BOARD OF STUDIES
NEW SOUTH WALES

2007

HIGHER SCHOOL CERTIFICATE EXAMINATION

Chemistry

General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Write using black or blue pen
- Draw diagrams using pencil
- Board-approved calculators may be used
- 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 9, 13, 15, 17 and 21

Total marks – 100

Section I Pages 2–23

75 marks

This section has two parts, Part A and Part B

Part A – 15 marks

- Attempt Questions 1–15
- Allow about 30 minutes for this part

Part B – 60 marks

- Attempt Questions 16–27
- Allow about 1 hour and 45 minutes for this part

Section II Pages 25–35

25 marks

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

Section I
75 marks

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

Use the multiple-choice answer sheet for Questions 1–15.

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1 Which of the following is a renewable resource?

(A) Ethanol

(B) Uranium

(C) Petroleum

(D) Aluminium

2 What type of reaction describes the polymerisation of glucose into cellulose?

(A) Addition

(B) Hydrolysis

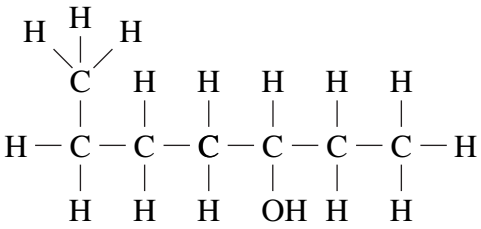
(C) Substitution

(D) Condensation

3 In a galvanic cell, what is the pathway of electron flow?

	Direction	*Medium*
(A)	anode to cathode	salt bridge
(B)	anode to cathode	external wire
(C)	cathode to anode	salt bridge
(D)	cathode to anode	external wire

4 What is the IUPAC name for the following compound?



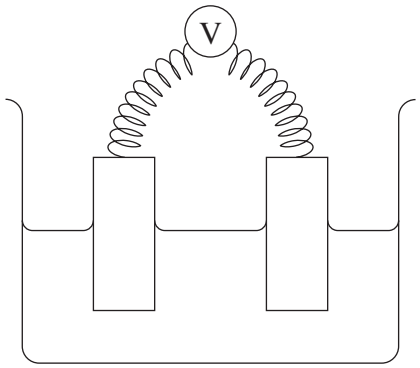
(A) Hexan-3-ol

(B) Hexan-4-ol

(C) Heptan-3-ol

(D) Heptan-5-ol

5 The diagram represents a cell in which two metals have been placed in a solution containing their respective metallic ions. The metals are connected to a voltmeter.



Which of the following combinations of metals would produce the highest reading on the voltmeter?

(A) Tin and zinc

(B) Copper and zinc

(C) Copper and silver

(D) Magnesium and lead

6 Which aqueous solution turns phenolphthalein pink?

(A) HCl

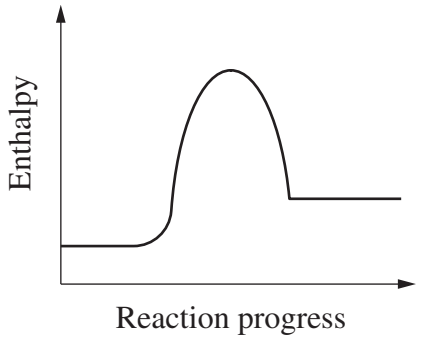
(B) NaCl

(C) NaOH

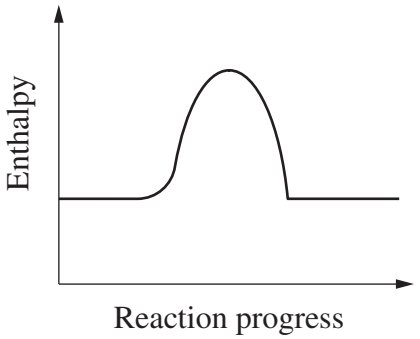
(D) CH_3OH

7 Which graph represents the enthalpy change for an acid-base neutralisation reaction?

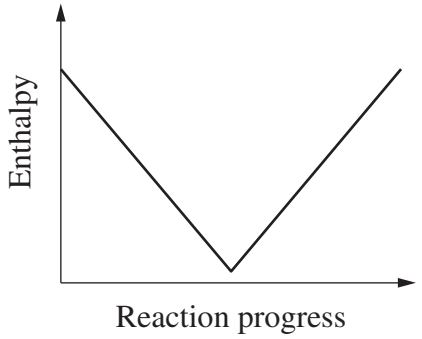
(A)



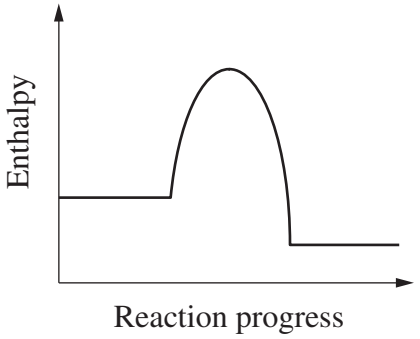
(B)



(C)



(D)



8 Acid *X* and acid *Y* are both monoprotic weak acids of equal concentration. Acid *X* is a stronger acid than acid *Y*.

Which statement about acid X and acid Y is correct?

(A) Acid *Y* is completely ionised in solution.

(B) The solution of acid *X* is less ionised than the solution of acid *Y*.

(C) The solution of acid *X* has a lower pH than the solution of acid *Y*.

(D) 1 mole of acid *Y* requires a greater volume of 1.0 mol L^{-1} NaOH for neutralisation than 1 mole of acid *X*.

9 Which of the following aqueous solutions has a pH greater than 7?

(A) Sodium citrate

(B) Sodium chloride

(C) Ammonium nitrate

(D) Ammonium chloride

10 A 0.1 mol L^{-1} HCl solution has a pH of 1.0.

What volume of water must be added to 90 mL of this solution to obtain a final pH of 2.0?

(A) 10 mL

(B) 180 mL

(C) 810 mL

(D) 900 mL

11 What is the consequence of having large concentrations of Mg^{2+} and Ca^{2+} ions in waterways?

(A) Turbidity

(B) Hardness

(C) Eutrophication

(D) Heavy metal contamination

12 Which of the following is always produced during combustion of fossil fuels?

(A) Water

(B) Carbon (soot)

(C) Sulfur dioxide

(D) Carbon dioxide

13 Consider the following reaction at equilibrium.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \qquad \Delta H = -92 \text{ kJ mol}^{-1}$$

What would be the effect of a decrease in pressure on this system?

(A) Heat will be absorbed.

(B) The equilibrium will not be disturbed.

(C) The concentration of NH_3 will increase.

(D) The reverse rate of reaction will decrease.

14 Which statement about Atomic Absorption Spectroscopy (AAS) is correct?

(A) AAS is an effective qualitative technique but it cannot be used for quantitative analysis.

(B) AAS measures the wavelengths of light emitted when electrons fall back to their ground state.

(C) In AAS, white light is shone through a vaporised sample in order to observe which wavelengths are absorbed.

(D) The wavelength of light used in AAS matches one of the spectral lines produced when the sample is analysed by a flame test.

15 The following equations show the overall effect of the presence of chlorine free radicals (•Cl) on ozone in the stratosphere.

$$\bullet Cl + O_3 \rightarrow \bullet ClO + O_2$$
$$\bullet ClO + \bullet O \rightarrow \bullet Cl + O_2$$

Which term best describes the role of the chlorine free radical in this process?

(A) Anion

(B) Catalyst

(C) Initiator

(D) Oxidant

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Chemistry

Centre Number

Student Number

Section I (continued)

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

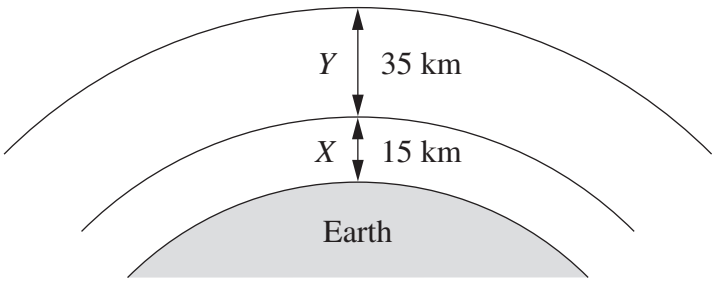
Answer the questions in the spaces provided.

Show all relevant working in questions involving calculations.

Marks

Question 16 (5 marks)

The diagram represents a section of the layered structure of Earth's atmosphere.



(a) Identify the layers of atmosphere labelled *X* and *Y*. **1**

X .....

Y .....

(b) Ozone is a gas found in layers *X* and *Y*. **4**

Explain the effect of ozone in each of these layers.

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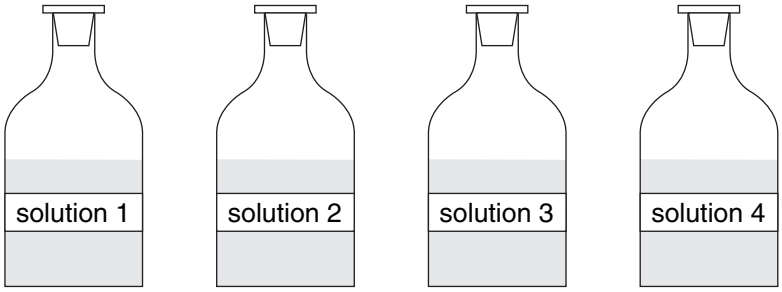
Marks

Question 17 (4 marks)

Each of the four bottles contains one of the following solutions:

- barium nitrate
- hydrochloric acid
- lead nitrate
- sodium carbonate.



A student mixed pairs of these solutions together and obtained the following results.

Reactants	*Observation*
solution 1 and solution 2	bubbles
solution 2 and solution 3	white precipitate
solution 2 and solution 4	no reaction
solution 1 and solution 3	white precipitate
solution 1 and solution 4	white precipitate

(a) Write a correctly balanced equation to represent the reaction between solution 1 and solution 2. **1**

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Question 17 continues on page 11

Marks

Question 17 (continued)

(b) Use the information to identify the four solutions. **2**

Solution	*Identity*
1	
2	
3	
4	

(c) Why would it be inappropriate to use flame tests to identify these solutions? **1**

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Question 18 (3 marks)

Describe the role of a chemist employed in an industry or enterprise, and a chemical principle used by the chemist. (Choose an occupation other than teaching.) **3**

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Chemistry

Centre Number

Section I – Part B (continued)

Student Number

Marks

Question 19 (7 marks)

There are many benefits and problems associated with the use of radioisotopes in industry and medicine. **7**

Evaluate the impact on society of the use of radioisotopes in both industry and medicine. In your answer, give examples of specific radioisotopes, making reference to their chemical properties.

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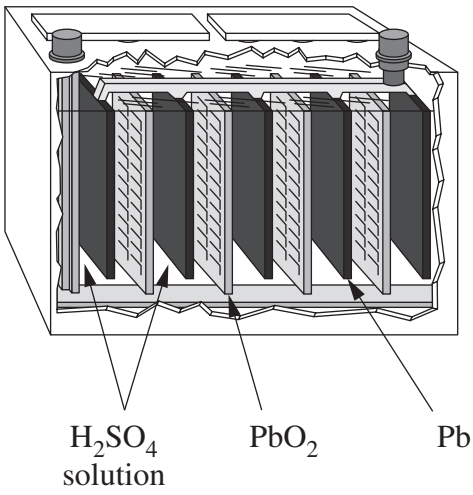
Marks

Question 20 (4 marks)

The diagram represents a typical car battery.



Chemistry 2, HSC Course, by Thickett, Jacaranda Science / Wiley, 1st Edition, © 2006; Reprinted with permission of John Wiley & Sons Australia

As the battery discharges, the following half reactions occur:

$$Pb(s) + SO_4^{2-}(aq) \rightarrow PbSO_4(s) + 2e^-$$

$$PbO_2(s) + SO_4^{2-}(aq) + 4H^+(aq) + 2e^- \rightarrow PbSO_4(s) + 2H_2O(l)$$

(a) Identify the anode, then write the equation that represents the overall chemical reaction. **2**

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(b) Explain one benefit of car batteries lasting several years. **2**

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Chemistry

Centre Number

Section I – Part B (continued)

Student Number

Marks

Question 21 (5 marks)

Red cabbage indicator chart

Colour	red		violet		purple		blue		green		yellow		
pH	1	2	3	4	5	6	7	8	9	10	11	12	13	14

(a) State what colour the red cabbage indicator would be in a 0.005 mol L^{-1} solution of H_2SO_4. Show your working. **1**

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(b) Using the red cabbage indicator, what colour would the solution be if 10 mL of 0.005 mol L^{-1} H_2SO_4 was diluted to 100 mL? **1**

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(c) What volume of 0.005 mol L^{-1} KOH is required to neutralise 15 mL of the diluted solution of H_2SO_4? **3**

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Marks

Question 22 (7 marks)

The following article was sourced from the internet.

> In 2004, Australia's Minister for the Environment announced that the allowable amounts of sulfur in unleaded petrol and diesel would be reduced over the next 5 years.
>
> Currently sulfur in diesel is 500 parts per million (ppm) but it will be cut to 50 ppm on 1 January 2006 and capped at 10 ppm from January 2009.

(a) Calculate the volume of sulfur dioxide produced when a full tank (capacity 60 kg) of diesel is consumed at 25°C and 100 kPa in November 2007. **3**

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(b) Evaluate the effect of the sulfur reduction policy on the environment. **4**

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Centre Number

Section I – Part B (continued)

Student Number

Marks

Question 23 (3 marks)

When hexanoic acid and ethanol are mixed together under certain conditions, esterification occurs. **3**

Describe the conditions necessary for this reaction and give the structural formulae and names of the products.

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Marks

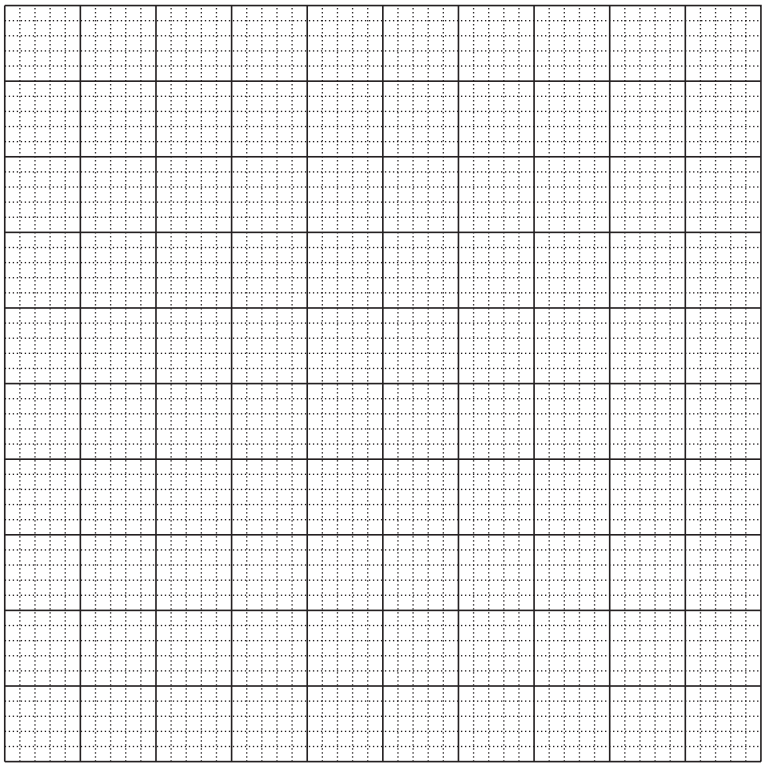
Question 24 (5 marks)

The heats of combustion ($-\Delta H_c$) of three alkanols were determined.

The results are shown in the table.

Alkanol	*Heat of combustion* (kJ mol^{-1})
methanol	480
ethanol	920
butan-1-ol	1800

(a) Plot a graph of the heat of combustion versus the molecular weight for the three alkanols. **3**



Molecular weight

Question 24 continues on page 19

Marks

Question 24 (continued)

(b) (i) Use the graph to estimate the heat of combustion of propan-1-ol. **1**

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(ii) The theoretical value for the heat of combustion of propan-1-ol is more than 2000 kJ mol^{-1}. **1**

Suggest a chemical reason, other than heat loss, for the difference between this value and the estimated value from part (b) (i).

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End of Question 24

Marks

Question 25 (5 marks)

Sodium hydrogen carbonate, $NaHCO_3$, is commonly used to neutralise chemical spills that are a potential hazard to the environment. **5**

Assess the effectiveness of $NaHCO_3$ in this role, with reference to its chemical properties.

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Centre Number

Student Number

Section I – Part B (continued)

Marks

Question 26 (4 marks)

Explain how the structure and properties of polyethylene and polystyrene relate to the way each is used. **4**

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Marks

Question 27 (8 marks)

The diagrams represent equipment used in an investigation to determine the chloride ion concentration in a water sample.

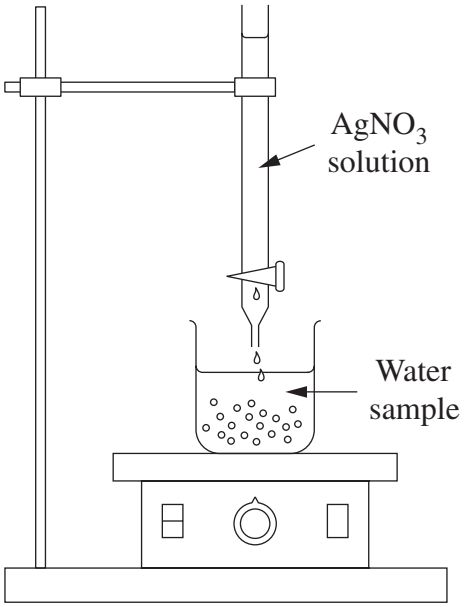

Figure 1

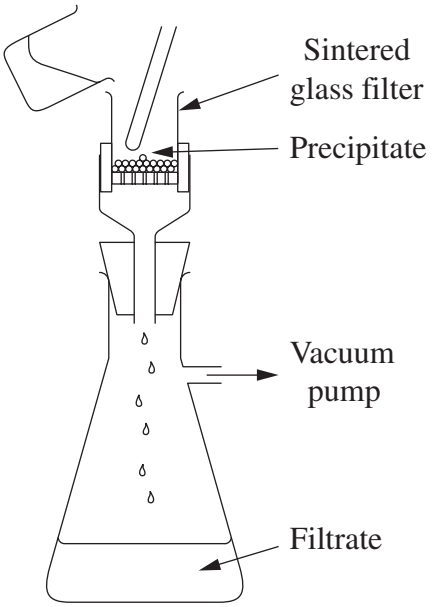

Figure 2

(a) Describe how you could, using the equipment in the diagram, determine the chloride ion concentration in a water sample. Include a balanced equation. **3**

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Question 27 continues on page 23

Marks

Question 27 (continued)

(b) If the volume of the water sample being tested is 50.0 mL and the mass of the dried precipitate obtained is 3.65 g, calculate the chloride ion concentration in the water sample in ppm. **3**

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(c) Why is it important to determine the chloride ion concentration in water? **2**

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End of Question 27

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Chemistry

Section II

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

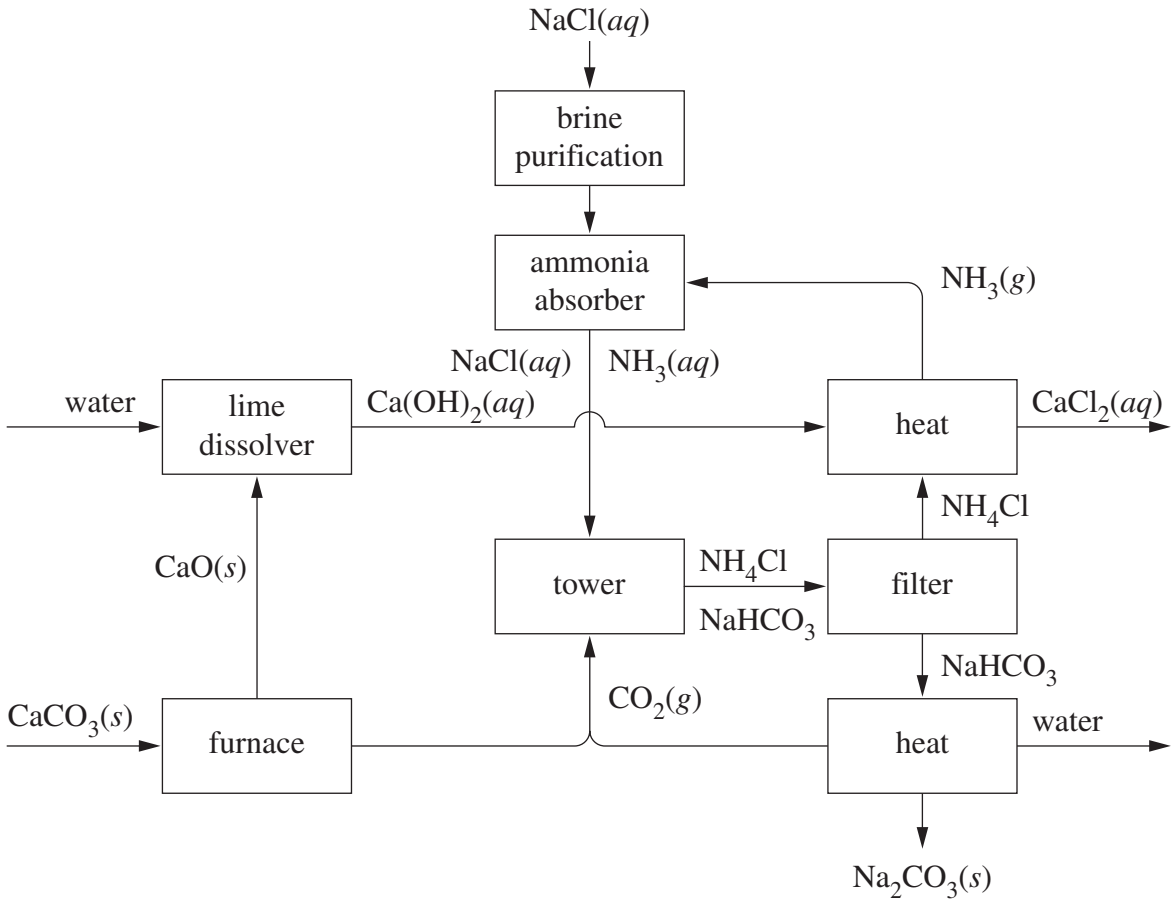
Answer the question in a writing booklet. Extra writing booklets are available.

Show all relevant working in questions involving calculations.

Marks

Question 28 — Industrial Chemistry (25 marks)

(a) The diagram is a flowchart of the reactions involved in an important industrial process.



(i) Identify this industrial process and write a balanced equation to represent the overall chemical reaction that occurs. **2**

(ii) The products of the reaction formed in the tower are sodium hydrogen carbonate and ammonium chloride. **2**

Describe how these two substances are separated.

Question 28 continues on page 27

Question 28 (continued)

(b) Over the past century the production of sodium hydroxide has evolved from the mercury process, to the diaphragm process, to the membrane process. **6**

Analyse the factors that contributed to each of the changes in the production process.

(c) Hydrogen sulfide can be removed from natural gas via the following process.

$$2H_2S(g) + SO_2(g) \rightleftharpoons 3S(s) + 2H_2O(g) \qquad \Delta H = -145 \text{ kJ mol}^{-1}$$

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

(ii) Calculate the equilibrium constant, when 1.00 mol of H_2S and 1.00 mol of SO_2 react in a 1.00 L vessel at 373 K to give 0.50 mol of water vapour under equilibrium conditions. **2**

(iii) Identify FOUR factors that would maximise the removal of $H_2S(g)$ in this reaction. **2**

(d) Describe the impact that saponification products have had on society and the environment. **4**

(e) You performed a first-hand investigation to model an equilibrium reaction.

(i) Outline the procedure used and the results you obtained. **2**

(ii) Identify a risk associated with this procedure. **1**

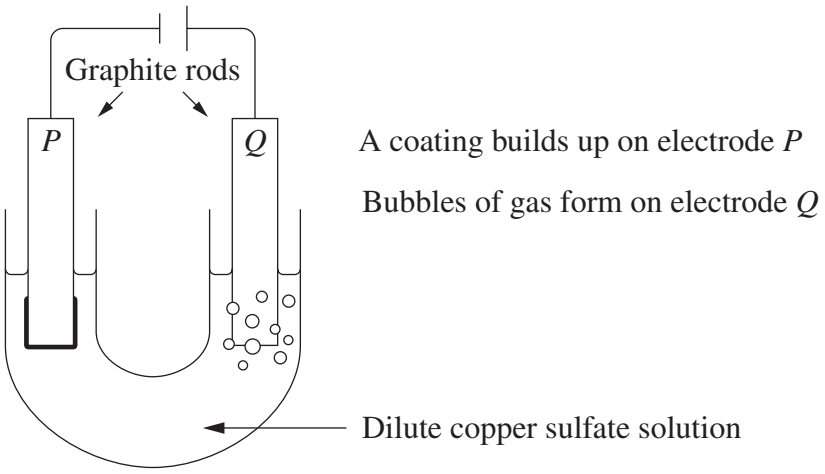
(iii) Describe how this procedure models equilibrium and state a limitation of the model. **3**

End of Question 28

Marks

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

(a) The diagram shows an electrolytic cell.



(i) Explain why graphite rods are used in an electrolytic cell. **2**

(ii) Describe, with the use of half equations, the processes that occur at the anode and cathode. **2**

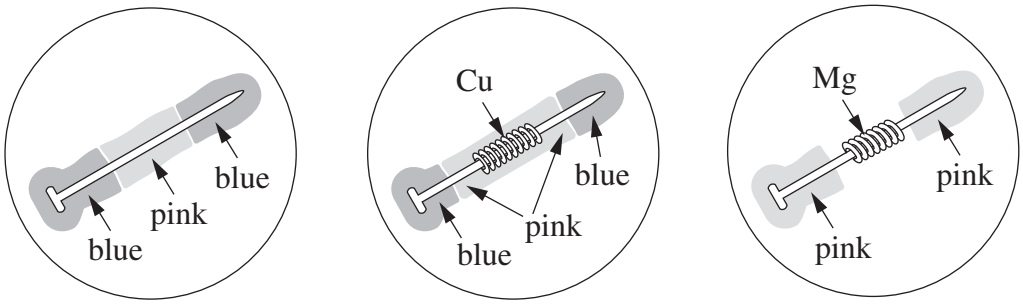
(b) Corrosion is a major problem for vessels that have to operate in a variety of aquatic environments. **6**

Analyse how the factors in aquatic environments have impacted on the choice of metals used in the construction of vessels over time.

Question 29 continues on page 29

Question 29 (continued)

(c) The diagram represents three separate petri dishes each containing a mixture of agar, sodium chloride solution, phenolphthalein and an indicator which turns blue in the presence of Fe^{2+}. Nails are added to each dish.



Dish A
Nail

Dish B
Nail with Cu wire

Dish C
Nail with Mg ribbon

(i) Why does the mixture contain sodium chloride solution? **1**

(ii) Write two half equations to explain the presence of the blue and pink colours in *dish B*. **2**

(iii) In which dish would the nail be protected from corrosion? Explain your answer. **2**

(d) The work of early scientists has increased our understanding of electron transfer reactions. Describe the impact of this work on society. **4**

(e) You performed a first-hand investigation to compare and describe the rate of corrosion of metals in different acidic and neutral solutions.

(i) Outline the procedure used and the results you obtained. **2**

(ii) Identify a risk associated with this procedure. **1**

(iii) Use your results to explain why shipwrecks at great depth experience accelerated corrosion. **3**

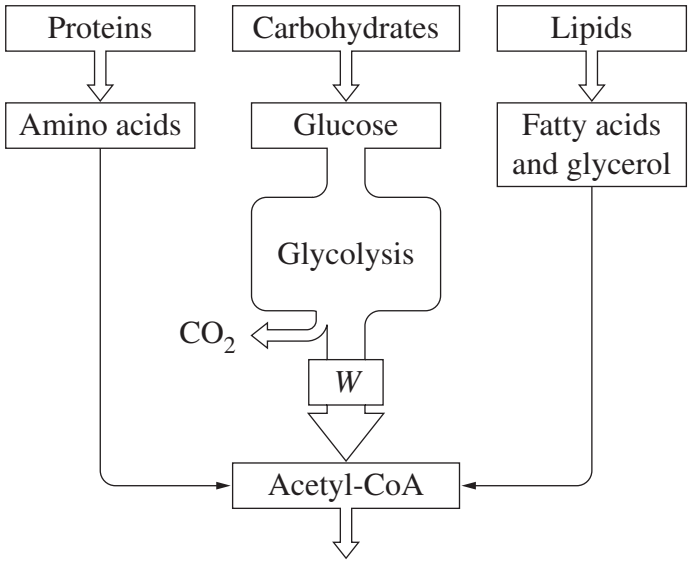
End of Question 29

Marks

Question 30 — The Biochemistry of Movement (25 marks)

The flowchart outlines an important biological process.

(a)



(i) Identify substance *W* and the site where it undergoes oxidation to form acetyl-CoA. **2**

(ii) Identify the form in which energy is captured, and account for the overall number of these molecules produced per glucose molecule during glycolysis. **2**

(b) In the study of chemistry, scientists use models to test and relate ideas. **6**

Analyse how the use of models or diagrams has contributed to our understanding of the structure and chemical features of carbohydrates, fats and proteins.

Question 30 continues on page 31

Question 30 (continued)

(c) (i) State an IUPAC name for the substance with the common name, lactic acid, $C_3H_6O_3$. **1**

(ii) Using structural formulae, write the balanced equation for the formation of lactic acid in anaerobic respiration. **2**

(iii) The production of lactic acid results in a change in cellular pH. **2**

Explain the impact this would have on muscles.

(d) Describe how knowledge of aerobic respiration has increased our understanding of muscle activity during gentle exercise. **4**

(e) You performed a first-hand investigation to observe the effect of changes in pH on the reaction of a named enzyme.

(i) Outline the procedure used and the results you obtained. **2**

(ii) Identify a risk associated with this procedure. **1**

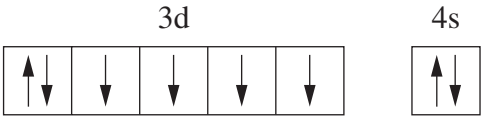
(iii) Enzymes will only function at a specific pH. Explain this in terms of their structure. **3**

End of Question 30

Marks

Question 31 — The Chemistry of Art (25 marks)

(a) The electron spin orbital diagram represents the 3d and 4s electrons for an element in the first transition series.



(i) Identify this element and explain the arrangement of electrons in these sub-shells in terms of the Pauli exclusion principle and Hund's rule. **3**

(ii) This element can form an ion with an oxidation state of +3. In your writing booklet, draw an electron spin orbital diagram to represent this ion. **1**

(b) In the study of chemistry, scientists use models to test and relate ideas. **6**

Analyse the contribution of using Lewis models in the development of our understanding of the structure of complex ions formed by transition metals. Use specific examples in your answer.

(c) Transition elements can have variable oxidation states.

(i) Determine the oxidation state of manganese in MnO_4^- and MnO_2. **1**

(ii) Explain which of these two species would be the stronger oxidising agent. **2**

(iii) Write a half-equation to represent the oxidation of the $Cr^{3+}(aq)$ ion to form the acidified dichromate ion $Cr_2O_7^{2-}(aq)$ and give an example of an oxidising agent that would cause this to happen. **2**

(d) Describe how our understanding of the chemistry of specific pigments used by an ancient culture has influenced our choice of pigments used today. **4**

Question 31 continues on page 33

Marks

Question 31 (continued)

(e) You have performed a first-hand investigation to observe the flame colour of a number of different cations.

(i) Outline the procedure you used to identify the Sr^{2+} ion. **2**

(ii) Identify a risk associated with this procedure. **1**

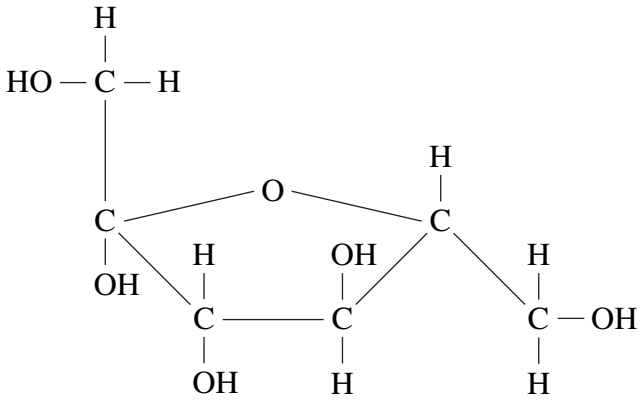
(iii) Explain how the flame colour of the Sr^{2+} ion relates to electron excitation and emission spectra. **3**

End of Question 31

Marks

Question 32 — Forensic Chemistry (25 marks)

(a) The structure represents fructose.



(i) What is the molecular formula for this compound? **1**

(ii) Sucrose is a disaccharide formed from fructose and another monosaccharide. **3**

Identify the other monosaccharide and explain why these two monosaccharides are reducing sugars whereas sucrose is not.

(b) Evaluate the implications of the use of DNA as an identification molecule for society. **6**

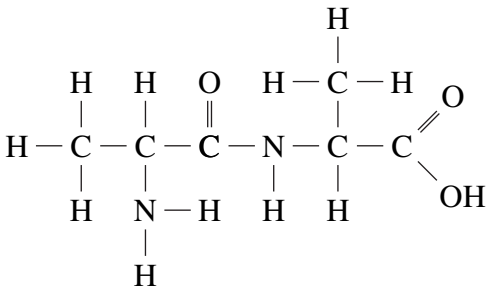
Question 32 continues on page 35

Marks

Question 32 (continued)

(c) (i) What is the general structural formula for an amino acid? **1**

(ii) The structure represents a specific dipeptide. **2**



Using structural formulae, write a balanced equation to show the cleaving of the peptide bond.

(iii) Outline how proteins can be broken into different lengths in the chain. **2**

(d) Describe how the results of some forensic investigations are improved by the use of mass spectrometry. **4**

(e) You performed first-hand investigations to separate mixtures by both chromatography and electrophoresis.

(i) Describe the chromatography procedure you used. **2**

(ii) Identify a risk associated with this procedure. **1**

(iii) Explain how the different properties of mixtures enable them to be separated by chromatography and electrophoresis. **3**

End of paper

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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

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

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

1 H 1.008 Hydrogen																	2 He 4.003 Helium
3 Li 6.941 Lithium	4 Be 9.012 Beryllium											5 B 10.81 Boron	6 C 12.01 Carbon	7 N 14.01 Nitrogen	8 O 16.00 Oxygen	9 F 19.00 Fluorine	10 Ne 20.18 Neon
11 Na 22.99 Sodium	12 Mg 24.31 Magnesium											13 Al 26.98 Aluminium	14 Si 28.09 Silicon	15 P 30.97 Phosphorus	16 S 32.07 Sulfur	17 Cl 35.45 Chlorine	18 Ar 39.95 Argon
19 K 39.10 Potassium	20 Ca 40.08 Calcium	21 Sc 44.96 Scandium	22 Ti 47.87 Titanium	23 V 50.94 Vanadium	24 Cr 52.00 Chromium	25 Mn 54.94 Manganese	26 Fe 55.85 Iron	27 Co 58.93 Cobalt	28 Ni 58.69 Nickel	29 Cu 63.55 Copper	30 Zn 65.41 Zinc	31 Ga 69.72 Gallium	32 Ge 72.64 Germanium	33 As 74.92 Arsenic	34 Se 78.96 Selenium	35 Br 79.90 Bromine	36 Kr 83.80 Krypton
37 Rb 85.47 Rubidium	38 Sr 87.62 Strontium	39 Y 88.91 Yttrium	40 Zr 91.22 Zirconium	41 Nb 92.91 Niobium	42 Mo 95.94 Molybdenum	43 Tc [97.91] Technetium	44 Ru 101.1 Ruthenium	45 Rh 102.9 Rhodium	46 Pd 106.4 Palladium	47 Ag 107.9 Silver	48 Cd 112.4 Cadmium	49 In 114.8 Indium	50 Sn 118.7 Tin	51 Sb 121.8 Antimony	52 Te 127.6 Tellurium	53 I 126.9 Iodine	54 Xe 131.3 Xenon
55 Cs 132.9 Caesium	56 Ba 137.3 Barium	57–71 Lanthanoids	72 Hf 178.5 Hafnium	73 Ta 180.9 Tantalum	74 W 183.8 Tungsten	75 Re 186.2 Rhenium	76 Os 190.2 Osmium	77 Ir 192.2 Iridium	78 Pt 195.1 Platinum	79 Au 197.0 Gold	80 Hg 200.6 Mercury	81 Tl 204.4 Thallium	82 Pb 207.2 Lead	83 Bi 209.0 Bismuth	84 Po [209.0] Polonium	85 At [210.0] Astatine	86 Rn [222.0] Radon
87 Fr [223] Francium	88 Ra [226] Radium	89–103 Actinoids	104 Rf [261] Rutherfordium	105 Db [262] Dubnium	106 Sg [266] Seaborgium	107 Bh [264] Bohrium	108 Hs [277] Hassium	109 Mt [268] Meitnerium	110 Ds [271] Darmstadtium	111 Rg [272] Roentgenium							

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

Lanthanoids

57 La 138.9 Lanthanum	58 Ce 140.1 Cerium	59 Pr 140.9 Praseodymium	60 Nd 144.2 Neodymium	61 Pm [145] Promethium	62 Sm 150.4 Samarium	63 Eu 152.0 Europium	64 Gd 157.3 Gadolinium	65 Tb 158.9 Terbium	66 Dy 162.5 Dysprosium	67 Ho 164.9 Holmium	68 Er 167.3 Erbium	69 Tm 168.9 Thulium	70 Yb 173.0 Ytterbium	71 Lu 175.0 Lutetium

Actinoids

89 Ac [227] Actinium	90 Th 232.0 Thorium	91 Pa 231.0 Protactinium	92 U 238.0 Uranium	93 Np [237] Neptunium	94 Pu [244] Plutonium	95 Am [243] Americium	96 Cm [247] Curium	97 Bk [247] Berkelium	98 Cf [251] Californium	99 Es [252] Einsteinium	100 Fm [257] Fermium	101 Md [258] Mendelevium	102 No [259] Nobelium	103 Lr [262] Lawrencium

For elements that have no stable or long-lived nuclides, the mass number of the nuclide with the longest confirmed half-life is listed between square brackets.

The International Union of Pure and Applied Chemistry Periodic Table of the Elements (October 2005 version) is the principal source of data. Some data may have been modified.