2007

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
Write your student number on each section of this booklet
A data sheet and Periodic Table are provided at the back of this paper

Total marks 100
Section I
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 – 27.
Allow about 1 hour and 45 minutes for this part.
Section II
25 marks
Attempt ONE question from this section.
Attempt Question 28 – Industrial Chemistry.
Allow about 45 minutes for this section.

Teacher-in-charge: Miss Jackson

Task Weighting: 40%

Section I.

Part A - 15 marks

Attempt questions 1 - 15.
Allow about 30 minutes for this part.
Record your answers on the separate multiple-choice answer sheet.

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

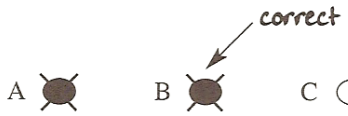
Sample: 2 + 4 = (A) 2 (B) 6 (C) 8 (D) 9

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 ○

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1. Which of the following statements is true for all addition polymers?

(A) They are naturally occurring polymers.
(B) They are formed from monomers, each of which contains double or triple bonds.
(C) They are formed from the reaction between functional groups on neighbouring monomers.
(D) They are formed by monomers combining without the loss of electrons.

2. The heat of combustion of ethanol is 1346 kJ mol^{-1}.
What mass of ethanol would be required to produce 3500 kJ of energy upon its complete combustion?

(A) 17.716 g
(B) 17.72 g
(C) 119.79 g
(D) 119.8 g

3. The uranium-238 isotope is unstable and emits a form of radiation.
Which of the following statements accounts for the instability of this isotope?

(A) It has too many neutrons compared to protons
(B) It has too many protons compared to neutrons
(C) It has too many protons and neutrons
(D) It has an incomplete outer shell of electrons

4. Which statement is correct concerning the addition of bromine water to cyclohexene?

(A) the reaction is rapid and is an example of non-destructive analysis
(B) the reaction is rapid and is an example of destructive analysis
(C) the reaction is slow and is an example of destructive
(D) the reaction is slow and is an example of non-destructive analysis

5. What is the oxidation state (oxidation number) of vanadium in ammonium orthovanadate, $(NH_4)_3VO_4$.

(A) +1
(B) +3
(C) +4
(D) +5

6. A titration was used to measure the concentration of citric acid in orange juice. The burette, pipette and reaction flask were carefully rinsed before the titration was conducted.

What should be the rinsing procedure for each piece of equipment?

	burette	*pipette*	*reaction flask*
(A)	Distilled water then the appropriate solution	Distilled water then the appropriate solution	Distilled water then the appropriate solution
(B)	Distilled water then the appropriate solution	Distilled water then the appropriate solution	Distilled water only
(C)	Distilled water only	Distilled water only	Distilled water only
(D)	Distilled water only	Distilled water only	Distilled water then the appropriate solution

7. Determine the pH of 50.0 mL of 0.0115 mol L^{-1} solution of sulfuric acid.

(A) 1.638
(B) 1.939
(C) 2.939
(D) 3.240

8. Which one of the following compounds, when dissolved in water, would NOT give an acidic solution?

(A) KCl
(B) NH_4Cl
(C) H_3PO_4
(D) SO_3

9. When food passes from the stomach to the small intestine, the pH changes from 2 to 8.
Which statement best compares the hydrogen ion concentration in the stomach to that of the small intestine?

(A) 60 times less
(B) 60 times greater
(C) 1 000 000 times less
(D) 1 000 000 times greater

10. The table below provides information about three indicators.

Indicator	*Colour change*	*pH range over which colour change takes place*
methyl orange	red to yellow	3.2 to 4.4
bromothymol blue	yellow to blue	6.0 to 7.6
phenolphthalein	colourless to pink	8.2 to 10.0

If equal volumes of these three indicators were mixed, what colour would be observed at pH 5.5?

(A) blue
(B) green
(C) orange
(D) yellow

11. In the commercial synthesis of ammonia, the process can be carried out at 35 000 kPa pressure and at a temperature of 500 K using an iron-based catalyst.
Why is a temperature of 500K chosen, rather than a lower temperature?

(A) A lower temperature would decrease the yield of ammonia.
(B) At a temperature of 500 K, a greater amount of ammonia is produced.
(C) A temperature of 500K is needed to maintain the reactants in the gaseous state.
(D) A lower temperature would decrease the rate of the reaction

12. Hydrogen sulfide, H_2S, is a weak acid which ionises in solution according to the following equations:

$$H_2S(aq) \leftrightarrow H^+(aq) + HS^-(aq)$$
$$HS^-(aq) \leftrightarrow H^+(aq) + S^{2-}(aq)$$

Manganese (II) sulfide, MnS, is a sparingly soluble pink solid which, when suspended in water, also exists in equilibrium with ions in solution:

$$MnS(s) \leftrightarrow Mn^{2+}(aq) + S^{2-}(aq)$$

In which of the following aqueous solutions would manganese (II) sulfide be most soluble?

(A) 1 mol L^{-1} NaHS
(B) 1 mol L^{-1} H_2S
(C) 1 mol L^{-1} $Mn(NO_3)_2$
(D) 1 mol L^{-1} HCl

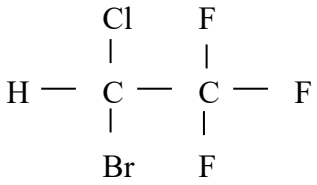
13. Which of the following halogen-containing compounds is NOT a source of ozone-destroying free-radicals in the stratosphere?

(A) CCl_4
(B) CH_2FCF_3
(C) CCl_2F_2
(D) $CBrClF_2$

14. Which statement identifies the layers of the Earth's atmosphere in order of increasing altitude?

(A) thermosphere, mesosphere, stratosphere, troposphere
(B) thermosphere, stratosphere, mesosphere, troposphere
(C) troposphere, mesosphere, stratosphere, thermosphere
(D) troposphere, stratosphere, mesosphere, thermosphere

15. The gas *halothane* is used as a general anaesthetic. Its structural formula is shown below: -



What is the systematic name of *halothane?*

(A) 1-bromo-1-chloro-2,2,2-trifluoroethane
(B) trifluorobromochloroethane
(C) 2-bromo-2 chloro-1,1,1-trifluoroethane
(D) 1-chloro-1-bromo-2,2,2-trifluoroethane

Section I (continued)

Part B - 60 marks

Attempt questions 16 – 27.
Read the whole of each question before commencing it.
Answer the questions in the spaces provided.
Show all relevant working in questions involving calculations.
Allow about 1 hour and 45 minutes for this part.

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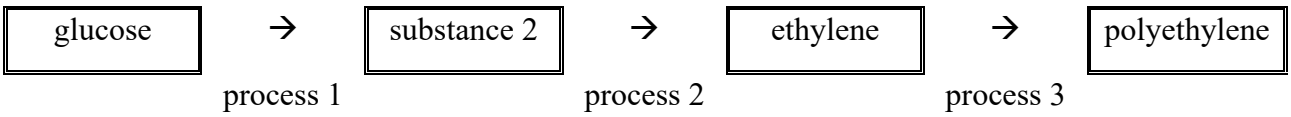
Question 16. (5 marks)

The flow chart shows some of the steps in the conversion of glucose into polyethylene.



(a) Complete the table to identify the numbered substance / processes. 2M

substance / process	Its identity
substance 2	
process 1	
process 2	
process 3	

(b) Outline the steps involved in process 3. 3M

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Question 17. (6 marks)

(a) Identify a radioisotope used for an industrial application and justify its selection for this application in terms of the properties of the isotope. 3M

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(b) Assess the risks associated with the use of radioisotopes. 3M

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Question 18. (6 marks)

In a first-hand investigation, a student was given the task of constructing a galvanic cell that would produce the highest possible voltage.

The following materials were available to the student -

* standard zinc electrodes
* standard copper electrodes
* standard lead electrodes
* standard tin electrodes
* 200 mL of 1.0 mol L^{-1} zinc sulfate
* 200 mL of 1.0 mol L^{-1} lead (II) nitrate
* 200 mL of 1.0 mol L^{-1} copper (II) sulfate
* 200 mL of 1.0 mol L^{-1} sodium chloride
* 200 mL of 1.0 mol l-1 tin (II) nitrate
* 200 mL of 1.0 mol L^{-1} potassium nitrate solution
* beakers
* measuring cylinders
* paper towelling
* electrical wires with alligator clips
* voltameter
* emery paper

(a) Select the materials that the student would have used to produce the highest possible voltage and draw a fully labelled diagram showing how the galvanic cell was constructed. 3M

(b) Write the redox half-equations and full equation to determine the maximum voltage that this cell could produce. Show full working. 3M

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Question 19. (4 marks)

As a part of the Chemistry course, you carried out a first-hand investigation to decarbonate soft drink and gather data to measure the mass changes involved and calculate the volume of gas released at 25ºC and 100 kPa.

Assess the validity of the conclusion you drew from this investigation. 4M

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Question 20. (5 marks)

Vinegar is essentially an aqueous solution of ethanoic acid. In a first-hand investigation to determine the concentration of ethanoic acid in vinegar, the following results were obtained.
25.0 mL of vinegar was diluted to 250.0 mL with distilled water in a volumetric flask. From this, three 25.0 mL aliquots were measured out, placed into separate conical flasks and two drops of phenolphthalein were added to each. Each aliquot was then titrated against a standard solution of potassium hydroxide.
An average titre of 22.5 mL of a 0.0851 mol L^{-1} potassium hydroxide solution was required to give a permanent, faint pink colour to this solution.

(a) Calculate the concentration of ethanoic acid in vinegar. Show all your working. 3M

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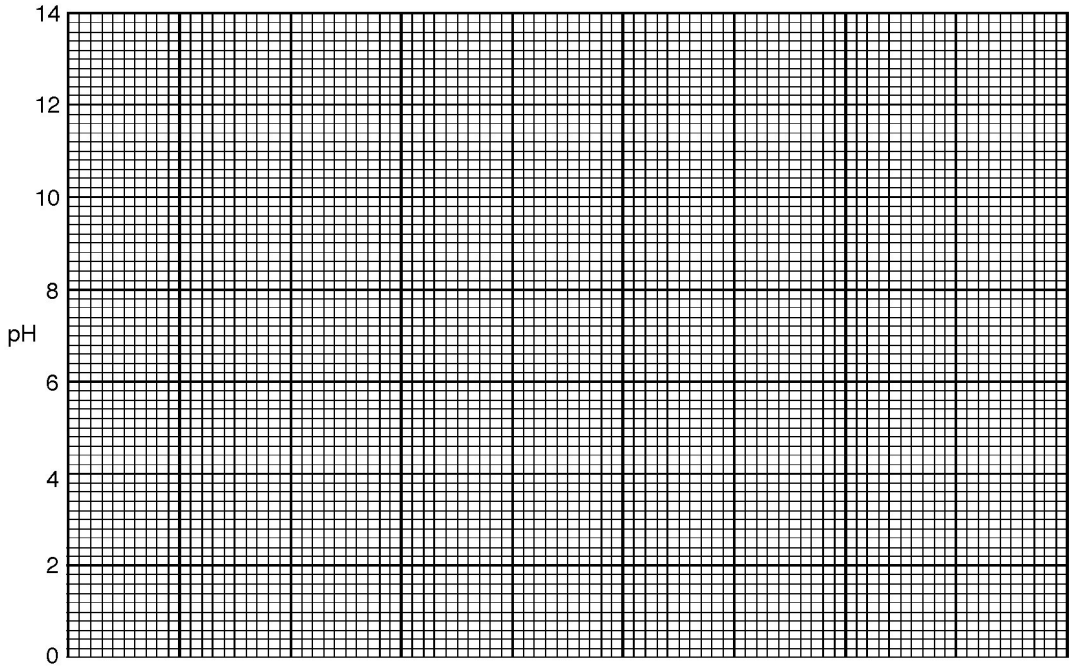
(b) Complete the titration curve for the first-hand investigation outlined above. 2M



Question 21. (4 marks)

Justify the statement "All Arrhenius acids are also Bronsted-Lowry acids however not all Bronsted-Lowry acids are also Arrhenius acids". 4M

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Question 22. (3 marks)

Describe the effect of buffers with reference to a specific example in a natural system. 3M

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Question 23. (6 marks)

(a) Draw a Lewis dot diagram of the ozone molecule. 1M

(b) Contrast the types of bonds present in ozone gas and oxygen gas. 2M

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(c) Compare the properties of the oxygen allotropes, O_2 and O_3, in terms of their stability to heat, stability to UV light and ONE other property. Tabulate your information. 3M

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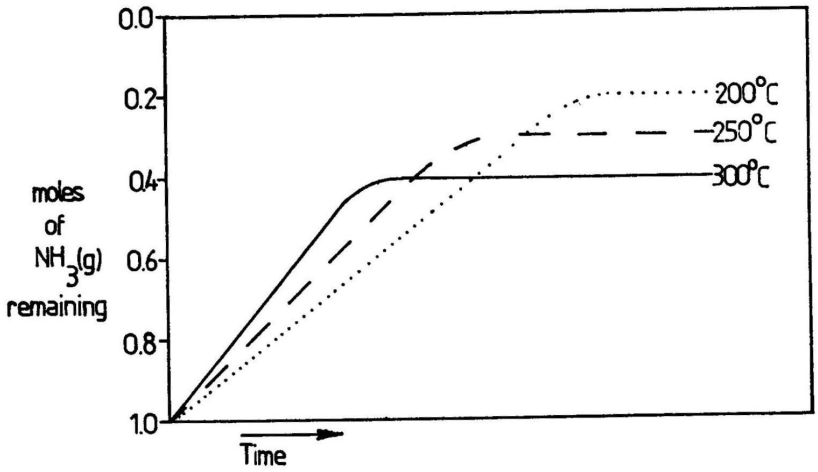
Question 24. (4 marks)

Ammonia decomposes according to the equation shown.

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

The graph below represents the decomposition of 1.0 mole of pure ammonia in the presence of a catalyst at various temperatures.



(a) Explain why the number of moles of ammonia remaining reaches a constant value at each temperature. 2M

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(b) Explain how the rate of decomposition of ammonia changes with temperature. 2M

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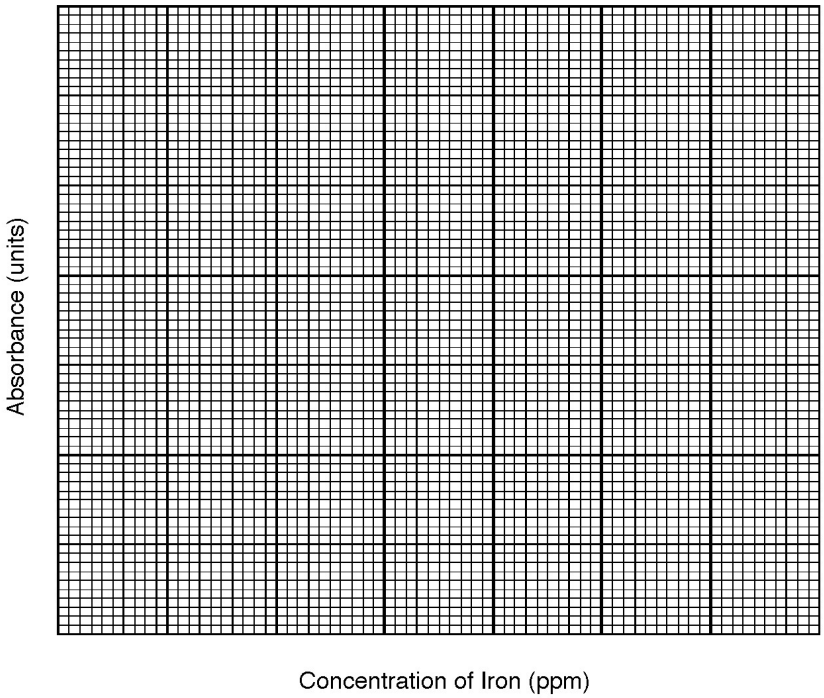
Question 25. (5 marks)

A sample of tank water is contaminated with iron since it shows signs of rust. The sample was analysed using atomic absorption spectroscopy (AAS). A calibration curve was prepared using standard iron solutions and the iron content in the sample was then determined.
The table below shows the results for the standard calibration curve.

Absorbance (units)	Content of Iron (ppm)
0.05	0.5
0.12	1.0
0.22	2.0
0.34	3.0
0.58	5.0

(a) Draw a line graph for the standard calibration curve on the grid provided 2M



(b) Determine the concentration of iron (ppm) in a tank water sample which has an absorbance of 0.38 units. 1M

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(c) Outline the AAS procedure used to analyse solutions. 2M

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Question 26. (5 marks)

Evaluate the significance of the development of the Haber Process between 1910 and 1918. 5M

Question 27. (7 marks)

Using an example drawn from each of the three core modules, analyse the impacts on the environment of the applications of chemistry.

Section II.

25 marks

Attempt question 28.
Allow about 45 minutes for this part.
Answer the question in a writing booklet. Extra writing booklets are available.
Show all relevant working in questions that require calculations.

Question 28. – Industrial Chemistry.

(a) For the reversible reaction represented by the equation:-

$$CS_{2(g)} + 4H_{2(g)} \leftrightarrows CH_{4(g)} + 2H_2S_{(g)}$$

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

(ii) 0.65 mol of carbon disulfide and 0.83 mole of hydrogen are mixed in a closed 2.5 L container, and the reaction allowed to establish equilibrium. At equilibrium, 0.095 mole of dihydrogen sulfide gas is present.
Calculate the equilibrium constant at 1000 Kelvin (727ºC). 2M

(iii) At 1200 Kelvin (927ºC), the equilibrium constant, K, has a value of 2.1.
Determine whether the reaction is endothermic or exothermic. 1M

(b) As a part of your course, you carried out a first-hand investigation to qualitatively analyse an equilibrium reaction.

(i) Describe the equilibrium reaction you analysed. 2M

(ii) Describe and account for each of TWO changes you imposed on this equilibrium reaction. 4M

(c) Distinguish between anionic, cationic and non-ionic detergents in terms of their chemical composition and uses. 4M

(d) With the aid of a suitable diagram, describe the production of sodium hydroxide by the mercury process. In your response, outline an advantage of this method over the use of the diaphragm process and the membrane process. 5M

(e) Analyse the processes necessary for the industrial production of sulfuric acid from Earth materials. 6M

CHEMISTRY

2007 --- THSC Marking Scheme

Section I - CORE.

Part A - multiple choice

1.	B
2.	D
3.	C
4.	B
5.	D

6.	B
7.	A
8.	A
9.	D
10.	D

11.	D
12.	D
13.	B
14.	D
15.	C

Part B - Extended Response

16. (a)

Criteria	Marks
Identifies all FOUR substances/processes – *substance 2 = ethanol, process 1 = fermentation, process 2 = dehydration, process 3 = polymerisation*	2
Identifies ONE of the substances / processes	1

16. (b)

Criteria	Marks
Outlines the THREE key steps in the process of free-radical addition polymerisation *(initiation, propagation, termination = IPT)*	3
Outlines TWO of the key steps in process of free-radical addition polymerisation **OR** Identifies the THREE key steps of the process of free-radical addition polymerisation	2
Identifies ONE of the key steps in the process of free-radical addition polymerisation	1

17. (a)

Criteria	Marks
1. Identifies a radioisotope and its use in an industrial application 2. Outlines relevant properties of the radioisotope 3. Relates the properties to the use of the named radioisotope	3
Two of the above three points	2
Identifies a radioisotope used in an industrial application OR Identifies a use of radioisotopes in an industrial application	1

17. (b)

Criteria	Marks
Describes TWO problems associated with the use of radioisotopes **AND** Makes a judgement	3
Describe ONE problem associated with the use of **radioisotopes** **AND** Makes a judgement	2
Identifies a problem associated with the use of radioisotopes	1

18. (a)

Criteria	Marks
Draws an appropriate scientific diagram of a galvanic cell that is fully labelled to identify :- *the electrodes (Zn & Cu), electrolytes($ZnSO_4$ & $CuSO_4$), salt bridge (paper towel soaked in KNO_3), and external circuit (alligator wires & voltmeter)*	3
An incompletely labelled diagram based on Zn & Cu electrodes and $ZnSO_4$ & $CuSO_4$ electrolytes	2
A scientific diagram of a galvanic cell	1

18. (b)

Criteria	Marks
Calculates the maximum voltage, showing appropriate working. *(+ 1.10 V)* Writes the two half-equations (including the states of matter) AND the overall equation (including the states of matter) *[may be a follow-through error if wrong electrodes chosen in part (a)]*	3
Calculates the maximum voltage, showing appropriate working. **OR** Writes the two half-equations (including the states of matter) AND the overall equation (including states)	2
Calculates the maximum voltage **OR** Writes the two half-equations **OR** Writes the overall equation	1

19.

Criteria	Marks
1. Identifies a relevant conclusion drawn from the results of the investigation 2. Describes two factors of the experimental design and explains how they could have influenced the experimental outcome 3. Makes a judgement about the conclusion drawn based on the effect each factor had on the investigation	4
1. Describes two factors of the experimental design and explains how they could have influenced the experimental outcome 2. Makes a judgement about the conclusion drawn based on the effect each factor had on the investigation	3
1. Identifies a relevant conclusion drawn from the results of the investigation 2. Describes one factor of the experimental design that may have influenced the experimental outcome	2
Identifies a relevant conclusion drawn from the results of the investigation **OR** Describes one factor of the experimental design that may have influenced the experimental outcome	1

20. (a)

Criteria	Marks
1. Writes a balanced chemical equation for the reaction between ethanoic acid and potassium hydroxide 2. Calculates the number of moles of potassium hydroxide as 1.91475×10^{-3} mol 3. Determines the number of moles of ethanoic acid using the mole ratio 4. Calculates the concentration of vinegar as 0.766 mol L^{-1}	3
Any TWO of the points outlined above	2
Any ONE of the points outlined above	1

20. (b)

Criteria	Marks
Circles the left-hand most graph which represents the pH changes when a weak acid and strong base are titrated	1

20. (c)

Criteria	Marks
Identifies ONE other property of a primary standard *(such as high molar mass, high level of purity, readily soluble in distilled water, reacts instantly and completely during titration)*	1

21.

Criteria	Marks
1. Outlines the Arrhenius theory of acids 2. Outlines the Bronsted-Lowry theory of acids 3. Outlines why an Arrhenius acid can be a Bronsted-Lowry acid 4. Outlines why a Bronsted-Lowry acid is not necessarily classified as an Arrhenius acid 5. Includes relevant example(s) & equation(s)	4
1. Outlines the Arrhenius theory of acids 2. Outlines the Bronsted-Lowry theory of acids 3. Outlines why an Arrhenius acid can be a Bronsted-Lowry acid **OR** Outlines why a Bronsted-Lowry acid is not necessarily classified as an Arrhenius acid	3
1. Outlines the Arrhenius theory of acids 2. Outlines the Bronsted-Lowry theory of acids	2
Outlines the Arrhenius theory of acids **OR** Outlines the Bronsted-Lowry theory of acids	1

22.

Criteria	Marks
1. Describes a system in nature that needs to be buffered 2. Identifies the components of the specific buffer system 3. Describes that the buffer system works to prevent large changes in pH when an acid or a base is added to the system eg. *Blood is buffered at pH = 7.4 by* H_2CO_3 / HCO_3^-	3
Two of the 3 points above	2
One of the three points above	1

23. (a)

Criteria	Marks
Diagram correctly shows the arrangement of valence electron in the ozone molecule	1

23. (b)

Criteria	Marks
Outlines ONE difference, written as a comparison, between ozone and oxygen in terms of their bonding. For example, *1. ozone contains a co-ordinate covalent bond and a double covalent bond within it whereas oxygen contains only a double covalent bond* *2. ozone has weak dipole-dipole interactions between molecules whereas oxygen has no dipole-dipole interactions but rather has dispersion forces between molecules*	2
Outlines ONE difference between ozone and oxygen in terms of their bonding	1

23. (c)

Criteria	Marks
1. Constructs a table with the columns and rows appropriately labelled and the table ruled up. 2. Correctly compares ozone and oxygen for their stability to heat *(oxygen stable; ozone unstable)* *3.* Correctly compares ozone and oxygen for their stability to UV light *(oxygen high stability, ozone moderate stability)* 4. Correctly compares ozone and oxygen for one other property (*eg. colour, boiling point, solubility in water, odour, reactivity)*	3
1. Constructs a table 2. Compares ozone and oxygen for TWO of points 2, 3 and 4 above	2
Compares ozone and oxygen for ONE property	1

24. (a)

Criteria	Marks
States that the system is at equilibrium **AND** Gives one characteristic of a system at equilibrium, stating how this feature explains the plateau present in each graph	2
States that the system is at equilibrium **OR** Gives one characteristic of a system at equilibrium, stating how this feature explains the plateau present in each graph.	1

24. (b)

Criteria	Marks
States that the rate of decomposition of ammonia increases as temperature increases **AND** Relates this increase to the proportion of molecules with sufficient kinetic energy	2
States that the rate of decomposition of ammonia increases as temperature increases.	1

25. (a)

Criteria	Marks
The line graph presented has the following features – • Graph covers >2/3 of the grid paper • Points are accurately plotted (as per the data provided) • Each point is precisely indicated (eg. as an "X") • The line of best fit is well placed	2
The line graph presented represents the data but is not totally accurate (not a clear line of best fit)	1

25. (b)

Criteria	Marks
Value for concentration of iron is accurately read from the graph. *(Value should be approximately 3-3 - 3.4 ppm)*	1

25. (c)

Criteria	Marks
Correct and accurate outline of the procedure for AAS including use of lamp, matching ions in solution and measurement of absorption.	2
Identifies AAS as a method used to analyse solutions and mentions one of the above	1

26.

Criteria	Marks
1. Outlines a social issue AND / OR (5 / 4) a political issue at the time of development of the Haber process 2. Explains reasons for restrictions on supplies to Germany 3. Outlines the impact of the Haber process at the time of discovery 4. Provides a judgement	4 - 5
1. Outlines a social OR political issue at the time of development of the Haber process 2. Explains reasons for restrictions on supplies to Germany 3. Outlines the impact of the Haber process at the time of discovery	3
Outlines a social OR political issue at the time of development of the Haber process **AND/OR** Explains reasons for restrictions on supplies to Germany **AND/OR** Outlines the impact of the Haber process at the time of discovery	1 – 2

27.

Criteria	Marks
1. Clearly identifies the components and shows how the components are related to each other in a thorough manner for one example from each of the core chemistry modules that has an impact on the environment. (ie THREE examples, one from each core module.) 2. Draws out, in an extensive manner, the implications for the environment of each of the three examples 3. Answer is written in a logical, structured format	7
1. Clearly identifies the components and shows how the components are related to each other in a thorough manner for TWO examples, each from a different core chemistry module, that has an impact on the environment **AND** 2. Outlines one example from the third core module. 3. Draws out the implications for the environment of each of the two examples.	6
Clearly identifies the components and shows how the components are related to each other in a thorough manner for ONE example from a core module **AND** Outlines TWO examples from the other core modules in a logical manner showing impact on the environment **OR** Clearly identifies the components and shows how the components are related to each other in a thorough manner for TWO examples showing impact on the environment.	5
Clearly identifies the components and shows how the components are related for one example from a core thoroughly **AND** provides one outline from a core module showing impact on the environment **OR** Outlines THREE examples, one from each core module in a logical manner, showing impact on the environment.	4
Clearly identifies the components and shows how the components are related for one example from one core module showing impact on the environment **OR** Outlines TWO examples from two of the core modules in a logical format **AND** Identifies ONE example from a core module.	3
Outlines ONE example from a core module AND identifies TWO examples from core modules **OR** Outlines TWO examples from two core modules **OR**	2

Identifies THREE examples, one from each core module.	
Identifies one example from one core module in a logical format relating this to environmental impact.	1

OPTION - Industrial Chemistry.

(a) (i)

Criteria	Marks
Correctly writes the equilibrium expression as $K = \frac{[CH_4]\ [H_2S]^2}{[CS_2]\ [H_2]^4}$	1

(a) (ii)

Criteria	Marks
Calculates the equilibrium constant as 0.027 showing appropriate and full working	2
Calculates the equilibrium constant as 0.027 but full working not shown **OR** Determines the moles of each species at equilibrium as - *CS_2 = 0.6025 mol, H_2S = 0.64 mol, CS_2 = 0.047 mol and H_2 = 0.095 mol*	1

(a) (iii)

Criteria	Marks
Identifies the forward reaction as endothermic (0.27<2.1) (**OR** exothermic if incorrect answer above has K>2.1)	1

(b) (i)

Criteria	Marks
1. (i) Describes a specific example of an equilibrium system that can be analysed qualitatively (ii) Includes a fully balanced equation of the equilibrium reaction 2. Describes the distinguishing features of the equilibrium system (eg. differing colours of species) that will allow it to be analysed qualitatively	2
EITHER 1. or 2. from above	1

(b) (ii)

Criteria	Marks
For each of the TWO changes being imposed on the equilibrium reaction – <u>Describes how the change is being imposed by -</u> 1. identifying what has been done 2. outlining the facet of the equilibrium reaction on which this would impact <u>Accounts for the impact of the change by -</u> 3. describes the qualitative changes of the system that would be observed 4. describes an appropriate reason for the observations	4
For each of the TWO changes being imposed on the equilibrium reaction covers 3 of the 4 points above	3
For each of the TWO changes being imposed on the equilibrium reaction covers 2 of the 4 points above, one point from 1 or 2 above AND one point from 3 or 4 above	2

Identifies a change made to the equilibrium reaction	1

(c)

Criteria	Marks
For each of the three types of detergent, identifies their composition AND identifies two uses , highlighting their unique features (ie. 3X 3 pieces of information) 8 or 9 correct pieces of information	4
6 or 7 correct pieces of information	3
4 or 5 correct pieces of information	2
1, 2 or 3 correct pieces of information	1

(d)

Criteria	Marks
1. Provides a well labelled diagram that represents the mercury process for sodium hydroxide production 2. Provides a thorough description of the mercury process for sodium hydroxide production 3. Provides relevant chemical equations 4. Outlines an advantage of the mercury process over the diaphragm and membrane processes	5
1. Provides a thorough description of the mercury process for sodium hydroxide production in words OR with a well labelled diagram 2. Provides relevant equations **AND/OR** Outlines an advantage of the mercury process over the diaphragm and membrane processes	4
Provides a basic description of the mercury process for sodium hydroxide production **AND/OR** Provides a basic diagram of the mercury process **AND/OR** Outlines an advantage of the mercury process over the diaphragm and membrane processes **AND/OR** Provides one correct equation **AND/OR** Identifies a commercial by-product of the process	1-2-3

(e)

Criteria	Marks
Describes the extraction (Frasch) and manufacturing (contact) processes necessary for the production of sulfuric acid Analyses the TWO steps by drawing out extensively the relationships between the steps, the chemistry of each step and/or the properties of the chemicals/chemical reactions (strong analysis of each = 6; weaker analysis = 5)	5-6
Describes the extraction (Frasch) and manufacturing (contact) processes necessary for the production of sulfuric acid Explains one step in one of the two processes	4
Describes ONE of the processes necessary for the production of sulfuric acid (ie. Frasch or Contact)	3
Outlines ONE of the processes necessary for the production of sulfuric acid	1-2

HAHS Trial HSC Examination

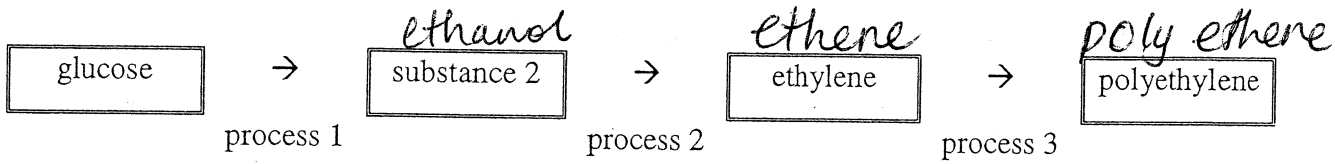
2007 - Chemistry

Exemplar Answers

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

Question 16. (5 marks)

The flow chart shows some of the steps in the conversion of glucose into polyethylene.



(a) Complete the table to identify the numbered substance / processes. 2M

substance / process	Its identity
substance 2	ethanol
process 1	fermentation
process 2	dehydration
process 3	addition polymerisation

(2)

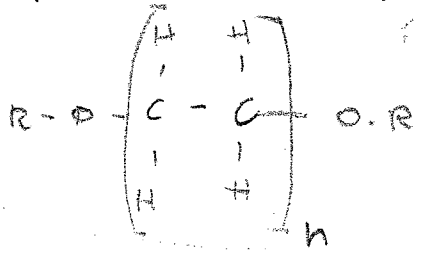
(b) Outline the steps involved in process 3. 3M

Polymerisation involves three steps. The first is initiation, where the double bond of the ethylene opens up to form a radical. where a free electron ~~Next is propagation~~ is in the molecule. Next is propagation. In this step the free radical joins with other ethylene molecules. The third step is termination. This occurs when a radical meets with another radical and polyethylene is formed.

(3)

(b) Outline the steps involved in process 3. 3M

Ethylene countains a double bond, in which a free radical is added eg R-O (peroxide), and this causes the double bond to break forming free radicals on the place the double bond once was eg: R-O-C-C (monomer unit), this free radicals will then join up with other monomer units to form a long branch of polyethylene: R-O-[C-C]n-, then this is only ended in termination, through reacting with another radical O-R (peroxide), and this terminates it, resulting in



which is now polyethylene. (3)

Question 17. (6 marks)

(a) Identify a radioisotope used for an industrial application and justify its selection for this application in terms of the properties of the isotope. 3M

Co-60 is a radioisotope that is used in industrial radiography that detects faults in in metals and metal welds.

It releases gamma rays that are able to be passed through metal, ~~so that it can expose~~ and can expose film/detated on the other side. Any welds or cracks in the metal enable more radiation to pass through, so by analysing the film, any problems can be detected. Co-60's long half life of 5.3 years means it can be ~~kept stored for~~ used for a relatively long period of time without replacement → convinient for users. (3)

Cobalt-60 is used in the irradiation of food and medical supplies. Cobalt-60 is used since it emits gamma rays. Gamma rays easily kill bacteria in food and on medical supplies. Also Cobalt-60 has a relatively long half-life, so it does not ~~to~~ need to replaced as frequently. (3)

Question 17. (6 marks)

(a) Identify a radioisotope used for an industrial application and justify its selection for this application in terms of the properties of the isotope. 3M

Americium-241 is used in smoke detectors & alarms. It is formed by bombarding $^{240}_{94}Pu$ with neutrons. $^{240}_{94}Pu + {}^{1}_{0}n \rightarrow {}^{241}_{94}Pu$. It is used in smoke detectors because $^{241}_{94}Pu \rightarrow {}^{241}_{95}Am + {}^{0}_{-1}e$ it is an alpha and beta emitter of radiation. These particles are able to ionise the air around the electector which is read as a constant electrical signal, when smoke or particulates enter the space between the electrodes in the smoke detector, it alters the rate of air being ionised and decreases the detected current hence sounding the alarm. (3)

(b) Assess the problems associated with the use of radioisotopes. 3M

The main problem concerned with radioisotopes is that emit radiation which is harmful to the human body - causing cell mutations etc. However, they are integral to the medical industry by allowing us to perform diagnostic proceedures inevasively. They also allow us to detect cracks and sterilise equipment hence an important tool in society. Another problem is the ~~the~~ short or long half lifes. Eg. Technectium 99m has too short of a half life (ie 6hrs) and must be produced on site. But americium-241 has too long a half life (432 yrs) which could cause environmental damage if disposed incorrectly. Hence even though there are harmful problems with the use of radioisotopes, they are outweighed compared to the benefits. (3)

(b) Assess the problems associated with the use of radioisotopes. 3M

The production of radioisotopes, firstly, involves the production of nuclear wastes. These wastes must be managed + disposed of thoroughly otherwise, it may harm the environment. Handling radioisotopes during both production and use exposes humans to potentially lethal radiation, causing mutations — cancer and even possibly death. (3) Regulations concerning the disposal and use of radioisotopes thus, need to be adhered to as the problems associated with the use of radioisotopes may be widespread and detrimental

(b) Assess the problems associated with the use of radioisotopes. 3M

Radioisotopes emmit radiation eg α, β, γ rays which can have detrimental effects are long periods of time. α - particles especially are highly ionising and if consumed into the body may ionise proteins such as DNA resulting in cancer and ultimately death. Environmental problems also arise when using radioactive isotopes, such that ~~an~~ isotopes such as uranium or americium in smoke alarm remain radiative for ages hence, when disposed of may cause detrimental environmental damage. (3)

Thus it can be seen the radioisotopes are safe, and only detrimental if inappropriately used or disposed of.

(b) Assess the problems associated with the use of radioisotopes. 3M

Radioisotopes emitt radiation in either alpha, beta or gamma form. All of which can be harmful if exposed to extensively, this is the main problem with its use since too much exposure can possibly cause cancer. Also the most of their half lives (not those used in industry or medical facilities) range from 5-6 years or less thus must be replaced frequently, having a high cost expense for the users. Also due to these half lives of radioisotopes, shielding structures must be either close to the area of use or in (3)

the actual place itself (cyclotrons in hospitals). These problems are negative but overall are not too significant compared to the benefits of the use of radioisotopes.

Question 18. (6 marks)

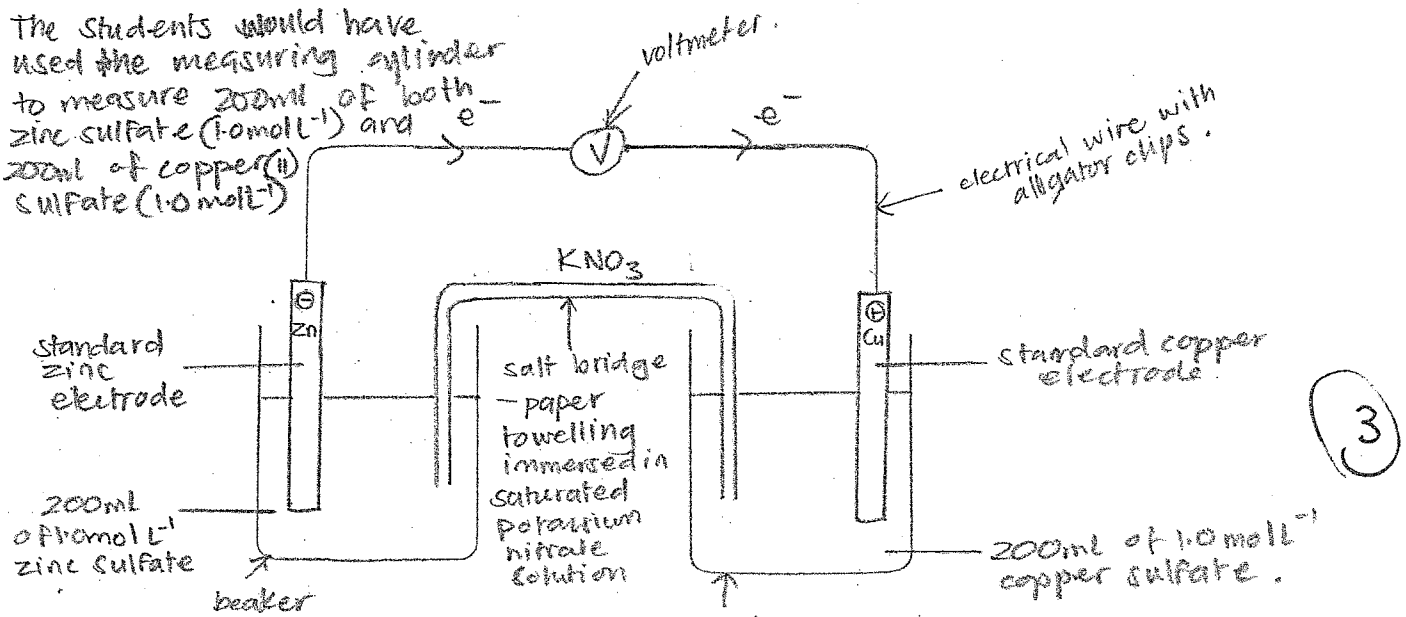
In a first-hand investigation, a student was given the task of constructing a galvanic cell that would produce the highest possible voltage.

The following materials were available to the student -

* standard zinc electrodes ✓
* standard copper electrodes ✓
* standard lead electrodes
* standard tin electrodes
* 200 mL of 1.0 mol L^{-1} zinc sulfate ✓
* 200 mL of 1.0 mol L^{-1} lead (II) nitrate
* 200 mL of 1.0 mol L^{-1} copper (II) sulfate ✓
* 200 mL of 1.0 mol L^{-1} sodium chloride
* 200 mL of 1.0 mol L^{-1} tin (II) nitrate
* 200 mL of saturated potassium nitrate solution
* beakers ✓
* measuring cylinders ✓
* paper towelling ✓
* electrical wires with alligator clips ✓
* voltmeter ✓
* emery paper ✓

(a) Select the materials that the student would have used to produce the highest possible voltage and draw a fully labelled diagram showing how the galvanic cell was constructed. 3M

* The students would have used the measuring cylinder to measure 200ml of both zinc sulfate ($1.0 mol L^{-1}$) and 200ml of copper(II) sulfate ($1.0 mol L^{-1}$)



3

* The students would have use emery paper to remove an oxide layers (or other layers) from the surface of the metals to ensure that the maximum surface area was available for the reaction to take place.

(b) Write the redox half-equations and full equation to determine the maximum voltage that this cell could produce. Show full working. 3M

$E^\circ(V)$

$Zn_{(s)} \rightarrow Zn^{2+}_{(aq)} + 2e^-$ $+0.76\ V$

$Cu^{2+}_{(aq)} + 2e^- \rightarrow Cu_{(s)}$ $+0.34\ V$

3

$Zn_{(s)} + Cu^{2+}_{(aq)} \rightarrow Zn^{2+}_{(aq)} + Cu_{(s)}$ $+1.10\ V$

Question 19. (4 marks)

As a part of the Chemistry course, you carried out a first-hand investigation to decarbonate soft drink and gather data to measure the mass changes involved and calculate the volume of gas released at 25°C and 100 kPa.

Assess the validity of the conclusion you drew from this investigation. 4M

The conclusion: the mass change was due to the ~~carbo~~ carbon dioxide escaping from the apparatus, is very valid. In order to validate this, a ~~separate~~ control was used where another soft drink was kept in the fridge and was open. The variable here was temperature and it was hypothesised that a warm environment will encourage the formation of carbondioxide as a result of Le Chatelier's principle which states that if a change is imposed on an equilibrium system, it will attempt to minimise the change. $CO_{2(g)} + H_2O_{(l)} \rightleftharpoons H_2CO_{3(aq)}$ + heat. Its forward reaction is exothermic, an increase in temperature will form CO_2 as heat is a reactant and the equilibrium is use or promote an endothermic reaction to resist the warm environment. ~~It was~~ Both the soft drink outside and in the fridge had their lids removed and were allowed to sit for five hours. It was observed that in the control, a very small ~~amount~~ mass change was observed as opposed to the soft drink outside. This reinforced that, because it was warm, the equilibrium ~~treat~~ formed CO_2. Therefore when the soft drink outside was compared to the control (temperature is the independant variable), the mass change was due to the formation and loss of CO_2, validating the conclusion.

(4)

Question 19. (4 marks)

As a part of the Chemistry course, you carried out a first-hand investigation to decarbonate soft drink and gather data to measure the mass changes involved and calculate the volume of gas released at 25°C and 100 kPa.

Assess the validity of the conclusion you drew from this investigation. 4M

The conclusion that carbon dioxide was released from the decarbonation caused the mass of soft drink to decrease was not valid. this was because a control was not used in the investigation. The soft drink was shaken, and the carbon dioxide gas allowed to escape. This was continued over a period of two days for one hour periods each day. In between this time, the bottles of soft drink were left standing with their lids open. This allowed some of the soft drink to evaporate. A control of already decarbonated drink was not left with it. This would have determined how much of the mass lost was due to evaporation. Thus, some of the mass lost in the decarbonation was due to evaporation but not taken into account when calculating the volume of CO_2 lost which makes the conclusion invalid. Also, the investigation was not carried out at a constant 25°C or 100kPa. The temperature + pressure fluctations over the two days would also make the conclusion invalid as the conclusion assumed it was a constant 25°C and 100kPa.

4

Question 20. (5 marks)

Vinegar is essentially an aqueous solution of ethanoic acid. In a first-hand investigation to determine the concentration of ethanoic acid in vinegar, the following results were obtained.

25.0 mL of vinegar was diluted to 250.0 mL with distilled water in a volumetric flask. From this, three 25.0 mL aliquots of the vinegar solution were measured out, placed into separate conical flasks and two drops of phenolphthalein were added to each. Each aliquot was then titrated against a standardised solution of potassium hydroxide with its known concentration being 0.0851 mol L^{-1}.

An average titre of 22.5 mL of the potassium hydroxide solution was required to give a permanent, faint pink colour to this solution.

(a) Calculate the concentration of ethanoic acid in vinegar. Show all your working. 3M

$KOH(aq) + CH_3COOH(aq) \rightarrow H_2O(l) + KCH_3COO(aq)$

$n_{KOH} = CV = 0.0851 \times 0.0225 = 1.91475 \times 10^{-3}$ mol

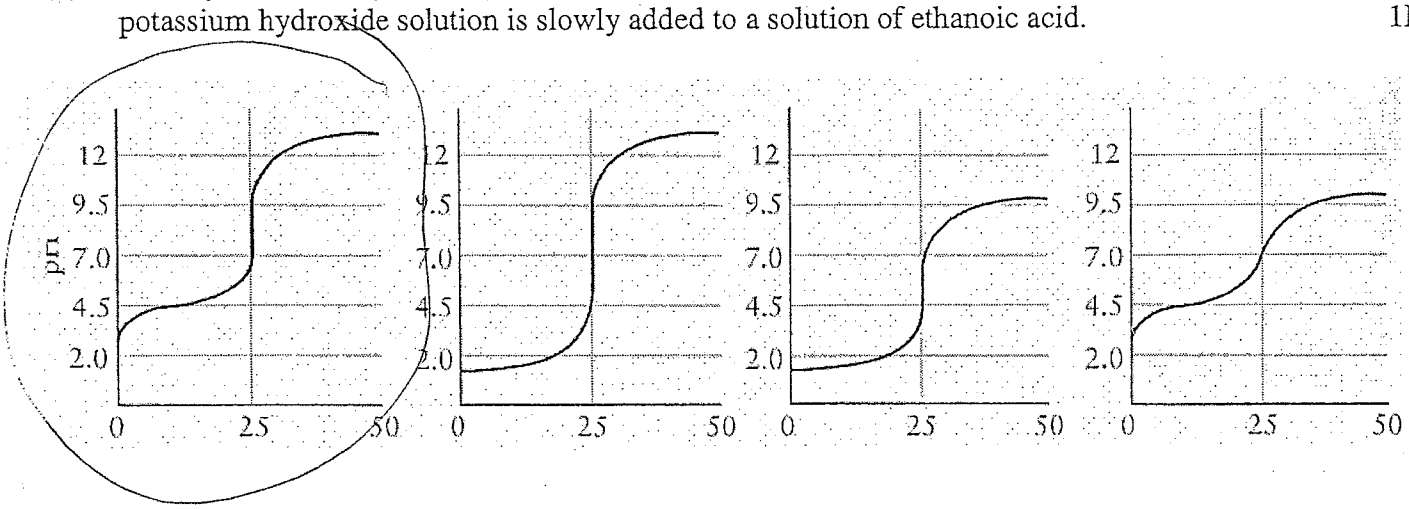
$n_{CH_3COOH} = n_{KOH} = 1.91475 \times 10^{-3}$ mol

$C_{CH_3COOH} = \frac{n}{V} = \frac{1.91475 \times 10^{-3}}{0.025} = 0.07659$ mol/L.

But since this was one $\frac{1}{10}$ of the original vinegar, the conc of ethanoic acid in vinegar $= 0.07659 \times 10 = 0.7659$ mol/L.

(3)

(b) Identify, **by circling the graph**, the titration curve which best represents the change in pH as a potassium hydroxide solution is slowly added to a solution of ethanoic acid. 1M



(1)

(c) The solution of potassium hydroxide was standardised by titration against a solution made from a primary standard. In this case, benzoic acid (C_6H_5COOH) would be an ideal acid to use as a primary standard.

One characteristic of a primary standard is that it is highly stable. Identify ONE other characteristics of a primary standard. 1M

relatively high molecular mass (1)

The primary standard must be ~~diss~~ able to be dissolved in distilled water. (1)

Question 21. (4 marks)
Justify the statement "All Arrhenius acids are also Bronsted-Lowry acids however not all Bronsted-Lowry acids are also Arrhenius acids". 4M

This statement is valid because Arrhenius stated that acids produce hydrogen ions in aqueous solution, and Bronsted-Lowry acids are acids which donate a proton (H^+) and so in water also produce hydrogen or more correct hydronium ions which are hydrogen ions attached to a water molecule by co-ordinate covalent bonding. However Bronsted-Lowry also postulated that acids are proton donors ~~and Are~~ which meant even in non-aqueous forms could donate this is evident in the reaction $HCl_{(g)} + NH_{3(g)} \rightarrow NH_4Cl$ (NH_3 bubbled through HCl). Although not in aqueous form, the HCl still donates a proton so is classified as an BL-acid. Arrhenius's ~~co~~ definition did not include non-aqueous acids as they had no ions without a solvent. Therefore not all BL-acids are also Arrhenius acids but all Arrhenius acids are BL-acids

use an equation to illustrate this!

4

Question 21. (4 marks)
Justify the statement "All Arrhenius acids are also Bronsted-Lowry acids however not all Bronsted-Lowry acids are also Arrhenius acids". 4M

Arrhenius acids are aqueous acids that produce H^+ ions in water. A Bronsted-Lowry base acid is defined as a proton donor. Therefore all Arrhenius acids are also Bronsted-Lowry acids as a H^+ ion is equivalent to a proton. Therefore, if an acid produces H^+ ion in water it is effectively donating a proton to water which makes it a Bronsted-Lowry acid. However, the reverse is not true as the Arrhenius definition of an acid only accounts for an acid in an aqueous solution. Therefore an acid dissolved in a non-aqueous solution is not an Arrhenius acid but may be a Bronsted-Lowry acid as it donates a proton. An amphoteric substance ~~does~~ may not contain a ? (H^+) ion so when it acts as an acid it is only a Bronsted-Lowry acid & not an Arrhenius acid. Therefore All Arrhenius acids are also Bronsted-Lowry acids however not all Bronsted-Lowry acids are also Arrhenius acids.

produce?

3

Question 21. (4 marks)

Justify the statement "All Arrhenius acids are also Bronsted-Lowry acids however not all Bronsted-Lowry acids are also Arrhenius acids". 4M

Arrhenius defined acids as substances which ionised in water to form H^+ ions, while Bronsted and Lowry defined acids as proton donors (protons in the form of H^+ ions). Acids ionise in water by donating a H^+ to a water molecule

eg. $HCl_{(aq)} + H_2O_{(l)} \longrightarrow H_3O^+_{(aq)} + Cl^-_{(aq)}$

Thus, Arrhenius acids are also Bronsted-Lowry acids as the making of an Arrhenius acid acid ionised in water by donating a proton to water, making it a Bronsted-Lowry acid. However, Bronsted-Lowry acids are a broader category as they do not have to be in aqueous solution with water to be an acid, as long as they donate a proton in the form of H^+ to another substance. Thus, HNO_3 reacting with NH_3: $HNO_{3(l)} + NH_{3(g)} \longrightarrow NH_4NO_{3(s)}$

In this case HNO_3 donated a proton to NH_3 so is a Bronsted-Lowry acid but as there is no water for it to dissolve in so would not have been classified as an acid by Arrhenius based on this reaction. Thus, the statement is justified.

3

Question 22. (3 marks)

Describe the effect of buffers with reference to a specific example in a natural system. 3M

Buffers are a solution which resist rapid changes in pH when small amounts of acids or bases are added. They consist of a weak acid and its conjugate base. A natural buffer system is in blood:

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

$$H_2CO_{3(aq)} \rightleftharpoons H^+_{(aq)} + HCO_3^-{}_{(aq)}$$

H_2CO_3 is the weak acid and HCO_3^- its conjugate base. If the blood becomes too acidic (by the addition of acidic substance or inhalation of excess CO_2), the H^+ conc. will increase causing both equilibria to shift to the right to reduce $[H^+]$ thereby increasing pH again. If blood becomes too basic due to a deficiency of H^+, the 2 equilibria will both shift right to increase $[H^+]$ and thus decrease pH again. This maintains the pH of blood at about 7.4.

3

Question 22. (3 marks)
Describe the effect of buffers with reference to a specific example in a natural system. 3M

Buffers are substances that resist changes in pH when small amounts of acid or base is added. This is important in natural system, where in the body, enzymes regulate body function, and the only operate at certain pH's, i.e. eg in blood, haemoglobin is a buffer that regulates pH, $Hb_{(aq)} + H_3O^+_{(aq)} \rightleftharpoons HHb^+_{(aq)} + H_2O_{(aq)}$. The buffer system contains Hb and HHb^+. If a base is added, the equilibrium will shift right to produce more Hb and H_3O^+ and if acid is added, equ^m will shift right to produce more $HHb^+ + H_2O$, thereby resisting changes in pH and maintaining pH levels in the body.

3

Question 22. (3 marks)
Describe the effect of buffers with reference to a specific example in a natural system. 3M

3

1. $H_2CO_{3(aq)} + H_2O_{(l)} \rightleftharpoons HCO_3^-_{(aq)} + H_3O^+_{(aq)}$
2. $haemoglobin_{(aq)} + CO_{2(aq)} + H_2O \rightleftharpoons oxyhaemoglobin_{(aq)} + H_3O^+_{(aq)}$
3. $CO_{2(g)} \rightleftharpoons CO_{2(aq)}$

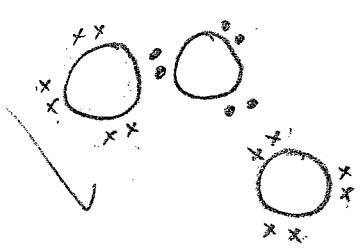
} blood

- Buffers are based on Le Chatelier's principle, that an equilibrium system will shift to resist a change to it. Buffers resist changes in pH.

In the bloodstream of humans, equations 1, 2 & 3 exist (1 is the buffer). When we breathe in, $CO_{2(g)}$ increases, shifting 3 right. This also shifts 2 right, increasing H_3O^+, & hence acidity. But then 1 shifts left, thus reducing H_3O^+ & reducing acidity. This works in reverse when we exhale. ∴ This is a natural buffer system.

Question 23. (6 marks)
(a) Draw a Lewis dot diagram of the ozone molecule. 1M

1



(b) Contrast the types of bonds present in ozone gas and oxygen gas. 2M

Ozone gas has a double covalent bond between two of the three oxygen atoms in the molecule similar to the oxygen molecule which has a double covalent bond - however the ozone molecule consists of three oxygen atoms and has a coordinate covalent bond between these oxygen atoms. Therefore ozone gas is (slightly) polar but oxygen gas is non-polar.

(c) Compare the properties of the oxygen allotropes, O_2 and O_3, in terms of their stability to heat, stability to UV light and ONE other property. Tabulate your information. 3M

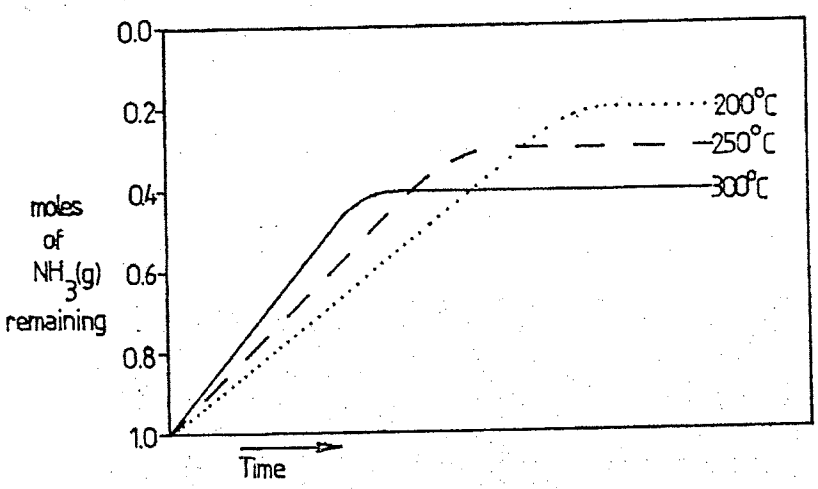
property	oxygen (O_2)	ozone (O_3)
stability to heat	Oxygen is very stable to heat	Ozone is not very stable to heat
stability to UV light	more stable than O_2, not as easily broken apart, but still relatively unstable	less stable to UV, extra O atom easily removed by high energy
~~B~~ boiling point	lower B.P. (due to weak dispersion forces)	higher B.P (due to slightly stronger dipole-dipole interactions)
Solubity	very very very low solubily	low solubility.
Colour	colourless	blue

Question 24. (4 marks)

Ammonia decomposes according to the equation shown.

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

The graph below represents the decomposition of 1.0 mole of pure ammonia in the presence of a catalyst at various temperatures.



(a) Explain why the number of moles of ammonia remaining reaches a constant value at each temperature. 2M

We decomposition of NH_3 is a equilibrium reaction that will result in a constant conc of reactants and products ~~become~~ the rate regardless of temperature. 2

Rate forward reaction = ~~to~~ rate of backward reaction. The moles of NH_3 at equilibrium differ for each temperature because the forward reaction is endothermic ∴ will obtain the greatest yield at a high temperature as demonstrated by the data. This is consistent with Le Chatelier's principle which states that ~~a system at~~ if a system at equilibrium is disturbed, then the equilibrium will shift ~~such that~~ to min the imposed change. ↑ temp then system will favour endothermic reaction (forward reaction).

(a) Explain why the number of moles of ammonia remaining reaches a constant value at each temperature. 2M

The number of moles of ammonia remaining reaches a constant value at each temperature because it has reached equilibrium between it and nitrogen and hydrogen gas. Every time an ammonia molecule gets decomposed, an ammonia molecule gets synthesised and so there is no change in the number of moles. 2

(b) Explain how the rate of decomposition of ammonia changes with temperature. 2M

The rate of decomposition increases with ^ temperature (increasing). this is because temperature is a measure of the kinetic energy of reactant molecules. therefore high temp means that there is
- greater chance of collisions ✓
- greater chance of successful collisions.

Also, at low temperatures, the reaction is slow due to the high activation energy (bonds between atoms in NH_3 are strong). 2

(b) Explain how the rate of decomposition of ammonia changes with temperature. 2M

Changes in temperature affect the rate of decomposition of ammonia because temperature is proportional to the kinetic energy of the species. A higher temperature means more kinetic energy and so the molecules are more likely to hit each other and with sufficient energy to react. A lower temperature means less kinetic energy and so molecules are less likely to hit each other and with less energy to react. 2

(b) Explain how the rate of decomposition of ammonia changes with temperature. 2M

the reaction $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$ is exothermic so as temperature increases according to le chateliers principle, the system will minimise disturbance by moving left. the kinetic energy of particles increases with increased temperature causing more collisions and hence increasing the rate of reaction. this is seen through the graph as the system reaches equilibrium faster at higher temperatures meaning that the rate of decomposition of ammonia increases as temperature increases. the more collisions that occur to form ammonia, the faster the NH_3 will decompose 2

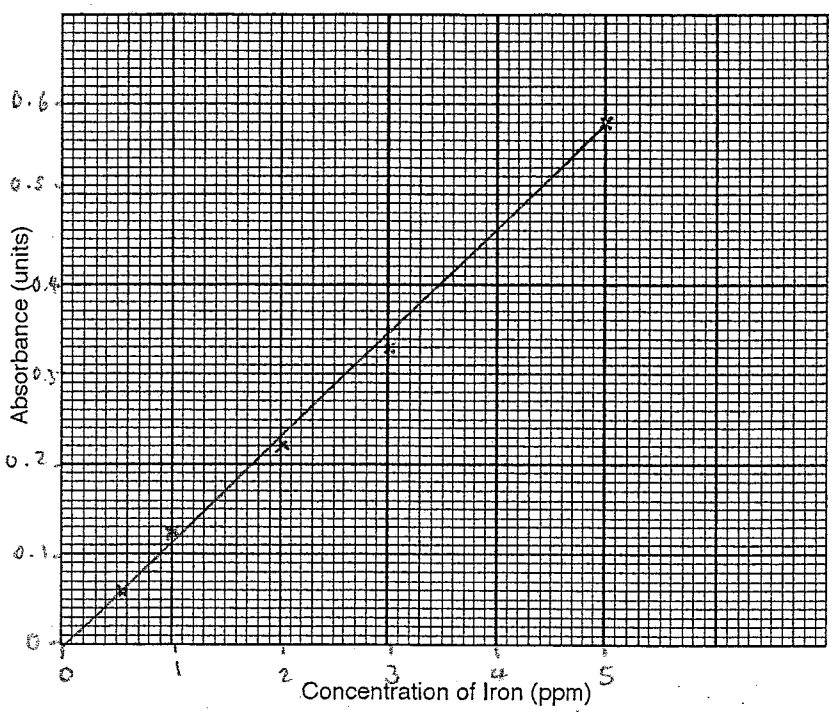
Question 25. (5 marks)

A sample of tank water is contaminated with iron since it shows signs of rust. The sample was analysed using atomic absorption spectroscopy (AAS). A calibration curve was prepared using standard iron solutions and the iron content in the sample was then determined.

The table below shows the results for the standard calibration curve.

Absorbance (units)	Content of Iron (ppm)
0.05	0.5
0.12	1.0
0.22	2.0
0.34	3.0
0.58	5.0

(a) Draw a line graph for the standard calibration curve on the grid provided 2M



✓ 2

(b) Determine the concentration of iron (ppm) in a tank water sample which has an absorbance of 0.38 units. 1M

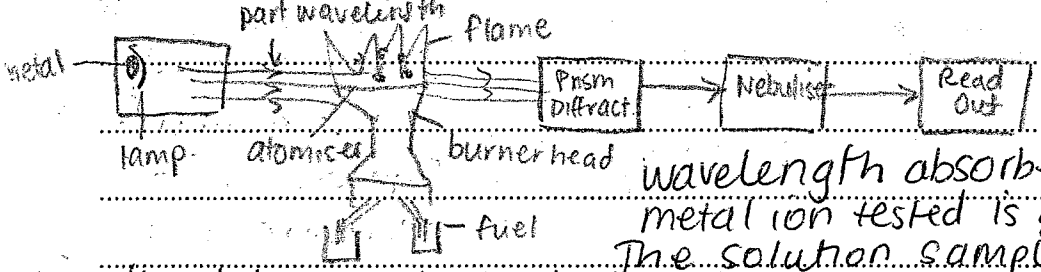
[Fe] = 3·3 ppm ✓ 1

(c) Outline the AAS procedure used to analyse solutions. 2M

A sample of a solution to be tested for a certain ion is aspirated into a flame, atomising the sample. A beam of a certain wavelength light (of the ion being tested for) is fired into the flame, after passing through a beam splitter. One half of the beam is read by a detector and is stored as initial intensity. The other half passes through the flame containing the sample. The sample will absorb some of the light if the ion being tested for is present. The less intense beam is then read by a detector which calculates the amount of light absorbed and shows this as a reading on a screen.

✓ 2

(c) Outline the AAS procedure used to analyse solutions. 2M



wavelength absorbed by a particular metal ion tested is given off by the lamp. The solution sample is sucked into the burner & atomised. The light that passes through is absorbed by the ions & that which is not absorbed is fed into a prism "diffractor" → into the nebuliser which sends the amount of light not absorbed to a computer which finds the diff. btwn what's emitted & what was left = absorbance. 2

 2007

(c) Outline the AAS procedure used to analyse solutions. 2M

A sample of the substance being analysed is heated in a high temperature flame to decompose its molecules into atoms/ions. A light source then emits a light with a wave length readily absorbed by the metal being analysed in the solution. A light detector detects how much light has been absorbed by the sample & calculates the concentration of the metal by comparing it to the standard calibration graph of a known solution. 2

Question 26. (5 marks)

Evaluate the significance of the development of the Haber Process between 1910 and 1918. 5M

The development of the Haber process was very significant to both the world and Germany. It was developed at a time when the British navy blockaded Germany's supply of ammonia from Chile. This severely damaged the German military as explosives and TNT could not be produced. The Haber process sustained the German military as the nitrogen was a major part of the production of explosives. This prolonged the first world war and allowed Germany to continue fighting. The Haber process was also very significant to farmers as nitrogen was a major part of fertilisers. From the development of the Haber process, farmers did not have to rely on imports and could continue to farm to feed the German people, saving millions who may have died from starvation. The natural by products of $H_{2(g)}$ and $N_{2(g)}$ were recycled or extracted, as H_2 is a very valuable industrial material. This increased the profitability and efficiency of the process. 5

Question 26. (5 marks)

Evaluate the significance of the development of the Haber Process between 1910 and 1918. 5M

The Haber process was developed by German chemist Fritz Haber in the period 1910-1918. At this time, Germany was involved in the First World War and thus had a high demand for explosives. These were produced using nitrates which were sourced from saltpetre imports from Chile. However, during the war, the Allies blocked of German imports which halted the supply of saltpetre required for nitrates. Thus, Germany was no source to produce the explosives for the war. However, Haber developed the Haber process in this period to synthesise NH_3 from N_2 and H_2 gases which Germany had ready access to.* The development of this process allowed NH_3 to be produced on large scales. The NH_3 could then be oxidised to form nitric acid which was a source of nitrates Germany could use to produce explosives and continue the war. Thus, the development of the Haber process in 1910-1918 had a significant effect as it prolonged war, which caused many deaths. At this time, the saltpetre was also used for fertiliser in Germany and without it, the people were beginning to starve. The Haber process which produced NH_3 which could be used to produce ammonium sulfate, a fertiliser which helped feed the people during the war, again prolonging it.

5

*according to the following eqn:

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

Question 27. (7 marks)

Using an example drawn from each of the three core modules, analyse the impacts on the environment of the applications of chemistry. CFC's, acid rain, renewable, ethene, ethanol, cellulose
tech ↓, knowledge ↑

Chemistry has had a both negative and positive effect on the environment. While initial processes developed were focused on social implication, more recent scientific understanding has emphasised the environmental impact of certain processes. For fuel sources, octane was chosen because of its availability and high energy output (5470kJ/mol), however it contributes to CO_2 emissions (which contributes to global warming and changing weather patterns) and its reserves are now dwindling. As such science is offering ethanol as an alternative. It produces less CO_2 (when combusted & needs less O_2 to combust completely) and is in general terms a 'renewable resource' thereby allowing a sustainable level of use without as much environmental damage. Research into enzymes is also being conducted to reduce the net CO_2 emissions by more effective production of ethanol.

$$C_2H_5OH + 3O_2 \rightarrow 2CO_2 + 3H_2O$$
$$2C_8H_{18} + 17O_2 \rightarrow 8CO_2 + 18H_2O$$

Acid rain is also negatively impacting on the environment. Since the beginning of industrial revolution, levels of NO_x, SO_2 and CO_2 have drastically increased and this has led to damage to eco-systems as acid rain changes the pH of soil, reducing solubility of important ions for plants (like P) and also can damage foliage of plants & rainforests. However modern chemistry has also led to the use of catalytic converters and scrubbers to reduce the levels of NO_x and SO_2 released so this has had a positive impact. Also other energy sources will lead to the reduction of CO_2 emissions.

$$SO_2 + Mg(OH)_2 \rightarrow MgSO_3 + H_2O$$
$$SO_2 + H_2O \rightarrow H_2SO_{3(aq)}$$

The use of CFC's was predominant prior to 1970s as it was not poisonous like NH_3, but it was not known then that CFC's contributed to ozone depletion, so it impacted negatively on the environment, where it has caused hole in ozone layer allowing more dangerous UV-B and UV-C rays to reach earth which kill phytoplankton which can affect aquatic food chains and lead to species loss. But use of TOMS and the Dobson UV spectrometer have led to the realisation of the impacts of these chemicals and now less harmful alternatives have been produced to be used instead, such as HFC's.

$$Cl\cdot + O_3 \rightarrow ClO + O_2$$

less O_3

So it can be seen that although chemistry has had a negative impact on the environment, advances in understanding and technology have led to a reduction or attempts at reducing these impacts.

Question 27. (7 marks)

Using an example drawn from each of the three core modules, analyse the impacts on the environment of the applications of chemistry. Applications of chemistry impact significantly on the environment -eg

In module one, the fermentation of glucose to produce ethanol was exposed as an alternative method of producing fuels and materials. The fermentation of glucose however, requires land for farming in order to supply glucose ~~for the~~. This uses precious water resources, and may lead to salinity. Wastes produced from fermentation must also be disposed of, adding to the amount of wastes filling up in the land fills. more details?

In module 3, the release and use of CFC poses significant problems for the environment. They destroy thousands of O_3 molecules in the stratosphere that acts as a radiation barrier. The Cl radical that are released as CFCs are broken down react with O_3: $Cl\cdot + O_3 \rightarrow ClO + O_2$

$ClO + O_3 \rightarrow Cl\cdot + 2O_2$.

The chlorine radical is regenerated!

The increased exposure to U.V radiation causes cancer in humans and is suggested to affect plankton, because of the increase

food chain. this will have adverse effects on all marine animals.
In module 2, the release of SO_2 and NOx into the atmosphere produces acid rain that damages buildings, destroys the wax coated on plant leaves and affects the skeletal growth of animals. $2SO_2 + O_2 \rightarrow 2SO_3$ and then
$SO_3 + H_2O \rightarrow H_2SO_4$

Applications of chemistry thus ~~that the~~ impacts significantly on the environment.

Question 28

a) i) $K_{eq} = \dfrac{[CH_4] \times [H_2S]^2}{[CS_2] \times [H_2]^4}$

ii).

	CS_2	H_2	CH_4	H_2S
Supplied (mol/L)	0.26	0.332	0	0
Reacted (mol/L)	0.019	0.076		
Equilibrium (mol/L)	0.241	0.256	0.019	0.038

$K = \dfrac{[H_2S]^2[CH_4]}{[H_2]^4[CS_2]} = \dfrac{(0.038)^2(0.019)}{(0.256)^4(0.241)} = 2.7436 \times 10^{-5} = 1.035 \times 10^{-3}$ = 0.027 (3 dec pl) 2 sign fig

iii) Endothermic

b) i) the equm reaction analysed what the production of N_2O_4 from $NO_2(g)$ in a closed environment. $2NO_2(g) \rightleftharpoons N_2O_4(g)$ ~~that~~ where $NO_2(g)$ is brown and $N_2O_4(g)$ is colourless, and conditions such as cooling, heating, changes in volumes were applied to the system and changes in colour was observed.

b) The qualitative equilibrium reaction was between NO_2 and N_2O_4:

$$2NO_{2(g)} \rightleftharpoons N_2O_{4(g)} + \text{heat}$$

Brown — colourless

2

ii) One change imposed to the system was heating by placing the sealed syringe containing the reaction in a hot water bath. Le Chatelier's principle states that when a system at equilibrium is disturbed it will readjust itself to counteract the imposed change. Since the forward reaction is exothermic heating the reaction caused the system to favour the endothermic side which was producing more NO_2. This made the syringe reaction in the syringe turn a darker brown.

4

Another change that was imposed was the increase of pressure by pushing the plunger on the syringe down to decrease the volume. When this happened the reaction was immediately a dark brown but then progressed to become lighter and almost colourless. This was because when there is an increase in pressure the system favours the side producing less gaseous moles which in this case would be N_2O_4. The initial darker brown was a result of immediate disturbance but the reaction re-established equilibrium by producing more N_2O_4 making the reaction turn lighter.

(b) (i) $Fe^{3+}_{(aq)}$ ($FeCl_3$) was reacted with $SCN^-_{(aq)}$ ($KSCN$) to come to the following equilibrium.

$Fe^{3+}_{(aq)} + SCN^-_{(aq)} \rightleftharpoons FeSCN^{2+}_{(aq)}$

(tan) (colourless) (red). the solution was the equally distributed among 8 clean, dry test tubes, labelled from A → H. with A kept aside for a colour-comparison the rest of the 7's were subjected to different changes in equilibrium, each producing qualitative results which were carefully analysed.

(b).

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

tan colourless blood red. 2

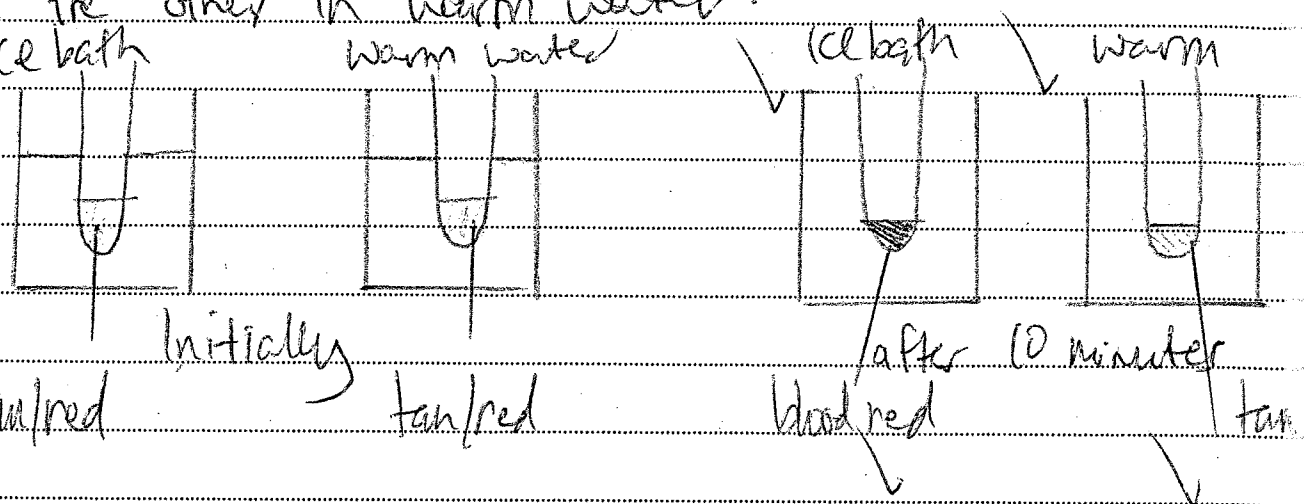
(ii) Changes imposed

① Adding $FeCl_3$ increased the concentration of Fe^{3+} ions. According to Le Chatelier's principle, a if a systemed equilibrium is disturbed then it will shift so that the imposed change is minimized. Thus, an increase in Fe^{3+} will prompt the equilibrium to favour the RHS in order to decrease the imposed change. The colour of the solution, thus, was observed to be more blood red 4

② the temperature was increased by placing the solution in a hot water bath ... the equilibrium will try to decrease the temperature by favouring the endothermic reaction this is the ~~backward~~ reverse reaction and thus the solution was observed to be less blood red and more tan coloured.

(1)

ii) Temperature: two testtubes were acquired one was placed in an ice bath, the other in warm water.

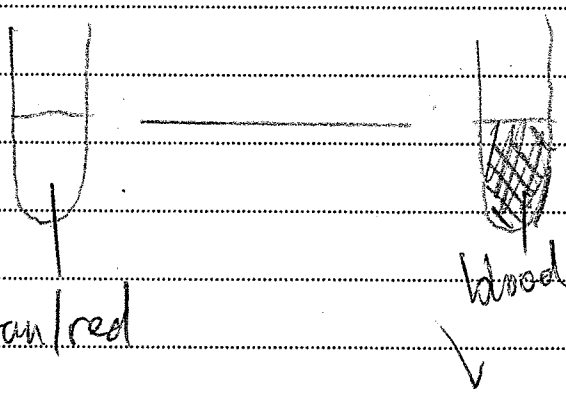


This showed the reaction was exothermic - why? how?

(2)

Added $FeCl_{3(aq)}$

3

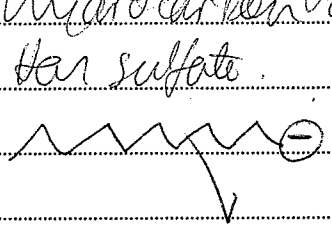
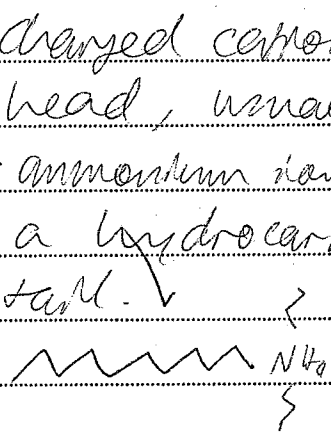
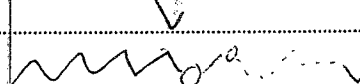


This increased the [Fe3+] and was shown by the blood red. the change in colour, that equilibrium shifted right!

(c)

Anionic	Composition	Uses.
	Hydrocarbon tail	Strong cleaner → laundry +
	negative anionic head	dishwashing
Cationic		
	Hydrocarbon tail	hair conditioners and fabric softeners.
	Positive anionic head	
Non ionic		
	Hydrocarbon tail	Dishwashers (low lathering).
	"head" is made of (CH_2-CH_2-O)	
	groups joined together with an	
	alcohol group at the end of an	

c.

Detergent	Comparison	Application
Anionic	Charged anionic head connected to a hydrocarbon tail. Has sulfate. 	General cleaning, shampoos, cleaning grime off cars. Used to wash hands and body, used to wash clothes.
Cationic	charged cationic head, usually ammonium ion, to a hydrocarbon tail. 	~~Antiseptic~~, disinfectant, hair conditioning, biocide.
Non-ionic	Set of oxygen atoms ~~and~~ with a alkanol functional group. 	Low-foam applications, dishwashers, can be used in washing machines

(d).

Anode: titanium

Anode reaction: $2Cl^-(aq) \rightarrow Cl_2(g) + 2e^-$ 5

Cathode: mercury

Cathode reaction: $Na^+(aq) + e^- \rightarrow Na(Hg)$

The NaCl is dissolved in the mercury cathode. This mercury is transferred into a second tank (with the sloping base of the tank causing gravity to move the mercury) where the Na(l) reacts with H_2O to produce NaOH.

$2NaCl + 2H_2O(l) \rightarrow 2NaOH(aq) + H_2(g)$.

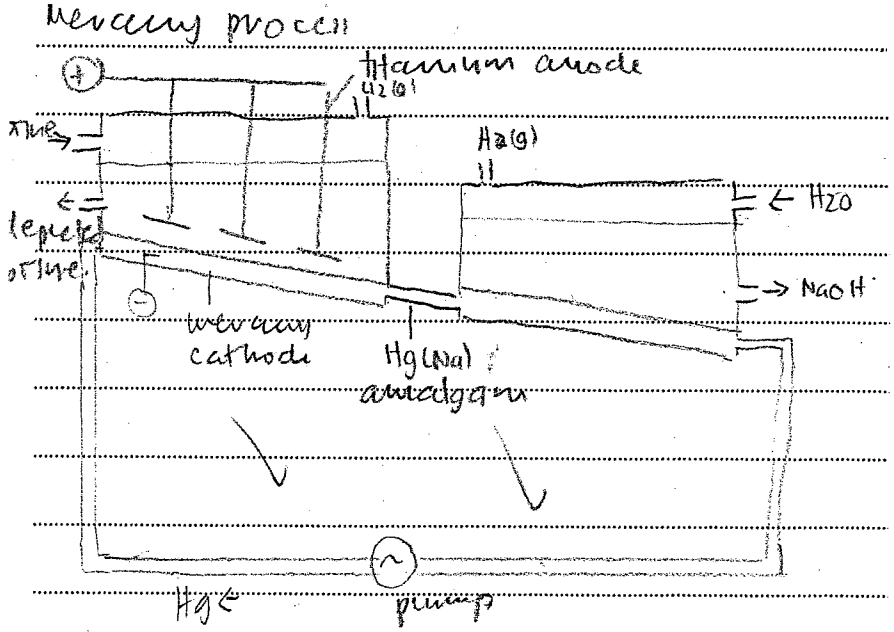
The mercury is recycled (see diagram) and pumped back to the first tank to begin the process again.

The overall process is thus: $2NaCl_{(aq)} + 2H_2O_{(l)} \rightarrow 2NaOH_{(aq)} + H_{2(g)} + Cl_{2(g)}$

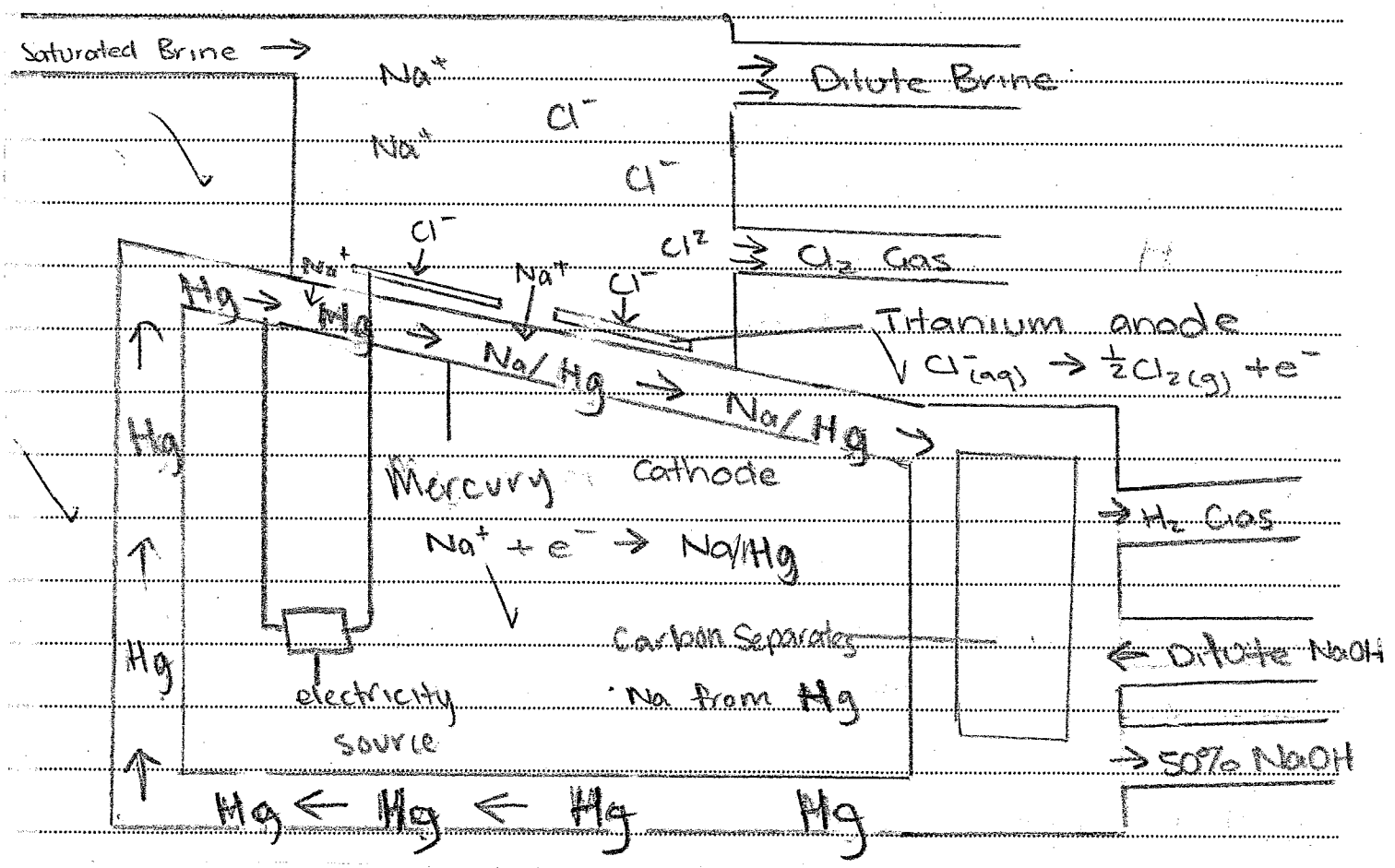
Advantages:

- It allows for greater safety, because Cl_2 and $H_2(g)$ are produced in separate parts of the plant (they can react explosively)

(d)



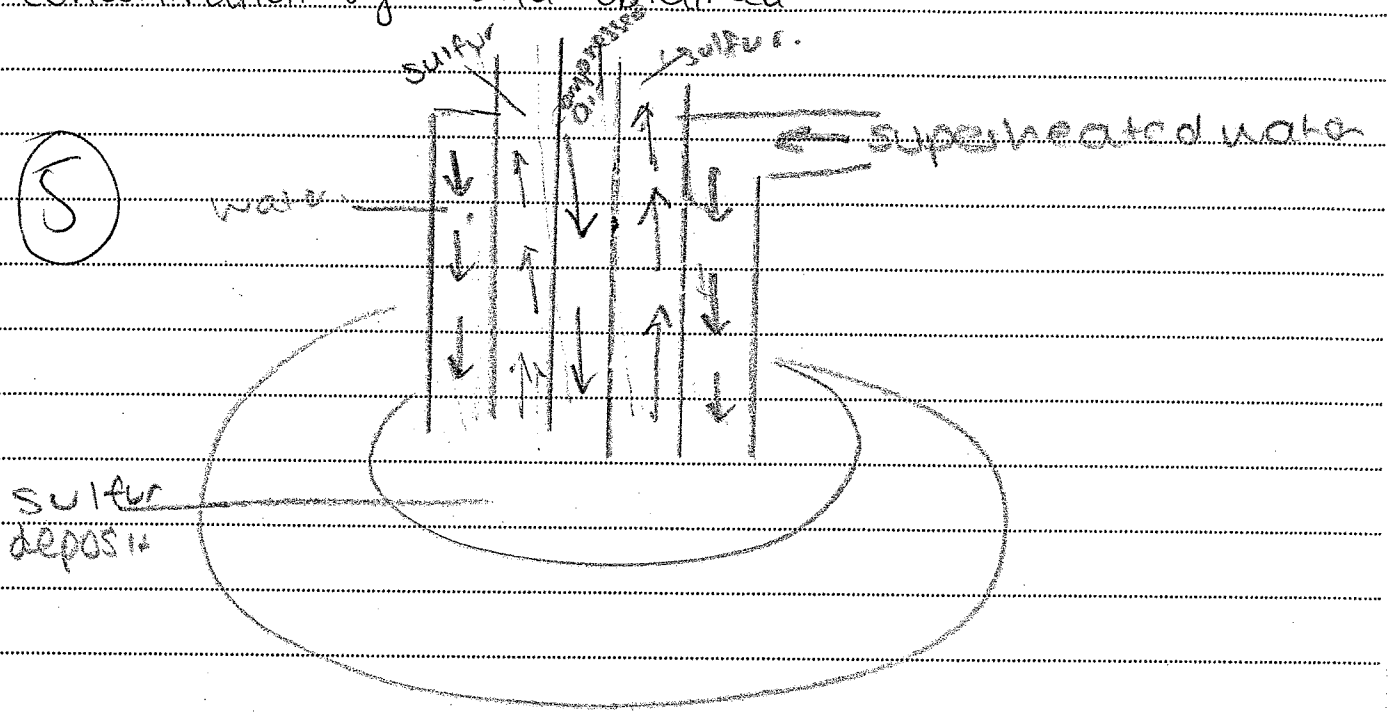
(d) Mercury



e) The earth contains sulfur deposits and complicated methods must be used for its extraction and the consequent making of H_2SO_4 (sulfuric acid).

The Frasch process is a common way of extracting sulfur from deposits underneath the earths surface. This process involves drilling down and putting 3 concentric pipes ~~into the~~ underground. The outside pipe contains superheated water (180°C) which is pumped down into the sulfur deposit. This melts the sulfur (low melting pt of 113°C). ~~and th~~ Compressed air is pumped down the central column. Due to the low density of sulfur, this air forces sulfur up the other pipe to the surface. Due to its ~~so~~ insolubility in water, at the earths surface it forms a solid again and readily

seperates from the water, leaving a high concentration of sulfur obtained



After the sulfur is obtained ~~it~~, ~~the~~ it must undergo the 'contact' process to form sulfuric acid. This involves 3 steps.

STEP 1

$S_{(s)} + O_{2(g)} \rightarrow SO_{2(g)}$. This must involves the sulfur being sprayed into a chamber that contains excess oxygen. It is conducted at high temp. and must be cooled before going on to the next step.

STEP 2

$2SO_{2(g)} + 2O_{2(g)} \rightleftharpoons 2SO_{3(g)}$. This step involves the reactants passing over ~~a~~ 3 catalyst beds, starting at 400°C. Catalysts of vanadium pentoxide (V_2O_5) ~~is~~ are used to increase reaction rate.

STEP 3

$SO_{3(g)} + H_2O_{(g)} \rightarrow H_2SO_{4(g)}$

$H_2SO_{4(g)} + SO_{3(g)} \rightarrow H_2S_3O_{7(g)}$ (oleum).

$H_2S_3O_{7(g)} + H_2O_{(g)} \rightarrow 2H_2SO_{4(g)}$

This step is carried out in stages including the formation of oleum ($H_2S_3O_7$). This is due to the highly exothermic nature of the reaction, where if H_2SO_4 was added directly to water, a dangerous flammable mist would result.

e) Sulfuric acid is industrially produced from the raw material, sulfur found in elemental form in underground deposits. It is extracted using the Frasch process, where superheated water at 160°C is pumped into the deposit to melt the sulfur (melting point: 119°C). Compressed air is forced down into the deposit to force the molten sulfur/water emulsion to the surface as sulfur has low density. As sulfur is insoluble in water, the two separate as the sulfur solidifies. Thus, pure S is easily extracted for making H_2SO_4. Why? How?

The sulfur is then converted to SO_2 by burning it in dry air: $S_{(s)} + O_{2(g)} \rightarrow SO_{2(g)}$

The SO_2 is then oxidised to SO_3:

(5) $2SO_{2(g)} + O_{2(g)} \rightleftharpoons 2SO_{3(g)} \quad -\Delta H$

This is an equilibrium reaction and requires compromise conditions to have an adequate yield at a reasonable rate. It is a slow reaction at room temp. so heat must be added to increase reaction rate so output is economical. However as the forward reaction is exothermic, added heat causes equilibrium to favour the reverse endothermic reaction, reducing yield of SO_3. Thus, a catalyst, V_2O_5, is used to increase reaction rate (by lowering the activation energy) without affecting yield. V_2O_5 is used in pellet form to increase surface area and thus efficiency. Under these conditions, a compromise temp. of 550°C can be used to provide adequate yield at a reasonable rate.

The SO_2 and O_2 mixture is first passed over a V_2O_5 bed at 550°C to convert 70% of it to SO_3. It is then cooled and passed over another V_2O_5 bed at 400°C this increases yield to about 97% the lower reaction rate here is acceptable as most of the SO_2 has been reacted. The SO_3 is then removed and the remaining SO_2 passed over another catalyst bed at 400°C to increase yield to 99.7%. All this is done at just above atmospheric pressure to push equilibrium to the right as there are less moles of gas on that side. A slight excess of oxygen is also used to shift equilibrium right and ∴ inc. yield

The SO_3 is then dissolved in concentrated H_2SO_4 to make oleum:

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

Oleum is then ~~reacted~~ water is then added to the oleum slowly with stirring to make H_2SO_4:

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

H_2O is not added directly to SO_3 to make H_2SO_4 as this reaction is highly exothermic so produces H_2SO_4 mist which is dangerous and difficult to separate from other gases in the reaction vessel.

Using this process allows elemental S from underground deposits to be converted to 98% H_2SO_4 relatively easily. The most difficult step is converting SO_2 to SO_3 as this requires compromise conditions between reaction rates and equilibrium yield. This is achieved with a V_2O_5 catalyst and the above described conditions.