Student Number_____

SYDNEY BOY HIGH SCHOOL

HIGHER SCHOOL CERTIFICATE

TRIAL EXAMINATION

2008

CHEMISTRY

General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Board approved calculators may be used
- Write using black or blue pen
- A Data Sheet and Periodic Table are provided at the back of this paper
- Show all working where necessary

- Write your STUDENT NUMBER on each page

Section 1

Total marks (75)
This section has two parts,
Part A and Part B

Part A
Total Marks (15)

- Attempt questions 1 – 15
- Allow about 30 minutes for this part

Part B
Total marks (60)

- Attempt Questions 16-27
- Allow about 1 hour and 45 minutes for this part

Section II
Total marks (25)

- Attempt option Question 28
- Allow about 45 minutes for this part

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SECTION 1

Part A

Attempt Questions 1-15 (15 Marks)

Answer **All** questions on the Answer Sheet provided

1. Ethene is produced on a commercial scale by which process?

   A. Condensation
   B. Catalytic cracking
   C. Polymerisation
   D. Hydrogenation

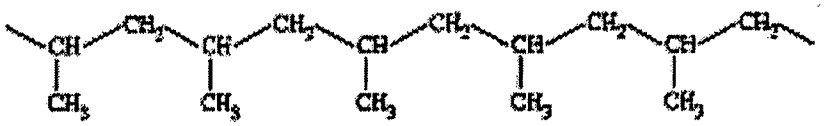
2. Consider the following standard reduction potentials:

Half-reaction	*E° (V)*
$Ca^{2+} + 2e^- \rightleftharpoons Ca$	-2.87
$Pb^{2+} + 2e^- \rightleftharpoons Pb$	-0.13
$Cu^{2+} + 2e^- \rightleftharpoons Cu$	+0.34
$Ag^{1+} + e^- \rightleftharpoons Ag$	+1.80

   Using the above table, which of the following metals is the strongest REDUCING AGENT?

   A. Ca
   B. Pb
   C. Cu
   D. Ag

3. 'X' is an unknown hydrocarbon which undergoes polymerisation to produce the polymer with a structure shown below.



   Which of the following is the correct name of 'X'?

   A. Ethene
   B. Propene
   C. Propane
   D. 1-methylethene

4. Which of the following equations represents B-decay?

(A) $^{14}_{6}C \rightarrow {}^{14}_{7}N + {}^{0}_{-1}e$

(B) $^{238}_{92}U \rightarrow {}^{232}_{90}Th + {}^{4}_{2}He$

(C) $^{35}_{17}Cl + {}^{0}_{-1}e \rightarrow {}^{35}_{16}S$

(D) $^{238}_{92}U + {}^{1}_{0}n \rightarrow {}^{94}_{35}Br + {}^{152}_{54}Xe + 3{}^{1}_{0}n$

5. The heat of combustion of ethanol is 1346 kJ mol^{-1}.
What mass of ethanol would be required to produce 250kJ of energy upon its complete combustion?

A. 0.19 g
B. 5.38 g
C. 8.54 g
D. 247.66 g

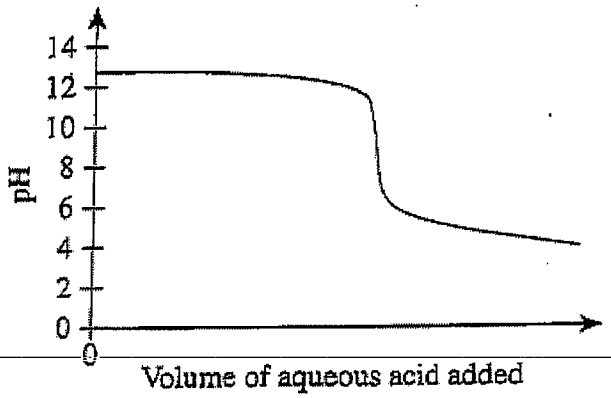
6. Consider each of the following equations:

(i) $HCl_{(aq)} \rightarrow H^{+}_{(aq)} + Cl^{-}_{(aq)}$
(ii) $HCl_{(aq)} + H_2O_{(l)} \rightarrow H_3O^{+}(aq) + Cl^{-}_{(aq)}$
(iii) $NH_{3(aq)} + H_2O_{(l)} \rightarrow NH_4^{+}{}_{(aq)} + OH^{-}_{(aq)}$
(iv) $NaOH_{(aq)} \rightarrow Na^{+}_{(aq)} + OH^{-}_{(aq)}$

An acid can be defined as a proton donor. This can be seen in

A. equation (i) only
B. equation (ii) only
C. equation (ii) and (iii)
D. all of the equations

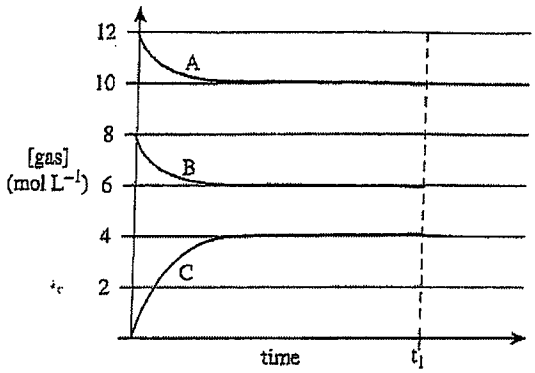
7. The graph below shows a titration curve of an aqueous alkali with an aqueous acid of similar concentration.



What could be the alkali and acid in this titration?

	Alkali	*Acid*
A.	NH_3	HCl
B.	NH_3	CH_3COOH
C.	NaOH	HCl
D.	NaOH	CH_3COOH

8. It is known that gases A and B reach equilibrium as they react together to form gas C. The variation in concentration of these gases was monitored and graphed as illustrated below.



By applying Le Chatelier's principle, it can be predicted that at time t_1 the yield of the forward reaction will

A. Increase if pressure is increased.
B. Decrease if pressure is increased.
C. Decrease if pressure is decreased.
D. Not be affected by a change in pressure.

9. Before carrying out a titration between acetic acid, CH_3COOH, and potassium hydroxide, KOH, the equipment must be rinsed appropriately.
If the acid is to be dispensed from the burette, which of the following indicates the best rinsing procedure?

	Burette	*Pipette*	*Conical flask*
A.	rinsed with CH_3COOH	rinsed with H_2O	rinsed with KOH
B.	rinsed with H_2O	rinsed with KOH	rinsed with H_2O
C.	rinsed with H_2O	rinsed with H_2O	rinsed with KOH
D.	rinsed with CH_3COOH	rinsed with KOH	rinsed with H_2O

10. An HSC Chemistry student wished to determine the hardness of tap water by performing a titration. The indicator used for this titration required the pH to be maintained at about 10.

Which of the following mixtures should the student use as her buffer solution?

A. Ammonium chloride and hydrochloric acid
B. Sodium hydroxide and sodium ethanoate
C. Sodium ethanoate and ethanoic acid
D. Ammonia and ammonium chloride

11. A student was attempting to detect the presence of calcium ions in a solution containing nitrate ions and only one other cation. Which of the following could be used as a positive test for calcium ions?

A. A red flame is produced when a fine mist of the solution is sprayed into a Bunsen flame.
B. A yellow-green flame is produced when a fine mist of the solution is sprayed into a Bunsen flame.
C. A white calcium chloride precipitate is produced after the addition of hydrochloric acid.
D. A small amount of white ammonium chloride precipitate is produced after the addition of ammonia.

12. A student wished to analyse the sulphate content of a lawn fertiliser. Which of the following would be the best reagent to add to a solution of the fertiliser to perform a gravimetric analysis?

A. Iron sulphate
B. Sodium sulphate
C. Barium carbonate
D. Barium chloride

13. The following table compares some properties of gaseous oxygen and the oxygen free radical.
Which alternative best fits the correct descriptions?

	Gaseous oxygen		Oxygen free radical	
A.	less reactive	monatomic	more reactive	molecular
B.	less reactive	molecular	more reactive	monatomic
C.	more reactive	monatomic	less reactive	molecular
D.	more reactive	molecular	less reactive	monatomic

14. The concentration of carbon dioxide (CO_2) in the troposphere over Dubbo is measured to be 1.28×10^{-5} mol L^{-1}.

    Assuming conditions of 25°C and 100 kPa, what is this concentration in parts per million (ppm)?

    A. 0.00317 ppm
    B. 0.317 ppm
    C. 317 ppm
    D. 317 000 ppm

15. Read the following statements and choose the correct response.

    A. To dilute a concentrated acid, water should carefully be added to the acid.
    B. To dilute a concentrated acid, the acid should carefully be added to water.
    C. A spill of strong sulphuric acid on a laboratory bench top should be neutralised by adding dilute sodium hydroxide to it.
    D. A spill of strong sulphuric acid on a laboratory bench top should be neutralised by adding concentrated sodium hydroxide to it.

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CHEMISTRY

SECTION I: PART A

Multiple Choice Answer Sheet

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

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Section I (continued)

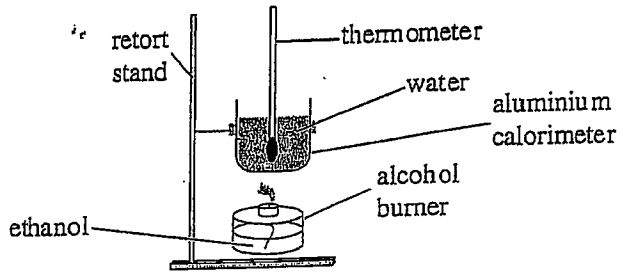
Part B

Total marks 60
Attempt Questions 16-27
Allow about 1 hour and 45 minutes for this part.

Answer Part B questions in the spaces provided.
Show all relevant working in questions that require calculations.

Question 16 (6 marks) Marks

A student assembled the following equipment in order to determine the molar heat of combustion of ethanol.



Experimental results found that the temperature of 100mL of water increased from 18°C to 58°C on burning 0.76 g of ethanol.

a) Define the term *molar heat of combustion.* 1

b) Write a balanced chemical equation to show the complete combustion of ethanol. 1

c) Calculate the molar heat of combustion of ethanol based on the experimental results. 2

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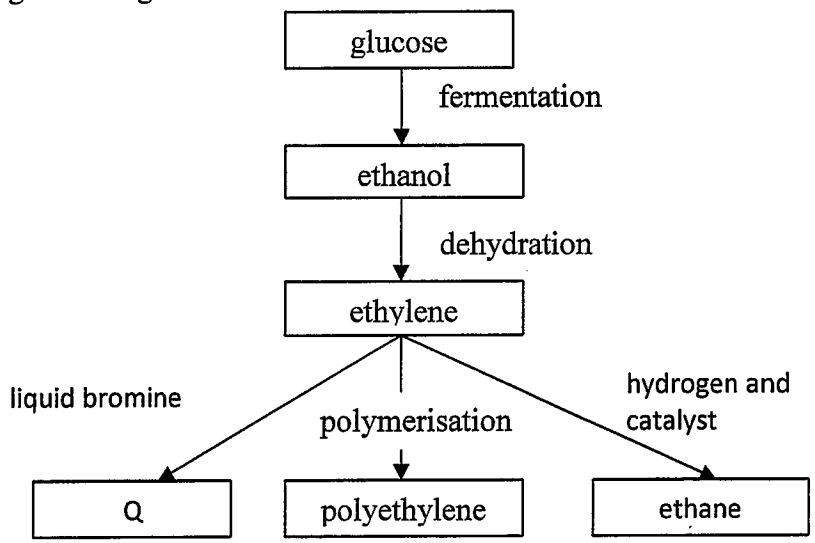
Marks

d) Explain how this calculated value would compare to the theoretical value. 2

Question 17 (4 marks)

The following flow diagram shows a series of reactions.



a) Draw a structural equation to illustrate the production of Q. 1

b) Ethylene can be readily converted into ethane. Give a reason for the presence of catalyst in the reaction. 1

c) Polyethylene can be used as a cling film. Describe this use in terms of its properties. 2

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Question 18 (6 marks) Marks

Assess the current and potential use of biomass as a means of reducing society's dependence upon fossil fuels. 6

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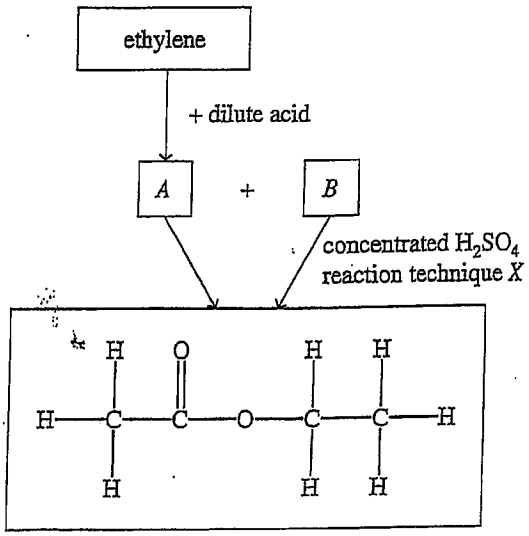
Question 19 (4 marks) Marks

The following flow chart shows a series of reactions using mainly carbon based compounds.



a) Identify the formula of compound A by writing a balanced equation that describes its production, as shown in the flow chart. 1

b) Name compound *B*. 1

c) Reaction technique X is needed to prevent the loss of volatile reactants and products. Identify two safety procedures needed when performing this technique and explain why they are necessary. 2

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Question 20 (7 marks) Marks

The allotropes of oxygen, O_2 and O_3, are both common in the Earth's atmosphere. However, they are found in different layers of the atmosphere.

a) Identify the layer of the atmosphere in which O_2 is most abundant. 1

b) Identify the layer of the atmosphere in which O_3 is most abundant. 1

c) With the use of Lewis electron dot structures, show how the shapes of ozone and oxygen are different. 2

d) Oxygen is sparingly soluble in water. Explain why ozone is considerably more soluble in water. 3

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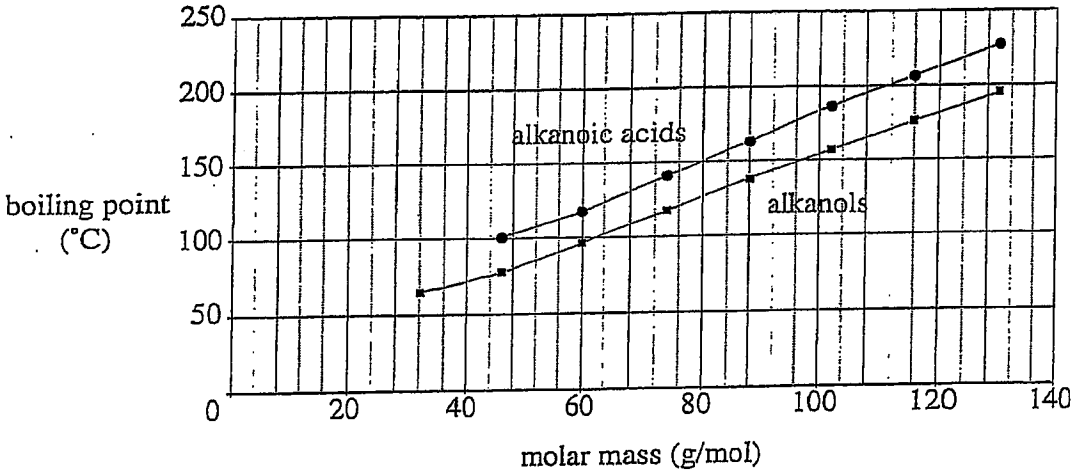
Question 21 (3 marks) Marks

During the HSC Chemistry course you performed a first-hand investigation in which you identified the pH of a variety of salt solutions. If solutions of NH_4Cl and Na_2CO_3 were used in this task, predict the acidic, basic or neutral nature that you would identify. Justify your prediction, inducing relevant equations in your answer. 3

Question 22 (5 marks)

Boiling points of straight-chained primary alkanols and alkanoic acids.



a) Using the graph above, explain the trend observed in the boiling points for molecules of the same molar mass. 3

Marks

b) Many products found in the supermarket contain acids or esters. Some of these are extracted from natural resources but an increasing number are being synthetically prepared. 2

Providing specific examples, outline the use of acids and esters in food products.

Question 23 (5 marks)

A titration was carried out using 0.246 mol L^{-1} HCl to standardise 25.0 mL aliquots of a solution of the weak base, sodium carbonate. An appropriate indicator was chosen to show the end point of the neutralisation. The results gained are shown in the table below.

Run	*1*	*2*	*3*	*4*	*5*
Initial burette volume (mL)	0.5	23.6	0.7	23.5	0.2
Final burette volume (mL)	23.5	45.8	23.0	46.2	22.4

a) Calculate the concentration of the sodium carbonate solution. Justify the steps in your calculation. 3

Marks

b) The student had a choice of indicators:
- Methyl orange; changes from red to orange from pH 3.0 to 4.5
- Phenolphthalein; changes from colourless to pink from pH 8.3 to 10.0

Select the indicator that should be used for this titration, giving a reason for your choice. 2

Question 24 (4 marks)

Ions such as lead, phosphate and copper can move from farms and industry into the environment where they can cause problems. 4

Describe and explain evidence for the need to monitor levels of ONE named ion used by society.

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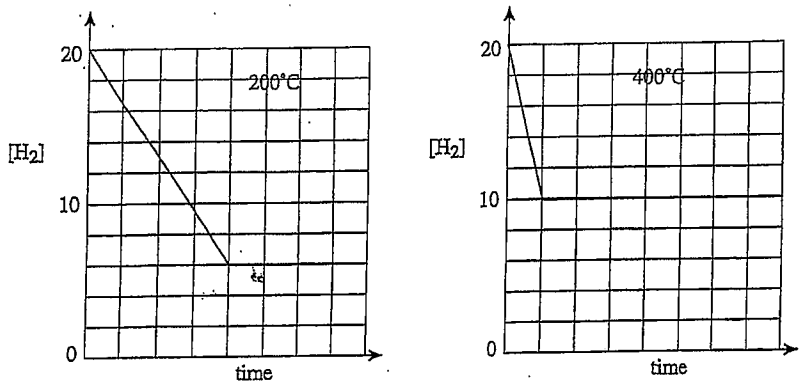
Question 25 (7 marks) Marks

The formation of ammonia from its constituent elements can be summarised using the following equation.

$$N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$$

This reaction was performed at two different temperatures. The change in the concentration of the hydrogen gas during reaction was monitored. The results were presented as follows.



Using these graphs, answer the following questions.

a) At which temperature was equilibrium achieved fastest? Explain your reasoning. 2

b) How can it be deduced that the formation of ammonia is exothermic? 2

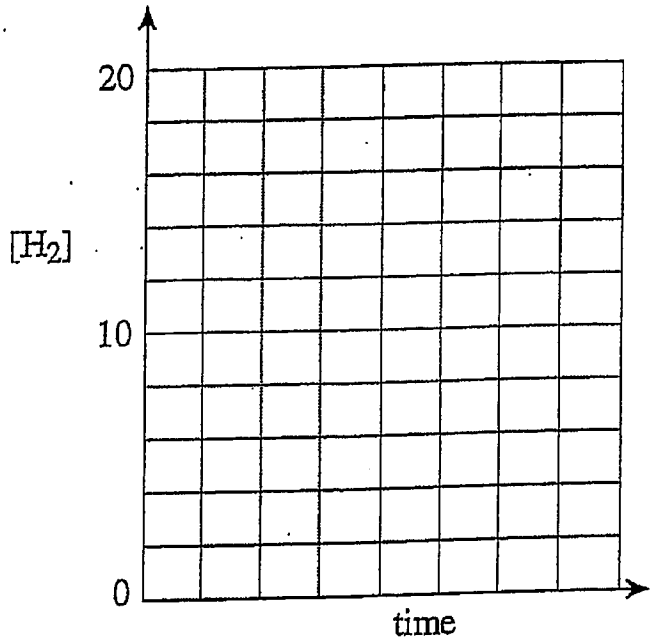
c) When this reaction is performed industrially, a catalyst is used. 1

Identify the catalyst.

Student Number_____

Marks

d) On the graph below, draw the curve to show how the concentration of hydrogen gas would vary during the reaction if a catalyst was used at 200°C. 2



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Question 26 (5 marks) Marks

Atomic absorption spectroscopy (AAS) provides a useful method in the analysis of ions. In fact, it could be described as the most significant advance of chemical analysis made in the 20^{th} century. 5

Evaluate the impact of the use of AAS on society and the environment.

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Question 27 (4 marks) Marks

In May 2003, heavy rains swept through the Sydney region. Describe a possible effect on each of the following factors that determine water quality of local waterways.

a) Turbidity 1

b) Total dissolved solids 1

c) Nitrogen to phosphorus ratio 1

d) pH 1

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Section II Marks

Question 28 – Industrial Chemistry (25 marks)

a) Sulphuric acid is a chemical of major importance to industrialised nations.

The production of sulphuric acid is a step-wise procedure. One of these steps is described by the equilibrium reaction

$$2SO_{2(g)} + O_{2(g)} \rightleftharpoons 2SO_{3(g)} + \text{heat}$$

(i) Write the expression for the equilibrium constant for the reaction as written above. 1

(ii) In one preparation, the following concentrations of gases were recorded at equilibrium. 2

$$[SO_2] = 0.4 \text{ mol L}^{-1}$$
$$[O_2] = 1.0 \text{ mol L}^{-1}$$
$$[SO_3] = 5.0 \text{ mol L}^{-1}$$

Calculate the value of the equilibrium constant, *K*.

(iii) Explain what would happen to the value of *K* and the position of equilibrium if 4

- The temperature at which the reaction was conducted was increased while keeping other conditions constant.
- The pressure on the reaction system was increased while keeping other conditions constant.

b) The large-scale use of many naturally occurring chemical products had led to the shrinkage of world resources.

(i) Identify one natural resource that is not a fossil fuel where its continual supply has become a problem. 1

(ii) Identify and describe a material that has been developed to replace the natural resource. 2

c) Sulphuric acid is one of the most important chemicals in industry and is produced in greater quantities that any other manufactured chemical.

(i) Safety is a particular concern when diluting sulphuric acid. Outline a procedure that you might follow to dilute a concentrated solution of sulphuric acid and explain why these safety precautions need to be followed. 4

(ii) Write balanced chemical equations to show sulphuric acid acting as an oxidising agent and a dehydrating agent. 2

(iii) Explain how an understanding of the properties of sulphuric acid is essential for its safe storage and transport. 3

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Marks

d) The production of sulphuric acid is one of the most important industrial processes for industrialised nations.

(i) Identify one industrial use of sulphuric acid. 1

(ii) Explain the role of oleum in the production of sulphuric acid. 2

e) Manipulating the reaction conditions of equilibrium reactions allows chemists to increase rates and yields of chemical reactions. An example of an equilibrium reaction is the production of carbonyl chloride.

$$CO(g) + Cl_2(g) + \text{heat} \rightleftharpoons COCl_2(g)$$

(i) Identify the factor which would change the value of *K* for this reaction. 1

(ii) Calculate the equilibrium constant for this reaction if equilibrium concentrations are: 2

CO: 0.50 M

Cl_2: 0.75 M

$COCl_2$:1.0 M.

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INDUSTRIAL CHEMISTRY:

(a) (i)_____

(a) (ii)_____

(a) (iii) _____

Student Number_____

INDUSTRIAL CHEMISTRY:

(b) (i) _____

(b) (ii) _____

Student Number_____

(c) (ii)_____

(c)(iii)_____

Student Number_____

INDUSTRIAL CHEMISTRY:

(d) (i) _____

(d) (ii) _____

(e) (i) _____

(e) (ii)_____

Data Sheet

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

Volume of 1 mole of 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 mass — 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 Phosphorous	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** 183.9 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

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
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 masses are not known, the relative atomic mass of the most common radioactive isotope is shown in brackets.

The atomic masses of Np and Tc are given for the isotopes ^{237}Np and ^{99}Tc.

Teacher copy (3) + extra page

2008

TRIAL HIGHER SCHOOL CERTIFICATE EXAMINATION

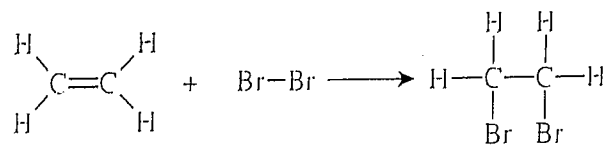
Chemistry

Section I: Part A.

Multiple Choice Answer Sheet

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

Part B

Sample answer	Syllabus content, course outcomes and marking guide
Question 16	
(a) The amount of heat released when one mole of a substance is completely combusted (burnt in sufficient oxygen) at constant temperature and pressure to produce carbon dioxide and water.	9.2.3 H7, H8, H13 • Correctly defines the molar heat of combustion. 1
(b) $C_2H_5OH_{(l)} + 3O_{2(g)} \rightarrow 2CO_{2(g)} + 3H_2O_{(g)}$	9.2.3 H9, H10, H13 • Correctly writes the balanced equation . . 1
(c) $q = m \times C \times \Delta T$ $= 100 \times 4.18 \times 40 = 0.1 \times 4.18 \times 10^3 \times 40$ $= 16720$ J $\Delta H = -q \div \frac{m}{M}$ $= -16720 \div \frac{0.76}{46.068}$ $= -1013496$ J/mol $= -1013.5$ kJ/mol	9.2.3 H8, H10, H13 • Correctly calculates the heat transferred to water • Correctly calculates the molar heat of combustion of ethanol (with negative sign) . . . . . 2 • Correctly calculates the heat transferred to water and the molar heat of combustion **without** negative sign OR • Correctly calculates the heat transferred to water only OR • Correctly calculates the molar heat of combustion of ethanol (with negative sign) 1
(d) The calculated value is probably lower than the theoretical value. Heat could be lost to the container and/or the surrounding environment; combustion may be incomplete (indicated by a build-up of soot on the base of the container); or some heat may have also been used to evaporate the water in the container.	9.2.3 H7, H8 • States that the calculated value would be lower than the theoretical value • Provides a clear explanation to account for this difference. . . . . 2 • States that the calculated value would be lower than the theoretical value OR • Provides a clear explanation to account for this difference OR • States that the calculated value would be lower than the theoretical value and gives a vague explanation 1
Question 17	
(a) 	9.2.1 H9 • Draws a correct structural equation 1
(b) The purpose of the catalyst is to speed up the rate of reaction (conversion of reactants to products) by lowering the activation energy. The catalyst remains in (or returns to) its original form at the end of the reaction.	9.2.1 H7, H8 • States a clear reason for the presence of the catalyst 1

Part B (Continued)

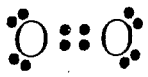
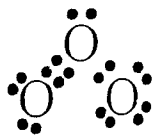
Sample answer	Syllabus content, course outcomes and marking guide
(c) Cling films are made from low-density polyethylene (LDPE).	9.2.1 H3, H4, H13 • Identifies several properties of LDPE • Clearly relates two or more properties to the use of the product. . . . . 2 • Identifies some properties of LDPE AND • Clearly relates one property to the use of the product 1

Property of LDPE	Suitability of property to use
Very flexible	Allows for it to be easily wrapped around items
Excellent cling properties	It can easily cling to itself
Transparent (fewer crystalline regions)	Better visibility of items that have been wrapped
Impermeable to water and resistant to most chemicals (including oil and grease)	Useful for sealing – keeps food crisp, prevents leakage, etc.
Melting point of approximately 115°C	Can be used to cover food that requires defrosting
Good elastic recovery and puncture resistance	Resistant to handling – retains toughness and pliability over a wide temperature range

Question 18

Biomass is material produced by living things, including plant material, which can be used to produce new substances or energy. There are a number of ways that biomass could be used to reduce our dependence on fossil fuels. One area of current research is in the area of the fermentation of suitable plant material, high in sugar or starch, to produce ethanol. The ethanol can then be used as an alternate transport fuel which would reduce our consumption of petrol (derived from a fossil fuel). Production of ethanol via fermentation has several advantages. The plant material (e.g. sugar cane, wheat etc.) is a renewable resource as opposed to petrol. The growth of the plant material also results in the absorption of carbon dioxide, partially off-setting the carbon dioxide released when the ethanol is combusted. However, to produce ethanol from plant material, large areas of arable land in a suitable climate must be made available to grow the crop. However, if ethanol could be produced from waste biomass high in cellulose (e.g. waste paper or corn field residue) this would not require this area of land to be set aside. Additionally, the cost of producing one litre of ethanol is higher than the current price of petrol. Although ethanol currently accounts for only a small percentage of fuel used for transport, as fermentation technology improves and the cost of petrol rises, the price of ethanol may become competitive and a greater amount of ethanol may be used as transport fuel in place of petrol from crude oil. Alternatively, cellulose-based feedstocks could be hydrolysed to produce glucose, which could be fermented to ethanol, which, in turn, could be dehydrated to ethene. The ethene could then be converted into a variety of petrochemicals. However, the cost of the production of ethene from cellulose is currently higher than the production of traditional synthetic polymers. As only a small amount of crude oil (less than 5%) is consumed to produce plastics, this strategy will have minimal impact on our consumption of crude oil.	9.2.1 H4, H5, H9, H14 • Describes at least two current and/or potential uses of biomass, encompassing fuel alternatives and the petrochemical industry. • Makes a clear judgment about the use of biomass for each application described, based on stated advantages and disadvantages of each application. • Relates the judgment to how biomass may reduce our dependence on fossil fuels. . . 6 • Describes at least two current and/or potential uses of biomass, encompassing fuel alternatives and the petrochemical industry. • Makes a clear judgment about the use of biomass for each application described, based on stated advantages and disadvantages of each application. OR • Describes at least two current and/or potential uses of biomass (may be only in one area e.g. fuel alternatives). • Makes a clear judgment about the use of biomass in this area, based on stated advantages and disadvantages of each application. • Relates the judgment to how biomass may reduce our dependence on fossil fuels. . . 5 • Describes at least two current and/or potential uses of biomass. • Outlines some advantages and disadvantages of these uses. OR • Describes at least two current and/or potential uses of biomass. • Explains in general terms how biomass may reduce our dependence on fossil fuels. OR • Describes at least two current and/or potential uses of biomass. • Makes a judgment about the described use based on some criteria.. 4

Question 19.		9.2.3, 9.3.5 H12, H13
(a)	$C_2H_4 + H_2O \rightarrow C_2H_5OH$ at 300°C in the presence of sulfuric or phosphoric acid.	• Writes a balanced equation for the production of ethanol by hydrating ethylene. 1
(b)	Acetic (ethanoic) acid.	• Correctly names acetic (ethanoic) acid. . . 1
(c)	Condenser used must not be sealed. This prevents the build-up of pressure which could otherwise cause the condenser to explode. The volatile reactants are flammable and so they must not be exposed to a naked flame or spark.	• Identifies two safety techniques and explains why they are needed. . . . . 2 • Identifies one safety technique and explains why it is needed. 1

Question 20	9.4.4 H6, H13
(a) Troposphere.	• Identifies the troposphere as the layer in the atmosphere in which oxygen is most abundant 1
(b) Stratosphere.	• Identifies the stratosphere as the layer in the atmosphere in which ozone is most abundant 1
(c) The Lewis electron dot structure for oxygen is  The Lewis dot structure for ozone is 	• Provides correct Lewis dot structure for both ozone and oxygen • Provides correct Lewis dot structure for either ozone or oxygent . . . . . 1 – correct shape
(d) Ozone and water are both polar molecules while oxygen is non-polar. Therefore the attraction between ozone and water is greater due to dipole-dipole interactions. Oxygen is only attracted to water by weak dispersion forces. This results in a greater relative solubility between ozone and water when contrasted with oxygen in water.	• Identifies that ozone is polar and oxygen is non-polar • Identifies that polarity of ozone creates attraction with polar water molecules • Identifies that oxygen is only attracted to water due to weak dispersion forces . . . . 3 • Identifies that ozone is polar and oxygen is non-polar • Identifies that polarity of ozone creates attraction with polar water molecules . . . 2 • Identifies that ozone is polar and oxygen is non-polar 1

both predictions correct but equns are not (1)

Part B (Continued)

Sample answer	Syllabus content, course outcomes and marking guide

Question 21

Salt	pH nature	Explanation or equations
NH_4Cl	acidic (pH < 7)	NH_4^+ ions react with water (as follows) to form an excess of H_3O^+ ions, thus lowering pH. $NH_4^+ + H_2O \rightleftharpoons NH_3 + H_3O^+$ Cl^- ion does not react with water.
Na_2CO_3	basic (pH > 7)	CO_3^{2-} ions react with water (as follows) to form an excess of OH^- ions, thus raising pH. $CO_3^{2-} + H_2O \rightleftharpoons HCO^{3-} + OH^-$ Na^+ ion does not react with water.

9.3.4 H11, H13

- Clearly states the correct pH nature for NH_4Cl, and Na_2CO_3
- Provides a thorough explanation for the pH nature of both salts, including correct ionic equations 3

- States the correct pH nature of each salt and provides a sound explanation of the pH nature of all both salts, including equations

OR

- Provides a thorough explanation of the pH nature of one salt only, including equations 2

- States the correct pH nature of each salt with no explanation

OR

- Provides limited explanation of the pH nature of the salts 1

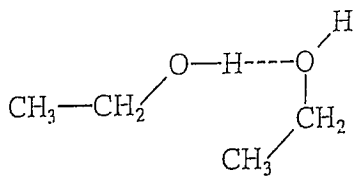
Question 22

(a) The observed trend is that for molecules of the same MM, alkanoic acids have a higher boiling point than the corresponding alkanol.

Alkanols and alkanoic acids of the same MM exhibit dispersion forces of equivalent strength. If these were the only forces present then alkanols and alkanoic acids of the same MM would have the same boiling point.

Alkanols also contain hydrogen bonding between neighbouring molecules (as seen in diagram). The $\delta+$ on H from the ——OH group of one molecule is attracted to the non-bonding electrons on the O of a neighbouring molecule.

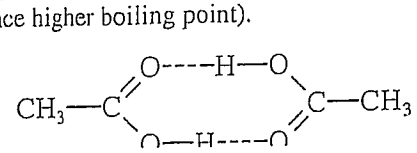
Ethanol



Alkanoic acid molecules can be involved in two sites of hydrogen bonding with a neighbouring molecule. The $\delta+$ on the H from the ——OH group of each molecule is hydrogen bonded to the non-bonding electrons on the O from the C═O group of the neighbouring molecule. This attraction is able to occur at two sites between each pair of molecules due to the shape of the molecules and orientation of the bonds (as can be seen in the diagram below).

The additional hydrogen bond that can occur between each pair of alkanoic acid molecules results in greater energy (higher temperatures) being needed to overcome intermolecular forces during boiling (hence higher boiling point).

Ethanoic acid



9.3.5 H2, H9

- Identifies the trend.
- Relates strength of intermolecular forces to boiling point.
- Thoroughly describes intermolecular forces in both alkanols and alkanoic acids.
- Identifies the presence of hydrogen bonding in both substances and clearly explains the reason for the alkanoic acids exhibiting more hydrogen bonds than the corresponding alkanol.
- Provides a clear and complete explanation for difference in boiling point. 3

- Identifies the trend.
- Relates strength of intermolecular forces to boiling point.
- Identifies the presence of hydrogen bonding in both substances.
- Provides a sound explanation for the difference in boiling point. 2

- Identifies the trend.
- Identifies the relationship between boiling point and intermolecular forces and identifies hydrogen bonding as a strong intermolecular force. 1

Part B (Continued)

Sample answer	Syllabus content, course outcomes and marking guide
(b)	9.3.3, 9.3.5 H3, H4 • Names an example of an acid and an example of an ester used in food production and outlines the use of both . . . . . 2 • Names an example of both an acid and an ester OR • Outlines the use of a specific, named acid OR • Outlines the use of a specific, named ester 1

Sample acids used in processed foods	Purpose of acid
Acetic acid, citric acid, tartaric acid, malic acid, fumaric acid or lactic acid	Preservative in pickles and other processed food
Phosphoric acid	Preservative in cola drinks
Sulfur dioxide (as sulfurous acid)	Preservative in dried fruits and wine
Ascorbic acid (vitamin C)	Antioxidant to protect soft drinks, jams, condensed milk and sausage

Acids are mostly used as preservatives in processed foods. Presence of the acid destroys most microbes present (that would cause food to spoil or go off) and prevents them multiplying, so over long periods the food material is conserved.

Sample esters used in processed foods	Purpose of ester
Isoamyl acetate	Artificial banana flavouring
Octyl gallate	Antioxidant in fats and oils for frying oils, seasoning, dehydrated soups, chewing gum
Polyglycerol esters and lactic acid esters	Emulsifiers in mayonnaise, margarine, creamy sauces
Triethyl citrate	Thickener in desserts, foam stabiliser

Esters can be used as flavour additives due to their strong scent and resulting effect on taste.

Emulsifiers allow water and oils to remain mixed together in an emulsion. The ester molecules stabilise emulsions in food products, preventing them from separating.

As an antioxidant, esters prevent oxidation of food in air. They help foodstuffs keep their taste and colour and remain edible over a longer period. They stop fats turning rancid.

Question 23 | 9.3.3 H10, H12

(a)

Run	*1 (rough)*	*2*	*3*	*4*	*5*
Initial burette volume (mL)	0.5	23.6	0.7	23.5	0.2
Final burette volume (mL)	23.5	45.8	23.0	46.2	22.4
Volume used	23.0	22.2	22.3	22.7	22.2

- Correct calculation justifying average titre used 3

Ignore the first (rough) titration and the fourth as they are too far away from the other readings. Therefore, the average volume of the concordant readings is 22.23 mL.

- Correct calculation using average of all values 2
- Correct equation.

OR

- Some correct working 1

$$Na_2CO_3 + 2HCl \rightarrow 2\,NaCl + CO_{2(g)} + H_2O_{(l)}$$

$$\text{Mol } Na_2CO_3 = \frac{1}{2}\text{mol(HCl)}$$

$$cV\,(Na_2CO_3) = \frac{1}{2}cV\,(HCl)$$

$$0.25 \times C = \frac{1}{2} \times 0.0246 \times 0.02223$$

$$Na_2CO_3 = 0.109 \text{ mol } L^{-1}$$

(b) Reaction between a strong acid and a weak base will produce an acidic solution, so methyl orange will be suitable.

- Chooses correct indicator and provides appropriate reason 2

Question 26

Criteria	Marks
• Thorough description and explanation of the need to monitor any named ion used by society. A thorough description would involve the source of the ion, how it moves into humans or other animals and a description of its harmful effects.	4
• Sound description and explanation of the need to monitor any named ion used by society. This description would involve the source of the ion and EITHER how it moves into humans or other animals OR a description of its harmful effects.	3
• A limited description or explanation of the need to monitor any named ion used by society. This would involve EITHER the source of the ion OR how it moves into humans or other animals OR a description of its harmful effects.	2
• Some knowledge of the need to monitor ions in society.	1

An ion such as lead needs monitoring in our environment for a number of reasons. Firstly, lead can escape from industry into waterways. from fuels such as petrol into the air and from the removal of lead based paints from renovation work into the air. Lead can then move into the food chain by being absorbed by fish across their gills into their blood supplies and stored in fat cells. Lead is a bioaccumulating chemical and remains in the fish body, accumulating throughout their life. It also passes up the food chain in increasing concentrations reaching dangerously high levels in animals at the top of the food chain such as tuna, swordfish, sharks and humans. In these animals and at these high concentrations it is toxic, causes brain damage and replaces calcium in bone. It can also be absorbed by humans by drinking water containing dissolved lead ions or by breathing air high in lead particles. In humans it can lead to retardation of intellectual development in children, anaemia or disruption to the reproductive system.

Question 25

(a) Equilibrium was achieved fastest at 400°C.

At this temperature, the concentration of hydrogen gas reached a constant value in the least amount of time.

9.4.2 H8, H13
- Correct explanation and temperature. . 1–2

(b) The formation of ammonia is maximised when the final concentration of hydrogen gas is at a minimum.

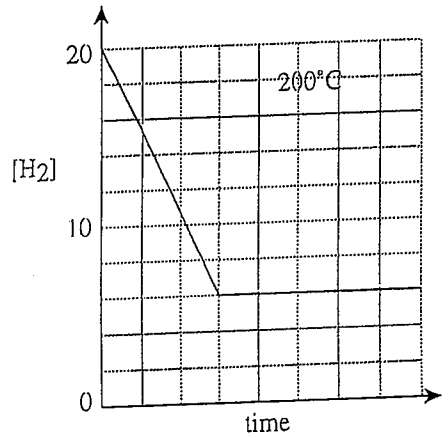
This occurs at the lower temperature of the two, showing that lower temperatures favour the formation of ammonia; therefore, the reaction is exothermic.

9.4.2 H3, H7, H8, H13, H14
- Correctly relates temperature to ammonia formation 1–2

(c) The catalyst is magnetite.

9.4.2 H3, H8
- Catalyst is magnetite or iron oxide 1

(d)



The curve drawn by the students needs to show that the time taken to reach equilibrium is less than the time taken on the graph supplied in the question book for that temperature, but the concentration of hydrogen gas at equilibrium is exactly the same value as that on the graph supplied in the question book for that temperature.

9.4.2 H8, H13
- Correct relationship between time and $[H^+]$ 1–2

Part B (Continued)

Sample answer	Syllabus content, course outcomes and marking guide
Question 26	

Various effects on society and the environment could be addressed. Key areas relating to the HSC course refer to the understanding of trace elements and effective pollution control. While quite a number of specific aspects have been outlined here it is not expected that all of them would be included in a student's answer:
• Atomic absorption spectroscopy (AAS) can measure trace quantities of elements in materials. Trace elements such as Cu, Zn, Co and Mo are required by all living organisms for the proper functioning of their physiological processes, but only in very small quantities. In high doses, they can be toxic.
• AAS revealed the importance of the trace metal lithium in stabilising mood swings in people.
• AAS allows chemists to investigate the role of trace elements in a wide variety of situations such as:
  • Soil analysis to promote the healthy growth of crops and stock.
  • Blood and urine analysis to detect deficiencies and thus alter diet accordingly.
  • Hair analysis to link trace mineral levels to behaviour disorders, cardiovascular disease and some cancers.
• In terms of society and the environment, the most significant impacts of AAS relate to the ability to identify trace metals in humans, animals, plants and the foods we eat. It has also enabled us to measure pollution from trace quantities of heavy metals.
• There are many positive effects on society and the environment. AAS has important applications in medicine, agriculture, mining, metallurgy, food analysis, biochemistry and environmental monitoring.
• Amongst the applications is the improvement in the speed of mineral exploration through more rapid assaying of ore samples. This is associated with monetary savings and greater efficiency.
• AAS is also used to detect corrosion in tinned foods, Hg levels in fish, Cu, Pb and Fe levels in wine and Mg levels in steel.
• Scientists have been able to establish which trace metals are required for specific biochemical pathways, which has had a large impact on our understanding of the functioning of the body. Prior to this knowledge, deficiency diseases could not be explained. Fertilisers can now be fortified with necessary micronutrients and diets supplemented where necessary.
• The EPA presently requires that industrial wastewater that is released into waterways must have a Hg concentration that is < 2ppm. Human food, such as fish and other seafood, should contain ≤ 0.5 ppm Hg. Measurements at these levels could not be made without the advent of AAS.
• However, AAS by no means provides all the answers. Whilst the discovery of the essentiality of trace elements has created vast benefits to agricultural production, the application of this knowledge to problems of human and animal health still depend on developing a clear understanding of how molecular and biochemical mechanisms are linked to the symptoms of deficiencies and their appearance.
	9.4.3 H1, H4, H13
	• Outlines several applications of the use of AAS.
	• Describes specific examples that cause an impact on society and the environment including those related to trace elements and those related to pollution control.
	• Outlines several beneficial effects resulting from the use of AAS.
	• Outlines limitations of AAS techniques.
	• Makes a comprehensive judgement based on criteria about the impact of AAS on both society and the environment and supports this judgement with specific evidence. . . 5
	
	• Outlines a few applications of the use of AAS.
	• Describes specific examples that cause an impact on society and the environment including those related to trace elements and those related to pollution control.
	• Outlines several beneficial effects resulting from the use of AAS.
	• Makes a clear judgement about the impact of AAS on both society and the environment and supports this judgement with specific evidence. 4
	
	• Outlines a few applications of the use of AAS.
	• Describes examples that cause an impact on society and the environment such as those related to trace elements or pollution control.
	• Outlines a few benefits resulting from the use of AAS.
	• Makes a judgement about the impact of AAS on both society and the environment. 3
	
	• Outlines a couple of applications of the use of AAS.
	• Outlines a few benefits resulting from the use of AAS.
	• Makes a simple judgement about the impact of AAS on society or the environment and supports this judgement. 2

Part B (Continued)

Sample answer	Syllabus content, course outcomes and marking guide
Question 26 (Continued) Overall, due to an increased understanding of trace elements, the development of AAS has had major health benefits for communities, as well as benefits for agriculture, mining and, therefore, the economy. AAS has also led to an application in pollution control, particularly with respect to the detection of very low levels of toxic heavy metals, especially in waterways and seafood. This has resulted in more stringent and sensitive pollution controls and greater accountability for organisations releasing these contaminants. Ultimately, this leads to a decrease in the level of pollutants being released into the environment. This, in turn, results in positive effects on the health of organisms and society, as well as related economic costs. *Some specific overall advantages and disadvantages of AAS analysis are listed below as possible inclusions in an answer:* **Beneficial impacts of AAS** • AAS has provided a quick, easy, accurate and highly sensitive means of determining the concentrations of over 65 elements. • AAS has enhanced our understanding of the importance and effects of trace elements, the existence of which was not known until AAS was developed. • It has hence led to the ability of detecting trace elements in very low concentrations and thus diagnosis of deficiencies or imbalances. • AAS has increased our ability to detect pollutants, such as heavy metals (e.g. Pb, Hg, Cd, Cr), at very low levels (measured in parts per million (ppm) and parts per billion (ppb)) in waterways and soils. • AAS is very specific as it can determine the concentration of a metal ion in the presence of other metals without any interference. • AAS provides very quick analysis by using multiple batches which is not possible with old techniques. • The reliability of results is high since many repetitions of the measurements can be made quickly. Old techniques were too slow. • It has earned millions of export dollars for Australia! **Limitations of AAS** • Chemists need to know for which element the sample is being analysed, such as testing for a particular pollutant or deficiency. • A series of standard solutions need to be prepared for accurate analysis. This means knowing what range of concentrations need to be prepared. • Some anions may interfere with AAS analysis. • Although many trace elements have been identified, the biochemical mechanisms of action and their implications for human health are unknown.	• Outlines a couple of applications of the use of AAS. • States an impact on either society or the environment. OR • Makes a simple judgement about the impact of AAS on either society or the environment. 1

Question 27	
(a) Turbidity will increase as more undissolved solids enter the waterway and become suspended. (b) Total dissolved solids will increase due to runoff. (c) Nitrogen:phosphorus ratio will increase as sewage and garden runoff adds nutrients. (d) pH will probably be unaffected or slightly lower since rain is slightly acidic.	9.4.5 H4, H8, H14 • Correct description of each effect . . . . . 4 • Correct description of 3 effects . . . . . 3 • Correct description of 2 effects . . . . . 2 • Correct description of 1 effect 1

Section II

Question 28 Industrial Chemistry

Sample answer	Syllabus outcomes and marking guide
(a) (i) $2SO_{2(g)} + O_{2(g)} \rightleftharpoons 2SO_{3(g)}$ $K = \dfrac{[SO_3]^2}{[SO_2]^2[O_2]}$	9.5.2 H8, H10 • Correct equilibrium expression (no units required). 1
(ii) $K = \dfrac{5^2}{0.4^2(1)}$ $= 156$	9.5.2 H10 • Correct response . . . . . 2 • Calculates equilibrium concentrations but substitutes incorrectly 1
(iii) Temperature increase leads to equilibrium shifting to the left. The value of K decreases. Pressure increase shifts equilibrium to the right. This does not change the value of K.	9.5.2 H3, H8, H13 • All four statements correct. . . . . 4 • Three statements correct . . . . . 3 • Two statements correct . . . . . 2 • One statement correct 1
(b) (i) Rubber which is the sap collected from the bark of rubber trees.	9.5.1 H3, H4 • Correctly identifies a dwindling natural resource. 1
(ii) Styrene-butadiene rubber is a polymer made from styrene and butadiene monomers.	• Correctly identifies a replacement material. AND • Describes one feature of the structure of the replacement material. . . . . 2 • Correctly identifies a replacement material. 1
(c) (i) Before performing the dilution eye protection, gloves and protective clothing should be put on. To dilute the acid, the concentrated acid must be slowly added to the water with continuous stirring. The ionisation of sulfuric acid is an exothermic process that releases heat energy. If water is added to the concentrated acid, the heat released can cause the water to boil, releasing steam and causing the acid to spit violently. This is highly dangerous and poses a significant safety hazard.	9.5.3 H7, H8, H12 • Outlines a procedure which indicates the need for wearing protective clothing or glasses. AND • States that sulfuric acid must be added to the water. AND • Explains the safety precautions by stating that the ionisation of sulfuric acid is exothermic. AND • Describes the effects and consequences of adding water to the acid . . . . . 4 • Any three of the above. . . . . 3 • Any two of the above. . . . . 2 • Any one of the above. 1
(ii) Oxidising agent: $Cu + 2H_2SO_4 \rightarrow CuSO_4 + 2H_2O + SO_2$ Dehydrating agent: $C_{12}H_{22}O_{11} + H_2SO_4 \rightarrow 12C + 11H_2O$	• Writes two correctly balanced chemical equations showing sulfuric acid acting as a dehydrating agent and an oxidising agent. . . . . 2 • Writes one correctly balanced chemical equation showing sulfuric acid acting as either a dehydrating agent or an oxidising agent. 1

Question 28 Industrial Chemistry (Continued) Sample answer	Syllabus content, course outcomes and marking guide
(d) (i) Production of ammonium sulfate fertiliser.	9.5.3 H3 • Correct use 1
(ii) Oleum ($H_2S_2O_7$) is the product of the dissolution of SO_3 into concentrated H_2SO_4. $SO_{3(g)} + H_2SO_{4(l)} \rightarrow H_2S_2O_{7(l)}$ Water is then added to the oleum to produce sulfuric acid: $H_2S_2O_{7(l)} + H_2O_{(l)} \rightarrow 2H_2SO_{4(l)}$ The sulfuric acid is produced in this stepwise procedure as adsorption of SO_3 in water is a highly exothermic process. It would normally produce a fog of H_2SO_4 that is very difficult to dissolve in water.	9.5.3 H7, H8 • Discusses formation of oleum using equation and why it is used as an intermediary . . . . . 2 • Only shows the formation of oleum. 1
(e) (i) Temperature.	9.5.2 H7, H8 • Identifies the factor which changes K . . . 1
(ii) $K = \frac{[COCl_2]}{[CO][Cl_2]}$ $= \frac{1.0}{0.5} \times 0.75$ $= 2.7$ *(units not required)*	9.5.2 H10, H14 • Writes a correct equilibrium constant expression. • Correctly calculates K, showing working . . . . . 2 • Writes a correct equilibrium constant expression. OR • Correctly calculates K without showing

(iii)

Criteria	Marks
Student correctly explains that concentrated sulfuric acid can be stored in iron containers because it is molecular and it is not until it is ionised by water that it can attack that metal AND The transport is also carried out in iron tankers with great care being taken to keep out moisture AND Diluted sulfuric acid must be stored in glass which is inert and will not be attacked by the hydronium ion.	3
Student refers to two of the above.	2
Students refers to only one aspect mentioned above	1

Question 28 Industrial Chemistry (Continued) Sample answer			Syllabus content, course outcomes and marking guide
(d)	(i)	Production of ammonium sulfate fertiliser.	9.5.3 H3 • Correct use 1
	(ii)	Oleum ($H_2S_2O_7$) is the product of the dissolution of SO_3 into concentrated H_2SO_4. $SO_{3(g)} + H_2SO_{4(l)} \rightarrow H_2S_2O_{7(l)}$ Water is then added to the oleum to produce sulfuric acid: $H_2S_2O_{7(l)} + H_2O_{(l)} \rightarrow 2H_2SO_{4(l)}$ The sulfuric acid is produced in this stepwise procedure as adsorption of SO_3 in water is a highly exothermic process. It would normally produce a fog of H_2SO_4 that is very difficult to dissolve in water.	9.5.3 H7, H8 • Discusses formation of oleum using equation and why it is used as an intermediary . . . . . 2 • Only shows the formation of oleum. 1
(e)	(i)	Temperature.	9.5.2 H7, H8 • Identifies the factor which changes K . . . 1
	(ii)	$K = \frac{[COCl_2]}{[CO][Cl_2]}$ $= \frac{1.0}{0.5} \times 0.75$ $= 2.7$ *(units not required)*	9.5.2 H10, H14 • Writes a correct equilibrium constant expression. • Correctly calculates K, showing working . . . . . 2 • Writes a correct equilibrium constant expression. OR • Correctly calculates K without showing