David Yoo

72+21 = 93

James Ruse Agricultural High School

2006

TRIAL HSC

EXAMINATION

Chemistry

Student No. 83583

Mark: 15 + 57 = 72

Total marks - 100

General Instructions

- Reading time - 5 minutes
- Working time - 3 hours
- Write using black or blue pen
- Draw diagrams using pencil
- Board - approved calculators may be used
- A data sheet and a Periodic Table are provided at the back of this paper
- Write your Student Number at the top of this page and those of 7, 8,10,12,14 and 16

Section I Pages 2-17

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

Part A - 15 marks
- Attempt Questions 1-15
- Allow about 30 minutes for this part

Part B - 60 marks
- Attempt Questions 16-26
- Allow about 1 hour and 45 minutes for this part

Section II Pages 18-21

25 marks
- Attempt Question 27
- Allow about 45 minutes for this section

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Section I
75 marks

Part A – 15 marks
Attempt Questions 1-15
Allow about 30 minutes for this part

Use the multiple choice answer sheet on page 7

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

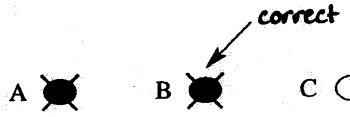
Sample: $2 + 4 =$ (A) 2 (B) 6 (C) 8 (D) 9

A ○ B ● C ○ D ○

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

A ● B ⊗ C ○ D ○

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



A ⊗ B ⊗ C ○ D ○

1. Consider the following reactions:

(i) $Ag^+ + Cl^- \rightleftharpoons AgCl$

(ii) $\overset{-4}{CH_4} + 2\overset{0}{O_2} \rightarrow \overset{+4\ -2}{CO_2} + 2\overset{-2}{H_2O}$

(iii) $Mg + 2HCl \rightarrow \overset{2+}{MgCl_2} + \overset{0}{H_2}$

(iv) $Mg(OH)_2 + 2HCl \rightarrow MgCl_2 + 2H_2O$

Which of the reactions can be considered an acid-base reaction(s).

(A) (i), (ii), (iii), (iv)

(B) (i), (iii) and (iv) only

(C) (iv) only

(D) (i) only

2. Which of the following equations represent the Haber process?

(A) $N + 3H \rightarrow NH_3$ $\Delta H = -91$ kJ

(B) $N_2 + 3H_2 \rightarrow 2NH_3$ $\Delta H = -91$ kJ

(C) $N_2 + 3H_2 \rightleftharpoons 2NH_3$ $\Delta H = +91$ kJ

(D) $N_2 + 3H_2 \rightleftharpoons 2NH_3$ $\Delta H = -91$ kJ

3. An unknown solution may contain one or more of the following ions: Mg^{2+}, SO_4^{2-}, CO_3^{2-}, Pb^{2+}, Cl^-
The solution gave a white precipitate with $Ba(NO_3)_2$ but no reaction with H_2SO_4.

Which of the ions may be present ?

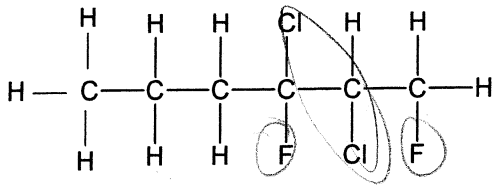
(A) Mg^{2+} and Cl^-

(B) Pb^{2+} and Cl^-

(C) Mg^{2+} and SO_4^{2-}

(D) Mg^{2+} and CO_3^{2-}

4. Consider the following haloalkane:



Which of the following is an isomer of the compound ?

(A) 1,1-dichloro-2-fluorohexane

(B) 1,2,5-trichloro-2-fluorohexane

(C) 1,3-dichloro-2,3-difluorohexane

(D) 2,3-dichloro-1,3-difluorohexane

5. A chemist wants to test for the presence of iron (III) ions in a water sample collected outside a factory. Which anion could be used to test for the presence of iron (III) ions in the water?

(A) SO_4^{2-}

(B) NO_3^-

(C) OH^-

(D) Cl^-

6. What is the product of adding bromine water to 2-hexene?

(A) 2,3-dibromohexene

(B) 2,3-dibromohexane

(C) 1,2-dibromohexane

(D) 1,2-dibromocyclohexene

7 Where on the Periodic Table would you most likely find elements which form basic oxides?

(A) Group 1

(B) Group 6

(C) Period 2

(D) Period 3

8. Which elements on the Periodic Table have radioisotopes?

(A) Only those elements after uranium.

(B) Only the actinides.

(C) Only elements with unstable proton-neutron ratio.

(D) Only metallic elements

9. A student constructed a galvanic cell using two different metals and electrolytes of the nitrates of the metals, under standard conditions.

Which combination of metals would give the greatest potential difference?

(A) copper and silver

(B) manganese and silver

(C) zinc and copper

(D) magnesium and zinc

10. The molar heat of combustion of propane is given in the data book as 2200 kJ mol^{-1}. What does this mean?

(A) 1 g of propane releases 2200 kJ of heat

(B) 44 g of propane releases 2200 kJ of heat

(C) 1 g of propane absorbs 2200 kJ of heat

(D) 44 g of propane absorbs 2200 kJ of heat

11. Which of the following is a common natural source of sulfur dioxide in the atmosphere?

(A) The action of sunlight on S and O_2

(B) Smelting metal ores

(C) Soil bacteria

(D) Volcanoes

12. Which of the following may be used as a catalyst in esterification?

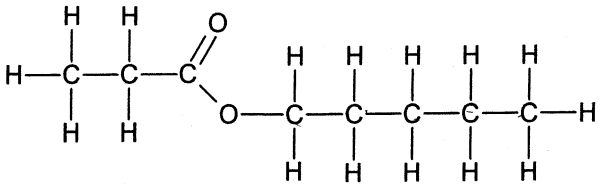
(A) H_2SO_4

(B) C_2H_5OH

(C) CH_3COOH

(D) H_2O

13. What is the name of the ester given below?



(A) butyl pentanoate

(B) pentyl butanoate

(C) propyl pentanoate

(D) pentyl propanoate

14 A soft drink may be decarbonated by heating. In observing the results, the equilibrium between gaseous and dissolved carbon dioxide can be examined.

$$CO_2(g) \rightleftharpoons CO_2(aq) \quad \leftarrow \text{heat}$$

What conclusion can be drawn about this reaction?

(A) The forward reaction is exothermic.

(B) Only the reverse reaction rate is increased with heating.

(C) Heat is absorbed in the reaction shown above.

(D) Only the forward reaction rate is increased with heating.

15. Which correctly describes the relationship between an acid and its conjugate base?

(A) They are ions of opposite charge.

(B) They both contain H atom.

(C) They neutralize each other to form a salt.

(D) They have formulae that differ by a proton.

Student Number 8353

Section I
Part A

Marks-----/15

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 ● ✓

14 1.5

JAMES RUSE AGRICULTURAL HIGH SCHOOL
2006 CHEMISTRY TRIAL HSC EXAM

Student Number 8355

Section I (continued)

Part B - 60 marks
Attempt Questions 16 to ~~28~~ 26.
Allow about 1 hour and 45 minutes for this part

Answer the questions in the spaces provided

Show all relevant working in questions involving calculations

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Marks

Question 16 (5 marks)

A buffer is known to contain two of these substances:

sodium dihydrogen phosphate — sodium hydrogen phosphate
ethanoic acid — sodium ethanoate

(a) Define a buffer **1**

a mixture or solution containing relatively ~~significant~~ concentrations ~~quantities~~ of both a weak acid and its conjugate base or a weak base and its conjugate acid which effectively resists a change in pH.
(not necessarily equal.)

(b) Using an equation, explain how the substances can be used as a buffer. **2**

Equal concentrations of $CH_3COOH_{(aq)}$ and $NaCH_3COO_{(aq)}$

$NaCH_3COO_{(aq)} \rightarrow Na^+_{(aq)} + CH_3COO^-_{(aq)}$

$CH_3COOH_{(aq)} + H_2O_{(l)} \rightleftharpoons H_3O^+_{(aq)} + CH_3COO^-_{(aq)}$ 2

- acid influx: equilibrium shifts to left, removing H_3O^+ and keeping pH relatively stable
- base influx: equilibrium shifts to right producing H_3O^+ to neutralise acid, keeping pH relatively stable.

(c) Use balanced ionic equations to demonstrate how one of the above compounds can behave as an amphiprotic substance. **2**

$H_2PO_4^-_{(aq)} + H_3O^+_{(aq)} \rightleftharpoons H_3PO_4_{(aq)}$

$H_2PO_4^-_{(aq)} + OH^-_{(aq)} \rightleftharpoons HPO_4^{2-}_{(aq)}$

sodium dihydrogen phosphate can act as an amphiprotic substance - able to react with both an acid and a base, accepting or giving up a proton 2

5

Marks

Question 17 (8 marks)

Sulfate in fertilizer may be analysed gravimetrically by precipitating the sulfate with barium ion and weighing the sulfate produced after filtering and drying. To test the technique, which is exactly what YOU did in the lab, a group of students performed the analysis on pure ammonium sulfate. They obtained the following results.:

Mass of sample of ammonium sulfate: 2.34 g $(NH_4)_2SO_4$

Mass of filter paper: 0.203 g

Mass of filter paper + 'dried' precipitate: 4.65 g $BaSO_4$.

(a) Calculate:

(i) the theoretical percentage of sulfate in ammonium sulfate **2**

$n(BaSO_4) = \frac{m}{Fw} = \frac{(4.65-0.203)}{233.37} = 1.91 \times 10^{-2}$ mol $= n(SO_4^{2-})$

$\%\ SO_4^{2-} = \frac{Fw(SO_4^{2-})}{Fw((NH_4)_2SO_4)} = \frac{32.07+16\times4}{14.01\times2+1.008\times8+32.07+16\times4} \times 100\%$

$= 72.7\%$ 2

(ii) the experimental percentage of sulfate in ammonium sulfate **3**

$n(SO_4^{2-}) = 1.906 \times 10^{-2}$ mol

$m(SO_4^{2-}) = n(SO_4^{2-}) \times (32.07+16\times4) = 1.83$ g

$\%\ m(SO_4^{2-}) = \frac{m(SO_4^{2-})}{m((NH_4)_2SO_4)} \times 100\% = \frac{1.83}{2.34} = 78.12\%$ (3 sig figs)

(b) Assess the accuracy of the above determination. Identify and explain two possible sources of error that can contribute to this particular discrepancy. **3**

Inaccurate as the experimental percentage of SO_4^{2-} is greater than theoretical.

possible errors:

① $BaSO_4$ solution may have remained on filter paper and crystallised when dried – not properly washed out.

② filter paper may still be wet from filtration.

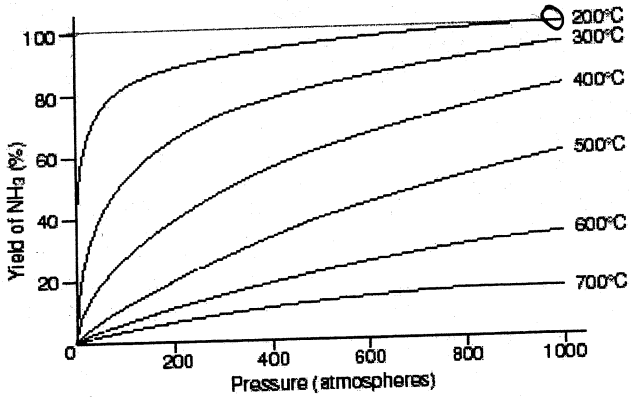
Both, increase in mass. 3

8

Marks

Question 18 (6 marks)

The graph shows the variation in percentage yield of the product with pressure at various temperatures for the Haber process.



$3H_2 + N_2 \rightleftharpoons 2NH_3 \quad \Delta H < 0.$

(a) Based on the graph, what conditions of temperature and pressure give the best yield for this process? Justify your answer. → highest point on graph (from available data). 2

200°C, 1000 atm, as these conditions which produce highest percentage yield of NH_3, from the graph.

also, it can be inferred from the graph that although higher pressures than 1000 atm would have negligible effect (plateau), lower temperatures may yield higher yield.

(b) In industry, the conditions usually used are 400 °C and 500 atm pressure. Explain the reason(s) for the use of these conditions. 2

(eg 200°C)

If temperature is too low, the yield may be high, but the rate of reaction will be slow, taking too long to reach equilibrium.

high pressures such as 1000 atm require more energy to produce, and as can be seen from the graph, there is not much difference in 500 atm and 1000 atm which outweighs the extra cost. (pressure for high yield and reaction rate)

(c) Identify the chemical composition of the catalyst used in this reaction and explain its role. 2

Fe_3O_4, magnetite, with a layer of reduced iron, provides a surface for gaseous reactants to react, lowers activation energy and provides an alternate pathway to reaction.

6

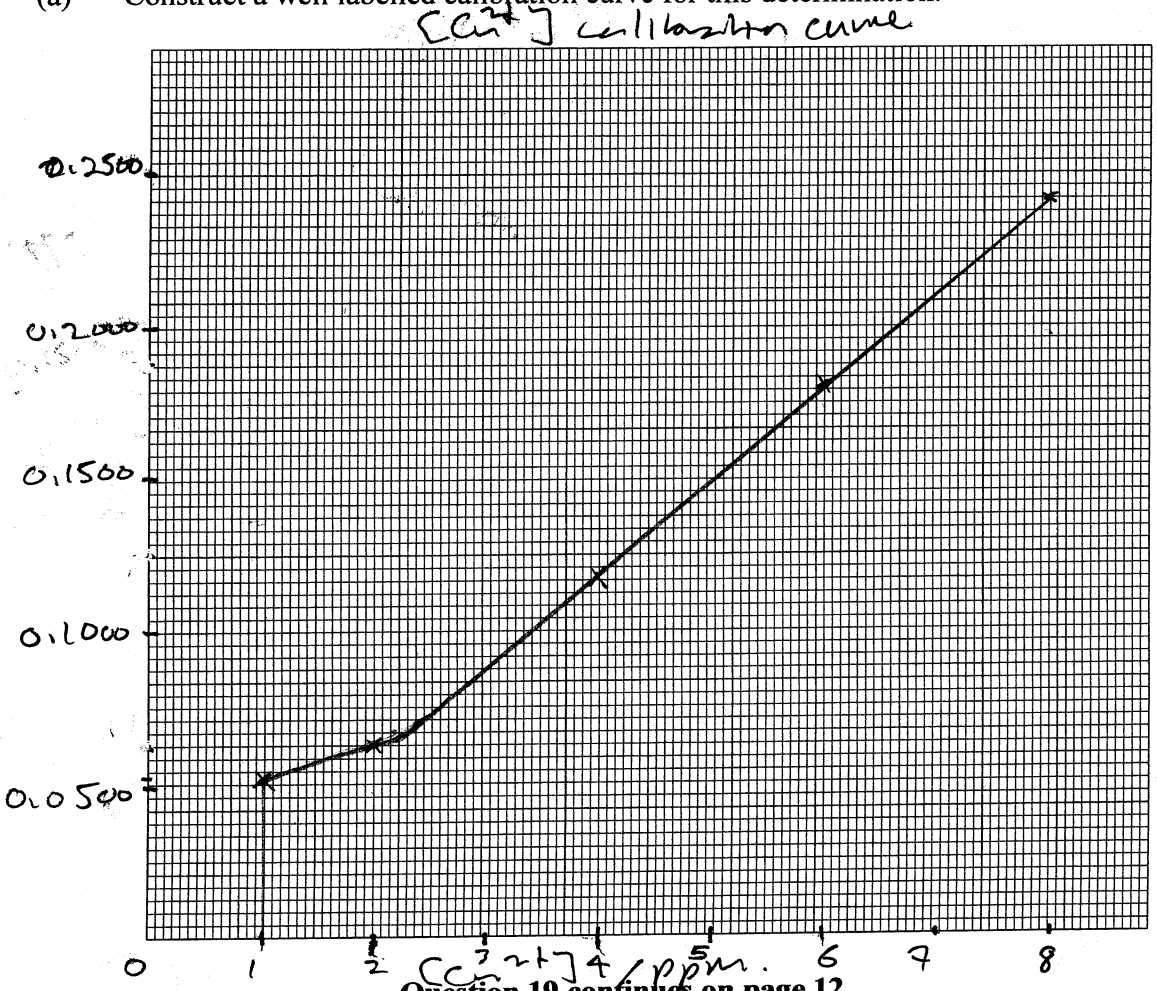
Marks

Question 19 (5 marks)

A group of students were assigned to determine the copper ion content of a certain brand of spring water. They prepared a series of standard copper ion solutions in *distilled* water and analysed the standard solutions and the undiluted spring water with the AAS instrument. They also tested some *distilled* water which they used to prepare the standard solutions. The results are given below:

Solution	*Cu^{2+} ion concentration (ppm)*	*Absorbance*
Standard 1	1.0 ✓	0.0521
Standard 2	2.0 ✓	0.0634
Standard 3	4.0 √	0.1205
Standard 4	6.0	0.1834
Standard 5	8.0	0.2467
Spring water	unknown	0.0412
distilled water	unknown	0.0501

(a) Construct a well labelled calibration curve for this determination. **3**



1
1
1
1
3

Question 19 continues on page 12

(b) Comment on the validity of the distilled water as a control. **2**

the distilled water poses a problem in that it also contributes to the calibration curve, but because distilled water was used to dilute all solutions, it affected all solutions more or less equally, and the considering the absorbance would result in the graph being shifted down. however, the value for spring water suggests that the

Question 20 (2 marks) **2**

Identify and describe two everyday uses of indicators.

testing soil pH - since plants require alkaline and other acidic soils. sprinkle universal B-SO$_4$ on soil sample mixed with universal indicator solution and compare with pH chart.

testing pool pH - pool cleaners can change pool pH, which should be buffered at around pH = 7.4 for eye and skin comfort. water sample is collected and tested. pH can be rectified.

distilled water is contaminated with Ca^{2+}. For ~~tap~~ ~~experiment~~, hence the distilled water, although it affected all solutions equally, renders the interpretation of the absorbance of spring water meaningless, and is hence invalid as a control.

4

Question 21 (8 marks)

Compare addition and condensation polymers using named examples of each type of polymer. **8**

Addition polymers (such as polyethene) are formed by the self-addition of monomer units to make up a polymer molecule whereas condensation polymers involve the elimination of a small molecule (usually water) from the structure for monomer units to join (such as cellulose & proteins). ✓1

Many addition polymers, like polyethene, are artificially produced industrially. Addition polymerisation involves the three steps of initiation, propagation and termination, where, in the example of polyethene, the double bonds at ethene are effectively made to open up to link to other monomers. This of course involves initiation by radicals. molecules ✓1

Cellulose, on the other hand is naturally produced in plants. ✓1 Many condensation polymers are naturally made — eg proteins, in the human body, and in bacteria, similar processes to that of in industrial procedures. polymerise Glucose monomer units into cellulose, except that except that the reaction mechanism, readily polymerisation of ethene into occurs in water is different. The addition polymer of polyethene can also produce physically different products substances depending on different reaction conditions. LDPE and HDPE are physically different and are used for different purposes, whereas cellulose is always in long chain strands. ✓1

Condensation polymers can also be prioritised industrially. eg Both types vary widely in their uses, depending on individual properties.

Marks

Question 22. (6 marks)

Ethylene can be transformed into many useful substances other than plastics.

(a) Complete the table for two substances derived from ethene other than plastics **4**

Name of useful substance	*Use*
Ethanol	solvent
ethan-1,2-diol	Antifreeze in cars.

2

2

(b) Write a balanced chemical equation to describe the formation of one of the substances listed in (a). **2**

$C_2H_4(g) + H_2O(g) \xrightarrow{dil\ H_2SO_4} C_2H_5OH(l)$

2

hydrolysis of ethene to produce ethanol

6

Marks

Question 23 (8 marks)

A student made these observations after doing the reactions:

- Metal X did not react with 1 molL^{-1} solution containing Y^{2+} ions.
- Metal Y in a 1 molL^{-1} solution of Z^{2+} ions formed metal Z
- Metal Z did not react with a 1 molL^{-1} solution of X^{2+}

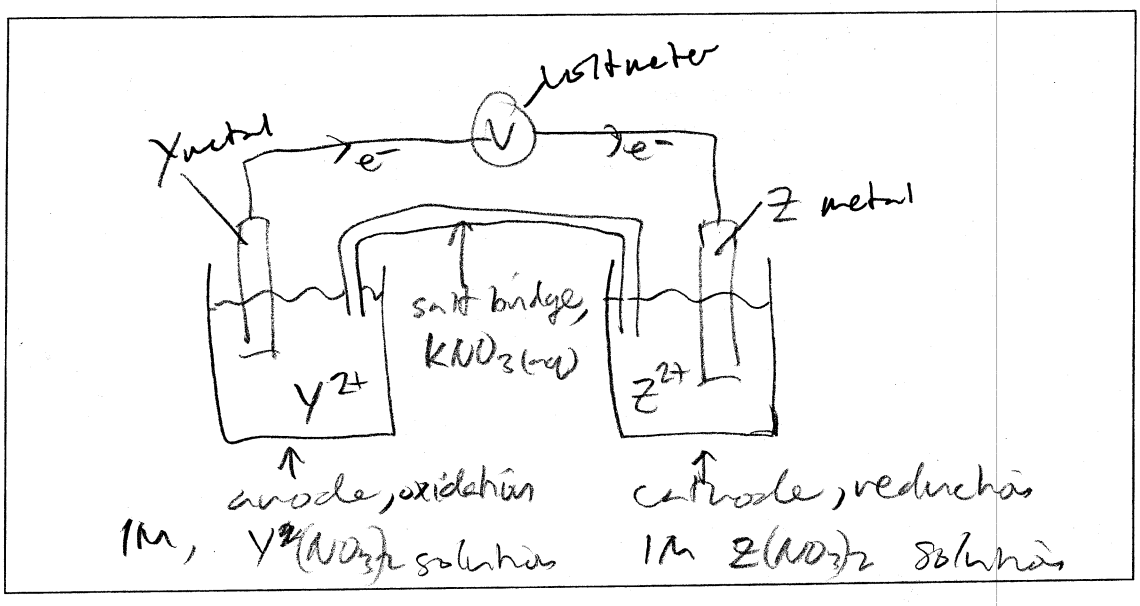
(a) List the metals X, Y and Z in order of increasing ease of oxidation. **1**

Z < X < Y

(b) List the ions in order of increasing ease of reduction. **1**

$Y^{2+} < X^{2+} < Z^{2+}$

(c) Draw a labelled diagram of an electrochemical cell made with two of the above metals that would produce the greatest voltage. Indicate on your diagram which is the anode and cathode and the direction of electron flow. **5**



(d) Write a balanced net ionic equation for the chemical reaction occurring in the electrochemical cell **1**

$Y_{(s)} \rightarrow Y^{2+}_{(aq)} + 2e^-$

$Z^{2+}_{(aq)} + 2e^- \rightarrow Z_{(s)}$

$Y_{(s)} + Z^{2+}_{(aq)} \rightarrow Z_{(s)} + Y^{2+}_{(aq)}$

Question 24 (5 marks)

Consider the properties of three acids.

Acids	*pH*
0.1 molL^{-1} acetic acid	2.9
0.1 molL^{-1} citric acid	2.1
0.1 molL^{-1} hydrochloric acid	1.0

(a) Give the systematic name for citric acid **1**

2-hydroxy propane-1,2,3-tricarboxylic acid

(b) Explain the difference in pH between the three acid solutions. **2**

Acetic acid and citric acid are weak acids, so only partial ionises ~~dissociates~~ → weak ~~less~~ $[H^+]$ less than 0.1, ~~the H+ is not available to be released as much~~ less H^+, resulting in a pH greater than 1.0, acetic being weaker than citric, and HCl being a strong acid, undergoing complete dissociation in water to produce $[H^+] = 1.0$ M, hence pH = 1.0.

(c) Calculate the pH after 100mL of 0.1 molL^{-1} hydrochloric acid solution is diluted by the addition of 400mL of distilled water. **2**

$[HCl] = \frac{100 \times 0.1}{400+100} = 0.02$ M

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

$= 1.7$ (to 1 dp)

Marks

Question 25 (3 marks)

A source of sulfur dioxide in the atmosphere is the burning of coal in power stations. Calculate the volume of sulfur dioxide released at 25°C and 100kPa when 10.0 million kg of coal containing 0.01% sulfur, is burnt. 3

$10^{-4} \times 10^{10}$

m(S) = 0.0001 × 10.0 × 10⁹ g = 10^6

= 1 × 10^6 g

n(S) = 3118 mol

$S_{(s)} + O_{2(g)} \rightarrow SO_{2(g)}$

n(SO_2) = n(S)

V(SO_2) = 24.79 × n(SO_2)

= 7.73 × 10^5 L

3

Question 26 (4 marks)

An ester is prepared in the laboratory by refluxing a mixture of appropriate alkanol and alkanoic acid using acid catalysis.

Identify two potential safety hazards and describe the experimental procedures that may be used to minimize these hazards in the preparation of the ester. 4

- Both alkanols and alkanoic acids, as well as esters produced, are extremely flammable and some are volatile, meaning that prolonged heating can result in explosive vapours being evolved. To prevent this, reflux condenser is used which cools the vapours, returning them to the reaction vessel, allowing safe, prolonged heating of volatile substances.

- heating at high temperatures may produce violent bubbling which may cause liquid to splash out and run down into ~~the bunsen flame~~ → potential fire hazard. Boiling chips are used to provide a nucleating site for bubbles ~~and~~ producing more controlled boiling. ~~with less~~

4

7

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Chemistry

Section II

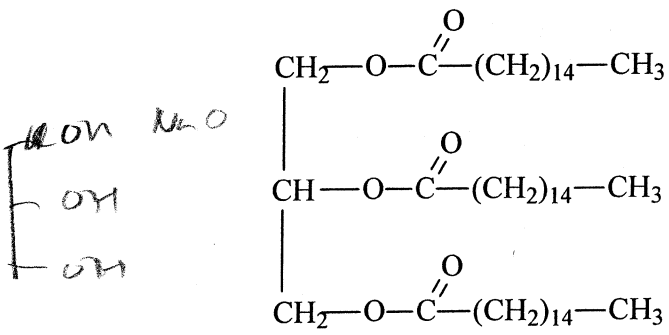
25 marks

Attempt question 27
Allow about 45 minutes for this section

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

Question 27 – Industrial Chemistry

(a) Glyceryl tripalmitate is a raw material used to make soap…



(i) Construct the structural formula of the soap formed from glyceryl tripalmitate. **1**

(ii) Identify the special type of mixture which forms when the soap is shaken with warm water and a small amount of glyceryl tripalmitate.. **1**

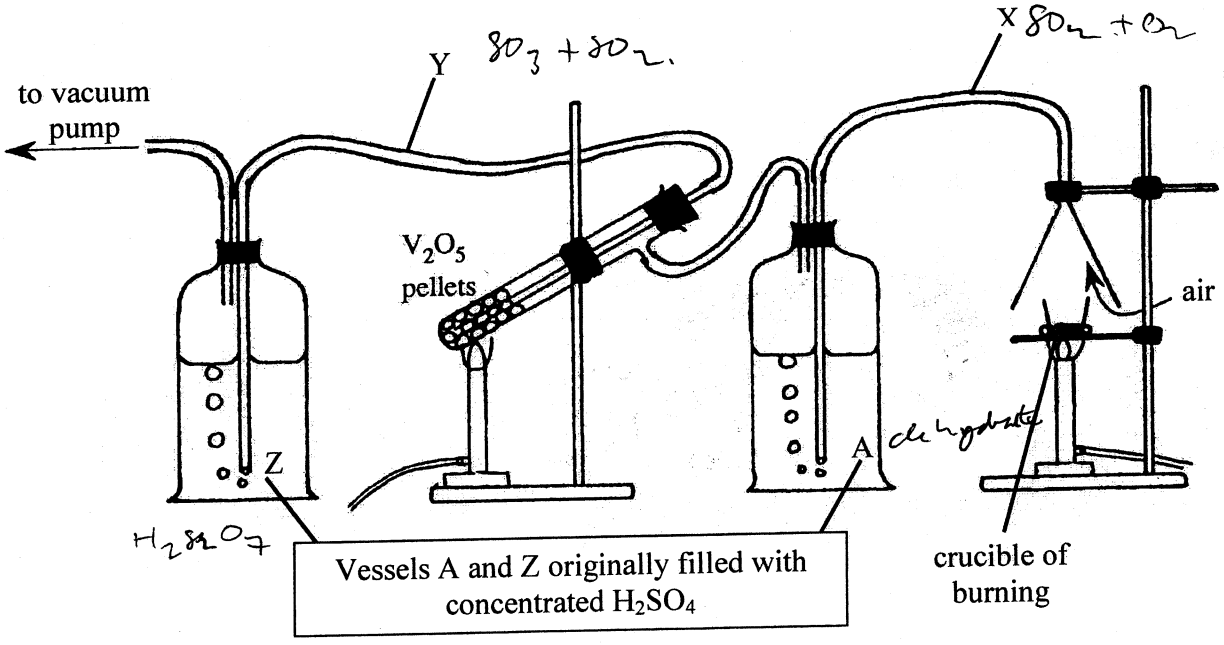
(iii) Other than glyceryl tripalmitate identify another fat or oil which can be used to make soap. **1**

(iv) Compare the environmental impacts of the use of soaps and non–phosphate detergents. **2**

Question 27 continues next page…

Marks

(b) In his quest for the *BHP Science Prize*, Ken Chemiski plans to prepare sulfuric acid using this relatively simple apparatus. Sulfur is burned in a crucible and the gas flow is forced through the apparatus using a vacuum pump.



(i) Evaluate the feasibility of Ken's apparatus to produce sulfuric acid ignoring safety issues **2**

(ii) Compare the gas composition in tube X with tube Y. **2**

(iii) Identify the role of the concentrated sulfuric acid in vessel A **1**

(iv) Construct a chemical equation for the reaction of gas Y as it bubbles through vessel Z. **1**

Question 27 continues next page...

Marks

(c) Chlorine gas can be prepared industrially by this equilibrium reaction...

$$4HCl_{(g)} + O_{2(g)} \rightleftharpoons 2Cl_{2(g)} + 2H_2O_{(g)}$$

An industrial chemist performs a small scale synthesis of this reaction in a two litre stainless steel tank and records this data...

	HCl	O_2	Cl_2	H_2O
Initial moles	0.548	0.625	0	0
Final moles at equilibrium	0.200	0.538	0.174	0.174

(i) Calculate the equilibrium constant from the data. **3**

(ii) Identify how the value of the equilibrium constant could be changed. **1**

(iii) Explain, using Le Châtelier's principle, how a change in volume will affect the equilibrium. **2**

(iv) Calculate the theoretical volume of chlorine produced at 25°C and 100 kPa, if the reaction went to completion. **2**

Question 27 continues next page...

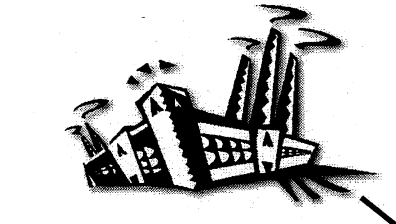
Marks

(d) Kaipara Harbour has a surrounding population of 75,000 with a mixed economy including dairy farming, market gardens, commercial prawn trawling in the harbour and offshore tuna fishing.. Three companies have expressed interest in building a sodium hydroxide production facility at Pouto located in Kaipara Harbour:

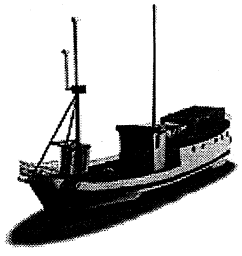
HGCL Ltd. has plans for a mercury process plant;
Mem-chlor-tech is proposing a membrane process plant;
and ***Chlorox Industries*** has plans for a diaphragm process plant.

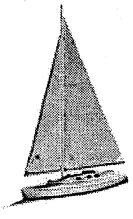
Imagine you are an Environmental Chemist for the Kaipara Regional Planning Authority.

- Write an environmental risk assessment comparing all three plant proposals and
- Make recommendations as to which proposal should be approved. **6**



Proposed site of NaOH factory





END of TEST

STUDENT No. 87583

21

JAMES RUSE AGRICULTURAL HIGH SCHOOL

David Yoo

TRIAL HIGHER SCHOOL CERTIFICATE EXAMINATION

ALL SCIENCE SUBJECTS

ALL COURSES

OPTION
ANSWER BOOK

COURSE	NAME OF OPTION	QUESTION NUMBER
Chemistry	Industrial Chem	27

DIRECTIONS TO CANDIDATES

Write your Student Number at the top Right-hand corner of this page

In the above table:

- Write the name of the course you are doing;
- Write the name of the Option you are answering;
- Write the Question Number of the Option you are answering

STUDENT No. 8353

Candidates may ask for an extra Option Answer Book if extra space is required for the answer. This practice is not encouraged, as marks are awarded on the *content* of the answer and not on the *length* of the answer.

27 (a)(i) $Na^+ O^- \overset{O}{\overset{\|}{C}}-(CH_2)_{14}-CH_3$ 1

(ii) Glyceryl tripalmitate is fat/oil 1

in oil in water emulsions, where the soaps is emulsifier

(iii) Beef tallow 1

(iv) Soap molecules have a long non-polar relatively hydrocarbon tail, which is usually linear and a polar head, whereas ancient detergents were initially branched in the non-polar tail. Because of this soaps were easily decomposed but detergent molecules were not easily biodegradable - due to branching, producing foam which could reduce oxygen in an aquatic environment - This problem has now been solved

Cationic detergents also have bacterial properties killing bacteria. This could kill bacteria which decomposes sewage and organic matter in water ways resulting in a build up of refuse - detrimental environmental impact. Comparatively, soap does not have such destructive impacts as some detergents can have.

similar!

IR!

2

15

STUDENT No. 8353

Marker's Use Only

(b)(i) Process is quite feasible - vacuum pump draws the gases through the entire apparatus, overcoming the technical difficulties of transporting reactants to next stage. Pressure and temperature not too different from ambient conditions - latm, air source of O_2 high temperatures to increase rate of reaction. One problem though, is the lack of heat exchangers - all reactions are highly exothermic. Excess heat caused adversely affect yield. Nevertheless, the apparatus should be able to produce some H_2SO_4.

2

(ii) SO_2, O_2, N_2, perhaps some water vapour from air $H_2O(g)$

2

SO_3, unreacted SO_2 and O_2, N_2

1

(iii) removal of moisture from air, using the property of a dehydrating agent

1

(iv) $SO_3(g) + H_2SO_4(l) \rightarrow H_2S_2O_7(s)$

1

clean from
Also vessel should be periodically removed to clean out final stages to reduce risk of leak to stop process.

16

STUDENT No. 8353

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(c) (i) $K_{eq} = \frac{[Cl_2(g)]^2[H_2O(g)]^2}{[HCl(g)]^4[O_2(g)]}$ 2

water is also included as it is not present in solvent concentrations.

$K = \frac{[0.174]^2[0.174]^2}{(0.2)^4(0.538)}$ 2L

$= 1.06$ X

will!

(ii) change in temperature ~~does not affect~~ 1

K_{eq} value

(iii) A increase in volume would result in a decrease in pressure causing the equilibrium to shift to the left, which had more gas volumes. According to Le Chatelier's principle, the equilibrium will shift in a way to try to reduce the effect of lowered pressure by shifting to the left, with more gas volumes. If the volume is decreased, the opposite would occur. According to Le Chatelier's principle the equilibrium will shift to the right, to with fewer gas volumes, to reduce the change in pressure. 2

(iv) $n(Cl_2) = \frac{1}{2} n(HCl_{(g)})$ init. 2

$= \frac{1}{2} \times 0.548$

$= 0.274$.

$V(Cl_2) = 24.79 \times n(Cl_2)$

$= 6.79$ L of $Cl_{2(g)}$ produced

4

17

STUDENT No. 8353

Marker's Use Only

(d) HGCL Ltd: Mercury process

Uses a mercury cathode to produce NaOH, which theoretically should stay contained within the system - but it has been found at other mercury process plants that a certain amount of mercury is lost into the waste brine solution, which is usually released back into the ocean. Mercury is a toxic heavy metal which is not only poisonous to animals, and hence detrimental to surrounding prawn and tuna industries, but also hazardous to humans, bio-accumulation of poisoned seafood can result in brain damage and disorders of the local as well as wider population of consumers of prawn and tuna products.

One environmental advantage this cell has over the soon to be dismissed diaphragm cell is that the anode and cathode compartments are separate, producing no by-products of OCl⁻ ions.

Dow phenol process - Chlorox Industries

This process does not use mercury - so no threat of mercury being released into the environment,

$Cl_2 + OH^- \rightarrow NaCl + ClO^-$

STUDENT No. 878[illegible]3

Marker's Use Only

but it does utilise an asbestos diaphragm to act as the salt bridge. This asbestos diaphragm must be ~~replaced~~ maintenanced/replaced regularly, posing health hazards for workers (who will be from the local community) as well as for the wider community (human population), if the used asbestos diaphragms are not disposed properly. Also, this diaphragm allows ~~Cl⁻~~ Na^+ ions from the brine in the anode compartment to cross over to the cathode so as to produce NaOH. However, this diaphragm is not ion-selective, Cl^- ions can cross over, contaminating the NaOH (not an environmental concern) but also OH^- ions can cross over to the anode where it react with $Cl_2(aq)$ to produce HOCl(aq), which produces OCl^- ions upon reaction with strong base OH^- ions. Releasing spent brine containing OCl^- ions is an environmental hazard as it is a strong reducing agent, possibly affecting aquatic life.

The membrane process (mem-chlor-tech) does not involve mercury or asbestos and has a selective membrane made of PTFE, poly tetra fluoro ethene, which only allows cations Na^+ to pass, generating no byproduct OCl(aq). Hence, the membrane process is the most environmentally sound and safe cell for the community and animal life, ~~and hence~~ Mem-~~chlo~~ Chlor-tec proposal should be approved.

/2

STUDENT NUMBER/NAME: .....

1. An unlabelled reagent bottle on a laboratory shelf contains a colourless liquid. A few drops of the liquid are shaken with bromine water in a test tube. The bromine water rapidly loses its colour. Which of the following could this substance be?

(A) Ethene
(B) Ethanol
(C) 1-hexene
(D) Methyl propanoate

2. Consider the following reaction

$$Zn_{(s)} + 2\,H^+ + 2\,MnO_{2\,(s)} \longrightarrow Zn^{2+} + Mn_2O_{3\,(s)} + H_2O_{(l)}$$

What is the oxidant in this reaction?

(A) $MnO_{2\,(s)}$
(B) $Mn_2O_{3\,(s)}$
(C) $Zn_{(s)}$
(D) H^+

3. Which of the following is true?

(A) Reduction is the loss of electrons
(B) Oxidation is the loss of electrons
(C) Oxidation is the reaction between acids and metals
(D) Oxidation is donating a proton

4. The radioisotope strontium – 90 undergoes beta decay. Which of the following is the remaining nucleus after decay?

(A) Krypton – 86
(B) Rubidium – 89
(C) Yttrium – 90
(D) Zirconium – 94

5. A spirit burner containing ethanol (molar mass 46gmol^{-1}) was used to heat a 200g sample of water, initially at 19°C, in a calorimeter. The initial mass of the spirit burner was 253.6g. After the water temperature reached 31°C, the spirit burner was extinguished and its mass was measured to be 251.9g.
From these results, which calculation gives the heat of combustion of ethanol, in kJg^{-1}?

(A) $\dfrac{200 \times 4.18 \times 103 \times 31 \times 19}{253.6 \times 251.9}$

(B) $\dfrac{200 \times 4.18 \times 10^3 \times (31 - 19)}{(253.6 - 251.9)}$

(C) $\dfrac{200 \times 4.18 \times 10^3 \times (31 - 19) \times 46}{(253.6 - 251.9)}$

(D) $\dfrac{200 \times 4.18 \times 10^3 \times (253.6 - 251.9)}{(31 - 19) \times 466}$

6. Which substance can act both as an acid and as a base, in dilute solutions?

(A) Calcium carbonate
(B) Ammonium nitrate
(C) Ethanol
(D) Water

7. The pH values of four acids and their concentrations are shown in the table below.

Acid	Conc. (mol L^{-1})	pH
P	0.01	2.0
Q	0.05	1.0
R	0.1	1.0
S	0.1	2.0

Which acid can donate more than one proton?

(A) P
(B) Q
(C) R
(D) S

8. Which group of substances below result in a lower pH when dissolved in water?

(A) Ammonia, sodium hydroxide, potassium carbonate
(B) Hydrogen chloride, ethanol, carbon monoxide
(C) Sodium oxide, magnesium oxide, calcium hydroxide
(D) Carbon dioxide, sulfur dioxide, hydrogen bromide

9. Which molecule contains a coordinate covalent bond?

(A) Water
(B) Ammonia
(C) Ozone
(D) Methane

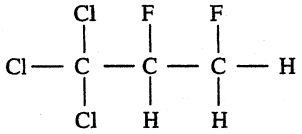
10. Two drops (0.1 mL) of 0.1 mol L^{-1} HCl is added to a small beaker of each of the following liquids.
In which case would the pH remain the same?

(A) A solution of ethanol and glucose, at equal concentrations
(B) Distilled water
(C) A solution of ethanol and ethanoic acid, at equal concentrations
(D) A solution of ammonia and ammonium chloride, at equal concentrations

11. When making the ester, ethyl propanoate, concentrated sulfuric acid is added to a mixture of ethanol and propanoic acid. One effect of the sulfuric acid is to increase the yield of the ester. Which of the following is the correct explanation for this increased yield?

(A) Sulfuric acid is a dehydrating agent and removes water as a reaction product.
(B) Sulfuric acid provides hydrogen ions which catalyse the reaction.
(C) The mixture becomes hot, which accelerates the reaction.
(D) The boiling point of the mixture increases, allowing a higher reaction temperature.

12. Identify the systematic name of the CFC molecule shown below.



(A) 1,1-dichloro-2,3-difluorobutane
(B) 1,2-difluoro-3,3,3-trichloropropane
(C) 1,1,1-trichloro-2,3-difluoropropane
(D) 1-trichloro-2,3-difluoropropane

13. Which of the following 4 carbon atom molecules has the highest boiling point?

(A) Butane
(B) Methyl propanoate
(C) Butanoic acid
(D) 2-butanol

14. Incomplete combustion of petroleum fuels is a major cause of atmospheric pollution.
Which of the following are two products of incomplete combustion?

(A) Carbon and water
(B) Carbon monoxide and hydrocarbons
(C) Ozone and carbon dioxide
(D) Nitrogen oxides and sulfur dioxide

15. Atmospheric pollution by heavy metals is monitored using dust deposit plates on which solid particles from the air settle.
An environmental scientist used atomic absorption spectroscopy to analyse the dust on one such plate. He found extremely high levels of lead.
Which of the following is the most appropriate immediate response of the scientist?

(A) Alert the local media
(B) Recommend that the nearby lead smelter be shut down
(C) Change the method of analysis, using gravimetric measurements
(D) Repeat the measurement and analyse other plates from the vicinity

Section I – continued

Part B

Total marks (60)
Attempt questions 16 – 26
Allow about 1 hour 45 minutes for this part

Answer the questions in the spaces provided

Show all relevant working in questions involving calculations.

Question 16 (5 marks) **Marks**

Polyvinyl chloride (PVC) is a polymer commonly used in water pipes, electrical conduit and containers for food and other organic materials.

(a) Give the systematic name of the monomer used to produce polyvinyl chloride. **1**

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(b) Identify a property of polyvinyl chloride that makes it suitable for ONE of the above uses. **1**

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(c) The compounds used to produce polymers such as polyvinyl chloride are presently obtained from the petrochemical industry. State why alternative sources of these compounds are needed and identify TWO such sources. **3**

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Question 17 (6 marks) **Marks**

Ethanol is manufactured from petrochemicals by the reaction of ethene with steam, in a high pressure vessel.

(a) Construct the equation for this reaction. **1**

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(b) Identify why high pressure is used for this reaction. **1**

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(c) Outline the steps by which ethanol is produced from sugar cane. **2**

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(d) Define the term *renewable resource* with reference to these TWO methods of producing ethanol. **2**

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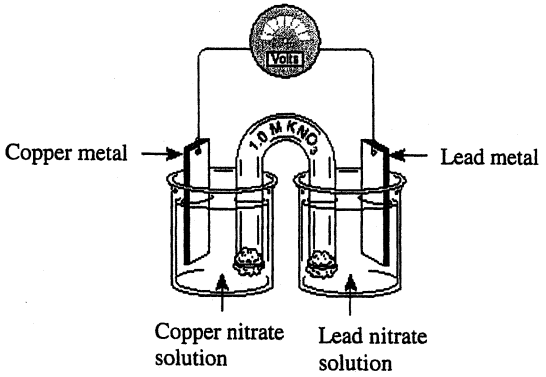
Question 18 (8 marks) **Marks**

The diagram below shows an electrochemical cell.



(a) Write an ionic equation to represent the overall reaction occurring in this cell. **1**

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(b) Identify the anode and state its polarity. **1**

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(c) Predict the reading on the voltmeter, assuming standard conditions. **1**

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(d) Describe THREE changes that could be observed during the operation of this cell. **3**

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(e) Outline any changes in nitrate ion concentrations as the cell operates. **2**

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Question 19 (4 marks) **Marks**

Identify a radioisotope which is used in medicine and describe problems associated with its use **4**

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Question 20 (4 marks)

Compare the terms *concentration* and *strength* as they apply to solutions of acids in water. In your answer identify ONE acid you have studied for which concentration and strength differ greatly. **4**

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Question 21 (11 marks)

A crusty white deposit around the rim of an irrigation pipe is thought to consist of a mixture of sodium chloride and sodium carbonate. To test for sodium carbonate a sample of the deposit is dissolved in water. The solution is filtered and then titrated with a standard 0.118 mol L^{-1} solution of nitric acid. The measurements are recorded below:

Mass of solid sample = 1.32 g
Volume of 0.118 mol L^{-1} HNO_3 titrated = 27.3 mL
Indicator used: methyl orange (pH range 3.5-5)

(a) Describe ONE laboratory test you could perform to show the presence of sodium ions in the sample. **1**

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(b) From the titration results calculate the mass and percentage by mass of sodium carbonate in the sample. **3**

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(c) Identify reasons why methyl orange was selected as the indicator for this titration. **1**

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Question 21 continues on the next page

Question 21 (continued)

Marks

(d) Outline a laboratory procedure you could perform to assay the proportion of sodium chloride in the sample using the titrated solution. **3**

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(e) Identify factors in the environment and irrigation farming which result in higher salt concentrations in soil. **3**

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Question 22 (7 marks) **Marks**

To analyse a white crystalline solid a student makes the following observations:

- A platinum wire dipped in the solid and held in a bunsen flame produces a bright red colour.
- The solid dissolves easily in water. The solution has a pH of approximately 9.
- In solution the compound has no visible reaction with dilute hydrochloric acid.

(a) Suggest what the white solid might be, and construct ionic equations for it dissolving in water to produce a basic solution. **3**

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(b) Describe TWO further tests you could perform to test your identification of the solid. Include relevant equations. **2**

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(c) Identify ONE metallic salt which produces an acidic solution in water and ONE which produces a neutral solution. **2**

Acidic:..... Neutral: .....

Question 23 (3 marks)

When 2.5L of HBr gas and 1.6L of NH_3 gas, measured at 25°C and 100kPa, are mixed, ammonium bromide is formed as a white solid.

(a) Demonstrate that this is an acid-base reaction, using Bronsted-Lowry definitions. **1**

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(b) Calculate the mass of ammonium bromide formed in this reaction. **2**

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Question 24 (4 marks)

Many fish recently died in a creek on the NSW North Coast. This was blamed by some local residents on the sewage treatment works which border the creek immediately upstream of the dead fish. Authorities stated that the sewerage plant was operating properly and that the fish deaths were a natural occurrence.

(a) Outline a procedure for sampling the creek water to detect any contamination from the sewerage plant, including safety precautions. **2**

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(b) Identify TWO chemical tests you would perform on your water samples and the expected results if discharge from the sewerage plant had entered the waterway. **2**

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Question 25 (4 marks)

Ammonium sulfate is often used as a lawn fertiliser.
A package is labelled "more than 90%" ammonium sulfate.
Describe a first-hand investigation you have performed which could be used to verify the labelling on this package. Identify safety measures taken during your investigation. **4**

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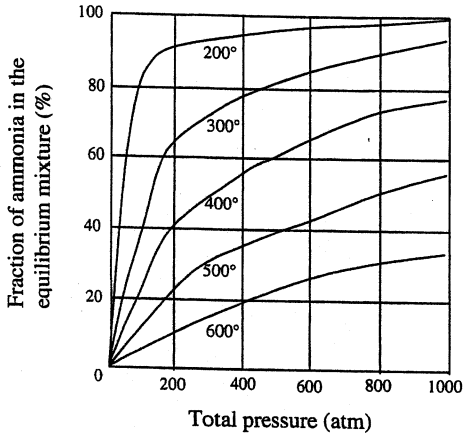
Question 26 (4 marks) **Marks**

The graph below shows the fractions of ammonia present at equilibrium when nitrogen and hydrogen are reacted in a pressure vessel.



(a) Construct a graph showing how the yield of ammonia varies with temperature, at a total pressure of 400 atm. **2**

(b) Referring to the energy of the reaction, explain the trend shown by the graph. **1**

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(c) Identify ONE industrial use of ammonia. **1**

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End of Section I

Question 27 – Industrial Chemistry (25 marks) **Marks**

(a) Describe equilibrium reactions. **4**

(b) (i) Identify THREE uses of sulfuric acid in industry. **3**

(ii) Describe ONE use of sulfuric acid identified above. **2**

(c) Explain ONE electrolysis method used to produce sodium hydroxide. **3**

(d) Distinguish between anionic, cationic and non-ionic detergents. **5**

(e) (i) What is the solvay process used to produce. **1**

(ii) Identify the raw materials used in the solvay process. **3**

(f) Describe saponification **4**

End of Question 27

NSW INDEPENDENT TRIAL EXAMS
CHEMISTRY HSC TRIAL – 2006
SUGGESTED ANSWERS

PART A

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

PART B

16. (a) Chloroethene 1

(b) Non-conductor of electricity, easily moulded and rigid, impervious to water, inert to organic materials. 1

(c) Petroleum is a non-renewable resource and supplies are being rapidly used up due to heavy demand for petrochemicals for a variety of uses such as fuels, plastics, lubricants, solvents etc. This demand is increasing as the world's population increases so alternative sources of these compounds are needed in the future. In the short term, recycling of plastics can help reduce this need for alternatives. However, compounds used as fuels cannot be recycled as they are destroyed in the process. 3

17. (a) $C_2H_4(g) + H_2O(g) \rightarrow C_2H_5OH(g)$ 1

(b) High pressure increases the equilibrium yield of ethanol, as the forward reaction occurs with a decrease in the number of gaseous molecules. 1

(c) Sugar solution is extracted from sugar cane by crushing.
The sugar solution is fermented with yeast, producing a dilute ethanol solution. The solution is distilled to separate ethanol, which has a lower boiling temperature than water. 2

(d) Ethanol produced from ethene is using non-renewable petroleum resources, and is therefore also non-renewable. Sugar cane is a renewable crop and ethanol produced from it is a renewable substance. 2

18. (a) $Pb_{(s)} + Cu^{2+} \longrightarrow Pb^{2+} + Cu_{(s)}$ 1

(b) $Pb_{(s)}$ electrode, negative 1

(c) (+0.34) – (–0.13) = 0.47 volts 1

(d) $Pb_{(s)}$ electrode corroding, blue colour of the solution fading, build up of Cu metal on the Cu electrode 3

(e) As the cell operates, nitrate ions migrate from the Cu/Cu^{2+} half-cell to the Pb/Pb^{2+} half-cell via the salt bridge. As a result the nitrate ion concentration goes down in the copper half-cell and increases in the lead half-cell, matching the changing concentrations of Cu^{2+} and Pb^{2+} ions. 2

19. eg. Iodine-131 is used in the treatment of an overactive thyroid gland. As only the thyroid takes up iodide ion the radioisotope concentrates there where its beta radiation destroys some thyroid cells, reducing the gland's activity toward normal levels.
Associated problems include collateral damage to surrounding tissue and exposure of another person in close proximity, such as a baby held close. Also the production and transport of the isotope involves operating a nuclear reactor (or cyclotron) and must be performed with stringent safeguards against radiation exposure of personnel, including medical staff. 4

20. The molar concentration of an acid is simply the number of moles of acid dissolved per litre of solution. Concentration can be measured by titration with a standard solution of a strong base, such as sodium hydroxide, using a suitable indicator, such as phenolphthalein. 2
The strength of an acid is the extent to which the acid ionises to produce hydrogen ions in dilute solution and can be measured with a pH meter. Acetic (ethanoic) acid is one example of an acid for which the strength is much less than its concentration. 2

21. (a) A small sample of the solid will produce an intense yellow colour in a bunsen flame. 1

(b) Moles HNO_3 used = 27.3 x 0.118mmol
Moles Na_2CO_3 in sample = 27.3 x 0.118 x 0.5mmol (1:2 mole ratio) 1
Mole mass of Na_2CO_3 = 106.0g
Mass of Na_2CO_3 in sample = 27.3 x 0.118 x 0.5 x 106/1000 = 0.171g 1
Percentage of Na_2CO_3 in sample = 0.171/1.32 = 12.9% by mass. 1

(c) Na_2CO_3 is a weak diprotic base. The neutralisation point, with HNO_3 is less than 7
Methyl orange changes colour in this range and provides a sharp end-point 1

(d) (Optional: Warm the titrated solution to expel any remaining carbon dioxide.)
Add dilute silver nitrate solution, shaking the flask, until no further precipitation occurs.
Filter the silver chloride precipitate through a previously weighed filter paper.
Wash the precipitate with distilled water.
Dry the precipitate and filter paper in a warm oven.
Reweigh to obtain the mass of silver chloride.
Calculate the mass, and percentage of sodium chloride from the 1: 1 mole relation:
58.5 g NaCl(s) → 143.4 g AgCl(s) 3

(e) Salt is naturally present in soil and ancient salt deposits underlie large areas of farmland. Irrigation raises the water table bringing dissolved salt towards the surface. Evaporation leaves a residue of salt which gradually builds up. Eventually the salt reaches levels which prevent crops or pasture growth. 3

22. (a) The solid could be calcium acetate or calcium citrate (soluble calcium salt of any weak acid) 1
eg., $Ca(OAc)_{2(s)} \rightarrow Ca^{2+} + 2OAc^-$ (OAc = acetate/ethanoate) 1
$OAc^- + H_2O \Leftrightarrow HOAc + OH^-$ 1

(b) eg., calcium ion: Add dilute sulfuric acid to a solution of the unknown.
Calcium ion forms a thin white precipitate of calcium sulfate.
$Ca^{2+} + SO_4^{2-} \Leftrightarrow CaSO_{4(s)}$ 1
Acetate ion: Add a few drops of dilute HCl to a small amount of the solid. The distinctive odour of acetic (ethanoic) acid can be detected.
$Ca(OAc)_{2(s)} + 2H^+ \rightarrow Ca^{2+} + 2\,HOAc$ 1

(c) Acidic solution: eg., copper sulfate (any salt of a weak base/strong acid) 1
Neutral solution: sodium chloride (any salt of a strong acid/strong base) 1

23. (a) In this reaction HBr is a proton donor, with the proton transferred to ammonia. HBr is the acid and NH_3 is the base, using Bronsted-Lowry definitions. 1

(b) NH_3 is the limiting reagent.
Moles of NH_3 = 1.5/24.79 = 0.065 mol 1
Moles of NH_4Br = moles NH_3
Mass of NH_4Br = 0.065 x (14.0 + 4.04 + 79.9) = 6.32 g 1

24. (a) Collect water samples separately at points upstream from the sewerage works, adjacent to the works and downstream below the works. Seal and label the collection containers, with date-time and location. Avoid entering the water, wear protective gloves and eye protection. 2

(b) Any two of the test for nitrate ion, phosphate ion, biological oxygen demand and dissolved oxygen. Discharge from the plant would be indicated by elevated levels of the first three or low dissolved oxygen in the downstream water samples compared with those upstream from the plant. 2

25. Dissolve a weighed sample, of approx. 1.0g in a small volume of distilled water, in a weighed beaker.
Filter the solution and collect the filtrate.
Add 20mL of 0.5molL^{-1} barium nitrate solution. Gently boil the mixture to coagulate the precipitate of barium sulfate. Allow to cool and settle.
Decant the clear liquid. Wash the precipitate, settle and decant again. Repeat washing.

Question 25 suggested answers continues on the next page

Question 25 continued

Dry the precipitate in the beaker, cool and weigh.
Calculate the mass of ammonium sulfate from the 1:1 mole ratio, and the percentage in the sample, using the sample's mass. 3
As cadmium is a toxic heavy metal care must be taken to avoid spillage and ingestion. Gloves and eye protection should be worn and the waste deposited in a heavy metal waste container.

26 (a) Draws appropriate graph. 1
(b) The graph shows that the equilibrium fraction of ammonia falls rapidly as the temperature increases. This is because the reaction is strongly exothermic and a higher temperature drives the equilibrium towards the reactants, reducing the yield of ammonia 2
(c) Answers may include fertilisers, plastics, nitric acid, cleaners and detergents. 1

Section II Options:

Q27. Industrial Chemistry

(a) Chemical reactions may be reversible. This means that the forward reaction and reverse reaction occur simultaneously. Undisturbed in a closed system, these reactions reach equilibrium. These reactions are governed by Le Chatelier's principle, i.e. when a system in equilibrium is disturbed, the system will adjust to minimise the disturbance. In a system where equilibrium has been reached, concentrations of reactants and products will stay constant, but not necessarily equal. 4

(b) (i) Identifies three uses of H_2SO_4. May include:
Manufacture of ammonium sulfate fertiliser
Manufacture of phosphate fertiliser
Dehydrating agent
Pickling steel
Manufacture of other chemicals. e.g. detergents, dyes, synthetic rubber, film, ink etc. 3

(ii) Describes one of the uses identified in (b)(i) e.g. H_2SO_4 reacts with NH_3 to form ammonium sulfate.
Ammonium sulfate is used as a fertiliser. The reaction is as follows:
$2NH_3(g) + H_2SO_4(aq) \longrightarrow (NH_4)_2SO_4(aq)$ 2

(c) Explains an electrolysis method used to produce sodium hydroxide. May include:
Mercury process
Diaphragm process
Membrane process 3

(d) Distinguishes between anionic, cationic and non-ionic detergents. i.e:
- Anionic: negatively charged head, long hydrocarbon tail; ionic head is usually SO_4^{2-} or SO_3^-
- Cationic: positively charged head, usually ammonium compounds.
- Non-ionic: have polar terminals, form H bonds between their Oxygens in their hydrocarbon tail and water, do not make many suds, used as laundry detergents. 5

(e) (i) Identifies Sodium carbonate 1
(ii) Identifies the raw materials used in the solvay process. May include:
NaCl
Ammonia
Calcium carbonate 3

(f) Describes saponification. e.g. Conversion in basic solution of fats and oils to glycerol and salts of fatty acids. 4

Q28. Shipwrecks, Corrosion & Conservation

(a) The origins of the minerals in the world's oceans come from two sources:
-The leaching by rainwater from terrestrial environments. The rainwater penetrates the rocks and soils leaching out minerals by the process of weathering. These dissolved minerals, which are mainly calcium ions, magnesium ions, hydrogen carbonate ions and silicate ions, are carried down to the oceans and seas by creeks and rivers.
-Dissolution of salts by water passing through hydrothermal vents in mid ocean ridges. Seawater penetrates down into cracks and fissures in mid ocean ridges coming near the hot magna heating the water. This hot water is forced back out through other cracks called hydrothermal vents and as it does it dissolves minerals in the rocks. Sulfides of iron, copper and zinc form deposits that settle on the ocean floor. Chlorides and sulfates of magnesium, calcium, sodium and potassium remain in solution. 4

(b) (i) The standard electrode potentials show that relative to hydrogen
Cu will give up electrons more readily than Ag
$Cu^{2+} + 2e \longrightarrow Cu \quad +0.34$
$Ag^+ + e \longrightarrow Ag \quad +0.80$
COPPER will therefore corrode 1

(ii) $Cu_{(s)} + 2Ag^+_{(aq)} \longrightarrow Cu^{2+}_{(aq)} + 2Ag_{(s)}$
$Cu \longrightarrow Cu^{2+} + 2e^- \quad -0.34$
$2Ag^+ + 2e \longrightarrow 2Ag \quad +0.80$
$Cu + 2Ag^+ \longrightarrow 2Ag + Cu^{2+} \quad +0.46V$ 2

(iii) Cu is the anode (where oxidation occurs). The anode will decrease in mass and the colour of the Cu^{2+} solution will darken as Cu^{2+} comes from the Cu as it gives up its electrons to form Cu^{2+} in solution
Ag is the cathode (where reduction occurs). The cathode will increase in mass as Ag^+ comes out of solution picking up an electron to form Ag 2

(c) (i) Mild steel has less than 0.2% C and is soft and malleable and has a high tensile strength. It is used in car bodies, pipes, roofing and shipbuilding.
Structural steel has 0.3 – 0.6% C and is hard and malleable and has a high tensile strength. It is used in beams and girders, railways and reinforcing for buildings.
Stainless steel has 10-20% Cr and 5-20% Ni and is hard, takes on a high polish and is resistant to corrosion. It is used in kitchen sinks and appliances, cutlery, surgical and instruments. 3

(ii) Rusting occurs in the presence of oxygen and water. At the site where iron oxidises to Fe^{2+} ions this is called the anodic site. The two electrons flow through the iron metal to a site where there is an impurity. This is the cathodic site. Here oxygen is reduced to hydroxide ions in a thin film of moisture on the iron surface or in the water if the iron is submerged.
The reduction reaction is: $O_2 + 2H_2O + 4e^- \longrightarrow 4OH^-$
The Fe^{2+} and OH^- ions migrate through the moisture and form insoluble $Fe(OH)_2$ ie:
$Fe^{2+} + 2OH^- \longrightarrow Fe(OH)_2$.
The $Fe(OH)_2$ is oxidised to iron(III) oxide:
$4Fe(OH)_2 + O_2 \longrightarrow 2(Fe_2O_3.H_2O) + 2H_2O$.
$2(Fe_2O_3.H_2O)$ is rust. 4

Question 28 suggested answers continue on the next page

NEAP CHEMISTRY TRIAL 2006

1. What is the systematic name for the monomer from which polyvinyl chloride is built?

(A) chloroethene
(B) 1,1-dichloroethene
(C) 1,2-dichloroethene
(D) vinyl chloride

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

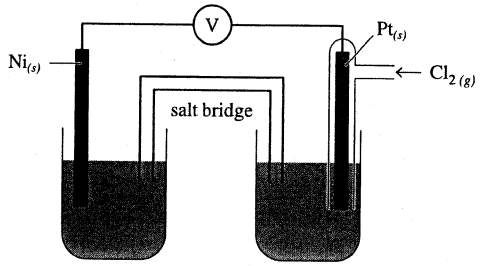
Using the above table, which of the following metals is the strongest REDUCING AGENT?

(A) Ca
(B) Pb
(C) Cu
(D) Ag

3. In which of the following does the nitrogen have an oxidation state of +4?

(A) HNO_3
(B) NO_2
(C) N_2O
(D) NH_4Cl

4. Consider the following diagram.



Which of the following describes what happens to the concentrations of Ni^{2+}, Cl_2 and Cl^- and the masses of the Ni and Pt electrodes as this galvanic cell spontaneously generates an electric current at 25°C and 100 kPa?

	Concentration of Ni^{2+}	*Concentration of Cl_2*	*Concentration of Cl^-*	*Mass of Ni electrode*	*Mass of Pt electrode*
(A)	decreases	increases	increases	increases	decreases
(B)	increases	decreases	increases	decreases	increases
(C)	decreases	no change	no change	increases	no change
(D)	increases	decreases	increases	decreases	no change

5. Carbon-14 radioactively decays via the emission of a beta particle. Which of the following is the product nuclide of this decay?

(A) boron-13
(B) carbon-13
(C) carbon-14
(D) nitrogen-14

6. Which of the following substances would NOT be present in the reaction flask during the preparation of ethyl propanoate?

(A) ethanoic acid
(B) ethanol
(C) propanoic acid
(D) sulfuric acid

7. An unknown solution is tested with four indicators to determine its pH. The table below shows the results obtained.

Indicator	*Acidic colour*	*pH range*	*Basic colour*	*Colour in unknown solution*
methyl orange	red	3.1 – 4.4	yellow	yellow
bromothymol blue	yellow	6.0 – 7.6	blue	green
phenol red	yellow	6.4 – 8.0	red	orange
phenolphthalein	colourless	8.3 – 10.0	bright pink	colourless

Which of the following statements gives the best range for the pH of the solution?

(A) The solution has a pH less than 8.3.
(B) The solution has a pH between 6.0 and 8.0.
(C) The solution has a pH between 6.4 and 7.6.
(D) The solution is neutral (pH = 7).

8. Which of the following species could best be described as amphiprotic?

(A) HNO_3
(B) NH_2^-
(C) $H_2PO_4^-$
(D) CH_3COO^-

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. During an experiment, a student measures the pH of a 0.01 mol L^{-1} solution of citric acid to be 3.6, but the pH of a 0.01 mol L^{-1} solution of hydrochloric acid is 2.0.

What is the most likely reason for this difference in pH?

(A) Citric acid is a stronger acid.
(B) Hydrochloric acid is a stronger acid.
(C) Citric acid is triprotic.
(D) Hydrochloric acid is more concentrated.

11. Which of the following substances would be least suitable for analysis by atomic absorption spectroscopy?

(A) iron
(B) sodium
(C) nitrogen
(D) potassium

12. A student wished to analyse the sulfate 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 sulfate
(B) sodium sulfate
(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

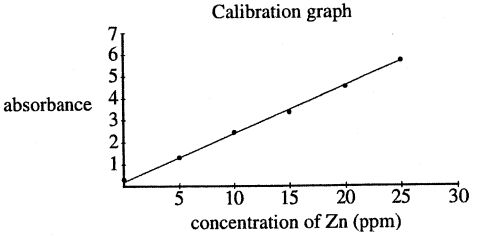
14. Microscopic membrane filters may be used as an alternative to chemical treatment of water. Which of the following is the best reason to use these filters?

(A) To remove harmful heavy metals.
(B) To remove large particulate matter.
(C) To remove fluoride and chloride.
(D) To remove harmful microorganisms.

15. A sample of water was collected downstream from a factory producing batteries. The sample was analysed for zinc content using the following method.

- Standard solutions of zinc were used to prepare a calibration curve.
- One litre of river water was collected.
- A 100 mL sample of this water was diluted to 1 L using distilled deionised water.
- A 50 mL sample of the dilute solution was used to aspirate into an atomic absorption spectrometer.

The following graph was obtained using standard solutions of zinc nitrate.



The absorbance reading of the 50 mL sample of the diluted river water was 1. Which of the following is closest to the concentration of zinc in the original river water sample?

(A) 10 ppm
(B) 40 ppm
(C) 50 ppm
(D) 100 ppm

Section I (continued)

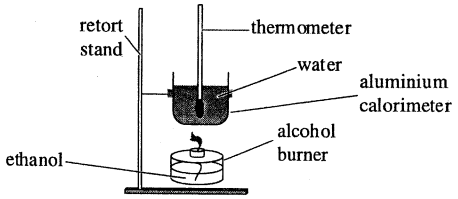
Part B

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 100 mL 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**

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

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

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

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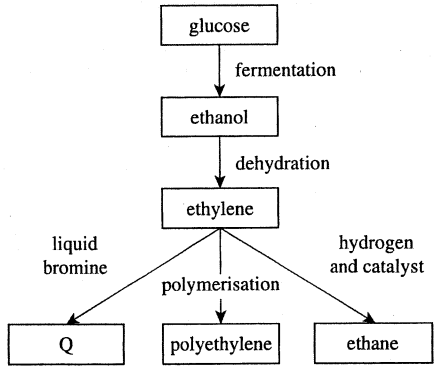
Marks

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 a catalyst in this reaction. **1**

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

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Marks

Question 18 (3 marks)

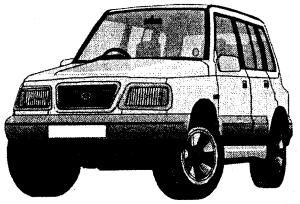
On February 1, 2004, the synthesis of the transuranic elements ununpentium (Z = 115) and ununtrium (Z = 113) was reported by Russian and American scientists.

Describe how transuranic elements such as ununpentium and ununtrium may be synthesised and identify ONE safe practice which must be adopted when working with radioactive elements such as these. **3**

Marks

Question 19 (5 marks)

A new vehicle is said to combine hybrid electric power with the capability of operating on a mixture of 15 per cent petrol and 85 per cent ethanol.



Evaluate the likelihood of the success of ethanol as an alternative fuel. **5**

Marks

Question 20 (6 marks)

Although the atmosphere naturally contains acidic oxides of carbon, nitrogen and sulfur, the levels of these oxides have been increasing since the industrial revolution.

It has been observed that the pH of rainwater is lower near significant sources of these gases.

(a) Account for the increasing concentration of oxides of nitrogen (NO_x) in the atmosphere. **2**

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(b) Explain the formation of acidic solutions from oxides of nitrogen and evaluate reasons for concern about the effects of acid rain. **4**

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Question 21 (3 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, including relevant equations in your answer. **3**

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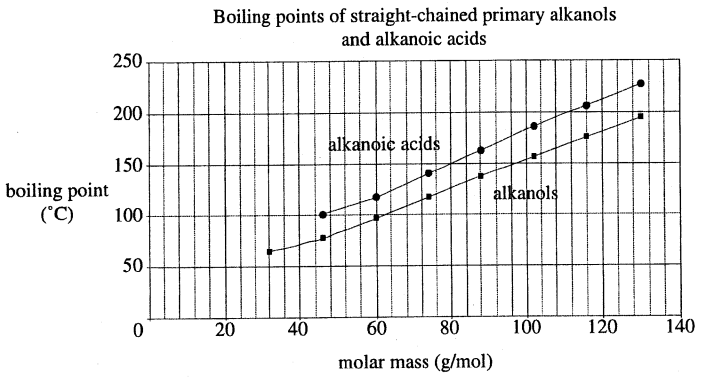
Marks

Question 22 (5 marks)



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

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(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.

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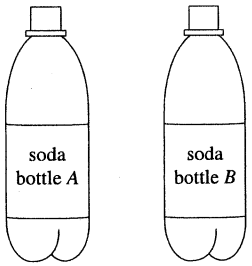
Marks

Question 23 (4 marks)

The following results were obtained during an investigation involving the decarbonation of two bottles of soda water. Each bottle was opened for a 24-hour period before re-sealing.



	bottle *A*	bottle *B*
Initial mass of sealed bottle (g)	125.5	125.5
Final mass of sealed bottle (g)	125.1	124.8
Change in mass (g)	0.4	0.7
Room conditions	cold	warm
Volume of CO_2 released at 25°C and 100 kPa (mL)	225.3	

(a) Calculate the volume of carbon dioxide (CO_2) gas lost from bottle *B* at 25°C and 100 kPa. **1**

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Question 23 continues on page 14

Marks

Question 23 (continued)

(b) In each bottle the following equilibrium process exists:

$$CO_{2(g)} + H_2O_{(l)} \rightleftharpoons H_2CO_{3(aq)} + \text{heat}$$

Explain the difference in the volume of carbon dioxide lost from the two bottles in terms of Le Chatelier's Principle. **3**

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Question 24 (4 marks)

It is well known that safety glasses should always be worn during practicals involving acids since spills and splashes can occur. The corrosive nature of acids can damage workbenches or pose a risk to people working in the lab.

A handbook for risk assessment states:

'To minimise risk, large acid spills should be neutralised with lime ($CaCO_3$) before mopping up.'

Assess this recommended method. **4**

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Marks

Question 25 (5 marks)

'Good up high, bad down low' is a statement which has often been made in reference to atmospheric ozone.

(a) Explain this statement. **3**

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(b) Use Lewis electron dot structures to demonstrate the formation of the bonds in an ozone molecule. **2**

Marks

Question 26 (4 marks)

A student was given a sample of an unknown soluble salt. She suspected the sample contained barium ions. Describe the procedures she may have used to confirm her suspicion. Include at least one precaution taken to minimise risk. **4**

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Marks

Question 27 (5 marks)

Lake Upyajumpa is located in a highly-developed farming region and has a factory that utilises the lake's water in the production of steel.

A sample was taken from Lake Upyajumpa and tested for water quality. Two of the results obtained were:

Dissolved oxygen (DO):	3 mg L^{-1}
Biological oxygen demand (BOD):	4.1 mg L^{-1}

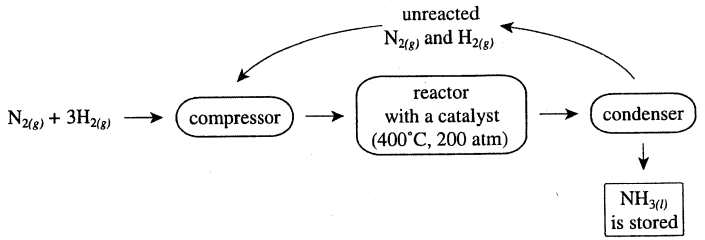
The reading obtained for DO was very low and vertebrate life within the lake would be in danger. The BOD value was borderline to indicating the lake was polluted.

Analyse the impact that the local community may have had which could have lead to the results of DO and BOD obtained. **5**

Marks

Question 28 (6 marks)

In a modern ammonia-producing plant many factors need to be monitored carefully. The following diagram describes the main features of such a plant:



In this production plant, the pressure and temperature are closely monitored for the combination of the reactant gases (in the reactor) and for the removal of the product (in the condenser).

Explain why the temperature and pressure must be carefully monitored in these chambers. Use appropriate equations to illustrate your answer. **6**

Question 29 — Industrial Chemistry (25 marks)

Marks

(a) (i) Identify the products of the Solvay process. **1**

(ii) Explain the importance of ammonia in the Solvay process using appropriate equations. **3**

(b) The chlor-alkali industry is one of the largest in developed countries. It produces chlorine, hydrogen and sodium hydroxide on a commercial scale by an electrolytic process. Analyse the chlor-alkali industry's choice of concentrated salt water (brine) for electrolysis, rather than molten sodium chloride or dilute sodium chloride. **7**

(c) Soaps and detergents are both cleaning agents.

(i) Draw structural diagrams to distinguish between a soap and a cationic detergent. **2**

(ii) List two different uses of both the soap and the cationic detergent. **2**

(iii) Account for one of the uses of either the soap or the cationic detergent by specific reference to the soap's or detergent's structure. **3**

(d) Sulfuric acid is produced commercially using the contact process but it may be modelled in the laboratory. One important step is the production of SO_3 according to:

$$2SO_{2(g)} + O_{2(g)} \rightleftharpoons 2SO_{3(g)} \quad \Delta H = -196 \text{ kJ mol}^{-1}$$

(i) In one laboratory preparation of SO_3 carried out in a 2 L reaction flask the number of mole of SO_2, O_2 and SO_3 were 0.224, 0.136 and 0.414 respectively at equilibrium. Calculate the value of the equilibrium constant for this reaction. **2**

(ii) Discuss the relationship between rate of reaction and equilibrium conditions with reference to the production of SO_3. **5**

Section I

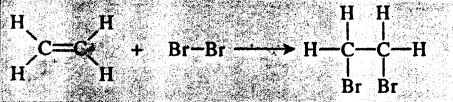
Part A

Answer and explanation	Syllabus content and course outcomes
Question 1 A The systematic name for the monomer from which polyvinyl chloride is built is chloroethene. Vinyl chloride is the common name for this species, and answers B and C give names for structures containing two Cl atoms (not one).	9.2.1 H9
Question 2 A The strongest reducing agent is most easily oxidised and therefore most difficult to reduce (lowest reduction potential on the table).	9.2.4 H7, H8, H14
Question 3 B The oxidation state of nitrogen in A is +5, in C it is +1 and in D it is –3. Only in NO_2 is it +4.	9.2.4 H6
Question 4 D The reactions occurring in this cell are: $Ni \rightarrow Ni^{2+} + 2e^-$ at the anode (nickel electrode); $Cl_2 + 2e^- \rightarrow 2Cl^-$ at the cathode (platinum electrode). Thus, over time the Ni electrode decreases in mass and the concentration of Ni^{2+} ions increases. The concentration of Cl_2 decreases and the concentration of Cl^- increases. The platinum electrode is unaffected.	9.2.4 H7, H8, H14
Question 5 D A beta particle is an e^-. The decay process occurring is: $^{14}_{6}C \rightarrow {}^{0}_{-1}e + {}^{14}_{7}N$ So the product is nitrogen-14.	9.2.5 H6
Question 6 A The production of ethyl propanoate occurs as follows: ethanol + propanoic acid $\overset{\text{conc. } H_2SO_4}{\rightleftharpoons}$ ethyl propanoate + water	9.3.5 H9
Question 7 C MO indicates that the solution has pH > 4.4 BB indicates that the solution has 6.0 < pH < 7.6 PR indicates that the solution has 6.4 < pH < 8.0 Ph indicates that the solution has pH < 8.3 Altogether, it can be determined that 6.4 < pH < 7.6	9.3.1 H10, H13, H14
Question 8 C Amphiprotic substances have the ability to donate a proton (act as acid) and to accept a proton (act as base): $H_2PO_4^- + HCl \rightleftharpoons H_3PO_4 + Cl^-$ $H_2PO_4^- + OH^- \rightleftharpoons HPO_4^{2-} + H_2O$ HNO_3 can only donate a proton, NH_2^- and CH_3COO^- can only accept a proton.	9.3.4 H8, H10

Part A (Continued)

Answer and explanation	Syllabus content and course outcomes
Question 9 D A burette is always rinsed with the solution it is going to dispense. A pipette is always rinsed with the solution it is going to dispense. A conical flask is always rinsed with water before use (or is clean and dry).	9.3.4 H11, H12
Question 10 B HCl is monoprotic, citric acid is triprotic. HCl is a strong acid, citric acid is a weak acid. Concentration of 0.01 $molL^{-1}$ is the same for each. pH of 2 for HCl implies $[H^+] = 0.01$ $molL^{-1}$ pH of 3.6 for citric acid implies $[H^+] = 2.5 \times 10^{-4}$ $molL^{-1}$ A higher pH means fewer H^+ ions in solution and less ionisation of the acid. Less ionisation means a weaker acid.	9.3.3 H8, H10, H13
Question 11 C AAS is most suited to ions of metallic elements. Nitrogen is the only non-metal in the list.	9.4.3 H4, H6
Question 12 D The SO_4^{2-} ions in the lawn food solution need to be precipitated out as $BaSO_4$. A solution of Ba^{2+} ions needs to be added. The compounds in A and B don't contain barium at all. Barium carbonate is insoluble and cannot be added as a solution.	9.4.3 H8, H11, H13
Question 13 B Gaseous oxygen is O_2. It is molecular and relatively less reactive than monatomic O atoms (oxygen free radicals), which contain reactive unpaired electrons.	9.4.4 H7, H8
Question 14 D Microscopic membrane filters are very fine-pored to remove microscopic-sized impurities (microorganisms). They are not suitable for large particulate matter. The pores are not small enough to trap ions such as fluoride and chloride or heavy metals effectively. Also, clean water at the end of the treatment process should still contain fluoride and chloride since they were additives included for specific purposes.	9.4.5 H3, H4, H5
Question 15 B An absorbance reading of 1 corresponds (approximately) to a Zn concentration of 4 ppm. The sample tested is one-tenth the concentration of river water, so the Zn concentration in river water is (approximately) 40 ppm.	9.4.3 H10, H13, H14

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

Sample answer	Syllabus content, course outcomes and marking guide
Question 18	9.2.5 H1, H3, H6, H13
Transuranic elements can be made by bombarding heavy nuclei such as uranium, plutonium, americium or lead, with high speed particles such as electrons, neutrons, small nuclei (helium or carbon nuclei) or even ions. Ununtrium (Z = 113) and ununpentium (Z = 115) were made by bombarding americium-243 with calcium-48 ions in a cyclotron. Safe practices: • Radioactive materials must always be stored in containers that are well shielded. You must never handle these materials with bare hands. • People who use radioactive materials must be well-trained to handle such things in a safe manner. • People must wear appropriate safety clothing which, depending in the radioactive isotope in use, may vary from gloves and face mask to specially laundered laboratory coats and overshoes, lead-lined aprons and, in the extreme, full protective suits. • People working in an around radiation facilities must wear radiation monitors (badges) that records the total amount of radiation they receive. • Proper procedures for safe storage and disposal of radioactive wastes must be established. • Clear signs must be displayed in any location where radiation equipment or materials are being used or stored.	• Correctly describes how transuranic elements may be synthesised and identifies ONE safe practice that must be adopted when working with them. . . . . 3 • Partially describes how transuranic elements may be synthesised and identifies ONE safe practice that must be adopted when working with them. . . . . 2 • Partially describes how transuranic elements may be synthesised OR • Identifies ONE safe practice that must be adopted when working with them. 1

Part B (Continued)

Sample answer	Syllabus content, course outcomes and marking guide
Question 19	9.2.3 H1, H3, H4, H5, H13, H16
There are numerous advantages and disadvantages to using ethanol as a fuel, such as: ADVANTAGES: • it is a renewable resource; • it is transportable; • it has a low ignition temperature and therefore is readily combustible; • it requires less oxygen than octane to completely burn, so it produces less soot and/or carbon monoxide; • it doesn't contribute to greenhouse gases because the carbon dioxide that it releases is essentially re-used in growing more plants (CO_2 neutral); • it does not produce sulfur dioxide and nitrogen oxides which are evident when other fossil fuels are combusted; • it can be mixed with other fuels (such as petrol); • it reduces our dependence on foreign fuel. DISADVANTAGES: • vast areas of land are necessary to supply enough plants to produce the quantity of ethanol required (monoculture, land degradation); • fossil-fuel energy is required to prepare and fertilise the land needed for growing the crops and for the fermentation and distillation processes; • the waste products from fermentation can be very smelly and difficult to dispose of; • it is currently still cheaper to produce fuel from fossil fuels than from ethanol; • vehicles presently on the road will require engine modifications if more than 10% ethanol is used; • it has a lower heat content than octane (46.0 kJ/g for octane and 30.6 kJ/g for ethanol) so there is a need to re-fuel more often; • it may be difficult to scale up production of ethanol to the quantities required for widespread use. CRITERIA TO BE CONSIDERED: • the cost of production, distillation etc. and the cost of altering infrastructure, designing and building new engines, etc.; • the energy content of ethanol compared with octane; • renewability and potential for long term use; • polluting emissions; • compatibility with technology.	• Demonstrates an extensive knowledge of ethanol's potential as an alternative fuel • Provides a comprehensive list describing the advantages and disadvantages of ethanol • Provides a suitable evaluation based on specific criteria ..... 5 • Demonstrates a thorough knowledge of ethanol's potential as an alternative fuel • Provides a basic list outlining advantages and disadvantages • Provides a judgement ..... 4 • Demonstrates a sound knowledge of ethanol's potential as an alternative fuel • Outlines several advantages and disadvantages of it use OR • Provides a judgement ..... 3 • Demonstrates a limited knowledge of ethanol's potential as an alternative fuel OR • Outlines several advantages and disadvantages of its use ..... 2 • Identifies some advantages and disadvantages of its use 1

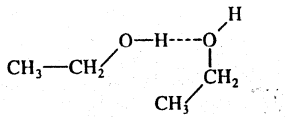
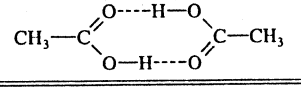
Part B (Continued)

Sample answer	Syllabus content, course outcomes and marking guide
Question 19 (continued)	
EVALUATION: There are several problems associated with the use of ethanol as a fuel (as seen above), but its advantages are ultimately more important. It is sensible to attempt to overcome the issues. Fossil fuel reserves will eventually be depleted and so a renewable alternative (such as ethanol) is crucial. As costs of dwindling fossil fuels continue to rise, the relative cost of ethanol will fall. Better production processes and suitable engines need to be developed so it can become economically viable, energy efficient and widely available. Our environmental wellbeing is of vast importance and ethanol's lower levels of polluting emissions make it a desirable energy source. In order to become a market reality in the future, ethanol will have to prove to be environmentally better than current fuels. In conclusion, it seems likely that ethanol will become a workable alternative fuel in the future as long as production processes are adapted.	

Part B (Continued)

Sample answer	Syllabus content, course outcomes and marking guide
Question 20	
(a) The major source of NO_x is motor vehicle exhaust (combustion engine). The other significant source is the burning of fossil fuels such as coal, oil and natural gas (for purposes such as generating electricity in coal-fired power stations or during primary metal production). Increasing use and number of cars and increased burning of fossil fuels over time has lead to higher levels of NOx being released into the atmosphere.	9.3.2 H4, H13 • Gives at least one correct source of NO_x emissions AND • identifies an increase in the source which leads to greater volumes of NO_x being released. . . . . 2 • Gives at least one correct source of NO_x emissions OR • Identifies an increase in the sources of NO_x which leads to greater volumes being released 1
(b) Formation of acidic solution from NO_x occurs when the nitrogen oxides dissolve in water to form an aqueous solution of nitric acid and/or nitrous acid. The reactions occurring are: $2NO_{2(g)} + H_2O_{(l)} \rightleftharpoons HNO_{2(aq)} + HNO_{3(aq)}$ OR $4NO_{2(g)} + 2H_2O_{(l)} + O_{2(g)} \rightleftharpoons 4HNO_{3(aq)}$ $HNO_{3(aq)} \rightarrow H^+_{(aq)} + NO_{3\ (aq)}^-$ (H^+ result in low pH!) Reasons for concern about production of acid rain include: • It contributes to acidification of lakes and other aquatic environments. Aquatic organisms can die as water acidity drops below pH 5. This disrupts the food web resulting in further deaths. • It can cause soil pH to drop, making it difficult for plants to absorb sufficient calcium or potassium. Growth is hindered and death of plants may result. • Changes in soil chemistry can also lead to the death of important micro-organisms and can release normally insoluble aluminium and mercury into soil water causing plants to absorb toxic levels of these and other heavy metals. • Protective waxes can be lost from leaves, causing leaf damage and thus substantial losses of trees and crops. • Buildings, statues and monuments made of carbonates (such as concrete, mortar, limestone and marble) can be gradually dissolved away: $CaCO_3(s) + 2HNO_{3(aq)} \rightarrow Ca(NO_3)_{(aq)} + CO_{2(g)} + H_2O$ • Acidic rain can also promote corrosion of metals, fade fabrics and degrade rubber. • Smog and acid rain can combine to form a "killer fog". JUDGEMENT: Damage to the natural and man-made environmental is both costly in a monetary sense as well as in cultural and ecological senses. For this reason, concerns about the effects of acid rain are warranted.	9.3.2 H4, H8, H13, H16 • Clearly explains the formation of acid solutions by dissolution of NO_x including the use of appropriate balanced equations. AND • Identifies and explains several and varied problems associated with acid rain. Demonstrates a thorough knowledge of the issues and implications and makes a clear judgement/evaluation about the value of these concerns. . . . . 4 • Outlines the formation of acid solutions by dissolution of NO_x. Includes appropriate equation. AND • Identifies several problems associated with acid rain and demonstrates a sound knowledge of the issues. A judgement/evaluation is made. . . . . 3 • Identifies need for dissolving of gases for formation of acid rain but little detail or no equations given. AND • Identifies some problems associated with acid rain. No evaluation. . . . . 2 • Identifies need for dissolving of gases for formation of acid rain but little detail and no equations given. OR • Identifies some problems with acid rain. No evaluation. 1

Part B (Continued)

Sample answer	Syllabus content, course outcomes and marking guide
Question 21	9.3.4 H11, H13
<table><tr><th>Salt</th><th>pH nature</th><th>Explanation or equations</th></tr><tr><td>NH_4Cl</td><td>acidic (pH < 7)</td><td>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.</td></tr><tr><td>Na_2CO_3</td><td>basic (pH > 7)</td><td>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.</td></tr></table>	• 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.

Part B (Continued)

Sample answer	Syllabus content, course outcomes and marking guide
Question 23	
(a) Bottle B: $n = \frac{m}{MM} = \frac{0.7}{44.01} = 1.59 \times 10^{-2}$ $V = n \times MV = 1.591 \times 10^{-2} \times 24.79$ $= 0.394$ L or 394 mL of CO_2 was released.	9.3.2 H10, H13 • Correctly calculates the volume of CO_2 released from Bottle *B* 1
(b) A greater amount of CO_2 gas was released in the warmer room. According to Le Chatelier, when the equilibrium system below is disturbed, the reaction will minimise the change while re-establishing equilibrium. $CO_{2(g)} + H_2O \rightleftharpoons H_2CO_{3(aq)} + \text{heat}$ At both temperatures, when the lid of the bottle is removed, the pressure of the system is reduced and the equilibrium balance is shifted to the left, releasing CO_2 gas. At the higher temperature of the warm room, there is a greater amount of heat in the system. According to Le Chatelier's Principle, the equilibrium system minimises the greater amount of heat by favouring the endothermic reverse process (to absorb some of the heat). This shifts the equilibrium further to the left than the equilibrium in the colder room. Since the reverse process releases CO_2 gas, a shift further to the left results in a greater volume of CO_2 being released at the higher temperature.	9.3.2 H8, H10, H13, H14 • Provides a thorough explanation of the effect of temperature change on the position of the equilibrium in the bottle • Relates the shift in equilibrium to Le Chatelier's principle • Correlates the relative equilibrium position to the amount of CO_2 gas released. . . . . 3 • Provides a sound explanation of the effect of temperature change on the position of the equilibrium in the bottle • Relates the shift in equilibrium to Le Chatelier's principle • Correlates the relative equilibrium position to the amount of CO_2 gas released. . . . . 2 • Correlates the amount of CO_2 gas released to the relative equilibrium position OR • Provides a limited explanation of the effect of temperature change on the position of the equilibrium in the bottle. 1

Part B (Continued)

Sample answer	Syllabus content, course outcomes and marking guide
Question 24	9.3.4 H4, H11

Usefulness of advice	Drawbacks of advice
Adding $CaCO_3$ neutralises (increases the pH of) the spill liquid. It reduces the risk of corrosive reaction between skin or eyes or equipment and the acid.	The base being used to neutralise acid could be mildly hazardous in its own right. Avoiding contact of lime with eyes, airways etc. would be necessary. $NaHCO_3$ (bicarb soda) is possibly a better choice of base to use since it is slightly less hazardous than $CaCO_3$ while serving the same purpose.
Fizzing of $CaCO_3$ when added clearly indicates a reaction with the acid. When the fizzing ceases, it can be assumed that all acid is neutralised. Continue to add lime until fizzing ceases. The area can then be washed up or hosed down safely.	Heat is released during the neutralisation process. There would be a need for caution of large amounts of heat posing a burn or heat hazard during the clean-up.
The base used is not strong or soluble and thus poses minimal risk, so it provides a neutralising action with minimal risk from the base itself.	The spill could be contained from spreading first by adding sand or vermiculite to the puddle of liquid. Once this has absorbed the spill, it can then be swept up. This may be less expensive than $CaCO_3$ and larger quantities may be readily available.
The powdered sample will absorb some of the liquid of the spill, thus preventing the spread of the liquid (into drains etc.)	It's not mentioned that the area will still need to be washed down with detergent and water after the bulk of the spill is cleared away.
The advice is suitable for small or large spills of acid and for spills of strong, weak, concentrated or dilute acid.	Apart from goggles, no safety gear is specifically mentioned. Also there is no mention of the need to ventilate the area.
Lime is readily available.	

- Demonstrates a thorough knowledge of the risks involved with acid spills and the use of neutralisation reactions to minimise the risk
- Thoroughly considers the advantages and disadvantages of using the recommended method
- Provides a detailed assessment or judgement of the problems and benefits of the method 4

- Demonstrates a sound knowledge of the risks involved with acid spills and the use of neutralisation reactions to minimise the risk

OR

- Outlines some of the advantages and disadvantages of using the recommended method
- Provides an overall judgement of the method 3

- Demonstrates a limited knowledge of the risks involved with acid spills and the use of neutralisation reactions to minimise the risk

OR

- Identifies an advantage and a disadvantage of using the recommended method

OR

- Provides an explanation of a problem or benefit of the method 2

- Identifies one advantage of using the method

OR

- Identifies one disadvantage of using the method 1

Part B (Continued)

Sample answer	Syllabus content, course outcomes and marking guide
Question 24 (continued)	

JUDGEMENT:

The method selected is essentially very useful and safe and gives the key information necessary to safely clear up a spill.

It minimises the risk from the acid spilt (neutralises it) and the base used in the clean-up (weak, solid form), while allowing the spill to be dealt with adequately (soaked-up liquid, fizzing as evidence of neutralisation, straightforward mop-up to finish).

However, more detail about how to go about the clean-up procedure could have been given, including working slowly from the edge of the spill inwards, adding more lime when fizzing subsides until no more fizzing occurs, and listing necessary protective gear to be worn.

Other weak base substances could be used apart from lime; however, it should be specified that the neutralising material be solid.

Question 25

(a) 'Good up high' refers to ozone in the stratosphere which acts as a filter for high-energy UVB radiation. The radiation is absorbed by the ozone, which decomposes into oxygen and a free radical.

'Bad down low' refers to ozone in the troposphere being a strong oxidant which acts as a respiratory irritant, can damage vegetation and is both an indicator of and contributor to photochemical smog.

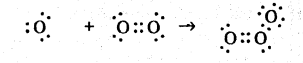
9.4.4 H4, H13

- Recognises that ozone exists in the stratosphere and the troposphere
- Ozone is a UV filter in the stratosphere
- Ozone is a pollutant in the troposphere . . 3

- States the two roles ozone may play in the atmosphere 2

- States a role that ozone plays in the atmosphere 1

(b) Ozone can be thought of as forming from molecular oxygen and an oxygen free radical.



oxygen free radical + molecular oxygen → ozone molecule

The oxygen molecule provides both of the shared electrons for the coordinate covalent bond. The two unpaired electrons on the free radical become a lone pair.

9.4.4 H6, H13

- Correctly shows the formation of ozone, including all lone pairs, and indicates the source of the bonding electrons for the coordinate bond 2

- Correctly draws molecular oxygen and an oxygen free radical. 1

Part B (Continued)

Sample answer	Syllabus content, course outcomes and marking guide
Question 26	9.4.3 H8, H11, H13
To identify barium: 1. A small sample of the unknown salt should be dissolved in water in a test-tube. 2. Add 2 mL of HCl and filter. 3. Add 2 mL of H_2SO_4 to the filtrate. 4. A white precipitate should form. 5. The presence of barium needs to be confirmed with a flame test. 6. Dip a platinum wire in concentrated HCl and then heat to red-hot in a non-luminous bunsen burner flame. 7. Dip the cleaned platinum wire into the sample and heat in the flame. 8. If Ba^{2+} ions are present, an apple-green flame will be produced. A risk-minimising precaution that must be taken is the wearing of safety glasses to ensure that acid splashes cannot reach the eyes.	• Outlines an appropriate method with all steps defined that would unambiguously identify the metal ion as barium AND • Includes an appropriate risk minimisation technique . . . . . 4 • Outlines an appropriate method with most steps defined that would identify the metal ion as barium AND • Includes an appropriate risk minimisation technique . . . . . 3 • Outlines a method with most steps defined that may identify the metal ion AND • Includes an appropriate risk minimisation technique . . . . . 2 • Outlines a method with most steps defined that may identify the metal ion OR • Includes an appropriate risk minimisation technique 1
Question 27	9.4.5 H4, H8, H11
• The low DO reading could be due to eutrophication, addition of organic waste material or an elevated water temperature. • The steel factory could be using the lake's water for cooling of plant machinery and as such cause the temperature of the lake to increase. The solubility of oxygen decreases with temperature and this could explain the low DO reading. • Farmers often use fertilizers to promote the growth of their crops. If fertilizer was applied a short time before rain or heavy watering there may have been run off into Upyajumpa which included dissolved fertilizer. The fertilizer would be rich in nitrates and phosphates. These nutrients would encourage growth of aquatic plants which would lead to a high value for BOD and consequently a low DO. • Any number of people could be dumping organic waste in the lake if there was no other way to dispose of the material. The organic material would begin to decompose and would use up dissolved oxygen.	• Proposes the possible role of the factory AND the farmers. Two or more valid reasons for the low DO/high BOD readings should be included with thorough explanations to link possible sources of contamination to the quality of the water and the test results given. . . . . 4–5 • Proposes the possible role of the factory AND • the farmers by briefly outlining two possible sources of contamination, with specific reference to the DO and BOD tests. . . . . 3 • Proposes the possible role of the factory OR • the farmers by outlining one possible reason for the lake's measurements. . . . . 2 • Proposes the possible role of the factory OR • the farmers by identifying one possible reason for the lake's measurements. 1

Part B (Continued)

Sample answer	Syllabus content, course outcomes and marking guide
Question 28	9.4.2 H7, H8
The temperature and pressure must be monitored in both the reaction chamber and the condenser chamber for the following reasons. The reaction chamber is where the hot mixture of nitrogen and hydrogen gases are passed over a catalyst and react to form ammonia. $N_{2(g)} + 3H_{2(g)} \overset{Fe/FeO}{\rightleftharpoons} 2NH_{3(g)} \quad \Delta H = -92\ kJ$ Temperature: the reaction is exothermic and the equilibrium (forward reaction) is favoured by low temperature. The rate of reaction is too slow at low temperatures and so a compromise temperature of around 500°C is used. The exothermic nature of the reaction means that the reaction must be carefully monitored to maintain this temperature. Pressure: the equilibrium (forward reaction) is favoured by high pressures as 4 mole of reactant gas produces only 2 mole of product gas. The pressure used is around 350 atmospheres which must be carefully monitored to maintain yield, by not dropping too low, and to ensure safety, by not going too high. The condenser chamber is where the ammonia is liquefied and collected. $NH_{3(g)} \rightleftharpoons NH_{3(l)}$ Pressure: the pressure of the gas mixture needs to be kept quite high to make it easier to liquefy the ammonia. Temperature: the gases are cooled and the liquid ammonia collected while the nitrogen and hydrogen are recycled to the reactor chamber. The pressure and temperature must be monitored to ensure that all of the ammonia is collected to ensure efficient conversion by further driving the equilibrium to replace the removed ammonia.	• Examines both the reactor and the condenser • Specifically addresses pressure and temperature • Specifically relates the need to monitor each to the equilibrium process • Addresses the extent of the reaction and the rate in the reactor • Addresses safety specifically with pressure • Addresses the temperature decrease while maintaining pressure in the condenser • Includes appropriate equations . . . . . 6 • Examines both the reactor and the condenser • Specifically addresses pressure and temperature • Relates the need to monitor each to the equilibrium process • Addresses the temperature decrease while maintaining pressure in the condenser • Addresses safety specifically with pressure • Includes an appropriate equation . . . . . 5 • Examines both the reactor and the condenser • Specifically addresses pressure and temperature • Addresses the extent of the reaction and the rate in the reactor • Addresses the temperature decrease while maintaining pressure in the condenser • Includes an appropriate equation . . . . . 4 • Mentions one of the two vessels and describes correctly the monitoring for both pressure and temperature conditions . . . . 3 • Mentions one of the two vessels and describes correctly the monitoring for one condition OR • Writes two correct equations . . . . . 2 • Mentions one of the two vessels and the need to monitor conditions for the equilibrium OR • Writes one correct equation 1

Section II

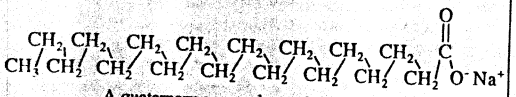
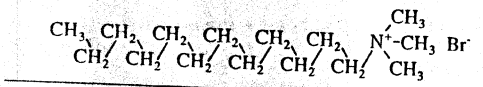
Question 29 Industrial Chemistry

		Sample answer	Syllabus content, course outcomes and marking guide
(a)	(i)	The products of the Solvay process are sodium carbonate and calcium chloride.	9.5.6 H3 • Correctly identifies the products Na_2CO_3 and $CaCl_2$ 1
	(ii)	Ammonia plays a vital role in the Solvay process, as it allows the formation of the hydrogen carbonate ion. In the process, carbon dioxide is bubbled through ammoniated brine. $CO_{2(g)} + NH_{3(aq)} + NaCl_{(aq)} + H_2O_{(l)} \rightarrow NaHCO_{3(s)} + NH_4Cl_{(aq)}$ The reaction is carried out at 0°C, and the sodium hydrogen carbonate crystallises. The ammonia is vital as carbon dioxide reacts with water only to a small extent, forming carbonic acid. $CO_{2(g)} + H_2O_{(l)} \rightleftharpoons H_2CO_{3(aq)}$ The ammonia acts as a base, accepting a proton from the carbonic acid, which produces the hydrogen carbonate ion and drives the equilibrium to the right. $NH_{3(aq)} + H_2CO_{3(aq)} \rightleftharpoons NH_4^+{}_{(aq)} + HCO_3^-{}_{(aq)}$	9.5.6 H3, H4, H13 • Recognises that CO_2 is bubbled through ammoniated brine • Explains that CO_2 reacts with brine only to a small extent • Explains that ammonia shifts the CO_2/H_2CO_3 to the right . . . . . 3 • Two of the above . . . . . 2 • One of the above 1

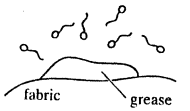
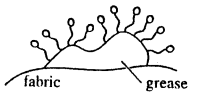
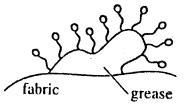
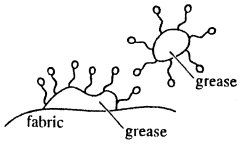
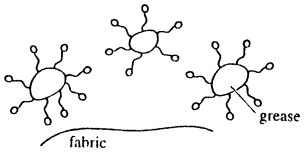
Question 29 Industrial Chemistry (Continued)

	Sample answer	Syllabus content, course outcomes and marking guide
(b)	The chlor-alkali industry uses brine to produce sodium hydroxide and chlorine gas by electrolysis. A number of factors lead to the use of brine. The possible reactants are molten sodium chloride, dilute sodium chloride solution and brine. Molten sodium chloride: Electrolysis yields sodium and chlorine according to $2NaCl_{(l)} \rightarrow 2Na_{(l)} + Cl_{2(g)}$ thus no sodium hydroxide is produced directly, but could be produced by reacting the molten sodium with water. $2Na_{(l)} + 2H_2O_{(l)} \rightarrow 2NaOH_{(aq)} + 2H_{2(g)}$ This would be dangerous and expensive, as the sodium chloride must be molten to allow electrolysis and the reaction of sodium and water is highly exothermic and constitutes a severe explosive risk. Dilute sodium chloride solution: The electrolysis of these solutions produces oxygen, hydrogen and sodium hydroxide but not chlorine. This is due to the reduction potentials of the possible reactants. At the cathode the two possible reactants are Na^+ ions and water molecules. $Na^+_{(aq)} + e^- \rightarrow Na_{(s)}$ $E° = -2.76$ V $2H_2O_{(l)} + 2e^- \rightarrow H_{2(g)} + 2OH^-_{(aq)}$ $E° = -0.83$V The reduction of water takes less energy, and hydrogen is produced. At the anode the two possible reactants are Cl^- ions and water molecules. $2Cl^-_{(aq)} \rightarrow Cl_{2(g)} + 2e^-$ $E = -1.36$V $2H_2O_{(l)} \rightarrow O_{2(g)} + 4H^+_{(aq)} + 4e^-$ $E = -1.23$V Under near-standard conditions oxygen is produced. Brine is a concentrated sodium chloride solution. Standard conditions no longer apply and while the same reactions as for dilute sodium chloride are possible at each electrode, chlorine ions are oxidised in preference to water and chlorine gas is produced at the anode. Concentration has a direct bearing on the product. The chlor-alkali industry uses brine as it is the safest and cheapest of the three possible reactants that produces the desired products.	9.5.4 H3, H8, H14 • Addresses the three possible reactants: molten NaCl, dilute NaCl solution and brine • Explains predicted products using equations for NaCl • Explains why molten NaCl is not used • Explains predicted and actual products from aqueous solutions using equations and $E°$ values • Explains the concentration dependence of the production of chlorine . . . . . 6–7 • Addresses the three possible reactants • Shows products from molten NaCl using equations but does not extend to production of NaOH • Explains predicted products using equations • Explains the concentration dependence of the production of chlorine . . . . . 4–5 • Addresses two of the possible reactants • For this pair, shows predicted products using equations • Explains the advantages of one over the other . . . . . 3 • Addresses any pair of reactants using equations . . . . . 2 • Addresses any pair of reactants 1

Question 29 Industrial Chemistry (Continued)

Sample answer	Syllabus content, course outcomes and marking guide
(c) (i) Sodium stearate, a common soap.	9.5.5 H9
$CH_3(CH_2)_{16}COO^-Na^+$	• Both structures correct 2
	• One structure correct 1
A quaternary ammonium salt, a common cationic detergent.	
$CH_3(CH_2)_{11}N^+(CH_3)_3Br^-$	
	
(ii) Soaps are used as cleaning agents for a wide range of applications, from personal bath soaps to laundry soaps. They are used to clean grease from many surfaces.	9.5.2 H4, H9
Most cationic detergents are powerful broad-spectrum biocides and form the basis of household and industrial disinfectant and sanitiser formulations.	• Lists appropriate uses for soap and cationic detergent 2
Their cationic nature causes them to adhere to negatively-charged surfaces such as glass, hair, fibre, metals and many plastics. They are not good cleaners of these materials but are used as antistatic agents, corrosion inhibitors, fabric softeners, hair conditioners, leather softeners, pigment wetting and dispersing agents and water and sewage treatment flocculants.	• Lists appropriate uses for soap or cationic detergent 1

Question 29 Industrial Chemistry (Continued)

Sample answer	Syllabus content, course outcomes and marking guide
(iii) Soap cleans materials by the dual nature of its structure. It has a hydrophobic tail, the hydrocarbon chain, and the charged carboxyl group acts as a hydrophilic head.	9.5.2 H8, H9
The soap is dissolved in water:	• Explains the dual nature of a surfactant with reference to hydrophilic and hydrophobic sections correctly
	• Explains how the surfactant attaches to the surface by one end, leaving the other end 'free'
The hydrophobic tail buries itself in the grease on the plate while the hydrophilic head remains in the water:	• Explains the formation of the emulsion or the function of the hydrocarbon tail for cationic detergent 3
	• Explains the dual nature of a surfactant • Describes in general terms the cleaning action 2
The grease begins to be pulled from the fabric with the help of some agitation of the water:	• Describes the parts of a surfactant 1
	
As more grease is exposed more soap molecules attach and the grease breaks into globules:	
	
The globules are stabilised by the soap which has its hydrophilic head forming a layer over the surface of the grease, keeping it away from other globules and dissolved in the water. This is an example of emulsification:	
	

Question 29 Industrial Chemistry (Continued)

Sample answer	Syllabus content, course outcomes and marking guide
(d) (i) $K_c = \frac{[SO_3]_e^2}{[SO_2]_e^2[O_2]_e}$ $[SO_2] = \frac{0.224}{2}M$ $[O_2] = \frac{0.136}{2}M$ $[SO_3] = \frac{0.414}{2}M$ $K_c = \frac{(0.207)^2}{(0.112)^2(0.068)}$ $K_c = 50.2$	9.5.2 H10 • Writes the equation for the equilibrium constant and calculates the correct value . . . . . 2 • Writes the equation for the equilibrium constant. 1
(ii) The production of SO_3 gas from SO_2 gas is an equilibrium process. It is at the heart of the contact process for the production of sulphuric acid. The specific conditions for this part of the process are: a temperature of about 400–450°C at close to 1 atm pressure and the use of a V_2O_5 catalyst. The reactant gases are mixed with oxygen in excess. The rate of reaction is how quickly equilibrium is established. The rate is favoured by high temperatures. The lower the temperature, the greater the yield, but the time taken to achieve equilibrium is far too great to be economical and vice versa. The temperature used is a compromise between a temperature that produces a very fast rate and one which will produce a reasonable amount of product at equilibrium. The rate is favoured by increased pressures. Increased pressure would increase both the rate and yield of this reaction. However, the reaction is carried out at close to atmospheric pressures. This is because the rate achieved by using the moderate temperature along with the catalyst is quite satisfactory as is the yield due to the use of excess oxygen and the recycling of reactant gases. It is economically less attractive to build expensive high pressure plant for the small gain in overall yield. Thus, rate and equilibrium considerations need to be carefully balanced to achieve a compromise that leads to an acceptable yield within a reasonable time.	9.5.3 H3, H8 • Lists conditions used for the contact process • Discusses rate and extent with temperature • Discusses rate and extent with pressure • Recognises that the conditions used are a compromise between the competing demands of rate and yield . . . . . 4–5 • Discusses rate and extent with temperature • Discusses rate and extent with pressure • Recognises that the conditions used are a compromise between the competing demands of rate and yield . . . . . 3 • Discusses one of temperature or pressure with regard to the rate and extent of the reaction. . . . . 2 • Mentions that compromise conditions are used 1

Section I
75 marks

Part A – 15 marks
Attempt Questions 1-15
Allow about 30 minutes for this part

Use the Multiple Choice Answer Sheet provided

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1 Why can ethylene be transformed readily into other compounds?

(A) It is a product of both fossil fuels and biomass.
(B) It has a highly reactive double bond.
(C) It easily loses two H atoms.
(D) It can be catalytically cracked to form many different alkanes.

2 $n\ (HO\text{-}C_6H_{10}O_4\text{-}OH) \rightarrow H\text{-}(O\text{-}C_6H_{10}O_4)_n\text{-}OH + (n\text{-}1)\ H_2O$

What type of reaction is this?

(A) catalytic cracking
(B) condensation polymerisation
(C) addition polymerisation
(D) oxidation and reduction

3 A student was investigating the heat of combustion of ethanol. She used an ethanol burner that had an initial mass of 68.0 g. She then lit the burner and placed it under a beaker containing 500 mL of water. After a few minutes, she noticed that the water temperature had risen from 24°C to 38°C and the burner now weighed 66.5 g.

She made the assumption that only the water was heated.

What would be the student's value for the heat of combustion for ethanol?

(A) 87.8 J mol^{-1}
(B) 29.3 kJ mol^{-1}
(C) 899 kJ mol^{-1}
(D) 1350 kJ mol^{-1}

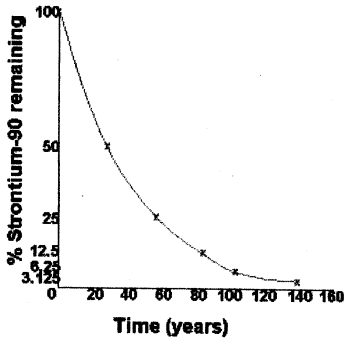
4 Consider the following reaction involving hydrogen ions.

$$2Na(s) + 2H^+(aq) \rightarrow H_2(g) + 2Na^+(aq)$$

Which statement about the hydrogen ions in this reaction is correct?

(A) They undergo an increase in oxidation state.
(B) They are classified as the oxidising agent.
(C) They lose electrons.
(D) They undergo an acid-base reaction with the sodium metal.

5 The graph shows the radioactive decay of strontium-90.



What is the approximate half-life of strontium-90?

(A) 30 years
(B) 50 years
(C) 80 years
(D) 140 years

6 An unknown chemical was extracted from a soil sample and sent to your laboratory. One of the first tests you carried out was to determine the pH of the chemical by using indicators. The following are the results:

Indicator	Colour
Phenolphthalein	Colourless
Methyl orange	Yellow
Bromothymol blue	Blue

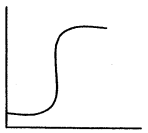
How should your laboratory classify the soil sample?

(A) strongly acidic
(B) slightly acidic
(C) neutral
(D) slightly alkaline

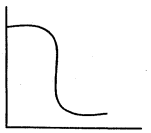
7 The pH of a 0.1 mol L^{-1} solution of a monoprotic acid was measured by a student and found to be close to 3. What proportion of the acid molecules remains unconverted to ions?

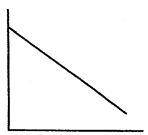
(A) 0 %
(B) 1 %
(C) 60 %
(D) 99 %

8 Which of the following curves would represent the change in pH in a conical flask when a solution of hydrochloric acid (from a burette) is added to a solution of sodium hydroxide (in the conical flask)?

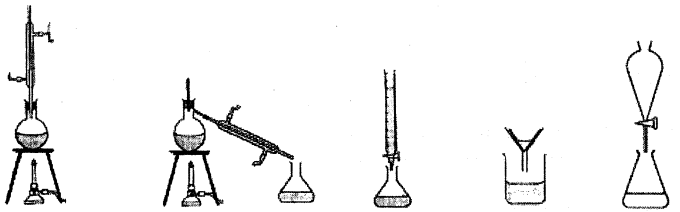
(A)


(B)


(C)


(D)


9 The following diagrams show equipment you have used in carrying out first-hand investigations in the school laboratory.



P Q R S T

Students were asked to perform an experiment in 3 steps:

Step1: The ester, ethyl propanoate, was prepared from ethanol, propanoic acid and a small amount of concentrated sulfuric acid.
Step 2: An impure sample of the ester was then separated from any unreacted acid, alcohol and sulfuric acid.
Step 3: A pure sample of the ester was collected.

The equipment used in each step of this experiment was:

	Step 1	Step 2	Step 3
(A)	P	T	Q
(B)	P	Q	S
(C)	Q	R	T
(D)	Q	T	S

10 Calculate the mass of carbon dioxide formed when 74.4 L of oxygen gas at 100 kPa and 25 °C completely combusts a sample of ethanol.

(A) 44 g
(B) 50 g
(C) 88 g
(D) 132 g

11 Identify the catalyst used in the Haber process.

(A) a zeolite
(B) concentrated sulfuric acid
(C) dilute sulfuric acid
(D) iron oxide

12 Identify the ion present in an unknown solution that produces bubbles with the addition of dilute nitric acid.

(A) Cl^-
(B) CO_3^{2-}
(C) PO_4^{3-}
(D) SO_4^{2-}

13 The three equations below summarise a series of reactions occurring in the atmosphere.

CCl_3F + UV radiation $\rightarrow$ Cl• + $\bullet CCl_2F$

Cl• + O_3 $\rightarrow$ $\bullet ClO$ + O_2

$\bullet ClO$ + O $\rightarrow$ Cl• + O_2

What do these three equations explain?

(A) Production of oxygen gas in the troposphere.
(B) Formation of ozone in the stratosphere.
(C) Absorption, by ozone, of harmful UV radiation.
(D) Production, destruction and regeneration of chlorine atoms.

14 $CHCl_2CF_3$ and $CHClFCClF_2$ are

(A) isomers
(B) isotopes
(C) allotropes
(D) CFCs

15 The treatment of water to make it suitable for human consumption is a process which occurs in steps.

Identify the INCORRECT statement relating to this process.

(A) The pH of the water is increased by the addition of lime or sodium hydroxide to assist in coagulation.
(B) Salts such as alum or iron (III) chloride are added to bring about coagulation and sedimentation of suspended materials.
(C) Chloride ions are added to kill bacteria in the water.
(C) Fluoride salts may be added to assist in the prevention of tooth decay in children.

Centre Number

Chemistry
Section I (continued)

Student Number

Part B – 60 marks
Attempt Questions 16-29
Allow about 1 hour and 45 minutes for this part

Answer the questions in the spaces provided.

Show all relevant working in questions involving calculations.

Question 16 (3 marks) **Marks**

(a) Using a labelled diagram, demonstrate how polystyrene can be produced from its monomer. **2**

(b) Explain ONE use of this polymer in terms of ONE of its physical properties. **1**

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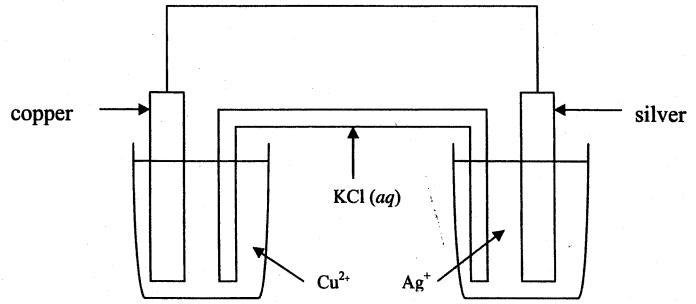
Question 17 (6 marks) **Marks**

In order to produce a cell with a voltage between 1.1 V and 1.2 V, a student constructed the following galvanic cell.



(a) Label the cathode on the above diagram. **1**

(b) Explain why KCl (*aq*) would be an *inappropriate* choice for the salt bridge in this cell. **2**

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(c) Calculate the cell potential, showing relevant half-equations, in order to evaluate the student's selection of electrodes and electrolytes. (Assume standard conditions.) **3**

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Question 18 (2 marks) **Marks**

Name an isotope used in industry. Explain how its use is related to its properties. **2**

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Question 19 (2 marks) **Marks**

Cobalt – 60 forms when cobalt – 59 captures a neutron.

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

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(b) Explain why cobalt – 60 is produced in a nuclear reactor rather than a cyclotron (particle accelerator). **1**

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Question 20 (7 marks)

Marks

Fossil fuels are currently the dominant source of both energy and raw materials needed for the production of polymers. However, the supply of fossil fuels is finite and rapidly diminishing. In the near future, a replacement source of both energy and polymer raw materials will need to be found and one potential source is ethanol. **7**

Using appropriate chemical equations, assess the potential of ethanol as a resource to replace fossil fuels for the supply of both polymers and energy.

Question 21 (4 marks)

Marks

(a) SO_2, K_2O, N_2O_5, CaO

From the list of oxides above, identify:

(i) a basic oxide **1**

(ii) an acidic oxide **1**

(b) Write a balanced equation for a reaction which illustrates the acidic or basic nature of one of the oxides you identified in part (a). **1**

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(c) Aluminium oxide is classified as amphoteric. Define the term amphoteric. **1**

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Question 22 (3 marks)

Marks

(a) State an industrial use for a named ester. **1**

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(b) (i) Draw the structural formula for the ester produced in the reaction between 1-butanol and ethanoic acid, in the presence of concentrated sulfuric acid. **1**

(ii) Name this ester. **1**

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Question 23 (8 marks) **Marks**

Hydrogen sulfide gas is extremely toxic if inhaled, has an unpleasant smell (rotten eggs) and is highly flammable. Stringent precautions are required when handling it.

(a) Explain why hydrogen sulfide is classified as a WEAK acid. **1**

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(b) Explain (with the aid of a chemical equation) why H_2S is considered a Bronsted-Lowry acid. **2**

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(c) Identify ONE conjugate acid-base pair involved in the equation you have written in (b) above. **1**

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Question 23 continues on page 15

Question 23 (continued) **Marks**

(d) Hydrogen sulfide *(g)* is formed when hydrochloric acid reacts with zinc sulfide.

$ZnS\ (s) + 2HCl\ (aq) \rightarrow ZnCl_2\ (aq) + H_2S\ (g)$

In an experiment performed in a fume cupboard 50.0 mL of 0.10M HCl was added to 0.11 g of solid zinc sulfide.

(i) Which reagent is in excess? *Show Your Working*. **2**

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(ii) What volume of hydrogen sulfide *(g)* is produced at 298K and 100 kPa in this experiment **2**

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End of Question 23

Question 24 (5 marks)

Marks

Caustic soda (sodium hydroxide) can be used to strip paint off furniture.
A 3.0 g container of caustic soda was dissolved in water and the volume of the solution was made up to 3.0 L.
The sodium hydroxide solution was then titrated with 0.026 mol L^{-1} hydrochloric acid solution.

(a) Calculate the concentration of the sodium hydroxide solution in mol L^{-1}. *Show your working*. **1**

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(b) Determine the pH of the hydrochloric acid solution. **1**

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(c) Evaluate the use of sodium hydroxide as a *primary standard*. **3**

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Question 25 (4 marks)

Marks

The Haber Process has been used for over 90 years for the industrial production of ammonia. This process must be carefully managed and monitored by industrial chemists. **4**

Analyse the impact of changes in pressure and temperature on the yield and rate of production of ammonia during the Haber Process.

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Question 26 (2 marks)

Marks

Explain why incomplete combustion of carbon-based fuels is considered a problem for the environment and identify how scientists can reduce the possibility of incomplete combustion occurring. **2**

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Question 27 (5 marks) **Marks**

(a) Identify the purpose of using standard solutions in atomic absorption spectroscopy (AAS). **1**

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(b) Assess the impact of atomic absorption spectroscopy (AAS) on scientific understanding of the effects of ONE trace element that you have studied. **4**

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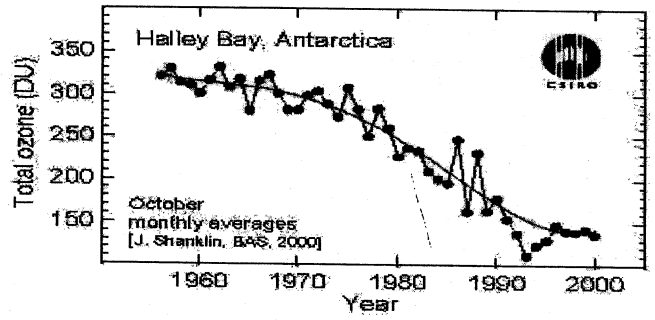
Question 28 (4 marks) **Marks**

This graph summarises the atmospheric ozone concentrations measured at Halley Bay.



(a) Identify the trends or patterns described by the graph. **2**

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(b) Explain ONE method of obtaining the data in the graph. **2**

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Question 29 (5 marks) **Marks**

The hardness of a sample of water was investigated using the following methods.

Method A

25.0 mL samples of water were titrated against ethylenediamine tetra-acetic acid (EDTA) with Eriochrome Black T indicator. 21.7 mL of EDTA was required. The hardness was calculated to be equivalent to 17 mg/L of $CaCO_3$.

Method B

Three drops of detergent were added to separate vials containing 5 mL samples of distilled water, hard water and the sample. After shaking the vials ten times the heights of froth were compared. The procedure was repeated twice. As the amount of froth in the three samples was only slightly less than in the distilled water the sample was determined to be soft.

(a) Identify which of the TWO methods is classified as *qualitative*. **1**

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(b) Using the following table, the results from Method A indicated the sample was soft. **1**

Water Hardness Scale	
Concentration of $CaCO_3$	**Classification**
less than 20 ppm	soft
20-60 ppm	slightly hard
60-120 ppm	moderately hard
more than 120 ppm	hard

Justify this conclusion.

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Question 29 continues on page 21

Question 29 (continued) **Marks**

(c) Compare the appropriateness of Method A and Method B for determining the hardness of the water. **3**

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End of Question 29

Question 30 – Industrial Chemistry (25 marks) **Marks**

(a) The gas carbon oxyfluoride (COF_2) decomposes to the gas tetrafluoromethane (CF_4) and carbon dioxide.

$2COF_2(g) \Leftrightarrow CF_4(g) + CO_2(g)$

The reaction is carried out at 200°C in a fixed volume 5.00 L container. Initially 0.400 mol of carbon oxyfluoride is present in the flask. At equilibrium 0.080 mol of carbon oxyfluoride remains.

(i) Write the expression for the equilibrium constant for this reaction. **1**

(ii) Determine the value of the equilibrium constant. **3**

(iii) An increase in temperature results in 0.090 mol of carbon oxyfluoride being present at equilibrium. Is the decomposition of carbon oxyfluoride exothermic or endothermic? Explain your answer **1**

(b) Outline the steps and conditions necessary for the industrial production of H_2SO_4 from its raw materials. **4**

(c) During the course of your studies you performed a first-hand investigation to identify the products of electrolysis of NaCl.

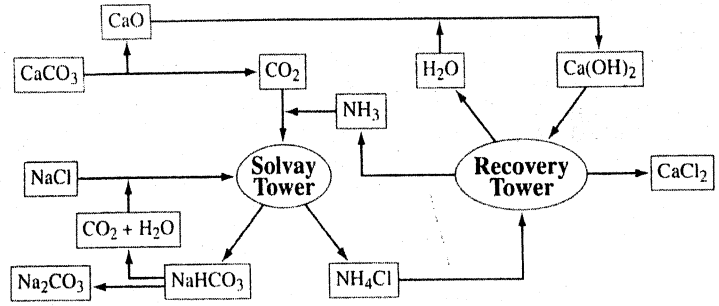
(i) Use equations to identify the products when both concentrated NaCl and dilute NaCl solutions are electrolysed. Explain the tests you used to identify the products in each case. **4**

(ii) What would be the products of electrolysis of *molten* sodium chloride? **1**

(d) During the past 50 years, different classes of synthetic detergents have been developed to replace soap as the dominant cleaning agent. Assess the impact on the environment of the use of these synthetic detergents as a replacement for soap. **5**

Question 30 continues on page 27

(e) The flow chart below summarises the Solvay Process.



(i) What are the raw materials needed for this industrial process? **1**

(ii) Write equations for the steps in the process which result in the formation of sodium hydrogen carbonate and ammonium chloride. **2**

(iii) The outputs of the Solvay process include sodium carbonate and a waste chemical product. Identify this waste product and explain how the disposal of this waste influences the choice of location of the manufacturing plant. **3**

End of Question 30