BOSTES | BOARD OF STUDIES TEACHING & EDUCATIONAL STANDARDS NSW

2014 HIGHER SCHOOL CERTIFICATE EXAMINATION

Chemistry

General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Write using black or blue pen
  Black pen is preferred
- Draw diagrams using pencil
- Board-approved calculators may be used
- A data sheet and a Periodic Table are provided at the back of this paper
- Write your Centre Number and Student Number at the top of pages 13, 17, 19, 21 and 23

Total marks – 100

Section I Pages 2–24

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 25–37

25 marks

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

Section I
75 marks

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

Use the multiple-choice answer sheet for Questions 1–20.

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1 In which layer of the atmosphere is ozone considered a pollutant?

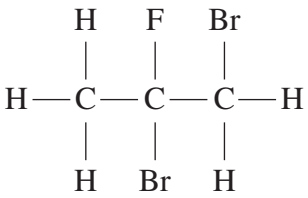
(A) Mesosphere

(B) Stratosphere

(C) Thermosphere

(D) Troposphere

2 What is the IUPAC name of the following compound?



(A) 1,2-dibromo-2-fluoropropane

(B) 2,3-dibromo-2-fluoropropane

(C) 2-fluoro-2,3-dibromopropane

(D) 2-fluoro-1,2-dibromopropane

3 Which row of the table correctly matches the scientist(s) with their theory of acids?

	Scientist(s)	*Theory*
(A)	Arrhenius	Acids contain oxygen
(B)	Brönsted and Lowry	Acids are proton donors
(C)	Davy	Acids are able to produce hydrogen ions in water
(D)	Lavoisier	Acids contain hydrogen

4 Which of the following equations correctly represents catalytic cracking of a petroleum fraction?

(A) $C_{15}H_{32}(g) \xrightarrow{AlSi_2O_6} C_{15}H_{32}(s)$

(B) $n\,C_2H_4(g) \xrightarrow{AlSi_2O_6} -\left(CH_2-CH_2\right)_n-(s)$

(C) $C_{15}H_{32}(g) \xrightarrow{AlSi_2O_6} C_7H_{16}(g) + 4C_2H_4(g)$

(D) $C_7H_{16}(g) + 4\,C_2H_4(g) \xrightarrow{AlSi_2O_6} C_{15}H_{32}(g)$

5 Which row of the table correctly matches the reactant and the product of an *addition reaction*?

	Reactant	*Product*
(A)	$CH_3 - CH_2 - CH_2 - CH_2 - OH$	$CH_3 - CH_2 - CH = CH_2$
(B)	$CH_3 - CH_2 - CH_2 - \underset{\displaystyle OH}{\underset{\vert}{CH}} - CH_3$	$CH_3 - CH_2 - CH = CH - CH_3$
(C)	$CH_3 - CH = CH - CH_2 - CH_3$	$CH_3 - CH_2 - \underset{\displaystyle Cl}{\underset{\vert}{CH}} - CH_2 - CH_3$
(D)	$CH_3 - C(=O) - OH$	$CH_3 - C(=O) - O - CH_3$

6 Drinking water is regularly tested to ensure that it is safe for consumption.

Which of the following test results indicates the highest drinking-water quality?

	Dissolved oxygen (mg/L)	*Nitrate* (mg/L)	*Total dissolved solids* (mg/L)	*Turbidity* (NTU)
(A)	2	0.1	50	50
(B)	8	0.1	50	2
(C)	2	2	200	2
(D)	8	2	200	50

7 This table contains information on three indicators.

Indicator	*pH range*	*Colour (lower pH – higher pH)*
Methyl orange	3.1 – 4.4	red – yellow
Methyl red	4.4 – 6.2	pink – yellow
Phenolphthalein	8.3 – 10.0	colourless – pink

A substance is tested with each of the indicators and the results are recorded below.

Indicator	*Colour*
Methyl orange	yellow
Methyl red	yellow
Phenolphthalein	colourless

Which of the following substances will produce these results?

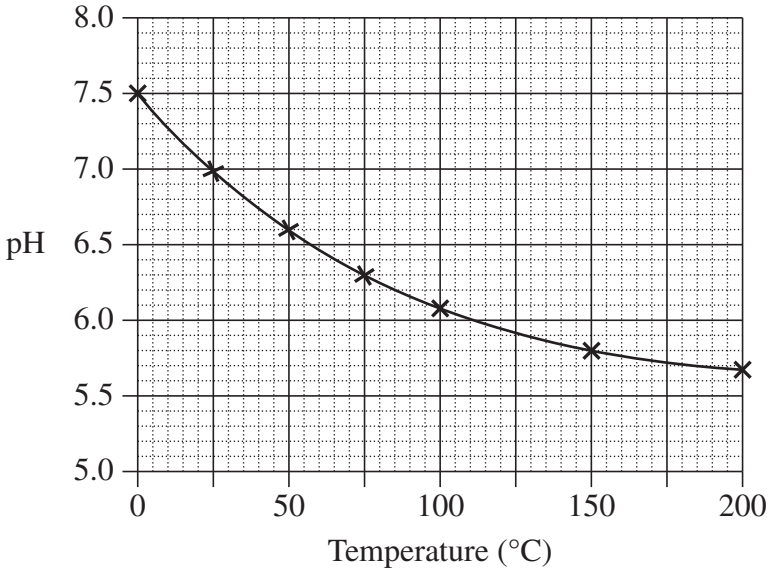
(A) Lemonade pH 2.9

(B) White wine pH 4.2

(C) Tap water pH 7.2

(D) Ammonia pH 11.2

8 The graph shows the pH of a solution of a weak acid, HA, as a function of temperature.



What happens as the temperature decreases?

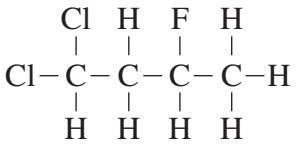
(A) HA becomes less ionised and the H^+ concentration increases.

(B) HA becomes less ionised and the H^+ concentration decreases.

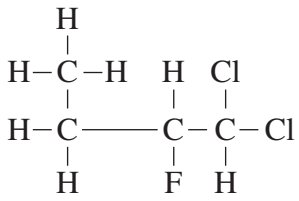
(C) HA becomes more ionised and the H^+ concentration increases.

(D) HA becomes more ionised and the H^+ concentration decreases.

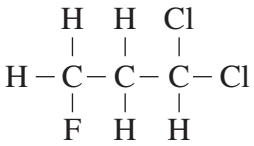
9 Four compounds, W, X, Y and Z, are represented below.



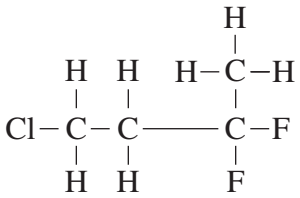
Compound W



Compound X



Compound Y



Compound Z

Which of the following is a pair of isomers?

(A) W and X

(B) W and Y

(C) X and Y

(D) Y and Z

10 The following equation represents a chemical system in equilibrium:

$$OCl^-(aq) + H_2O(l) \rightleftharpoons HOCl(aq) + OH^-(aq)$$

Which of the following is an acid/base conjugate pair?

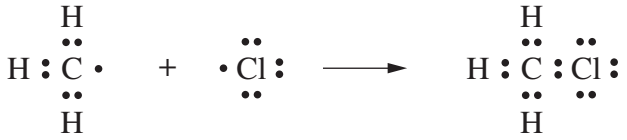
(A) H_2O / HOCl

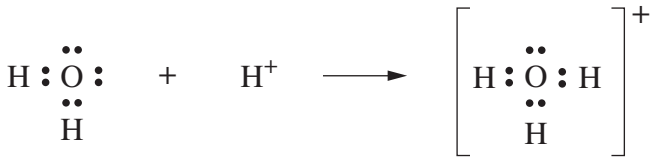
(B) HOCl / OH^-

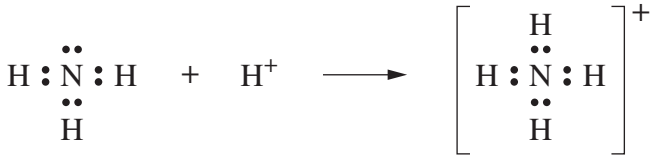
(C) HOCl / OCl^-

(D) OCl^- / H_2O

11 Which of the following does NOT represent the formation of a coordinate covalent bond?

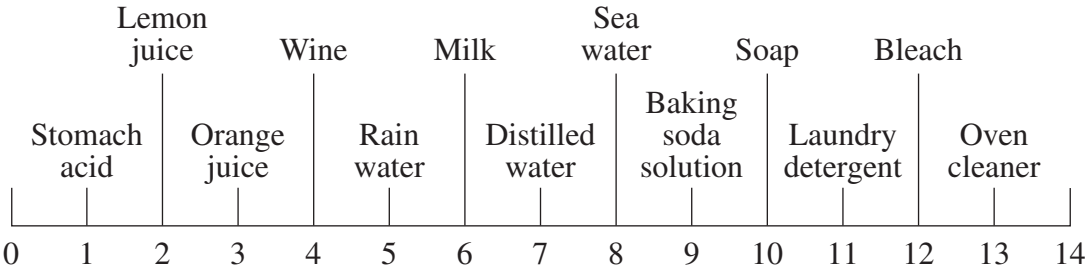
(A) 

(B) 

(C) 

(D) 

12 The diagram shows the pH values of some substances.



Based on the information provided, which of the following statements about the relative concentration of hydrogen ions is correct?

(A) It is 2 times higher in bleach than in milk.

(B) It is 10 times lower in stomach acid than in soap.

(C) It is 1000 times lower in distilled water than in wine.

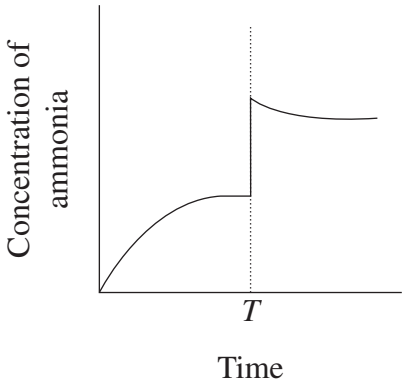
(D) It is 100 times higher in laundry detergent than in baking soda solution.

13 This equation shows an equilibrium established in the synthesis of ammonia from its component gases:

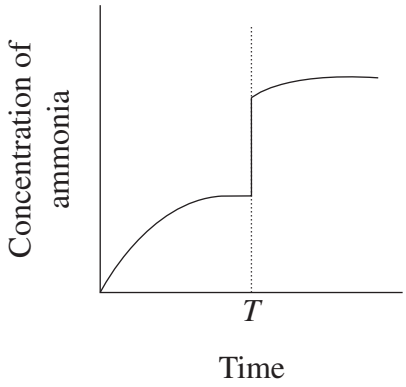
$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

If the volume of the reaction chamber is suddenly halved at time *T*, which of the following best depicts changes in the concentration of ammonia over time?

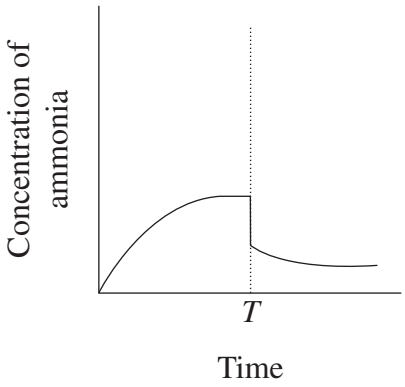
(A)



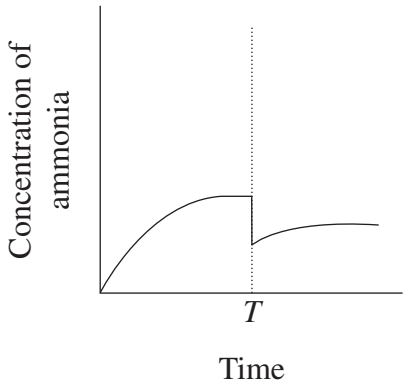
(B)



(C)



(D)



14 What is the pH of a 0.018 mol L^{-1} solution of hydrochloric acid?

(A) 0.74

(B) 0.96

(C) 1.04

(D) 1.74

15 If exactly one gram of each of the following compounds is treated with excess hydrochloric acid, which would release the greatest volume of $CO_2(g)$ at 25°C and 100 kPa?

(A) K_2CO_3

(B) $KHCO_3$

(C) Na_2CO_3

(D) $NaHCO_3$

16 In which of the following reactions is the metal species reduced?

(A) $2FeCl_2(aq) + Cl_2(g) \rightarrow 2FeCl_3(aq)$

(B) $CuS(s) + O_2(g) \rightarrow Cu(s) + SO_2(g)$

(C) $2Al(OH)_3(aq) \rightarrow Al_2O_3(s) + 3H_2O(l)$

(D) $Ca(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + H_2(g)$

17 What is the standard cell potential for the reaction of 1.0 mol L^{-1} acidified potassium dichromate $(K_2Cr_2O_7(aq))$ with aqueous sulfur dioxide $(SO_2(aq))$ under standard conditions?

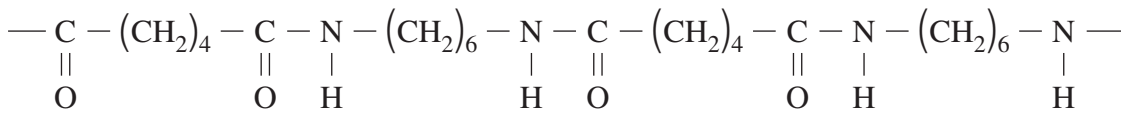
(A) 1.20 V

(B) 1.52 V

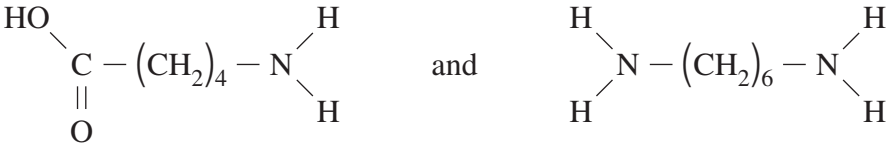
(C) 2.24 V

(D) 3.20 V

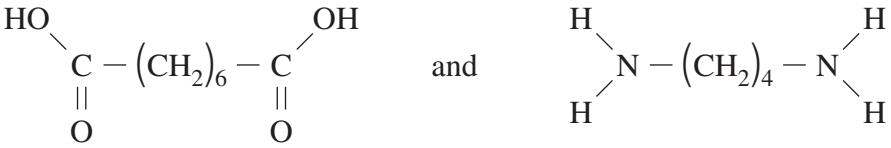
18 This is a representation of a segment of the polymer nylon 6,6.

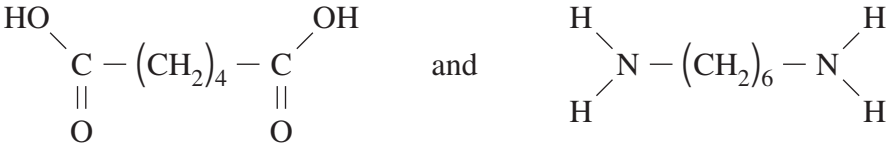


Which of the following represents the two monomers that are used to produce nylon 6,6?

(A) 

(B) 

(C) 

(D) 

19 An experimental car using ethanol as a fuel source requires 2270 kJ of energy for every kilometre travelled.

Given that the heat of combustion of ethanol is 1360 kJ mol^{-1}, what is the maximum distance that the car can travel on 1.0 kilogram of ethanol?

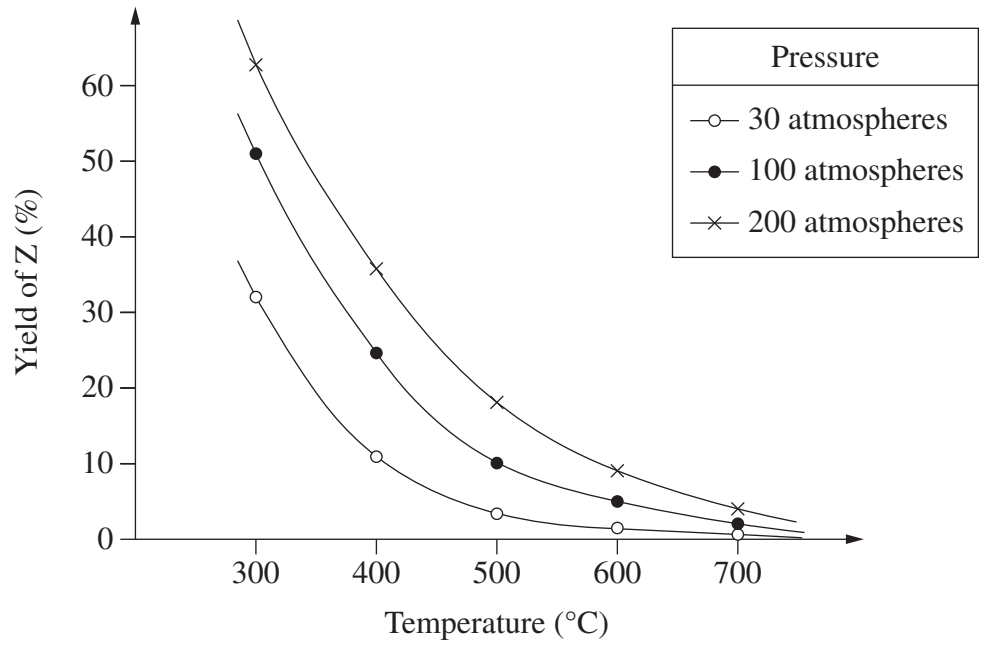
(A) 1.7 km

(B) 13 km

(C) 28 km

(D) 36 km

20 This graph represents the yield of an equilibrium reaction at different temperature and pressure conditions inside a reaction vessel.



Which of the following reactions could produce the trends shown in the graph?

(A) $X(g) + Y(g) \rightleftharpoons 3Z(g)$ $\Delta H = +100$ kJ

(B) $X(g) + Y(g) \rightleftharpoons 2Z(g)$ $\Delta H = -100$ kJ

(C) $2X(g) + 2Y(g) \rightleftharpoons Z(g)$ $\Delta H = +100$ kJ

(D) $4X(g) + 2Y(g) \rightleftharpoons 3Z(g)$ $\Delta H = -100$ kJ

Chemistry

Centre Number

Student Number

Section I (continued)

Part B – 55 marks
Attempt Questions 21–31
Allow about 1 hour and 40 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 transuranic artificial element curium–242 can be produced in two ways. The nuclear equations for the two processes are given below. **3**

Process *A*

$$^{241}_{95}\text{Am} + {}^{1}_{0}n \rightarrow {}^{242}_{95}\text{Am} \rightarrow {}^{242}_{96}\text{Cm} + {}^{0}_{-1}e$$

Process *B*

$$^{239}_{94}\text{Pu} + {}^{4}_{2}\text{He} \rightarrow {}^{242}_{96}\text{Cm} + {}^{1}_{0}n$$

Compare these two processes of production for the element curium–242.

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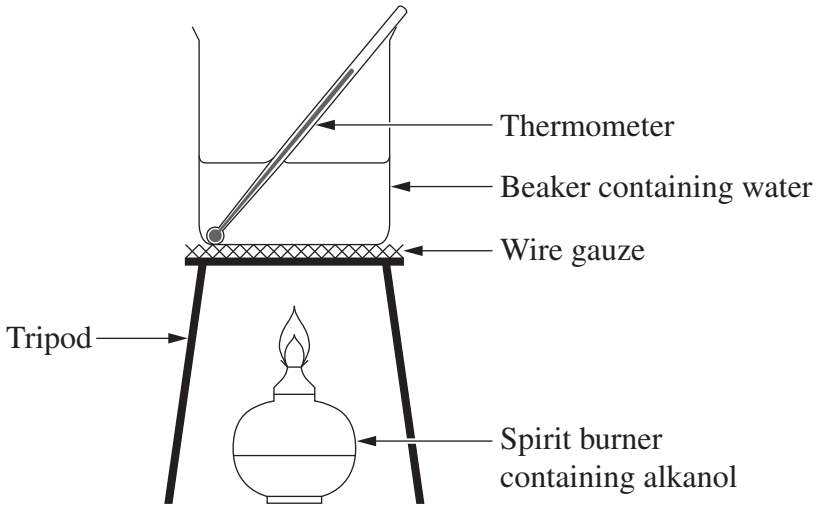
Question 22 (6 marks)

A student performed a first-hand investigation to determine the quantitative relationship between heat of combustion and molar mass of alkanols. The student did this by burning different alkanols to heat water as shown in the diagram below. The calculated heats of combustion for four of the alkanols are given in the table.



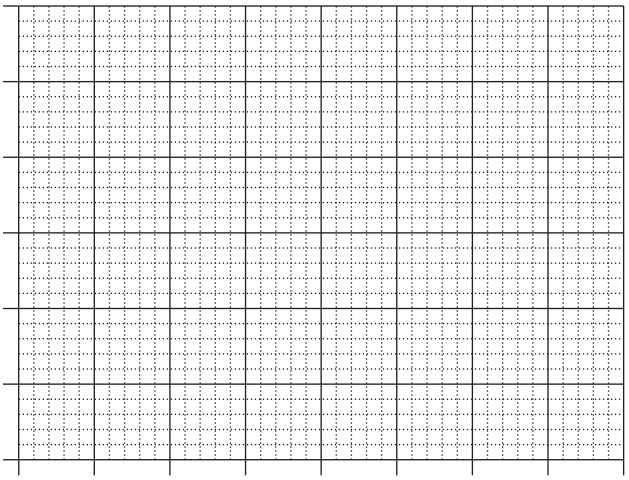
Alkanol	*Molar mass* ($g\ mol^{-1}$)	*Calculated heat of combustion* ($kJ\ mol^{-1}$)	*Theoretical heat of combustion* ($kJ\ mol^{-1}$)
methanol	32	150	726
ethanol	46	950	1367
propan-1-ol	60	1500	2021
butan-1-ol	74	2250	2676

Question 22 continues on page 15

Question 22 (continued)

(a) On the grid below, graph both the calculated and the theoretical heat of combustion against the molar mass of the alkanols. **3**

Heat of combustion versus molar mass



(b) Discuss the validity of the student's investigation. **3**

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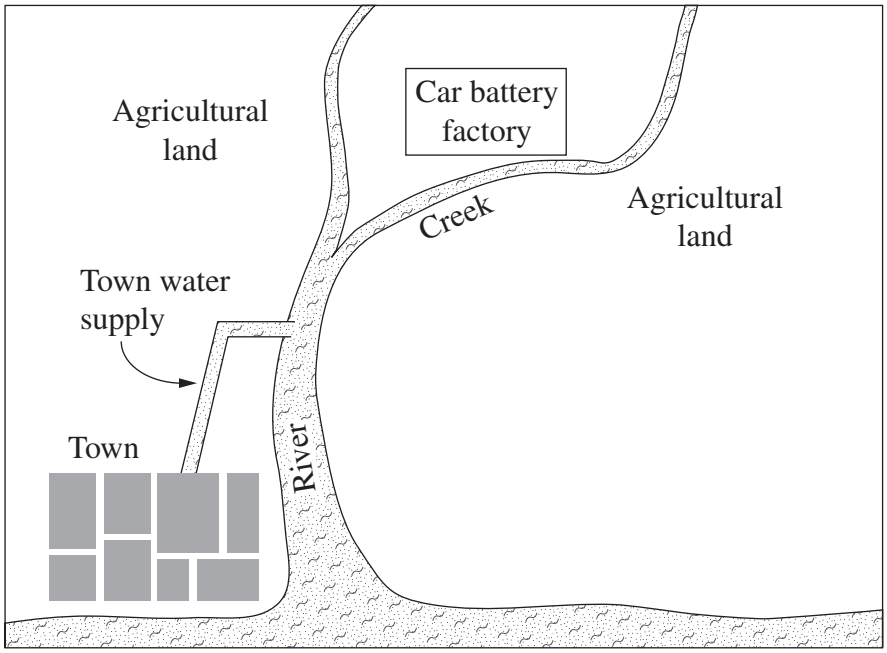
End of Question 22

Question 23 (3 marks)

This diagram shows a town situated near agriculture and industry.



The town relies on the river for its water supply.

(a) Identify ONE chemical species that could be a contaminant of the water supply. **1**

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(b) Explain the need to monitor the levels of a contaminant in water supplies. **2**

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Centre Number

Student Number

Section I – Part B (continued)

Question 24 (5 marks)

A solution contains carbonate, chloride and sulfate ions. **5**

Describe a sequence of tests that could be used to confirm the presence of each of these ions. Include ONE relevant chemical equation.

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Question 25 (4 marks)

Under conditions of low oxygen levels, octane can undergo incomplete combustion according to the following chemical equation:

$$2C_8H_{18}(l) + 17O_2(g) \rightarrow 6C(s) + 4CO(g) + 6CO_2(g) + 18H_2O(l)$$

(a) Explain the need to monitor this process. **2**

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(b) Calculate the mass of soot $(C(s))$ produced if 4.2 moles of octane are combusted in this way. **2**

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Centre Number

Student Number

Section I – Part B (continued)

Question 26 (6 marks)

A first-hand investigation to produce an ester is to be carried out in a school laboratory, using an alkanol, an alkanoic acid and a suitable catalyst.

(a) Name an ester that could be produced in a school laboratory. **1**

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(b) Describe how potential hazards associated with the three chemicals required for this investigation could be addressed. **5**

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Question 27 (6 marks)

Limestone $(CaCO_3)$ contributes to the hardness of water by releasing Ca^{2+} ions in water. The chemical equation for this exothermic reaction is shown.

$$CaCO_3(s) + H_2O(l) + CO_2(g) \rightleftharpoons Ca^{2+}(aq) + 2HCO_3^-(aq)$$

(a) Explain why increasing the temperature of hard water would reduce its hardness. **2**

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(b) Describe how atomic absorption spectroscopy (AAS) could be used to measure the effectiveness of heating water to reduce its hardness. **4**

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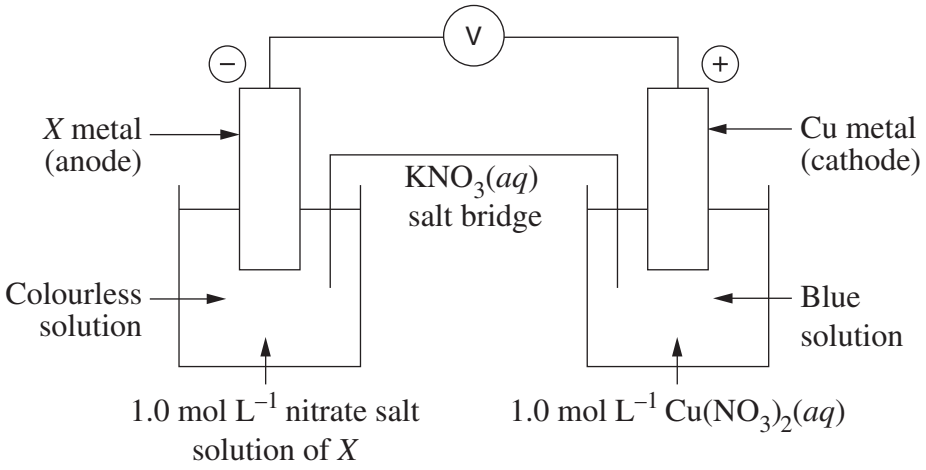
Question 28 (5 marks)

A galvanic cell has been constructed as shown in the diagram.



(a) Explain the colour change in the copper half-cell as the reaction proceeds. **2**

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(b) The theoretical standard potential for this galvanic cell is 2.02 V. **3**

Identify metal *X* and justify your answer.

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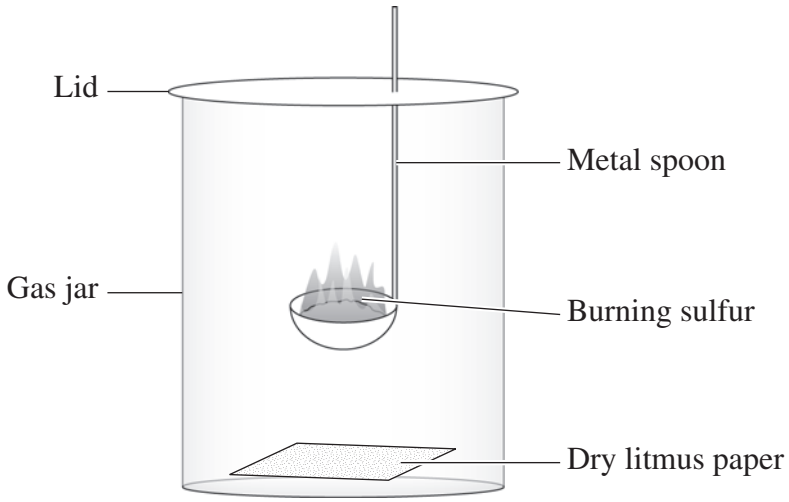
Question 29 (5 marks)

An experiment was performed to model the formation of acid rain. **5**

A sample of sulfur was burned on a metal spoon. While alight, it was placed in a gas jar with some dry litmus paper.



When a fine mist of water was sprayed into the jar, the litmus paper turned red.

Assess the suitability of this experiment as a model for the formation of acid rain.

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Question 30 (5 marks)

A batch of dry ice (solid CO_2) was contaminated during manufacture. To determine its purity, the following steps were carried out.

Step 1:	A 0.616 gram sample of the contaminated dry ice was placed in a clean, dry flask.
Step 2:	50.00 mL of 1.00 mol L^{-1} sodium hydroxide was added to the flask. The sodium hydroxide was in excess.
Step 3:	The flask was sealed to prevent loss of carbon dioxide gas and the reaction allowed to reach completion, according to this equation: $2NaOH(aq) + CO_2(s) \rightarrow Na_2CO_3(aq) + H_2O(l)$
Step 4:	The remaining sodium hydroxide was titrated against a 1.00 mol L^{-1} solution of hydrochloric acid. The average volume of HCl used was 27.60 mL.

(a) Calculate the number of moles of NaOH added in Step 2. **1**

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(b) Calculate the percentage purity by mass of this batch of dry ice. **4**

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Question 31 (7 marks)

With reference to the underlying chemistry and with relevant equations, assess the impacts on society of TWO uses of ethanol. **7**

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Chemistry

Section II

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

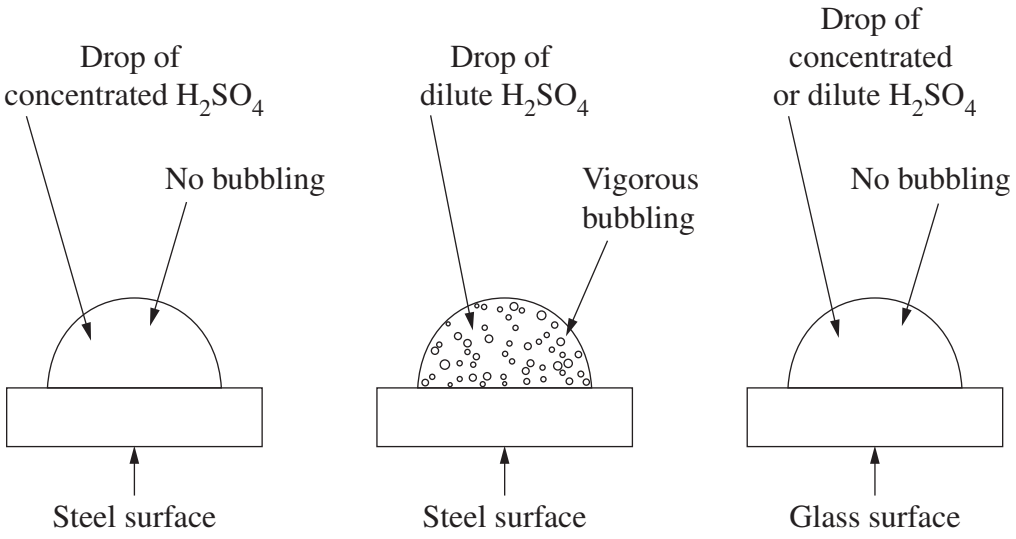
Answer parts (a)–(c) of the question in Section II Answer Booklet 1.
Answer parts (d)–(e) of the question in Section II Answer Booklet 2.
Extra writing booklets are available.

Show all relevant working in questions involving calculations.

Question 32 — Industrial Chemistry (25 marks)

Answer parts (a)–(c) in Section II Answer Booklet 1.

(a) This diagram illustrates some of the properties of sulfuric acid. **3**



Explain, with reference to the diagram, how sulfuric acid should be transported.

(b) Nitrosyl chloride is introduced into an empty container. It then dissociates into nitric oxide and chlorine according to the equation:

$$2NOCl(g) \rightleftharpoons 2NO(g) + Cl_2(g)$$

The reaction is endothermic.

(i) Explain the effect on the yield of $NO(g)$ if the temperature is increased. **2**

(ii) The equilibrium constant, K, for the reaction is 0.028. **3**

Calculate the equilibrium concentration of $NOCl(g)$ if the equilibrium concentration of $Cl_2(g)$ is 0.17 mol L^{-1}.

Question 32 continues on page 27

Question 32 (continued)

(c) Electrolysis is used in the industrial production of sodium hydroxide.

(i) Contrast the energy transformations in galvanic and electrolytic cells. **2**

(ii) The table shows the products of three different electrolytic cells involving aqueous or molten sodium chloride. **3**

Cell	*Anode*	*Cathode*
X	$O_2(g)$	$H_2(g)$
Y	$Cl_2(g)$	$H_2(g)$
Z	$Cl_2(g)$	$Na(l)$

Explain which of the three electrolytic cells from the table is used for the industrial production of sodium hydroxide.

Answer parts (d)–(e) in Section II Answer Booklet 2.

(d) An investigation is to be conducted to model a chemical step involved in the Solvay process.

(i) Outline a valid procedure that could be used to carry out the investigation. **2**

(ii) Describe TWO limitations associated with the procedure outlined in part (i). **3**

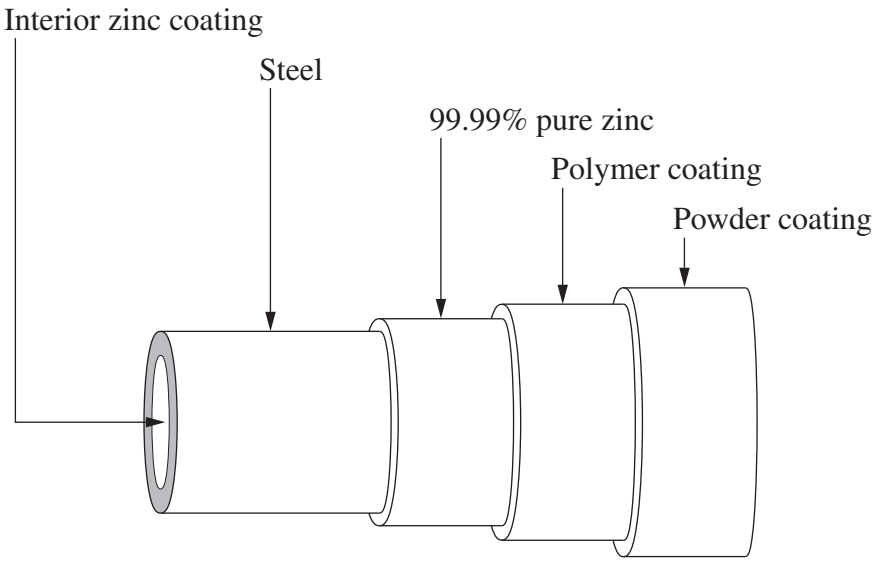
(e) Explain how the differences in the structure and composition of soaps and detergents determine their uses and their impacts on the environment. **7**

End of Question 32

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

Answer parts (a)–(c) in Section II Answer Booklet 1.

(a) This diagram shows the various layers of a pipe. **3**



Outline TWO reasons why this pipe would be resistant to corrosion.

(b) Iron corrodes differently under acidic and neutral conditions.

(i) Write an equation to represent the process of rusting under neutral conditions. **2**

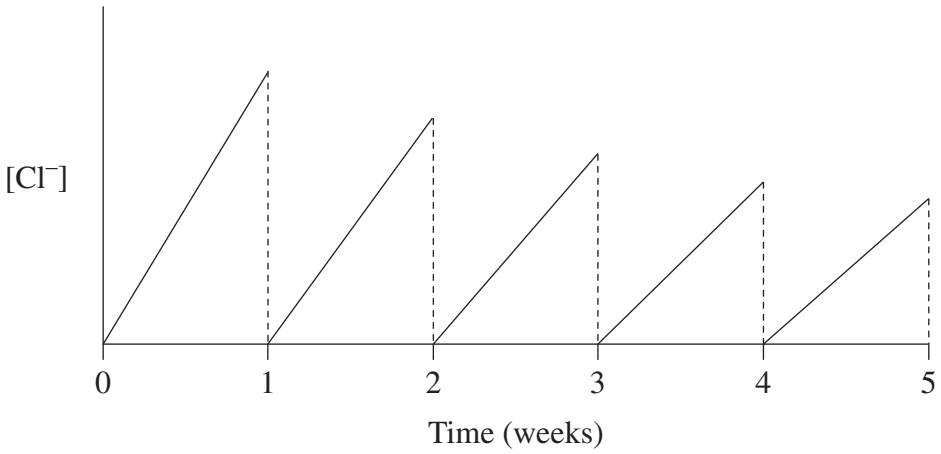
(ii) Explain why iron will corrode faster under acidic conditions than under neutral conditions. **3**

Question 33 continues on page 29

Question 33 (continued)

(c) A wooden artefact was recovered from a shipwreck. After it was removed from the ocean, it was placed in a tank of distilled water. The water was changed weekly and the chloride ion concentration was monitored. After 10 weeks, the artefact was dried slowly in a controlled environment.

The graph shows the chloride ion concentration in the tank in the first five weeks.



(i) Account for the shape of this graph. **2**

(ii) Explain the possible effect on the artefact if it had been simply left to dry instead of undergoing the procedure described above. **3**

Answer parts (d)–(e) in Section II Answer Booklet 2.

(d) An investigation is to be set up in a school laboratory to determine the rate of corrosion of iron in different oxygen concentrations.

(i) Identify the variables that need to be kept constant in this investigation. **2**

(ii) Describe TWO limitations in making qualitative and/or quantitative observations in this investigation. **3**

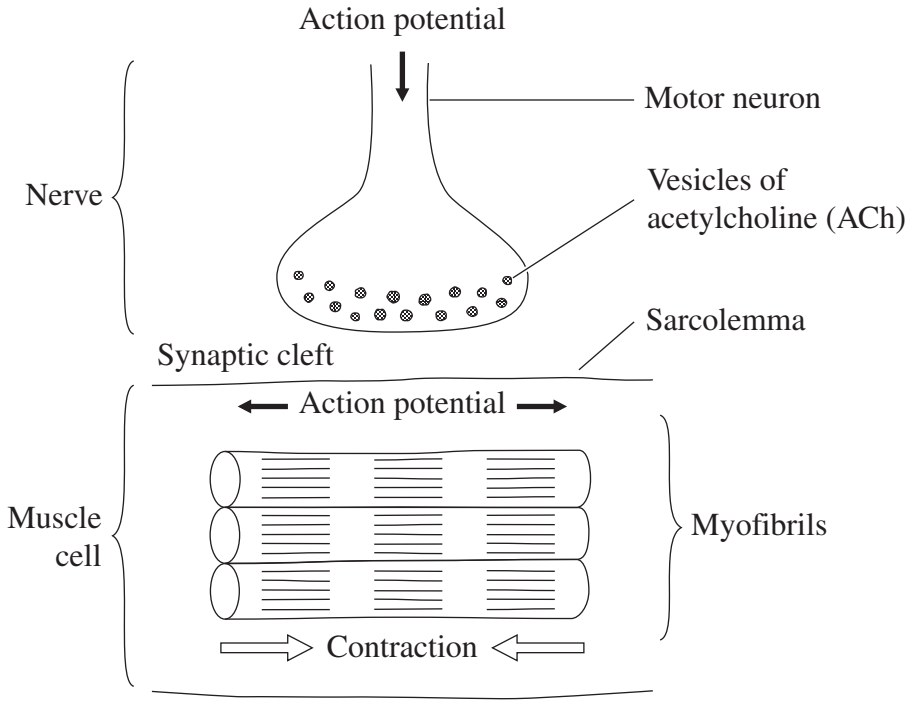
(e) Explain why a range of factors should be considered when using electrolysis to clean and stabilise a metal artefact. **7**

End of Question 33

Question 34 — The Biochemistry of Movement (25 marks)

Answer parts (a)–(c) in Section II Answer Booklet 1.

(a) The diagram represents the junction between a nerve and a muscle cell. An action potential in the nerve causes contraction in the muscle cell. **3**



In your answer booklet, write steps 5 and 6 to show how this contraction occurs.

Step 1	Action potential travels down nerve to endplate
Step 2	ACh (chemical neurotransmitter) is released into synaptic cleft
Step 3	ACh initiates action potential on the muscle cell membrane (sarcolemma)
Step 4	Action potential travels along sarcolemma, through T tubules to sarcoplasmic reticulum
Step 5	
Step 6	
Step 7	Enzyme (myosin ATP-ase) allows breakdown of ATP to release energy
Step 8	Actin and myosin slide over each other
Step 9	Muscle shortens (contracts)

Question 34 continues on page 31

Question 34 (continued)

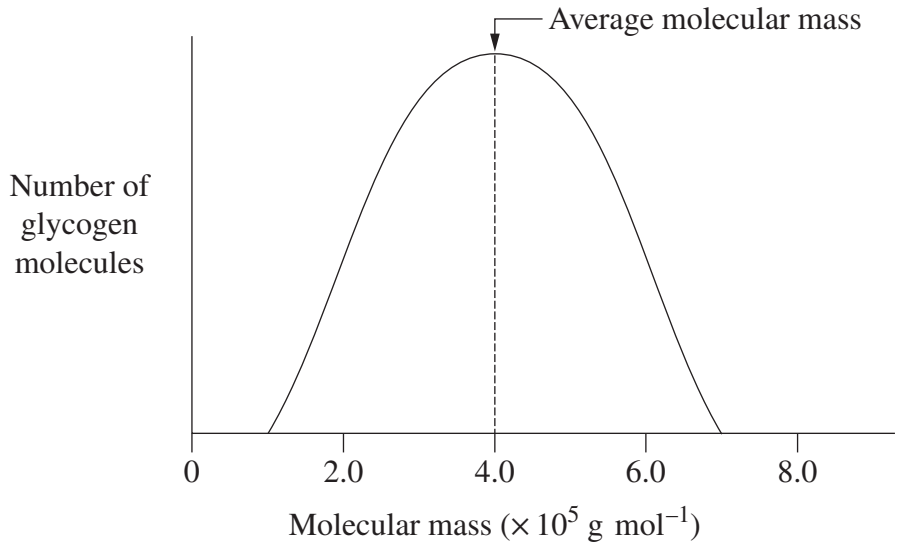
(b) (i) Name an enzyme and outline its function. **2**

(ii) Explain how a change in pH might change the shape and structure of an enzyme. **3**

(c) Glucose is a carbohydrate monomer which forms the extensively branched polymer, glycogen.

(i) Explain an advantage of the extensive branching of the chains of a glycogen molecule. **2**

(ii) The graph shows the distribution of molecular mass of a large number of glycogen molecules. **3**



Calculate the number of glucose monomers in an average glycogen molecule.

Question 34 continues on page 32

Question 34 (continued)

Answer parts (d)–(e) in Section II Answer Booklet 2.

(d) An investigation is to be set up to represent the structure of fatty acids.

(i) Identify the essential features of fatty acid molecules that should be included in this representation. **2**

(ii) Describe TWO limitations of using models or diagrams to represent fatty acid molecules. **3**

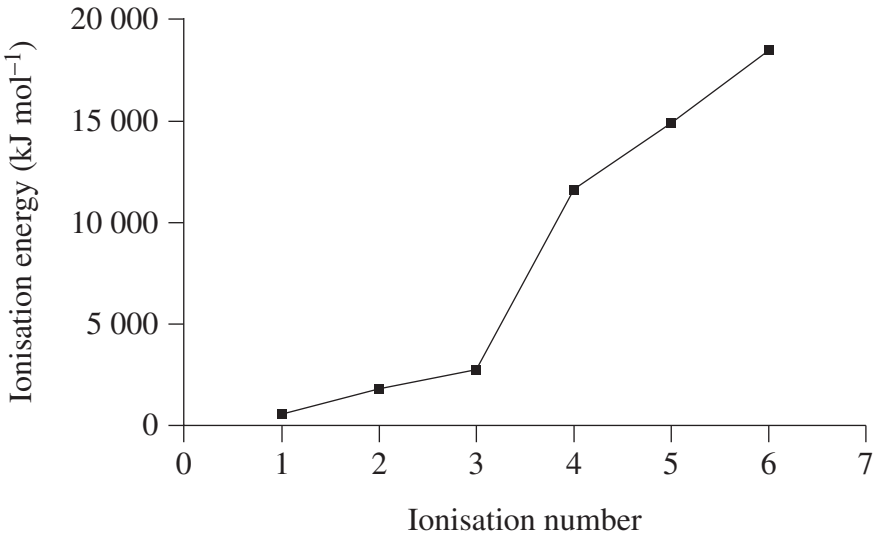
(e) Explain how damage to mitochondria affects ATP production and energy output of cells. **7**

End of Question 34

Question 35 — The Chemistry of Art (25 marks)

Answer parts (a)–(c) in Section II Answer Booklet 1.

(a) The successive ionisation energies of aluminium are presented below. **3**



Explain the trend in ionisation energy.

(b) Pigments play a significant role in the creation of cave paintings by Aboriginal people.

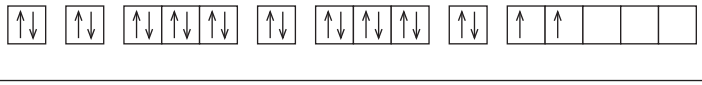
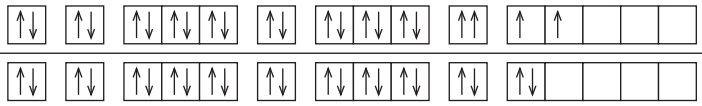
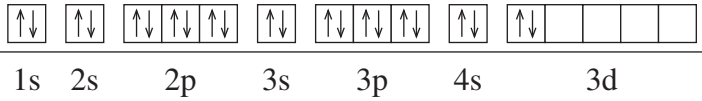
(i) Outline the process used to prepare and attach pigments to cave walls. **2**

(ii) Describe THREE pigments used by Aboriginal people in traditional art, with reference to their chemical composition and colour. **3**

Question 35 continues on page 34

Question 35 (continued)

(c) Three electron configurations are presented in the table. For elemental titanium, the ground state is represented by I, while II and III are both invalid ground state electron configurations.

		Electron Configurations
I	Ground state	
II	Invalid	
III	Invalid	
		1s 2s 2p 3s 3p 4s 3d

(i) Write a valid electron configuration for Ti^{3+}. **2**

(ii) Explain why II and III do not represent the ground state configuration for elemental titanium. **3**

Answer parts (d)–(e) in Section II Answer Booklet 2.

(d) An investigation is to be conducted to study the changes in oxidation state of a transition metal.

(i) Outline a valid procedure that could be used to carry out the investigation. **2**

(ii) Describe TWO limitations of the procedure outlined in part (i). **3**

(e) Explain the role of electrons in determining colour. **7**

End of Question 35

Question 36 — Forensic Chemistry (25 marks)

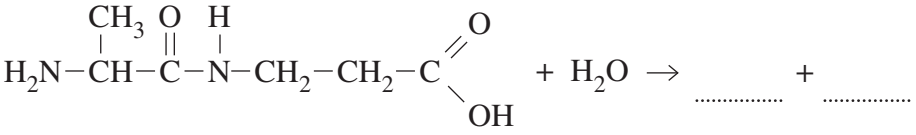
Answer parts (a)–(c) in Section II Answer Booklet 1.

(a) This picture shows a forensic scientist collecting a blood sample from a crime scene. **3**

Explain TWO errors that this scientist is making while collecting the blood sample.

(b) Hydrolysis can be used to break down proteins into amino acids.

(i) This equation represents the hydrolysis of a dipeptide. **2**

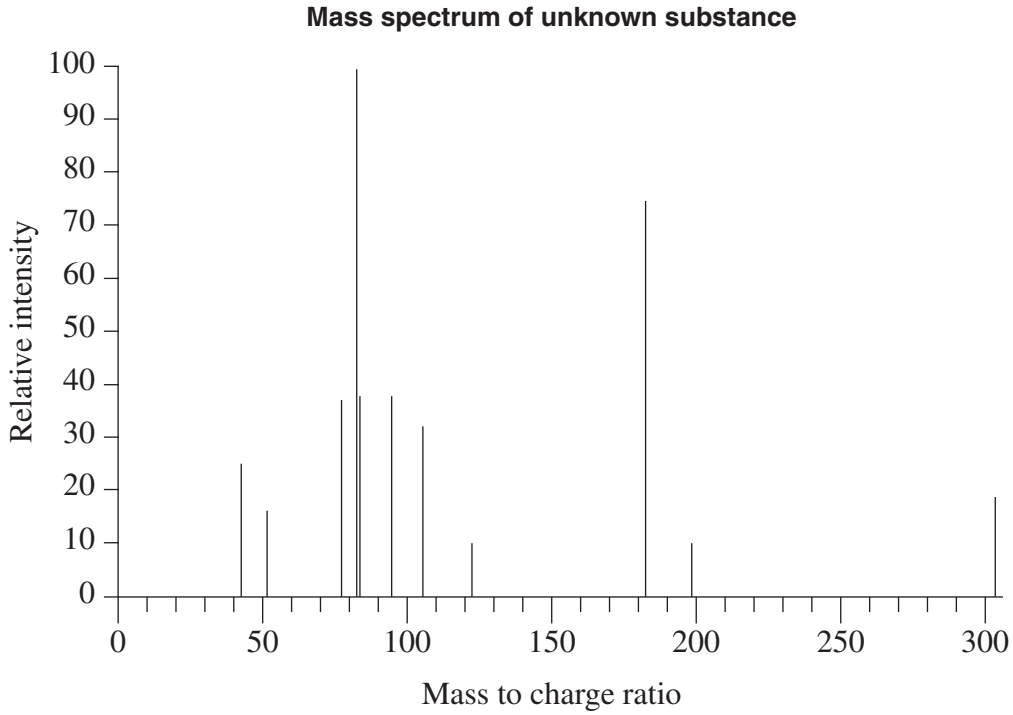


In your answer booklet, draw the TWO products of the hydrolysis of the dipeptide.

(ii) Describe how protein hydrolysis is used in forensic analysis. **3**

Question 36 continues on page 36

(c) (i) An unknown substance was collected. It was analysed and its mass spectrum collected. **2**



This table shows the mass to charge ratio of a selection of fragments in the mass spectrum for three compounds of interest in forensic investigations.

Compound name	*Significant fragments (mass to charge ratio)*
Caffeine	67 109 194
Cocaine	82 94 182
Paracetamol	43 109 151

Using the information in the table, identify the unknown substance and justify your choice.

(ii) Describe how mass spectrometry can be useful for analysing forensic evidence. **3**

Question 36 continues on page 37

Question 36 (continued)

Answer parts (d)–(e) in Section II Answer Booklet 2.

(d) An investigation is to be conducted in a school laboratory to separate organic compounds using chromatography.

(i) Outline a valid procedure that could be used in a school laboratory to carry out the investigation. **2**

(ii) Describe TWO limitations of carrying out the procedure outlined in part (i). **3**

(e) Explain why DNA evidence may be challenged when used in court cases. **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

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

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

Atomic Number	79
Symbol	Au
Standard Atomic Weight	197.0
Name	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 65.38 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 87.61 Strontium	39 Y 88.91 Yttrium	40 Zr 91.22 Zirconium	41 Nb 92.91 Niobium	42 Mo 95.96 Molybdenum	43 Tc 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 183.9 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 Polonium	85 At Astatine	86 Rn Radon
87 Fr Francium	88 Ra Radium	89–103 Actinoids	104 Rf Rutherfordium	105 Db Dubnium	106 Sg Seaborgium	107 Bh Bohrium	108 Hs Hassium	109 Mt Meitnerium	110 Ds Darmstadtium	111 Rg Roentgenium	112 Cn Copernicium						

Lanthanoids

57 La 138.9 Lanthanum	58 Ce 140.1 Cerium	59 Pr 140.9 Praseodymium	60 Nd 144.2 Neodymium	61 Pm 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 173.1 Ytterbium	71 Lu 175.0 Lutetium

Actinoids

89 Ac Actinium	90 Th 232.0 Thorium	91 Pa 231.0 Protactinium	92 U 238.0 Uranium	93 Np Neptunium	94 Pu Plutonium	95 Am Americium	96 Cm Curium	97 Bk Berkelium	98 Cf Californium	99 Es Einsteinium	100 Fm Fermium	101 Md Mendelevium	102 No Nobelium	103 Lr Lawrencium

Elements with atomic numbers 113 and above have been reported but not fully authenticated.

Standard atomic weights are abridged to four significant figures.

Elements with no reported values in the table have no stable nuclides.

The International Union of Pure and Applied Chemistry Periodic Table of the Elements (February 2010 version) is the principal source of data. Some data may have been modified.