CRANBROOK SCHOOL

Student Number

2014
YEAR 12 MID-YEAR EXAMINATION

Chemistry

General Instructions

- Reading time – 5 minutes
- Working time – 2 hours
- Write using black or blue pen
- Draw diagrams using pencil
- Board-approved calculators may be used
- Use the Data Sheet and Periodic Table provided
- Use the Multiple-Choice Answer Sheet provided
- Write your Centre Number and Student Number at the top of this page, the Multiple-Choice Answer Sheet, and on the booklet for Section II.
- **Section II** is answered in the booklet.

Total marks – 67

This paper has two Sections, Section I and Section II

Section I (57 marks)

Part A – 20 marks
- Attempt Questions 1-20
- Allow about 35 minutes for this part

Part B – 37 marks
- Attempt Questions 21-31
- Allow about 1 hour and 10 minutes for this part

Section II (10 marks)
- Attempt Question 32 in a booklet
- Allow about 15 minutes for this part

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2014 YEAR 12 MID-YEAR EXAMINATION
CHEMISTRY

Part A – 20 marks
Attempt Questions 1-20
Allow about 35 minutes for this part

Use the multiple-choice answer sheet provided for Questions 1-20

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.

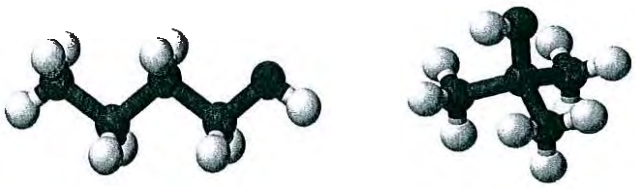
A ● B ⊗ C ○ D ○

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

correct

A ⊗ B ⊗ ← C ○ D ○

1 The models represent compounds of carbon, hydrogen and oxygen.



These compounds can be described as

(A) isomers.

(B) alkanols.

(C) polar.

(D) all of the above.

2 The compound formed when bromine water reacts with hex-2-ene is

(A) 2-bromohexane.

(B) 2,3-dibromohexane.

(C) 3-bromohexane.

(D) 1,2-dibromohexane.

3 The concentration of ozone in the atmosphere above Antarctica has been closely monitored over the last twenty years. At times, measurements have shown a 'hole' that has developed in the ozone layer.
The reason that this 'ozone hole' is cause for serious concern is that it :

(A) Allows oxygen to leak from the stratosphere.

(B) Means that humans will be exposed to more HCFCs.

(C) Increases the greenhouse effect and hence the Earth's temperature.

(D) Exposes humans to increased levels of harmful ultraviolet radiation.

4 Which two ions might cause eutrophication of waterways ?

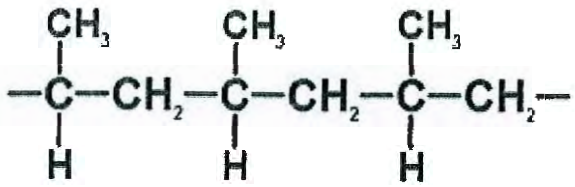
(A) H^+ and OH^-.

(B) NO_3^- and PO_4^{3-}.

(C) Ca^{2+} and Mg^{2+}.

(D) Na^+ and Cl^-.

5 A hydrocarbon undergoes addition polymerisation to form the polymer shown below.



The hydrocarbon is

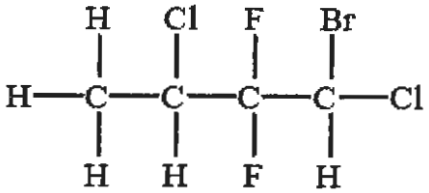
(A) ethylene.

(B) propane.

(C) propene.

(D) 1-methylethane.

6. Consider the structural formula shown below.



Which of the following is the **systematic name** for this compound?

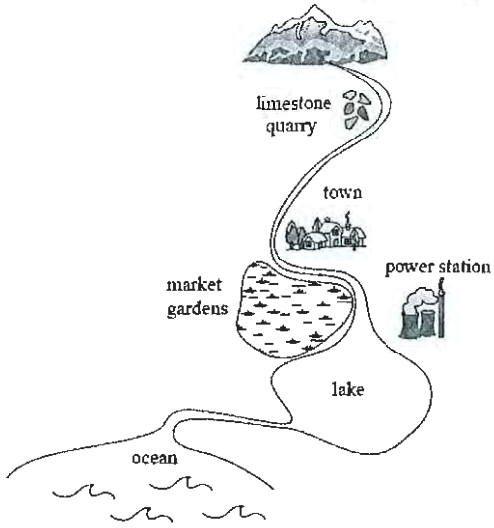
(A) 1-bromo-1,3-dichloro-2,2-difluorobutane.

(B) 2,4-dichloro-4-bromo-3,3-difluorobutane.

(C) 1,3-dichloro-1-bromo-2,2-difluorobutane.

(D) 1-chlorobromo-2-difluoro-3-chlorobutane.

7 Tests reveal that the water in the lake shown in the diagram below is 'hard' water.



Which is the most likely source of contaminants that would cause this problem?

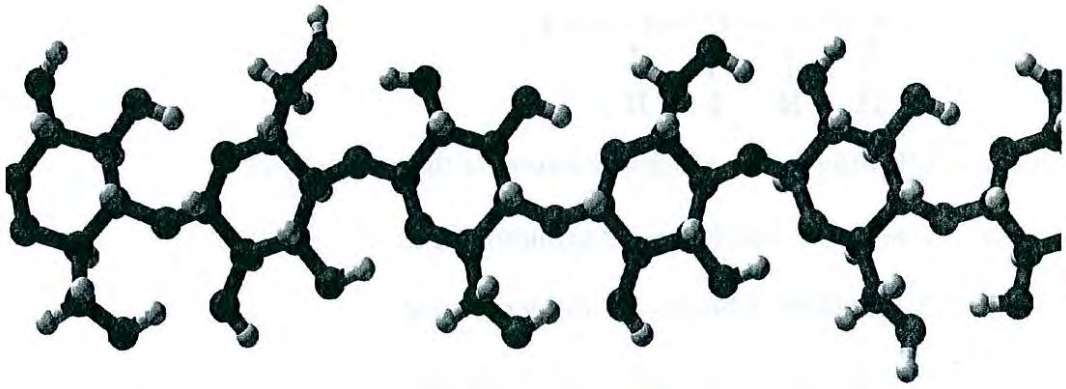
(A) town.

(B) Power station.

(C) Market gardens.

(D) Limestone quarry.

8 A model of a compound consisting of carbon, hydrogen and oxygen atoms is shown.



Which of the following statements relating to the compound is INCORRECT?

(A) The compound is formed by a condensation reaction of glucose.

(B) The compound dissolves readily in water.

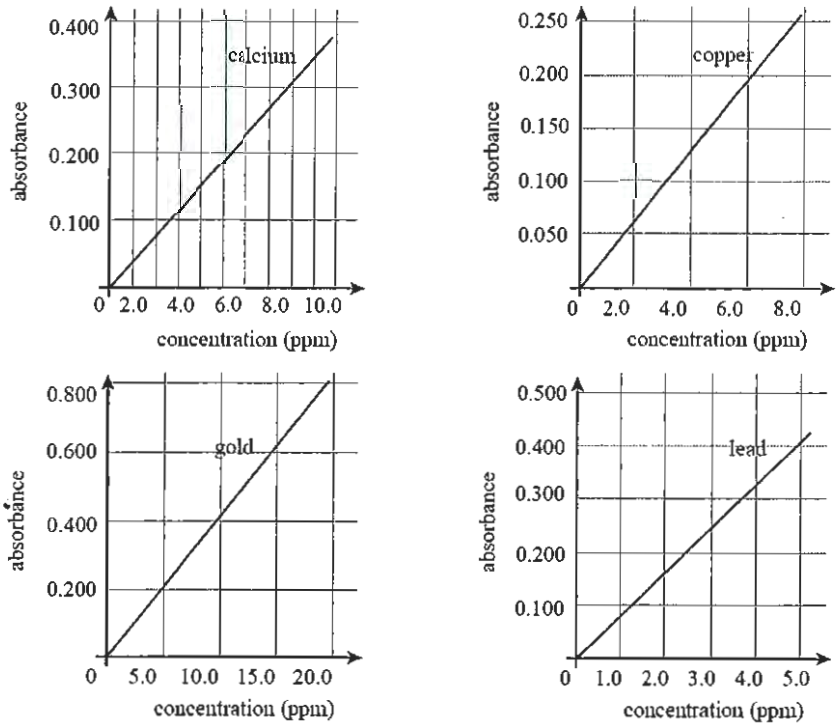
(C) The compound is an important example of biomass.

(D) The compound can be fermented in acidic conditions, using suitable enzymes, to form ethanol.

9 The wavelengths recommended for some elements, whose concentrations were to be measured using atomic absorption spectroscopy, are shown in the table below.

Element	*Recommended wavelength (nm)*
Calcium	422.7
Copper	324.8
Gold	242.8
lead	217.0

Absorption measurements for standard solutions of these elements at the recommended wavelengths produced the following calibration curves.



The solid waste from a gold mine was analysed and the following results were obtained:

Absorbance	*wavelength (nm)*
0.30	217.0
0.20	324.8
0.10	422.7
0.05	242.8

The element present in the highest concentration is:

(A) Calcium.

(B) Copper.

(C) Gold.

(D) Lead.

10 An unknown solid compound X was dissolved into water and the resulting colourless solution was divided between three test-tubes. The table shows the results of three tests performed on this solution containing compound X.

Test	HCl added	Na_2SO_4 added	$Ba(OH)_2$ added
Observations	White precipitate	White precipitate	White precipitate

Based on these observations, compound X could be:

(A) Lead(II) nitrate

(B) Barium nitrate

(C) Iron(II) carbonate

(D) Calcium hydroxide

11 The heat of combustion of ethanol is 1346 kJ mol^{-1}. A 2.16 g sample of ethanol was burnt to heat a 300 mL sample of water. 75% of the heat released was absorbed by the water. The change in temperature of the water was closest to

(A) 2°C

(B) 13°C

(C) 38°C

(D) 51°C

12 A solution of acetic acid was titrated with standardised sodium hydroxide solution in order to determine the concentration of the acetic acid solution. The CORRECT information about the equivalence point of the titration and the most suitable indicator to use for the titration is

	Equivalence point	***Suitable indicator***
(A)	pH < 7	methyl orange
(B)	pH < 7	phenolphthalein
(C)	pH > 7	methyl orange
(D)	pH > 7	phenolphthalein

13 In the following equation

$HCO_3^-(aq) + H_2O(l) \rightleftharpoons H_2CO_3(aq) + OH^-(aq)$

(A)	H_2O is acting as an acid	OH^- is acting as its conjugate base
(B)	HCO_3^- is acting as an acid	OH^- is acting as its conjugate base
(C)	HCO_3^- is acting as a base	H_2O is acting as its conjugate acid
(D)	H_2O is acting as a base	HCO_3^- is acting as its conjugate acid

14 A student reacted solid anhydrous sodium carbonate with excess hydrochloric acid. The balanced equation is shown below.

$Na_2CO_3(s) + 2HCl(aq) \rightarrow 2NaCl(aq) + H_2O(l) + CO_2(g)$

The student collected 3.04 L of gas from the reaction at 25°C and 100 kPa.

What mass of anhydrous sodium carbonate had reacted?

(A) 13.0 g

(B) 14.2 g

(C) 26.0 g

(D) 31.2 g

15 In which row of the following table are the listed oxides CORRECTLY classified?

	Acidic	***Basic***	***Neutral***	***Amphoteric***
(A)	SO_2	K_2O	BaO	ZnO
(B)	Na_2O	MgO	NO	NO_2
(C)	CO_2	SO_2	NO	ZnO
(D)	Cl_2O_7	K_2O	H_2O	Al_2O_3

15 Definitions of acids have changed over the past two centuries as chemical knowledge developed. Which scientist(s) defined an acid as a compound producing hydrogen ions in water?

(A) Davy

(B) Lavoisier

(C) Arrhenius

(D) Lowry and Brönsted

16 When carbon dioxide gas dissolves in water, an equilibrium is established and heat is released.

$CO_2\ (g) \rightleftharpoons CO_2\ (aq)$

The solubility of carbon dioxide gas in water is increased by

(A) decreasing the temperature.

(B) making the water slightly acidic.

(C) decreasing the pressure.

(D) adding more water.

17 A student diluted a solution of an acid by mixing 10 mL with 90 mL of water. If the original solution had a pH of 3.1, the final solution will have a pH of

(A) 2.1

(B) 3.1

(C) 4.1

(D) 5.1

18 A substance was tested with the following indicators. The results are shown below.

Indicator	*Colour*
Methyl orange	Yellow
Bromothymol blue	Blue
Phenolphthalein	Pink

The substance tested could be

(A) water.

(B) 0.1 mol L^{-1} ethanoic acid.

(C) 0.1 mol L^{-1} hydrochloric acid.

(D) 0.1 mol L^{-1} sodium carbonate solution.

19 A student pipetted 25.0 mL of a sodium hydroxide solution into a conical flask, added a few drops of litmus indicator and titrated this with a 0.015 mol L^{-1} solution of hydrochloric acid. The volume of hydrochloric acid required was 11.55 mL.

What is the concentration of sodium hydroxide, expressed to the correct number of significant figures?

(A) 7×10^{-3} mol L^{-1}

(B) 6.9×10^{-3} mol L^{-1}

(C) 6.93×10^{-3} mol L^{-1}

(D) 6.930×10^{-3} mol L^{-1}

20 The table below lists the boiling points of some alkanols and their corresponding alkanoic acids.

Alkanols		*Alkanoic Acids*	
Substance	***BP (Kelvin)***	***Substance***	***BP (Kelvin)***
propan-1-ol	370	propanoic acid	414
butan-1-ol	390	butanoic acid	434
pentan-1-ol	411	pentanoic acid	459

What is the principal reason for the higher boiling points of the alkanoic acids compared with their corresponding alkanols?

(A) The greater dispersion forces between the molecules of the alkanoic acids

(B) The ionic bonding that occurs in the alkanoic acids when they become ionised

(C) The stronger acidic properties of the alkanoic acids

(D) The greater extent of hydrogen bonding between the alkanoic acid molecules

Chemistry

Student Number

Part B – 37 marks
Attempt Questions 21-28
Allow about 1 hour and 25 minutes for this part

Answer the questions in the spaces provided.
Show all relevant working in questions involving calculations.

Question 21 (6 marks)

A student carried out a first-hand investigation to distinguish between saturated and unsaturated hydrocarbons. The teacher provided the student with cyclohexane and cyclohexene.

(a) Draw structural formulae and molecular formulae for both compounds. **2**

(b) Discuss TWO reasons why this pair of compounds was chosen for the investigation. **2**

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Question 21 continues on the next page

Question 21 (continued)

(c) Outline TWO risks and the safety precautions taken when carrying out this investigation. 2

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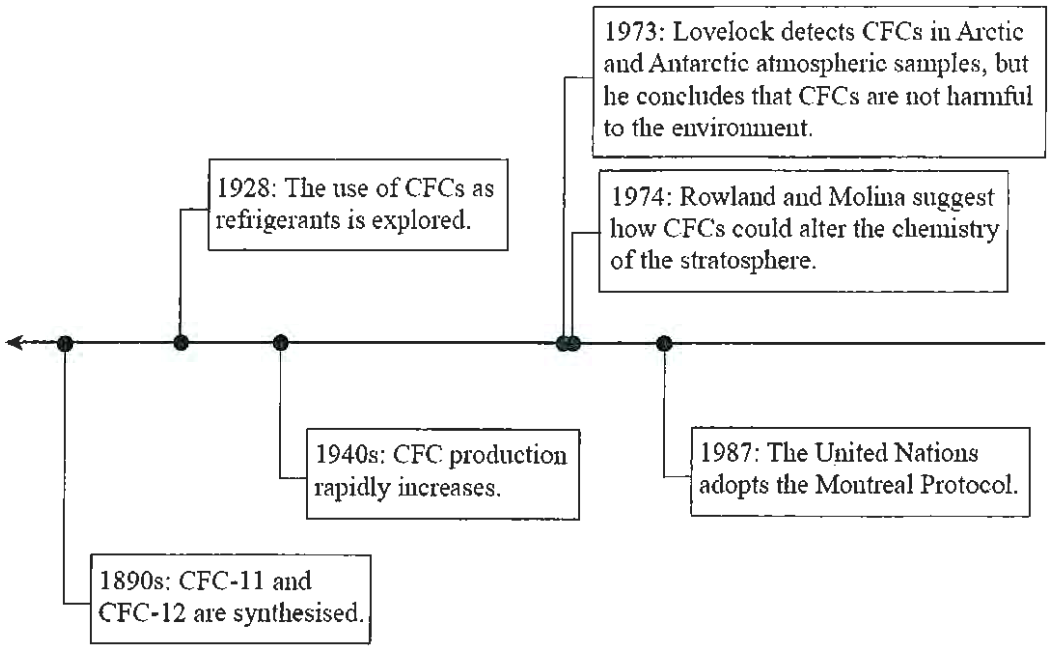
Question 22 (3 marks)

With reference to the incomplete timeline shown below, describe the impact that human activity and technology have had on the chemistry of the stratosphere.



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Question 23 (2 marks)

Explain how microscopic membrane filters can be used to purify contaminated water of bacteria and viruses. **2**

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Question 24 (4 marks)

Justify the use of atomic absorption spectroscopy in the mining industry, and in safeguarding the environment. **4**

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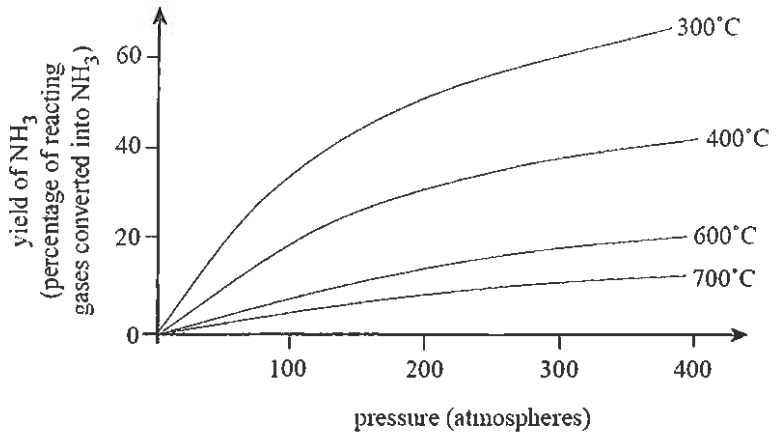
Question 25 (3 marks)

The percentage of ammonia in the equilibrium mixtures resulting from the synthesis of ammonia from its elements is shown in the graph below.



With reference to the above graph and a suitable balanced chemical equation, explain the effects of temperature and pressure on the percentage yield of ammonia at equilibrium.

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Question 26 (3 marks)

You have studied the fermentation of carbohydrates to form ethanol.

(a) Write a balanced equation for the reaction you have studied. **1**

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(b) Describe the conditions needed for this reaction to produce an adequate yield of ethanol. **2**

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Question 27 (4 marks)

(a) Identify a synthetic biopolymer you have studied. **1**

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(b) Discuss why the manufacture/use of this polymer is significant for society. **3**

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Question 28 (3 marks)

(a) Write an equation for the formation of an acidic oxide. **1**

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(b) Write an equation for the reaction of the acidic oxide chosen in (a) with water. **1**

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(c) A solution of an acidic oxide was found to have a hydrogen ion concentration of 4.3×10^{-5} mol L^{-1}. Calculate the pH of this solution. **1**

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Question 29 (4 marks)

A student determined the concentration of an unknown solution of sulfuric acid using the following method.

Step 1	He weighed out 4.00 g of sodium hydroxide.
Step 2	He dissolved the sodium hydroxide in a little de-ionised water and made it up to 1000 mL in a volumetric flask.
Step 3	He carried out a titration using 25.0 mL of the 0.10 mol L^{-1} sodium hydroxide solution with the unknown sulfuric acid, using bromothymol blue indicator. He recorded the results, as in the table below.

Titration	*Volume of sulfuric acid used*
1	8.5 mL
2	8.2 mL
3	7.9 mL

(a) Calculate the concentration of the sulfuric acid. **1**

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(b) Assess the validity and reliability of these results. **3**

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Question 30 (3 marks)

Explain, using two equations, why the dihydrogen phosphate ion can be used as a component of a buffer solution. **3**

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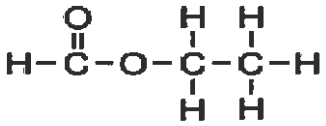
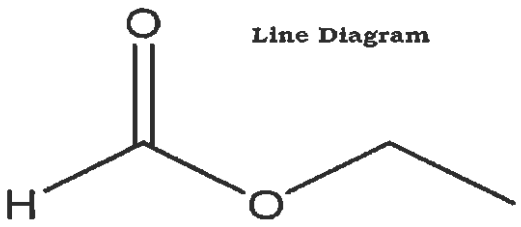
Question 31 (2 marks)

The ester, ethyl methanoate, can be represented by a structural diagram or by a line diagram, as shown below.



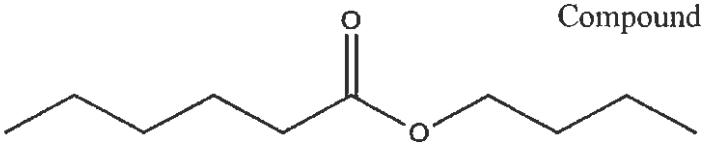
Structural Diagram



Line Diagram

Another ester, **X**, is represented by the line diagram below.

Compound **X**



Draw the structural formulae and name the organic compounds which are used in the preparation of Compound **X**. **2**

Section II

10 marks
Attempt Question 32
Allow about 15 minutes for this section

Answer question 31 in a writing booklet. Extra writing booklets are available.
Show all relevant working in questions involving calculations

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Marks

Question 32 – Industrial Chemistry (10 marks)

a) Nitric oxide gas (NO) reacts with hydrogen gas to produce nitrogen gas and water vapour. This is a reversible reaction.

(i) Write a balanced chemical equation for this reaction. **1**

(ii) Initially a mixture of 0.2M nitric oxide, 0.03M hydrogen and 0.75M water vapour was allowed to reach equilibrium (initially there was no nitrogen). At equilibrium, the concentration of nitric oxide was 0.087M. Determine the value of K. **3**

b) Write a chemical equation to show concentrated sulfuric acid acting as a dehydrating agent. **1**

c) A flask that initially contained only 0.45M $NO_2(g)$ was found to contain 0.15M $N_2O_4(g)$ after equilibrium had been reached.

(iii) Calculate the equilibrium constant for the reaction. **2**

$$2NO_2\ (g) \leftrightarrows N_2O_4\ (g)$$

(iv) The production of $SO_{3\ (g)}$ from $SO_{2(g)}$ is also an equilibrium reaction. Explain how the conditions used in the industrial process maximise the rate and yield of $SO_{3(g)}$. **3**

End of Paper

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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

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

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

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 65.41 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							

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] ium	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.

Student Number

CHEMISTRY – MULTIPLE-CHOICE ANSWER SHEET

ATTEMPT ALL QUESTIONS

Question	**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 ○
	9	A ○	B ○	C ○	D ○
	10	A ○	B ○	C ○	D ○
	11	A ○	B ○	C ○	D ○
	12	A ○	B ○	C ○	D ○
	13	A ○	B ○	C ○	D ○
	14	A ○	B ○	C ○	D ○
	15	A ○	B ○	C ○	D ○
	16	A ○	B ○	C ○	D ○
	17	A ○	B ○	C ○	D ○
	18	A ○	B ○	C ○	D ○
	19	A ○	B ○	C ○	D ○
	20	A ○	B ○	C ○	D ○