ACADEMIC ASSOCIATES

WACE 3A & 3B
CHEMISTRY

TRIAL EXAMINATION PAPER 1

Student Name: _____

Date: _____ / _____ / _____

Time Commenced: _____

Time allowed for this paper

Reading time before commencing work: Ten minutes
Working time for paper: Three hours

Materials required for this paper

- Chemistry Data Sheet – this is located at the end of this book.

Materials to be provided by the candidate

Standard Items: pens, pencils, eraser, correction fluid, ruler, highlighters.

Special Items: non-programmable calculators satisfying the conditions set out by the Curriculum Council for this course.

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STRUCTURE OF THIS PAPER

Section	Number of questions available	Number of questions to be answered	Suggested working time (minutes)	Marks available	Percentage of exam
Section One: Multiple choice	25	25	50	25	25
Section Two: Short answer	12	12	60	70	35
Section Three: Extended answer	6	6	70	80	40
					100

Instructions to candidates

- Write answers in the spaces provided.
- Working or reasoning should be clearly shown when doing calculations.
- Final numerical answers should be quoted to three significant figures.

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SECTION ONE: MULTIPLE-CHOICE 25% (50 marks)

This section has **25** questions. Answer **all** questions. For each question write your answer in the box opposite. Marks will not be deducted for incorrect answers. No marks will be given if more than one answer is completed for any question.

Suggested working time for this section is 50 minutes.

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1. Consider a neutral atom X with the electron configuration 2, 8, 8, 2. Which of the following is true?

   (a) The atom has an atomic number of 18.
   (b) The atom is in an excited state.
   (c) The atom forms a fluoride with the formula XF_2.
   (d) The stable ion of X has the same configuration as a neon atom. Answer ☐

2. If an element Y is located in group 15 of the periodic table, which of the following responses best describes element Y?

   (a) Y can only bond covalently with other non metals.
   (b) The potassium salt of Y has the formula K_2Y.
   (c) Y can form a trigonal planar molecule with the formula YF_3.
   (d) Y can form polar covalent molecules when bonded with hydrogen. Answer ☐

3. An element has the first five successive ionisation energies (in kJ mol^{-1})

   600 1200 4900 6500 8200

   Which of the following elements is it?

   (a) calcium
   (b) argon
   (c) sodium
   (d) aluminium Answer ☐

4. 2.40 g of substance X (with a molar mass of 64.0 g mol L^{-1}) reacts exactly with 250.00 mL of a 0.0500 mol L^{-1} solution of Y to produce substance Z. The values of **a** and **b** in the equation **a**X + **b**Y → **c**Z are, respectively

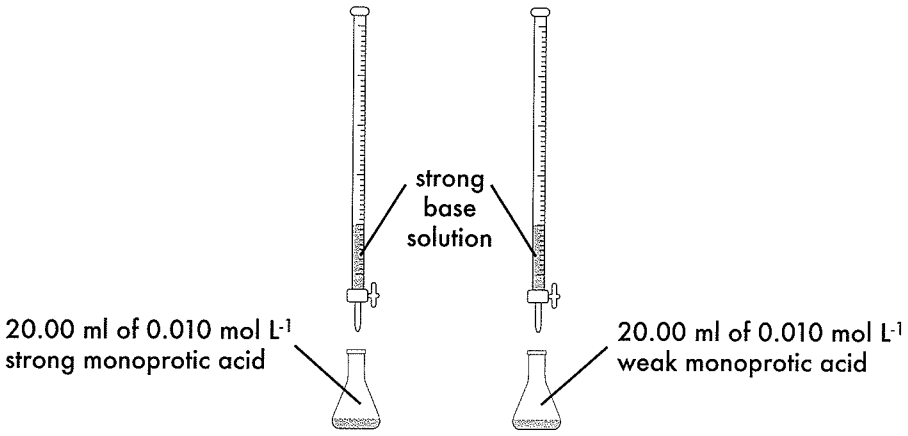
   (a) 2, 2
   (b) 1, 3
   (c) 3, 1
   (d) 2, 3 Answer ☐

5. The Brönsted-Lowry theory is one theory that is used in acid/base chemistry to correctly define acids and bases. According to this theory, which statement best describes a base?

(a) A base is a proton (H^+) donor.
(b) A base accepts protons (H^+) in water.
(c) A base produces protons (H^+) in water.
(d) A base accepts protons (H^+).

Answer ☐

6. Two titrations are carried out below:



Which of the following statements is true?

(a) Both burettes should be rinsed with strong base solution and then distilled water before the titrations.
(b) The final pH of both titration solutions at the equivalence point will be the same.
(c) Phenolpthalein would be a suitable indicator for both titrations.
(d) The weak acid will require a lower volume of base compared to the strong acid to reach the equivalence point.

Answer ☐

7. Buffer solutions are used as a means of keeping pH at a nearly constant value in a wide variety of chemical applications. Which of the following pairs of substances would **not** be useful as a buffer in aqueous solution?

(a) HPO_4^{2-} and $H_2PO_4^-$
(b) H_2CO_3 and HCO_3^-
(c) H_3O^+ and OH^-
(d) CH_3COO^- and CH_3COOH

Answer ☐

8. A student obtains a sample of 1.00×10^{-8} mol L^{-1} nitric acid solution at 25°C and measures its pH. The pH reading on the meter will be:

(a) exactly 6.50.
(b) somewhere just below 7.00.
(c) unobtainable as it impossible to have such a solution.
(d) exactly 8.00.

Answer ☐

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9. A 2.50 gram sample of potassium carbonate is added to some distilled water and the resulting solution stirred. The water has a pH of 7.00 before the solid is added. Which of the following statements best describes what happens when the solution is formed?

(a) The CO_3^{2-} ions and water react and as a result the pH increases above 7.00.
(b) The K^+ and water react and as a result the pH drops below 7.00.
(c) There is no chemical reaction and the pH does not change.
(d) The CO_3^{2-} ions and water react and as a result the pH decreases below 7.00.

Answer ☐

10. Solutions of 0.100 mol L^{-1} of sodium nitrate, sulfuric acid, ethanoic acid and lithium hydroxide are made up in a laboratory. Which solution would contain the lowest concentration of ions?

(a) $NaNO_3$
(b) H_2SO_4
(c) CH_3COOH
(d) LiOH

Answer ☐

11. A student is asked to calculate the oxidation number of the bolded element in each of the formulae shown below:

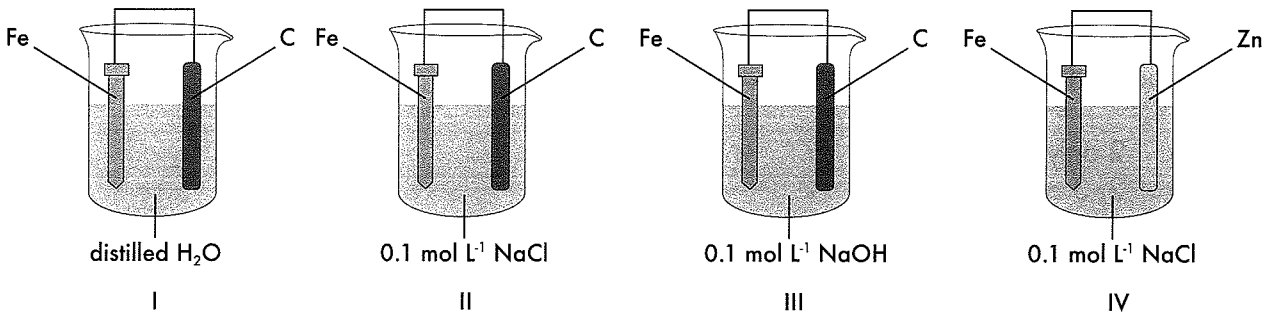
A: $Li_2\mathbf{Cr}O_4$ B: $K\mathbf{Mn}O_4$ C: $Na_3\mathbf{P}O_4$ D: $Na_2\mathbf{S}O_3$

In which of the following does the bolded element have an oxidation number of +5?

(a) A.
(b) B.
(c) C.
(d) D.

Answer ☐

12. Identical iron nails are placed in various solutions. The nails are connected through conducting wires to carbon in systems I to III and to zinc in system IV as shown below.



In which of the above systems would the iron nail be expected to rust the most rapidly?

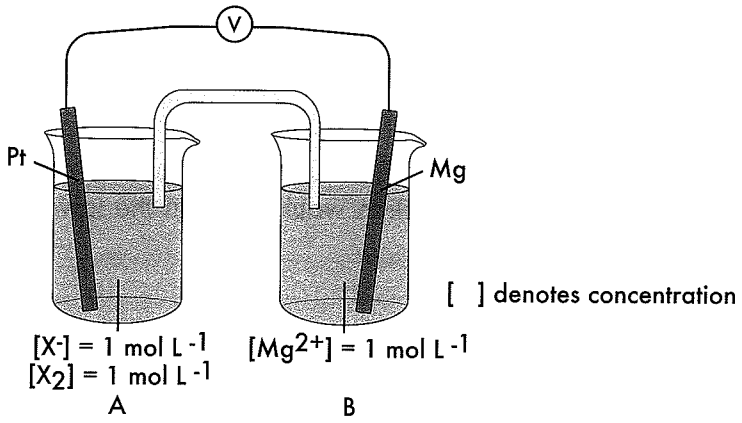
(a) system I
(b) system II
(c) system III
(d) system IV

Answer ☐

13. Consider the following galvanic cell, for which the E° values are

$$X_2 + 2e^- \rightarrow 2X^- \qquad + 0.54 \text{ volts}$$

$$Mg^{2+} + 2e^- \rightarrow Mg \qquad - 2.37 \text{ volts}$$



Which of the following statements is correct?

(a) The voltmeter reading is +1.83 volts.
(b) The Mg electrode will become negatively charged with respect to the Pt electrode and electrons will flow along the wire from the Mg to the Pt.
(c) In half cell B, the reaction is $Mg^{2+} + 2e^- \rightarrow Mg$.
(d) If a piece of Mg is placed in a 1.00 mol L^{-1} KX solution, X_2 is formed. Answer ☐

Questions 14 and 15 refer to the table below.

Name of indicator	pH range	Colour (low pH – high pH)
1. Methyl red	4.4 – 6.2	red – yellow
2. Bromothymol blue	6.0 – 7.6	yellow – blue
3. Phenolphthalein	8.3 – 10.0	colourless – pink
4. Methyl violet	0.0 – 2.0	yellow – violet

14. A chemist uses a 0.1034 mol L^{-1} sodium hydroxide solution to standardise a nitric acid solution. Which of the following indicators would be suitable?

(a) 2 only.
(b) 2, 3 and 4 only.
(c) 1, 2 and 3 only.
(d) All of 1, 2, 3 and 4. Answer ☐

15. If methyl red is used in a titration between ethanoic acid (added from a burette) and a standard solution of sodium hydroxide (in a conical flask with indicator) then

(a) the end point of the titration would occur after the equivalence point.
(b) the end point would occur at the equivalence point of the titration.
(c) no colour change would occur.
(d) the end point of the titration would occur before the equivalence point has been reached. Answer ☐

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Questions 16 and 17 refer to the reaction below at equilibrium.

$$2\ NO_{2(g)} \rightleftharpoons O_{2(g)} + 2\ NO_{(g)} \qquad \Delta H = +115\ kJ\ mol^{-1}$$

16. Which of the following changes will **decrease** the equilibrium yield of $NO_{2(g)}$ in the mixture once equilibrium is re-established?

(a) Heating the equilibrium system.
(b) Decreasing the volume of the equilibrium system.
(c) Increasing the partial pressure of NO gas without changing the temperature and pressure of the equilibrium system.
(d) Increasing the partial pressure of O_2 gas without changing the temperature and pressure of the equilibrium system.

Answer ☐

17. A catalyst was added to the reaction mixture. Comparing the new reaction system to the old reaction system, which one of the following will remain unchanged?

(a) The activation energy for the forward reaction.
(b) The energy of the transition state.
(c) The ΔH of the reaction.
(d) The rate of the reverse reaction.

Answer ☐

18. Which of the following molecules is trigonal planar?

(a) H_2O
(b) PH_3
(c) SO_3
(d) CH_3I

Answer ☐

19. Iron (III) sulfide is insoluble and black in colour. It is the product formed when solutions of iron (III) nitrate and potassium sulfide are mixed according to the equation

$$2\ Fe^{3+}_{(aq)} + 3\ S^{2-}_{(aq)} \rightarrow Fe_2S_{3\,(s)}$$

100 mL of a 3.00 mol L^{-1} iron (III) nitrate solution is added to a solution containing 0.300 moles of potassium sulfide. What is the number of moles of iron (III) sulfide precipitated?

(a) 0.300 moles
(b) 0.250 moles
(c) 0.150 moles
(d) 0.100 moles

Answer ☐

20. 75.0 mL of a 0.250 mol L^{-1} solution of $MgC\ell_2$ is added to 50.0 mL of water and thoroughly mixed. In the resulting solution, the concentration of the chloride ions would be

(a) 0.300 mol L^{-1}
(b) 0.100 mol L^{-1}
(c) 0.150 mol L^{-1}
(d) 0.200 mol L^{-1}

Answer ☐

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21. Which one of the following statements about trends in the elements in group 14 of the Periodic Table is **true**?

(a) Electrical conductivity of the elements tends to decrease going down the group.
(b) The melting point of the elements tends to increase going down the group.
(c) Bonding in the elements changes from metallic to covalent going down the group.
(d) The oxides of the elements tend to become more basic going down the group.

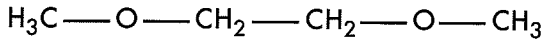
Answer ☐

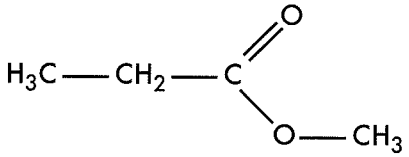
22. Which of the following will produce a ketone when reacted with acidified dichromate solution?

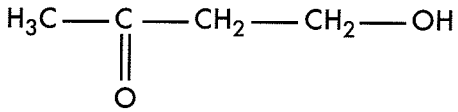
(a) $HOCH_2CH_2OH$
(b) $H_3CCH(OH)CH_3$
(c) $(CH_3)_3COH$
(d) $CH_3CH_2CH_2CH_2CH_2OH$

Answer ☐

23. Which of the following compounds are isomers of ethyl ethanoate?

1. 

2. 

3. 

(a) 1 and 2 only
(b) 2 and 3 only
(c) 1 only
(d) 2 only

Answer ☐

24. Consider the organic compounds below.

I hexan-1-ol
II butanal
III butan-1-ol
IV pentane

Which of the following lists the compounds in order of **decreasing** boiling point?

(a) I > II > III > IV
(b) I > IV > II > III
(c) IV > II > III > I
(d) I > III > II > IV

Answer ☐

25. Which of the following substances **cannot** be a product of the oxidation of $CH_3CH_2CH_2OH$?

(a) CH_3CH_2CHO
(b) H_2O
(c) CH_3CH_2COOH
(d) CH_3COCH_3

Answer ☐

END OF SECTION ONE

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SECTION TWO: SHORT ANSWER 35% (70 marks)

This section has **12** questions. Answer **all** questions. Write your answers in the space provided.

Spare pages are included at the end of this trial paper if required.

Suggested working time for this section is 60 minutes

Question 26 (4 marks)

Arsenic is a notoriously poisonous metal obtained from the reduction of As_4O_6 using coke. The temperature at which it is reacted is 750°C and the reaction is as follows.

$$As_4O_{6(g)} + 6\ C_{(s)} \rightleftharpoons As_{4(g)} + 6\ CO_{(g)} \qquad \Delta H +692\ kJ\ mol^{-1}$$

(a) Write the equilibrium constant expression for the reaction.

(2 marks)

(b) Predict the effect on the equilibrium yield of As_4, if the temperature of the system was decreased to 300°C. (2 marks)

Question 27 (3 marks)

Place each of the following substances into the appropriate column, based on the **most significant** type of intermolecular force present in the substance.

CO_2 CH_3CH_2COOH NH_3 CH_3COCH_3 H_2S SO_3

Dispersion forces	Hydrogen bonding	Dipole-dipole interactions

Question 28 (6 marks)

A student has two bottles of organic liquids, but the labels have fallen off. The student knows that the organic liquids are 2-methyl propan–2–ol and pentan–2–ol.

(a) Describe a chemical test which could be used to determine the two liquids. (1 mark)

(b) What would the student observe during the chemical tests? (2 marks)

(c) Write any chemical equations relevant to the observations you made in (b). (3 marks)

Question 29 (8 marks)

Buffer solutions are necessary to keep the correct pH for effective bodily functions to be maintained. One such buffer is the carbonic acid/hydrogencarbonate ion buffer found in blood plasma, which must maintain a pH of between 7.35 and 7.45.

(a) What is the buffer capacity of a system? (2 marks)

(b) Excess lactic acid and hydrogen ions are produced by the body when exercising. Explain, using Le Chatelier's Principle, how the human body blood plasma buffer responds to the addition of a small amount of H^+ ions. Use equations in your answer. (3 marks)

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(c) Strenuous exercise increases the rate of carbon dioxide output significantly. The carbon dioxide then undergoes a series of equilibrium reactions.

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

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

i) After strenuous exercise would the pH of the blood buffer system initially increase, decrease or stay the same? (circle the appropriate response) (1 mark)

Increase Decrease Stay the same

ii) Explain your answer to i), using the equations above and Le Chatelier's Principle. (2 marks)

Question 30 **(4 marks)**

Write the equation for the reaction that occurs in each of the following procedures. If no reaction occurs, write 'no reaction'. For full marks, chemical equations should refer only to those species consumed in the reaction and the new species produced. These species may be **ions** [for example $Ag^+_{(aq)}$], **molecules** [for example $NH_{3(g)}$, $NH_{3(aq)}$, $CH_3COOH_{(l)}$, $CH_3COOH_{(aq)}$] or **solids** [for example $BaSO_{4\,(s)}$, $Cu_{(s)}$, $Na_2CO_{3\,(s)}$].

(a) An excess of warm dilute hydrochloric acid is added to solid potassium sulfite. (2 marks)

Equation:

(b) Some bromine water is shaken with a sample of cyclohexene. (2 marks)

Equation:

Question 31 (4 marks)

Write observations for any reactions that occur in the following procedures. In each case, describe in full what you would observe. Include any: colours, odours, precipitates (give the colour), gases evolved (give the colour or describe as colourless).

If no change is observed, you should state this.

(a) Ammonia gas is mixed with hydrogen chloride gas. (2 marks)

Observation:_____

_____

_____

(b) Copper (II) nitrate solution is added to sodium carbonate solution (2 marks)

Observation:_____

_____

_____

Question 32 (5 marks)

Consider the following substances: $Mg(HSO_4)_2$ NH_3 graphite Na K_2CO_3

Complete the table below using the following information.

i) Substance may be "covalent molecular", "ionic", "metallic", or "covalent network".

ii) Once added to distilled water and stirred, will the pH of the resulting solution "increase", "decrease" or remain "unchanged" from the neutral pH of the distilled water?

Substance	i) Classification of substance	ii) Effect on pH
$Mg(HSO_4)_2$		
NH_3		
graphite		
Na		
K_2CO_3		

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Question 33 **(8 marks)**

(a) Determine the pH of a 0.0138 mol L^{-1} calcium hydroxide solution at 25°C. (4 marks)

(b) 15.0 mL of orange cordial concentrate has a pH of 2.55. If 305 mL of distilled water is added to the cordial, calculate the pH of the resultant solution. (4 marks)

Question 34 **(5 marks)**

(a) The dihydrogenphosphate ion can act either as a Brönsted-Lowry acid or a Brönsted-Lowry base.

i) Write an equation showing the ion acting as a base. (1 mark)

ii) Write an equation showing the ion acting as an acid. (1 mark)

(b) A 1.00×10^{-2} mol L^{-1} solution of phosphoric acid has a pH of 2.25, whereas a 1.00×10^{-2} mol L^{-1} solution of hydrochloric acid has a pH of 2.00. Account for the difference in pH levels. (3 marks)

Question 35 (8 marks)

For each species listed in the table below, draw the electron dot structure, representing all valence shell electron pairs either as **:** or as – **and** state or draw the shape of the molecule or ion.

For example, water (H:Ö:H or H–Ö–H or H–Ō–H)

Species	Electron dot structure (showing all valence shell electrons)	Shape (sketch or name)
sulfur trioxide SO_3		
Phosphine PH_3		
Nitrite NO_2^-		
Silane SiH_4		

Question 36 (5 marks)

A chemist accidentally stores a solution of dilute 1.00 mol L^{-1} nitric acid in a zinc lined metal tank at 25°C and an undesired reaction takes place.

(a) Use the Standard Reduction Potentials Table to distinguish the reaction that would take place in the tank.

(3 marks)

Oxidation: _____

Reduction: _____

Overall: _____

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(b) What would the chemist observe in the tank? (1 mark)

(c) Calculate the emf for the overall reaction in part (a) (1 mark)

Question 37 **(10 marks)**

A chemical is known to have the molecular formula C_3H_5Br. Draw structural formula for and name all the isomers of the chemical. Be sure to include all of the hydrogen atoms in your structures.

Structures	Names

END OF SECTION TWO

SECTION THREE: EXTENDED ANSWER 40% (80 Marks)

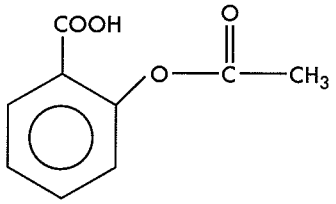
This section contains **six (6)** questions. You must answer **all** questions. Write your answers in the space provided.

Spare pages are included at the end of this trial paper if required.

Suggested working time for this section is 70 minutes.

Question 38 (14 marks)

Aspirin is a drug used to relieve headaches and pains. The active ingredient in aspirin is known as acetylsalicylic acid ($C_9H_8O_4$). It is a **monoprotic** acid and its chemical formula is shown below.



Chemical companies use unreactive chemicals in tablets, to increase the size of a tablet for practical and handling reasons.

A chemist wants to determine the percentage of active ingredient in an aspirin sample. The chemist follows the steps below.

1. Crush a 1.62 gram tablet and dissolve in water.
2. Transfer the solution to a volumetric flask and make up to the 100 mL mark.
3. Pipette 20 mL samples of this solution into a conical flask and add a suitable indicator.
4. Add a standard solution of 0.0142 mol L^{-1} NaOH to the burette and titrate against the aspirin solution until the end point is reached.
5. Record the results of the titration in a table.

The results of the titration are shown in the table below.

Titration	Trials			
	1	2	3	4
Final reading (mL)	8.40	18.38	26.37	19.09
Initial reading (mL)	0.20	10.48	18.55	11.31
Titre (mL)				

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(a) Why did the chemist do four trials for the titration? (1 mark)

(b) Complete the table and determine the average volume of NaOH used. (1 mark)

(c) Calculate the concentration of acetylsalicylic acid in the 100 mL volumetric flask. (5 marks)

(d) Commercial samples of aspirin are required to contain no more than 7.00% by mass of the active ingredient. The maker of this sample tablet claims the tablet contains between 6.00% and 7.00% by mass of the active ingredient. Is the maker's claim true? (Show full working). (4 marks)

(e) The chemist researches that acetylsalicylic acid is soluble in ethanol. What type of intermolecular force would be most significant between the acid and ethanol molecules?

(1 mark)

(f) In the box below, draw a diagram showing the force acting between the two molecules.

(2 marks)

Question 39 **(18 marks)**

The Ostwald Process is a chemical process used for producing nitric acid. In the first reaction, ammonia is oxidised by heating with oxygen in the presence of a platinum catalyst.

(i) $4\ NH_{3(g)} + 5\ O_{2\,(g)} \rightleftharpoons 4\ NO_{(g)} + 6\ H_2O_{(g)}$ $\Delta H = -907\ kJ\ mol^{-1}$

In the second reaction, nitric oxide is converted into nitrogen dioxide.

(ii) $2\ NO_{(g)} + O_{2(g)} \rightleftharpoons 2\ NO_{2(g)}$ $\Delta H = -114\ kJ\ mol^{-1}$

And finally, the nitrogen dioxide is absorbed by water to yield the nitric acid. The nitric oxide product is recycled.

(iii) $3\ NO_{2(g)} + H_2O_{(l)} \rightleftharpoons 2HNO_{3(aq)} + NO_{(g)}$ $\Delta H = -117\ kJ\ mol^{-1}$

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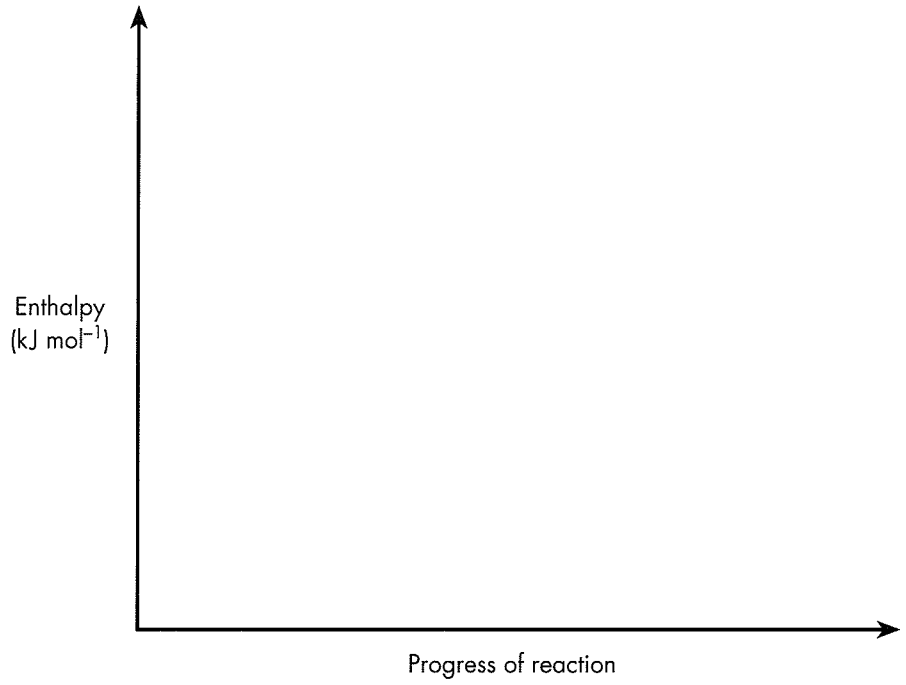
In the first step, a side reaction takes place which can reduce the percentage yield of nitric acid. The ammonia is converted into nitrogen gas. This equation is shown below.

(iv) $4\ NH_{3(g)} + 6NO_{(g)} \rightarrow 5\ N_{2(g)} + 6\ H_2O_{(g)}$

(a) Assume the activation energy for the uncatalysed reaction pathway is +244 kJ mol^{-1} in the first step, sketch a labelled energy profile diagram on the axes below showing the following:

(5 marks)

- Reactants and products
- Catalysed versus uncatalysed reaction pathways
- Activation energy for the reaction
- Enthalpy change.



(b) "The platinum catalyst in the first reaction increases the rate of attainment of equilibrium." Explain, using relevant chemical theories, how the catalyst achieves this.

(3 marks)

(c) If the Ostwald Process is 96.0% efficient, calculate the mass of nitric acid produced if 1.80 tonnes of ammonia is consumed in the process.

(6 marks)

(d) Assume the remainder of the ammonia is consumed in the side reaction in point (iv). Calculate the volume of nitrogen gas produced if the pressure of the reacting vessel is 650 kPa and the temperature is 912° C.

(4 marks)

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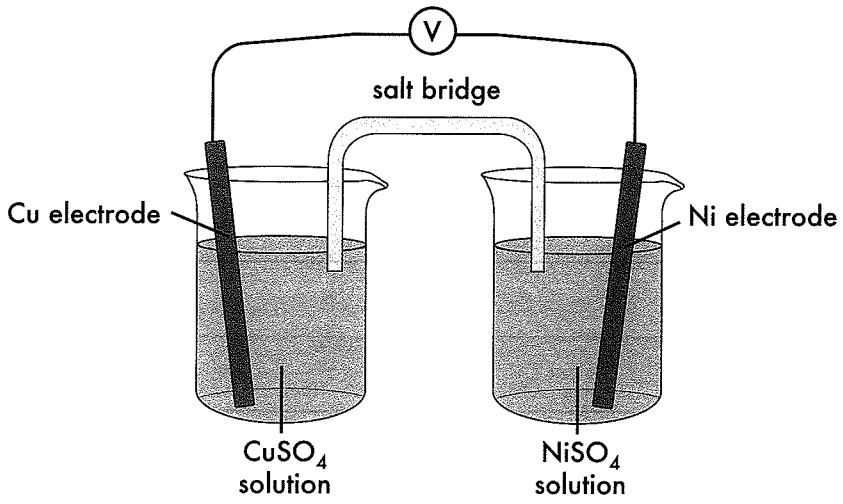
Question 40 (14 marks)

A galvanic cell was set up below to operate at standard conditions by some students.



(a) In the space below, name the cathode and anode. (2 marks)

Anode:	Cathode:

(b) What are the likely anode and cathode reactions in the above cell? Use the Standard Reduction Potentials Table to predict the overall equation. (3 marks)

Anode:
Cathode:
Overall:

(c) What role does a salt bridge play in a galvanic cell? (2 marks)

(d) During their first trial, the students noted that the reaction was quite slow compared to their subsequent trials. List three potential sources of error in the students' first trial.

(3 marks)

(e) The hydrogen/ oxygen galvanic fuel cell is one of the earliest design fuel cells ever made.
i) How is the fuel cell different from other galvanic cells?
ii) What is one major advantage of using a fuel cell?

(4 marks)

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Question 41 **(10 marks)**

A compound known as melamine is used in kitchen counter tops and fabrics. It was also used as a crop fertiliser. Melamine contains the elements carbon, hydrogen and nitrogen only.

(a) In an experiment, 0.329 g of melamine is burnt in a current of dry air, and 0.140 g of water and 0.344 g of carbon dioxide are produced. Calculate the empirical formula of melamine.
(5 marks)

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(b) A sample of melamine evaporates to occupy a volume of 73.0 mL at 200°C and 2.30 atm pressure. If a 0.545 g sample of melamine is used, calculate the molecular mass of the compound.

(3 marks)

(c) What is the molecular formula of melamine? (2 marks)

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Question 42 **(9 marks)**

Soap is used in the household as a cleansing agent. Its main component is sodium stearate. The chemical formula for sodium stearate is $CH_3(CH_2)_{16}COO^-Na^+$. Soaps contain a hydrophilic end (which helps attract to water), and a hydrophobic end (which helps attract to non polar particles such as grease).

(a) Draw the structure of sodium stearate and indicate its hydrophilic and hydrophobic ends.

(2 marks)

(b) Explain, in terms of ion-dipole forces, how the hydrophilic end "is attracted" to water. Include a diagram in your answer.

(2 marks)

(c) One factor that prevents a soap working effectively is the presence of calcium ions in water. If a high concentration of calcium ions is present, the water is known as hard water. Calcium ions react with the stearate ions to form an insoluble substance known as scum.

i) Write a chemical equation below showing how scum forms. (1 mark)

ii) A 45.0 mL sample of hard water was added to excess soapy water solution, the resulting scum was collected, dried, weighed and found to have a mass of 0.0874 g. Calculate the concentration of calcium ions in the original sample of hard water in parts per million. Assume the density of the hard water is 1.00 g L^{-1}.

(4 marks)

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Question 43 (15 marks)

Butane ($CH_3CH_2CH_2CH_3$), Butanal ($CH_3CH_2CH_2CHO$) and 1-Butanamine ($CH_3CH_2CH_2CH_2NH_2$) are three examples of different classes of organic chemicals.

Compare and contrast the **physical** and **chemical** properties of each. Write your response in terms of:

- Chemical structures
- Intramolecular and intermolecular forces
- Chemical reactions
- Solubility in different solvents

To obtain maximum marks, include diagrams, equations and illustrations. Your response should be approximately one to two pages in length.

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END OF PAPER 1

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SOLUTIONS TO TRIAL PAPER

Section One: Multiple Choice

1. (c) X is in group 2 and forms a 2+ ion. Thus it will form XF_2, which is stable.

2. (d) Y could be nitrogen and form ammonia molecules.

3. (a) A large jump is indicated from the second to third ionisation energy, indicating a likely 2+ charge on the ion of the element. Therefore the element is group 2 and is calcium.

4. (c) n(X) = 2.40/64.0 = 0.0375 moles
n(Y) = cV = 0.0500 x 0.2500 = 0.0125 moles
Ratio n(X)/n(Y) = 0.0375/0.0125 = 3.00
Therefore ratio is 3:1.

5. (d) Brönsted–Lowry defines a base as a proton (H^+) acceptor for all solvents, not just water.

6. (c) Phenolpthalein changes colour across the end point of both reactions.

7. (c) Buffers must consist of an acid and its conjugate base. The conjugate base of H_3O^+ is H_2O not OH^-.

8. (b) $[H^+] = 1.00 \times 10^{-8} + 1.00 \times 10^{-7}$
$pH = -\log (1.1 \times 10^{-7})$
$= 6.96$
Therefore pH is little less than 7.

9. (a) Carbonate ions react with water ion to form conjugate hydrogencarbonate acid and hydroxide ions. This solution is moderately basic and thus pH will increase.

10. (c) Ethanoic acid is a weak acid and ionises to a much lesser extent than H_2SO_4, as well as the complete dissociation of $NaNO_3$ and LiOH.

11. (c) Oxidation Number P – 8 = -3. Thus oxidation number of P is +5.

12. (b) Rusting is accelerated by the presence of NaCl. In IV, zinc would corrode in preference to iron.

13. (b) Mg is oxidised and therefore electrons flow from it to the Pt electrode.

14. (c) End point change is from pH approximately 4 to 10. Methyl violet is out of this range.

15. (a) The end point of this reaction is at an approximate pH of 5, and the equivalence point has a pH of approximately 9-10, therefore the end point would occur after the equivalence point.

16. (a) Increasing the temperature of a system at equilibrium will favour the endothermic reaction. Thus forward reaction is favoured and yield of nitrogen dioxide will decrease.

17. (c) Enthalpy change is unaffected by the addition of a catalyst.

18. (c) Other molecules are bent (a) and (b) and tetrahedral (d).

19. (d) This must be considered as a limiting reagent question to determine the moles of iron (III) sulfide formed.
$n(Fe^{3+}) = cV = 2 \times 0.300 \times 0.1 = 0.600$ moles
$n(S^{2-}) = cV = 0.300$ moles
Actual ratio $S^{2-}/ Fe^{3+} = 3/2 = 1.5$
Stoich ratio $S^{2-}/ Fe^{3+} = 0.300/0.600 = 0.500$ i.e. S^{2-} is the limiting reagent
$n(Fe_2S_3) = 1/3 \times n(S^{2-}) = 0.300/3$
$= 0.100$ moles

20. (a) n(before) = n(after)
$c_1V_1 = c_2V_2$
$0.250 \times 0.0750 = c_2 \times 0.125$
$\therefore c_2 = 0.150$ M
$[Cl^-] = 2 \times [MgCl_2]$
$= 0.300$ molL^{-1}

21. (d) As you proceed down the group, you go from non metals to metals, indicating oxides will go from being acidic to basic.

22. (b) 2-propanol is the only secondary alcohol amongst the alternatives.

23. (b) The first molecular formula has the structure $C_4H_{10}O_2$, the others are $C_4H_8O_2$.

24. (d) I has hydrogen bonding and has the greatest dispersion forces due to greater number of electrons in the molecule; III has hydrogen bonding and dispersion forces to some extent; II has dipole to

dipole interactions and some dispersion forces; and IV has purely dispersion forces.

25.(d) Oxidation of propan-1-ol could yield propan-1-al and propanoic acid. Water is a product in the combustion of any organic compound, also an oxidation reaction.

Section Two: Short Answer

26.(a) $K = \dfrac{[CO]^6 \times [As_4]}{[As_4O_6]}$

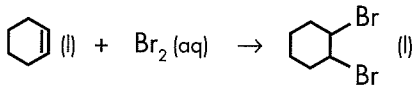
(b) A decrease in the temperature favours the exothermic process, thus As_4 yield would DECREASE.

27. Dispersion forces are CO_2 and SO_3
Hydrogen bonding are CH_3CH_2COOH and NH_3
Dipole – dipole interactions are H_2S and CH_3COCH_3

28. (a) Add a little acidified permanganate or acidified dichromate solution into both.
(b) No reaction with the 2-methyl-2-propanol (no colour change) as it is a tertiary alcohol.
Permanganate solution will change from purple to pink/Dichromate solution will change from orange to green in pentan-2-ol as it is a secondary alcohol.
(c) $\{ Cr_2O_7^{2-} + 14H^+ + 6e^- \rightarrow 2Cr^{3+} + 7H_2O \}$ (or MnO_4^- half equation)
$\{ C_5H_{12}O \rightarrow C_5H_{10}O + 2H^+ + 2e^- \} \times 3$
Overall: $3C_5H_{12}O + Cr_2O_7^{2-} + 8H^+ \rightarrow 2Cr^{3+} + 7H_2O + 3C_5H_{10}O$

29. (a) The ability of a buffer solution to neutralise excess acid or base without a big change in pH of solution.
(b) $HCO_3^- + H^+ \rightleftharpoons H_2CO_3$
Reaction 1
$H_2CO_3 + OH^- \rightleftharpoons H_2O + HCO_3^-$
Reaction 2
The concentration of hydrogen ions increases, therefore the equilibrium of Reaction 1 shifts to the right. Reaction 2 also occurs and its equilibrium favours the products. According to Le Chatelier's Principle, the system will move to counteract an increase in concentration.
(c) i) Decrease
ii) The system increases in carbon dioxide concentration. According to Le Chatelier's Principle, the system will move to decrease the concentration of carbon dioxide and both equilibriums will shift to the right, therefore hydrogen ion concentration increases and pH initially decreases.

30.(a) $K_2SO_{3(s)} + 2H^+_{(aq)} \rightarrow 2K^+_{(aq)} + SO_{2(g)} + H_2O_{(l)}$

(b)  (l)

31.(a) Pungent, colourless gases are added together and a white (mist) solid is formed.
(b) A blue solution is added to a colourless solution and a green solid forms.

32.

Substance	Classification of substance	Effect on pH
$Mg(HSO_4)_2$	Ionic	Decrease
NH_3	Covalent Molecular	Increase
graphite	Covalent Network	Unchanged
Na	Metallic	Increase
K_2CO_3	Ionic	Increase

33.(a) $[OH^-] = 2 \times [Ca(OH)_2] = 0.0276$ mol L^{-1}
$[H^+] = 1.00 \times 10^{-14} / 0.0276$
$= 3.62 \times 10^{-13}$ mol L^{-1}
pH $= -\log [H^+] = -\log (3.62 \times 10^{-13})$
$= 12.4$
(b) $[H^+] = 10^{-pH} = 10^{-2.55} = 2.818 \times 10^{-3}$ mol L^{-1}
then $n(H^+) = (0.0150)(2.818 \times 10^{-3})$
$= 4.227 \times 10^{-5}$ mol

$$[H^+]_{FINAL} = \frac{4.227 \times 10^{-5}}{0.320}$$

$= 1.32 \times 10^{-4}$ mol L^{-1}
$\therefore$ pH $= 3.88$

34.(a) i) $H_2PO_4^- + H_2O \rightleftharpoons H_3PO_4 + OH^-$
ii) $H_2PO_4^- + H_2O \rightleftharpoons HPO_4^- + H_3O^+$
(b) Phosphoric acid is a weak acid and hydrochloric acid is a strong acid. A strong acid is more ionised in solution. Therefore, a greater concentration of hydrogen ions is present in hydrochloric acid compared to phosphoric acid, i.e. HCl has a lower pH.

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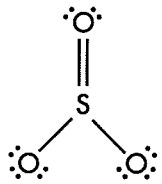
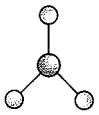
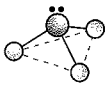
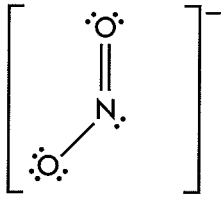
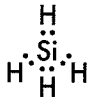
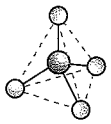
35.

Species	Structural formula (showing all valence shell electrons)	Shape (sketch or name)
sulfur trioxide SO_3		Trigonal planar 
Phosphine PH_3		Pyramidal 
Nitrite NO_2^-		V-shaped (bent) 
Silane SiH_4		Tetrahedral 

36.(a) Oxidation: $\{Zn \rightarrow Zn^{2+} + 2e^-\}$ 0.76 Volts

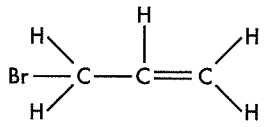
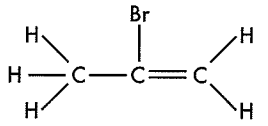
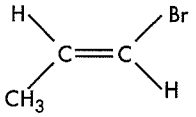
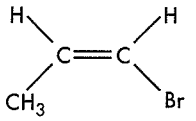
Reduction: $\{NO_3^- + 2H^+ + e^- \rightarrow NO_2 + H_2O\} \times 2$ 0.79 Volts

Overall: $3\ Zn + 2\ NO_3^- + 4H^+ \rightarrow Zn^{2+} + 2NO_2 + 2H_2O$

(b) A brown, pungent gas would be evolved from the tank.

(c) emf = 0.79 + 0.76 = 1.55 Volts

37.

Structures	Names
	3-bromo-1-propene or (3–bromoprop–1–ene)
	2- bromo-1-propene or (2–bromoprop–1–ene)
	trans-1-bromopropene or (trans–bromoprop–1–ene)
	cis-1-bromopropene or (cis–bromoprop–1–ene)
	bromocyclopropane

Section Three: Extended answer

38.

Titration	Trials			
	1	2	3	4
Final reading (mL)	8.40	18.38	26.37	19.09
Initial reading (mL)	0.20	10.48	18.55	11.31
Titre (mL)	**8.20**	**7.90**	**7.82**	**7.78**

(a) To ensure an accurate volume of base was being titrated and ensure consistency of technique.

(b) Average titre = (7.90 + 7.82 + 7.78)/3 = 7.83 mL

(c) $n(OH^-)$ = cV

= 0.0142 x 0.007833

= 1.11×10^{-4} mol

Acid is monoprotic, therefore ratio acid:base = 1:1

Therefore, $n(H^+)$ = $n(OH^-)$ = 1.11×10^{-4} mol

$n(H^+)_{in\ 100mL} = (1.11 \times 10^{-3}) \times \left(\frac{100}{20}\right) = 5.56 \times 10^{-4}$ mol

$c(H^+) = n/V = 5.56 \times 10^{-4}/0.100 = 5.56 \times 10^{-3}$ mol L^{-1}

(d) $n(H^+)$ = 5.56×10^{-4} mol

m(aspirin) = $5.56 \times 10^{-4} \times 180.154$

= 0.100 g

M(Aspirin) = (9 x 12.01) + (8 x 1.008) + (4 x 16) = 180.154

%(aspirin) = $\left(\frac{0.100}{1.62}\right) \times 100\% = 6.18\%$ Therefore the claim is true!

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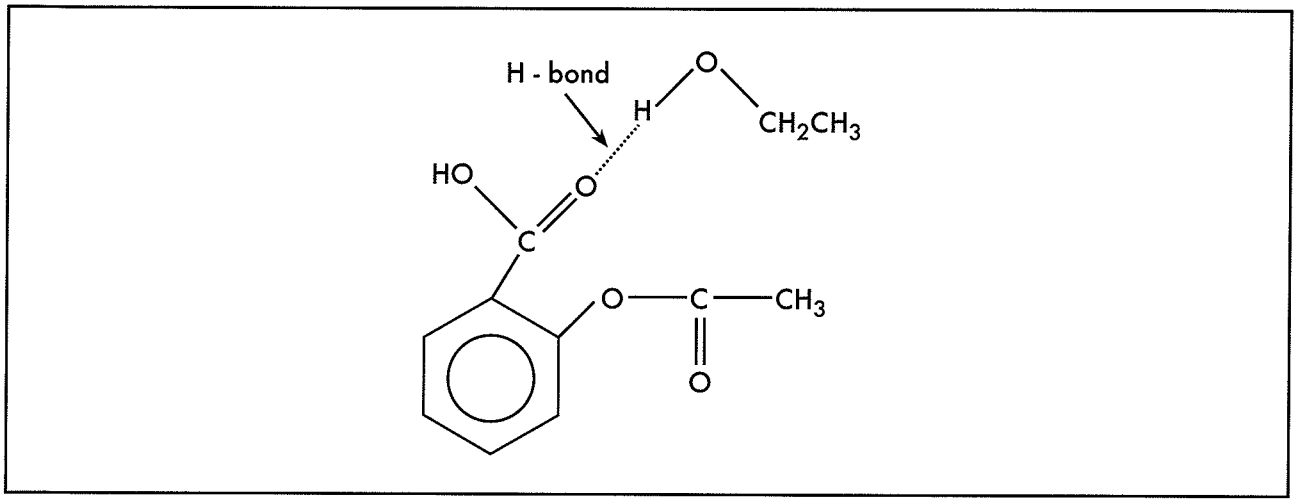
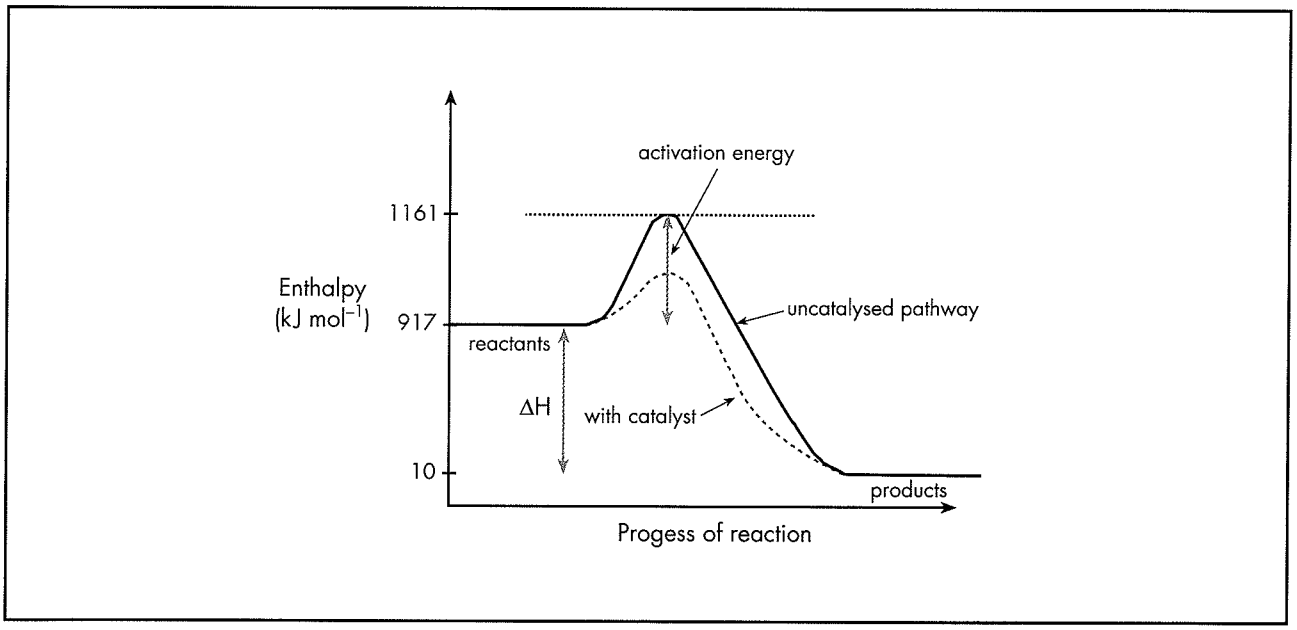
(e) Hydrogen bonding

(f)



39.(a)



(b) The activation energy is decreased, therefore providing a lower energy pathway for the reaction. More particles will have enough energy to react. More collisions will occur, therefore there will be a faster attainment of equilibrium.

(c) $n(NH_3) = \frac{1.80 \times 10^6 \times 0.960}{17.034}$

$= 1.014 \times 10^5$ mol

$M(NH_3) = \frac{(1 \times 14.01) + (3 \times 1.008)}{17.034}$

From equation $n(HNO_3) = (HNO_3) = \frac{2}{3} \times n\ (NH_3)$

Therefore $n(HNO_3) = n(HNO_3) = \frac{2}{3} \times n\ (NH_3)$

$= 6.76 \times 10^4$ mol

$$M(HNO_3) = \frac{(1 \times 1.008) + (1 \times 14.01) + (3 \times 16)}{63.018}$$

$$m(HNO_3) = 6.76 \times 10^{-4} \times 63.018$$
$$= 4.26 \text{ tonnes}$$

(d) $$n(NH_3) = \frac{0.0400 \times 1.8 \times 10^6}{17.034}$$

$$= 4.23 \times 10^3 \text{ mol}$$

$$n(N_2) = \frac{5}{4} \times n(NH_3)$$
$$= \frac{5}{4} \times 4.23 \times 10^3$$
$$= 5.28 \times 10^3 \text{ mol}$$

$$PV = nRT$$
$$V = nRT/P$$
$$= \frac{5.28 \times 10^3 \times 8.315 \times (912+273.1)}{650}$$
$$= 80.1 \text{ kL}$$

40. (a) Anode is nickel, cathode is copper.

(b)

Anode:	$Ni_{(s)} \rightarrow Ni^{2+}_{(aq)} + 2e^-$	0.26 Volts
Cathode:	$Cu^{2+}_{(aq)} + 2e^- \rightarrow Cu_{(s)}$	0.34 Volts
Overall:	$Cu^{2+}_{(aq)} + Ni_{(s)} \rightarrow Ni^{2+}_{(aq)} + Cu_{(s)}$	0.60 Volts

(c) The function of the salt bridge is to keep a charge balance (counterions) between the beakers whilst keeping the half reaction solutions separated.

(d) Loose wires/wires not connected properly, faulty voltmeter, solutions not 1 mol L^{-1} or temperature not at 25°C, solutions are contaminated, salt bridge not in contact with the solutions, electrodes not "clean".

(e) i) They do not store the oxidant or reductant within the cell, they are continuously replaced.
ii) The only product is steam, no hazardous waste products are formed/or hydrogen gas produces more energy per gram used than other energy sources such as methane.

41. (a) $n(C) = n(CO_2) = 0.344/44.01 = 7.816 \times 10^{-3}$ mol
$m(C) = 7.816 \times 10^{-3} \times 12.01 = 0.0938$ g
$n(H) = 2n(H_2O) = 2 \times 0.140/18.016 = 1.554 \times 10^{-2}$ mol
$m(H) = 1.554 \times 10^{-2} \times 1.008 = 1.556 \times 10^{-2}$ g
$m(N) = 0.329 - 0.0938 - 0.01566$
$= 0.219$ g
$n(N) = 0.219/14.01$
$= 1.56 \times 10^{-2}$ mol

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	C	H	N	
n	$\frac{7.816 \times 10^{-3}}{7.816 \times 10^{-3}}$	$\frac{1.55 \times 10^{-2}}{7.816 \times 10^{-3}}$	$\frac{1.56 \times 10^{-2}}{7.816 \times 10^{-3}}$	(Divide by smallest number)
Ratio	1	2	2	

Therefore, the empirical formula is CH_2N_2

(b) $PV = nRT$

$n = PV/RT$

$$= \frac{2.30 \times 101.3 \times 0.0730}{8.315 \times 473.1}$$

$= 4.324 \times 10^{-3}$ mol

$M = m/n = 0.545 / 4.324 \times 10^{-3}$

$= 126$ g mol^{-1}

(c) $M(EF) = 12.01 + (2 \times 1.008) + (2 \times 14.01) \approx 42.046$ g mol^{-1}

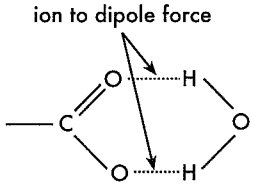
$\therefore MF \approx 3EF$, so MF is $C_3H_6N_6$

42. (a)

$CH_3(CH_2)_{16}COO^-Na^+$

hydrophobic end hydrophilic end

(b) The negative end of the soap ion attracts to the positive end of a water molecule dipole. This creates an ion to dipole force between the soap and the water.



(c) i) $Ca^{2+}_{(aq)} + 2\ CH_3(CH_2)_{16}COO^-_{(aq)} \rightarrow Ca[CH_3(CH_2)_{16}COO]_{2\ (s)}$

ii) M(scum) = (1 x 40.08)
(36 x 12.01)
(70 x 1.008)
(4 x 16)

607

n(scum) = m/M
= 0.0874/ 607
= 1.4399×10^{-4} mol

$n(Ca^{2+})$ = n (scum)
= 1.4399×10^{-4} mol

$m(Ca^{2+})$ = n x M
= $1.4399 \times 10^{-4} \times 40.08$
= 5.77×10^{-3} g

$$ppm = \frac{5.77 \times 10^{-3} \times 1000}{0.045}$$

45 mL = 45 g = 0.045 kg

= 128 ppm

43.

BUTANE

- Butane is a flammable colourless gas at room temperature.
- A member of the alkane family, with single covalent bonds between carbons.
- Has a low melting point and boiling point due to weak dispersion forces between molecules.
- Butane has carbon to carbon and carbon to hydrogen covalent bonds within the molecule.
- Butane has dispersion forces between molecules.
- Butane, like all organic chemicals, can undergo combustion to form carbon dioxide and steam. In limited supply of air, it can form carbon monoxide and steam. These reactions are also combustion reactions and used as a source of fuel because of the exothermic nature of the chemical reaction.
- Butane may undergo substitution reactions with halogens to form halobutane.
- Butane is non polar in nature due to it having only weak dispersion forces between its molecules. It is insoluble in polar solvents, such as water, and highly soluble in solvents such as kerosene or hexane liquid, due to similar non- polar intermolecular forces.

BUTANAL

- Butanal is a member of the aldehyde family, an organic compound with a carbon to oxygen double covalent bond at the end of the molecule.
- Besides the double bond at the end of the molecule, butanal has single carbon to carbon and carbon to hydrogen covalent bonds within its molecules.
- Butanal has dispersion forces and dipole to dipole interactions between molecules.
- Butanal will have a higher melting and boiling point than butane due to the stronger forces of attraction between molecules (dipole to dipole interactions).
- Butanal can also undergo combustion to form carbon dioxide and steam or carbon monoxide and steam in limited air supply.
- Butanal may be reacted with acidified potassium permanganate or acidified potassium dichromate solution to form butanoic acid.
- Butanal is a polar molecule due to the carbon to oxygen double covalent bond. It is soluble in most organic solvents and has some solubility in polar solvents, such as water.

1-Butanamine

- Butanamine is a member of the amine family of organic chemicals. Butanamine contains the amino ($-NH_2$) functional group on the end of the carbon chain.
- Butanamine has single carbon to carbon, carbon to hydrogen and nitrogen to hydrogen covalent bonds in its structure.

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- Butanamine has dispersion forces and hydrogen bonding interactions between molecules, and thus will have a higher melting and boiling point compared to butanal and butane. This is because of the strength of the hydrogen bonds between molecules.
- Butanamine is moderately basic and may undergo acid – base reactions.
- Butanamine is soluble in polar solvents, such as water, as it can hydrogen bond to the water.

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