Student Number: ……..…….…..

2008
TRIAL HIGHER SCHOOL CERTIFICATE

CHEMISTRY 2 UNIT

General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Write using blue or black pen
- Draw diagrams using pencil
- Board-approved calculators may be used
- A data sheet and a Periodic Table are provided with this paper
- Write your student number at the top of this page

Total marks – 100

Section 1
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 16–24
- Allow about 1 hour and 45 minutes for this part

Section II
25 marks
- Attempt Question 25
- Allow about 45 minutes for this section

This task is weighted 35% HSC Chemistry assessment mark

Section I

Part A – 15 marks

Allow about 30 minutes for this section.

Instructions

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

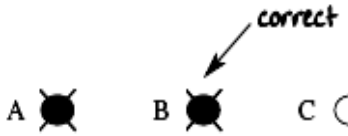
Sample: $2 + 4 =$ (A) 2 (B) 6 (C) 8 (D) 9

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.



A ⊗ B ⊗ C ○ D ○

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 Identify the product formed when water is added to ethylene.

A Ethane
B Styrene
C Polyethylene
D Ethanol

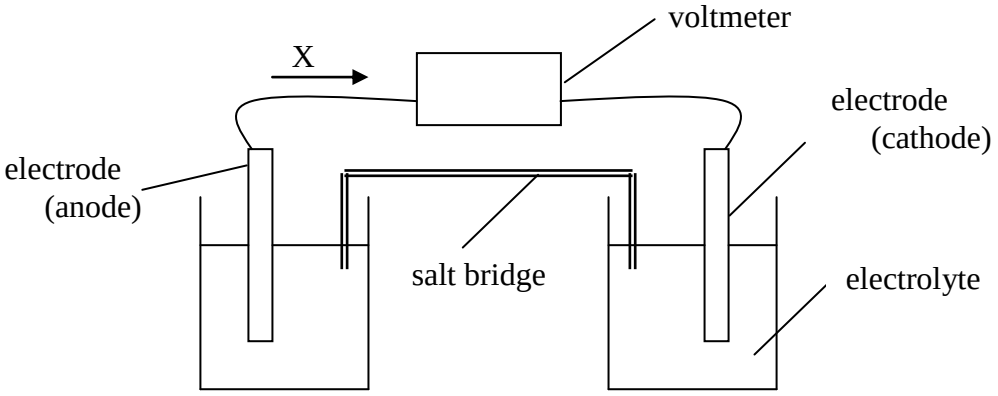
2 Identify the condition which promotes the fermentation of sugars.

A Temperatures in excess of 50°C
B Presence of yeast enzymes
C Air in the fermentation mixture
D Sulfuric acid as a catalyst

3 Identify the organic group that the compound $CH_3CH_2CHOHCH_2CH_3$, belongs to.

A Alkanols
B Polymers
C Esters
D Alkanoic acids

4 In the galvanic cell diagram, what does the arrow (marked X) represent?



A The direction of electrolyte flow
B The direction of flow in the salt bridge
C The direction of migration of negative ions
D The direction of electron flow

5 Identify the TRUE statement about transuranic elements.

A They are artificial elements made in nuclear reactors.
B They all have atomic numbers less than 92.
C They are all stable, non-radioactive elements.
D They have a neutron to proton ratio in their nucleus of 1.

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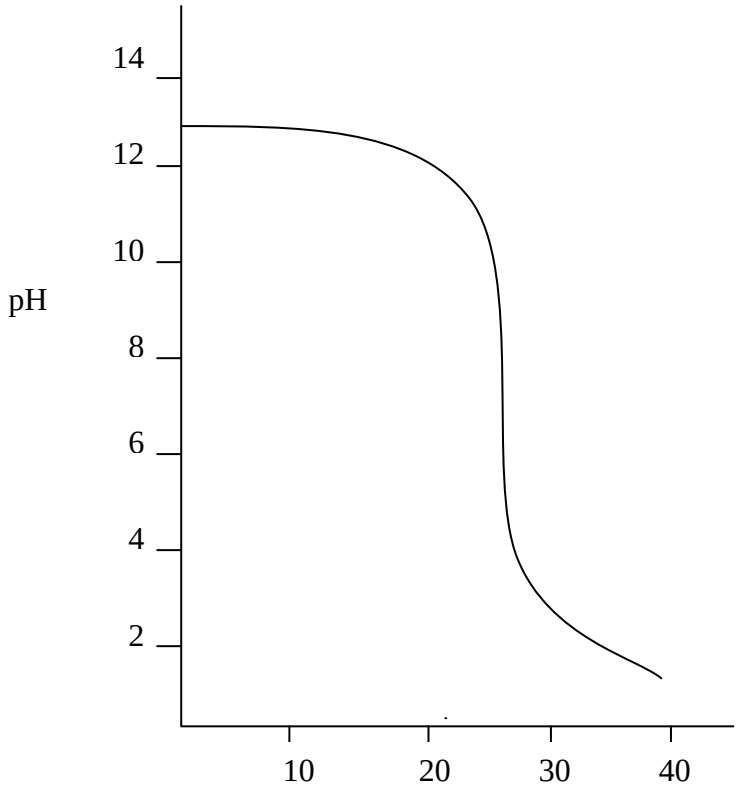


Identify the titration represented by the curve shown in the diagram.

A Strong base + weak acid
B Weak base + strong acid
C Strong base + strong acid
D Weak base + weak acid

7 Identify which of the following is a property of acids.

A They turn red litmus blue.
B They produce OH^- ions in solution.
C They are proton acceptors.
D They have a pH less than 7 at 25°C.

8 Large amounts of sulfur dioxide may be released into the atmosphere by industrial activities. Identify an industrial activity that would release sulfur dioxide.

A Use of fertilisers in agriculture
B Burning of fossil fuels
C Combustion of petrol in internal combustion engines
D Geothermal hot springs

9 10 mL of a strong acid is made up to 100 mL using distilled water. Identify the effect of the addition of the 90 mL of water on the pH of the solution.

A Increase the pH by 10.
B Decrease the pH by 10.
C Increase the pH by 1.
D Decrease the pH by 1.

10 Identify which of the following is NOT characteristic of a chemical equilibrium reaction.

A The reactants are completely consumed in the reaction.
B Forward and reverse reactions take place at the same rate.
C The amounts of any of the species in the reaction remain constant with time.
D Chemical equilibrium can only be maintained in a closed system.

11 Consider the following equilibrium reaction:

$$CO_2(g) + H_2O(l) \rightleftharpoons H_2CO_3(g) + \text{heat}$$

In this reaction, what effect would an increase in temperature have on the system?

A Decrease the amount of H_2CO_3
B Increase the amount of H_2CO_3
C Have no effect on the equilibrium
D Decrease the amount of CO_2

12 Which ion, when present in high concentration, is associated with hardness in water?

A Sodium ion
B Magnesium ion
C Chloride ion
D Aluminium ion

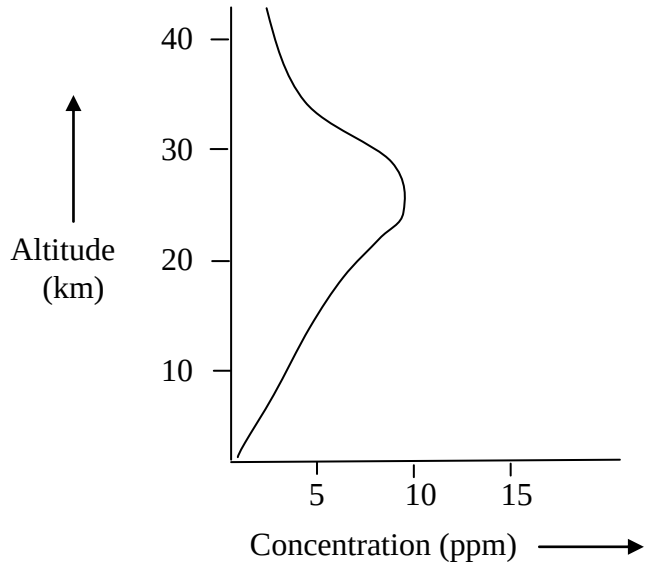
13 A solution is thought to contain one of the following cations:

barium, lead(II), copper(II), iron(II).

Tests were carried out to determine the ion present: a solution of the ion did not produce a precipitate with either sodium hydroxide or hydrochloric acid; a flame test of a solution of the ion produced a pale green flame. Which ion was present?

A Barium
B Lead(II)
C Copper(II)
D Iron(II)

14 The graph below shows the concentration of a gas in the atmosphere with increasing altitude.



What gas is being indicated in the graph?

A Oxygen
B Nitrogen
C Ozone
D Carbon dioxide

15 Water quality is often monitored for organic matter by determining the concentration of dissolved oxygen that is needed for the complete breakdown of the organic matter by aerobic bacteria. What aspect of water quality is being determined?

A Dissolved oxygen
B Aerobic bacteria levels
C Biochemical oxygen demand
D Nitrogen-to-phosphorus ratio

Section I (continued)

Part B – 60 marks
Attempt Questions 16–24
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 (10 marks)

(a) The equation below represents a polymerisation reaction:

$$n\ (CH_2CHCl) \longrightarrow (-CH_2CHCl-)_n$$

(i) Give the SYSTEMATIC name of the monomer AND the COMMON name of the polymer in this reaction. **2**

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(ii) Identify the type of polymerisation process shown. **1**

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(iii) Identify a use for this polymer and relate its use to the properties of the polymer. **3**

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Question 16 continues on page 8

Marks

Question 16 (continued)

(b) You have carried out a first-hand investigation to compare the reactivity of an alkene with its corresponding alkane.
Explain the results obtained from this investigation .
Include a relevant chemical equation in your answer. **4**

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Question 17 (4 marks)

Analyse the relationship between the position of elements in the Periodic Table, and the acid–base behaviour of their oxides. **4**

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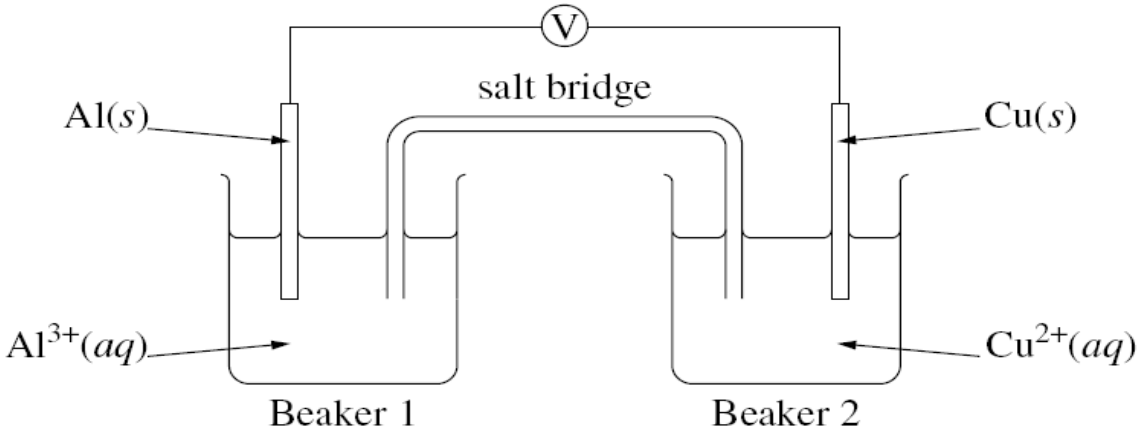
Marks

Question 18 (5 marks)

A student set up the cell shown below.



(a) Identify two observations that could be made as the above cell operates. **2**

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(b) Identify a suitable solution that could be used to soak the filter paper to form a salt bridge. **1**

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(c) Justify how each of the two solutions will be disposed of at the end of the experiment. **2**

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Marks

Question 19 (6 marks)

The atmosphere contains a mixture of gases.

(a) Argon is a major constituent of the atmosphere. The concentration of argon in the atmosphere is 0.93% (v/v). Calculate its concentration in ppm. **2**

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(b) The changes in the concentration of ozone in the stratosphere are being constantly monitored. Describe the changes that have been observed and describe how this information was obtained. **4**

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Marks

Question 20 (7 marks)

A 0.1 mol L^{-1} solution of nitric acid and a 0.1 mol L^{-1} solution of acetic acid was prepared..

(a) Calculate the pH of the nitric acid solution. **1**

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(b) The acetic acid had a pH of 2.9. Compare this with the value you calculated for nitric acid and explain any difference in the pH of these two acids. **3**

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(c) One of the above acids can be used to form a buffer by adding equimolar amounts to a solution of its conjugate base. Explain, through the use of suitable equation(s), how the resulting solution buffers against changes in pH when small amounts of a strong acid or strong base are added to it. **3**

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Marks

Question 21 (5 marks)

Assess the suitability of ethanol as a fuel. **5**

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Question 22 (7 marks)

On Wednesday 2nd July 2008, the ABC news reported on the effort to clean up an outbreak of blue-green algae in Qingdao which threatened the sailing events in the Beijing Olympics.

Stories in the media speculated on possible causes of the outbreak.

(a) Identify an ion that is often responsible for outbreaks of algal growth and identify a factor that could affect the concentrations of that ion in a natural water body. **2**

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Question 22 continues on page 13

Marks

Question 22 (continued)

(b) Describe a test that could be used to monitor the possible eutrophication of the Qingdao coastline. **2**

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The Winkler method was used to determine the amount of dissolved oxygen in a sample of water taken from a waterway.

In this procedure, oxygen reacts with Mn^{2+} under alkaline conditions to produce a precipitate of $MnO(OH)_2$.

$$2Mn^{2+}(aq) + O_2(aq) + 4OH^-(aq) \longrightarrow 2MnO(OH)_2(s)$$

The precipitate is then dissolved in acid and reacted with iodide, forming iodine and Mn^{2+}.

$$2MnO(OH)_2(s) + 4I^-(aq) + 8H^+(aq) \longrightarrow 2I_2(aq) + 2Mn^{2+}(aq) + 6H_2O(l)$$

Finally, the amount of iodine produced is determined by reacting it with thiosulfate ion.

$$2I_2(aq) + 4S_2O_3^{2-}(aq) \longrightarrow 4I^-(aq) + 2S_4O_6^{2-}(aq)$$

(c) Combine the equations above to determine an overall equation for the reaction between oxygen gas and the thiosulfate ion. **1**

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(d) A 50 mL water sample required 8.0 mL of 0.010mol L^{-1} thiosulfate ions for the oxygen in it to be completely reacted.
Calculate the moles of dissolved oxygen in the 50 mL sample. **2**

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Marks

Question 23 (7 marks)

Evaluate the Haber process with respect to the conditions required for maximum product yield. Include in your answer the conditions used industrially for this process. **7**

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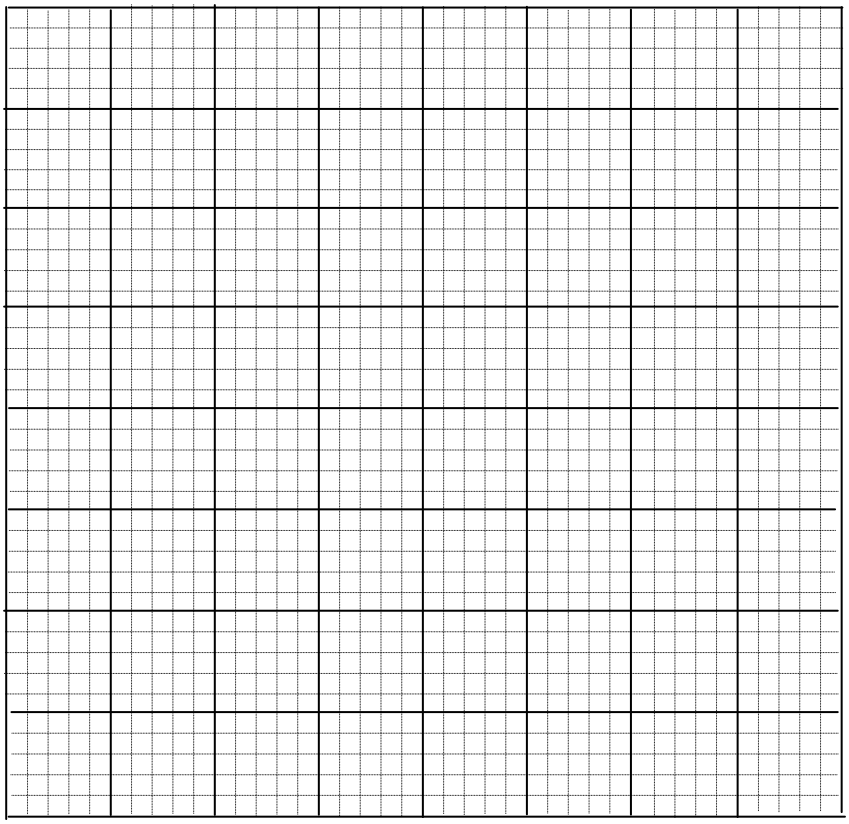
Marks

Question 24 (9 marks)

The boiling points of alkanols and alkanoic acids versus molecular weight are shown in the table below.

Molecular weight	46	60	74	88
Alkanols boiling point (°C)	78	97	117	138
Alkanoic acid boiling point (°C)	100	118	141	164

(a) Draw line of best fit graphs of the data for each of these organic molecules. **3**



Molecular weight

(b) Name the products formed when butanoic acid and ethanol are refluxed with a concentrated sulfuric acid catalyst. **2**

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Question 24 continues on page 16

Marks

Question 24 (continued)

(c) Write a complete balanced equation for the reaction. **1**

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(d) Draw a fully labelled diagram of the equipment set-up for the reaction. **3**

End of Section I

Section II

25 marks
Attempt Questions 25
Allow about 45 minutes for this section

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

Show all relevant working in questions involving calculations.

Marks

Question 25 – Industrial Chemistry (25 marks)

(a) Phosgene gas ($COCl_2$) is prepared by the reaction summarised in the following equation.

$$CO_{(g)} + Cl_{2(g)} \rightarrow COCl_{2(g)}$$

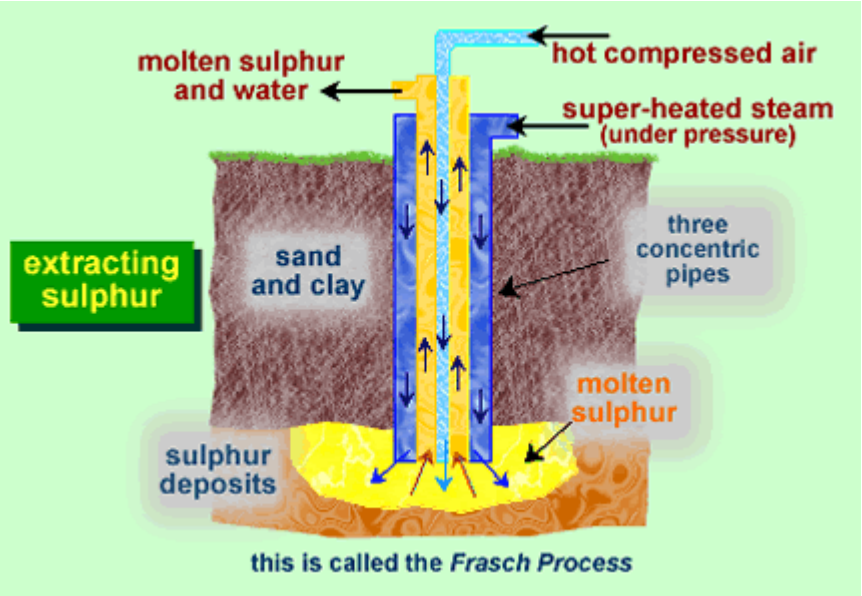
The graph below shows what happens when all three gases are mixed in the presence of a carbon catalyst.

(i) Identify what occurred 3 minutes after the gases were mixed. **1**

(ii) At 4 minutes after mixing the temperature of the gases was increased to a new constant temperature. The graph below plots the changes in concentration of the three gases and these can be used to determine that the reaction is exothermic.
Explain how the changes in the concentration of the three gases supports the conclusion that the reaction is exothermic. **3**

(iii) At 9 minutes after mixing, extra phosgene was added to the system and equilibrium was re-established in the following two minutes.
Complete the graph supplied in your answer booklet to show how the concentration of phosgene changed in the two-minute period following the addition of the extra phosgene. **2**

(b) The Frasch Process is used to mine elemental sulfur in some parts of the world.



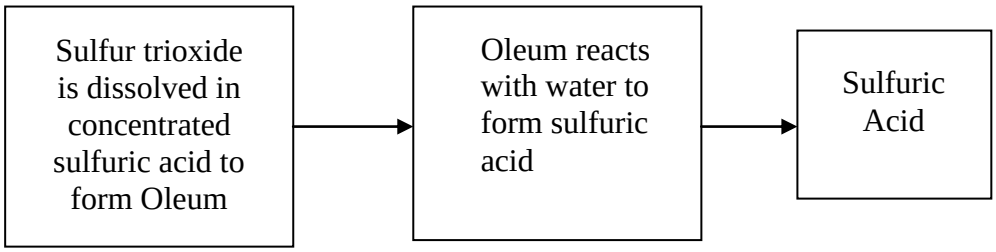
Identify the properties of sulfur that allow its extraction and analyse potential environmental issues that may be associated with its extraction. **4**

(c) Sulfuric acid is one of the world's most widely used chemicals. The Contact process produces it industrially. Sulfur dioxide, air and water are the main feedstocks in its production. The first step in the process is the production of sulfur trioxide.
Analyse the reaction for the formation of sulfur trioxide to determine the conditions that would maximise its yield. **5**

(d) The Contact process produces sulfuric acid.

(i) Name two MAIN uses for sulfuric acid. **2**

(ii) Below is a partial flowchart of the Contact process showing the production of sulfuric acid from sulfur trioxide.
Write balanced equations for the reactions occurring in the first two boxes. **2**



(e) You performed a first-hand investigation in the school laboratory to observe the reactions of sulfuric acid.

(i) Outline the experimental method used and the observations you made for each reaction. **4**

(ii) For one of the above reactions, identify a safety risk associated with its procedure and suggest a safe work practice to minimise this risk. **2**

End of Examination

Section I – Multiple choice

Answer sheet

	A	B	C	D
1				
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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

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

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

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.

Marking guidelines

Section I – Part A

1 D
2 B
3 A
4 D
5 A
6 C
7 D
8 B
9 C
10 A
11 A
12 B
13 A
14 C
15 C

Section I – Part B

Question 16(a)(i)

Criteria	Marks
Correctly identifies BOTH names of the polymer	1
Correctly identifies ONE of the names of the polymer	1

Suggested answer:
Chloroethene and Polyvinyl chloride (or PVC).

Question 16(a)(ii)

Criteria	Marks
Correctly identifies the type of polymerisation	1

Suggested answer:
Addition polymerisation

Question 16(a)(iii)

Criteria	Marks
Correctly identifies a use of PVC and relates the use to at least TWO properties	3
Correctly identifies a use of PVC and a property of PVC OR Correctly identifies at least TWO properties of PVC	2
Correctly identifies a use of PVC OR Correctly identifies a property of PVC	1

Suggested answer:
Uses include drain pipes and guttering. The linear chains of the polymer reduces flexibility because of the close packing of the chains one to another; this stiffness and rigidity make them suitable for the uses given.

Question 16(b)

Criteria	Marks
Correctly explains the results obtained in the investigation and includes a relevant chemical equation in the answer	4
Correctly explains the result(s) obtained in the investigation OR Correctly describes the result(s) obtained in the investigation and includes a relevant chemical equation in the answer	2 - 3
Correct equation OR Correctly identifies a result of the investigation	1

Suggested answer:
Alkenes – react spontaneously by addition across the double bond causing bromine water to decolourise. $C_6H_{12}(g) + HOBr(aq) \longrightarrow C_6H_{12}BrOH(l)$
Alkanes – relatively unreactive; reaction with bromine water very slow (over a day or so).

Question 17

Criteria	Marks
Correctly describes the trends in acid–base behaviour of oxides of elements and relates this to the position of elements in the Periodic Table	4
Correctly describes trends in acid–base behaviour of oxides of elements	3
Provides two correct statements about acid–base behaviour of oxides of elements OR Two correct equations	2
Provides one correct statement about acid–base behaviour of oxides of elements	1

Suggested answer:
Acidic oxides react with water to form an acid. They are generally oxides of non-metals, elements found at the right of the Periodic Table.
Basic oxides react with water to form a base. They are generally oxides of metals, elements found towards the left of the Periodic Table.
The oxides of some metals found towards the right of the periodic table react with both acids and bases (are amphoteric) whilst a few elements (C, O, and N) form oxides that are neutral.
Generally, the oxides of elements become acidic as you move left to right across a period in the Periodic Table and more basic as you move down a group.

Question 18(a)

Criteria	Marks
Correctly identifies two observations that could be made as the cell operates	2
Correctly identifies an observation that could be made as the cell operates	1

Suggested answer:
Any two of:

- Decrease in the intensity of blue colour in Beaker 2
- Decrease in size of magnesium electrode / clean appearance electrode
- Increase in size of copper electrode / clean appearance electrode

Question 18(b)

Criteria	Marks
Correctly identifies a suitable solution that could be used to soak the filter paper	1

Suggested answer:
Potassium nitrate

Question 18(c)

Criteria	Marks
Correctly justifies the disposal of BOTH solutions	2
Correctly justifies the disposal of a solution OR Correctly identifies the disposal of BOTH solutions	1

Suggested answer:
Copper solution should be placed in a heavy metal waste container for disposal later and magnesium solution is poured down the sink as it is safe to do so.

Question 19(a)

Criteria	Marks
0.935 (v/v) = 0.93 mL/100 mL	1
Correct answer	1

Suggested answer:
0.935 (v/v) = 0.93 mL/100 mL = 0.93 × 10 000 mL/kL = **9300 ppm**

Question 19(b)

Criteria	Marks
Correctly describes the changes that have been observed in ozone concentration and how the information was obtained	4
Correctly describes/identifies the change(s) that have been observed in ozone concentration and correctly identifies how the information was obtained OR Correctly identifies the change(s) that have been observed in ozone concentration and correctly describes how the information was obtained	2 - 3
Correctly describes the changes that have been observed in ozone concentration and how the information was obtained	1

Suggested answer:
In 1976, measurements made with ground-based Dobson UV spectrophotometers and on air samples collected by high-altitude balloons and aircraft, indicated a decrease in ozone concentrations over Antarctica in spring.
As the 1980's progressed, the ozone loss continued to worsen. Since 2005, the "ozone hole" has been smaller and fairly steady in size. Satellites now measure ozone concentrations using infra-red radiometers, as well TOMS UV spectrometry. Ground-based UV lasers (lidars) and chemiluminescence of air samples are also used to make ozone measurements so reliability can be determined.

Question 20(a)

Criteria	Marks
Correctly calculates the pH of the acid	1

Suggested answer:
$pH = -\log_{10} [0.1] = 1$

Question 20(b)

Criteria	Marks
Correctly compares the pH values of the two acids and explains the differences in terms of acid strength, hydronium ion concentration and the pH calculation	3
Distinguishes the acids in terms of their 'strength' and hence their $[H^+]$ (can be through use of a diagram) AND Correctly relates pH with $[H^+]$ OR Correctly compares the pH values of the two acids	2
Correctly compares the pH values of the two acids OR Distinguishes the acids in terms of their 'strength' or degree of ionisation OR Correctly relates pH with $[H^+]$	1

Suggested answer:
The nitric acid has a lower pH value compared to acidic acid. This is because nitric acid is a strong acid and is totally ionised, resulting in a higher concentration of hydronium ions when compared to acetic acid, which is a weak acid and only about 1% ionised. The lower concentration of hydronium ions in acetic acid results in a higher pH value when it is calculated since $pH = -\log_{10} [H^+]$.

Question 20(c)

Criteria	Marks
Correctly identifies that acetic acid and the ethanoate ion form the buffer (can be an equation if clear concept is understood) AND Correctly explains, using suitable equation(s), how the resulting solution acts as a buffer when small amounts of a strong acid or strong base are added to it	3
Correctly explains, using suitable equation(s), how the resulting solution acts as a buffer when small amounts of a strong acid or strong base are added to it OR Correctly identifies that acetic acid and the ethanoate ion form the buffer AND Includes a correct suitable equation(s) that illustrate a buffering reaction	2
Correctly identifies that acetic acid and the ethanoate ion form the buffer OR Correct suitable equation that illustrates a buffering reaction OR Correct statement about buffers	1

Suggested answer:

Acetic acid forms a buffer solution with equimolar amounts of the ethanoate ion. An equilibrium exists within the buffer:

$$CH_3COOH_{(aq)} + H_2O_{(l)} \rightleftharpoons CH_3COO^-_{(aq)} + H_3O^+_{(aq)}$$

When small amounts of a strong acid are added to the solution, the equilibrium shifts to the left, reducing the hydronium ion concentration, so the pH of the solution is not lowered significantly.

When small amounts of a strong base are added to the solution, it reacts with the hydronium ion, lowering its concentration. The equilibrium shifts to the right, restoring most of the hydronium ion, so the pH of the solution is not raised significantly.

Question 21

Criteria	Marks
Identifies properties of ethanol that make it a suitable fuel Explains the problems and benefits arising from the use of ethanol Provides a judgement of the potential for ethanol to be used as an alternative fuel	4 - 5
Describes the problems and benefits arising from the use of ethanol AND Identifies a property of ethanol that make it a suitable fuel OR Provides a judgement of the potential of ethanol as an alternative fuel	2 - 3
Identifies one reason for the need for alternative fuels OR Identifies an advantage or disadvantage of using ethanol as a fuel	1

Suggested answers:

Answer should include an assessment and five main points:

- Ethanol is a liquid at room temperature and readily combusts to release considerable energy
- Advantage: a renewable resource
- Advantage: could reduce greenhouse gas emissions/combusts cleanly
- Disadvantage: large amounts of arable that would be required for growing suitable crops
- Disadvantage: necessity of disposal of large amounts of fermentation by-products/need to modify cars/energy required for distillation

Question 22(a)

Criteria	Marks
Correctly identifies an ion that can result in outbreaks of algae and a possible source of contamination	2
Correctly identifies an ion that can result in outbreaks of algae OR Correctly identifies a possible source of contamination	1

Suggested answer:

Phosphate and fertiliser in run-off from farms. Also accept nitrate.

Question 22(b)

Criteria	Marks
Describes a test that could be used to monitor the possible eutrophication	2
Identifies a test that could be used to monitor the possible eutrophication OR Describes a test that might indicate possible eutrophication	1

Suggested answer:
Phosphate concentrations are best determined using colorimetry. The phosphate ions in the water sample are reacted with acidified ammonium molybdate and reduced to form molybdenum blue, which gives the solution a blue colour. A colorimeter is used to compare the intensity of the blue colour against standards of known concentration and hence determine the concentration of phosphate in the sample.

1 mark for describing DO test, BOD test, precipitation

Question 22(c)

Criteria	Marks
Writes a correctly balanced equation, including subscripts	1

Suggested answer:
$O_{2\,(g)} + 4H^+_{(aq)} + 4S_2O_3^{2-}{}_{(aq)} \rightarrow 2H_2O_{(l)} + 2S_4O_6^{2-}{}_{(aq)}$,

also accept $O_{2\,(g)} + 8H^+_{(aq)} + 4OH^-_{(aq)} + 4S_2O_3^{2-}{}_{(aq)} \rightarrow 6H_2O_{(l)} + 2S_4O_6^{2-}{}_{(aq)}$

Question 22(d)

Criteria	Marks
Correctly calculates the moles of oxygen in the sample	2
Correctly calculates the moles of thiosulfate ions used	1

Suggested answer:
Moles of thiosufate ions = $0.008 \times 0.010M = 8 \times 10^{-5}$ moles
Mole ratio of oxygen to thiosufate = 1:4
Moles of oxygen in 50mL sample = $\frac{8 \times 10^{-5} \text{ moles}}{4}$
$= 2 \times 10^{-5}$ moles

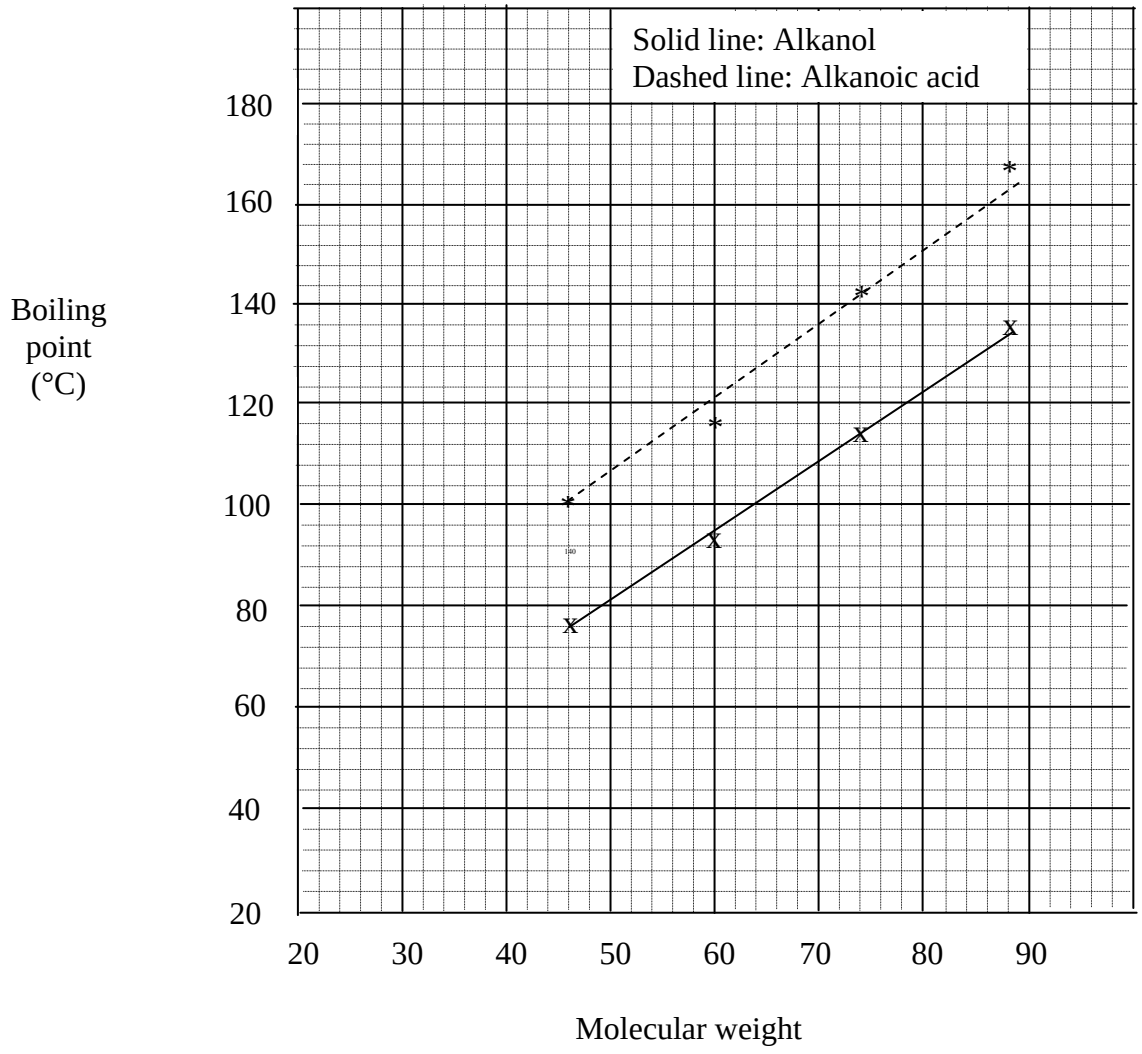
Question 23

Criteria	Marks
• Demonstrates an extensive knowledge of the Haber process including the industrial conditions required for maximum product yield. • Provides a comprehensive explanation of why the industrial conditions used produce maximum product yield and relates them to the nature of the reaction • Provides an evaluation	6-7
• Demonstrates a thorough knowledge of the Haber process • Explains why some reaction conditions are required for maximum product yield	4-5
• Demonstrates a sound knowledge of the Haber process OR • Demonstrates a limited knowledge of the Haber process and identifies (a) reaction condition(s) that is (2 marks)/are (3 marks) used industrially	2-3
Of	1

Question 24(a)

Criteria	Marks
Correct units and labels X and Y axes, including unit for boiling point	1
Correct placements of points on graph and drawing of lines of best fit	1
Appropriate indication of which line refers to which molecular group	1

Suggested answer:



Question 24(b)

Criteria	Marks
Both products correctly identified	2
One product correctly identified	1

Suggested answer:
Ethyl butanoate and water

Question 24(c)

Criteria	Marks
Correct balanced equation, including equilibrium arrow, subscripts and condensed structural formulae	1

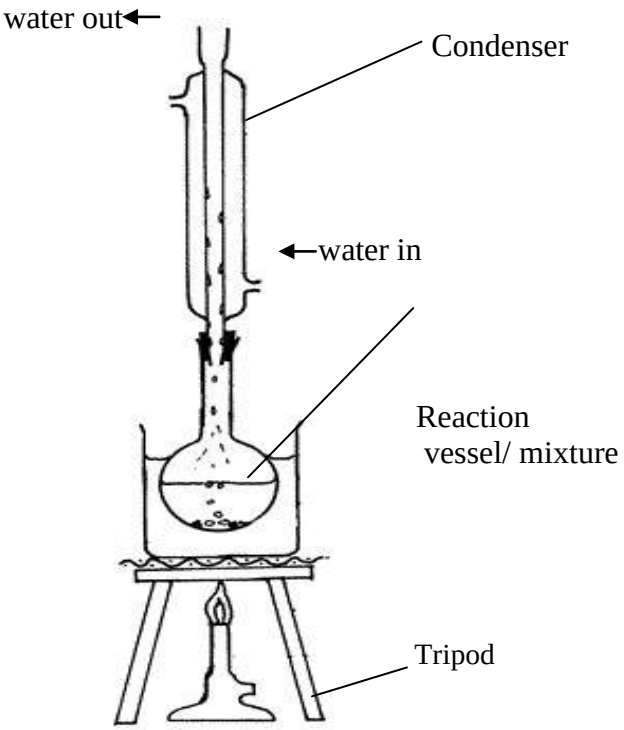
Suggested answer:

$$C_3H_7COOH_{(l)} + C_2H_5OH_{(l)} \underset{}{\overset{\text{conc. } H_2SO_4}{\rightleftharpoons}} C_3H_7COOC_2H_{5(l)} + H_2O_{(l)}$$

Question 24(d)

Criteria	Marks
Condenser shown and labelled including water in &water out AND Reaction vessel shown and labelled AND Tripod shown with bunsen/wire gauze OR other more appropriate heating	3
Two of the above correct OR Three done poorly	2
One of the above correct OR Two poorly done/three done very poorly	1

Suggested answer:



Section II

Question 25(a)(i)

Criteria	Marks
Correctly identifies change shown in graph	1

Suggested answer:
Equilibrium was reached.

Question 25(a)(ii)

Criteria	Marks
Uses data from the graph and Le Chatelier's principle to explain how the changes in the concentration of the gases supports the conclusion that the reaction is exothermic	3
Correctly identifies the changes in the concentration of the three gases from the graph AND Identifies a new equilibrium is established after 6 minutes	2
Correctly identifies a change in a gases concentration from the graph OR Identifies a new equilibrium is established after 6 minutes OR Makes a correct statement about exothermic equilibrium reactions	1

Suggested answer:
The concentration of the product ($COCl_2$) falls after 4 minutes while the concentrations of both of reactant gases increase, until a new equilibrium is established. Since the rise in temperature favours the formation of reactants over product (i.e. the equilibrium as shifted to the left), Le Chatelier's principle can be applied to determine that the reaction is exothermic.

Question 25(a)(iii)

Criteria	Marks
Line drawn include spike for initial increase and a curve for the decline to equilibrium, with the final concentration higher than the 7-8 minute level	2
Draws a line that indicates phosgene concentration is higher after 9 minutes OR Line drawn indicates equilibrium has been re-established	1

Suggested answer:

Question 25(b)

Criteria	Marks
Correctly identifies at least TWO properties of sulfur that allow its extraction and describes TWO potential environmental issues that may be associated with its extraction	4
Correctly identifies at least ONE property of sulfur that allows its extraction AND Correctly describes ONE potential environmental issue that may be associated with its extraction OR Correctly identifies at least TWO potential environmental issues that may be associated with its extraction	2 -3
Correctly identifies a property of sulfur that allows its extraction OR Correctly identifies a potential environmental issue that may be associated with its extraction	1

Suggested answer:

The properties of sulfur that allow its extraction are:

- It melts at 113°C so it can be easily melted by superheated steam.
- It's insoluble in water, so easy to separate from water at the surface.
- It has a low density of 2.07 gm cm^{-3}, so its emulsion with water can be carried to the surface by compressed air.
- It is inert, non-toxic and non-volatile, so it is safe to work with.

The environmental problems associated with the mining of sulfur include:

- Water from the process is hot and contains unidentified dissolved minerals. It must be recycled rather than releasing it to the environment, which can result in pollution.
- Care must be taken to avoid the oxidation of sulfur to form sulfur dioxide, as sulfur dioxide can contribute to acid rain.
- Caverns that remain underground after extraction are difficult to back-fill and can result in subsidence.

Question 25(c)

Criteria	Marks
• Writes a correct balanced chemical equation for the formation of sulfur trioxide • Applies Le Chatelier's principle to the equilibrium to determine the conditions required for the maximum yield of sulfur trioxide • Analyses temperature condition in terms of a rate/yield compromise and includes the use of a catalyst	4 -5
• Applies Le Chatelier's principle to the equilibrium to determine some conditions required for the maximum yield of sulfur trioxide AND • Writes a correct balanced chemical equation for the formation of sulfur trioxide OR • Identifies that reaction is an exothermic equilibrium	2 - 3
Correctly identifies a condition required for the maximum yield of sulfur trioxide OR Writes a correct balanced chemical equation for the formation of sulfur trioxide OR Differentiates rate and yield	1

Question 25(d)(i)

Criteria	Marks
Correctly identifies two MAIN uses of sulfuric acid	2
Correctly identifies a MAIN use of sulfuric acid	1

Suggested answer:
The manufacture of fertilisers and detergents.

Question 25(d)(ii)

Criteria	Marks
Correct equations for both of the steps, including subscripts	2
Correct equations for both of the steps, excluding subscripts OR Correct equations for ONE of the steps, including subscripts OR Equations for both of the steps including subscripts but contain minor errors	1

Suggested answer:

$$SO_{3(g)} + H_2SO_{4(l)} \longrightarrow H_2S_2O_{7(l)}$$

$$H_2S_2O_{7(l)} + H_2O_{(l)} \longrightarrow 2H_2SO_{4(l)}$$

Question 25(e)(i)

Criteria	Marks
• Correctly outlines the experimental method used for each reaction • Correctly outlines the observations made for each reaction	4
• Correctly outlines the experimental method and the observations made for each reaction with minor omissions	3
• Correctly outlines the experimental method used for each reaction OR • Correctly outlines the observations made for each reaction OR • Outlines some of the experimental method used and identifies some observations made for reactions	2
Correctly identifies a step or observation for the investigation	1

Suggested answer:

The teacher demonstrated the experiment due to the risks associated with handling concentrated sulfuric acid.

1. A few crystals of potassium bromide were placed in a test tube in a test tube rack in a working fume cupboard.
2. A few drops of concentrated sulfuric acid were added to the test tube using a plastic dropper.
3. A 150 mL beaker was placed in the fume cupboard and sucrose was added to a depth of 1 cm.
4. 10 mL of concentrated sulfuric acid was added to the sugar and the mixture was stirred with a glass rod.

Observations

1. Brown vapour rose from the test tube. The brown coloured solution cleared over a few minutes.
2. The sucrose mixture slowly darkened to a black colour. After a few minutes, vapour could be seen rising form the beaker. The mixture rose up the beaker to the top and a porous black solid remained at the end of the experiment.

Question 25(e)(ii)

Criteria	Marks
Correctly identifies a safety risk associated with the procedure and identifies a safe work practice to minimise this risk	2
Correctly identifies a safety risk associated with the procedure OR Correctly identifies a safe work practice for the procedure	1

Suggested answer:

Concentrated sulfuric acid is extremely corrosive. It should only be handled by a teacher and used in an operating fume cupboard. The teacher must wear goggles, protective clothing and gloves.