

Marking Scheme and Answers

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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Allow about 15 minutes for this part

A  B  C  D 

correct (arrow pointing to B)

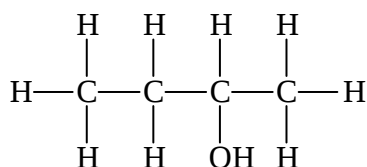
Answer Box for Questions 1 - 8				
1	☒ A	☐ B	☐ C	☐ D
2	☐ A	☐ B	☒ C	☐ D
3	☐ A	☐ B	☐ C	☒ D
4	☒ A	☐ B	☐ C	☐ D
5	☐ A	☐ B	☐ C	☒ D
6	☐ A	☒ B	☐ C	☐ D
7	☐ A	☒ B	☐ C	☐ D
8	☐ A	☐ B	☐ C	☒ D

► 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

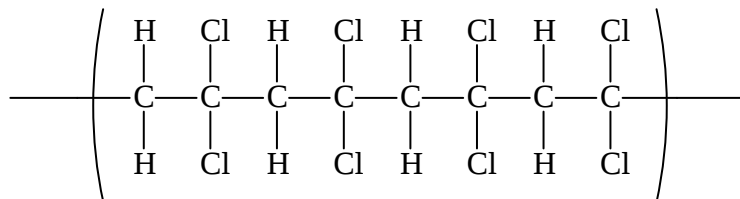
3 Ethanol has good solubility in octane. Which statement best explains this fact?

- (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.

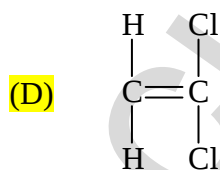
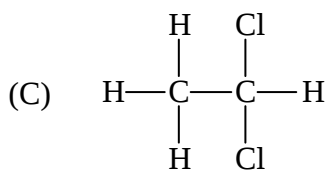
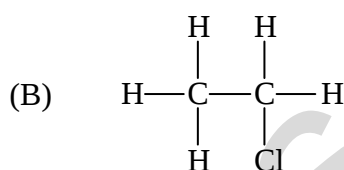
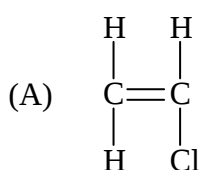
4 Which of the following is the industrial source of ethylene?

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

- 5 **Saran**TM 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...



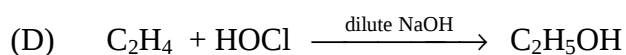
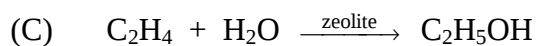
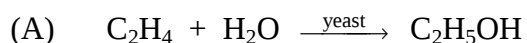
Which of the following is the structure of the monomer?



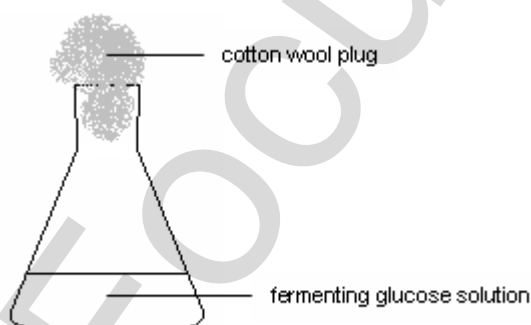
- 6 Assuming no heat loss, what mass of ethanol must be burned to increase the temperature of 250 g of water from 25°C to 95°C, given that the heat of combustion of ethanol is 1409 kJ mol⁻¹?

- (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?



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	$\text{C}_2\text{H}_5\text{OH}$ produced	$\text{C}_6\text{H}_{12}\text{O}_6$	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 KNO₃ (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 KNO₃ 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.

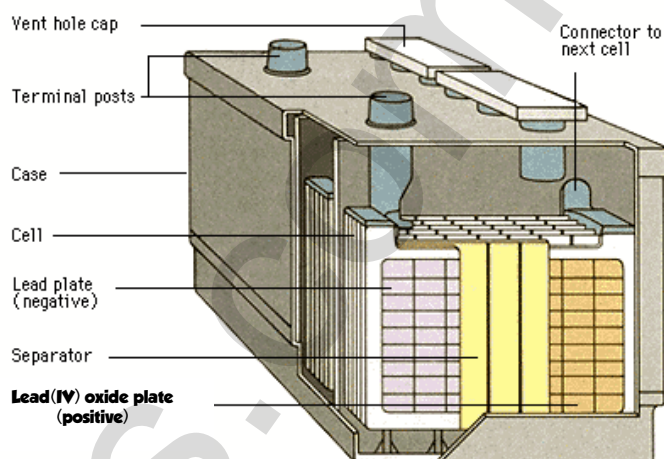
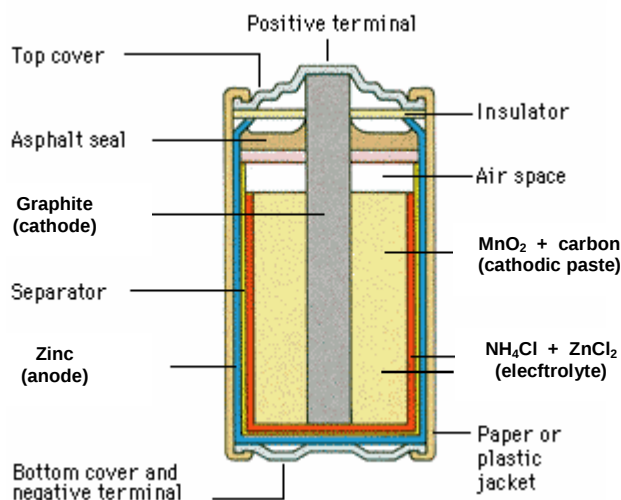
The copper electrode develops a coating (deposit) of copper/gains mass.

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... $\text{Zn}_{(s)} \rightarrow \text{Zn}^{2+}_{(aq)} + 2e^-$ (1 mark)
- Reduction reaction... $2\text{MnO}_{2(s)} + 2\text{NH}_4^+_{(aq)} + 2\text{H}_2\text{O}_{(l)} + 2e^- \rightarrow 2\text{NH}_{3(aq)} + 2\text{Mn}(\text{OH})_{3(s)}$ (1 mark)
 $2\text{MnO}_{2(s)} + 2\text{NH}_4^+_{(aq)} + 2e^- \rightarrow \text{Mn}_2\text{O}_{3(s)} + 2\text{NH}_{3(g)} + \text{H}_2\text{O}_{(l)}$

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... $\text{Pb}_{(s)} + \text{SO}_4^{2-} \rightarrow \text{PbSO}_{4(s)} + 2e^-$ (1 mark)
- Reduction reaction... $\text{PbO}_{2(s)} + \text{SO}_4^{2-}_{(aq)} + 4\text{H}^+ + 2e^- \rightarrow \text{PbSO}_{4(s)} + 2\text{H}_2\text{O}_{(l)}$ (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.

HIGHER SCHOOL CERTIFICATE EXAMINATION
Chemistry

DATA SHEET

Avogadro constant, N_A	$6.022 \times 10^{23} \text{ mol}^{-1}$
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	$4.18 \times 10^3 \text{ J kg}^{-1} \text{ K}^{-1}$

Some useful formulae

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

Some standard potentials

$\text{K}^+ + \text{e}^-$	$\rightleftharpoons$	K(s)	-2.94 V
$\text{Ba}^{2+} + 2\text{e}^-$	$\rightleftharpoons$	Ba(s)	-2.91 V
$\text{Ca}^{2+} + 2\text{e}^-$	$\rightleftharpoons$	Ca(s)	-2.87 V
$\text{Na}^+ + \text{e}^-$	$\rightleftharpoons$	Na(s)	-2.71 V
$\text{Mg}^{2+} + 2\text{e}^-$	$\rightleftharpoons$	Mg(s)	-2.36 V
$\text{Al}^{3+} + 3\text{e}^-$	$\rightleftharpoons$	Al(s)	-1.68 V
$\text{Mn}^{2+} + 2\text{e}^-$	$\rightleftharpoons$	Mn(s)	-1.18 V
$\text{H}_2\text{O} + \text{e}^-$	$\rightleftharpoons$	$\frac{1}{2}\text{H}_2(\text{g}) + \text{OH}^-$	-0.83 V
$\text{Zn}^{2+} + 2\text{e}^-$	$\rightleftharpoons$	Zn(s)	-0.76 V
$\text{Fe}^{2+} + 2\text{e}^-$	$\rightleftharpoons$	Fe(s)	-0.44 V
$\text{Ni}^{2+} + 2\text{e}^-$	$\rightleftharpoons$	Ni(s)	-0.24 V
$\text{Sn}^{2+} + 2\text{e}^-$	$\rightleftharpoons$	Sn(s)	-0.14 V
$\text{Pb}^{2+} + 2\text{e}^-$	$\rightleftharpoons$	Pb(s)	-0.13 V
$\text{H}^+ + \text{e}^-$	$\rightleftharpoons$	$\frac{1}{2}\text{H}_2(\text{g})$	0.00 V
$\text{SO}_4^{2-} + 4\text{H}^+ + 2\text{e}^-$	$\rightleftharpoons$	$\text{SO}_2(\text{aq}) + 2\text{H}_2\text{O}$	0.16 V
$\text{Cu}^{2+} + 2\text{e}^-$	$\rightleftharpoons$	Cu(s)	0.34 V
$\frac{1}{2}\text{O}_2(\text{g}) + \text{H}_2\text{O} + 2\text{e}^-$	$\rightleftharpoons$	2OH^-	0.40 V
$\text{Cu}^+ + \text{e}^-$	$\rightleftharpoons$	Cu(s)	0.52 V
$\frac{1}{2}\text{I}_2(\text{s}) + \text{e}^-$	$\rightleftharpoons$	I^-	0.54 V
$\frac{1}{2}\text{I}_2(\text{aq}) + \text{e}^-$	$\rightleftharpoons$	I^-	0.62 V
$\text{Fe}^{3+} + \text{e}^-$	$\rightleftharpoons$	Fe^{2+}	0.77 V
$\text{Ag}^+ + \text{e}^-$	$\rightleftharpoons$	Ag(s)	0.80 V
$\frac{1}{2}\text{Br}_2(\text{l}) + \text{e}^-$	$\rightleftharpoons$	Br^-	1.08 V
$\frac{1}{2}\text{Br}_2(\text{aq}) + \text{e}^-$	$\rightleftharpoons$	Br^-	1.10 V
$\frac{1}{2}\text{O}_2(\text{g}) + 2\text{H}^+ + 2\text{e}^-$	$\rightleftharpoons$	H_2O	1.23 V
$\frac{1}{2}\text{Cl}_2(\text{g}) + \text{e}^-$	$\rightleftharpoons$	Cl^-	1.36 V
$\frac{1}{2}\text{Cr}_2\text{O}_7^{2-} + 7\text{H}^+ + 3\text{e}^-$	$\rightleftharpoons$	$\text{Cr}^{3+} + \frac{7}{2}\text{H}_2\text{O}$	1.36 V
$\frac{1}{2}\text{Cl}_2(\text{aq}) + \text{e}^-$	$\rightleftharpoons$	Cl^-	1.40 V
$\text{MnO}_4^- + 8\text{H}^+ + 5\text{e}^-$	$\rightleftharpoons$	$\text{Mn}^{2+} + 4\text{H}_2\text{O}$	1.51 V
$\frac{1}{2}\text{F}_2(\text{g}) + \text{e}^-$	$\rightleftharpoons$	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.

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

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

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

h 12 – PoM