BOARD OF STUDIES
NEW SOUTH WALES

2013

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 25

Total marks – 100

Section I Pages 2–28

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 29–44

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 Which pair of reactants is used to industrially synthesise ammonia?

(A) H_2 and C

(B) H_2 and N_2

(C) H_2O and N_2

(D) H_2O and NO_2

2 What is the purpose of the flame in atomic absorption spectroscopy (AAS)?

(A) To ionise the sample

(B) To produce a spectrum

(C) To atomise the substance

(D) To provide the absorption wavelength

3 What is the main environmental problem associated with chlorofluorocarbon compounds?

(A) Acid rain

(B) Eutrophication

(C) Global warming

(D) Ozone depletion

4 Butan-1-ol burns in oxygen according to the following equation.

$$C_4H_9OH(l) + 6O_2(g) \rightarrow 4CO_2(g) + 5H_2O(l)$$

How many moles of carbon dioxide would form if two moles of butan-1-ol were burnt in excess oxygen?

(A) 2

(B) 4

(C) 8

(D) 10

5 When placed in the Periodic Table, the recently discovered element 116 would be found in the same group as

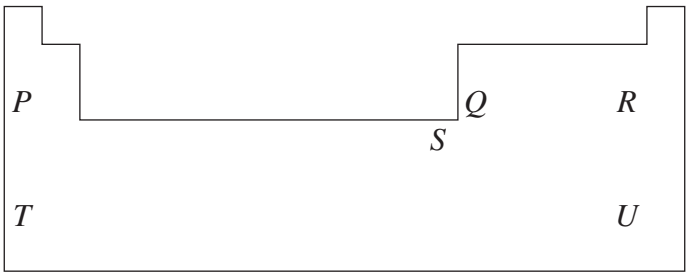
(A) element 16.

(B) element 43.

(C) element 87.

(D) element 102.

6 A representation of the Periodic Table is shown. The positions of six different elements, *P*, *Q*, *R*, *S*, *T* and *U* are given.



Which row of the following table shows the correct acid and base reactivities of the oxides of these elements?

	Oxide reacts with acid only	*Oxide reacts with base only*	*Oxide reacts with both acid and base*
(A)	*P*, *T*	*R*, *U*	*Q*, *S*
(B)	*P*, *R*	*T*, *U*	*Q*, *S*
(C)	*Q*, *R*	*P*, *S*	*T*, *U*
(D)	*Q*, *S*	*R*, *U*	*P*, *T*

7 Which of the following is the correct equation for an INCOMPLETE combustion of octane?

(A) $C_8H_{18}(l) + 8O_2(g) \rightarrow 8CO_2(g) + 9H_2(g)$

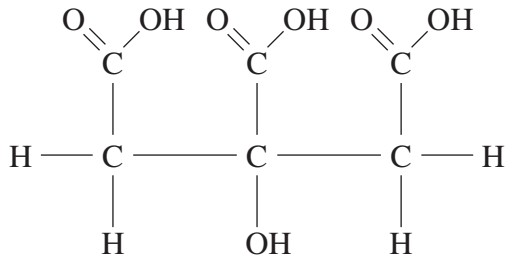
(B) $C_8H_{18}(l) + \frac{25}{2}O_2(g) \rightarrow 8CO_2(g) + 9H_2O(l)$

(C) $C_8H_{18}(l) + 6O_2(g) \rightarrow 3CO(g) + 5C(s) + 9H_2O(l)$

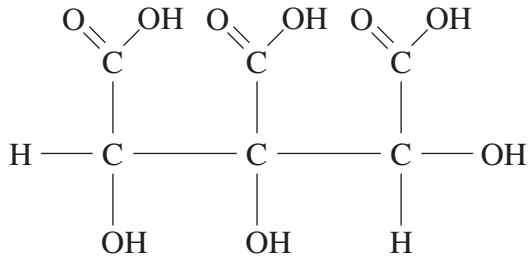
(D) $C_8H_{18}(l) + 13O_2(g) \rightarrow 4CO(g) + 4C(s) + 9H_2O(l)$

8 Which of the following structural formulae shows citric acid, also known as 2-hydroxypropane-1,2,3-tricarboxylic acid?

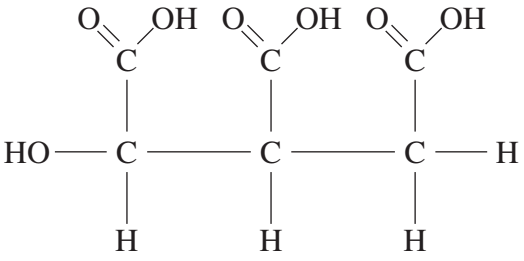
(A)



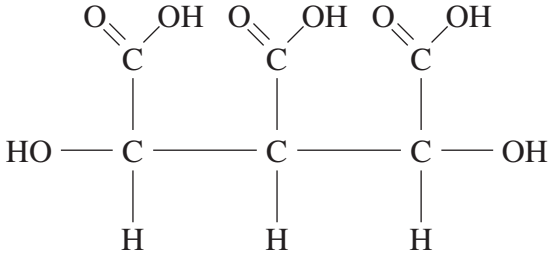
(B)



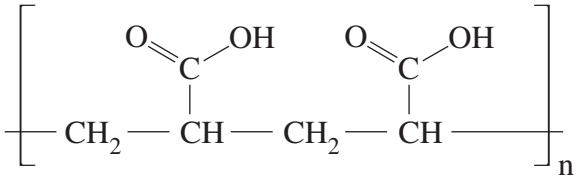
(C)



(D)



9 A portion of a resin made from acrylic acid ($CH_2{=}CHCOOH$) is shown.



Which type of reaction results in the formation of this polymer?

(A) Addition

(B) Condensation

(C) Dehydration

(D) Esterification

10 The following equilibrium is set up in a sealed reaction vessel.

$$N_2O_4(g) \rightleftharpoons 2NO_2(g) \qquad \Delta H = +54.8 \text{ kJ mol}^{-1}$$

Which of the following would INCREASE the yield of nitrogen dioxide?

(A) Adding a catalyst to the reaction vessel

(B) Decreasing the volume of the reaction vessel

(C) Raising the temperature of the reaction vessel

(D) Increasing the pressure by adding argon to the reaction vessel

11 The table shows the heat of combustion for four compounds.

Compound	*Heat of combustion* (kJ mol^{-1})
CO	233
CH_4	890
C_2H_2	1300
C_2H_6	1560

Which of these compounds would produce the greatest amount of energy if 1.00 g of each is burnt?

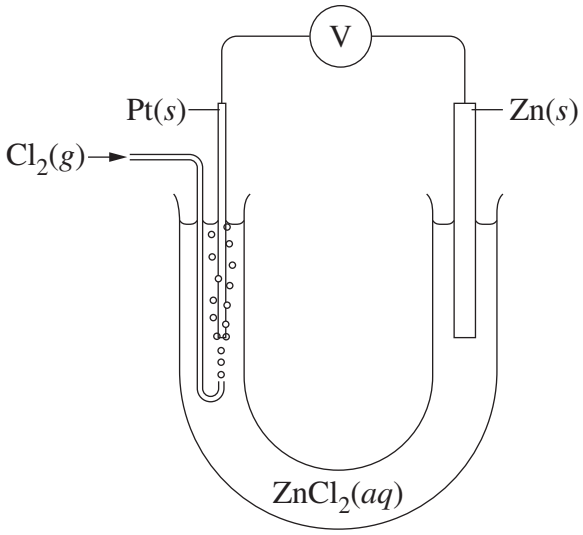
(A) CO

(B) CH_4

(C) C_2H_2

(D) C_2H_6

12 An experiment was set up as shown.



Which of the following statements is correct?

(A) The chlorine gas is the anode.

(B) The zinc electrode is the anode.

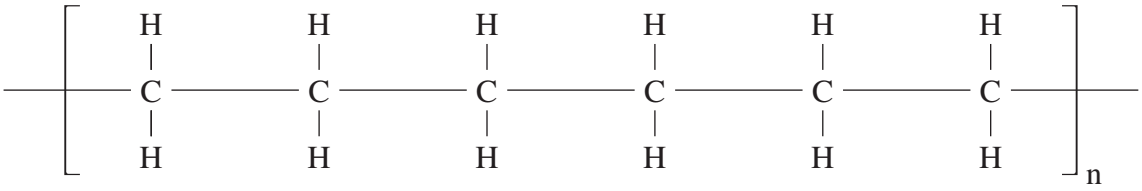
(C) The platinum electrode is the anode.

(D) There is no anode because there is no salt bridge.

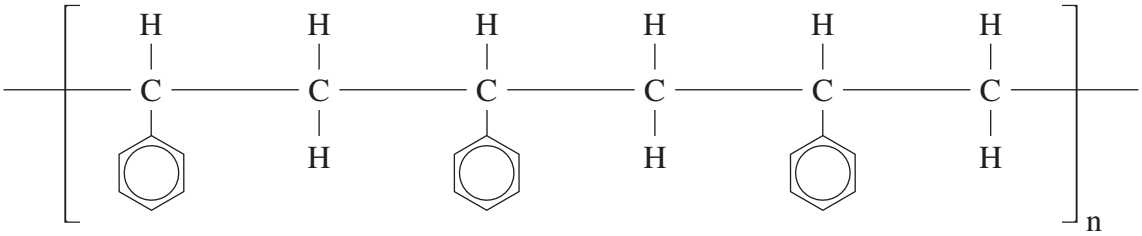
13

What is the structure of the polymer most likely to have been used in the manufacture of the cup shown?

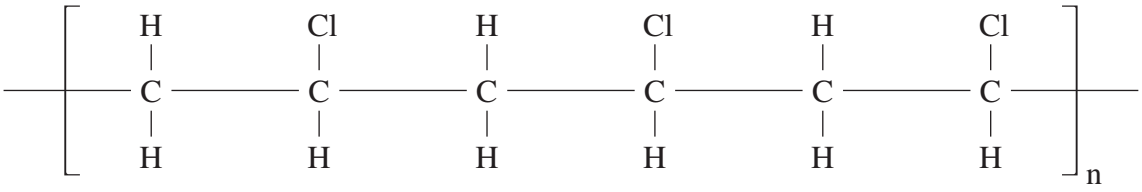
(A)



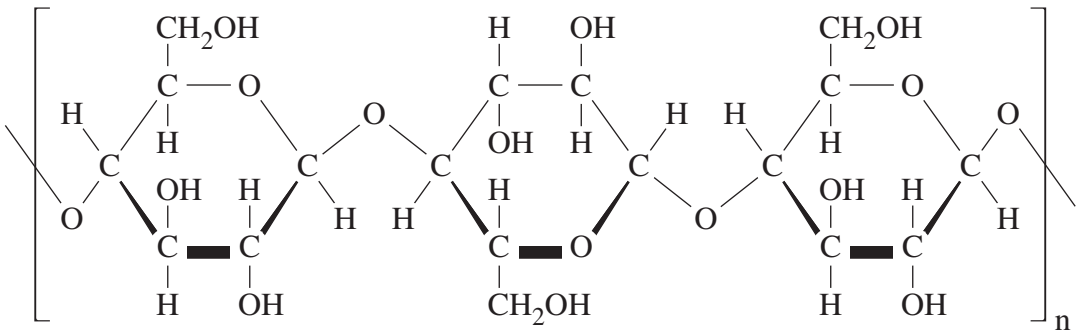
(B)



(C)



(D)



14 Sodium reacts with water to give hydrogen gas and sodium hydroxide solution.

What volume of gas would be produced from the reaction of 22.99 g of sodium at 25°C and 100 kPa?

(A) 11.36 L

(B) 12.40 L

(C) 22.71 L

(D) 24.79 L

15 A pH 3.0 solution of HCl(*aq*) is diluted by adding water to produce a pH 5.0 solution.

Which row in the following table correctly identifies an appropriate volume of the original solution and the volume of water added for this dilution?

	Volume of original solution (mL)	*Volume of water added* (mL)
(A)	100	900
(B)	100	1000
(C)	10	990
(D)	1	1000

16 Which two species will react to form a product containing a coordinate covalent bond?

(A) Ca(*s*) and $2H^+(aq)$

(B) $H_2O(l)$ and $H^+(aq)$

(C) $Ag^+(aq)$ and $Cl^-(aq)$

(D) $NH_4^+(aq)$ and $OH^-(aq)$

17 A 25.0 mL sample of a 0.100 mol L^{-1} hydrochloric acid solution completely reacted with 23.4 mL of sodium hydroxide solution.

What volume of the same sodium hydroxide solution would be required to completely react with 25.0 mL of a 0.100 mol L^{-1} acetic acid solution?

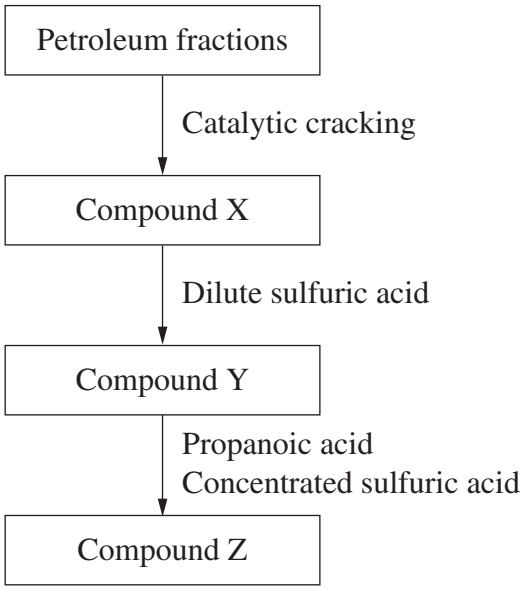
(A) Less than 23.4 mL

(B) 23.4 mL

(C) More than 23.4 mL

(D) Unable to calculate unless the concentration of the sodium hydroxide solution is also known

18 Consider the following series of reactions.



Which row in the table correctly identifies Compounds X, Y and Z?

	Compound X	*Compound Y*	*Compound Z*
(A)	Propene	Propan-1-ol	Ethyl propanoate
(B)	Propene	Ethanol	Propyl ethanoate
(C)	Ethanol	Ethylene	Propyl ethanoate
(D)	Ethylene	Ethanol	Ethyl propanoate

19 A solution was obtained by boiling flowers in water. After various substances were added to separate samples of the solution, the colour of each was noted.

Substance added	*Colour observed*
0.1 mol L^{-1} HCl(*aq*)	Bright pink
0.01 mol L^{-1} HCl(*aq*)	Bright pink
0.001 mol L^{-1} HCl(*aq*)	Pale yellow
Distilled water	Bright yellow
0.001 mol L^{-1} NaOH(*aq*)	Bright yellow
0.01 mol L^{-1} NaOH(*aq*)	Bright yellow

For which of the following titrations would it be appropriate to use this solution as an indicator?

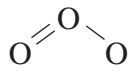
(A) $HCl(aq) + NH_3(aq)$

(B) $HCl(aq) + NaOH(aq)$

(C) $CH_3COOH(aq) + NH_3(aq)$

(D) $CH_3COOH(aq) + NaOH(aq)$

20 The structures of ozone and molecular oxygen are shown.



Ozone

Oxygen

Ozone is more easily decomposed than molecular oxygen because

(A) it is polar.

(B) it is a bent molecule.

(C) it has a greater molecular mass.

(D) it has a lower average bond energy.

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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 (6 marks)

Please turn over

Question 21 (6 marks)

An ester and an acid are both listed as additives on a food label.

(a) Why is acid used as a food preservative? **2**

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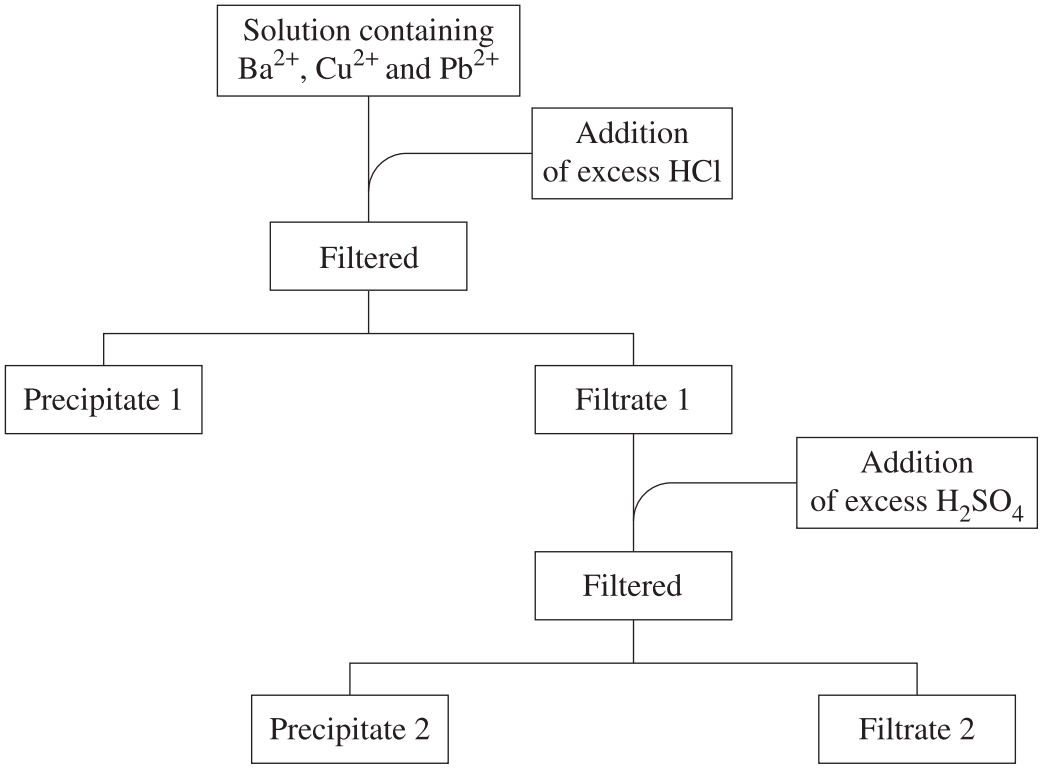
(b) Explain, on a labelled diagram, why reflux is used to produce an ester. **4**

Question 22 (5 marks)

A solution contains three cations, Ba^{2+}, Cu^{2+} and Pb^{2+}. The flow chart indicates the plan used to confirm the identity of these cations.



(a) Name Precipitate 2. **1**

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(b) Write a balanced net ionic equation for the formation of Precipitate 1. **2**

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(c) Suggest a test and the expected result that would confirm the identity of the metal cation remaining in Filtrate 2. **2**

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Question 23 (7 marks)

A 20.72 g sample of solid lead was placed into 0.100 L of 1.00 mol L^{-1} silver nitrate solution.

(a) Complete the table. Show relevant calculations in the space below the table. **5**

Chemical species	$Pb^{2+}(aq)$	$Pb(s)$	$Ag^{+}(aq)$	$Ag(s)$	$NO_3^{-}(aq)$
Moles in final mixture					
Balanced chemical equation					

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(b) With reference to only ONE species in the product mixture, explain why care must be taken in disposing of the final mixture. **2**

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Question 24 (4 marks)

Consider this chemical system which is at equilibrium.

$$X(g) + Y(g) \rightleftharpoons Z(g) + \text{heat}$$

(a) Explain the effect of decreasing the volume of the reaction vessel. **2**

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(b) Explain the effect of adding a catalyst to this equilibrium mixture. **2**

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Question 25 (4 marks)

An indicator is placed in water. The resulting solution contains the green ion, Ind^-, and the red molecule, *HInd*. **4**

Explain why this solution can be used as an indicator. In your response, include a suitable chemical equation that uses Ind^- and *HInd*.

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Centre Number

Student Number

Section I – Part B (continued)

Question 26 (4 marks)

Explain how microscopic membrane filters purify contaminated waters, in terms of their design and composition. **4**

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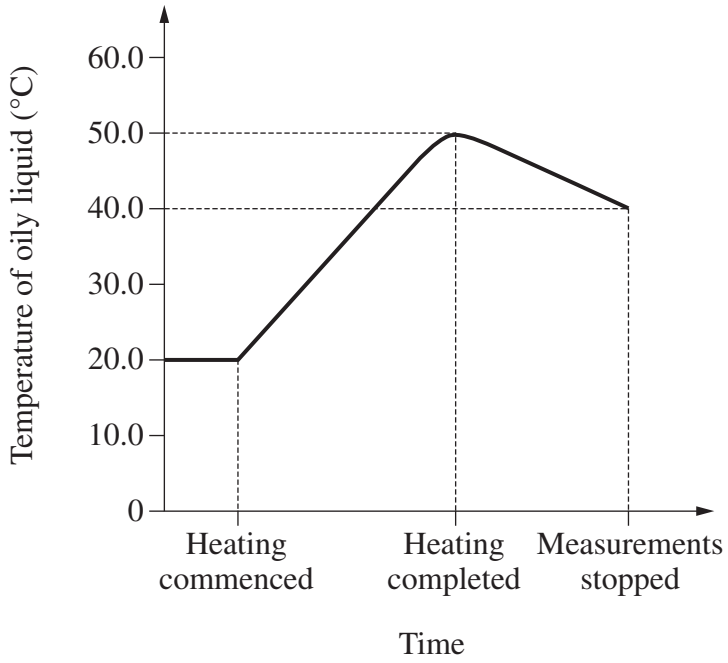
Question 27 (4 marks)

A 0.259 g sample of ethanol is burnt to raise the temperature of 120 g of an oily liquid, as shown in the graph. There is no loss of heat to the surroundings. **4**



Using the information shown on the graph, calculate the specific heat capacity of the oily liquid. The heat of combustion of ethanol is 1367 kJ mol^{-1}.

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Centre Number

Student Number

Section I – Part B (continued)

Question 28 (5 marks)

Please turn over

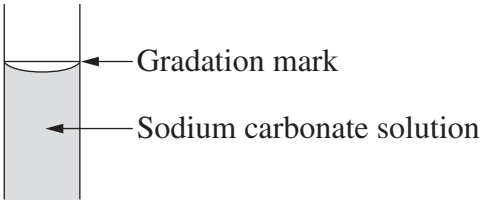
Question 28 (5 marks)

A student attempted to determine the concentration of a hydrochloric acid solution. The following steps were performed.

Step 1. A conical flask was rinsed with water.

Step 2. A 25.0 mL pipette was rinsed with water.

Step 3. The student filled the pipette with a standard sodium carbonate solution to the level shown in the diagram.



Step 4. The standard sodium carbonate solution in the pipette was transferred to the conical flask. The student ensured that all of the sodium carbonate solution was transferred to the conical flask by blowing through the pipette. Three drops of an appropriate indicator were added to the conical flask.

Step 5. A burette was rinsed with the hydrochloric acid solution and then filled with the acid. The student then carried out a titration to determine the concentration of the hydrochloric acid solution.

In steps 2, 3 and 4 above the student did not follow acceptable procedures.

(a) Identify the mistake the student made in step 4 and propose a change that would improve the validity of the result. **2**

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Question 28 continues on page 23

Question 28 (continued)

(b) Explain the effect of the mistakes made in steps 2 and 3 on the calculation of the concentration of the hydrochloric acid solution. **3**

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End of Question 28

Please turn over

Question 29 (2 marks)

Consider this chemical equation. **2**

$$2Cl^-(aq) + Br_2(l) \rightarrow 2Br^-(aq) + Cl_2(g)$$

Will the reaction occur spontaneously? Justify your response.

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Centre Number

Student Number

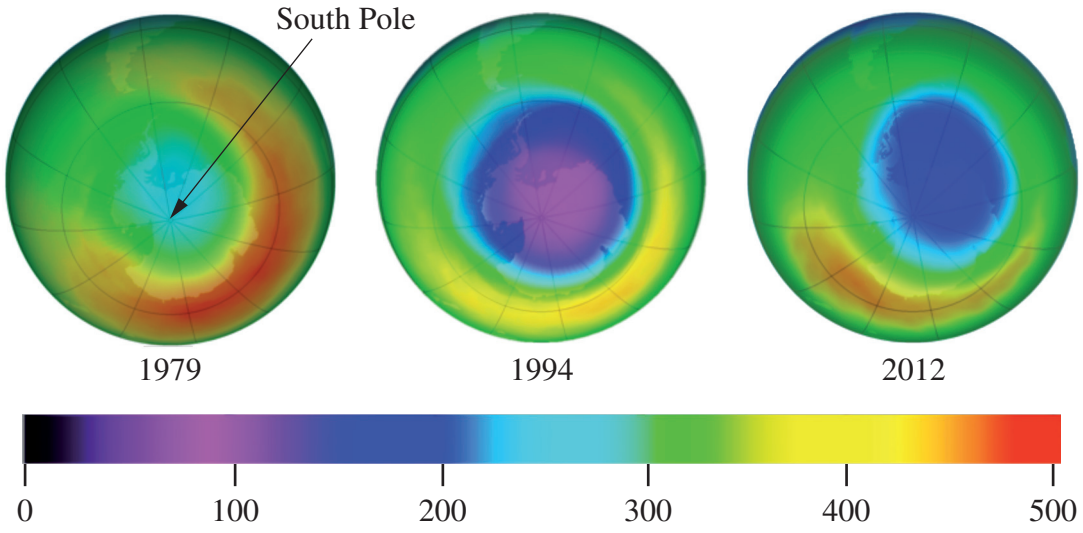
Section I – Part B (continued)

Question 30 (6 marks)

Please turn over

Question 30 (6 marks)

The images below represent the concentration of ozone in the atmosphere above Antarctica near the South Pole for the years 1979, 1994 and 2012, measured at the same time each year. **6**



Acknowledgement: Courtesy of NASA

Account for the changes in ozone concentration above Antarctica between 1979 and 2012. Your response should include relevant equations.

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Question 30 continues on page 27

Question 30 (continued)

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End of Question 30

Please turn over

Question 31 (8 marks)

(a) Construct separate flow diagrams to show the steps used in the production of polyethylene and those used in the production of a recently developed biopolymer. **5**

Polyethylene	Name of biopolymer: .....

(b) Justify the use of a recently developed biopolymer over a polymer obtained from fossil fuel. **3**

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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.

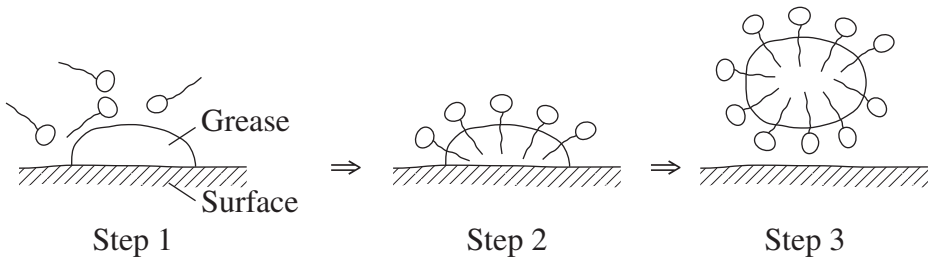
Show all relevant working in questions involving calculations.

Question 32 — Industrial Chemistry (25 marks)

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

(a) The diagram shows a sequence of steps in the removal of grease from a surface. **3**

Explain the process shown in these steps.



(b) Hydrogen iodide is a colourless gas that will decompose into colourless hydrogen gas and purple iodine gas according to the following endothermic reaction.

$$2HI(g) \rightleftharpoons H_2(g) + I_2(g)$$

(i) A 1.0 L glass container was filled with 0.60 moles of hydrogen iodide gas. When equilibrium was established, there were 0.25 moles of iodine gas present in the container. **3**

Calculate the equilibrium constant for this reaction.

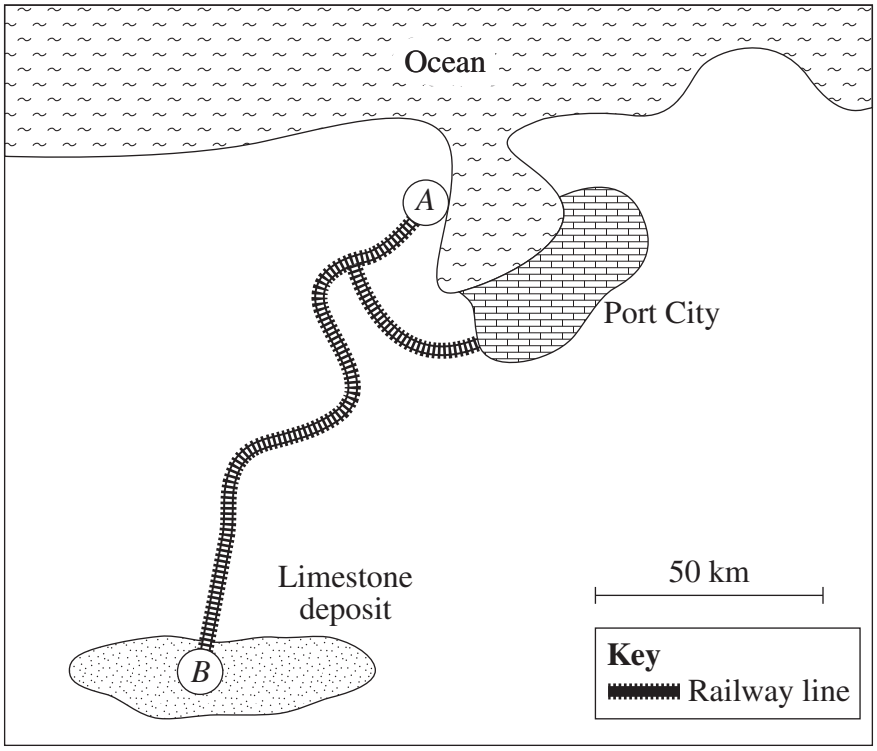
(ii) The container was then cooled. **2**

Explain the change in the appearance of its contents.

Question 32 continues on page 31

Question 32 (continued)

(c) The diagram shows a region where construction of a Solvay plant is being considered.



(i) Why is limestone important in the Solvay process? Include a relevant chemical equation in your response. **2**

(ii) Justify which of sites *A* or *B* would be the preferred location for a Solvay plant. **3**

Question 32 continues on page 32

Question 32 (continued)

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

(d) A first-hand investigation is conducted on the electrolysis of an aqueous solution of sodium chloride.

(i) Justify the use of a safety precaution, other than wearing safety glasses, when carrying out this investigation. **2**

(ii) Describe how the THREE products of this electrolysis could be identified. **3**

(e) There is often a compromise between maximising yield and minimising the environmental impact of industrial processes. **7**

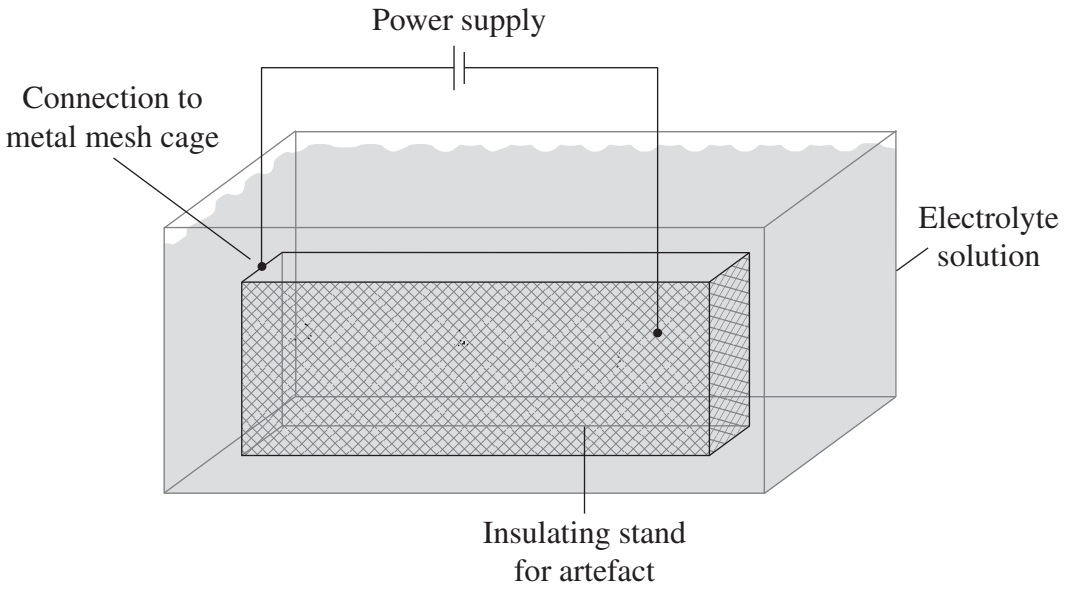
Justify this statement with reference to the production of sulfuric acid.

End of Question 32

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

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

(a) The treatment of a marine artefact is shown. **3**



Explain why this process is used.

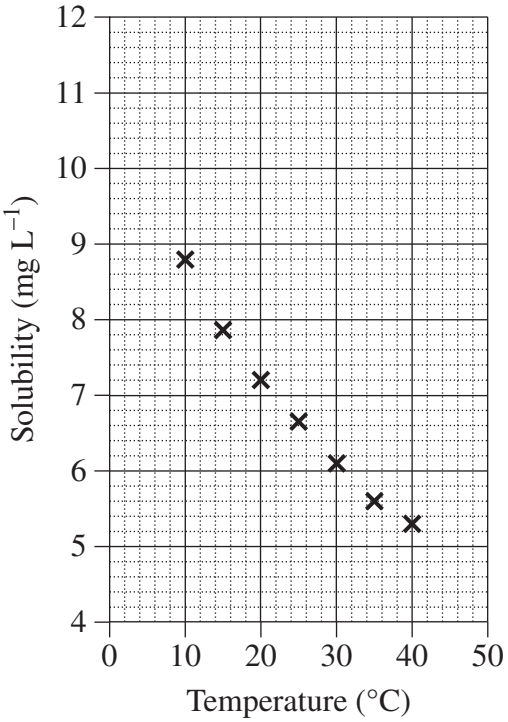
(b) (i) Write a balanced chemical equation for the corrosion of tin in shallow water. **2**

(ii) Summarise the role of electron transfer in corrosion reactions. Include relevant equations in your answer. **3**

Question 33 continues on page 34

Question 33 (continued)

(c) The solubility of oxygen in sea water at various temperatures is shown in the graph.



(i) Predict the solubility of oxygen at 4°C. **2**

(ii) Analyse the factors that affect the concentration of dissolved oxygen at increasing depths in the ocean. **3**

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

(d) (i) Design a suitable first-hand investigation that could be carried out in a school laboratory to compare the effectiveness of different ways of preventing the corrosion of iron in a marine environment. Include relevant diagrams in your answer. **3**

(ii) Use the expected results of the investigation to justify the ongoing use of iron in the construction of ocean-going vessels. **2**

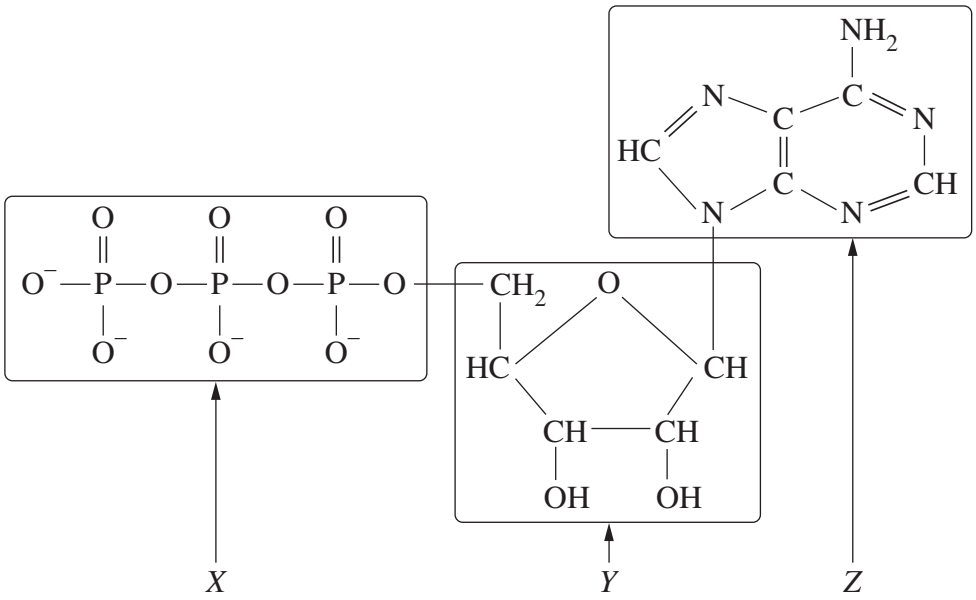
(e) From the scientists studied in this option, assess whose work has most changed the nature of scientific thinking about redox reactions. **7**

End of Question 33

Question 34 — The Biochemistry of Movement (25 marks)

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

(a) The molecule below is adenosine triphosphate (ATP). **3**



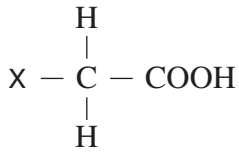
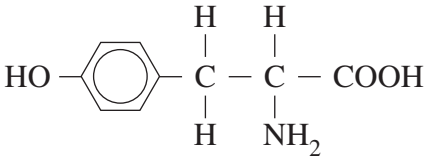
Explain which part of the molecule, *X*, *Y* or *Z*, is the most important biologically. Include a relevant equation in your answer.

Question 34 continues on page 36

Question 34 (continued)

(b) The table below gives the abbreviation and structural formulae for two amino acids.

Part of the glycine molecule has been replaced by X.

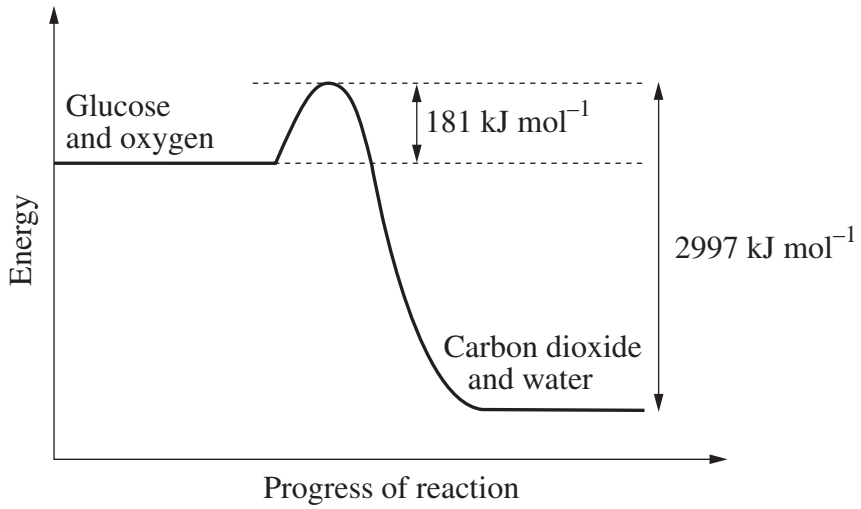
Name	*Abbreviation*	*Formula*
Glycine	Gly	
Tyrosine	Tyr	

(i) Write an equation using the correct structural formulae showing the formation of a dipeptide between glycine and tyrosine. **2**

(ii) Explain, in terms of chemical bonding, how the three-dimensional shape of a protein depends upon its primary structure. **3**

Question 34 continues on page 37

(c) The following energy profile is for the combustion of glucose during cellular respiration.



(i) The hourly energy requirement of an astronaut is supplied by 36.0 g of glucose. **2**

Using the energy profile above, determine the energy required by the astronaut in one hour.

(ii) Calculate the volume of oxygen consumed by the astronaut in one hour. The conditions are 25°C and 100 kPa. Include a chemical equation in your answer. **3**

Question 34 continues on page 38

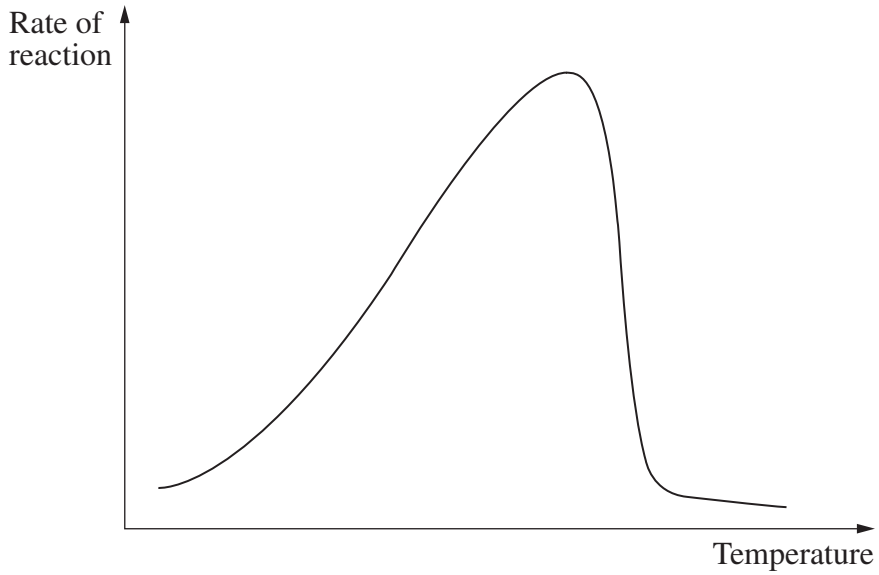
Question 34 (continued)

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

(d) A first-hand investigation was conducted to demonstrate the effect of temperature on the reaction of an enzyme.

(i) Describe a procedure that could be used to demonstrate the effect of temperature on the reaction of an enzyme. **3**

(ii) A sketch showing a student's results is provided below. **2**



Explain the shape of the curve.

(e) 'Give me a muscle biopsy and I'll tell you whether you should be a sprinter or a marathon runner.' **7**

Evaluate the scientific accuracy of this statement in terms of muscle fibre structure and function.

End of Question 34

Question 35 — The Chemistry of Art (25 marks)

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

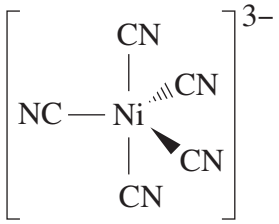
(a) The emission spectrum of a metal salt is observed with a spectroscope. **3**

Explain the processes by which emission lines arise. Include an energy level diagram for the lines marked **A** and **B** in your response.

(b) (i) Identify in which of the *s*, *p*, *d* or *f* blocks of the Periodic Table the element Ra is found. Justify your answer. **2**

(ii) An atom has FIVE valence electrons in its *d* orbital. Using an orbital diagram of the valence shell of the atom, explain how Hund's rule determines the electronic configuration. **3**

(c) The structure of a nickel cyanide complex is shown.



(i) What is the oxidation state of nickel in this complex? Justify your answer. **2**

(ii) Explain the bonding of the complex with the aid of a Lewis structure for the cyanide ligand. **3**

Question 35 continues on page 40

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

(d) A first-hand investigation is conducted to demonstrate the oxidising strength of potassium permanganate.

(i) Describe a procedure that could be used to demonstrate the oxidising strength of potassium permanganate. **2**

(ii) What does this investigation show about the oxidising strength of potassium permanganate? Use half-equations in your answer. **3**

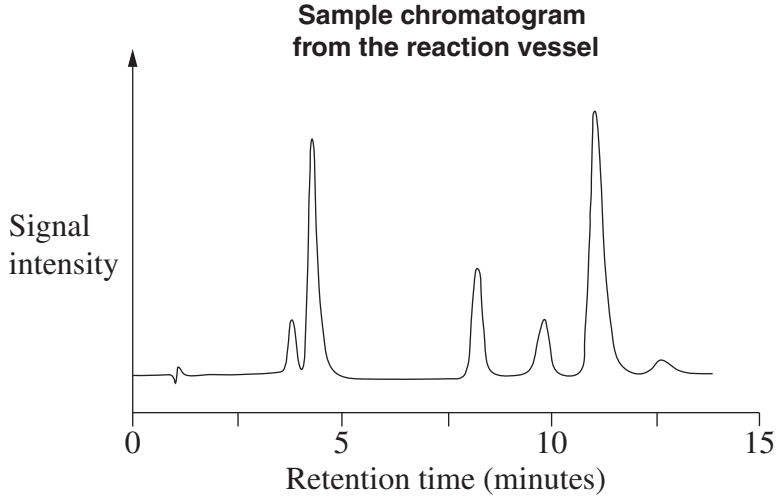
(e) Discuss the principles involved in using infra-red and ultraviolet spectroscopy for the analysis of pigments. **7**

End of Question 35

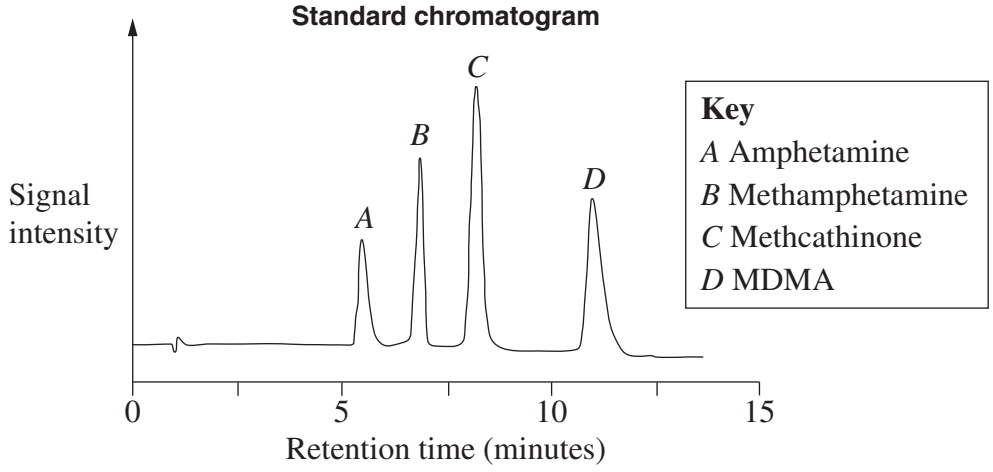
Question 36 — Forensic Chemistry (25 marks)

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

(a) A sample was collected from inside a reaction vessel at a suspected illegal drug laboratory. The sample was analysed by high performance liquid chromatography (HPLC). The chromatogram obtained from the collected sample is provided below. **3**



The chromatogram of a standard mixture containing four compounds commonly produced in illegal drug laboratories is also provided.



By referring to the chromatograms, explain how this information could be used as evidence to support a guilty verdict in a court case.

Question 36 continues on page 42

(b) (i) Information about three polysaccharides (cellulose, glycogen and starch) is provided in the table below. **2**

X	Y	Z
Plant polysaccharide	Animal polysaccharide	Plant polysaccharide
Contains branched and linear chains	Contains highly branched chains	Contains linear chains

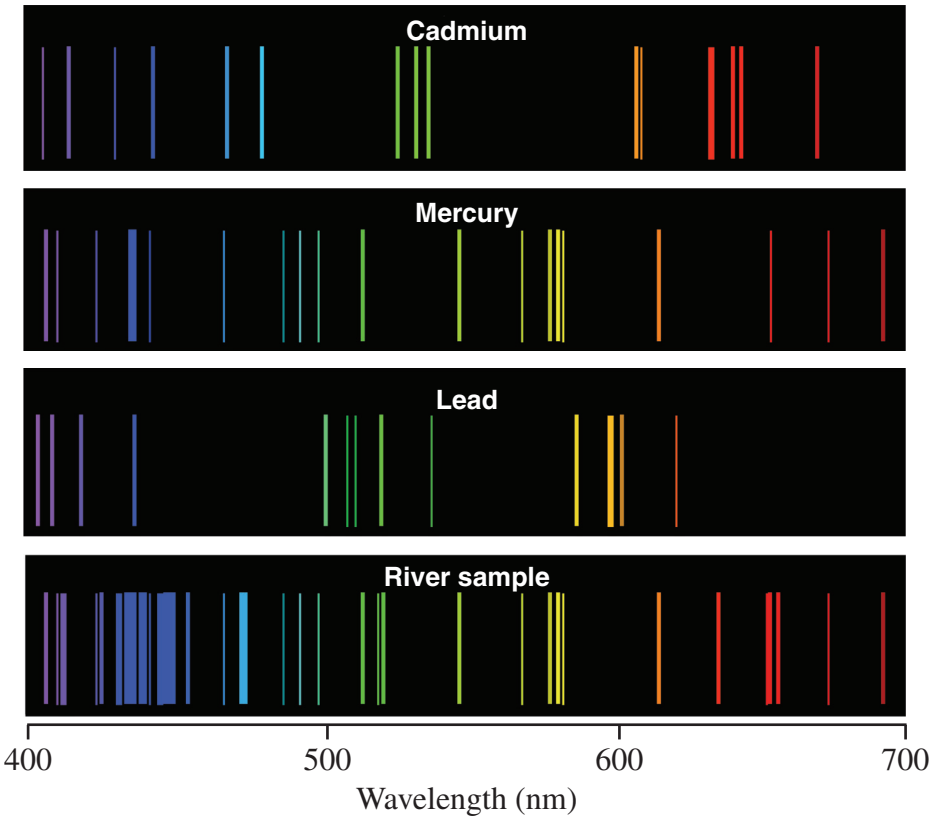
Identify X, Y and Z.

(ii) Select ONE of cellulose, glycogen or starch and explain its primary function in terms of its composition and structure. **3**

Question 36 continues on page 43

(c) A pesticide manufacturer is suspected of releasing waste water contaminated with heavy metal ions into a local river. Atomic emission spectroscopy is used to identify the possible pollutants.

(i) Use the following emission spectra to identify a metal pollutant in the river. Justify your answer. **2**



(ii) Outline a procedure that could be used in a school laboratory to SAFELY produce and analyse the emission spectrum of an element. **3**

Question 36 continues on page 44

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

(d) Alkanes, alkenes, alkanols and alkanoic acids are four different classes of organic compounds.

(i) Describe a simple test that would confirm that a compound is organic. **2**

(ii) Describe a sequence of tests that could be used to distinguish between any THREE of the classes of organic compounds named above. **3**

(e) A chemist working in a forensic laboratory is asked to analyse a residue of an explosive. They selected chromatography as the preferred analytical technique over electrophoresis. Justify this decision. **7**

End of paper

DATA SHEET

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

Volume of 1 mole ideal gas: at 100 kPa and

at 0°C (273.15 K) ..... 22.71 L

at 25°C (298.15 K) ..... 24.79 L

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

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

Some useful formulae

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

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

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.