SYDNEY GRAMMAR SCHOOL

2007
FORM VI
TRIAL HSC EXAMINATION

Chemistry

General Instructions

- Reading time – 5 minutes.
- Working time – 3 hours
- Board-approved calculators may be used
- Write using blue or black pen
- Draw diagrams using pencil
- A Data Sheet and Periodic Table are provided at the back of this paper
- Write your candidate number and master's initials at the top of each page in Part B and on the answer booklet

CHECKLIST	
Each boy should have the following :	
1 Question Paper	
1 Multiple Choice Answer Sheet	
1 5 - Page Booklet	

Chemistry Classes.

1 MMB	2 RJF	3 JAG
4 JAG	5 TW	6 MTK

Section I Pages 2 - 22

Total marks (100)

This section has two parts, Part A and Part B

Part A
Total marks **(15)**
- Attempt Questions 1-15
- Allow about 25 minutes for this Section

Part B
Total marks **(69)**
- Attempt Questions 16-27
- Allow about 2 hours for this Section

Section II Pages 23-26
Total marks **(16)**
- Attempt Question 28 in this section.
- Allow about 35 minutes for this Section

Part A

Total marks (15)
Attempt Questions 1-15
Allow about 25 minutes for this Part

Use the multiple-choice Answer Sheet.

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

Sample 2 + 4 =

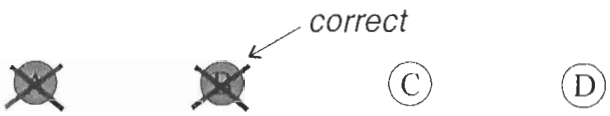
(A) 2 (B) 6 (C) 8 (D) 9

Ⓐ Ⓑ Ⓒ Ⓓ

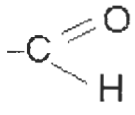
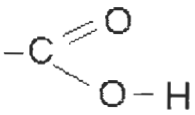
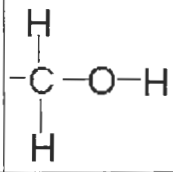
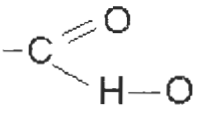
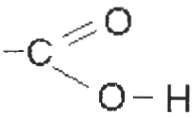
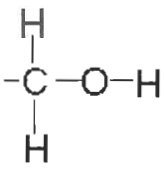
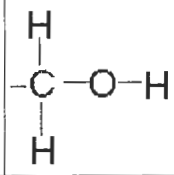
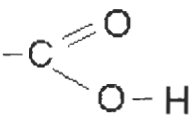
If you think you have made a mistake, put a cross through the incorrect answer and fill in the new answer.

Ⓐ Ⓑ Ⓒ Ⓓ

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



1 Which of the following combinations listed below correctly identifies the functional groups of alkanol and alkanoic acid.

	alkanol functional group	alkanoic acid functional group
A		
B		
C		
D		

2 What was the Montreal Protocol and its subsequent amendments designed to do?

(A) reduce the release of greenhouse gases.
(B) ban production of greenhouse gases.
(C) limit the production of greenhouse gases to developing countries.
(D) phase out the use of CFCs, halons and related substances.

3 Which of the following substances could cause eutrophication in a water supply?

(A) Ammonium nitrate
(B) Sodium chloride
(C) Calcium sulfate
(D) Sulfuric acid

4 Concentrated sulfuric acid is classified as an oxidising agent. The sulfate ion is usually converted to sulfur dioxide as shown in the following equation:

$$Sn_{(s)} + 2H_2SO_{4(l)} \rightleftharpoons SnSO_{4(aq)} + SO_{2(g)} + 2H_2O_{(l)}$$

Which statement concerning this reaction is correct?

(A) The oxidation state of sulfur does not change.
(B) Tin is reduced as its oxidation state changes from 0 to +II.
(C) The oxidation state of sulfur decreases from +VI to +IV.
(D) The sulfuric acid loses electrons as it is converted to sulfur dioxide.

5 Which of the following tests is best used to monitor the total dissolved solids in water?

(A) hardness
(B) dissolved oxygen and biochemical oxygen demand
(C) concentration of lead ions
(D) conductivity

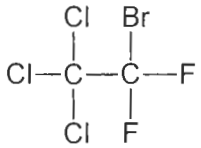
6 The composition of unpolluted dry air at sea level is given in the table below.

Substance	**% by volume**
Nitrogen	78.1
Oxygen	20.9
Argon	0.93
Carbon dioxide	0.038
others	each < 0.01

Which of the following represents the concentration in ppm (by volume) of carbon dioxide in the troposphere?

(A) 38 ppm
(B) 380 ppm
(C) 3800 ppm
(D) 38000 ppm

7 What is the name of the following compound?



(A) 1 – bromo – 1,1,1 – trichloro – 1,2 - difluoroethane
(B) 2 – bromo – 1,1,1 – trichloro – 2,2 - fluoroethane
(C) 1 – bromo – 2,2,2 – trichloro – 1,1 - difluoroethane
(D) 1,1,1 – bromo – 2 – trichloro – 2,2 - difluoroethane

8 Which statement best represents Arrhenius' definition of an acid?

(A) Acids contain oxygen.
(B) Acids are proton donors.
(C) Acids contain hydrogen.
(D) Acids form hydrogen ions in water.

9 Which of the following is the best indicator for a strong acid – weak base titration?

(A) phenolphthalein
(B) bromothymol blue
(C) methyl orange
(D) universal indicator

10 Consider the following information about the oxides of three elements **X**, **Y** and **Z** (not their chemical symbols).

- The oxide of **X** reacts with base only.
- The oxide of **Y** reacts with acid only.
- The oxide of **Z** reacts with both acid and base.

Which of the following could represent **X**, **Y** and **Z** respectively?

(A) Cl, Na, Mg
(B) S, Li, Al
(C) Zn, Cl, P
(D) K, P, Zn

11 What would be the pH of a 0.1 M solution of citric acid?

(A) less than 1.0
(B) 1.0
(C) between 1.0 and 7.0
(D) greater than 7.0

12 Which isotope is most likely to be radioactive?

(A) ^{17}O
(B) ^{19}F
(C) ^{45}Ca
(D) ^{1}H

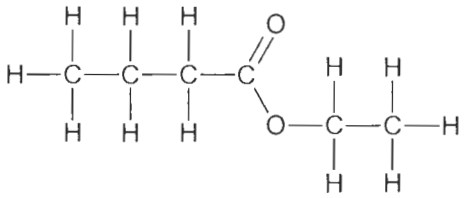
13 Which of the following reactions will occur as written?

(A) $Cu_{(s)} + Zn(NO_3)_{2(aq)} \rightarrow Cu(NO_3)_{2\,(aq)} + Zn_{(s)}$
(B) $Cu_{(s)} + Sn(NO_3)_{2\,(aq)} \rightarrow Cu(NO_3)_{2\,(aq)} + Sn_{(s)}$
(C) $2Ag_{(s)} + Cu(NO_3)_{2\,(aq)} \rightarrow 2AgNO_{3(aq)} + Cu_{(s)}$
(D) $Sn_{(s)} + Cu(NO_3)_{2\,(aq)} \rightarrow Sn(NO_3)_{2\,(aq)} + Cu_{(s)}$

14 What is the name of the process by which ethanol is purified from aqueous solution?

(A) distillation
(B) fermentation
(C) filtration
(D) polymerisation

15 What is the IUPAC name of the following ester?



(A) butyl ethanoate
(B) ethyl propanoate
(C) ethyl butanoate
(D) butyl propanoate

Masters' Initials | Candidate Number

Part B

Total marks (69)
Attempt ALL Questions
Allow about 2 hours for this Part

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

Question 16 (4 marks) **Marks**

When a zinc strip is placed in a solution of silver nitrate a chemical reaction takes place.

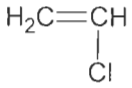
(a) Write half-equations for the oxidation and reduction reactions taking place, and write a balanced chemical equation for the overall reaction. **2**

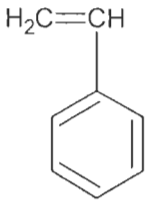
(b) Calculate the E_{cell} if these two half-reactions comprised an electrochemical cell under standard conditions. **1**

(c) Predict and explain any observations that would be made if a silver strip was placed in a solution of zinc nitrate. **1**

Question 17 (3 marks) **Marks**

The structures of two commercially significant monomers are shown.





(a) Identify the systematic name of ONE of the monomers.

_____ 1

(b) Describe the type of polymerisation that the monomers shown above undergo.

_____ 1

_____

_____

_____

(c) Draw the structure of a polymer made from one of the above monomers.

1

Masters' Initials | Candidate Number

Question 18 (5 marks) **Marks**

Oxygen has two allotropes O_2 and O_3.

(a) In the space provided draw Lewis electron dot diagrams for O_2 and O_3.

1

(b) Contrast two properties (chemical or physical) of O_2 and O_3 and explain these properties on the basis of molecular structure and/or bonding.

4

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Masters' Initials | Candidate Number

Question 19 (4 marks) **Marks**

Identify a buffer in a natural system and explain how the buffer works with reference to your example.

4

Question 20 (4 marks)

(a) Give the name and formula for ONE amphiprotic ion.

2

(b) Write the formulas for an acid-base conjugate pair. Identify which is the acid and which is the base.

2

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Masters' Initials | Candidate Number

Question 21 (7 marks) **Marks**

In the course of his studies a pupil measured the pH of identical concentrations of hydrochloric acid and acetic acid.

(a) Explain the difference in pH of the two solutions. **2**

He then diluted each solution by a factor of 10.0.

(b) Describe the procedure he should use to perform this task. **2**

When he re-measured the pH of each solution, the pH of the hydrochloric acid had increased by one pH unit, but that of the acetic acid had increased by only 0.5 pH units.

(c) Explain why pH increases as the solutions are diluted. **1**

(d) Explain why the two solutions change pH by different amounts. **2**

Question 22 (8 marks) **Marks**

Consider the table of boiling points given below.

substance	**bp (^{o}C)**
ethyl ethanoate	77
ethanol	78
water	100
ethanoic acid	118
sulfuric acid	337

(a) Explain the difference in boiling point between ethanol and ethanoic acid. **2**

(b) Write a balanced chemical equation, using structural formulas, for the reaction between ethanol and ethanoic acid to form an ester. **2**

(c) Justify the use of *heating under reflux* when carrying out this reaction. **2**

Question 22 continued on next page.

Masters' Initials | Candidate Number

Question 22 continued **Marks**

(d) Discuss the usefulness of distillation as a technique to separate the product ester from the reaction mixture.

1

(e) Explain the use of esters in processed foods and cosmetics.

1

Question 23 (9 marks)

A quality control chemist was given the task of checking the amount of citric acid ($C_6H_8O_7$) in sachets to be sold in supermarkets.

The sachet contained 1.750g of powder. The contents of a sachet was transferred quantitatively to a conical flask and dissolved in 20mL of water. An indicator was added and the acid titrated with standardised 1.050 M sodium hydroxide solution. 23.80mL of base was required to reach the end point.

(a) Identify a suitable indicator for the titration and justify your choice.

2

(b) State how you would identify the end point of the titration.

1

Question 23 continued on next page.

Question 23 continued **Marks**

(c) Calculate the percentage of citric acid in the sachet. [Citric acid was the only acid present.]

4

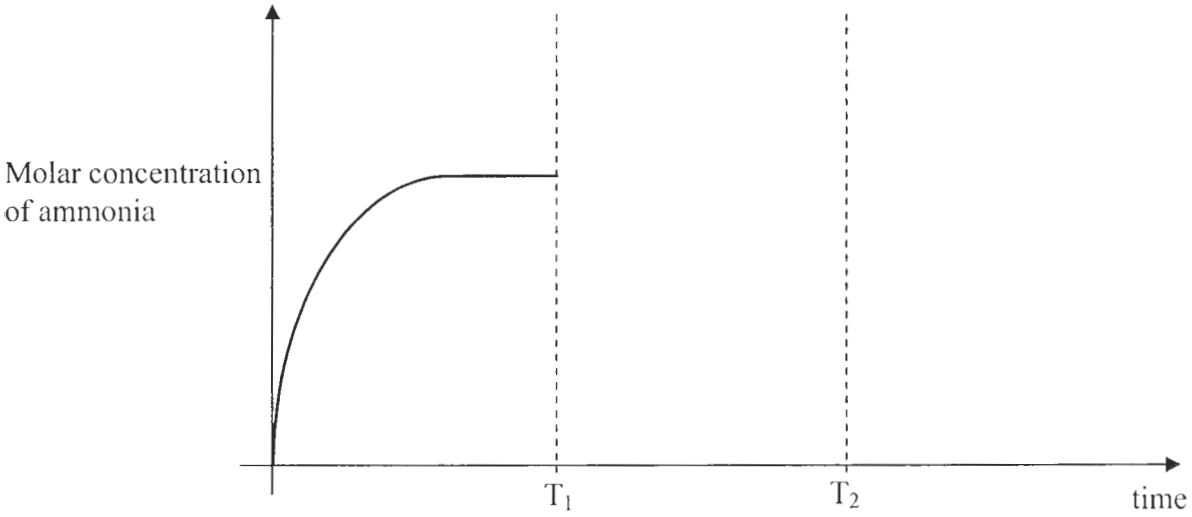
(d) Explain the use of acids as food additives.

2

Masters' Initials | Candidate Number

Question 24 (4 marks) **Marks**

A laboratory experiment was set up to model the Haber process. Nitrogen gas and hydrogen gas were passed over an iron/iron oxide catalyst at 500°C and 25MPa. The molar concentration of ammonia gas was monitored over a period of time and the data graphed as shown below.



At time T_1 the volume of the reaction vessel was doubled while the temperature remained constant.

Sketch on the graph above:

(i) the change in concentration of ammonia gas at T_1. **1**

(ii) the concentration of ammonia after T_1 when a new equilibrium was reached at T_2. **1**

(iii) Explain the changes that you have sketched on the graph. **2**

Question 25 (9 marks) **Marks**

A sample of water was collected from a storm water channel. This channel runs into the ocean. Samples were analysed on site and in the school laboratory. The results are recorded in the table below.

Property	Values	Typical clean water values
Temperature	17°C	N/A
Total dissolved solids	3500 ppm	<100
pH	7.5	6.5-7.3
Dissolved oxygen	9 mg/L	7-9 mg/L
Total phosphate	0.1 mg/L	0.01 mg/L
Nitrate	0.5 mg/L	0.1 mg/L

(a) Identify a property in the above table that should be tested 'on site'.

_____ **1**

(b) Justify your response to part (a).

_____ **1**

_____

(c) Briefly describe how you would find the mass of undissolved solids in the water sample.

_____ **2**

_____

_____

_____

Question 25 continued on next page.

Masters' Initials | Candidate Number

Question 25 continued **Marks**

(d) Propose one reason to explain the relatively high value of total dissolved solids:

_____ **1**

_____

(e) It is suspected that lead has contaminated the storm water channel. Describe a chemical test that could be carried out on the water sample to determine the presence of lead ions.

_____ **2**

_____

_____

_____

(f) The concentrations of ions in substances used by society need to be monitored. Justify this statement with reference to ONE ion you have studied.

_____ **2**

_____

_____

_____

Question 26 (5 marks) **Marks**

The presence of CFCs and halons in the upper atmosphere has led to a decrease in ozone levels in spring, particularly over Antarctica.

(a) What is a CFC?

_____ **1**

_____

(b) Identify one possible origin of CFCs in the atmosphere.

_____ **1**

_____

(c) Explain how CFCs destroy ozone. Use relevant chemical equations in your response.

_____ **3**

_____

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Masters' Initials | Candidate Number

Question 27 (7 marks) **Marks**

Evaluate the potential of ethanol as a fuel to replace petroleum.

7

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Section II

16 marks
Attempt question 28 in this section.
Allow about 35 minutes for this section.

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

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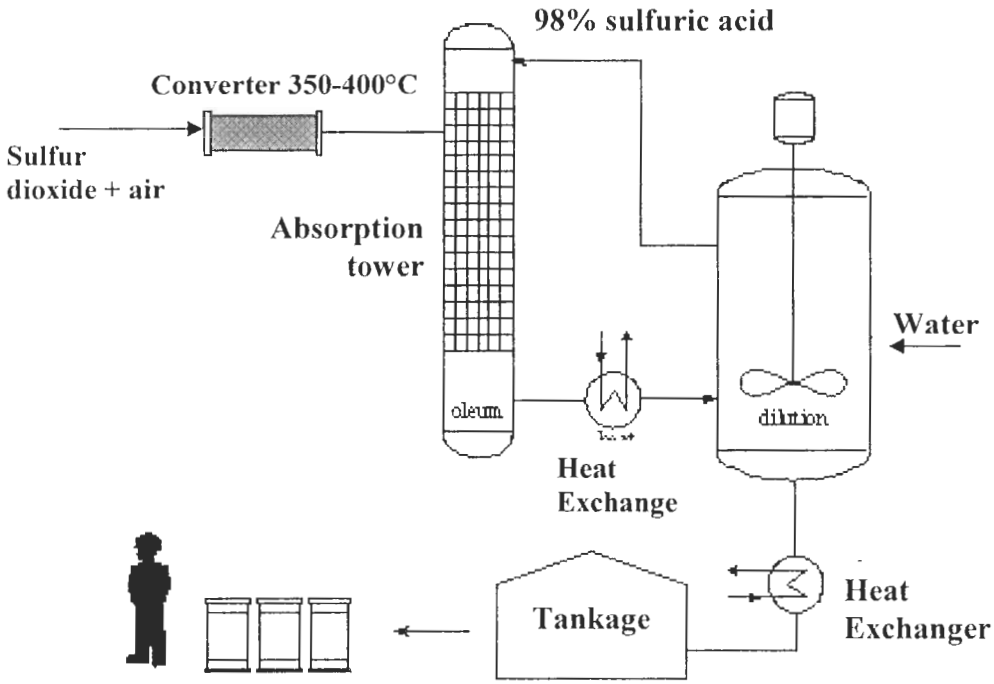
Question 28 (16 marks) **Marks**

(a) The diagram below shows the production of sulfuric acid by the Contact process.



(i) Write an equation for the reaction which occurs in the converter. **1**

(ii) Name the catalyst which is present in the converter. **1**

(iii) The pressure in the converter is about 100 kPa and the temperature is nearly 400°C. Explain why these conditions are used. **2**

(iv) Explain why heat exchangers are necessary whenever the concentration of sulfuric acid changes. **1**

(v) Based on the properties of sulfuric acid, describe the safety precautions that are necessary for its transport. **3**

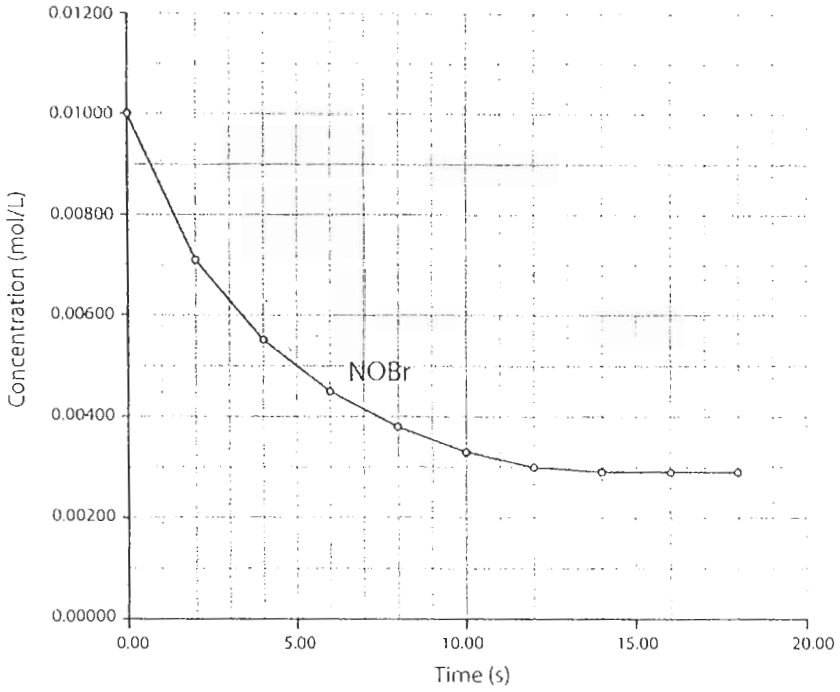
(vi) Identify TWO uses of sulfuric acid. **2**

Question 28 continued on next page.

(b) Experimental data has been collected for the decomposition of nitrosyl bromide (NOBr) as a function of time at constant temperature in a closed system. The reaction equilibrium is:

$$2NOBr_{(g)} \rightleftharpoons 2NO_{(g)} + Br_{2(g)}$$

The graph shows the change in concentration of NOBr with time.



(i) At what time does the system reach equilibrium? **1**

(ii) Using data from the graph above, calculate the value of K for the decomposition of NOBr. **4**

(iii) Both NOBr and Br_2 are reddish brown, so this property cannot be used to monitor the system as it approaches equilibrium. Identify a measurable property of the system that a chemist can readily use to determine when the system has reached equilibrium. **1**

Data Sheet

Avogadro's constant, N_A		6.022×10^{23} mol^{-1}
Volume of 1 mole ideal gas:	at 100 kPa and	
	at 0 °C (273 K)	22.71L
	at 25 °C (298K)	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 Jkg^{-1}K^{-1}

Some useful formulae

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

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
$SO_4^{2-} + 4H^+ + 2e^-$	$\rightleftharpoons$	$SO_{2(g)} + 2H_2O$	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
$\frac{1}{2} O_2 + 2H^+ + 2e^-$	$\rightleftharpoons$	H_2O	1.23 V
$\frac{1}{2} Cr_2O_7^{2-} + 7H^+ + 3e^-$	$\rightleftharpoons$	$Cr^{3+} + \frac{7}{2} H_2O$	1.36 V
$\frac{1}{2} Cl_{2(g)} + e^-$	$\rightleftharpoons$	Cl^-	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 — 79 — Symbol of element
Atomic Weight — 197.0 — Name of element
Au — 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 65.41 Zinc	31 Ga 69.72 Gallium	32 Ge 72.64 Germanium	33 As 74.92 Arsenic	34 Se 78.96 Selenium	35 Br 79.90 Bromine	36 Kr 83.80 Krypton
37 Rb 85.47 Rubidium	38 Sr 87.62 Strontium	39 Y 88.91 Yttrium	40 Zr 91.22 Zirconium	41 Nb 92.91 Niobium	42 Mo 95.94 Molybdenum	43 Tc [97.91] Technetium	44 Ru 101.1 Ruthenium	45 Rh 102.9 Rhodium	46 Pd 106.4 Palladium	47 Ag 107.9 Silver	48 Cd 112.4 Cadmium	49 In 114.8 Indium	50 Sn 118.7 Tin	51 Sb 121.8 Antimony	52 Te 127.6 Tellurium	53 I 126.9 Iodine	54 Xe 131.3 Xenon
55 Cs 132.9 Caesium	56 Ba 137.3 Barium	57□71 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 [209.0] 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 [266.1] Seaborgium	107 Bh [264.1] Bohrium	108 Hs [277] Hassium	109 Mt [268] Meitnerium	110 Ds [271] Darmstadtium	111 Rg [272] Roentgenium							

Lanthanides

57 La 138.9 Lanthanum	58 Ce 140.1 Cerium	59 Pr 140.9 Praseodymium	60 Nd 144.2 Neodymium	61 Pm [144.9] 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 [244.1] Plutonium	95 Am [243.1] Americium	96 Cm [247.1] Curium	97 Bk [247.1] Berkelium	98 Cf [251.1] 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

SYDNEY GRAMMAR SCHOOL

2007
FORM VI
TRIAL HSC EXAMINATION

Chemistry crib

General Instructions

- Reading time – 5 minutes.
- Working time – 3 hours
- Board-approved calculators may be used
- Write using blue or black pen
- Draw diagrams using pencil
- A Data Sheet and Periodic Table are provided at the back of this paper
- Write your candidate number and master's initials at the top of each page in Part B and on the answer booklet

CHECKLIST	
Each boy should have the following :	
1 Question Paper	
1 Multiple Choice Answer Sheet	
1 5 - Page Booklet	

Chemistry Classes.

1 MMB	2 RJF	3 JAG
4 JAG	5 TW	6 MTK

Section I Pages 2 - 22

Total marks (100)

This section has two parts, Part A and Part B

Part A
Total marks **(15)**
- Attempt Questions 1-15
- Allow about 25 minutes for this Section

Part B
Total marks **(69)**
- Attempt Questions 16-27
- Allow about 2 hours for this Section

Section II Pages 23-26
Total marks **(16)**
- Attempt Question 28 in this section.
- Allow about 35 minutes for this Section

Part A

Total marks (15)
Attempt Questions 1-15
Allow about 25 minutes for this Part

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

Masters' Initials | Candidate Number

Part B

Total marks (69)
Attempt ALL Questions
Allow about 2 hours for this Part

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

Question 16 (4 marks) **Marks**

When a zinc strip is placed in a solution of silver nitrate a chemical reaction takes place.

(a) Write half-equations for the oxidation and reduction reactions taking place, and write a balanced chemical equation for the overall reaction.

$Zn_{(s)} \rightarrow Zn^{2+} + 2e^-$ *Oxidation*

$Ag_{+(aq)} + e^- \rightarrow Ag_{(s)}$ *Reduction* } (1 mark)

$2AgNO_{3(aq)} + Zn_{(s)} \rightarrow Zn(NO_3)_{2(aq)} + 2Ag_{(s)}$ *(1 mark)* **2**

(b) Calculate the E_{cell} if these two half-reactions comprised an electrochemical cell under standard conditions.

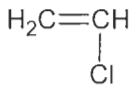
$E_{cell} = +0.76 + 0.80V) = 1.56V$ **1**

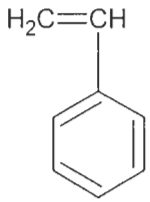
(c) Predict and explain any observations that would be made if a silver strip was placed in a solution of zinc nitrate.

No visible reaction because zinc is more active metal than silver – no displacement would be expected. **1**

Question 17 (3 marks) **Marks**

The structures of two commercially significant monomers are shown.





(a) Identify the systematic name of ONE of the monomers.

chloroethene or phenylethene **1**

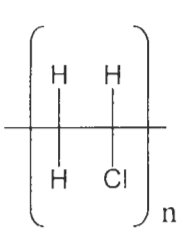
(b) Describe the type of polymerisation that the monomers shown above undergo.

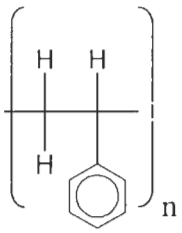
These monomers undergo addition polymerisation.

—C=C— *bond breaks – beginning of linkage and polymer chain, containing all the reactant atoms* **1**

(c) Draw the structure of a polymer made from one of the above monomers.

1





Masters' Initials | Candidate Number

Question 18 (5 marks) **Marks**

Oxygen has two allotropes O_2 and O_3.

(a) In the space provided draw Lewis electron dot diagrams for O_2 and O_3.

1

(b) Contrast two properties (chemical or physical) of O_2 and O_3 and explain these properties on the basis of molecular structure and/or bonding.

contrasts 1 prop (1 mark)

contrasts 2 props or contrasts 1 prop and explains this (2 marks)

contrasts 2 props and explains 1 very well or contrasts 2 props and includes satisfactory explanation (3 marks)

contrasts 2 props and explains the contrasts at a high level (4 marks) 4

Sample answer

Ozone is much more soluble in water than oxygen (570mg/L compared to 10mg/L). This is because oxygen does not have a dipole moment since it is a linear molecule whereas ozone is bent and as a result has a dipole moment. Water is a polar solvent and hence dissolves substances with hydrogen bonding or dipole moments present better than substances with only dispersion forces present between molecules (like oxygen). Ozone has a higher boiling point than oxygen even when its larger molecular weight is taken into account. This is again because of the bent shape of the molecule and the existence of a dipole as well as dispersion forces. Since oxygen only has dispersion forces between the molecules, which are weaker than dipole-dipole, less energy is required to overcome the intermolecular forces of oxygen and hence a lower temperature is required for oxygen to boil than ozone.

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Masters' Initials | Candidate Number

Question 19 (4 marks) **Marks**

Identify a buffer in a natural system and explain how the buffer works with reference to your example.

Identify a buffer in a natural system and explain how the buffer works with reference to your example. 4

Criteria	Marks
• As below + uses equations to show buffer reactions for acid and base	4
• As below + uses equations to show buffer reactions for acid or base	3
• As below + describes how the buffer responds to pH changes	2
• Identifies a buffer pair and the natural system in which it works	1

- Very poorly done.
- Many boys totally confused amphiprotic with buffers and hence only stated one ion as important to the buffer.

4

Question 20 (4 marks)

(a) Give the name and formula for ONE amphiprotic ion.

Give the name and formula for ONE amphiprotic ion. 2

Criteria	Marks
• Gives name and formula for amphiprotic ion	2
• Gives name or formula for amphiprotic ion	1

- Some confusion between amphoteric and amphiprotic
- Too many boys answered with a compound instead of an ion.

2

(b) Write the formulas for an acid-base conjugate pair. Identify which is the acid and which is the base.

Write the formulas for an acid-base conjugate pair. Identify which is the acid and which is the base. 2

Criteria	Marks
• Gives formulae for conjugate pair AND identifies acid and base.	2
• Gives formulae for conjugate pair	1

- generally well done

2

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Masters' Initials | Candidate Number

Question 21 (7 marks) **Marks**

In the course of his studies a pupil measured the pH of identical concentrations of hydrochloric acid and acetic acid.

(a) Explain the difference in pH of the two solutions.

(a)

Identifies different $[H_3O^+]$ and relates $[H_3O^+]$ to pH	2
Identifies that the solutions have different $[H_3O^+]$ because of different strengths	1

2

He then diluted each solution by a factor of 10.0.

(b) Describe the procedure he should use to perform this task.

(b)

Identifies the use of a pipette and volumetric flask (of appropriate capacities)	2
Identifies the use of a pipette *and* volumetric flask, **or** Identifies the use of a pipette *or* volumetric flask of specified capacity	1

2

When he re-measured the pH of each solution, the pH of the hydrochloric acid had increased by one pH unit, but that of the acetic acid had increased by only 0.5 pH units.

(c) Explain why pH increases as the solutions are diluted.

(c)

Identifies that $[H_3O^+]$ decreases as the solutions are diluted and explains how $[H_3O^+]$ is related to pH (eg $pH = -\log[H_3O]^+$)	1

1

(d) Explain why the two solutions change pH by different amounts.

(d)

Explains the change in HCl (dilution) *and* HOAc (dilution plus shift in equilibrium position)	2
Explains the change in HCl *or* HOAc	1

2

Question 22 (8 marks) **Marks**

Consider the table of boiling points given below.

substance	**bp (^oC)**
ethyl ethanoate	77
ethanol	78
water	100
ethanoic acid	118
sulfuric acid	337

(a) Explain the difference in boiling point between ethanol and ethanoic acid.

(a)

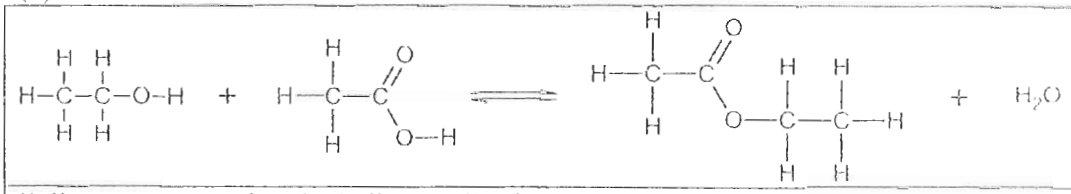
Explanation including dispersion forces **and** hydrogen bonding	2
Explanation involving hydrogen bonding **or** dispersion forces	1

Note: both ethanol and acetic acid can form a maximum of one H- bond per molecule.
Also, forces are 'stronger' or 'weaker' **not** 'more' or 'less'

2

(b) Write a balanced chemical equation, using structural formulas, for the reaction between ethanol and ethanoic acid to form an ester.

(b)



Fully correct equation, including equilibrium arrow (I ignored states **but** (aq) is **not** appropriate.)	2
Two correct (organic) structural formulas	1

2

Question 22 continued on next page.

Masters' Initials | Candidate Number

Question 22 continued **Marks**

(c) Justify the use of *heating under reflux* when carrying out this reaction.

(c)

Identifies that heating under reflux allows prolonged heating at the boiling point without loss of material , **and** Identifies that higher temperature means that equilibrium is achieved sooner. (The position of the equilibrium is **not** affected significantly; in any case the reaction is exothermic.)	2
Identifies that heating under reflux allows prolonged heating at the boiling point without loss of material , **or** Identifies that higher temperature means that equilibrium is achieved sooner. (The position of the equilibrium is **not** affected significantly; in any case the reaction is exothermic.)	1

2

(d) Discuss the usefulness of distillation as a technique to separate the product ester from the reaction mixture.

(d)

Distillation would separate ethyl acetate and **unreacted ethanol** from the reaction mixture, but would not separate these two substances.	1

1

(e) Explain the use of esters in processed foods and cosmetics.

(e)

Esters often have sweet, fruity odours. (EtOAc may be a solvent in cosmetics) **NB** the question says 'explain' not 'identify'	1

1

Question 23 (9 marks) **Marks**

A quality control chemist was given the task of checking the amount of citric acid ($C_6H_8O_7$) in sachets to be sold in supermarkets.

The sachet contained 1.750g of powder. The contents of a sachet was transferred quantitatively to a conical flask and dissolved in 20mL of water. An indicator was added and the acid titrated with standardised 1.050 M sodium hydroxide solution. 23.80mL of base was required to reach the end point.

(a) Identify a suitable indicator for the titration and justify your choice.

(a)

Identifies *phenolphthalein* **and** explains why the equivalence point is basic (citrate ion is basic – conjugate base of a weak acid **or** weak acid/strong base titration).	2
Identifies *phenolphthalein* **or** identifies that the equivalence point is basic	1

2

(b) State how you would identify the end point of the titration.

(b)

Identifies that the end point occurs at the first permanent colour change **or** identifies the colour change (colourless → pink **or** red)	1

1

Question 23 continued on next page.

Masters' Initials | Candidate Number

Question 23 continued **Marks**

(c) Calculate the percentage of citric acid in the sachet. [Citric acid was the only acid present.]

(c)

Correctly calculates the % citric acid (91.45%) to 4 sig figs	4
Correctly calculates the % citric acid (91.45%)	3
Calculates the chemical amount of citric acid in the sample (8.330 mmol)	2
Calculates the chemical amount of NaOH (24.99 mmol)	1

4

(d) Explain the use of acids as food additives.

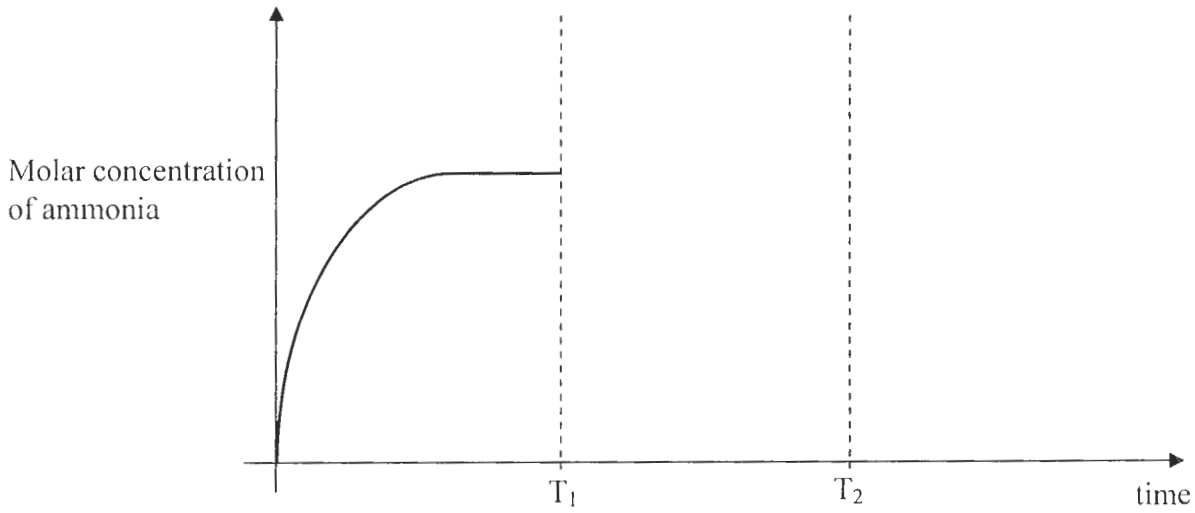
(d)

Identifies two of: the low pH inhibits the growth of microorganisms **or** low pH prevents oxidation **or** the sour taste enhances the flavour.	2
Identifies one of: the low pH inhibits the growth of microorganisms **or** low pH prevents oxidation **or** the sour taste enhances the flavour.	1

2

Question 24 (4 marks) **Marks**

A laboratory experiment was set up to model the Haber process. Nitrogen gas and hydrogen gas were passed over an iron/iron oxide catalyst at 500°C and 25MPa. The molar concentration of ammonia gas was monitored over a period of time and the data graphed as shown below.



At time T_1 the volume of the reaction vessel was doubled while the temperature remained constant.

Sketch on the graph above:

(i) the change in concentration of ammonia gas at T_1. 1

(i) Sharp drop in $[NH_3]$ on graph. Should be half initial concentration, but any sharp drop = 1 mark

(ii) the concentration of ammonia after T_1 when a new equilibrium was reached at T_2 1

(ii) Concentration drops further, exponential decay, levels off at T_2 when equilibrium is reached. Sigmoid curve or ↑ concentration = 0 marks.

(iii) Explain the changes that you have sketched on the graph. 2

(iii) 1 mark for explaining each change in (i) and (ii) above.
For (i) an explanation relating doubled (or increased) volume to halved (or decreased) concentration
For (ii) an explanation relating to Le Châtelier's principle.

Note that Le Châtelier himself is not personally responsible for the change in equilibrium position and neither is his principle! Also don't abbreviate: LCP, conc. *etc.*
Another common faux pas was to refer to 'forward' or 'reverse' reactions without writing an equation!

Masters' Initials | Candidate Number

Question 25 (9 marks) **Marks**

A sample of water was collected from a storm water channel. This channel runs into the ocean. Samples were analysed on site and in the school laboratory. The results are recorded in the table below.

Property	Values	Typical clean water values
Temperature	17°C	N/A
Total dissolved solids	3500 ppm	<100
pH	7.5	6.5-7.3
Dissolved oxygen	9 mg/L	7-9 mg/L
Total phosphate	0.1 mg/L	0.01 mg/L
Nitrate	0.5 mg/L	0.1 mg/L

(a) Identify a property in the above table that should be tested 'on site'.

(a) Temperature

1

(b) Justify your response to part (a).

(b) The temperature of the sample can change if energy is transferred as heat from the sample to the surroundings or vice versa.

1

(c) Briefly describe how you would find the mass of undissolved solids in the water sample.

2

(c) Filter the solution through a filter paper of known mass, then dry and weigh filter paper + undissolved solids, calculate mass of undissolved solids. 1 mark for the filtration step, 1 mark for more detail about weighing *etc.*

Note that to calculate the *percentage* of undissolved solids you would have to take a *known mass* of solution, however this was not explicit in the question and was not required.

Question 25 continued on next page.

Question 25 continued **Marks**

(d) Propose one reason to explain the relatively high value of total dissolved solids:

(d) Any reasonable answer involving the stormwater passing over/through **dissolvable** material.

In many cases it was not clear if boys were talking about dissolved or undissolved solids. **Boys had to explicitly refer to dissolving to get the mark.**

1

(e) It is suspected that lead has contaminated the storm water channel. Describe a chemical test that could be carried out on the water sample to determine the presence of lead ions.

(e) Adding a solution of $I^-_{(aq)}$ → canary yellow precipitate of $PbI_{2(s)}$.

One mark for chemical test (**not AAS**) and one for result.

Many boys said adding $Cl^-_{(aq)}$ to give a white ppt but this is not Pb-specific, $Ag^+_{(aq)}$ will give a white precipitate of $AgCl_{(s)}$. **1 mark only for this.**

2

(f) The concentrations of ions in substances used by society need to be monitored. Justify this statement with reference to ONE ion you have studied.

(f) 1 mark for ion and a specific effect of that ion.
Second mark for detail as to why the monitoring the **concentration** of this ion is important.

2

Masters' Initials | Candidate Number

Question 26 (5 marks) **Marks**

The presence of CFCs and halons in the upper atmosphere has led to a decrease in ozone levels in spring, particularly over Antarctica.

(a) What is a CFC?

(a) Haloalkane containing Cl, F but no H atoms.

1

(b) Identify one possible origin of CFCs in the atmosphere.

(b) From aerosols, refrigerators *etc*

1

(c) Explain how CFCs destroy ozone. Use relevant chemical equations in your response.

(c) First mark for equation involving production of Cl radical from CFC
Second mark for equation showing the destruction of O_3 by the Cl radical
Third mark for any further related equation, in the best answers this involved the regeneration of the Cl radical.

3

Question 27 (7 marks) **Marks**

Evaluate the potential of ethanol as a fuel to replace petroleum.

3 positives and 3 negative **detailed** points needed, PLUS a thorough evaluation.

Many boys quoted one of the points below but did not have sufficient detail to attract a mark

Positives
- carbon neutral
Renewable resource
More complete combustion
Less S → less SO_2 production
Lower combustion temp → less NO_x production

Negatives
Lower enthalpy of combustion per mol and per g
Cars need modifications to run on >10-15% EtOH
Takes up arable land otherwise used for food
Process, distillation etc costly in terms of energy

Plus thorough evaluation taking into account both positives and negatives.

Some boys gave a very long introduction about why a replacement for petroleum as a fuel was needed or why ethanol can replace petroleum as a chemical feedstock for industry, be careful and read the question!

7

Masters' Initials

Candidate Number

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Section II

16 marks
Attempt question 28 in this section.
Allow about 35 minutes for this section.

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

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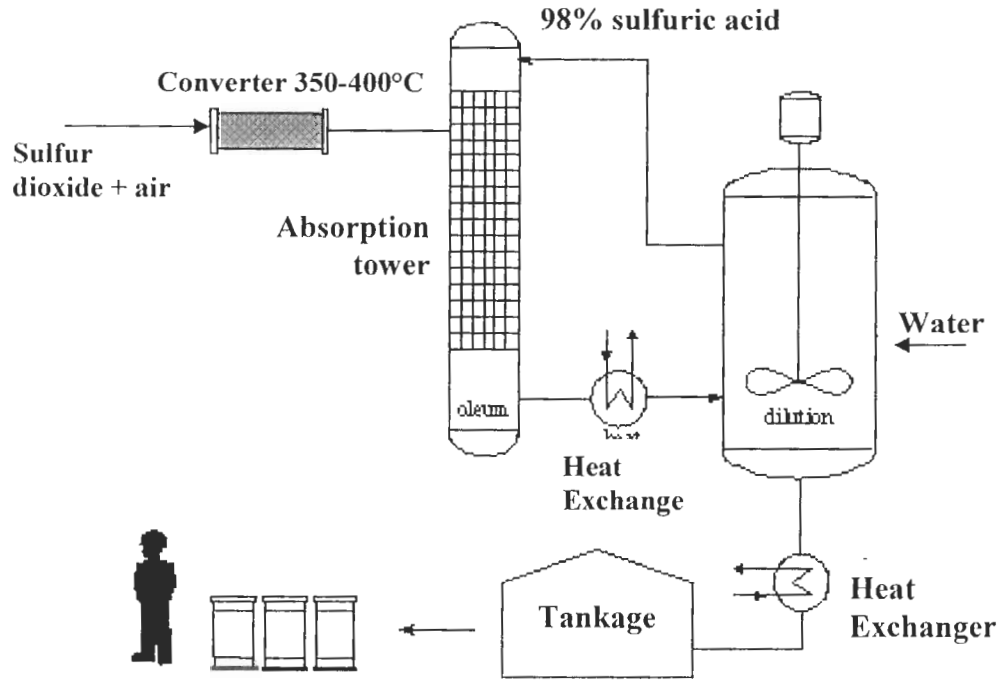
Question 28 (16 marks) **Marks**

(a) The diagram below shows the production of sulfuric acid by the Contact process.



(i) Write an equation for the reaction which occurs in the converter. 1

(ii) Name the catalyst which is present in the converter. 1

(iii) The pressure in the converter is about 100 kPa and the temperature is nearly 400°C. Explain why these conditions are used. 2

(iv) Explain why heat exchangers are necessary whenever the concentration of sulfuric acid changes. 1

(v) Based on the properties of sulfuric acid, describe the safety precautions that are necessary for its transport. 3

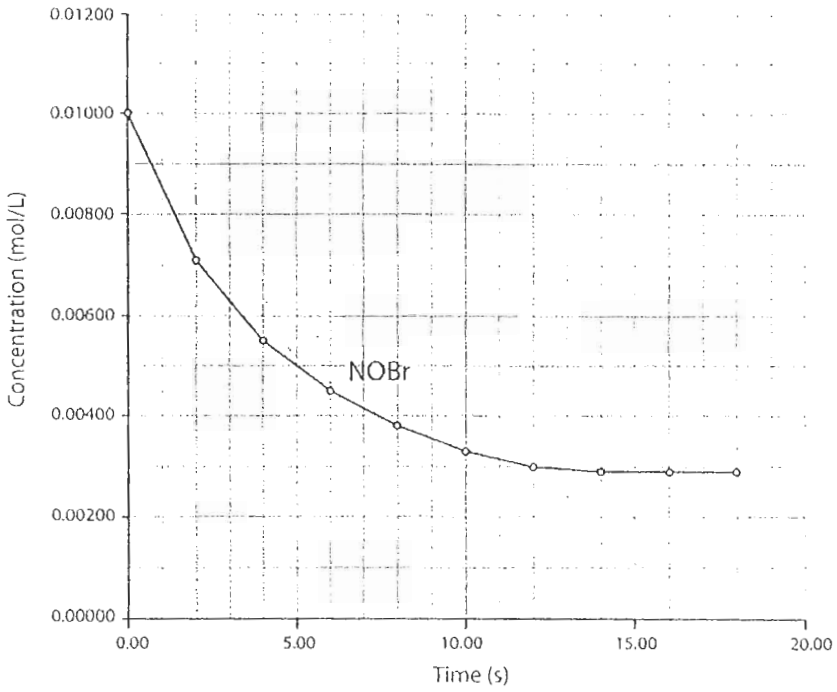
(vi) Identify TWO uses of sulfuric acid. 2

Question 28 continued on next page.

(b) Experimental data has been collected for the decomposition of nitrosyl bromide (NOBr) as a function of time at constant temperature in a closed system. The reaction equilibrium is:

$$2NOBr_{(g)} \rightleftharpoons 2NO_{(g)} + Br_{2(g)}$$

The graph shows the change in concentration of NOBr with time.



(i) At what time does the system reach equilibrium? 1

(ii) Using data from the graph above, calculate the value of K for the decomposition of NOBr. 4

(iii) Both NOBr and Br_2 are reddish brown, so this property cannot be used to monitor the system as it approaches equilibrium. Identify a measurable property of the system that a chemist can readily use to determine when the system has reached equilibrium. 1

Data Sheet

Avogadro's constant, N_A		6.022×10^{23} mol^{-1}
Volume of 1 mole ideal gas:	at 100 kPa and	
	at 0 °C (273 K)	22.71L
	at 25 °C (298K)	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 Jkg^{-1}K^{-1}

Some useful formulae

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

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
$SO_4^{2-} + 4H^+ + 2e^-$	$\rightleftharpoons$	$SO_{2(g)} + 2H_2O$	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
$\frac{1}{2} O_2 + 2H^+ + 2e^-$	$\rightleftharpoons$	H_2O	1.23 V
$\frac{1}{2} Cr_2O_7^{2-} + 7H^+ + 3e^-$	$\rightleftharpoons$	$Cr^{3+} + \frac{7}{2} H_2O$	1.36 V
$\frac{1}{2} Cl_{2(g)} + e^-$	$\rightleftharpoons$	Cl^-	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 — 79 — Symbol of element
Atomic Weight — Au 197.0 — Name of element
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 65.41 Zinc	31 Ga 69.72 Gallium	32 Ge 72.64 Germanium	33 As 74.92 Arsenic	34 Se 78.96 Selenium	35 Br 79.90 Bromine	36 Kr 83.80 Krypton
37 Rb 85.47 Rubidium	38 Sr 87.62 Strontium	39 Y 88.91 Yttrium	40 Zr 91.22 Zirconium	41 Nb 92.91 Niobium	42 Mo 95.94 Molybdenum	43 Tc [97.91] Technetium	44 Ru 101.1 Ruthenium	45 Rh 102.9 Rhodium	46 Pd 106.4 Palladium	47 Ag 107.9 Silver	48 Cd 112.4 Cadmium	49 In 114.8 Indium	50 Sn 118.7 Tin	51 Sb 121.8 Antimony	52 Te 127.6 Tellurium	53 I 126.9 Iodine	54 Xe 131.3 Xenon
55 Cs 132.9 Caesium	56 Ba 137.3 Barium	57□71 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 [209.0] 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 [266.1] Seaborgium	107 Bh [264.1] Bohrium	108 Hs [277] Hassium	109 Mt [268] Meitnerium	110 Ds [271] Darmstadtium	111 Rg [272] Roentgenium							

Lanthanides

57 La 138.9 Lanthanum	58 Ce 140.1 Cerium	59 Pr 140.9 Praseodymium	60 Nd 144.2 Neodymium	61 Pm [144.9] 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 [244.1] Plutonium	95 Am [243.1] Americium	96 Cm [247.1] Curium	97 Bk [247.1] Berkelium	98 Cf [251.1] 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