Question 26 (5 marks)

Linarite is a mineral containing copper and lead, and is found in Scotland and Spain. Its chemical formula is $PbCuSO_4(OH)_2$. This mineral is soluble in both nitric and sulfuric acids, but is non-reactive in hydrochloric acid.

A student was given a sample of linarite and asked to dissolve it to produce a solution of lead, copper and sulfate ions. The student was then asked to perform a single test for each ion that could be used to confirm the presence of that ion in the solution.

(a) Which acid should the student use? Explain your reasoning. **2**

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(b) Complete this table to summarise the student's test results for the presence of each ion in the solution from the mineral sample. **3**

Ion tested	*Test procedure*	*Expected results*
lead		
copper		
sulfate		

Marks

Question 27 (7 marks)

Chlorofluorocarbons (CFCs) have been used by humans for many years as refrigerants, foaming agents, solvents and aerosol propellants. In recent years, it was discovered that they cause damage to the ozone layer in the stratosphere.

(a) Identify and name a CFC that could cause damage to the ozone layer. **1**

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(b) Outline how this CFC damages the ozone layer, using chemical equations where appropriate. **4**

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(c) Outline the action being taken to alleviate the problems associated with the use of CFCs and the destruction of the ozone layer. **2**

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Section II

Total marks 25
Attempt ONE question from Questions 28–32.
Allow about 45 minutes for this section.

Answer the question in a writing booklet. Extra writing booklets are available.

Show all relevant working in questions that require calculations.

Marks

Question 28 — Industrial Chemistry (25 marks)

(a) The large-scale use of many naturally occurring chemical products had led to the shrinkage of world resources.

(i) Identify one natural resource that is not a fossil fuel where its continual supply has become a problem. **1**

(ii) Identify and describe a material that has been developed to replace the natural resource. **2**

(b) Water gas is a fuel that contains both carbon monoxide and hydrogen gases. It can be produced by passing steam over hot coke at a pressure of about 3000 kPa and a temperature of about 1000°K. The equation for this reaction is shown below.

$$C + H_2O \Leftrightarrow CO + H_2 \quad \Delta H = 40.6 \text{ kJ/mol}$$

(i) Write an expression for the equilibrium constant for this reaction. **1**

(ii) Describe and explain **one** change that could be made to the system to increase the yield. **3**

(iii) At 800°K, an equilibrium is established and the concentrations of water and carbon monoxide were measured as shown in the table below.

Species	*Equilibrium concentration (mol L^{-1})*
CO	0.200
H_2O	0.050

Determine the equilibrium concentration of H_2, given that at the beginning of the reaction only the reactants were present in the reaction vessel. **1**

(iv) Calculate the equilibrium constant (K) for the reaction. **1**

(v) Predict the effect of increasing the temperature to 1000°K on the value of the equilibrium constant. **1**

(c) Sulfuric acid is one of the most important chemicals in industry and is produced in greater quantities that any other manufactured chemical.

(i) Safety is a particular concern when diluting sulfuric acid. Outline a procedure that you might follow to dilute a concentrated solution of sulfuric acid and explain why these safety precautions need to be followed. **4**

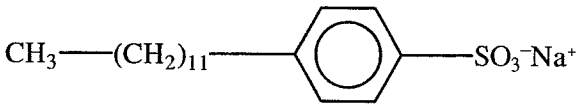
(ii) Write balanced chemical equations to show sulfuric acid acting as an oxidising agent and a dehydrating agent. **2**

Question 28 continues on page 19

Question 28 (Continued)

Marks

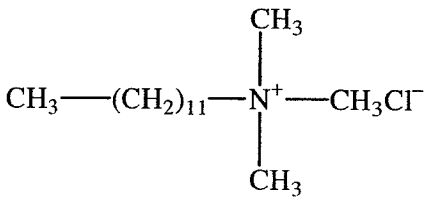
(d) The structure of the synthetic detergent, an alkylbenzene sulfonate, is shown below.



(i) Classify this detergent. **1**

(ii) Account for the cleaning action of alkylbenzene sulfonates in terms of their chemical properties. **3**

(iii) The structure of another detergent, an ammonium salt, is shown below.



Explain why the alkylbenzene sulfonate is a better choice than the ammonium salt for cleaning china and glass. **2**

(e) You performed a first-hand investigation in which you modelled one of the steps in the Solvay process in the school laboratory.

(i) Identify the step you modelled by representing it as a chemical equation. **1**

(ii) Outline the method you used to model the step you identified in part (i). **2**

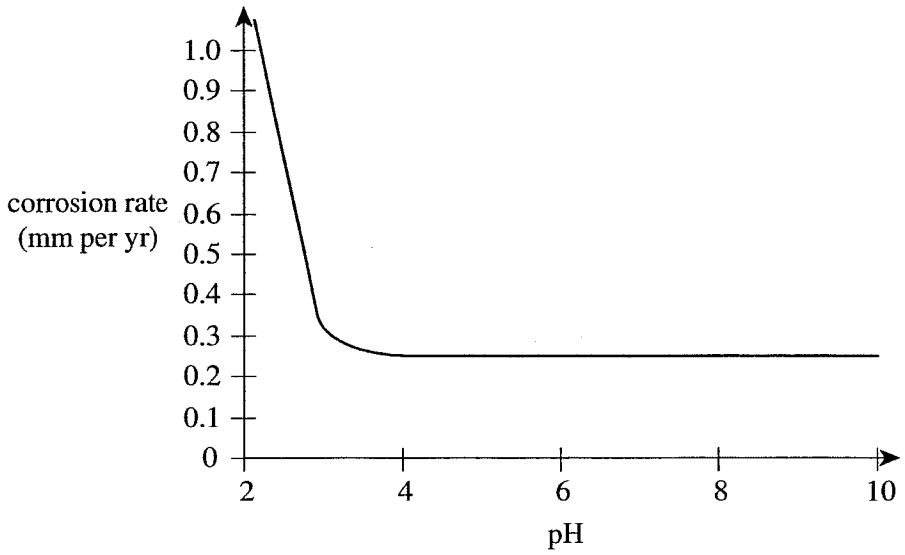
End of Question 28

Marks

Question 29 — Shipwrecks, Corrosion and Conservation (25 marks)

(a) The corrosion of metals often results in the formation of an oxide layer. In the case of aluminium and stainless steel the layer exhibits passivity.

Iron produces oxide layers that include iron (II) oxide, FeO. The following graph shows the effect that pH has on the corrosion of iron coated with a thin layer of FeO in aerated water at room temperature.



(i) Explain what passivity means. **1**

(ii) Does the iron (II) oxide layer produced on the iron exhibit passivity? Explain your answer in terms of the graph above. **2**

(iii) With the use of appropriate equations describe and explain the variation in the graph observed when the pH of the water is lower than 3. **4**

(b) In your study of this option, you have performed a first hand investigation to compare the effectiveness of different protections used to coat a metal and prevent that metal from corrosion.

(i) Recount the procedure you followed for an investigation to compare two different coatings that may protect a metal from corrosion. **3**

(ii) Identify three variables you controlled to ensure the validity of the investigation. **2**

(iii) Evaluate the effectiveness of each of these coatings. **4**

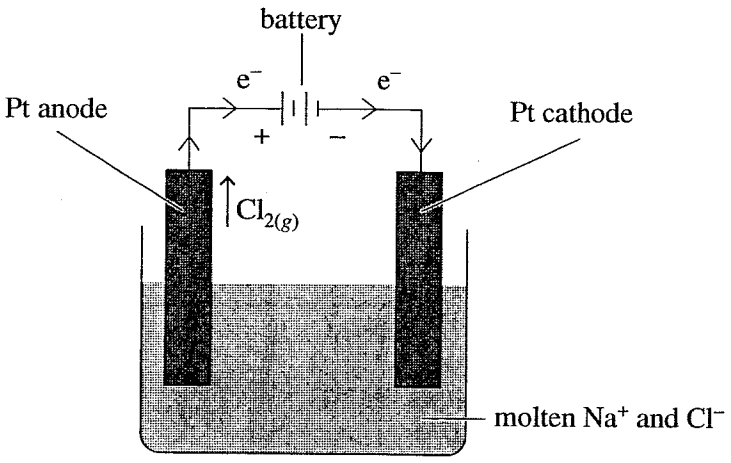
(c) Identify an Australian maritime project that has undergone restoration. Describe the restoration techniques used. For **one** of these techniques, justify its use in comparison to an alternate technique. **5**

Question 29 continues on page 21

Question 29 (Continued)

Marks

(d) The following diagram shows an electrolytic cell.



(i) Define the term electrolyte. **1**

(ii) Using appropriate equations relevant to this diagram, explain why this cell requires a battery for it to operate under standard conditions. **2**

(iii) Discuss why is it necessary for the cell to use molten NaCl rather than dilute aqueous NaCl. **1**

End of Question 29

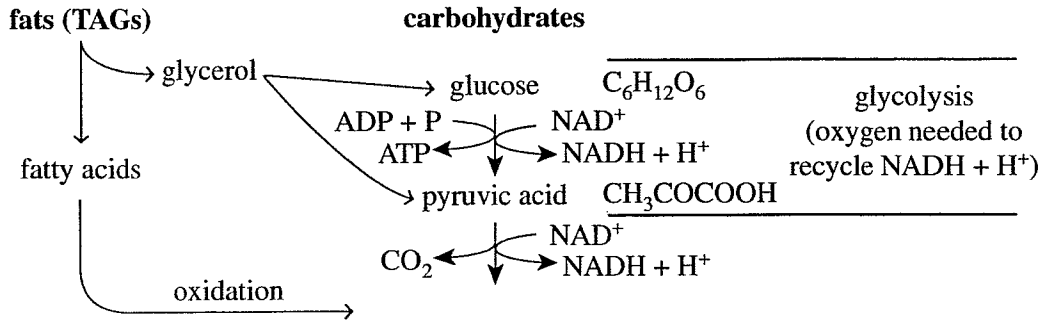
Marks

Question 30 — The Biochemistry of Movement (25 marks)

(a) Identify the general formula for a fatty acid and that part of the molecule that should mix with water. Explain why this occurs. **3**

(b) Identify the stage of respiration that uses NADH and $FADH_2$ and describe the role of these compounds in the production of ATP. Write equations to summarise the processes in ATP regeneration. **4**

(c) (i) Identify the product formed from pyruvic acid and the oxidation of fatty acids. **1**



(ii) Discuss the role of oxidation of fatty acids in the inhibition of the conversion of pyruvic acid to this product. **3**

(d) (i) Using a named example, account for the relationship between the chemical features of a protein and its shape. **3**

(ii) Describe a model you used to develop understanding of the relationship between protein structure and function and discuss the validity of using models for this purpose. **4**

(e) Compare the energy outputs of the stages of aerobic respiration with the energy output from anaerobic respiration. Evaluate the usefulness of both processes to exercise. **7**

Marks

Question 31 — The Chemistry of Art (25 marks)

(a) (i) Identify the names of the pigments traditionally used by early Aboriginals. **2**

(ii) Explain why blue or purple pigments were not used by early Aboriginals. **1**

(b) Transition metals can show variable oxidation states in their compounds. For example, the oxidation states of copper are copper (I) and copper (II). Outline, using another example, the basis for the difference in oxidation states in terms of electron structures. **3**

(c) (i) Choose a ligand from the following list and explain why it is a ligand. **2**

NH_3, NH_4^+, H_3O^+, Cl^-.

(ii) Draw the structure of the complex ion X $(H_2O)_6^{3+}$. **2**

(d) Using period 4 elements as examples, explain the relationship between the number of electrons in the outer shell of an element and its electronegativity. **4**

(e) In your study of this option, you performed a first hand investigation to gather information about the oxidising strength of $KMnO_4$.

(i) Outline the procedure you followed to perform this investigation. **2**

(ii) Summarise the observations of your experiment and account for these results. **3**

(f) Discuss the use of different parts of the electromagnetic spectrum in the identification of copper based pigments in a painting. **6**

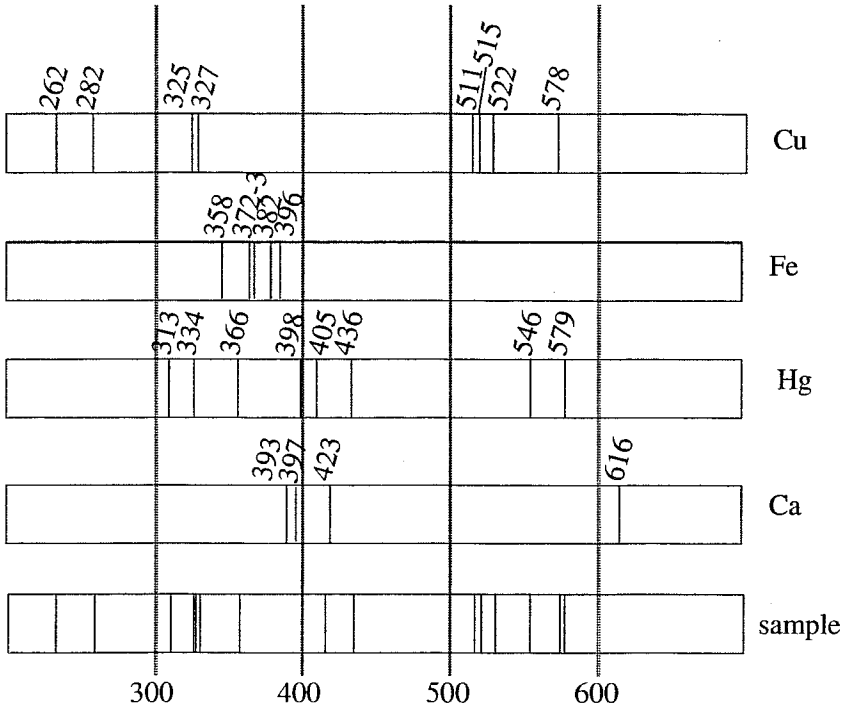
Marks

Question 32 — Forensic Chemistry (25 marks)

(a) (i) Identify a technique used in the analysis of small samples. **1**

(ii) Describe the chemical composition of amino acids and their role in protein structure. **3**

(b) The following diagram shows emission spectra for a number of different metals and a soil sample recovered from a forensic investigation.



(i) Identify which elements are present in the soil sample. **2**

(ii) Explain how line emission spectra identify the presence of elements in a sample. **4**

(c) Describe the process used to analyse DNA and assess the use of DNA analysis in forensic chemistry. **7**

(d) During your study of forensic chemistry, you performed a first hand investigation to distinguish between reducing and non-reducing sugars.

(i) Define a carbohydrate. **1**

(ii) Outline the procedure used in your investigation and describe the results obtained. **3**

(iii) Describe the chemical reaction that produces polysaccharides, using an example, and compare the composition of plants and animals in terms of their polysaccharides. **4**

End of paper

Data Sheet

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

Volume of 1 mole of 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

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

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

Periodic Table of the Elements

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 Phosphorous	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** [98.91] 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 Lanthanides	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** [223.0] Francium	88 **Ra** [226.0] Radium	89–103 Actinides	104 **Rf** [261.1] Rutherfordium	105 **Db** [262.1] Dubnium	106 **Sg** [266.1] Seaborgium	107 **Bh** [264.1] Bohrium	108 **Hs** [277] Hassium	109 **Mt** [268] Meitnerium	110 **Ds** [271] Darmstadtium	111 **Rg** [272] Roentgenium							

KEY

Atomic number

Atomic mass

79 **Au** 197.0 Gold — **Symbol of element**, Name of element

Lanthanides	57 **La** 138.9 Lanthanum	58 **Ce** 140.1 Cerium	59 **Pr** 140.9 Praseodymium	60 **Nd** 144.9 Neodymium	61 **Pm** [146.9] 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
Actinides	89 **Ac** [227.0] Actinium	90 **Th** 232.0 Thorium	91 **Pa** 231.0 Protactinium	92 **U** 238.0 Uranium	93 **Np** [237.0] Neptunium	94 **Pu** [244.1] Plutonium	95 **Am** [243.1] Americium	96 **Cm** [247.1] Curium	97 **Bk** [247.1] Berkelium	98 **Cf** [251.1] Californium	99 **Es** [252.1] Einsteinium	100 **Fm** [257.1] Fermium	101 **Md** [258.1] Mendelevium	102 **No** [259.1] Nobelium	103 **Lr** [262.1] Lawrencium

Where the atomic weight is not known, the relative atomic mass of the most common radioactive isotope is shown in brackets.

The atomic masses of Np and Tc are given for the isotopes ^{237}Np and ^{99}Tc.