NSW EDUCATION STANDARDS AUTHORITY

2017 | HIGHER SCHOOL CERTIFICATE EXAMINATION

IMPORTANT:
This resource was developed to support a previous version of the syllabus.
It may contain content that differs from the current syllabus.

Chemistry

General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Write using black pen
- Draw diagrams using pencil
- NESA approved calculators may be used
- A data sheet and Periodic Table are provided at the back of this paper

Total marks: 100

Section I – 75 marks (pages 2–28)

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 21–30
- Allow about 1 hour and 40 minutes for this part

Section II – 25 marks (pages 29–39)

- Attempt ONE question from Questions 31–35
- 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 an experiment, 30 mL of water is to be transferred into a conical flask.

Which piece of equipment would deliver the volume with the greatest accuracy?

A. Burette

B. Beaker

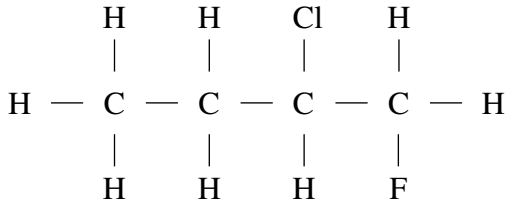
C. Test tube

D. Measuring cylinder

2 Which row of the table correctly matches an ion with its flame colour during a flame test?

	Ion	*Flame colour*
A.	Barium	Orange-red
B.	Calcium	Blue-green
C.	Carbonate	Orange-red
D.	Copper	Blue-green

3 What is the name of this compound?



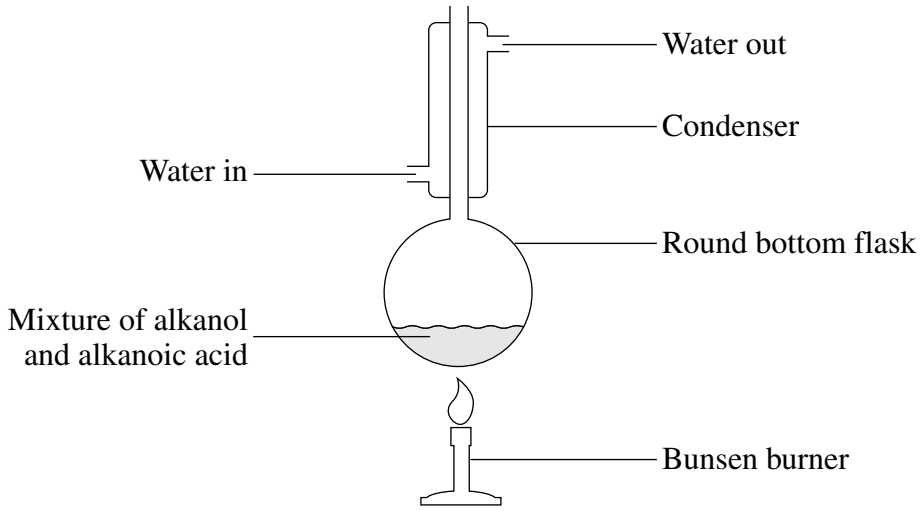
A. 2-chloro-1-fluorobutane

B. 3-chloro-4-fluorobutane

C. 1-fluoro-2-chlorobutane

D. 4-fluoro-3-chlorobutane

4 Esterification can be carried out in a school laboratory using the equipment shown.



How could the safety of the process shown be improved?

A. Place a stopper on top of the condenser.

B. Add concentrated sulfuric acid to the flask.

C. Change the direction of water flow through the condenser.

D. Replace the Bunsen burner with an electric heating mantle.

5 Which of the following substances is amphiprotic in nature?

A. HSO_4^-

B. H_2SO_4

C. SO_4^{2-}

D. H_2SO_3

6 Which of the following is a transuranic element that is most likely to have been produced in a nuclear reactor?

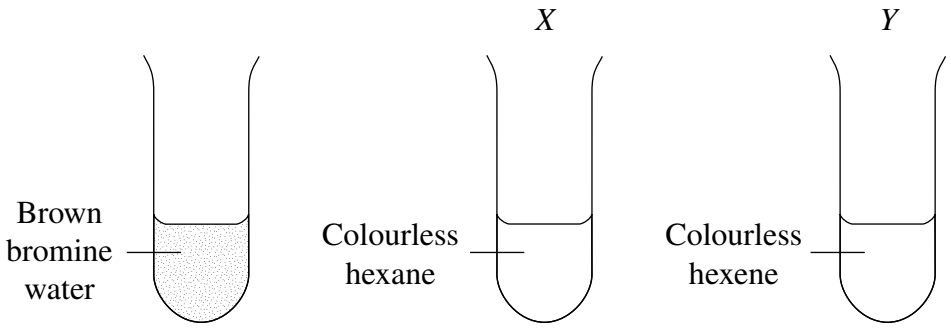
A. Co-60

B. Np-239

C. U-238

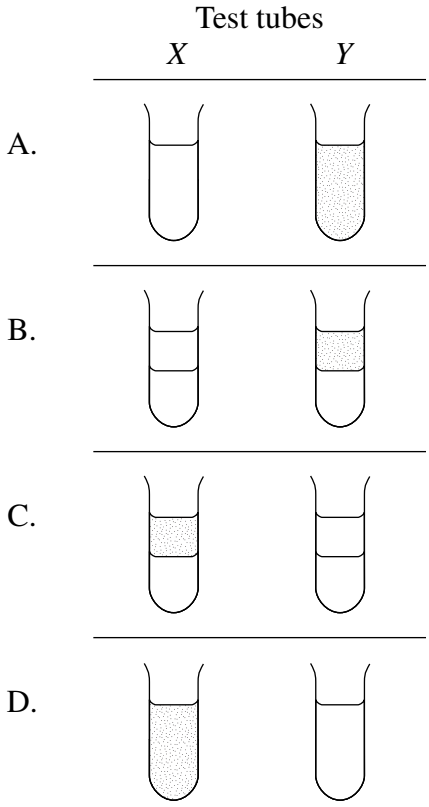
D. Hs-265

7 Three test tubes were set up as shown.



Bromine water was added to *X* and *Y* in the absence of UV light.

Which of the following best represents the changes in test tubes *X* and *Y*?



8 There are two unlabelled solutions. One is barium nitrate and the other lead nitrate.

Which of the following could be added to the two unlabelled solutions to distinguish between them?

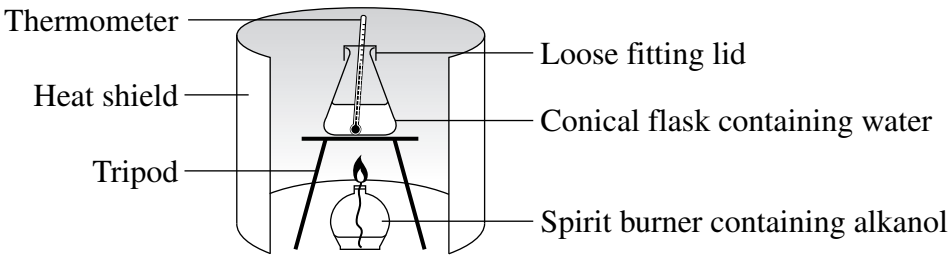
A. Sodium sulfate

B. Sodium nitrate

C. Sodium chloride

D. Sodium carbonate

9 The following equipment was set up to measure the heat of combustion of an alkanol.



Black deposits were observed on the bottom of the conical flask and the heat of combustion measured was lower than the theoretical value.

Which of the following equations could account for these observations?

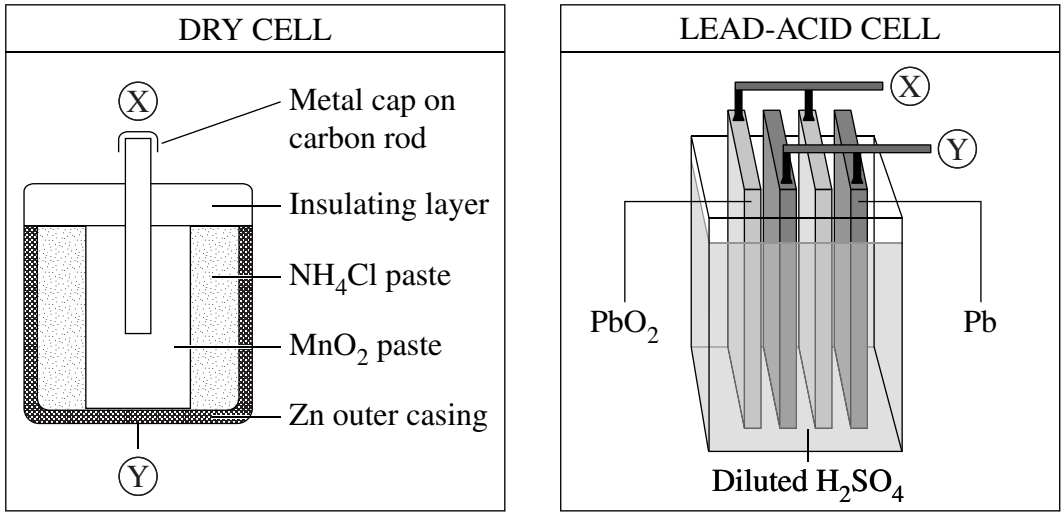
A. $2C_2H_6(g) + 7O_2(g) \longrightarrow 4CO_2(g) + 6H_2O(g)$

B. $C_3H_8O(g) + 4O_2(g) \longrightarrow CO_2(g) + CO(g) + 4H_2O(g)$

C. $2C_4H_{10}O(g) + 3O_2(g) \longrightarrow 8C(s) + 2H_2(g) + 8H_2O(g)$

D. $2C_2H_6O(g) + 4O_2(g) \longrightarrow 2CO_2(g) + 2C(s) + 6H_2O(g)$

10 The diagrams show a dry cell and a lead-acid cell. The electrodes are labelled Ⓧ and Ⓨ.



When either cell is connected to supply energy, which row of the table correctly describes the electrodes and their charges?

	Electrode Ⓧ		*Electrode* Ⓨ	
A.	Anode	Positive	Cathode	Negative
B.	Cathode	Positive	Anode	Negative
C.	Anode	Negative	Cathode	Positive
D.	Cathode	Negative	Anode	Positive

11 Consider the following redox reaction.

$$2K_2Cr_2O_7(aq) + 2H_2O(l) + 3S(s) \longrightarrow 2Cr_2O_3(aq) + 4KOH(aq) + 3SO_2(g)$$

Which species is being oxidised?

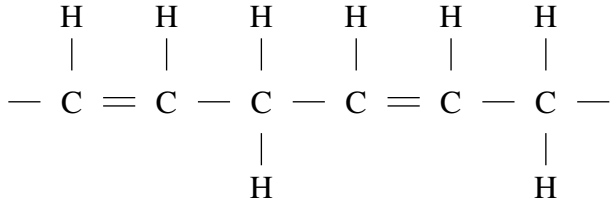
A. Cr^{6+}

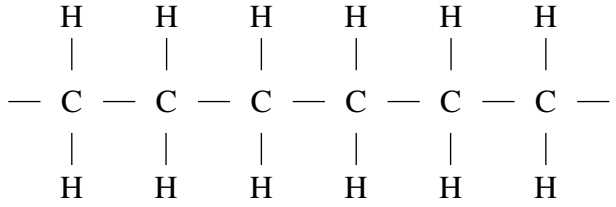
B. K^{+}

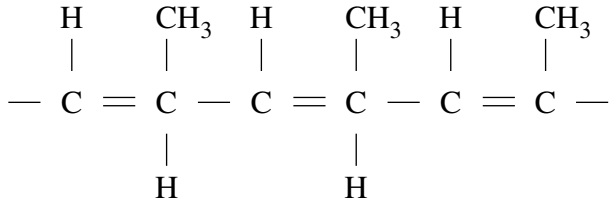
C. O^{2-}

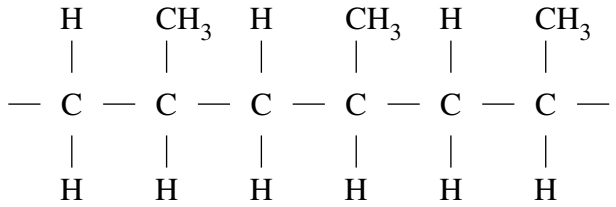
D. S

12 What is the product when propene undergoes addition polymerisation?

A.


B.


C.


D.


13 25.0 mL of a 0.100 mol L^{-1} acid is to be titrated against a sodium hydroxide solution until final equivalence is reached.

Which of the following acids, if used in the titration, would require the greatest volume of sodium hydroxide?

A. Acetic

B. Citric

C. Hydrochloric

D. Sulfuric

14 One litre of an aqueous solution is formed from mixing equal volumes of 0.2 mol L^{-1} hydrochloric acid (HCl) and 0.2 mol L^{-1} sodium chloride (NaCl).

How effective as a buffer is the aqueous solution formed?

A. Ineffective, because HCl is a strong acid

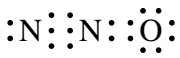
B. Effective, because Cl^- is the conjugate base of HCl

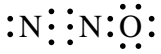
C. Ineffective, because NaCl forms a neutral salt solution

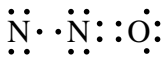
D. Effective, because the pH would change when a solution of NaOH is added

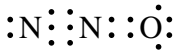
15 Dinitrogen oxide (N_2O) contains a coordinate covalent bond.

Which Lewis electron dot structure correctly represents N_2O?

A. 

B. 

C. 

D. 

16 The following equilibrium is established in a closed system.

$$CO_2(g) + H_2O(l) \rightleftharpoons H_2CO_3(aq) \qquad \Delta H = -19.4 \text{ kJ mol}^{-1}$$

How can the gas pressure in the system be decreased?

A. Add more $CO_2(g)$

B. Add hydroxide ions to the solution

C. Decrease the volume of the container

D. Increase the temperature of the system

17 What is the density of ozone at 25°C and 100 kPa?

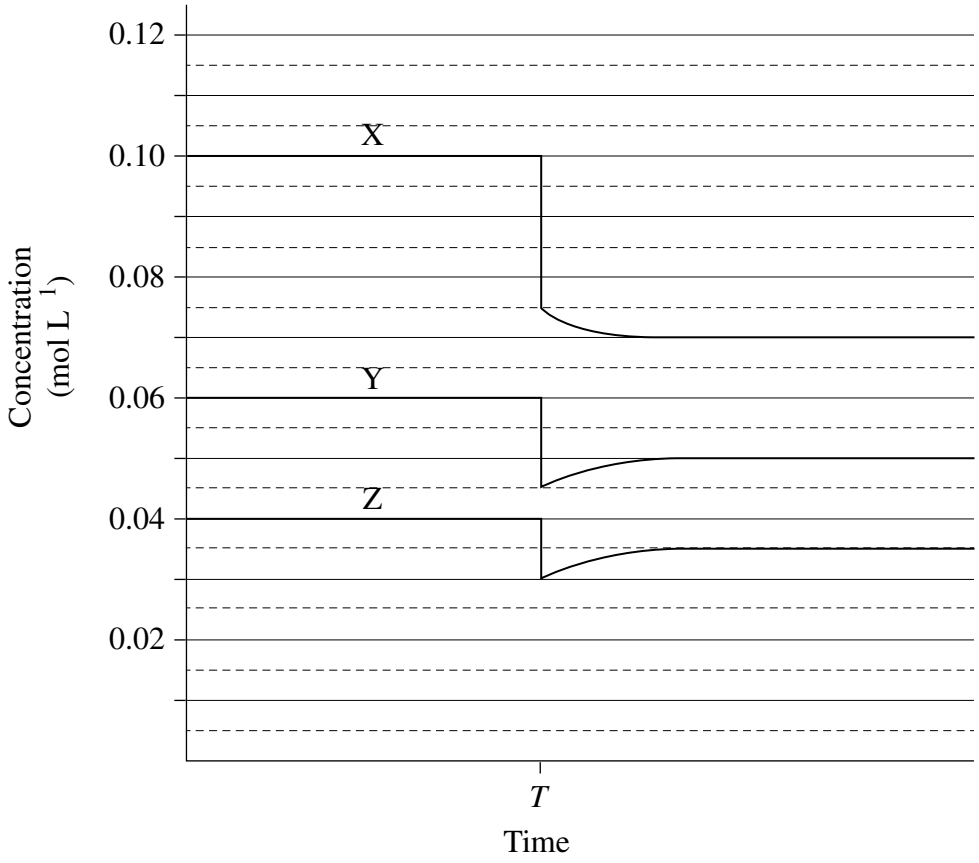
A. 1.291 g L^{-1}

B. 1.500 g L^{-1}

C. 1.936 g L^{-1}

D. 2.114 g L^{-1}

18 Three gases X, Y and Z were mixed in a closed container and allowed to reach equilibrium. A change was imposed at time *T* and the equilibrium was re-established. The concentration of each gas is plotted against time.



Which reaction is represented by the graph?

A. $X(g) + Y(g) \rightleftharpoons 2Z(g)$

B. $2X(g) \rightleftharpoons Y(g) + Z(g)$

C. $2X(g) \rightleftharpoons Y(g) + 3Z(g)$

D. $X(g) \rightleftharpoons Y(g) + Z(g)$

19 The sulfate content of a fertiliser is 48% by mass. 1.20 g of this fertiliser is completely dissolved in water and an excess of $Ba(NO_3)_2(aq)$ is added.

What mass of precipitate would be formed?

A. 0.006 g

B. 0.58 g

C. 1.40 g

D. 1.57 g

20 20.0 mL of 0.020 mol L^{-1} barium hydroxide solution is added to 50.0 mL of 0.040 mol L^{-1} hydrochloric acid solution.

What is the pH of the final solution?

A. 0.2

B. 1.6

C. 1.8

D. 2.9

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Centre Number

Student Number

Chemistry

Section I Part B
Answer Booklet

55 marks
Attempt Questions 21–30
Allow about 1 hour and 40 minutes for this part

Instructions

- Write your Centre Number and Student Number at the top of this page.
- Answer the questions in the spaces provided. These spaces provide guidance for the expected length of response.
- Extra writing space is provided at the back of this booklet. If you use this space, clearly indicate which question you are answering.
- Show all relevant working in questions involving calculations.

Please turn over

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Question 21 (5 marks)

(a) Outline ONE effect of ozone in the troposphere and ONE in the stratosphere. **2**

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(b) Qualitatively compare TWO properties of oxygen (O_2) and ozone (O_3). **2**

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(c) Using ONE chemical equation, show how a chlorine radical (Cl•) reacts with ozone. **1**

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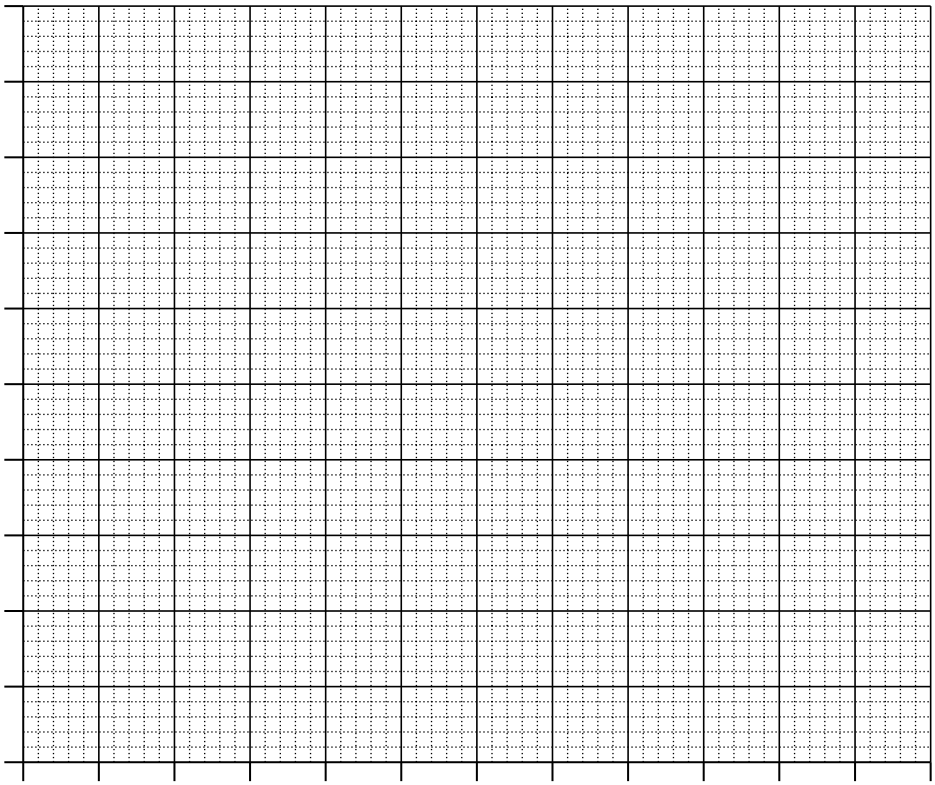
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Question 22 (5 marks)

Atomic absorption spectroscopy was used to determine the concentration of zinc in a water sample. The absorbance of a series of standard solutions of known concentration of zinc was measured. The results are shown in the table.

Zinc concentration (ppm)	0.00	1.00	2.00	3.00	4.00	5.00
Absorbance	0.00	0.17	0.34	0.48	0.65	0.83

(a) Plot the data on the grid and draw a line of best fit. **3**



(b) In order for water to be considered safe for drinking, the concentration of zinc must be less than 2.80 ppm. **2**

The absorbance of the water sample was 0.58. Explain whether this water is safe for drinking.

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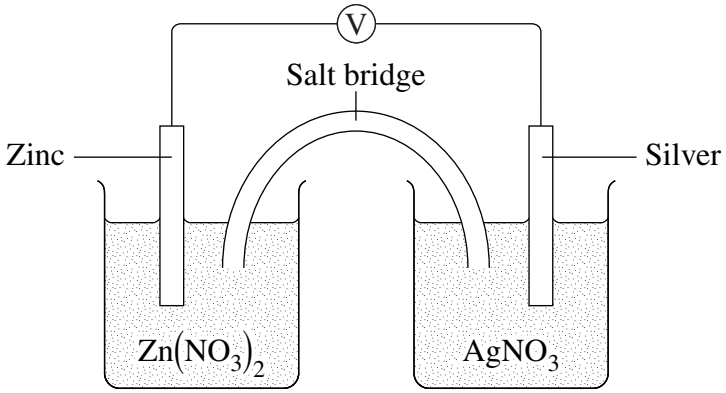
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Question 23 (6 marks)

The diagram shows a galvanic cell.



(a) Explain why a salt bridge is required. **2**

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(b) The initial mass of each electrode was 10.0 g. After some time, the electrodes were removed from the solutions, dried and reweighed. The mass of the zinc electrode had changed by 1.00 g. **4**

Calculate the new mass of the silver electrode.

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Question 24 (5 marks)

A solution of sodium hydroxide was titrated against a standardised solution of acetic acid which had a concentration of 0.5020 mol L^{-1}.

(a) The end point was reached when 19.30 mL of sodium hydroxide solution had been added to 25.00 mL of the acetic acid solution. **3**

Calculate the concentration of the sodium hydroxide solution.

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(b) Explain why the pH of the resulting salt solution was not 7. Include a relevant chemical equation in your answer. **2**

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Question 25 (4 marks)

Outline the steps that can be used to convert cellulose to polyethylene. Include relevant chemical equations in your answer. **4**

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Question 26 (7 marks)

(a) Outline TWO reasons why the release of sulfur dioxide into the atmosphere is a concern. **3**

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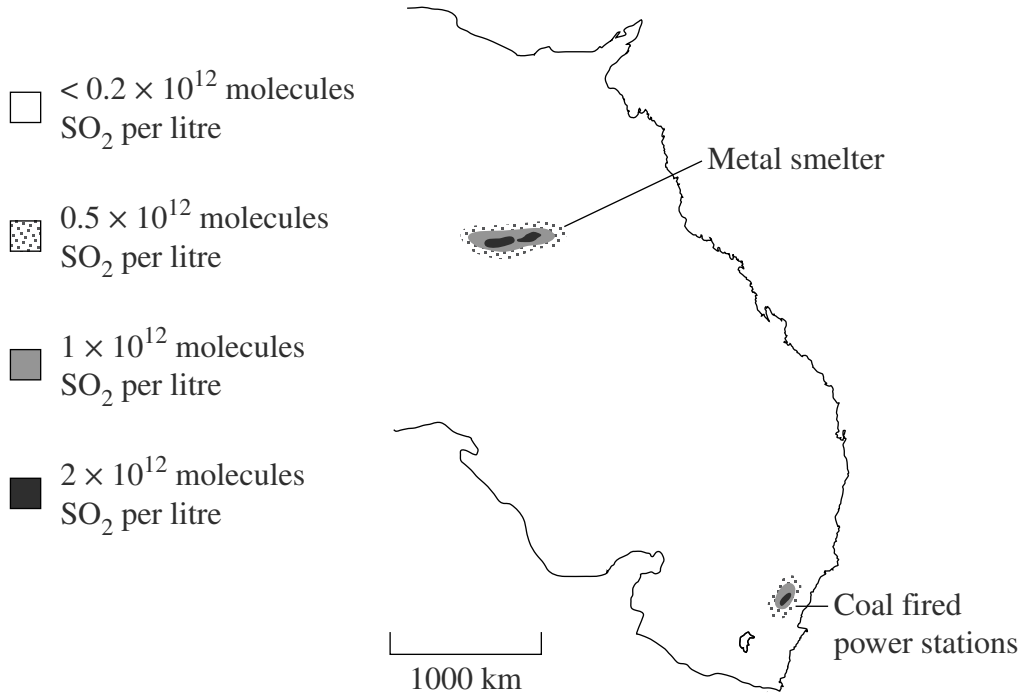
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Question 26 continues on page 21

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(b) The diagram shows the concentrations of sulfur dioxide (SO_2) in the lower atmosphere above a landmass. High concentrations of sulfur dioxide were recorded above a metal smelter and coal fired power stations. **4**



Explain the varying concentrations of sulfur dioxide shown on the map. Include relevant chemical equations in your answer.

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End of Question 26

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Question 27 (5 marks)

The boiling points and molar masses of three compounds are shown in the table. **5**

Compound	*Boiling point* (°C)	*Molar mass* ($g\ mol^{-1}$)
Acetic acid	118	60
Butan-1-ol	117	74
Butyl acetate	116	116

Acetic acid, butan-1-ol and butyl acetate have very different molar masses but similar boiling points. Explain why in terms of the structure and bonding of the three compounds.

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Question 28 (7 marks)

(a) Outline TWO advantages and TWO disadvantages of using ethanol as an alternative fuel for motor vehicles. **4**

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(b) The molar heat of combustion $\left(\Delta H_c\right)$ for ethanol is 1360 kJ mol^{-1}. **3**

Calculate the energy generated per kg of CO_2 released by the combustion of ethanol.

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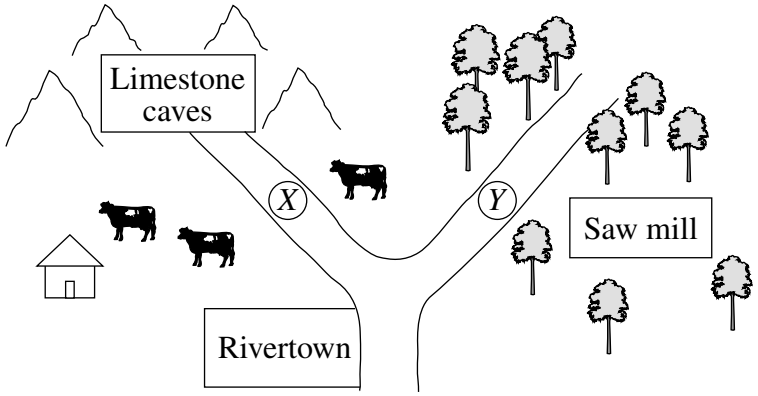
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Question 29 (4 marks)

Rivertown sits at the junction of two rivers. **4**



A simple water purification system has been purchased for the town water supply. It consists ONLY of a sedimentation tank, pH control, sand filters and a chlorination facility.

The system is to draw water either from Site *X* or Site *Y*.

A water chemist has obtained the following data from each site.

Factor	*X*	*Y*
Turbidity (NTU)	2	400
pH	7.3	6.0
Calcium (ppm)	120	5
Phosphate (ppm)	1.00	0.0001

Question 29 continues on page 25

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Question 29 (continued)

With reference to the information provided, justify which of the sites, *X* or *Y*, would be the preferred water source for the town water supply.

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End of Question 29

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Question 30 (7 marks)

Analyse the conditions required to optimise the production of ammonia using the Haber process. **7**

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Chemistry

Section II

25 marks
Attempt ONE question from Questions 31–35
Allow about 45 minutes for this section

Answer parts (a)–(d) of one question in the Section II Writing Booklet. Extra writing booklets are available.

Show all relevant working in questions involving calculations.

Pages

Question 31 Industrial Chemistry 30–31

Question 32 Shipwrecks, Corrosion and Conservation 32

Question 33 The Biochemistry of Movement 33–34

Question 34 The Chemistry of Art 35–36

Question 35 Forensic Chemistry 37–39

Question 31 — Industrial Chemistry (25 marks)

Answer parts (a) and (b) of the question on pages 2–4 of the Section II Writing Booklet. Start each part of the question on a new page.

(a) (i) Write an equation using structural formulae to describe saponification. Use ethyl propanoate as one of the reactants. **2**

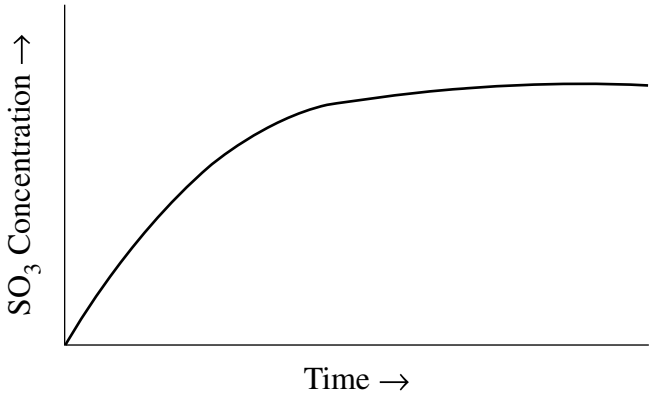
(ii) Describe a procedure that can be used to carry out saponification and test the product in a school laboratory. **3**

(b) The Contact process for the production of sulfuric acid includes a step whereby sulfur dioxide is converted to sulfur trioxide in an equilibrium reaction:

$$SO_2(g) + \tfrac{1}{2}O_2(g) \rightleftharpoons SO_3(g) \quad \Delta H = -99 \text{ kJ mol}^{-1}$$

SO_2 and O_2 were added to a closed container. The production of SO_3 over time is shown on the graph below.

(i) Copy the graph below into your answer booklet and sketch a second curve on the same axes to demonstrate the production of SO_3 over time when the reaction is repeated at a higher temperature. Clearly label the two curves. **2**



(ii) At a certain temperature, the equilibrium constant, *K,* is 12.1 for this reaction as written in the equation above. **4**

At the same temperature, 1.0 mol SO_2 and 1.0 mol O_2 were added to a 1.0 litre closed container. At a point in time, the concentration of SO_3 in the container was measured as 0.70 mol L^{-1}.

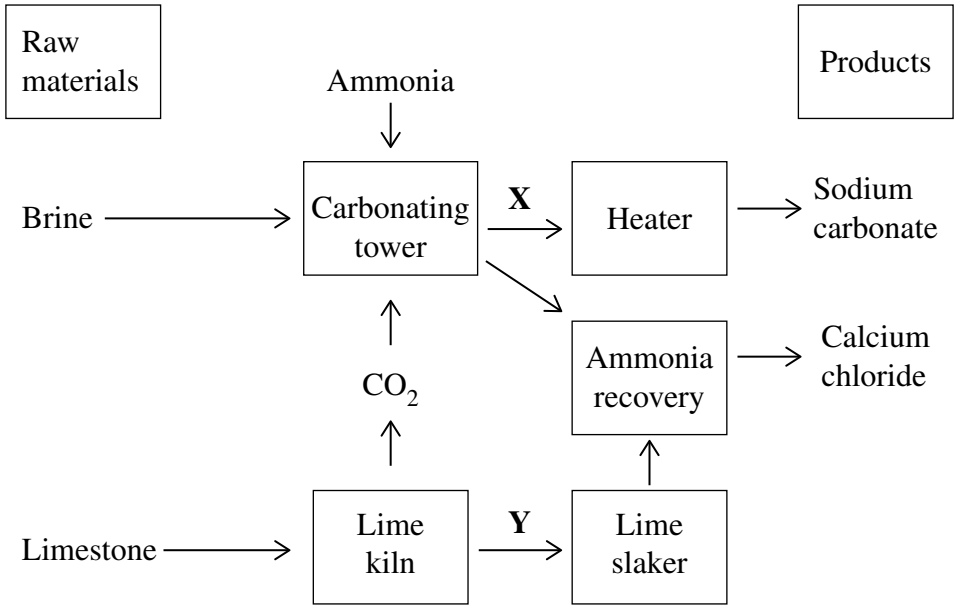
Had equilibrium been reached in the container at this point? Use calculations to justify your answer.

Question 31 continues on page 31

Question 31 (continued)

Answer parts (c) and (d) of the question on pages 5–8 of the Section II Writing Booklet. Start each part of the question on a new page.

(c) The raw materials required to produce sodium carbonate by the Solvay process are limestone and brine. Part of the process is represented by the flow chart.



(i) Name the products labelled **X** and **Y**. **2**

(ii) How is the brine purified? Include a relevant chemical equation in your answer. **2**

(iii) Explain the role of ammonia in the manufacture of sodium carbonate. Include relevant chemical equation(s) in your answer. **3**

(d) Assess the extent to which technological advances have overcome the technical and environmental issues associated with the industrial production of sodium hydroxide. **7**

End of Question 31

Question 32 — Shipwrecks, Corrosion and Conservation (25 marks)

Answer parts (a) and (b) of the question on pages 2–4 of the Section II Writing Booklet. Start each part of the question on a new page.

(a) A first-hand investigation is to be carried out to compare the rate of corrosion of metals in acidic and neutral solutions.

(i) Outline a suitable procedure for this investigation. **2**

(ii) Explain the expected result. Include relevant half equations in your answer. **3**

(b) (i) Outline TWO different ways to increase the rate of an electrolysis reaction. **2**

(ii) When two carbon electrodes were placed in a blue, 3 mol L^{-1} solution of $CuCl_2$ and connected to a 6 V DC power supply, bubbles started appearing at the anode. After some time, the mass of the cathode had increased and the intensity of the blue colour had decreased. **4**

Account for these observations. Include relevant chemical equations in your answer.

Answer parts (c) and (d) of the question on pages 5–8 of the Section II Writing Booklet. Start each part of the question on a new page.

(c) In 1912, the ship *Titanic* sank in water over 3 km deep. The wreck was discovered in 1985.

(i) Why did scientists predict that the rate of corrosion would have been slow at this depth? **2**

(ii) Explain why extra precautions need to be taken when retrieving wooden artefacts from sea water compared to fresh water. **2**

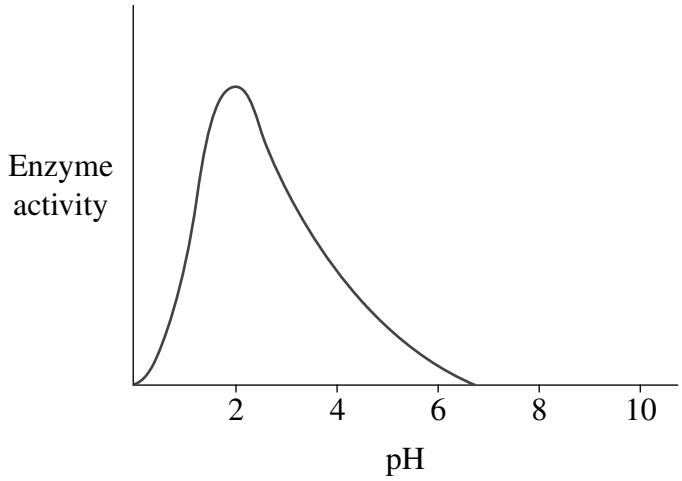
(iii) Describe how electrolysis can be used to remove chloride ions from a metallic artefact. Support your answer with a labelled diagram. **3**

(d) Analyse the effect that the work of Volta and Davy had in reducing corrosion of ocean-going vessels. **7**

Question 33 — The Biochemistry of Movement (25 marks)

Answer parts (a) and (b) of the question on pages 2–4 of the Section II Writing Booklet. Start each part of the question on a new page.

(a) (i) The graph shows the activity of a biological enzyme over a given pH range. **2**



Explain the activity of the enzyme at pH 9.

(ii) Describe a suitable procedure to investigate the effect of temperature on enzyme activity. **3**

(b) (i) How does the structure of ATP give rise to energy production? **2**

(ii) Each gram of mammalian skeletal muscle consumes ATP at a rate of 1×10^{-3} mol min^{-1} during contraction. Concentrations of ATP in muscle are about 4×10^{-3} mol L^{-1} and the density of muscle tissue is 1.2 g mL^{-1}. **4**

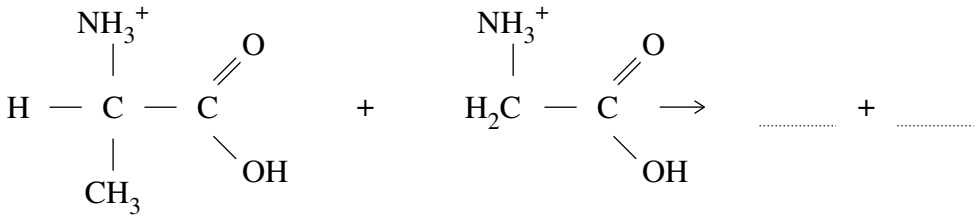
How long could contraction continue on ATP alone?

Question 33 continues on page 34

Question 33 (continued)

Answer parts (c) and (d) of the question on pages 5–8 of the Section II Writing Booklet. Start each part of the question on a new page.

(c) (i) This incomplete equation represents the formation of a dipeptide from alanine and glycine. **2**



In your writing booklet, complete the equation.

(ii) Explain, using a model, why enzymes are specific to their substrate. **3**

(iii) Outline the limitations of the model described in part (ii). **2**

(d) Explain how long chain fatty acids are used in the production of usable energy. **7**

End of Question 33

Question 34 — The Chemistry of Art (25 marks)

Answer parts (a) and (b) of the question on pages 2–4 of the Section II Writing Booklet. Start each part of the question on a new page.

(a) (i) Outline a test that can be carried out to observe the flame colour of ONE metal ion. Include a safety precaution in your answer. **2**

(ii) Account for the flame colour that should be observed in part (i). **3**

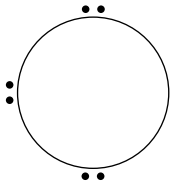
(b) (i) Outline the two main components of paint. **2**

(ii) Explain how the colour of ONE mineral used by Aboriginal peoples relates to its chemical composition and the position of its metallic component in the Periodic Table. **4**

Question 34 continues on page 36

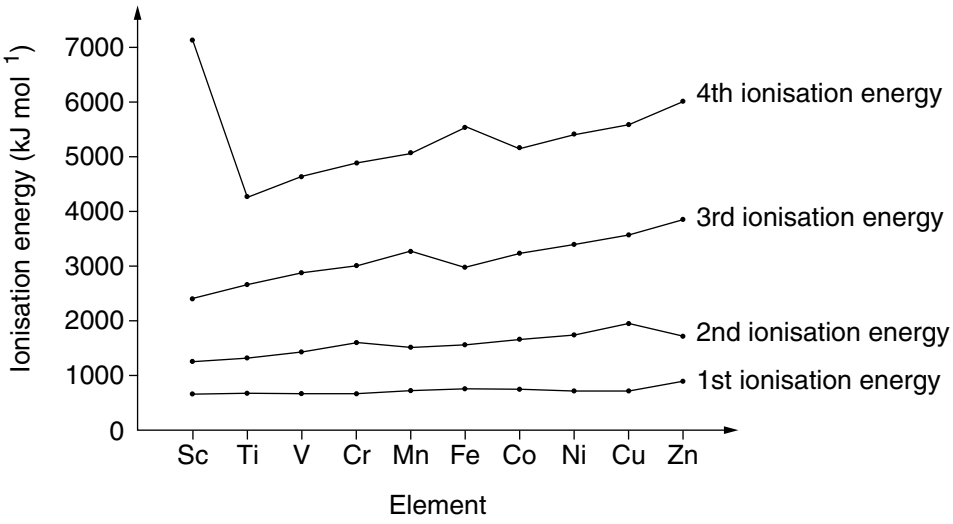
Answer parts (c) and (d) of the question on pages 5–8 of the Section II Writing Booklet. Start each part of the question on a new page.

(c) (i) A student draws this Lewis electron dot structure to represent an oxygen atom. **3**



Identify the error in the representation and justify your answer using Hund's rule.

Use the following graph to answer parts (ii) and (iii). The graph shows the successive ionisation energies for some elements.



(ii) Explain why the predominant oxidation state of scandium (Sc) is 3+. **2**

(iii) Explain why Sc^{3+} compounds are white or colourless whereas V^{3+} compounds have colour. **2**

(d) Using an example, explain the bonding in complex ions of transition metals. **7**

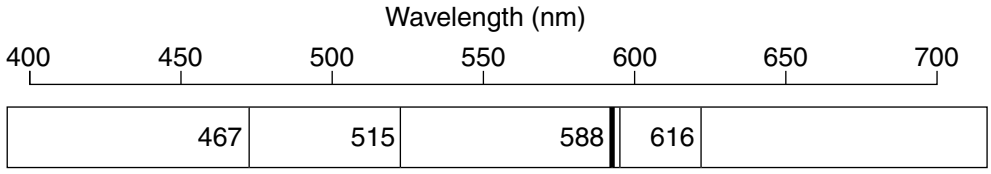
End of Question 34

Question 35 — Forensic Chemistry (25 marks)

Answer parts (a) and (b) of the question on pages 2–4 of the Section II Writing Booklet. Start each part of the question on a new page.

(a) (i) Outline a test that could be carried out in a school laboratory to distinguish between sodium carbonate and starch. **2**

(ii) The emission spectrum of sodium is shown. **3**



With reference to atomic structure, explain how the lines on the emission spectrum are produced.

(b) (i) A group of students tried to use chromatography to separate the pigments extracted from a plant leaf. They put a small spot of the pigments on a strip of paper and drew a line across the paper to show the starting point. They then allowed solvent to run up the paper. **2**

Explain why a pencil rather than a pen should be used to draw the line.

(ii) The students then tried to use chromatography to separate an alkanol and an alkanoic acid. They found that the spot of the alkanol and alkanoic acid mixture did not move when an alkane was used as the solvent. **4**

Justify a modification to the experiment that would lead to the separation of the alkanol and the alkanoic acid.

Question 35 continues on page 38

Question 35 (continued)

Answer parts (c) and (d) of the question on pages 5–8 of the Section II Writing Booklet. Start each part of the question on a new page.

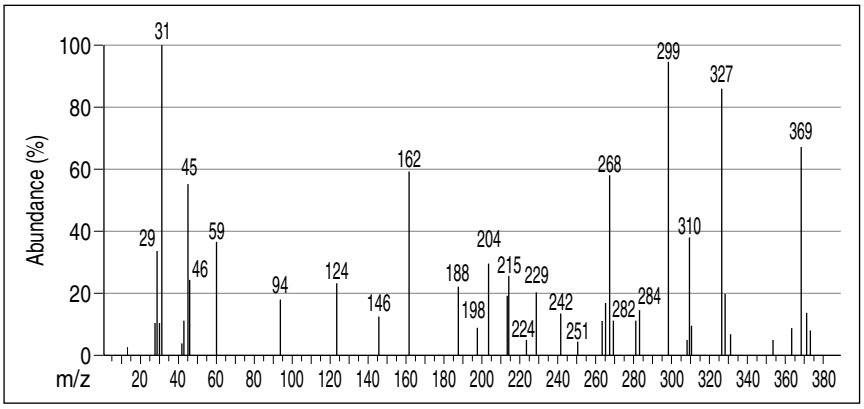
(c) Electrophoresis of proteins can be used to test for performance enhancing drugs.

(i) Using structural formulae, draw a chemical equation to show how a protein fragment can become positively charged in a low pH solution. **2**

(ii) Explain how electrophoresis is used to separate and identify proteins. Include a labelled diagram in your answer. **3**

(iii) Mass spectrometry can be used to identify other drugs in a blood sample. Below is a spectrum obtained from the analysis of a blood sample. **2**

Analysis of a blood sample



The mass spectra of four substances (Diagrams 1 to 4) are shown on the next page.

Using the diagrams, deduce which of the substances are present in the blood sample. Justify your answer.

(d) Discuss the use of DNA analysis in finding lost relatives. Include the relevant underlying chemistry in your answer. **7**

Question 35 continues on page 39

Question 35 (continued)

Diagram 1 Methoxyp.d

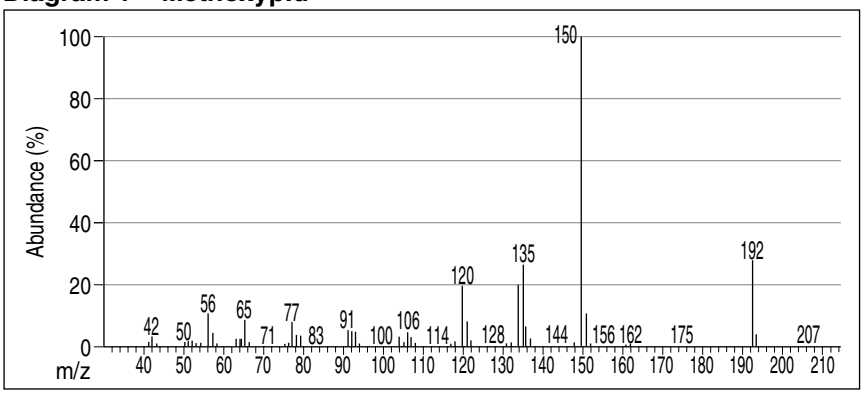


Diagram 2 Trifluor.d

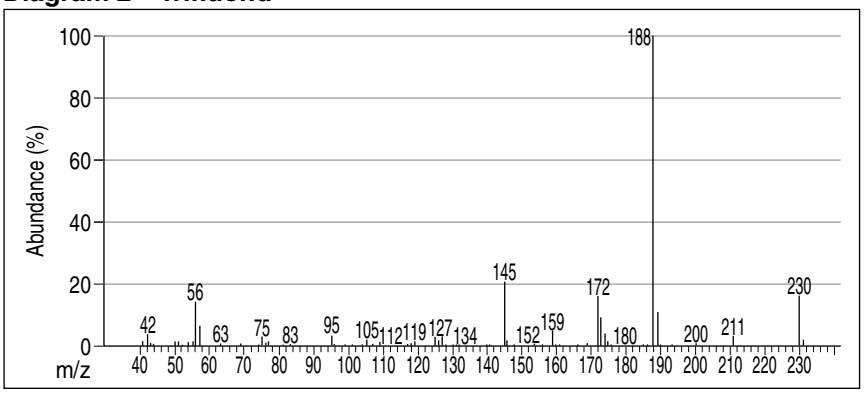


Diagram 3 Heroin

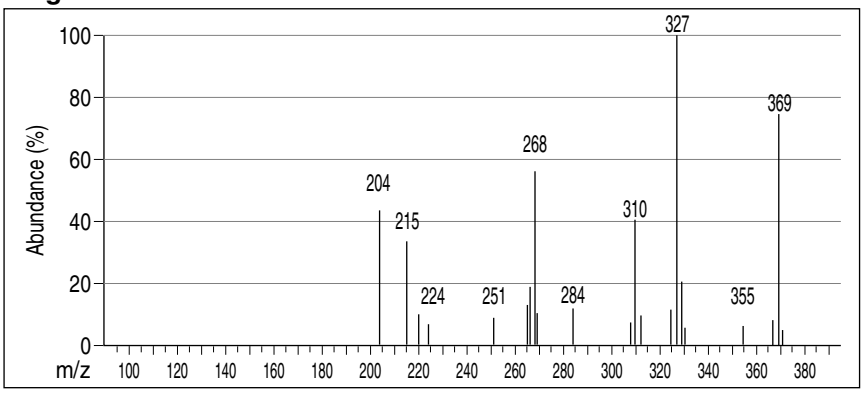
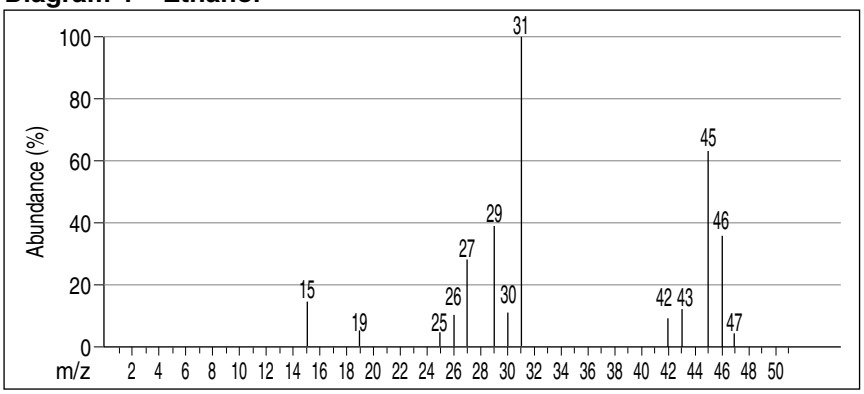


Diagram 4 Ethanol



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Chemistry

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

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

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	113 Nh Nihonium	114 Fl Flerovium	115 Mc Moscovium	116 Lv Livermorium	117 Ts Tennessine	118 Og Oganesson

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

Standard atomic weights are abridged to four significant figures.

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

Information on elements with atomic numbers 113 and above is sourced from the International Union of Pure and Applied Chemistry Periodic Table of the Elements (November 2016 version).

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