2009

Trial HSC Examination

Chemistry

General Instructions
Reading time – 5 minutes
Working time – 3 hours

* Write using blue or black pen
* Draw diagrams using pencil
* Approved calculators may be used
* Do NOT use liquid paper or white out on this exam paper. If you make a mistake, cross it out then continue writing.
* If you do use liquid paper/white out, anything written over it will NOT be remarked at a later date.
* A data sheet and periodic table are provided at the end of the paper and may be detached for your convenience.
* The multiple-choice answer sheet is provided on page 2 and should be detached for your convenience.

Write your student number on the front page of each section of the examination

Total marks 100
Section I
CORE MODULES
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 – 30.
Allow about 1 hour and 45 minutes for this part.

Section II
OPTION MODULE
25 marks
Attempt ONE question only from this section.
Attempt Question 31 – Industrial Chemistry.
Allow about 45 minutes for this section.

Teacher-in-charge: Miss Jackson

Task Weighting: 40%

Multiple-choice Answer Sheet

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 this by writing the word correct and drawing an arrow as follows:

correct ↓

(A) ⊗ (B) ⊗ (C) ⬭ (D) ⬭

Part A

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) ⬭

Section I.

Part A.

15 marks

Attempt questions 1 - 15.
Allow about 30 minutes for this part.
Select the alternative A, B, C or D that best answers the question AND record your answer on the multiple-choice answer sheet.
The multiple-choice answer sheet is located on PAGE 2 and should be detached for your convenience.
Ensure you write your student number on the multiple-choice answer sheet.

1. If equal volumes of the following aqueous solutions are mixed, which one will have the highest pH?
   (A) 1 mol/L sodium hydroxide and 1 mol/L ethanoic (acetic) acid
   (B) 1 mol/L ammonia solution and 1 mol/L sulfuric acid
   (C) 1 mol/L sulfuric acid and 1 mol/L barium hydroxide
   (D) none - they will all be neutral and have a pH of 7

2. 25.0 mL of a solution of sulfuric acid that has a pH of 3.0 is pipetted into a 250.0 mL volumetric flask and distilled water added to make up exactly 250.0 mL of solution.
   What is the pH of the final solution?
   (A) 2.0
   (B) 3.7
   (C) 4.0
   (D) 4.3

3. What is produced when a basic oxide reacts with an acid?
   (A) hydrogen gas and a salt
   (B) water and a salt
   (C) oxygen and a salt
   (D) a salt only

4. Identify the conjugate acid of the polyatomic ion, HPO_4^{2-}.
   (A) PO_4^{3-}
   (B) H_3PO_4
   (C) $H_2PO_4^{1-}$
   (D) HPO_4^{1-}

5. Aluminium reacts with dilute sulfuric acid to form aluminium sulfate and hydrogen gas.
   What is the maximum mass of aluminium sulfate produced when 1.40 g of aluminium is added to 85.0 mL of 0.765 mol/L sulfuric acid?
   (A) 7.42 g
   (B) 11.1 g
   (C) 17.6 g
   (D) 22.2 g

6. Allan, a student, carries out an investigation to determine the pH of a variety of household substances using a pH probe.

Listed are seven features of experimental design that Allan used.

(1) calibrated the pH probe with a standard solution of 1.00 mol/L HCl
(2) repeated the measurements of each household substance several times
(3) compared his hypothesis with that of three other groups in the class
(4) compared his results with published results
(5) used the same volume of solution of each household substance
(6) compared his results with three other groups within the class
(7) rinsed the pH probe in distilled water several times between testing each household substance

Which list identifies features of experimental design that will primarily increase the reliability of the results Allan collects?

(A) 1, 2, 3, 4, 5, 6, 7
(B) 1, 3, 4, 5
(C) 2, 3, 6, 7
(D) 2, 6

7. The table below shows the pH of 0.1 mol/L solutions of three monoprotic acids, X, Y and Z.

Acid	**Concentration (mol/L)**	**pH**
X	0.1	2.1
Y	0.1	2.9
Z	0.1	1.0

The degree of ionisation of these acids can be calculated and would be:-

	Degree of ionisation (%)		
	Acid X	**Acid Y**	**Acid Z**
(A)	21	29	10
(B)	80	13	100
(C)	4.8	3.4	10
(D)	7.9	1.3	100

8. Which of the following is most likely to be a stable isotope?

(A) hydrogen-3
(B) oxygen-18
(C) chlorine-36
(D) calcium-40

9. Consider the following reaction.

$$Ca_{(s)} + 2Fe^{3+}_{(aq)} \rightarrow Ca^{2+}_{(aq)} + 2Fe^{2+}_{(aq)}$$

Determine the standard cell voltage.
(A) -2.10 V
(B) +2.10 V
(C) +3.64 V
(D) +4.41 V

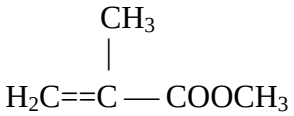
10. Consider the reaction:

$$Ca_{(s)} + H_2O_{(l)} \rightarrow H_{2(g)} + Ca^{2+}_{(aq)} + 2OH^-_{(aq)}$$

Which statement about this reaction is correct?
(A) water molecules are reducing agents
(B) oxygen atoms in water are oxidised to hydroxide ions
(C) hydrogen atoms in water are reduced to hydrogen gas
(D) this is not a redox reaction

11. Which polymer is made by the polymerisation of methyl methacrylate?

Methyl methacrylate



(A)

(B)

(C)

(D)

12. The structures of two commercially significant monomers are shown.

A **B**

Identify the correct statement.

(A) monomer A has the IUPAC name ethenyl chloride and forms the polymer, poly vinyl chloride
(B) monomer B forms the polymer polystyrene through addition polymerisation
(C) monomer A forms the polymer poly vinyl chloride through condensation polymerisation
(D) monomer B has the IUPAC name ethenyl benzene and forms a polymer via condensation polymerisation

13. How many isomers of the compound C_4H_9Cl exist?

(A) 2
(B) 4
(C) 6
(D) 8

14. Identify the element most likely to cause heavy metal water pollution.

(A) calcium
(B) iron
(C) lead
(D) sodium

15. Water treatment plants in Sydney carry out the following basic procedures, but not in the sequence listed.

1. sand filtration
2. sedimentation
3. flocculation
4. aeration
5. chlorination
6. screening

What is the correct order of these procedures?

(A) 4, 1, 6, 2, 3, 5
(B) 6, 4, 3, 2, 1 ,5
(C) 1, 6, 3, 2, 5, 4
(D) 4, 6, 2, 3, 1, 5

Section I (continued)

Part B.

60 marks

Attempt questions 16 – 28.
Read the whole of each question before commencing it.
Answer the questions in the spaces provided.
Allow about 1 hour and 45 minutes for this part.

Question 16. (2 marks)

Describe TWO factors that contribute to contamination of water in catchment areas. 2M

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Question 17. (3 marks)

A full bottle of 2.5 mol/L sulfuric acid was dropped in a laboratory accident. Solid sodium hydrogen carbonate was used to neutralise the spilled acid.

Justify the choice of solid sodium hydrogen carbonate to clean up the spill. Include relevant equation(s). 3M

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Question 18. (5 marks)

Citrus fruits have a sharp, sour taste that is due to the presence of citric acid.

(a) Draw the structural formula of citric acid. 1M

(b) Identify citric acid by its IUPAC name. 1M

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(c) "*When equal volumes of 0.01 mol/L solutions of citric acid and hydrochloric acid are neutralised using a standard solution of sodium hydroxide, the volume of sodium hydroxide used to neutralise the citric acid solution will be three times the volume used to neutralise the hydrochloric acid solution.*"
Critically assess this statement. 3M

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Question 19. (4 marks)
Sulfuric acid was classified as an acid by the theories proposed by Bronsted-Lowry, Lavoisier and Davy.
Explain why each of these three theories classified sulfuric acid as an acid. Use equations, where appropriate, in your response. 4M

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Question 20. (2 marks)
Ethanol can be used as a fuel extender added to petrol.
Explain why ethanol forms a solution with petrol (octane). 2M

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Question 21. (5 marks)
A student decarbonated a sample of soda water by opening the bottle it was in and leaving it for a period of time, weighing it at regular intervals. She also used a non-carbonated sample of water as a control, recording its mass at the same time intervals.

	Mass (g)					
	Initial (0 hours)	**After 12 hours**	**24 hours**	**36 hours**	**48 hours**	**60 hours**
soda water	385.0	382.6	381.1	380.7	380.3	380.0
plain water	385.0	384.7	384.2	383.7	383.4	383.0

(a) Identify the dependent variable in this investigation. 1M

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(b) Graph the information shown for each water sample on the same graph. 2M

This question continues on the next page.

(c) Interpret the trends shown by the graph. 2M

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Question 22. (3 marks)
Biopolymer carry bags are increasingly being used in place of bags made from polyethylene.
Discuss the benefits and problems associated with the use of biopolymer carry bags. 3M

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Question 23. (2 marks)
Outline TWO technologies used by scientists to collect data on ozone levels in the atmosphere. 2M

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Question 24. (4 marks)
(a) Identify the origins of CFCs in the atmosphere. 1M

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(b) Discuss, using relevant equations, the problems associated with the use of CFCs. 3M

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Question 25. (5 marks)
The smelting of chalcopyrite ($CuFeS_2$) during the production of copper can be represented by the reaction:-

$$2CuFeS_{2(s)} + 5O_{2(g)} + 2SiO_{2(s)} \rightarrow 2Cu_{(l)} + 4SO_{2(g)} + 2FeSiO_{3(l)}$$

(a) Calculate the volume (at 25 ^oC and 100 kPa) of sulfur dioxide that would be released into the atmosphere from the smelting of 1 tonne of chalcopyrite (assume the sulfide mineral is pure). 2M

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(b) The release of sulfur dioxide pollutes the atmosphere resulting in acid rain.
(i) Define the term "acid rain". 1M

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(ii) Outline one impact of acid rain on the environment. 1M

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(iii) Outline one impact of acid rain on society. 1M

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Question 26. (6 marks)
During your practical work, you performed a first-hand investigation to distinguish between an alkane and its corresponding alkene.

(a) Name the alkene used in your investigation. 1M

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(b) Identify a potential hazard in your investigation and outline how you addressed this hazard. 2M

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(c) Describe the procedure you used for your first-hand investigation. 3M

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Question 27. (3 marks)
Earlier this year a new transuranic element, *ununbium*, was produced. It existed for 0.05 seconds.

(a) Define the term transuranic element. 1M

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(b) Outline how transuranic elements such as ununbium are produced. 2M

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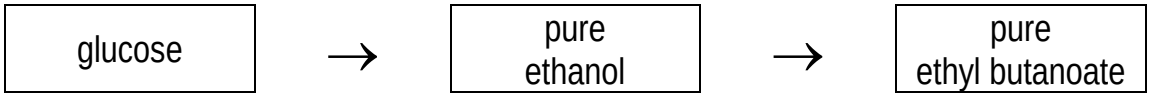
Question 28. (7 marks)
The flowchart shows a series of steps involved in the production of ethyl butanoate.



Describe the chemistry and procedures involved in each step, using labelled diagrams where appropriate. 7M

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Question 29. (4 marks)
Explain the need for monitoring the products of a chemical reaction such as combustion. 4M

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Question 30. (5 marks)
The Haber process is used to synthesise ammonia from its elements.

(a) Write a balanced equation for the reaction (include states). 1M

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(b) Explain the impacts of increased temperature on the reaction system. 4M

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Section II

25 marks

Attempt Question 31 – **Industrial Chemistry**.

Answer the questions in the separate writing booklet provided.
Ensure that you clearly identify each answer [eg. (a) (i) ….].
You may ask for additional writing booklets if required.
Allow about 45 minutes for this part.

Question 31 - Industrial Chemistry.

(a) (i) Outline one industrial use of sulfuric acid. 1M

(ii) Describe the Frasch process for extracting sulfur from mineral deposits. Illustrate your answer using a labelled diagram. 3M

(iii) One of the intermediate products in the synthesis of sulfuric acid is oleum.
Identify its formula. 1M

(iv) One step in the industrial production of sulfuric acid involves the conversion of sulfur dioxide into sulfur trioxide.
Justify the choice of reaction conditions used in the industrial conversion of sulfur dioxide into sulfur trioxide to optimise the yield in the shortest time possible. 6M

(b) You performed a first-hand investigation to qualitatively analyse an equilibrium reaction.

(i) Write a balanced equation to describe the equilibrium reaction you analysed. 1M

(ii) Describe the qualitative feature of this reaction that allowed you to analyse the effects of changes imposed on the equilibrium reaction. 2M

(c) (i) Compare anionic and cationic detergents in relation to their chemical structure. 2M

(ii) Account for the ability of a detergent molecule to cause the emulsification of water and oil when a mixture of water, oil and detergent is agitated. 3M

This question continues on the next page.

(d) Over a nickel catalyst, at a high temperature and in a closed container, ethane and steam react to form carbon monoxide and hydrogen.

$$C_2H_{6(g)} + 2H_2O_{(g)} \leftrightarrow 2CO_{(g)} + 5H_{2(g)} \qquad \Delta H = -200 \text{ kJ/mol}$$

The equilibrium constant has a value of 0.0060 at a temperature of 727 °C and a pressure of 202 kPa.

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

(ii) Predict what will happen to the value of K in each of the following cases.
Your answer should be in terms of "*increases, decreases or remains the same*".

(x) temperature is increased
(y) pressure is increased
(z) a catalyst is added 2M

(iii) In a mixture of ethane, steam, carbon monoxide and hydrogen the concentrations of species are :-

species	**$C_2H_{6(g)}$**	**$H_2O_{(g)}$**	**$CO_{(g)}$**	**$H_{2(g)}$**
concentration (mol/L)	0.055	0.037	0.021	0.100

Evaluate whether this mixture is at equilibrium. 3M

HIGHER SCHOOL CERTIFICATE EXAMINATION

Chemistry

DATA SHEET

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

Volume of 1 mole ideal gas: at 100 kPa and

at 0°C (273.15 K) ..... 22.71 L

at 25°C (298.15 K) ..... 24.79 L

Ionisation constant for water at 25°C (298.15 K), K_w ..... 1.0×10^{-14}

Specific heat capacity of water ..... 4.18×10^3 J kg^{-1} K^{-1}

Some useful formulae

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

Some standard potentials

$K^+ + e^-$	$\rightleftharpoons$	$K(s)$	–2.94 V
$Ba^{2+} + 2e^-$	$\rightleftharpoons$	$Ba(s)$	–2.91 V
$Ca^{2+} + 2e^-$	$\rightleftharpoons$	$Ca(s)$	–2.87 V
$Na^+ + e^-$	$\rightleftharpoons$	$Na(s)$	–2.71 V
$Mg^{2+} + 2e^-$	$\rightleftharpoons$	$Mg(s)$	–2.36 V
$Al^{3+} + 3e^-$	$\rightleftharpoons$	$Al(s)$	–1.68 V
$Mn^{2+} + 2e^-$	$\rightleftharpoons$	$Mn(s)$	–1.18 V
$H_2O + e^-$	$\rightleftharpoons$	$\frac{1}{2}H_2(g) + OH^-$	–0.83 V
$Zn^{2+} + 2e^-$	$\rightleftharpoons$	$Zn(s)$	–0.76 V
$Fe^{2+} + 2e^-$	$\rightleftharpoons$	$Fe(s)$	–0.44 V
$Ni^{2+} + 2e^-$	$\rightleftharpoons$	$Ni(s)$	–0.24 V
$Sn^{2+} + 2e^-$	$\rightleftharpoons$	$Sn(s)$	–0.14 V
$Pb^{2+} + 2e^-$	$\rightleftharpoons$	$Pb(s)$	–0.13 V
$H^+ + e^-$	$\rightleftharpoons$	$\frac{1}{2}H_2(g)$	0.00 V
$SO_4^{2-} + 4H^+ + 2e^-$	$\rightleftharpoons$	$SO_2(aq) + 2H_2O$	0.16 V
$Cu^{2+} + 2e^-$	$\rightleftharpoons$	$Cu(s)$	0.34 V
$\frac{1}{2}O_2(g) + H_2O + 2e^-$	$\rightleftharpoons$	$2OH^-$	0.40 V
$Cu^+ + e^-$	$\rightleftharpoons$	$Cu(s)$	0.52 V
$\frac{1}{2}I_2(s) + e^-$	$\rightleftharpoons$	I^-	0.54 V
$\frac{1}{2}I_2(aq) + e^-$	$\rightleftharpoons$	I^-	0.62 V
$Fe^{3+} + e^-$	$\rightleftharpoons$	Fe^{2+}	0.77 V
$Ag^+ + e^-$	$\rightleftharpoons$	$Ag(s)$	0.80 V
$\frac{1}{2}Br_2(l) + e^-$	$\rightleftharpoons$	Br^-	1.08 V
$\frac{1}{2}Br_2(aq) + e^-$	$\rightleftharpoons$	Br^-	1.10 V
$\frac{1}{2}O_2(g) + 2H^+ + 2e^-$	$\rightleftharpoons$	H_2O	1.23 V
$\frac{1}{2}Cl_2(g) + e^-$	$\rightleftharpoons$	Cl^-	1.36 V
$\frac{1}{2}Cr_2O_7^{2-} + 7H^+ + 3e^-$	$\rightleftharpoons$	$Cr^{3+} + \frac{7}{2}H_2O$	1.36 V
$\frac{1}{2}Cl_2(aq) + e^-$	$\rightleftharpoons$	Cl^-	1.40 V
$MnO_4^- + 8H^+ + 5e^-$	$\rightleftharpoons$	$Mn^{2+} + 4H_2O$	1.51 V
$\frac{1}{2}F_2(g) + e^-$	$\rightleftharpoons$	F^-	2.89 V

Aylward and Findlay, *SI Chemical Data* (5th Edition) is the principal source of data for this examination paper. Some data may have been modified for examination purposes.

PERIODIC TABLE OF THE ELEMENTS

1 H 1.008 Hydrogen																	2 He 4.003 Helium
3 Li 6.941 Lithium	4 Be 9.012 Beryllium											5 B 10.81 Boron	6 C 12.01 Carbon	7 N 14.01 Nitrogen	8 O 16.00 Oxygen	9 F 19.00 Fluorine	10 Ne 20.18 Neon
11 Na 22.99 Sodium	12 Mg 24.31 Magnesium											13 Al 26.98 Aluminium	14 Si 28.09 Silicon	15 P 30.97 Phosphorus	16 S 32.07 Sulfur	17 Cl 35.45 Chlorine	18 Ar 39.95 Argon
19 K 39.10 Potassium	20 Ca 40.08 Calcium	21 Sc 44.96 Scandium	22 Ti 47.87 Titanium	23 V 50.94 Vanadium	24 Cr 52.00 Chromium	25 Mn 54.94 Manganese	26 Fe 55.85 Iron	27 Co 58.93 Cobalt	28 Ni 58.69 Nickel	29 Cu 63.55 Copper	30 Zn 65.41 Zinc	31 Ga 69.72 Gallium	32 Ge 72.64 Germanium	33 As 74.92 Arsenic	34 Se 78.96 Selenium	35 Br 79.90 Bromine	36 Kr 83.80 Krypton
37 Rb 85.47 Rubidium	38 Sr 87.62 Strontium	39 Y 88.91 Yttrium	40 Zr 91.22 Zirconium	41 Nb 92.91 Niobium	42 Mo 95.94 Molybdenum	43 Tc [97.91] Technetium	44 Ru 101.1 Ruthenium	45 Rh 102.9 Rhodium	46 Pd 106.4 Palladium	47 Ag 107.9 Silver	48 Cd 112.4 Cadmium	49 In 114.8 Indium	50 Sn 118.7 Tin	51 Sb 121.8 Antimony	52 Te 127.6 Tellurium	53 I 126.9 Iodine	54 Xe 131.3 Xenon
55 Cs 132.9 Caesium	56 Ba 137.3 Barium	57–71 Lanthanoids	72 Hf 178.5 Hafnium	73 Ta 180.9 Tantalum	74 W 183.8 Tungsten	75 Re 186.2 Rhenium	76 Os 190.2 Osmium	77 Ir 192.2 Iridium	78 Pt 195.1 Platinum	79 Au 197.0 Gold	80 Hg 200.6 Mercury	81 Tl 204.4 Thallium	82 Pb 207.2 Lead	83 Bi 209.0 Bismuth	84 Po [209.0] Polonium	85 At [210.0] Astatine	86 Rn [222.0] Radon
87 Fr [223] Francium	88 Ra [226] Radium	89–103 Actinoids	104 Rf [261] Rutherfordium	105 Db [262] Dubnium	106 Sg [266] Seaborgium	107 Bh [264] Bohrium	108 Hs [277] Hassium	109 Mt [268] Meitnerium	110 Ds [271] Darmstadtium	111 Rg [272] Roentgenium							

KEY

Atomic Number
79
Au
Symbol of element
Atomic Weight
197.0
Gold
Name of element

Lanthanoids

57 La 138.9 Lanthanum	58 Ce 140.1 Cerium	59 Pr 140.9 Praseodymium	60 Nd 144.2 Neodymium	61 Pm [145] Promethium	62 Sm 150.4 Samarium	63 Eu 152.0 Europium	64 Gd 157.3 Gadolinium	65 Tb 158.9 Terbium	66 Dy 162.5 Dysprosium	67 Ho 164.9 Holmium	68 Er 167.3 Erbium	69 Tm 168.9 Thulium	70 Yb 173.0 Ytterbium	71 Lu 175.0 Lutetium

Actinoids

89 Ac [227] Actinium	90 Th 232.0 Thorium	91 Pa 231.0 Protactinium	92 U 238.0 Uranium	93 Np [237] Neptunium	94 Pu [244] Plutonium	95 Am [243] Americium	96 Cm [247] Curium	97 Bk [247] Berkelium	98 Cf [251] Californium	99 Es [252] Einsteinium	100 Fm [257] Fermium	101 Md [258] Mendelevium	102 No [259] Nobelium	103 Lr [262] Lawrencium

For elements that have no stable or long-lived nuclides, the mass number of the nuclide with the longest confirmed half-life is listed between square brackets.

The International Union of Pure and Applied Chemistry Periodic Table of the Elements (October 2005 version) is the principal source of data. Some data may have been modified.

Marking Guidelines THSC Exam 2009
Year 12 CHEMISTRY

Multiple choice

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

16.

Marking criteria	*Marks*
Identifies TWO factors and provides their main features	2
Identifies ONE factor and provides its main features OR Identifies TWO factors	1

17.

Marking criteria	*Marks*
Provides an equation for the neutralisation reaction between an acid and a metal carbonate AND Outlines TWO advantages of using $NaHCO_3$ with an acid spill	3
Provides an equation for the neutralisation reaction between an acid and a metal carbonate AND Outlines ONE advantage of using $NaHCO_3$ with an acid spill	2
Identifies TWO properties of $NaHCO_3$ that make it useful when dealing with an acid spill	1

18. a.

Marking criteria	*Marks*
Presents a structural formula that shows the correct number and type of each atom, their correct spatial arrangement and all covalent bonds drawn	1

18. b.

Marking criteria	*Marks*
Correctly identifies citric acid by its IUPAC name as 2-hydroxypropane-1,2,3-tricarboxylic acid	1

18. c.

Marking criteria	*Marks*
Provides a judgment about the correctness of the statement – "the statement is correct". AND Outlines TWO reasons for this judgement → (1) NaOH is a strong base so even though citric acid is a weak acid whereas HCl is a strong acid, both acids will be fully consumed in the neutralisation reaction with NaOH. (2) Citric acid is triprotic whereas hydrochloric acid is monoprotic, thus the neutralisation of citric acid will requires three times the volume of NaOH.	3
Provides a judgment about the correctness of the statement – "the statement is correct". AND Outlines ONE reason for this judgement →see above for an appropriate reason.	2
Identifies that NaOH is a strong base, HCl is a strong acid and citric acid is a weak acid OR Identifies that HCl is a strong, monoprotic acid and citric acid is a weak, triprotic acid.	1

19.

Marking criteria	*Marks*
Outlines the theory put forward by each of the THREE scientists, relating H_2SO_4 to each AND Provides an equation that demonstrates H_2SO_4 acting as a proton donor	4
Outlines the theory put forward by each of the THREE scientists, relating H_2SO_4 to each	3
Outlines the theory put forward by TWO of the scientists	2
Outlines the theory put forward by ONE of the scientists	1

20.

Marking criteria	*Marks*
Identifies that ethanol has a non-polar component AND Identifies that petrol (octane) is also a non-polar molecule AND Outlines that dispersion forces will form between them, allowing a solution to form (like dissolves like)	2
Identifies that ethanol has a non-polar component AND Identifies that petrol (octane) is also a non-polar molecule AND Outlines that this will allow a solution to from	1

21.a.

Marking criteria	*Marks*
Identifies the dependent variable as the mass of bottle and the liquid it contains	1

21.b.

Marking criteria	*Marks*
Graph shows TWO line graphs that have accurately plotted points and lines of best fit for each AND Provides a key that distinguishes between the soda water and the plain water lines	2
Graph shows TWO line graphs that have accurately plotted points and lines of best fit for each	1

21.c.

Marking criteria	*Marks*
Identifies that both soda water and plain water loss	2

mass as time progresses AND Identifies that the soda water loses mass at a decreasing rate whereas the plain water losses mass at a constant rate	
Identifies that both soda water and plain water loss mass as time progresses OR Identifies that the soda water loses mass at a decreasing rate whereas the plain water losses mass at a constant rate	1

22.

Marking criteria	*Marks*
Outlines TWO benefits and TWO problems associated with the use of biopolymer carry bags	3
Outlines TWO benefits and ONE problem associated with the use of biopolymer carry bags OR Outlines ONE benefit and TWO problems associated with the use of biopolymer carry bags	2
Outlines ONE benefit and ONE problem associated with the use of biopolymer carry bags	1

23.

Marking criteria	*Marks*
Identifies TWO technologies and give the main features of each	2
Identifies ONE technology and give its main features	1

24.a.

Marking criteria	*Marks*
Identifies TWO sources of CFCs	1

24.b.

Marking criteria	*Marks*
(1) Provides a series of equations to show how a CFC eventually decomposes ozone (2) Relates the destruction of ozone to the increased levels of ultraviolet radiation reaching the Earth's surface (3) Outlines one problem that results from this increased level of UV radiation	3
Provides TWO of the three points outlined above	2
Provides ONE of the three points outlined above	1

25.a.

Marking criteria	*Marks*
Calculates and states the volume of SO_2 as 270132 L	2
Calculates the number of moles of $CuFeS_2$ as 5448 mol	1

25.b.(i).

Marking criteria	*Marks*
States that acid rain has a pH below 5 (or 5.5)	1

25.b.(ii).

Marking criteria	*Marks*
Outlines one impact of acid rain on the environment	1

25.b.(iii).

Marking criteria	*Marks*
Outlines one impact of acid rain on society	1

26.a.

Marking criteria	*Marks*
Identified an alkene that could be used in this experiment	1

26.b.

Marking criteria	*Marks*
Identifies one hazard and outlined how the hazard was addressed.	2
Identifies one hazard (*It is worth noting that a physical property is not necessarily a hazard. A link must be made to how this makes the substance a danger. It is worth going back and checking the MSDS information (easily found online) for the reagents you have encountered in this course.)*	1

26.c.

Marking criteria	*Marks*
Procedure is described thoroughly and could be followed to produce results that are both valid and reliable. (Includes – reagents, exact quantities, equipment, controlled variables, repetition and a logical and informative description)	3
Procedure is described well (but lacking one or more exact details) and could be used to produce results that are either valid or reliable	2
A method is outlined that has potential, if more detail was provided, to produce results that are valid and reliable.	1

27.a.

Marking criteria	*Marks*
States that a transuranic element is an element that occurs after uranium on the periodic table	1

27.b.

Marking criteria	*Marks*
Identifies TWO machines (or methods) and outlines how they both produce transuranic elements OR Identifies one machine and provides extensive details	2
Names ONE method of producing transuranic elements	1

28.

Marking criteria	*Marks*
Provides a detailed description, including reactions (chemistry) and conditions, for each of the following steps; → fermentation → purification of ethanol →esterification →purification of ethyl butanoate AND Includes ONE (6) or TWO (7) relevant, labelled diagrams	6 - 7
Provides a detailed description of 2 of the steps listed above AND outlines the other 2 steps AND includes 1 diagram	5
Provides a detailed description of 2 of the steps above AND includes 1 diagram	4
Outlines 2 of the steps identified above	3

Outlines 1 of the steps identified above	2
Includes one correct fact relevant to the process	1

29.

Marking criteria	*Marks*
(1) Displays a thorough knowledge of the possible different reaction products, either due to identified varying reaction conditions OR due to the presence of impurities in the reaction reactants, using an appropriate example. (2) Outlines ONE or TWO reasons why monitoring of the products is essential (reasons specifically related to the products of the reaction)	3 - 4
Describes a chemical reaction that can produce different products. AND Provides a reason why monitoring the reaction is needed.	2
Describes a chemical reaction that can produce different products. OR Provides a reason why monitoring the reaction is needed.	1

30.a.

Marking criteria	*Marks*
Correct, balanced equation for the equilibrium reaction between nitrogen gas, hydrogen gas and ammonia gas that includes states and an equilibrium arrow.	1

30.b.

Marking criteria	*Marks*
Outlines TWO cause and effect relationships of increasing temperature on the Haber process, specifically → (1) *Yield of ammonia is decreased* (effect) because the reverse endothermic reaction that absorbs heat will be favoured (Le Chatelier's Principle) (cause) (2) *Rate of reaction is increased* (effect) because the particles will have more kinetic energy and therefore will collide more frequently and with greater success (Collision Theory) (cause)	4
Outlines THREE of the cause/effect statements from those shown above	3
Outlines TWO of the cause/effect statements from those shown above	2
Outlines ONE of the cause/effect statements from those shown above	1

OPTION – Industrial Chemistry

a. (i).

Marking criteria	*Marks*
Identifies an *industrial use* of sulfuric acid and provides its main features.	1

a.(ii).

Marking criteria	*Marks*
(1) Draws a diagram that is accurately and correctly labelled. (2) Describes, thoroughly, the main features of the THREE principal steps of the Frasch process. In brief → • *Injection of superheated water → melts sulfur, forming a water/sulfur mixture* • *injection of hot, compressed air →forms an emulsion of water and sulfur AND lift the emulsion from the underground cavern to the surface of the ground* • *emulsion placed into a cooling pond →emulsion mixture cools on contact with the air, the sulfur solidifies at air temps (while the water remains liquid) and settles out of the mixture*	3
(1) Draws a diagram that is accurately and correctly labelled. (2) Describes, thoroughly, the main features of the TWO of the principal steps of the Frasch process.	2
Describes, thoroughly, the main features of the ONE of the principal steps of the Frasch process.	1

a.(iii).

Marking criteria	*Marks*
Identifies the formula of oleum as $H_2S_2O_7$	1

a.(iv).

Marking criteria	*Marks*
(1) Provides a correct, balanced equation for the conversion of sulfur dioxide into sulfur trioxide. (2) Outlines FOUR reaction conditions that are used in the industrial conversion of SO_2 into SO_3. (3) Provides specific details for TWO (5) OR THREE (6) of these conditions :- temp (^oC)= 550/600 → 400 → 400 → 400; pressure = 150 kPa; catalyst = V_2O_5; air:SO_2 ratio = 5:1 (4) Thoroughly justifies how each of the FOUR conditions increases yield &/or increases reaction rate.	5 - 6
(1)Outlines ONE (2 marks), TWO (3 marks) or THREE (4 marks) reaction conditions that are used in the conversion of SO_2 into SO_3. (2) Justifies the conditions by identifying whether each increases yield or increases reaction rate.	2 - 4
Identifies ONE reaction condition used in the conversion of SO_2 into SO_3.	1

b.(i)

Marking criteria	*Marks*
Provides a correct, balanced equation for an equilibrium reaction that could be monitored qualitatively (ie. macroscopic properties that are distinctive and observable.)	1

b.(ii).

Marking criteria	*Marks*
Identifies a qualitative feature of the equilibrium system described in (i) that could be used to monitor the system as changes are imposed on it (e.g. colour) AND provides the specific characteristics of this feature with respect to the reactants and the products of the reaction.	2
Identifies a qualitative feature that could be used to monitor the equilibrium system (e.g. colour)	1

c.(i).

Marking criteria	*Marks*
Provides TWO comparisons (similarities and/or differences) between the structure of an anionic and a cationic detergent. The correct text type must be used.	2
Provides ONE comparison (similarity and/or difference) between the structure of an anionic and a cationic detergent. The correct text type must be used.	1

c.(ii).

Marking criteria	*Marks*
Identifies the THREE relevant features of a detergent molecule that contribute to its ability to emulsify oil and water (namely, polar head, non-polar hydrocarbon tail, like-charged heads) AND Relates each feature to its role in the formation of an emulsion of oil and water when detergent is added and the mixture is agitated, specifically → *Upon agitation, the oil is broken up into very small droplets that are suspended throughout the water uniformly, each with the detergent molecules organised so that the hydrocarbon tail is buried into the oil while the like-charged polar heads are coating the surface of each droplet and interacting with water molecules.* (1) A detergent molecule has a polar head that is attracted to polar water molecules via dipole-dipole interactions. (2) A detergent molecule has a non-polar hydrocarbon tail that is attracted to non-polar oil via dispersion forces. (3) The like-charged polar heads surrounding each oil droplet repel preventing the oil droplets from recombining.	3
Outlines TWO of the features of a detergent molecule and relates each to its role in the emulsification process.	2
Outlines ONE of the features of a detergent molecule and relates it to its role in the emulsification process.	1

d.(i).

Marking criteria	*Marks*
Writes a fully detailed and correct equilibrium constant expression (must include K =)	1

d.(ii).

Marking criteria	*Marks*
Predicts the impact on the value of K for ALL THREE changes being imposed on the equilibrium system correctly → (x) value of K decreases (y) value of K remains the same (z) value of K remains the same	2
Predicts the impact on the value of K for ONE of the changes being imposed on the equilibrium system correctly → see above	1

d.(iii).

Marking criteria	*Marks*
Answer displays a thorough understanding of equilibrium constant calculations by showing → (1) The expression for the reaction quotient, Q (not K!!). (2) The calculated value of Q as 5.58×10^{-5}. (3) Makes the judgement that the system is NOT in equilibrium.	
Answer gives TWO of the three steps outlined above.	2
Answer gives ONE of the three steps outlined above.	1

HAHS Trial HSC Examination

2009 - Chemistry

Exemplar Answers

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

Question 16. (2 marks)
Describe TWO factors that contribute to contamination of water in catchment areas. 2M

The increase in nutrients, especially phosphate and nitrate from fertiliser runoff on farms may lead to eutrophication. (2)
Heavy metal water pollution from runoff water from mines such as lead

Question 16. (2 marks)
Describe TWO factors that contribute to contamination of water in catchment areas. 2M (2)

1/ The proximity of the catchment to land devoted to agricultural practice. Land within/near the catchment can be used for grazing, leading to the increased chance of contamination of the water through cattle faeces. Also, run-off such as pesticides and fertiliser may also increase the nutrient content of the water, leading to eutrophication and algal blooms.
2/ If sewage is discharged along the path of the water in the catchment, the water may increase in N and P nutrients. Hence, the proximity of sewage discharge sites to the dam walls determines the concentration of these nutrients, which could potentially cause algal bloom in the raw water.

Question 16. (2 marks)
Describe TWO factors that contribute to contamination of water in catchment areas. 2M

→ run-off from use of fertilisers → during periods of rain, nutrients on the surface are carried off into the catchment area. (2)

→ animal faeces → grazing animals are usually located around the catchment area and is carried by rain water.

Question 17. (3 marks)
A full bottle of 2.5 mol/L sulfuric acid was dropped in a laboratory accident. Solid sodium hydrogen carbonate was used to neutralise the spilled acid.

Justify the choice of solid sodium hydrogen carbonate to clean up the spill. Include relevant equation(s). 3M

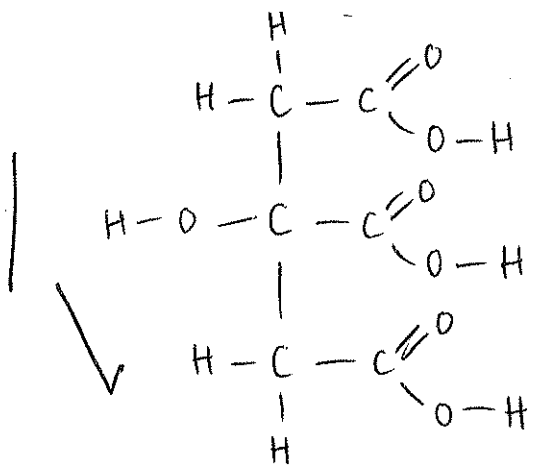
H_2SO_4 at 2-5 mol/L^{-1} is concentrated and a strong acid that is corrosive and costly to dispose. Using $NaHCO_3$, a weak base, allows the spill to be neutralised before mopping up. (3)

$2NaHCO_{3(s)} + H_2SO_4(aq) \rightarrow 2H_2O(l) + 2CO_2(g) + Na_2SO_4$

- bubbles of gaseous $CO_2(g)$ produced can enable us to tell when neutralisation reaction is complete ~~and it is safe~~
- $NaHCO_3$ is a solid and can be used to contain the spill by placing a ring of powder around spill. It is also safe to handle
- $NaHCO_3$ is relatively weak so reaction with acid will produce less heat & be less violent than if a strong base was used → safer.

Question 18. (5 marks)
Citrus fruits have a sharp, sour taste that is due to the presence of citric acid.

(a) Draw the structural formula of citric acid. 1M



(b) Identify citric acid by its IUPAC name. 1M

2-hydroxypropane-1,2,3-tricarboxylic acid

3

(c) *"When equal volumes of 0.01 mol/L solutions of citric acid and hydrochloric acid are neutralised using a standard solution of sodium hydroxide, the volume of sodium hydroxide used to neutralise the citric acid solution will be three times the volume used to neutralise the hydrochloric acid solution."*

Critically assess this statement. 3M

This statement is correct because the citric acid (refer to above diagram) has three donatable protons in its structure while the hydrochloric acid only has one donatable proton (i.e H-Cl). ~~Therefore~~ When a strong base is added (i.e NaOH), it will cause the acid to fully ionise. Therefore, hydrochloric acid will completely ionise undergoing its only stage of ionisation, while citric acid will undergo three ionisations to release all three protons. Thus, the mols of ~~hydrogen~~ protons (i.e H^+) released by citric acid will be three times that of ~~HCl~~ hydrochloric acid and signifying that three times more mols of NaOH is required for complete neutralisation (i.e three times more volume of same concentration NaOH)

Critically assess this statement. 3M

This statement is true, neutralisation occurs when an equal amount of OH^- is added to the H^+ ions. Since citric acid is triprotic, one molecule will release 3 H^+ ions whereas sodium hydroxide HCl will release only 1 H^+ ions. Therefore, 3 times the amount of sodium hydroxide will be needed to neutralise the citric acid.

Although citric acid is a weak acid, it will completely ionise when reacted with a strong base.

Hydrochloric acid is strong so it will always completely ionise.

2

Question 19. (4 marks)
Sulfuric acid was classified as an acid by the theories proposed by Bronsted-Lowry, Lavoisier and Davy.
Explain why each of these three theories classified sulfuric acid as an acid. Use equations, where appropriate, in your response. 4M

Sulfuric acid has the formula: H_2SO_4

- Davy observed that acids react with metals to give of $H_{2(g)}$. As such he proposed that acids contain hydrogen. This was later extended by Liebig to "acids contain replaceable hydrogen". Since H_2SO_4 contains hydrogen and gives off $H_{2(g)}$ when reacted with a metal, it is classified as an acid. $H_2SO_{4(aq)} + Mg_{(s)} \rightarrow MgSO_{4(aq)} + H_{2(g)}$. (4)
- Lavoisier observed that non-metallic oxides dissolved in water to produce acidic solutions. Thus he proposed acids contained oxygen. H_2SO_4 contains oxygen and was created by $SO_{3(g)} + H_2O_{(l)} \rightarrow H_2SO_{4(aq)}$ (non-metallic oxide). As such, it was classified an acid.
- Bronsted Lowry stated that acids are proton donors. In the reaction, $H_2SO_{4(aq)} + H_2O_{(l)} \rightarrow HSO_4^-{}_{(aq)} + H_3O^+{}_{(aq)}$, H_2SO_4 is donating a H^+/proton to H_2O, making it ~~an acid~~ a B-L acid

Question 19. (4 marks)
Sulfuric acid was classified as an acid by the theories proposed by Bronsted-Lowry, Lavoisier and Davy.
Explain why each of these three theories classified sulfuric acid as an acid. Use equations, where appropriate, in your response. 4M

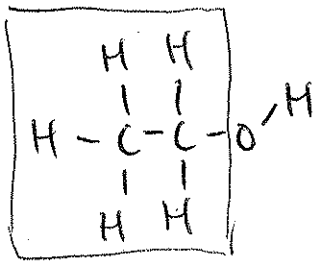
1/ Lavoisier, in 1776, proposed through observation of the nature of many oxides, that acids were substances which contained oxygen. As H_2SO_4 consists of oxygen atoms, it was deemed an acid ~~by~~ under Lavoisier

2/ Sir Humphrey Davy's theory ~~~~ (refined by Liebig) outlines that acids contain 'replaceable hydrogen'. This was backed up by the fact that acids react with metals, producing a salt and $H_{2(g)}$. As H_2SO_4 could react as follows: e.g. $Ca_{(s)} + H_2SO_{4(aq)} \rightarrow CaSO_{4(s)} + H_{2(g)}$, it contained 'replaceable hydrogen' (H_2 evolves to gas) and was hence an acid under Davy's theory.

3/ Bronsted-Lowry proposed the currently accepted method that acids are proton donors (and bases proton acceptors). For each B-L acid, there

is a conjugate B-L base. In the ionisation of H_2SO_4, $H_2SO_4(aq) + H_2O(l) \rightarrow HSO_4^-(aq) + H_3O^+(aq)$, H_2SO_4 donates H^+ (a proton) to water, thus making it an acid under Bronsted Lowry.

non-polar →

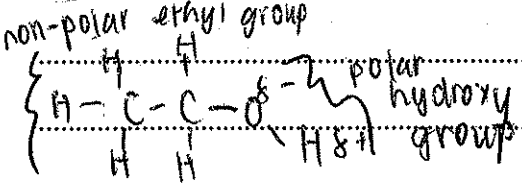


Question 20. (2 marks)
Ethanol can be used as a fuel extender added to petrol.
Explain why ethanol forms a solution with petrol (octane). 2M

ethanol consists of a non-polar akyl group and a polar hydroxyl group. The non-polar ~~alkly~~ ~~aklyl~~ akyl group can form dispersion forces with octane as octane is also a non-polar hydrocarbon. This follows the rule, "like dissolves like" where two non-polar substances ~~dissolve each of~~ can form a solution. (2)

Ethanol can be used as a fuel extender added to petrol.
Explain why ethanol forms a solution with petrol (octane). 2M

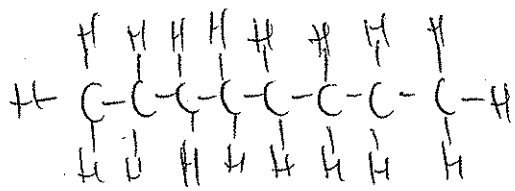
non-polar ethyl group



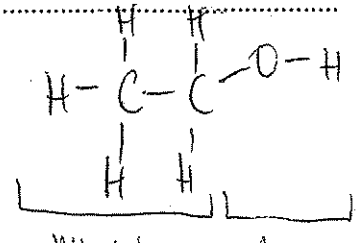
As ethanol consists of a non-polar ethyl group end and a polar hydroxy group end, it possesses the ability to interact with non-polar as well as polar molecules via dispersion forces and dipole-dipole or hydrogen bonding respectively. As octane is a symmetrical molecule, it is non-polar and hence interacts with ethanol's ethyl group via dispersion forces. Hence, due to this interaction, octane can dissolve in ethanol, forming a solution. (2)

Ethanol can be used as a fuel extender added to petrol.
Explain why ethanol forms a solution with petrol (octane). 2M

petrol (octane) is a mixture of hydrocarbons chains that is non-polar. Ethanol has both a non-polar hydrocarbon end and a polar end (due to the hydroxy functional group). Thus, since LIKE DISSOLVES LIKE, the non-polar hydrocarbon end of ethanol is able to form dispersion forces with the ~~non-~~ polar hydrocarbon chains of the petrol and thus form a solution by dissolving in it. (2)



octane non-polar hydrocarbon chain.



Question 21. (5 marks)
A student decarbonated a sample of soda water by opening the bottle it was in and leaving it for a period of time, weighing it at regular intervals. She also used a non-carbonated sample of water as a control, recording its mass at the same time intervals.

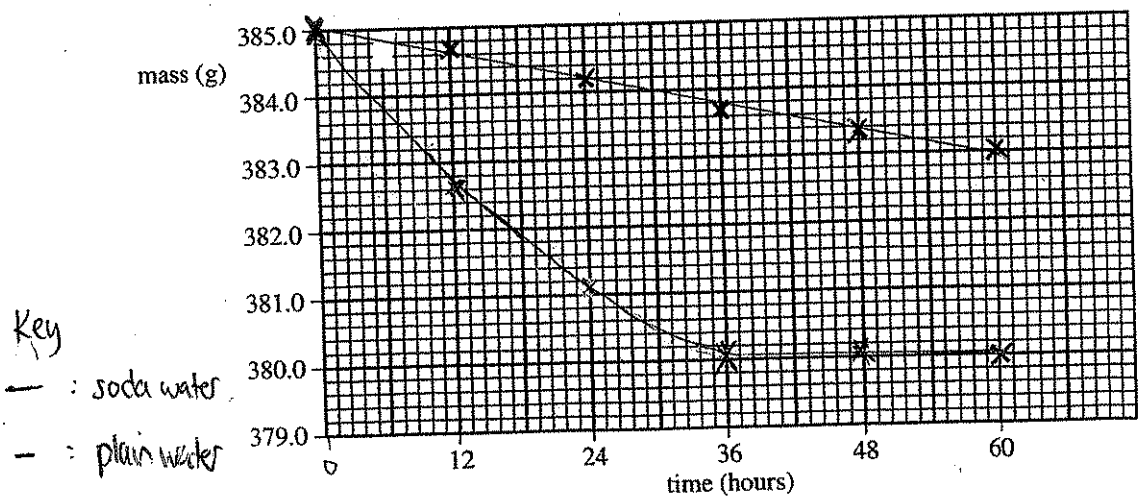
	Mass (g)					
	Initial (0 hours)	**After 12 hours**	**24 hours**	**36 hours**	**48 hours**	**60 hours**
soda water	385.0	382.6	381.1	380.7	380.3	380.0
plain water	385.0	384.7	384.2	383.7	383.4	383.0

(a) Identify the dependent variable in this investigation. 1M

~~The volume/mass of carbon dioxide gas dissolved in soda water~~ The mass of the soda water and the plain water (1)

(b) Graph the information shown for each water sample on the same graph. 2M

~~The bottle was~~ Mass of soda water and non-carbonated water over a period of 60 hours.



(2)

(c) Interpret the trends shown by the graph. 2M

Soda water - When the bottle was first opened, $CO_{2(aq)}$ quickly turned into $CO_{2(g)}$ and escaped into the atmosphere resulting in the steep drop in ~~mass~~ weight. as an equilibrium is achieved with the air $CO_{2(aq)} \rightleftharpoons CO_{2(g)}$, ~~the~~ $CO_{2(aq)}$ ~~is~~ concentration stabilises resulting in the straightening of the ~~line~~ graph. (2)

plain water - there is a roughly constant decrease in mass which occurs from the constant evaporation of the water.

(c) Interpret the trends shown by the graph. 2M

- The mass of the plain water decreases at a constant rate most likely due to evaporation of the water from the bottle used as a control. (2)

- The mass of the soda water decreases much faster than the plain water to begin with (CO_2 release) and then at a decreasing rate.
It can be seen that the carbon dioxide is released (approx 3g over 60hrs) from the soda water when the bottle is opened.

Question 22. (3 marks)
Biopolymer carry bags are increasingly being used in place of bags made from polyethylene.
Discuss the benefits and problems associated with the use of biopolymer carry bags. 3M

- A benefit associated with the use of biopolymer carry bags is that biopolymers are B biodegradable, unlike polyethylene. This means that they have no negative effects on the environment which is beneficial in contrast to polyethylene which does not degrade and can pollute waterways and choke fish. (3)
- Another benefit is that biopolymers are made from B renewable resources which means that less fossil fuels are used in contrast to polyethylene.
- A problem is that biopolymer carry bags are more P expensive to produce than polyethylene because current technology favours polyethylene production.
- Another problem is that significantly P large amounts of land are required to produce the biomass from which biopolymers are created, which impacts on society's living conditions.

Discuss the benefits and problems associated with the use of biopolymer carry bags. 3M

Benefits · Biopolymers are B biodegradable and readily decompose in the environment, unlike polyethene. This reduces waste and space taken up by landfills. (3)
· Can be produced from B renewable sources (eg. lactic acid for making PLA)
Eg. lactic acid is derived from dextrose sugars milled from corn starch.
Green plants can be grown and harvested for production of biopolymers in relatively short periods. However, whereas polyethene comes from ~~petrochem~~ petroleum & fossil fuels which is a non-renewable resource and will soon run out.

Problems · B lots of arable farming land needs to be used if mass production of biopolymers takes place — for the planting of energy crops.
This diverts land & resources from planting food crops. Price of food may increase.
Also, B energy is required to plant, harvest & process crops. Fossil fuels are less costly. Thus Biopolymers bags will cost consumers more.

Question 23. (2 marks)
Outline TWO technologies used by scientists to collect data on ozone levels in the atmosphere. 2M

1/ UV spectrophotometers: These are ground based instruments which face to the sky. They measure the amount of radiation reaching the Earth's surface at a ~~radiation~~ wavelength which O_3 absorbs, then at wavelengths on either side of this value. Comparison of these values give an idea of O_3 concentration as a function of geographical position. (2)

2/ TOMS (Total ozone mapping spectrometers). These work on the same principle as UV spectrophotometers, however they are housed in satellites which orbit the Earth and face down towards the Earth. TOMS give an idea of O_3 concentration as a function of geographical position AND altitude.

Outline TWO technologies used by scientists to collect data on ozone levels in the atmosphere. 2M

Ozone sonde are carried on high altitude balloons or aircraft and collect air samples. This sample is analysed by an electrochemical concentration cell (ECC) which reacts Ozone with potassium iodide to produce an electric current. Thus Ozone concentration can be determined. (2)

UV lasers

Ground based uv lasers are fired into the atmosphere. The degree of absorption of UV light at various wavelengths by ozone is measured with a spectrophotometer and this is used to calculate ozone concentrations / Levels.

Outline TWO technologies used by scientists to collect data on ozone levels in the atmosphere. 2M

4 UV Spectrophotometer is used by scientists to map ozone concentration as a function of altitude, collecting data from using balloons to record atmospheric ozone levels. (2)

OMI (Ozone mapping instrument) is an ozone mapping instrument developed by NASA that uses satellite technology to map ozone levels over the whole surface of the earth.

Question 24. (4 marks)
(a) Identify the origins of CFCs in the atmosphere. 1M

Their use, previously, as aerosol propellants which directly released them into the atmosphere and as cooling agents in refrigerators and air conditioners, which leaked after many years. (1)

9

Question 24. (4 marks)

(a) Identify the origins of CFCs in the atmosphere. 1M

CFCs were originally made to replace toxic ammonia for use as a refrigerant (coolant) gas. Their inert, non-toxic nature made them suitable for use also as propellants and blowing agents. (deodorants, aerosol) used in industry (1)

Question 24. (4 marks)

(a) Identify the origins of CFCs in the atmosphere. 1M

CFCs used in refrigerants (in refrigerators & air conditioning), aerosol propellants and solvents for cleaning electrical circuit boards. These CFCs ~~are~~ can leak into atmosphere from these products (eg. when crushed for recycling etc.) (1)

(b) Discuss, using relevant equations, the problems associated with the use of CFCs. 3M

CFCs ~~were~~ are highly inert and pass through the stratosphere unaffected. As they pass the ozone layer, they are decomposed by UV light, to create the destructive Cl radical

$CCl_2F_2(g)$ + UV radiation $\rightarrow$ $Cl^{\bullet}(g)$ + $CClF_2^{\bullet}(g)$

$Cl^{\bullet}(g) + O_3(g) \rightarrow ClO^{\bullet}(g) + O_2(g)$

$ClO^{\bullet}(g) + O^{\bullet}(g) \rightarrow Cl^{\bullet}(g) + O_2(g)$ (3)

This chain reaction continues, and causes the destruction of the ozone layer. Thus, one CFC molecule / or one $Cl^{\bullet}$ can destroy tens of thousands of O_2 molecules. This allows more harmful UV light to reach the earth's surface, thus causing mutations in DNA (cancer & eye diseases) and destroying plastics.

(b) Discuss, using relevant equations, the problems associated with the use of CFCs. 3M

CFCs are very inert and do not react in the troposphere but reach the stratosphere. Here they are exposed to UV light and produce chlorine free radicals eg. $CCl_3F \xrightarrow{\text{UV radiation}} CCl_2F^{\bullet} + Cl^{\bullet}$

The chlorine free radical reacts with ozone

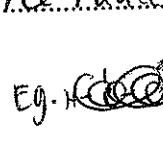
eg. $Cl^{\bullet} + O_{3(g)} \rightarrow ClO^{\bullet} + O_{2(g)}$ (3)

the ClO then either decomposes or reacts with ozone to form more chlorine free radicals to continue to deplete ozone. eg $2ClO\cdot \rightarrow 2Cl\cdot + O_{2(g)}$

... the use of CFC's depletes the ozone layer and which allows more UV radiation to reach the earth's surface. This damages living tissue and can cause cancer cells and cataracts, also destroying plant life. These problems are significant and are caused by the use of CFCs in refrigerants, aerosols and other applications.

(b) Discuss, using relevant equations, the problems associated with the use of CFCs. 3M

CFCs deplete ozone in the stratosphere. When CFCs leak into the atmosphere they undergo a reaction with UV light to produce chlorine free radicals. These chlorine free radicals can then deplete ozone.

Eg.  $F-\overset{F}{\underset{F}{\overset{|}{\underset{|}{C}}}}-Cl + \text{UV light} \rightarrow F-\overset{F}{\underset{F}{\overset{|}{\underset{|}{C}}}}\cdot + Cl\cdot$

$Cl\cdot_{(g)} + O_{3(g)} \rightarrow ClO\cdot_{(g)} + O_2$

Depletion of ozone means more UV radiation reaching earth.

- This increases the rate of skin cancers in humans and cases of eye cataracts.
- In marine ecosystem, UV light can reduce productivity of phytoplankton and hence decrease their survival rates. Since they are at the bottom of food chain, the entire aquatic ecosystem is affected adversely. (3)
- Plant photosynthetic rates are reduced and this decreases productivity of sensitive crops. (eg. soybeans). Crop produce reduced, thus less food for humans → price of food increases → aggravates recession problem.
- Also CFCs increase global warming as it is a greenhouse gas.

* Chlorine oxide free radicals can undergo reactions to produce more chlorine radical. Chain reaction continues.

DO NOT WRITE IN THIS BOOKLET – use your own paper

Question 25. (5 marks)
The smelting of chalcopyrite ($CuFeS_2$) during the production of copper can be represented by the reaction:-

$$2CuFeS_{2(s)} + 5O_{2(g)} + 2SiO_{2(s)} \rightarrow 2Cu_{(l)} + 4SO_{2(g)} + 2FeSiO_{3(l)}$$

$n = \frac{V}{V_M}$

1 tonne = 1000 kg = 1 000 000 g.

(a) Calculate the volume (at 25 °C and 100 kPa) of sulfur dioxide that would be released into the atmosphere from the smelting of 1 tonne of chalcopyrite (assume the sulfide mineral is pure). 2M

$n_{CuFeS_2} = m/M$

$M_{CuFeS_2} = 63.55 + 55.85 + (32.07 \times 2)$

$= 183.54$ g/mol.

$n_{CuFeS_2} = 1000\,000 \div 183.54$

$= 5448.40...$

$n_{SO_2} = 2 \times n_{CuFeS_2}$

$= 10896.8$

$V_{SO_2} = n.V_M$

$= 10896.8 \times 24.79$

$= 270132$ L (nearest L) ✓

2

(a) Calculate the volume (at 25 °C and 100 kPa) of sulfur dioxide that would be released into the atmosphere from the smelting of 1 tonne of chalcopyrite (assume the sulfide mineral is pure). 2M

$n_{CuFeS_2(s)} = \frac{m}{M} = \frac{1000\,000}{63.55 + 55.85 + 2(32.07)} = 5448.40...$ mol

$n_{SO_2} = \frac{4}{2} n_{CuFeS_2} = 2(5448.40...) = 10\,896.8...$ mol.

$V_{SO_2} = nV_M = (10\,896.8...) \times 24.79 = 270\,131.85$ L.

$= 270.13$ kL. ✓

ie. 270.13 kL of SO_2 would be released into the atmosphere.

2

(b) The release of sulfur dioxide pollutes the atmosphere resulting in acid rain.

(i) Define the term "acid rain". 1M

acid rain is rain with pH < 5. ✓

1

(ii) Outline one impact of acid rain on the environment. 1M

Acid rain can also lower the pH of water bodies. This pH change may go outside the pH tolerance range of fish, resulting in fish death or their inability to reproduce. This will decrease the biodiversity and/ reduce life / food in the ~~ac~~ aquatic food chain. ✓

(ii) Outline one impact of acid rain on the environment. 1M

Acid rain removes nutrients from the soil such as molybdenum, magnesium, phosphorus, and calcium which are important nutrients for the growth of crops. ✓ 1

(iii) Outline one impact of acid rain on society. 1M

Acid rain reduces nutrients in soil therefore crop growth is affected resulting in higher prices for the cost of food which may cause a strain on weekly budgets of lower income earners ✓ 1

(iii) Outline one impact of acid rain on society. 1M

Acid rain can lower pH of soil, reducing the productivity of crops and possibly kill them. This will reduce food supplies to society and may lead to an increase in food prices or starvation. ✓ 1

(iii) Outline one impact of acid rain on society. 1M

the weathering of monuments made of limestone leads to a loss of historical artefacts that will not be able to be recovered ✓ 1

$CaCO_3 + H_2SO_4 \rightarrow CaSO_{4(aq)} + CO_{2(g)} + H_2O_{(l)}$

Question 26. (6 marks)
During your practical work, you performed a first-hand investigation to distinguish between an alkane and its corresponding alkene.

(a) Name the alkene used in your investigation. 1M

cyclohexene ✓ 1

(b) Identify a potential hazard in your investigation and outline how you addressed this hazard. 2M

The toxic fumes of the substances used (cyclohexane, cyclohexene and bromine water). Thus, the investigation was done in a well ventilated place – the windows in the classroom were opened. ✓ 2

3

(b) Identify a potential hazard in your investigation and outline how you addressed this hazard. 2M

~~the potential of glass breaker~~ the potential of knocking over the bottles containing the cyclohexane / hexene that can lead to broken glass or spreading of contents.

Thus precaution was taken to ensure that one person used the bottle at a time in a non-crowded area or allowed the teacher to pour the contents for us.

(b) Identify a potential hazard in your investigation and outline how you addressed this hazard. 2M

A potential hazard in this investigation is that bromine water is toxic and volatile. This hazard was addressed by ~~shorten~~ using only small amounts of bromine water in the investigation and also minimising the time the bottle of bromine water was opened. 2

(c) Describe the procedure you used for your first-hand investigation. 3M

An identical amount of cyclohexane and cyclohexene was added to separate test tubes (about 2mL). A few drops of bromine water (tan coloured) was added to each test tube. Each test tube was stoppered and vigourously shaken for 30seconds and then placed back into the test tube rack for the layers to separate. This was done in the classroom, minimising exposure to uv light which would have changed the results obtained. Our group's results were compare with those of other groups in the class to establish reliability. 3

good! ✓ and any changes observed.

DRAFT PERFORMANCE BANDS

CHEMISTRY

The typical performance in this band:

Band 6	• demonstrates an extensive knowledge and understanding of the concepts of the chemistry course content including context, prescribed focus areas and domain • displays an outstanding ability to describe and explain chemistry concepts, including abstract ideas, clearly and accurately, and to apply the concepts to unfamiliar situations • applies a high level of critical thinking skills in developing appropriate solutions to problems involving a long sequence of related tasks • analyses, evaluates and extrapolates chemical data effectively, identifies complex relationships, quantifies explanations and descriptions, and synthesizes information to draw conclusions • communicates succinctly, logically and sequentially using a variety of scientific formats • demonstrates a high level ability to design an experimental procedure
Band 5	• demonstrates a thorough knowledge and understanding of the concepts of the chemistry course content including context, prescribed focus areas and domain • effectively communicates a detailed understanding of chemistry concepts using appropriate chemistry terminology and scientific formats, and applies the concepts to unfamiliar situations • analyses information given in written, tabular, graphical and diagrammatic forms and relates this to other relevant information • displays competence in manipulating equations to solve problems involving a number of steps • demonstrates a thorough knowledge of the use of appropriate experimental procedures
Band 4	• demonstrates a sound knowledge and understanding of the concepts of the chemistry course content including context, prescribed focus areas and domain • describes concepts and information clearly in written, graphical and diagrammatic forms such as structural and electron-dot formulae, and applies these concepts in familiar situations • demonstrates a broad ability to carry out calculations and or substitute into equations, to use relevant symbols and units when manipulating chemical data including stoichiometric data, and to construct balanced chemical equations • displays proficiency in selecting relevant data from information given in written, tabular, graphical and diagrammatic form • describes correct apparatus for a particular chemical measurement and has an adequate understanding of experimental methodology.
Band 3	• demonstrates a basic knowledge and understanding of the concepts of the chemistry course content including context, prescribed focus areas and domain • uses simple chemistry definitions, terms, diagrams and graphs to communicate understanding of chemistry concepts • substitutes data from information given in written, tabular, graphical and diagrammatic form, and manipulates basic chemical data including stoichiometric data
Band 2	• demonstrates a limited knowledge and understanding of the chemistry course content including context, prescribed focus areas and domain • recalls elementary terminology and formulae related to some areas of chemistry • makes simple substitutions of data in chemical calculations • describes simple safety precautions in experimental procedure
Band 1	•

5

Question 27. (3 marks)
Earlier this year a new transuranic element, *ununbium*, was produced. It existed for 0.05 seconds.

(a) Define the term transuranic element. 1M

An element with an atomic number greater than 92. ✓ 1

(b) Outline how transuranic elements such as ununbium are produced. 2M

Transuranic elements can be produced in nuclear reactors, where an atom is bombarded with neutrons.

eg $^{238}_{92}U + {}^{1}_{0}n \rightarrow {}^{239}_{93}Np + {}^{0}_{-1}e$. ✓

or ~~by bombarding~~ in particle accelerators where a charged nuclei is accelerated and collided into a target nucleus. ✓ 2

eg. $^{238}_{92}U + {}^{2}_{1}H \rightarrow {}^{238}_{93}Np + 2({}^{1}_{0}n)$.

(b) Outline how transuranic elements such as ununbium are produced. 2M

- In nuclear reactor, the controlled decay of uranium-235 is used to obtain neutrons.
- These neutrons are then used to bombard the nucleus of target atoms.

Eg. The production of Neptunium.

$^{238}_{92}U + {}^{1}_{0}n \rightarrow {}^{239}_{92}U$ 2

U-239 is highly unstable and rapidly undergoes β decay to form the transuranic element.

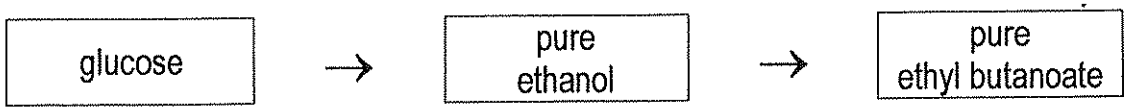
$^{239}_{92}U \rightarrow {}^{0}_{-1}e + {}^{239}_{93}Np$

(b) Outline how transuranic elements such as ununbium are produced. 2M

Elements 93 to 95 are produced by the bombardment of neutrally charged neutrons to the uranium atom in a nuclear reactor (where neutrons are freely available)* Elements with a higher atomic number than this are produced when entire nuclei of atoms are bombarded to a target nuclei in a particle accelerator. Different atoms of different elements can combine in an ion-accelerator, producing elements with higher atomic numbers. ✓2

* these atoms then undergo radioactive (beta decay) to form new elements with different atomic numbers.

Question 28. (7 marks)
The flowchart shows a series of steps involved in the production of ethyl butanoate.



Describe the chemistry and procedures involved in each step, using labelled diagrams where appropriate. 7M

~~If~~ From the flow chart glucose undergoes fermentation to produce ethanol. However the ethanol produced is not pure and thus needs to be distilled. ~~Fermentation~~ Fermentation involves ~~the~~ the addition decomposition of glucose to form ethanol. A buchner flask has sucrose added, the yeast and water added to allow ~~for~~ for fermentation the sucrose is hydrolysed ($C_{12}H_{22}O_{11(aq)} + H_2O_{(l)} \rightarrow 2C_6H_{12}O_{6(aq)}$). The formation of ~~ethanol allows to~~ glucose allows the production of ~~ethanol~~ ethanol by the yeast. The yeast ferment at the ~~in~~ conditions of that are anaerobic, sterile, 37° temperature 7.

of 37°C along with glucose. Thus the ethanol is produced within 48 hours.

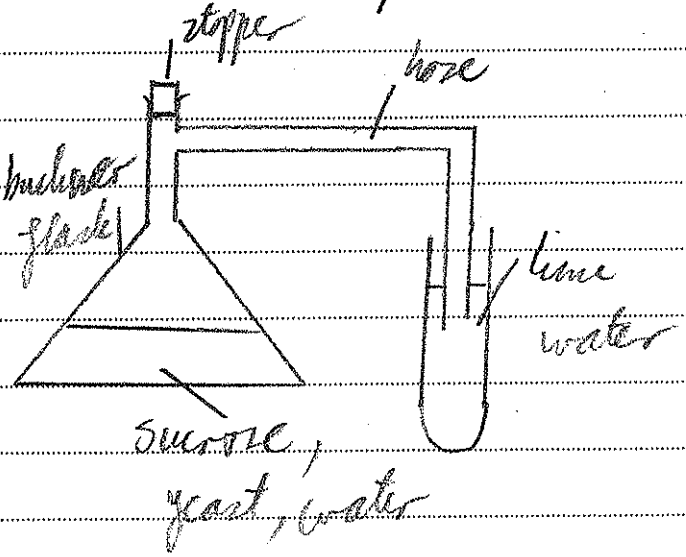
$C_6H_{12}O_{6(aq)} \xrightarrow{} 2C_2H_5OH_{(aq)} + 2CO_{2(g)}$

The carbon dioxide gas is detected ~~through the rea~~ by the reaction with ~~lime~~ lime water as shown in ~~the~~ ~~d~~ d here:

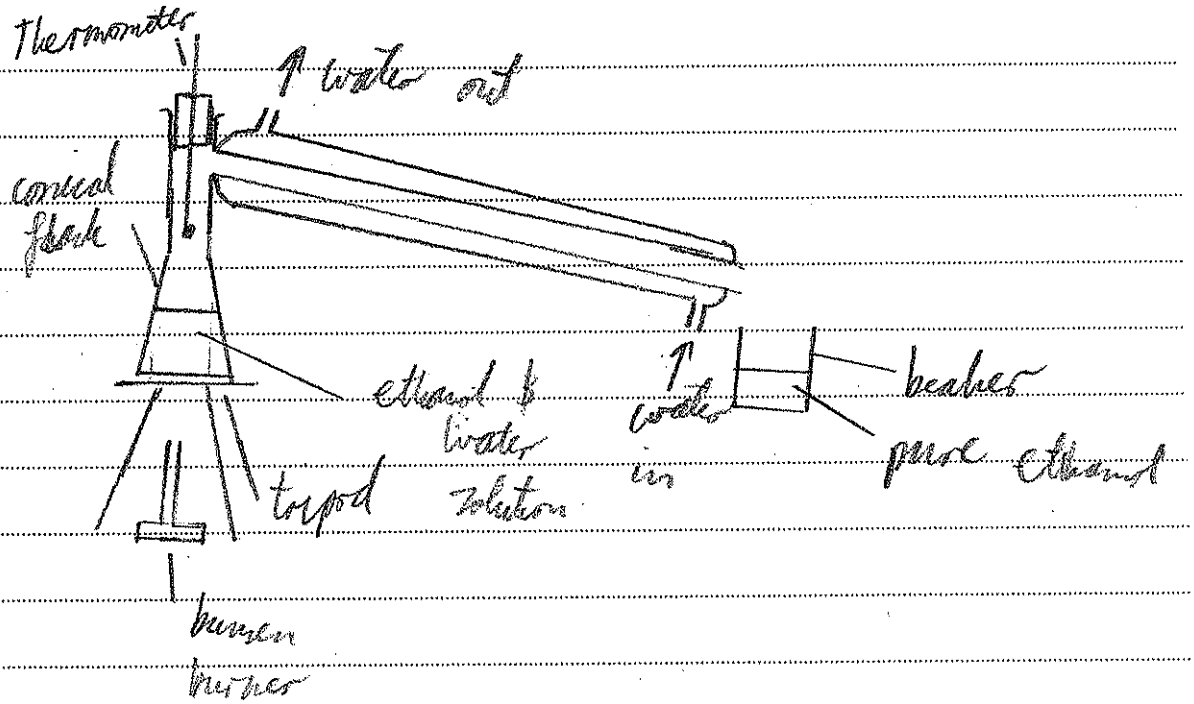
$CO_{2(g)} + CaO_{(aq)} \rightarrow CaCO_{3(s)}$

The solution of lime water turns from colourless to milky colour.

Fermentation process:



~~The~~ The yeast cannot produce a pure liquid of ethanol as it will die in an ethanol concentration of (15% v/v). Thus the mixture is distilled at 78°C in the apparatus below **



(The yeast was filtered from the solution before distillation)

Question 28. (7 marks)
The flowchart shows a series of steps involved in the production of ethyl butanoate.

glucose → pure ethanol → pure ethyl butanoate

Describe the chemistry and procedures involved in each step, using labelled diagrams where appropriate. 7M

* The anaerobic fermentation of glucose is used to produce ethanol. Conditions:
  - yeast is used as the micro-organism which ferments the glucose.
  - Nutrients is added for yeast (eg. PO_4^{3-}) & source of sugar ✓
  - 35°C
  - pH 3.7 – 4.6
  - sulfite (to kill any unwanted bacteria)

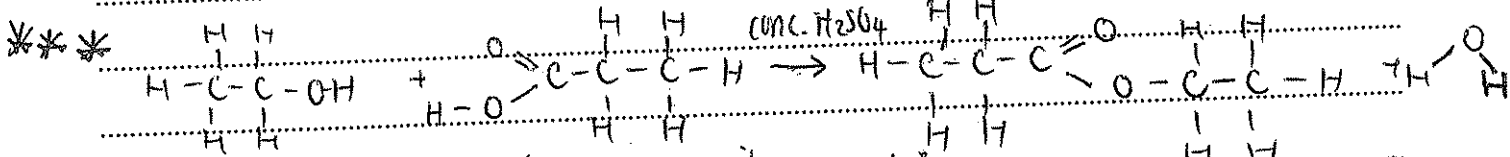
7

$C_6H_{12}O_6 \longrightarrow 2C_2H_5OH + 2CO_2(g)$

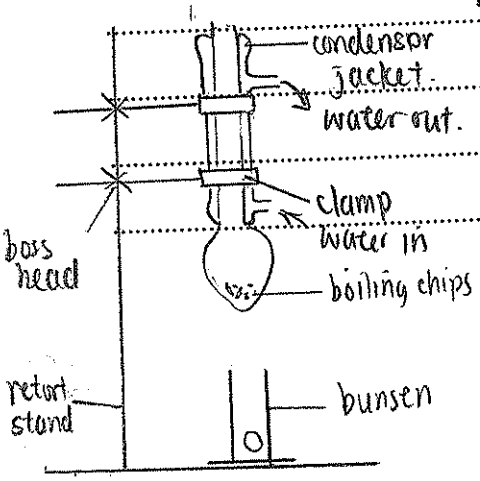
The fermentation vessel is placed in incubator for 3-5 days & in anaerobic condition

** The ethanol mixture obtained is then distilled to obtain pure ethanol.
Heated mixture up to around 80°C using distillation apparatus. ✓

• Ethanol was then reacted with butanoic acid in process of esterification.

*** 

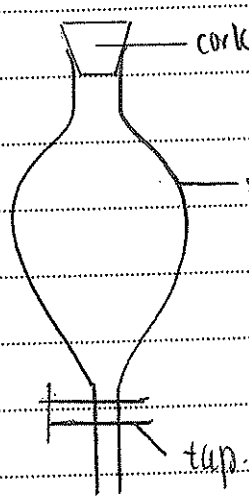
ethanol + butanoic acid ⇒ ethyl butanoate + water.



Refluxing apparatus.

• The water flow was adjusted so that the reactants stayed in the lower half of the vessel during the refluxing. Sulfuric acid is used as a catalyst and dehydrating agent to increase rate of reaction and yield. • Heated for around 35 min. The mixture was then allowed to cool and the bottom of the esterification flask carefully removed.

Q-28. ****



1. The mixture obtained is then placed in a separatory funnel and 25mL of water added.
2. separatory funnel is corked and shaken. Allow time for immiscible layers to settle.
3. Carefully open cap to drain lower layer.
Water is used since both the alkanol & alkanoic acid is polar and water is polar so they are highly soluble in water (can form hydrogen bonds)
The ester is not as soluble in water because of the structure of its alkyl groups.
4. 25mL water is added again and steps 2 and 3 are repeated.
5. Na_2CO_3 is added as it will react with the acid, removing it to obtain a more pure ester. Water is also added and the separatory funnel is shaken again. Allowed time for layers to settle. before draining bottom layer.

The remaining liquid should be the pure ethyl butanoate.

excellent answer.

Question 29. (4 marks)
Explain the need for monitoring the products of a chemical reaction such as combustion. 4M

Combustion will create different products under differing conditions.
Eg. $2\,C_8H_{18(l)} + 25\,O_{2(g)} \rightarrow 16\,CO_{2(g)} + 18\,H_2O_{(g)}$
Here, complete combustion occurs
$2\,C_8H_{18(l)} + 17\,O_{2(g)} \rightarrow 16\,CO_{(g)} + 18\,H_2O_{(g)}$
or $2\,C_8H_{18(l)} + 13\,O_{2(g)} \rightarrow 8\,C_{(s)} + 8\,CO_{(g)} + 18\,H_2O_{(g)}$
Here, incomplete combustion occurs
As such, when there is sufficient O_2, complete combustion will occur but when there is limited O_2, incomplete combustion occurs yielding carbon monoxide and/or soot. Carbon monoxide is a toxic gas ~~that~~ when inhaled and soot is carcinogenic and hence these products should be minimised to protect human health.
By monitoring the products, when soot or CO is detected, it is an indication that insufficient O_2 is available for combustion. This can then be corrected by supplying more O_2 as a reactant to prevent incomplete combustion.
Further, ~~is~~ incomplete combustion yields less energy than complete combustion. To ensure maximum efficiency of fuel, products need to be monitored to prevent incomplete combustion.

4

Question 29. (4 marks)
Explain the need for monitoring the products of a chemical reaction such as combustion. 4M

Combustion is a process which turns chemical energy into heat energy by reacting substances with $O_{2(g)}$.
Combustion can be either incomplete or complete.
In the complete combustion of ethane, the products are carbon dioxide and water. $2\,C_2H_{6(g)} + 4\tfrac{1}{2}\,O_{2(g)} \rightarrow 4\,CO_{2(g)} + 6\,H_2O_{(g)}$
The products of complete combustion are quite harmless, however if there is an insufficient supply of oxygen, incomplete combustion occurs.
$C_2H_{6(g)} + 2\,O_{2(g)} \rightarrow 1\,CO_{(g)} + 1\,C_{(s)} + 3\,H_2O_{(g)}$
Carbon monoxide is a toxic gas which ~~inhibits the~~ displaces oxygen in the blood causing the body to die. Soot or carbon is a carcinogenic substance.

4

21

These products of incomplete combustion are very harmful to humans and to the environment.

Also if impurities such as sulfur are present, toxic sulfur dioxide gas could form. $S_{(s)} + O_{2(g)} \rightarrow SO_{2(g)}$.

~~There for~~ Therefore it is important to monitor combustion reactions to make sure there is ~~an of~~ a sufficient supply of oxygen gas to allow for complete combustion.

Question 29. (4 marks)
Explain the need for monitoring the products of a chemical reaction such as combustion. 4M

It is vital to monitor the products of a combustion reaction as there are different products formed under certain conditions.
Complete combustion occurs when there is a plentiful supply of oxygen and the products formed are carbon dioxide and water. eg. $2C_8H_{18(l)} + 25O_{2(g)} \rightarrow 16CO_{2(g)} + 18H_2O_{(l)}$
Incomplete combustion occurs when there is an insufficient supply of oxygen and the products formed may be soot (C), carbon monoxide, carbon dioxide and water.
eg. $2C_8H_{18(l)} + 15O_{2(g)} \rightarrow 8C_{(s)} + 4CO_{(g)} + 4CO_{2(g)} + 18H_2O_{(l)}$
There is a need to monitor the products of incomplete combustion as the products produced can have detrimental effects on humans. Carbon (soot) is a carcinogenic substance and can irritate the lungs while carbon monoxide can deprive the body of oxygen. Also, incomplete combustion reduces the efficiency of a fuel supply thus rendering a much lower energy yield.
Therefore, it is important to monitor the products of combustion as these products can be harmful to humans and the environment.

A

Question 30. (5 marks)
The Haber process is used to synthesise ammonia from its elements.

(a) Write a balanced equation for the reaction (include states). 1M

$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \quad \Delta H = -92.4\ kJ$

(b) Explain the impacts of increased temperature on the reaction system. 4M

The Haber process is exothermic. If the temperature is increased the yield of ammonia decreases as according to Le Chatelier's principle, if a system at equilibrium is disturbed, it will shift position to counteract the change, thus establishing new equilibrium. As heat is added, the reaction will attempt to remove it to minimise disturbance, there endothermic reverse reaction which absorbs heat is favoured ∴ more reactants are formed → less $NH_3(g)$.

However, increase in temperature increases reaction rate as more heat → particles have more kinetic energy therefore they move faster which results in more collisions and the more collisions, the more likely the reaction will occur. Therefore, as ↑ in temperature reduces ammonia yield but ↑ increase reaction rate, a compromise at 400°C is reached in order to achieve a balance between yield, reaction rate as well as costs. Catalyst Fe_3O_4 is used to allow lower temperatures → improves reaction rate.

(b) Explain the impacts of increased temperature on the reaction system. 4M

Le Chatelier's Principle states that if a change is imposed on a system already at equilibrium then the system will shift in such a way as to counteract and minimise the change. Thus, increasing the temperature will favour the endothermic reaction ie the reverse reaction ✓ and as a result decrease the yield of NH_3. However, increasing the temperature increases the rate of reaction of the system. This is because an increase in temperature causes the reactant molecules to possess more kinetic energy. This corresponds to an increase in the frequency and number of collisions, which in turn allow increases the rate of successful collisions and thereby increasing the rate of reaction.

Question 31 Industrial Chemistry

ai) Sulfuric Acid is used to manufacture fertilisers such as sulphate of ammonia

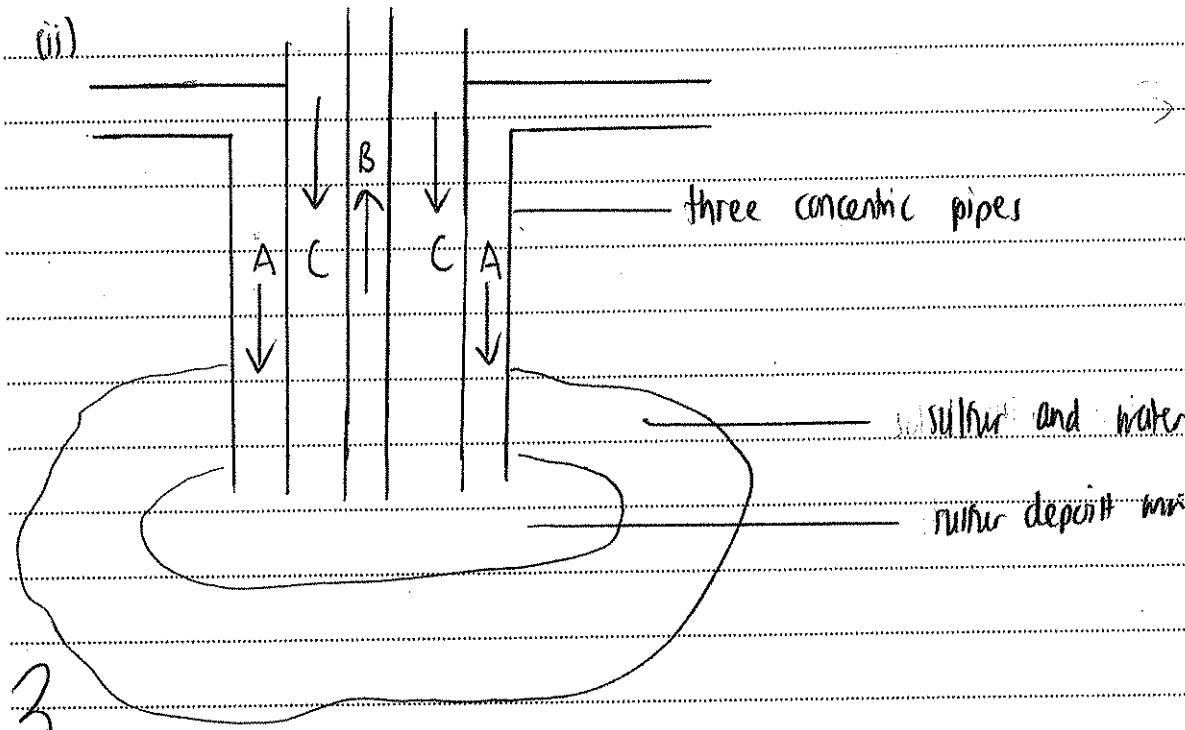
$2NH_3 + H_2SO_4 \rightarrow (NH_4)_2SO_4$

Fantastic

31

a) (i) H_2SO_4 is used in the production of fertilisers such as ~~supp~~ sulfate of ammonia which is used to help crops achieve higher growth rate due to added nutrients

(ii)

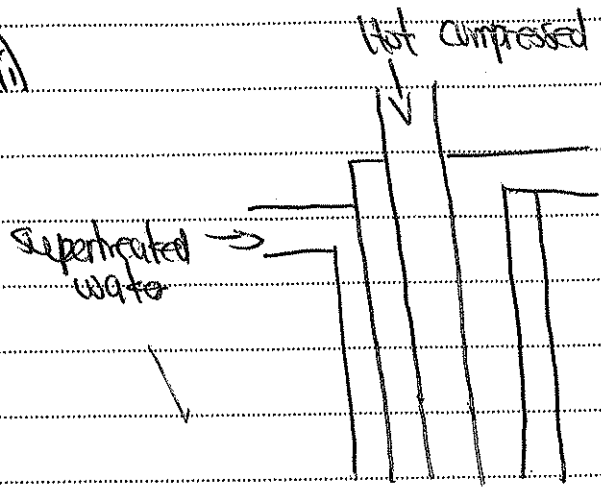


22

Superheated water ~~is used as~~ (temp = 165°C) is used to melt the sulfur which has a melting point of 113°C. It enter the mine through concentric pipe A.

Compressed air then ~~is~~ enter through C, causing the water and sulfur to form a foamy emulsion. The sulfur, air and water are pushed up back out through pipe B, onto the earth by the compressed air. The emulsion of sulfur and water is allowed to cool. The sulfur solidifies thus separating from the water.

ii)



1) Superheated water is forced through the outer pipe at 165°C (under pressure to stop evaporation). This is done to melt the sulfur (solid, as sulfur has a high melting point (113°C)
2) Hot compressed air is forced through the middle pipe. This is done to create a foamy liquid dispersion between the molten sulfur and water. This is because sulfur is insoluble in water.
3) The force (pressure) from the hot compressed air forces the air, sulfur, water mixture up the middle pipe to the outside. This pipe is located in the middle (surrounded by hot water) so that it doesn't solidify in the pipe (as it would if temp. dropped to below 113°C)
4) The sulfur and water dispersion is then separated as the mixture cools down (the temp is below 113°C and the sulfur solidifies). This is because sulfur is non-polar while water is polar, and so they don't dissolve together.

3

Superb

(iii) oleum = $H_2S_2O_7$

6 (iv) $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$ $\Delta H = -kJ$

The catalytic oxidation of SO_2. The SO_2 is passed through three catalyst beds of V_2O_5. At the first bed the temperature is 550°-600°C and a yield of 70% SO_3 is obtained. The mixture is then cooled to around 400°C and is passed through the 2nd & 3rd catalyst beds yielding 97% and 99.7% SO_3 respectively.

In this reaction, the conditions which favour reaction rate include increasing temperature which is done on the first catalyst bed so as to increase reaction rate. As temperature is increased, the molecules have more kinetic energy, which leads to faster movement of the particles which improves chances of collision and for a reaction to occur, particles must collide and at a suitable orientation, therefore increasing temperature improves reaction rate.

- A catalyst V_2O_5 is used. The catalyst are finely grounded to increase surface area, thus increasing reaction rate. A catalyst lowers the activation energy required for a reaction to occur by providing an alternate pathway for the reactant molecules. As the reaction is able to proceed at lower temperature, reaction rate is improved
- Increasing pressure: There are 3 moles of gaseous molecules on the left hand side while there is only two on the right hand side. According to Le-Chetelier, if pressure is increased, the system at equilibrium will try to counteract this, by favouring the reaction which will decrease the pressure. Therefore the reaction proceeds to the right, improving reaction yield rate. Increased pressure also increase concentration of reactants due to fewer less space, therefore increasing collisions & increasing rate.

the reactions which favour yield of SO_3:

- decreased temperature, as the reaction is exothermic so the endothermic reverse reaction that absorbs heat energy is favoured ~~therefore reduction~~ if temperature are high. If they are low, the forward reaction which produces heat will be favoured.
- Increased pressure: as the forward reaction is favoured (explained above) SO_3 yield will increase as it is a product
- an excess of oxygen: if excess oxygen is added, the reaction that uses it up will be favoured in order to minimise the disturbance. ie. forward reaction favoured. → SO_3 increases
- Removing SO_3 from reaction vessel: as it is being removed, the system will try to produce more SO_3 to minimise to change :. reactants are formed into products.

The conditions used are therefore

- use of catalyst V_2O_5 at first catalyst bed, at 2nd & 3rd catalyst beds
- compromise of temperature. 600°C for fast reaction rate but cooled to 400°C to improve yield
- Increase pressure.

[continued overleaf.]

- small excess of O_2
- removing SO_3 from reaction vessel.

These conditions optimise the yield in the shortest time possible

T R↓ Y↓ NO_2 Y↓ H_2SO_4 ↑Y↓
P R↓ Y↓ V_2O_5 R↓

(ii) In the catalytic oxidation of sulfur dioxide into sulfur trioxide (oxidation) the following conditions are imposed on the reaction system to achieve optimal yield of sulfur trioxide and rate of reaction:

$2SO_{2(g)} + O_{2(g)} \overset{V_2O_5}{\rightleftharpoons} 2SO_{3(g)} + heat$

Justify = give reasons; ie relate to LCP & collision theory

- temperature: ↓ 400 - 550°C

not well done ✗ This to ensure that the reaction rate is appreciable / significant ✗ but not incur a reduction in equilibrium yield of sulfur trioxide.

- pressure: a pressure higher than atmospheric pressure (1.5 atm - but not significantly high as to incur the expense of high pressure apparatus.

Y↓ Rx↓ By having a high pressure, the equilibrium will be driven to favour the forward reaction as this reaction direction results in products of less moles of gas (i.e. reduce pressure)

- concentration of ↑ a 5:1 ratio of air to sulfur dioxide is used since reactants of air contains only 21% oxygen. Thus the mole ratio of $O_{2(g)}$ to $SO_{2(g)}$ will be 2:1. 2:1

R↓ Having the $O_{2(g)}$ in excess drives reaction is driven to completion favouring yield of sulfur trioxide.

- catalyst: use of vanadium(V) oxide (V_2O_5) catalyst impregnated uniformly onto the silica pellets in the catalyst beds exposes a greater surface area to be more efficient lowering E_a of activation to increase reaction rate. R↓

- removal of $SO_{3(g)}$: by removing sulfur trioxide gas in absorbing it with H_2SO_4 to form $H_2S_2O_7$ (oleum) we reduce the $[SO_{2(g)}]$. Consequently this will cause equilibrium to shift to favour the forward reaction so as to increase $[SO_{3(g)}]$ Y↓

b) i) $CoCl_4^{2-}$ + $6H_2O_{(aq)}$ ⇌ $[Co(H_2O)_6]^{2+}$ + $4Cl^-$
(blue) (pink)

ii) the qualitative feature of this system is the colour of the solution. when the equilibrium lies to the left, the colour of the solution is blue, while, when it lies to the right, the colour of the solution is pink. this distinction in colour on either sides of the equilibrium system, allowed me to determine how changes to the system such as adding heat, acid and Cl^- ions affected the equilibrium. eg. by adding salt (NaCl) to the system, i was able to realise that this caused the equilibrium to favour the left hand side, because it turned blue.

b) i) $Fe^{3+}_{(aq)}$ + $SCN^-_{(aq)}$ ⇌ $FeSCN^{2+}_{(aq)}$

ii) We were able to investigate the effects of changes imposed on this equilibrium system due to the characteristic colours that each species (ie Fe^{3+}, SCN^- and $FeSCN^{2+}$) exhibited when in solution.

$Fe^{3+}_{(aq)}$ + $SCN^-_{(aq)}$ ⇌ $FeSCN^{2+}_{(aq)}$
yellow-brown colourless blood-red

Thus when we imposed a change on the system and either the reactants or products concentration were increased as a consequence there would a change in colour characterised by the particular colour the dominant species exhibited combined to produce.

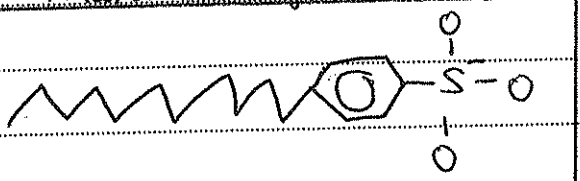
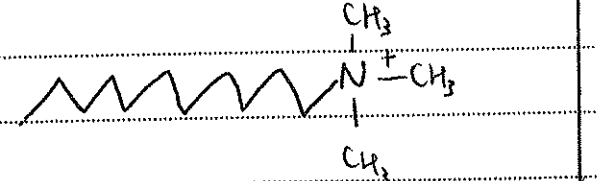
ii) $Fe^{3+}_{(aq)}$ was yellow-brown coloured.
$SCN^-_{(aq)}$ was colourless.
$FeSCN^{2+}_{(aq)}$ was blood red.

by diluting the solution to a pink colour, this would indicate the equilibrium lied close to the middle.
Also, the effect of changes imposed could be detected as the solution changed colour.

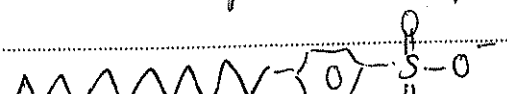
continued overleaf.

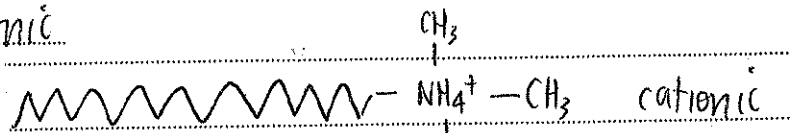
equilibrium
More tan coloured → shifted to the left.
More blood red coloured → equilibrium shifted to the right.
great answer.

c) i)

Anionic detergents	Cationic detergents
	
Anionic detergents comprise of a hydrocarbon chain as the tail	Cationic detergents comprise of a hydrocarbon chain as a tail
Anionic detergents have a negatively charged head group such as the benzene sulfonate group	Cationic detergents have a positively charged head group such as the quaternary ammonium group

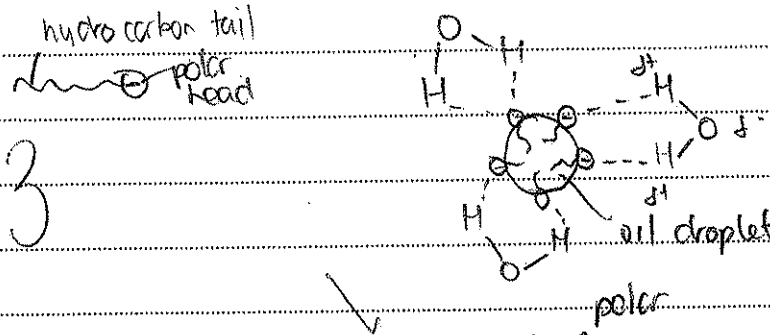
d (i) Both anionic and cationic detergents consist of a non-polar hydrocarbon tail which forms dispersion forces with other non-polar substances such as oil, dirt, oil. However, the both contain a different polar head. Anionic detergents contain a negative polar head such as an alkyl benzene sulfonate whereas cationic detergents have a positive ammonium head.


anionic


cationic

ii) A detergent molecule ~~will be ionic in water~~ has a long non-polar hydrocarbon tail and a polar, charged head.

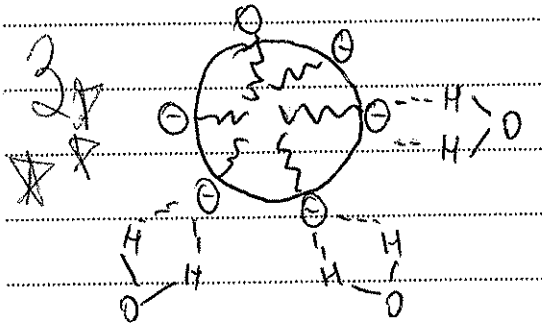
When a mixture of oil, water and detergent is agitated, the non-polar hydrocarbon tail will ~~the bond~~ form dispersion bonds with the non-polar oil, following the rule "like dissolves like". At the same time, the polar heads of the hydrocarbon will form an ion-dipole bond with the polar water molecules. This is shown below, where the oil and detergent has formed a miscelle



3

Further, the same charge of the ^ heads repel other heads in other micelles. This prevents the micelles from coalescing.
Thus, the detergent ~~acts~~ forms micelles with oil which then disperse throughout the water, forming an emulsion

(III). Detergent molecules consist of both non-polar and polar portions. The head is polar, therefore is attracted to other polar substances such as water (therefore is termed hydrophilic) the hydrocarbon tail is non-polar therefore is attracted to other non-polar substances such as oils (ie hydrophobic / lipophilic). As water is polar and oil is non-polar, they do not usually mix unless there is present an emulsifying agent such as detergent, which allows the formation of an emulsion. As Like dissolves like. The non-polar tail is buried in the oil. through the formation of dispersion forces which are stronger than those which exist between oil molecules. The polar head dissolves in water through dipole-dipole forces of attraction of hydrogen bonding. This forms a micelle.



O = oil
⊖ = detergent molecule / emulsifying agent.
---- = hydrogen bonding
H / O = water.

Many oil globules such as the one above are formed within the water. As the polar heads surrounding the oil are negatively charged, they will repel other oil globules through electrostatic repulsion thus forming an emulsion in which the oil particles are evenly suspended throughout the water forming an oil-in-water emulsion with the detergent molecule acting as an emulsifying agent

when oil is agitated increasing surface area
∴ ability for detergent to surround oil and form micelle

ii) The hydrocarbon (non-polar) tails of detergent molecules dissolve in the non-polar oil, ~~whereas the polar ionic~~ through dispersion forces, whereas the polar ionic head dissolves in polar water through ion-dipole bonding. When the mixture is agitated, the detergent molecules are able to orientate and enclose an oil droplet, forming a micelle. The negative head charges of the detergent then repel each other, and so each micelle never coalesces to reform larger oil droplets. Thus, an emulsion of water and oil is created.

d) (i) $K_{eq} = \frac{[H_{2(g)}]^5 [CO_{(g)}]^2}{[C_2H_{6(g)}][H_2O_{(g)}]^2}$

(ii) (x) decreases
(y) remains the same.
(z) remains the same.

(iii) $Q = \frac{[H_{2(g)}]^5 [CO_{(g)}]^2}{[C_2H_{6(g)}][H_2O_{(g)}]^2}$

$= \frac{(0.100)^5 (0.021)^2}{(0.055)(0.037)^2}$

$= 5.85696 \times 10^{-5}$

$\neq 0.0060$

The system is not yet at equilibrium. As Q is smaller than the value for K_{eq}, the concentration of the reactants is still very higher and the equilibrium favours the right hand side in order to establish equilibrium.