Student Number	
Mark / 28	

Chemistry

Production of Materials

Theory Test • 2004

General Instructions

- Reading time – 5 minutes
- Working time – 45 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 and may be removed for convenience
- Write your Student Number at the top of this page

Total Marks – 28

Part A – 8 marks
- Attempt Questions 1 – 8
- Allow about 15 minutes for this part

Part B – 20 marks
- Attempt Questions 9 – 12
- Allow about 30 minutes for this part

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Part A – 8 marks
Attempt Questions 1–8
Allow about 15 minutes for this part

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

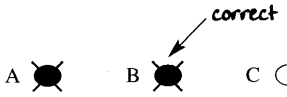
Sample: $2 + 4 =$ (A) 2 (B) 6 (C) 8 (D) 9

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 – 8				
1	A ○	B ○	C ○	D ○
2	A ○	B ○	C ○	D ○
3	A ○	B ○	C ○	D ○
4	A ○	B ○	C ○	D ○
5	A ○	B ○	C ○	D ○
6	A ○	B ○	C ○	D ○
7	A ○	B ○	C ○	D ○
8	A ○	B ○	C ○	D ○

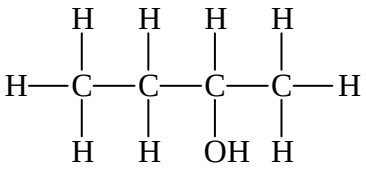
► ***Mark your answers for Questions 1 – 8 in the Answer Box on page 3.***

---

1 Which of these statements describes the flow of electrons in a galvanic cell*?*

(A) Electrons flow from the anode to the cathode.
(B) Electrons flow from the cathode to the anode.
(C) Electrons flow through the electrolyte solutions.
(D) Electrons flow through the salt bridge between the anode and the cathode.

2 What is the IUPAC name for the compound shown below*?*



(A) 2–hydroxybutane
(B) 2–hydroxybutanol
(C) 2–butanol
(D) 1–methyl–1–propanol

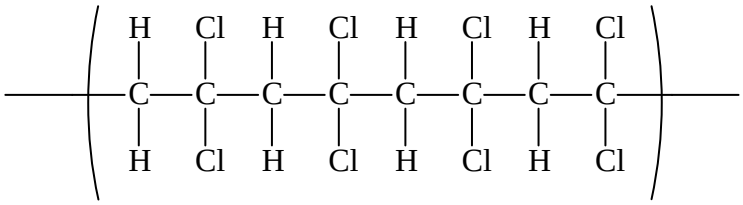
3 Ethanol has good solubility in octane. Which statement best explains this fact*?*

(A) Ethanol and octane are non–polar molecules.
(B) Ethanol and octane are highly volatile.
(C) Ethanol and octane both have an even number of carbon atoms.
(D) Ethanol's ethyl group aids its solubility in octane.

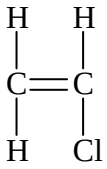
4 Which of the following is the industrial source of ethylene*?*

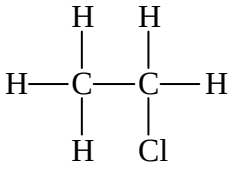
(A) cracking of alkanes
(B) dehydration of ethanol
(C) recycling of polyethylene
(D) fractional distillation of crude oil

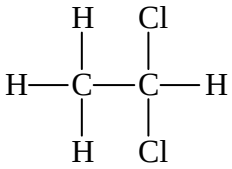
5 ***Saran***™ food wrap is made of an addition polymer processed into a thin, flexible cling film. A segment of the polymer molecule has the structure of…

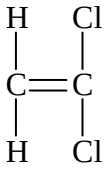


Which of the following is the structure of the monomer?

(A) 

(B) 

(C) 

(D) 

6 Assuming no heat loss, what mass of ethanol must be burned to increase the temperature of 250 g of water from 25°C to 95°C, given that the heat of combustion of ethanol is 1409 kJ mol^{-1}?

(A) 0.86 g
(B) 2.4 g
(C) 4.8 g
(D) 0.86 kg

7 Which equation shows the production of ethanol from ethylene?

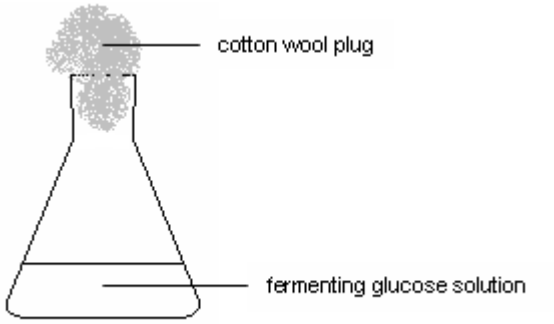
(A) $C_2H_4 + H_2O \xrightarrow{\text{yeast}} C_2H_5OH$

(B) $C_2H_4 + H_2O \xrightarrow{\text{dilute } H_2SO_4} C_2H_5OH$

(C) $C_2H_4 + H_2O \xrightarrow{\text{zeolite}} C_2H_5OH$

(D) $C_2H_4 + HOCl \xrightarrow{\text{dilute NaOH}} C_2H_5OH$

8 Boris fermented a dilute solution of glucose for one week and then analysed the contents of the fermentation vessel as shown below.
Which trend describes the changes in mass during the week of fermentation?



	MASS OF…			
	CO_2 produced	**C_2H_5OH produced**	**$C_6H_{12}O_6$**	**Fermentation flask**
(A)	increased	increased	decreased	increased
(B)	decreased	increased	increased	increased
(C)	increased	decreased	decreased	decreased
(D)	increased	increased	decreased	decreased

Part B – 20 marks
Attempt Questions 9 – 12
Allow about 30 minutes for this part

► ***Show all relevant working in questions involving calculations.***

Question 9 (5 marks)

Charlotte performs a first–hand investigation involving a galvanic cell constructed from these materials…

copper metal, 1 mol L^{-1} copper(II) sulfate, lead metal, 1 mol L^{-1} lead(II) nitrate, and saturated $KNO_{3\,(aq)}$

(a) Identify a hazardous risk in this experiment. **(1 mark)**

_____

(b) Identify the anode. **(1 mark)**

_____

(c) Describe the role of the salt bridge containing saturated KNO_3 solution? **(1 mark)**

_____

_____

(d) Charlotte lets the cell run continuously for a week. Describe TWO changes which would have occurred in the cell after one week. **(2 marks)**

_____

_____

_____

Question 10 (5 marks)

Draw a labelled diagram of the structure of EITHER a dry cell or a lead–acid cell and write the oxidation and reduction half reactions occurring in the cell.

Question 11 (5 marks)

Assess the potential of ethanol as an alternative to octane (petrol) as a car fuel.

Question 12 (5 marks)

(a) Identify a named biopolymer and the name of the specific organism or enzyme(s) used in its production. **(2 marks)**

_____

(b) Describe ONE use of the biopolymer in (a) and describe how this use (or potential use) relates to TWO properties of the biopolymer. **(3 marks)**

_____

_____

_____

_____

_____

_____

_____

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
Atomic Weight
79 Au 197.0 Gold
Symbol of element
Name of element

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 Answers

Chemistry

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A ○ B ● C ○ D ○

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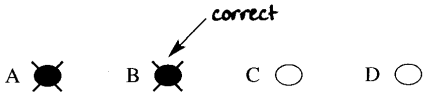

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---

1 Which of these statements describes the flow of electrons in a galvanic cell?

(A) Electrons flow from the anode to the cathode.
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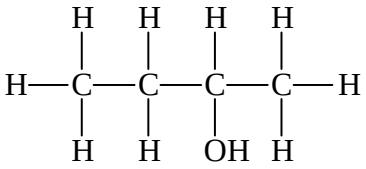

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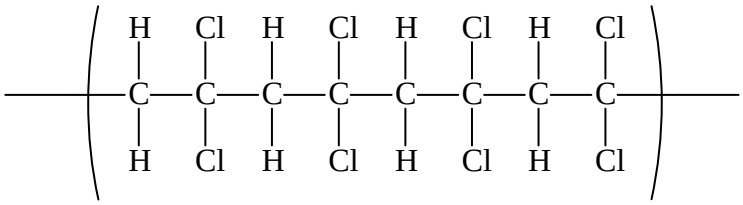

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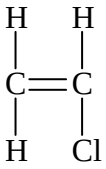
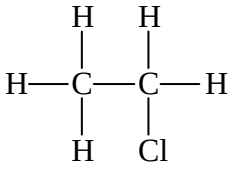
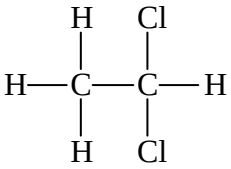
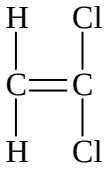
(A) 

(B) 

(C) 

(D) 

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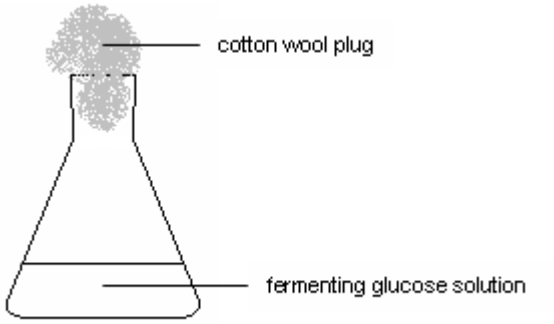


	MASS OF…			
	CO_2 produced	**C_2H_5OH produced**	**$C_6H_{12}O_6$**	**Fermentation flask**
(A)	increased	increased	decreased	increased
(B)	decreased	increased	increased	increased
(C)	increased	decreased	decreased	decreased
(D)	increased	increased	decreased	decreased

Part B – 20 marks
Attempt Questions 9 – 12
Allow about 30 minutes for this part

► ***Show all relevant working in questions involving calculations.***

Question 9 (5 marks)

Charlotte performs a first–hand investigation involving a galvanic cell constructed from these materials…

copper metal, 1 mol L^{-1} copper(II) sulfate, lead metal, 1 mol L^{-1} lead(II) nitrate, and saturated $KNO_{3\,(aq)}$

(a) Identify a hazardous risk in this experiment. **(1 mark)**

Lead(II) nitrate is toxic.

(b) Identify the anode. **(1 mark)**

Lead

(c) Describe the role of the salt bridge containing saturated KNO_3 solution? **(1 mark)**

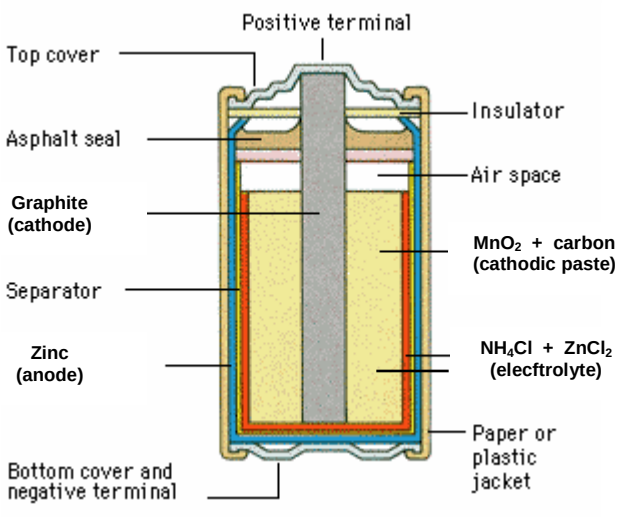
The salt bridge completes the cell circuit.
The salt bridge allows for ion migration between the anode and cathode compartments.
The salt bridge maintains electrical charge neutrality in the anode and cathode compartments.

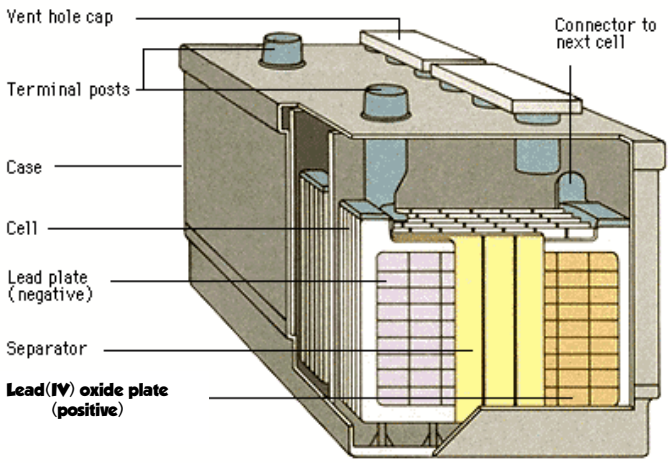
(d) Charlotte lets the cell run continuously for a week. Describe TWO changes which would have occurred in the cell after one week. **(2 marks)**

The lead electrode becomes smaller/loses mass.
The lead(II) nitrate solution becomes more concentrated.
The copper electrode develops a coating (deposit) of copper/gains mass.
The copper(II) sulfate solution becomes less blue/less concentrated.
The cell voltage decreases.

Question 10 (4 marks)

Draw a labelled diagram of the structure of EITHER a dry cell or a lead–acid cell and write the oxidation and reduction half reactions occurring in the cell.





Dry Cell diagram should show…

- Anode 'can' of zinc. (1 mark).
- Central cathode of carbon rod surrounded by a cathodic paste of MnO_2 and carbon. (1 mark)
- Electrolyte of NH_4Cl and $ZnCl_2$ at the porous separator between the zinc and the cathodic paste and mixed into the cathodic paste also. (1 mark)
- Oxidation reaction… $Zn_{(s)} \rightarrow Zn^{2+}_{(aq)} + 2e^-$ (1 mark)
- Reduction reaction… $2MnO_{2\,(s)} + 2NH_4^+{}_{(aq)} + 2H_2O_{(l)} + 2e^- \rightarrow 2NH_{3\,(aq)} + 2Mn(OH)_{3\,(s)}$ (1 mark)

  $2MnO_{2\,(s)} + 2NH_4^+{}_{(aq)} + 2e^- \rightarrow Mn_2O_{3\,(s)} + 2NH_{3\,(g)} + H_2O_{(l)}$

Lead–Acid Cell diagram should show…

- Anode plate of lead. (1 mark)
- Cathode plate of PbO_2 (1 mark)
- Electrolyte of 35% H_2SO_4 (1 mark)
- Oxidation reaction… $Pb_{(s)} + SO_4^{2-} \rightarrow PbSO_{4\,(s)} + 2e^-$ (1 mark)
- Reduction reaction… $PbO_{2\,(s)} + SO_4^{2-}{}_{(aq)} + 4H^+ + 2e^- \rightarrow PbSO_{4\,(s)} + 2H_2O_{(l)}$ (1 mark)

Question 11 (5 marks)

Assess the potential of ethanol as an alternative to octane (petrol) as a car fuel.

Sample Answer

Ethanol is a renewable resource while octane is a non-renewable resource. The production and use of ethanol is carbon dioxide neutral, while petrol adds carbon dioxide to the atmosphere. Ethanol is a high octane fuel. Unlike petrol, ethanol burns cleanly and hence does not release large amounts of pollutants such as CO and aromatic hydrocarbons such as benzopyrene As a petrol additive, it enhances the combustion of petrol. However, its production from biomass can require almost as much energy as what is obtainable from it when completely combusted. Also, being more oxygenated than petrol, it releases less energy per mole and per gram than petrol. Therefore, to obtain an equivalent amount of mileage from ethanol, more ethanol must be burnt. This requires a bigger fuel tank. The use of greater than 20% ethanol with petrol also necessitates car engine modification. There is also the problem of environmental pollution caused by the release of large quantities of fermentation liquor, soil degradation and soil erosion if vast quantities of agricultural land are devoted to crops for ethanol production.

Overall, if the production of ethanol can be made less energy demanding, such as the use of novel strains of bacteria for a more efficient fermentation, solar powered distillation units and the use of scraps and waste as raw materials, then ethanol has a very promising potential as a car fuel.

Marking Guidelines

1 – 3 Advantages cited = 1 – 3 marks
1 – 3 Disadvantages cited = 1 – 3 marks ► ***At least one disadvantage must be given.***
Judgement = 1 mark

Question 12 (5 marks)

(a) Identify a named biopolymer and the name of the specific organism or enzyme(s) used in its production. **(2 marks)**

Biopolymer name: Biopol or poly–3–hydroxybutyrate–polyhydroxy–3–valerate or poly(β–hydroxybutanoate), cellulose, cellulose nitrate, etc. (1 mark)

► Can be a modified natural biopolymer, e.g. rayon

Name of specific organism or enzyme(s) used in the production of the named biopolymer. (1 mark)

e.g. *Alcaligenes eutrophus* or bacteria. ► *Spelling errors ignored.*

(b) Describe ONE use of the biopolymer in (a) and describe how this use (or potential use) relates to TWO properties of the biopolymer. **(3 marks)**

Use of biopolymer. (1 mark)

Use of biopolymer related to two properties of the biopolymer. (2 marks)

e.g. Biopol is used in the manufacture of shampoo bottles.

Properties related to use: Biopol is flexible, biodegradable, waterproof.

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 — Symbol of element — Atomic Weight — Name of element

Example: 79 Au 197.0 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.