Student Number	
Mark / 24	

Chemistry

HSC Course
Production of Materials
Theory Test • 2002

General Instructions

- Reading time – 5 minutes
- Working time – 40 minutes
- 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 Student Number at the top of this page

Assessment Weighting – 4%

Total Marks – 24

Part A – 4 marks
- Attempt Questions 1 – 4
- Allow about 5 minutes for this part

Part B – 20 marks
- Attempt Questions 5 – 10
- Allow about 35 minutes for this part

Part A – 4 marks
Attempt Questions 1 – 4
Allow about 5 minutes for this part

Select the alternative A, B, C or D that best answers the question. Fill in the response oval completely.

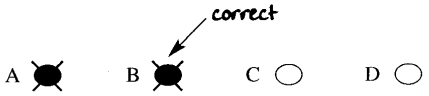
Sample: $2 + 4 =$ (A) 2 (B) 6 (C) 8 (D) 9

A ○ B ● C ○ D ○

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

A ● B ⊗ C ○ D ○

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



Answer Box for Questions 1 – 4

1	**A** ○	**B** ○	**C** ○	**D** ○
2	**A** ○	**B** ○	**C** ○	**D** ○
3	**A** ○	**B** ○	**C** ○	**D** ○
4	**A** ○	**B** ○	**C** ○	**D** ○

Mark your answers for Questions 1 – 4 in the Answer Box on page 1.

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1 Which of the following lists contains only condensation polymers*?*

(A) cellulose, protein, starch
(B) cellulose, polyvinyl chloride, polyethylene
(C) polystyrene, starch, protein
(D) polyvinyl chloride, polyethylene, polystyrene

2 Which of the following defines the term *cracking* used in the petrochemical industry*?*

(A) addition of hydrogen to a compound
(B) preparation of a polymer from a hydrocarbon monomer
(C) formation of saturated hydrocarbons from alkanes
(D) conversion of long chain hydrocarbons to shorter chain molecules

3 A mixture of ethanol and ethylene is heated with concentrated sulfuric acid in a closed container and a reaction occurs. What is the likely outcome*?*

(A) more ethylene forms
(B) more ethanol forms
(C) CO_2 and H_2O form
(D) butane forms

4 In which of the following equations is the species printed in **bold** type being reduced*?*

(A) $3Zn^{2+} + 2\mathbf{Al}_{(s)} \rightarrow 3Zn_{(s)} + 2Al^{3+}$
(B) $2Br^{-} + \mathbf{Cl_2}_{(g)} \rightarrow Br_{2\ (l)} + 2Cl^{-}$
(C) $2H^{+} + \mathbf{Mg}_{(s)} \rightarrow Mg^{2+} + H_{2\ (g)}$
(D) $2H_2O_{(l)} + 3I_2 + 2\mathbf{S_2O_3}^{2-} \rightarrow S_4O_8^{2-} + 4H^{+} + 6I^{-}$

Part B – 20 marks
Attempt Questions 5 – 10
Allow about 35 minutes for this part

Show all relevant working in questions involving calculations.

Question 5 (4 marks)

Three groups of students set out to determine the heat of combustion of the three alkanols… methanol, CH_3OH; ethanol, C_2H_5OH; and 1–propanol, C_3H_7OH.

Each group measured out 100 mL of water into a container and heated the water by burning a measured mass of alcohol. Their results are shown below…

Alcohol burned	Mass of H_2O heated (g)	Temperature rise (°C)	Mass of alcohol burned (g)	Heat of Combustion (kJ mol $^{-1}$)
methanol	100	10	0.185	725
ethanol	100	10	0.142	
1–propanol	100	10	0.125	2016

(a) Given that 4.18 J are required to raise the temperature of 1.00 g of water by 1.00 °C, use the above data to determine the following values…

(i) Heat of combustion of ethanol in kJ g $^{-1}$ **(1 mark)**

_____

_____

_____

_____

(ii) Heat of combustion of ethanol in kJ mol $^{-1}$ **(1 mark)**

_____

_____

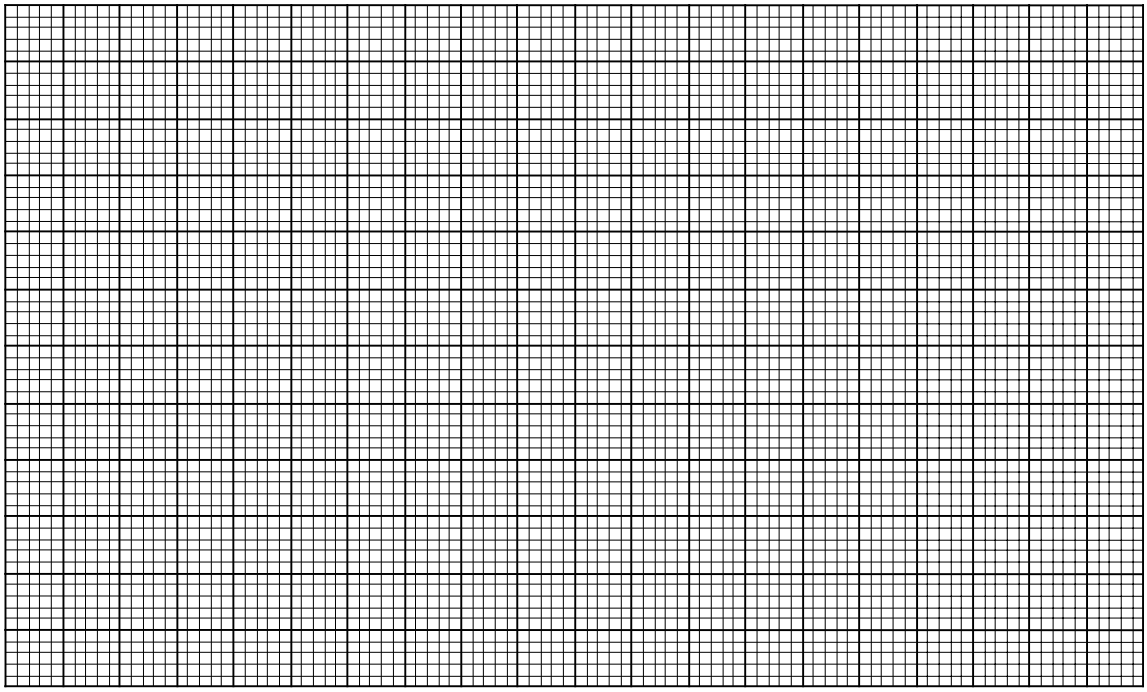
_____

_____

Question 5 continues on page 4

Question 5 (continued)

(b) Plot the heat of combustion (kJ mol^{-1}) against molar mass for all three alkanols. Clearly label the axes. **(1 mark)**



(c) Use the graph to predict the heat of combustion of 1–butanol, C_4H_9OH in kJ mol^{-1}

_____

Question 6 (3 marks)

(a) Give a balanced equation for the conversion of ethylene to ethanol. **(1 mark)**

_____

Question 6 continues on page 5

Question 6 (continued)

(b) Account for ethanol's extensive use as a solvent for polar and non-polar substances. Use a diagram to explain your answer. **(2 marks)**

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Question 7 (3 marks)

An electrochemical cell was constructed using two half-cells. One half-cell consisted of tin metal and a tin(II) chloride solution and the other half-cell consisted of zinc metal and zinc chloride solution**.**

- Draw a diagram of the galvanic cell.
- Label the anode and the cathode.
- Indicate the direction of electron flow.

Question 8 (5 marks)

(a) Explain the term *biopolymer* and identify an example. **(2 marks)**

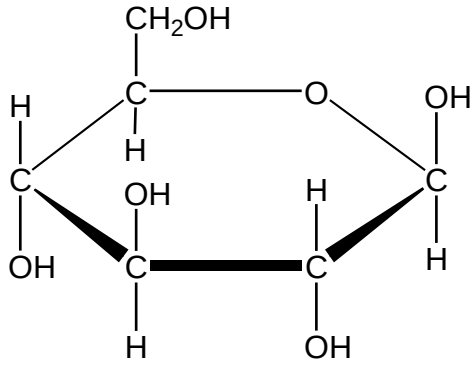
_____

_____

_____

_____

(b) Cellulose is a polymer of β–glucose. A β–glucose molecule is shown below….



Draw a segment of a cellulose molecule by joining three glucose molecules together. **(3 marks)**

Question 9 (2 marks)

A student was asked to perform a first-hand investigation to compare the reactivities of hexane and hexene by observing their reactions with bromine water.

(a) Describe the reaction(s) observed by the student when the procedures were carried out in a darkened laboratory. **(1 mark)**

_____

_____

_____

(b) Write an equation to show any addition reaction(s) that occurred. **(1 mark)**

_____

Question 10 (3 marks)

Alkenes and their derivatives are important substances in the production of polymers.
Polyvinyl chloride (PVC) is one such polymer.

(a) Draw the structure of polyvinyl chloride showing three linked monomer units. **(1 mark)**

_____

(b) Describe **one** use of polyvinyl chloride and a property which makes it useful for this purpose. **(2 marks)**

_____

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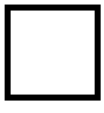


DATA SHEET

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

Volume of 1 mole ideal gas: at 101.3 kPa (1.00 atm) and

at 273 K (0°C) ..... 22.41 L

at 298 K (25°C) ..... 24.47 L

Ionisation constant for water at 298 K (25°C), 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* (4th 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 of element	Au
Atomic Weight	197.0
Name of element	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 65.39 Zinc	31 Ga 69.72 Gallium	32 Ge 72.61 Germanium	33 As 74.92 Arsenic	34 Se 78.96 Selenium	35 Br 79.90 Bromine	36 Kr 83.80 Krypton
37 Rb 85.47 Rubidium	38 Sr 87.62 Strontium	39 Y 88.91 Yttrium	40 Zr 91.22 Zirconium	41 Nb 92.91 Niobium	42 Mo 95.94 Molybdenum	43 Tc [98.91] Technetium	44 Ru 101.1 Ruthenium	45 Rh 102.9 Rhodium	46 Pd 106.4 Palladium	47 Ag 107.9 Silver	48 Cd 112.4 Cadmium	49 In 114.8 Indium	50 Sn 118.7 Tin	51 Sb 121.8 Antimony	52 Te 127.6 Tellurium	53 I 126.9 Iodine	54 Xe 131.3 Xenon
55 Cs 132.9 Caesium	56 Ba 137.3 Barium	57–71 Lanthanides	72 Hf 178.5 Hafnium	73 Ta 180.9 Tantalum	74 W 183.8 Tungsten	75 Re 186.2 Rhenium	76 Os 190.2 Osmium	77 Ir 192.2 Iridium	78 Pt 195.1 Platinum	79 Au 197.0 Gold	80 Hg 200.6 Mercury	81 Tl 204.4 Thallium	82 Pb 207.2 Lead	83 Bi 209.0 Bismuth	84 Po [210.0] Polonium	85 At [210.0] Astatine	86 Rn [222.0] Radon
87 Fr [223.0] Francium	88 Ra [226.0] Radium	89–103 Actinides	104 Rf [261.1] Rutherfordium	105 Db [262.1] Dubnium	106 Sg [263.1] Seaborgium	107 Bh [264.1] Bohrium	108 Hs [265.1] Hassium	109 Mt [268] Meitnerium	110 Uun — Ununnilium	111 Uuu — Unununium	112 Uub — Ununbium	113	114 Uuq — Ununquadium	115	116 Uuh — Ununhexium	117	118 Uuo — Ununoctium

Lanthanides

57 La 138.9 Lanthanum	58 Ce 140.1 Cerium	59 Pr 140.9 Praseodymium	60 Nd 144.2 Neodymium	61 Pm [146.9] Promethium	62 Sm 150.4 Samarium	63 Eu 152.0 Europium	64 Gd 157.3 Gadolinium	65 Tb 158.9 Terbium	66 Dy 162.5 Dysprosium	67 Ho 164.9 Holmium	68 Er 167.3 Erbium	69 Tm 168.9 Thulium	70 Yb 173.0 Ytterbium	71 Lu 175.0 Lutetium

Actinides

89 Ac [227.0] Actinium	90 Th 232.0 Thorium	91 Pa 231.0 Protactinium	92 U 238.0 Uranium	93 Np [237.0] Neptunium	94 Pu [239.1] Plutonium	95 Am [241.1] Americium	96 Cm [244.1] Curium	97 Bk [249.1] Berkelium	98 Cf [252.1] Californium	99 Es [252.1] Einsteinium	100 Fm [257.1] Fermium	101 Md [258.1] Mendelevium	102 No [259.1] Nobelium	103 Lr [262.1] Lawrencium

Where the atomic weight is not known, the relative atomic mass of the most common radioactive isotope is shown in brackets.
The atomic weights of Np and Tc are given for the isotopes ^{237}Np and ^{99}Tc.

Marking Scheme and Outcomes

Chemistry

HSC Course
Production of Materials
Theory Test • 2002

Assessment Weighting – 4%

Total Marks – 24

Working Time – 40 minutes

		OUTCOMES														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
QUESTION	1									•						
	2									•						
	3								•	•						
	4							•						•		
	5							•			•			•		
	6									•						
	7								•	•						
	8									•						
	9								•	•				•		
	10							•	•					•		

Part A – Answer Box for Questions 1 – 4

1	**A** ◎	**B** ○	**C** ○	**D** ○
2	**A** ○	**B** ○	**C** ○	**D** ◎
3	**A** ◎	**B** ○	**C** ○	**D** ○
4	**A** ○	**B** ◎	**C** ○	**D** ○

1 Which of the following lists contains only condensation polymers*?*

(A) cellulose, protein, starch
(B) cellulose, polyvinyl chloride, polyethylene
(C) polystyrene, starch, protein
(D) polyvinyl chloride, polyethylene, polystyrene

2 Which of the following defines the term *cracking* used in the petrochemical industry*?*

(A) addition of hydrogen to a compound
(B) preparation of a polymer from a hydrocarbon monomer
(C) formation of saturated hydrocarbons from alkanes
(D) conversion of long chain hydrocarbons to shorter chain molecules

3 A mixture of ethanol and ethylene is heated with concentrated sulfuric acid in a closed container and a reaction occurs. What is the likely outcome*?*

(A) more ethylene forms
(B) more ethanol forms
(C) CO_2 and H_2O form
(D) butane forms

4 In which of the following equations is the species printed in **bold** type being reduced*?*

(A) $3Zn^{2+} + 2\mathbf{Al}_{(s)} \rightarrow 3Zn_{(s)} + 2Al^{3+}$
(B) $2Br^{-} + \mathbf{Cl_2}_{(g)} \rightarrow Br_{2\,(l)} + 2Cl^{-}$
(C) $2H^{+} + \mathbf{Mg}_{(s)} \rightarrow Mg^{2+} + H_{2\,(g)}$
(D) $2H_2O_{(l)} + 3I_2 + 2\mathbf{S_2O_3}^{2-} \rightarrow S_4O_8^{2-} + 4H^{+} + 6I^{-}$

Part B – 20 marks

Question 5 (4 marks)

Three groups of students set out to determine the heat of combustion of the three alkanols… methanol, CH_3OH; ethanol, C_2H_5OH; and 1–propanol, C_3H_7OH.

Each group measured out 100 mL of water into a container and heated the water by burning a measured mass of alcohol. Their results are shown below…

Alcohol burned	Mass of H_2O heated (g)	Temperature rise (°C)	Mass of alcohol burned (g)	Heat of Combustion (kJ mol^{-1})
methanol	100	10	0.185	725
ethanol	100	10	0.142	
1–propanol	100	10	0.125	2016

(a) Given that 4.18 J are required to raise the temperature of 1.00 g of water by 1.00 °C, use the above data to determine the following values…

(i) Heat of combustion of ethanol in kJ g^{-1} **(1 mark)**

Heat of combustion (kJ/g) = – m C ΔT / mass ethanol
kJ/g = – (100g x 4.18 J/g/°C x 10°C) / 0.142 = **29.4 kJ/g**

(ii) Heat of combustion of ethanol in kJ mol^{-1} **(1 mark)**

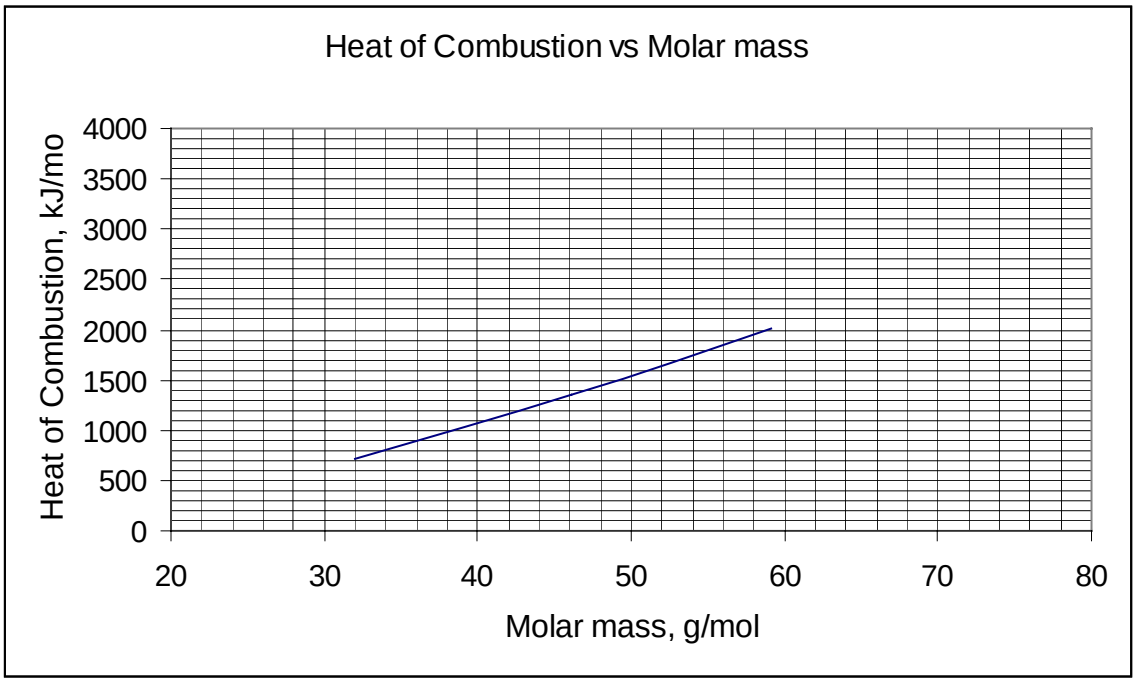
Heat of combustion = – m C ΔT / n
n = # moles of ethanol = (0.142g / 46.068 g/mol) = 3.08 x 10^{-3} mol
kJ/mol = – (100g x 4.18 J/g/°C x 10°C) / 3.08 x 10^{-3} mol = **1360 kJ/mol**

☞ *Heat of combustion is defined as the heat evolved, ∴ in this linguistic context a negative sign is not required, but will be accepted.*

Question 5 continues on page 4

Question 5 (continued)

(b) Plot the heat of combustion (kJ mol $^{-1}$) against molar mass for all three alkanols. Clearly label the axes. **(1 mark)**



(c) Use the graph to predict the heat of combustion of 1–butanol, C_4H_9OH in kJ mol $^{-1}$

Extrapolated value is about **2600 kJ/mol**

Criteria	Marks
Correct calculation of heat of combustion for the units specified	**2**
Graph drawn with the proper values on y - axis	**1**
Correct extrapolated value	**1**

Question 6 (5 marks)

(a) Give a balanced equation for the conversion of ethylene to ethanol including reaction conditions. **(1 mark)**

$$C_2H_4 + H_2O \rightarrow C_2H_5OH$$

Criterion	Mark
Correct equation including heating with catalyst of conc. H_2SO_4 or H_3PO_4	**1**

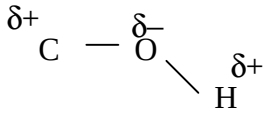
Question 6 continues on page 5

Question 6 (continued)

(b) Account for ethanol's extensive use as a solvent for polar and non-polar substances. Use a diagram to explain your answer. **(2 marks)**

Criterion	Marks
The answer should include a depiction of the molecular structure of ethanol and as a cause of the resulting charge polarization within the molecule to explain its ability to dissolve various types of substances.	**2**

Ethanol has both polar (the – OH) and non-polar,(the C_2H_5 –) parts. The polarity of the hydroxy group is due to the much greater electronegativity of oxygen compared with carbon and hydrogen. The non-polar ethyl group enables ethanol to dissolve non-polar substances such as hexane. Hence, ethanol is able to dissolve both polar and non-polar substances. The partial charges on the polar part of the molecule are…



Question 7

An electrochemical cell was constructed using two half-cells. One half-cell consisted of tin metal and a tin(II) chloride solution and the other half-cell consisted of zinc metal and zinc chloride solution**.**

- Draw a diagram of the galvanic cell.
- Label the anode and the cathode.
- Indicate the direction of electron flow.

Criterion	Marks
Correctly drawn diagram with labels	**2**
Correct direction of electron flow	**1**

Question 8

(a) Explain the term *biopolymer* **(1 mark)** and identify an example **(1 mark)**.

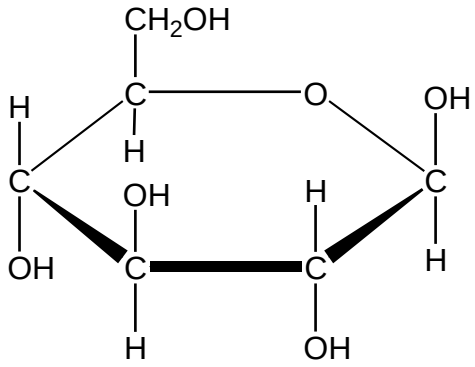
"Biopolymers are polymers that are made totally or in large part by living things." (Smith)
"Naturally occurring polymer generated using renewable resources like microorganisms or plants." (OTEN)
"A natural polymer." (Thickett)
"These are naturally occurring polymers such as cellulose, starch, and gluten..." (Syllabus Notes)

Examples… **cellulose, starch, protein, rubber, carboxymethyl cellulose (CMC), PLA, PHA or PHB (poly ß–hydroxyalkanoate), etc.**

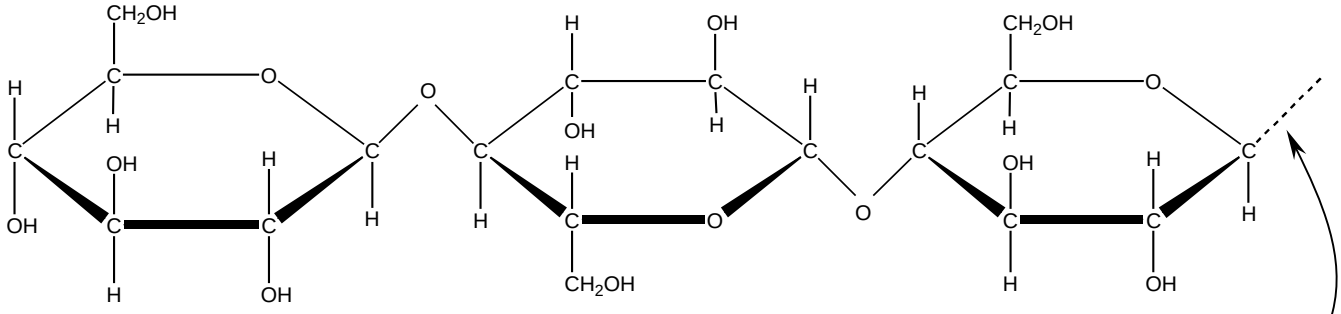
Question 8 continues on page 6

Question 8 (continued)

(b) Cellulose is a polymer of β–glucose. A β–glucose molecule is shown below….



Draw a segment of a cellulose molecule by joining three glucose molecules together. **(3 marks)**



One mark for showing three glucoses joined via the – O – linkage with suitable termination, e.g.

One mark for showing one – O – linkage up and one down.

One mark for showing the three – CH_2OH groups alternately up, down, up.

Question 9 (2 marks)

A student was asked to perform a first-hand investigation to compare the reactivities of hexane and hexene by observing their reactions with bromine water.

(a) Describe the reaction(s) observed by the student when the procedures were carried out in a darkened laboratory. **(1 mark)**

The hexene immediately decolourised the bromine water.

(b) Write an equation to show any addition reaction(s) that occurred. **(1 mark)**

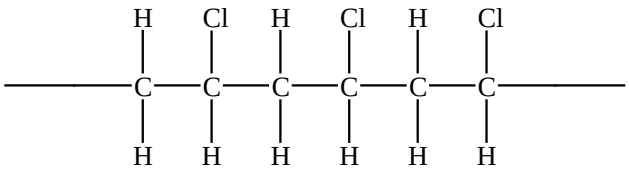
$CH_3CH_2CH_2CH_2CH = CH_2 \quad + \quad Br_{2\ (aq)} \quad \rightarrow CH_3CH_2CH_2CH_2CHBrCH_2Br$

☞ Production of bromohydroxyhexane is also acceptable.

Question 10 (3 marks)

Alkenes and their derivatives are important substances in the production of polymers.
Polyvinyl chloride (PVC) is one such polymer.

(a) Draw the structure of polyvinyl chloride showing three linked monomer units. **(1 mark)**



(b) Describe **one** use of polyvinyl chloride and a property which makes it useful for this purpose. **(2 marks)**

e.g. PVC can be used to make electrical conduit because it is an electrical insulator.
The presence of Cl atoms in the polymer make it flame resistant.

e.g. PVC is used for credit cards because it is a tough, rigid polymer.

Must relate property to usage for **two marks**.
Usage without related property gains **one mark**.
Property without specific use gains **one mark**.