2013 SECTION A

Instructions for Section A

- Answer all questions in pencil on the answer sheet provided for multiple-choice questions.
- Choose the response that is correct or that best answers the question.
- A correct answer scores 1, an incorrect answer scores 0.
- Marks will not be deducted for incorrect answers.
- No marks will be given if more than one answer is completed for any question.
- 1 × 30 = 30 marks, 35 minutes

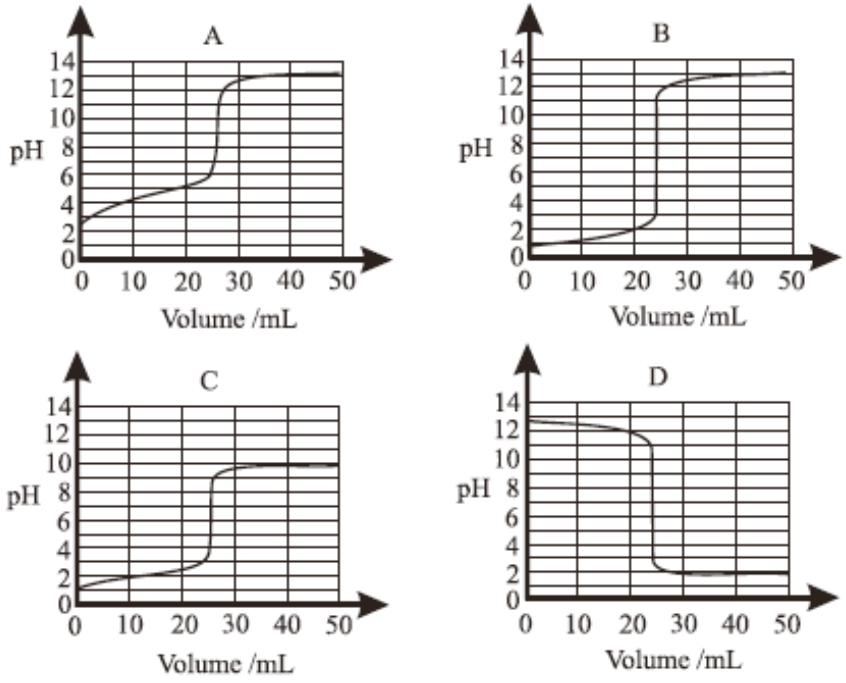
Question 1

A student wishes to determine the zinc content of a corroded piece of zinc. She dissolves the 1.46 g sample in sulfuric acid, and then adds excess sodium carbonate, Na_2CO_3. This neutralises the acid and precipitates the zinc as zinc carbonate. Once the precipitate has been collected, it is heated strongly to produce zinc oxide, ZnO (molar mass 81.4 g mol^{-1}). The mass of zinc oxide obtained is 1.62 g. The purity of the zinc is close to

A. 44.0 %
B. 50.0 %
C. 76.0 %
D. 89.0 %

Questions 2 and 3 refer to the four titration curves below.

In all the cases the initial concentrations of the acids and bases involved in the titrations were 0.10 M.



Question 2

Which of the titration curves best applies to reaction between 0.10 M HCl(aq) and 0.10 M NH_3(aq)?

A. Curve A.
B. Curve B.
C. Curve C.
D. Curve D.

Question 3

Which of the indicators listed would be the least suitable choice for any of the four titrations?

A. Methyl orange.
B. Methyl red.
C. Bromothymol blue.
D. Phenolphthalein.

Question 4

Which of the following occurs during the analysis of a sample using atomic absorption spectroscopy?

A. a change in molecules as their covalent bonds vibrate and rotate
B. a change in the spin alignment of certain carbon nuclei placed in a strong magnetic field
C. deflection of charged particles by a combination of electric and magnetic fields
D. movement of electrons in gaseous atoms to an excited state

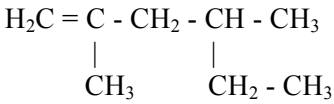
Question 5

In which alternative does the underlined element have the same oxidation number in each compound?

A. $\underline{Fe}Cl_2$, $\underline{Fe}Cl_3$, $O\underline{Cl}_2$
B. $\underline{Mg}O$, $H_2\underline{O}$, $H_2\underline{O}_2$
C. $K\underline{N}O_3$, $\underline{N}_2O_4$, $\underline{N}H_3$
D. $K_2\underline{S}_2O_7$, $K_2\underline{S}O_4$, $\underline{S}O_3$

Question 6

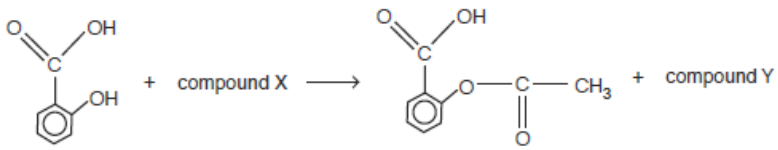
What compound is shown below?



A. 2-methyl - 4- ethyl - 1- pentene
B. 2,4 - dimethyl - 1- hexene
C. 3,5 dimethyl - 5 - hexene
D. 4-ethyl -2- methyl -1 - pentene

Question 7

The synthesis of aspirin can be represented by the following equation:



The formulas of compound X and compound Y are, respectively,

A. $C_4H_6O_3$ and $C_2H_4O_2$
B. $C_2H_4O_2$ and H_2O_2
C. $C_2H_6O_2$ and H_2O
D. C_3H_6O and CH_4

Question 8

After a synthesis of aspirin in the laboratory, a student wanted to find the percentage conversion to aspirin by sampling the solution in the reaction vessel after the reaction.
Consider the following techniques.

I acid–base titration
II thin-layer chromatography
III UV-visible spectroscopy

Which of the above techniques could be used to determine the amount of aspirin produced?

A. I and III only
B. I, II and III
C. I only
D. III only

Question 9

Human blood plasma contains many dissolved substances including glucose, urea, amino acids and the ions Fe^{2+}, Na^{+}, Cl^{-}, K^{+}, HCO_3^{-}, Ca^{2+}, and Mg^{2+}. There may also be other chemicals such as caffeine, alcohol or other drugs present in the plasma. The most suitable method for analysis for the following substances would be:

	Ca^{2+}	**Glucose**	**Caffeine**
A.	Atomic Absorption Spectroscopy	Gas Chromatography	Gas Chromatography
B.	UV-Visible Spectroscopy	Atomic Absorption Spectroscopy	Gas Chromatography
C.	Atomic Absorption Spectroscopy	High Performance Liquid Chromatography	High Performance Liquid Chromatography
D.	Gas Chromatography	UV-Visible Spectroscopy	Atomic Absorption Spectroscopy

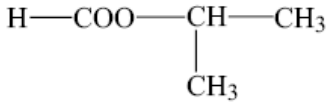
Question 10

Many proteins adopt a helical shape. This shape is mainly due to

A. Attraction between C=O groups and N-H groups on sections of the protein chain.
B. Bonds between N-H groups on neighbouring amino acid residues.
C. The formation of disulfide, S-S, links within section of the protein chain.
D. Ionic bonds between COO^{-} and NH^{+}.

Question 11

What is the number of peaks and the ratio of areas under the peaks in the ^{1}H NMR spectrum for the ester with the following structure:



	Number of Peaks	**Ratio of Areas**
A.	3	6:1:1
B.	4	6:1:1
C.	2	1:1:1
D.	4	1:1:1

Question 12

Lithium hydride, LiH, is an ionic compound but its solubility in water, is due to its ability to react with water. This reaction has been considered as a source of hydrogen for hydrogenoxygen fuel cells. When solid lithium hydride, LiH, is added to water, the overall reaction that occurs is represented by the equation:

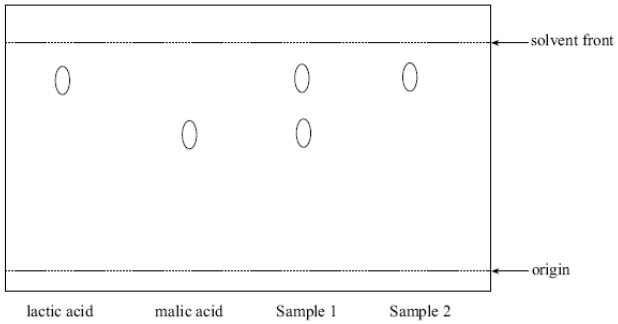
$$LiH(s) + H_2O(aq) \rightarrow Li^+(aq) + H_2(g) + OH^-(aq)$$

This reaction is most accurately described as

A. an hydrolysis reaction.
B. an acid-base reaction.
C. a redox reaction.
D. both an acid-base reaction and a redox reaction.

Question 13

A process known as malo-lactic fermentation occurs in some wines. During this process malic acid is converted into lactic acid. The extent of malo-lactic fermentation in one wine over a period of time was analysed by thin layer chromatography using a polar stationary phase.
Two samples of the wine were spotted onto the chromatography plate.
Reference samples of lactic acid and malic acid were also spotted onto the plate.
The chromatogram obtained is shown below:



Which one of the following is true?

A. Lactic acid adsorbs more strongly to the stationary phase than malic acid.
B. Malic acid has a larger R_f value than lactic acid.
C. Lactic acid is less soluble in the mobile phase than malic acid.
D. Malo-lactic fermentation had occurred in sample 2.

Question 14

The following information relates to an organic compound X:

- Compound X mixes with $Br_2(aq)$ to produce a colourless solution.
- Compound X undergoes extended oxidation using an acidified dichromate solution to produce an organic product which is not a carboxylic acid.
- Compound X does not react with Na_2CO_3 to evolve a colourless gas.

Which of the following is most likely to be the formula of Compound X?

A. $CH_3CHCHCH_2OH$
B. $CH_3CHCHCOOH$
C. $HOCH_2CH_2CH_2CH_3$
D. $CH_3CH(OH)CHCHCH_2CH_3$

Question 15

An acid-base indicator (HY) is itself a weak acid that reacts according to the balanced equation:

$$HY(aq) + H_2O(l) \rightarrow Y^-(aq) + H_3O^+(aq)$$

The acidity constant, $\mathbf{K_a}$, for this equation at a fixed temperature is 10^{-6} M.
The pH, at which the concentrations of $Y^-(aq)$ and HY(aq) are equal, is

A. 3
B. 6
C. 9
D. 12

Question 16

The reaction shown below has an activation energy of 79 kJ mol^{-1}.

$2NO_2(g) \rightarrow N_2O_4(s)$ $\Delta H = +55$ kJ mol^{-1}

The activation energy for the reverse reaction, $N_2O_4(g) \rightarrow 2NO_2(g)$, is

A. 24 kJ mol^{-1}
B. -55 kJ mol^{-1}
C. 79 kJ mol^{-1}
D. -79 kJ mol^{-1}

The next **two** questions refer to the equilibria involving haemoglobin, Hb, and the transport of oxygen, O_2, and carbon monoxide, CO, by the blood.

$Hb_4 + 4O_2 \rightleftharpoons Hb_4(O_2)_4$ Equilibrium 1

$Hb_4 + 4CO \rightleftharpoons Hb_4(CO)_4$ Equilibrium 2

Question 17

Considering Equilibrium 1, under normal conditions, in blood entering the lung tissue, it is correct to state

A. $[Hb_4]$ will be low, $[O_2]$ will be high and so the equilibrium will move right
B. $[Hb_4]$ will be high, $[O_2]$ will be high and so the equilibrium will move right
C. $[Hb_4]$ will be low, $[O_2]$ will be high and so the equilibrium will move left
D. $[Hb_4]$ will be high, $[O_2]$ will be high and so the equilibrium will move left.

Question 18

Oxygen is used as a treatment for carbon monoxide poisoning. The basis of this treatment is to move

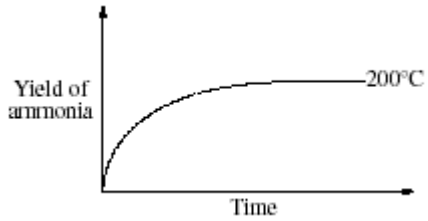
A. Equilibrium 1 to the right, so causing Equilibrium 2 to move to the right
B. Equilibrium 1 to the left, so causing Equilibrium 2 to move to the left
C. Equilibrium 1 to the right, so causing Equilibrium 2 to move to the left
D. Equilibrium 1 to the left, so causing Equilibrium 2 to move to the right.

Question 19

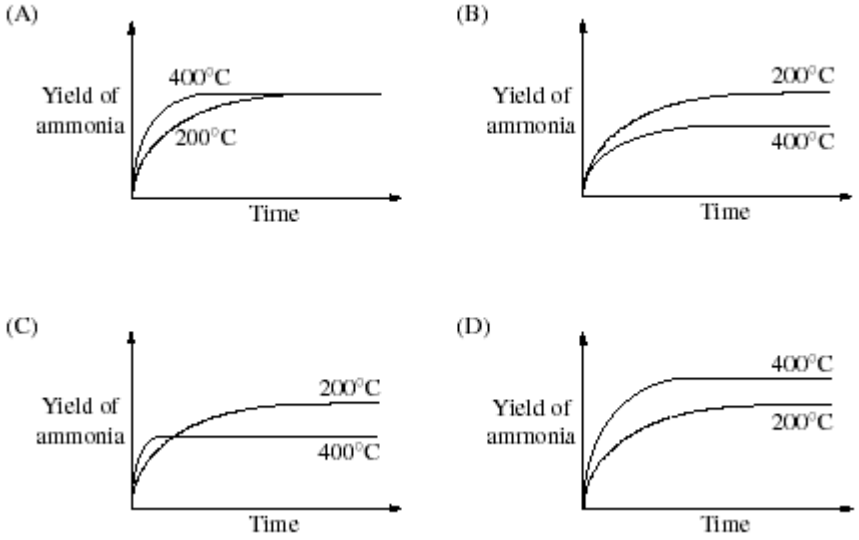
Ammonia is produced from hydrogen and nitrogen, according to the equation.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \qquad \Delta H = -91 \text{ kJ mol}^{-1}$$

The graph shows the yield of ammonia produced at 200^0C and 100 kPa.

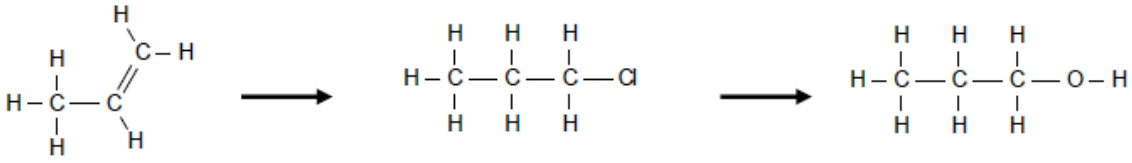


Which graph shows a correct comparison of the yield of ammonia produced at a temperature of 400°C and 100 kPa with the yield produced at 200°C and 100 kPa?



Question 20

The chemical pathway shown is for the manufacture of 1-propanol.



In this pathway,

A. two addition reactions are performed and only one product is formed
B. two substitution reactions are performed and three products will be formed
C. a substitution reaction is followed by an addition reaction
D. an addition reaction is followed by a substitution reaction

The following information refers to the next 2 questions.

A commonly used primary standard in analytical chemistry is potassium hydrogen phthalate ($KC_8H_5O_4$), a monoprotic acid of molar mass 204.1 g mol^{-1}.

A student uses potassium hydrogen phthalate to determine the percentage by mass of ammonia present in a newly released "U-Bute" cleaning solution.

24.6 g of "U-Bute" solution is measured into a 200.0 mL standard flask and deionised water is added to make up 200.0 mL of solution. A 25.0 mL aliquot of this solution is placed into a conical flask. Three drops of methyl red indicator are then added to the solution and it is titrated against 1.00 M hydrogen phthalate solution until a permanent yellow-orange colour change is noted. A titre of 9.23 mL is required to reach endpoint.

The relevant equation for this acid-base reaction is

$$C_8H_5O_4(aq) + NH_3(aq) \rightarrow C_8H_4O_4 + NH_4^+(aq)$$

Question 21

The mass of potassium hydrogen phthalate needed to prepare 250.0 mL of a 1.00 M solution is approximately:

A. 41 g
B. 51 g
C. 102 g
D. 204 g

Question 22

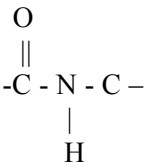
The amount (in mol) of ammonia present in the 24.6 g sample is

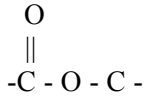
A. 1.15×10^{-3}
B. 9.23×10^{-3}
C. 7.38×10^{-2}
D. 1.85

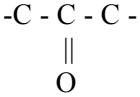
Question 23

Which of the following correctly shows the link, which forms when glucose and fructose undergo a condensation reaction?

A. -C - O - C-

B.


C.


D.


Question 24

Hydrogen peroxide (H_2O_2) is a strong oxidant as well as being a weak reductant. It can be predicted that solutions of hydrogen peroxide will undergo a decomposition reaction.

A galvanic cell could be set up using hydrogen peroxide as the reactant in both half-cells. Which one of the following is correct with respect to this galvanic cell?

	Electrode at which the oxidation number of oxygen in H_2O_2 decreases	**Maximum voltage of the cell under standard conditions (volts)**
A.	anode	1.09
B.	cathode	1.09
C.	anode	2.45
D	cathode	2.45

Use the following information to answer Questions 25 and 26.

The molar enthalpy of combustion of the biochemical fuel methyl palmitate, $C_{17}H_{34}O_2$, was determined in a bomb calorimeter, which had been previously chemically calibrated using the combustion of benzoic acid.
The data from the experiment is shown below.

molar enthalpy of combustion of methyl palmitate	-1.07×10^4 kJ mol^{-1}
molar mass of methyl palmitate	270 g mol^{-1}
mass of methyl palmitate burnt in calorimeter	0.378 g
temperature change due to burning methyl palmitate	4.53°C

Question 25

The calibration factor of the calorimeter, in kJ °C^{-1}, is closest to
A. 2.50
B. 3.00
C. 3.50
D. 4.00

Question 26

Consider the following situations:

I The volume of water surrounding the reaction chamber in the calorimeter was only 90% of the volume specified for the operation of the calorimeter.

II The outer layer of insulation on the calorimeter was removed.

During the calibration of the calorimeter using benzoic acid combustion, which of the above situations would result in a calculated calibration factor, which is greater than the actual value?

A. I only
B. II only
C. both I and II
D. neither I nor II

Question 27

The metal platinum will not dissolve in nitric acid or hydrochloric acid under standard conditions. However, platinum will dissolve in a mixture of the two acids. The relevant half-reactions are:

$PtCl_4^{2-}(aq) + 2e^- \rightarrow Pt(s) + 4Cl^-(aq)$ E^0_1

$Pt^{2+}(aq) + 2e^- \rightarrow Pt(s)$ E^0_2

$NO_3^-(aq) + 4H^+(aq) + 3e^- \rightarrow NO(g) + 2H_2O(l)$ E^0_3

Commencing with the lowest value, what is the order of standard reduction potentials, which is consistent with the information about dissolving platinum?

A. $E^0_1 < E^0_3 < E^0_2$

B. $E^0_3 < E^0_2 < E^0_1$

C. $E^0_2 < E^0_1 < E^0_3$

D. $E^0_2 < E^0_3 < E^0_1$

Question 28

Bromine is reacted with two different fatty acids.

Sample A: 0.366 mole of bromine reacts exactly with 0.183 mole of fatty acid A.
Sample B: 0.429 mole of bromine reacts exactly with 0.143 mole of fatty acid B.

Fatty acid A and fatty acid B could be, respectively

A. myristic and oleic
B. oleic and linoleic
C. linoleic and linolenic
D. stearic and oleic

Question 29

Rechargeable nickel-cadmium batteries are widely used in mobile computers and mobile telephones as a source of electrical power. The equation for the discharging process can be written as:

$Cd(s) + 2NiO(OH)(s) + 2H_2O(l) \rightarrow Cd(OH)_2(s) + 2Ni(OH)_2(s)$

The species reacting at the negative electrode during the discharge process is

A. $Cd(OH)_2(s)$
B. $Cd(s)$
C. $Ni(OH)_2(s)$
D. $NiO(OH)(s)$

Question 30

Which of the following statements about fuel cells is most accurate?

A. Fuel cells only convert chemical energy to electrical energy.
B. Fuel cells utilise only acid electrolytes.
C. Fuel cells indirectly involve combustion reactions.
D. Fuel cells are rechargeable.

End of Section A Questions

SECTION B – Short Answer Section

Instructions for Section B

This section consists of **9** short answer questions, which are to be answered in the spaces provided.
To obtain full marks for your responses you should

- Numerical answers must be given to the appropriate number of significant figures; unsimplified answers will not be given full marks.
- Show all working in your answers to numerical questions. No credit will be given for an incorrect answer unless it is accompanied by details of the working.
- **All** chemical equations must be balanced and formulas for individual substances must include an indication of state; for example, H2(g); NaCl(s).
- **95** marks, 115 minutes

Question 1 (9 marks)

The Kjeldahl method in analytical chemistry is a method for the determination of the nitrogen content of substances. It was developed by Johan Kjedahl in 1883 and 130 years later is still an official standard method for the determination of nitrogen in all kinds of food samples. It is also used in environmental analysis and in agriculture for determining nitrates and ammonium content.

In an analysis of a food sample for nitrogen content, the following steps were followed.

1. The sample was digested in sulfuric acid to convert all the nitrogen to $NH_4^+(aq)$
   N containing compound $\rightarrow NH_4^+(aq)$.
2. NaOH(aq) is then added to the mixture to convert all the $NH_4^+(aq)$ ions to $NH_3(g)$
   $NH_4^+(aq) + OH^-(aq) \rightarrow NH_3(g) + H_2O(l)$.
   The solution is heated to ensure that all the $NH_3(g)$ is liberated.
3. The liberated $NH_3(g)$ is then passed into 100.0 mL of 0.100 M HCl(aq).
4. When all the $NH_3(g)$ has been absorbed, the solution from (3.) is titrated with 0.200 M NaOH.

The following data were recorded:
Mass of food sample: 5.152 g
Average titre volume: 31.41 mL

a) Write balanced equations for the reactions occurring in Steps 3 and 4. **2 marks**

b) Calculate the **n**(HCl) which reacted with the $NH_3(g)$ produced from the food sample. **2 marks**

c) Calculate the mass of nitrogen present in the food sample. **1 mark**

d) Determine the %, by mass, of nitrogen in the food sample. **1 mark**

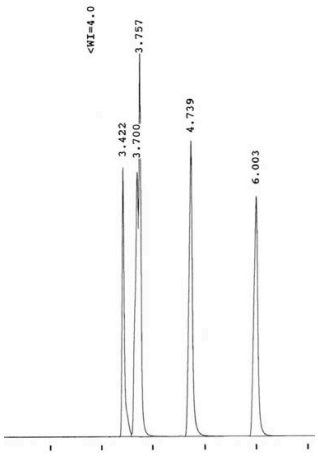
e) In an alternative version of the Kjeldahl process, the $NH_3(g)$ produced is absorbed into boric acid solution, $H_3BO_3(aq)$.
Boric acid is a weak acid. Its hydrolysis may be represented by the equilibrium

$$H_3BO_3(aq) + H_2O(l) \rightleftharpoons B(OH)_4^-(aq) + H^+(aq)$$

What would be the pH, at 25°C of a 0.647 M aqueous solution of boric acid? **3 marks**

Question 2 (8 marks)

A sample containing a mixture of alkanols is injected into a gas chromatograph. The following chromatogram is obtained. Note: the chromatogram shows the exact retention times above each peak.



Further experimentation establishes the identity of each peak as shown in the following table.

Retention time (min)	Alkanol
3.422	Methanol
3.700	Ethanol
3.757	2-methylpropanol
4.739	1-propanol
6.003	1-butanol

a) Suggest a method that could have been used to establish the identity of each peak. **1 mark**

b) A brewing company wishes to use this column for the determination of the ethanol content of wine samples. Would this column be suitable for this analysis? Explain your answer. **1 mark**

c) If a sample of 1-pentanol is injected into this column, what retention time might you expect? Explain how you arrived your answer. **2 marks**

d) It is often difficult to distinguish structural isomers because their properties can be very similar. Does this analysis support the use of gas chromatography in separating structural isomers? Explain your answer. **2 marks**

e) If the concentration of 1-butanol in the above mixture is doubled, what change would you expect to see in the chromatogram? **1 mark**

f) The chromatogram above was produced with the instrument set at 140°C. If the instrument was set at 160°C instead of 140°C, how would the chromatogram change? **1 mark**

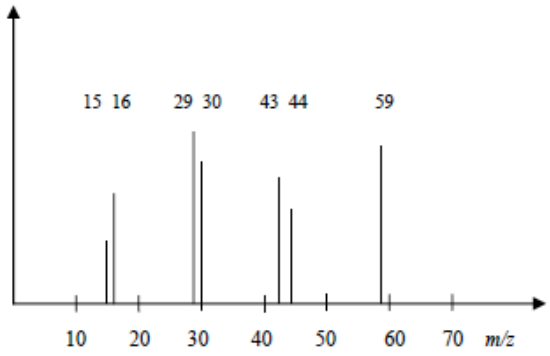
Question 3 (9 marks)

a) A 2.800 g sample of an organic molecule is found to contain 1.710 g of carbon and 0.664 g of nitrogen.

i. The compound also contains hydrogen. What is the mass of hydrogen in the sample? **1 mark**

ii. Determine the empirical formula of the molecule. **2 marks**

b) The mass spectrum of the molecule is shown below.



i. What is the value of the base peak for this molecule? **1 mark**

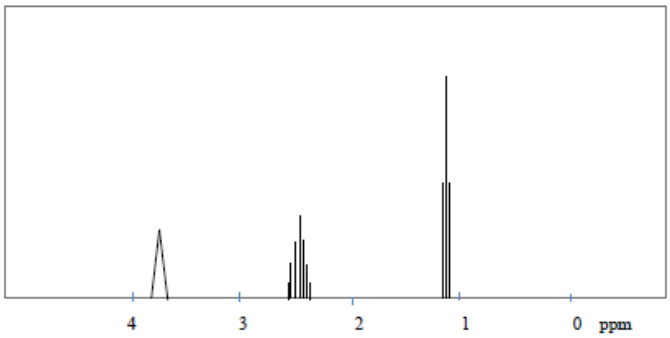
ii. What is the molecular formula of the molecule? **1 mark**

c) There are two possible structures for this molecule. Draw and name both isomers. **2 marks**

Isomer 1 Isomer 2

Name**:** _____ Name**:** _____

d) The proton NMR spectrum below can be used to confirm the identity of this molecule.



What is the identity of the molecule? Explain how the NMR spectrum has helped you arrive at this conclusion. **2 marks**

Question 4 (14 marks)

Early in 2013 there was much discussion about the use of peptide supplements in sport in Australia. Some peptide supplements can work to help the body recover from strenuous activity and may be deemed usable. Others can encourage the body to release growth hormones and are generally banned.

One supplement, not a peptide, on the WADA (Word Anti-Doping Authority) list of prohibited supplements, is known by a variety of names including DMAA and Geranamine. Its systematic name is 4-methylhexan-2-amine. It is banned because of potential serious health risks.

a) Draw the structural formula, showing all bonds, of this compound. **1 mark**

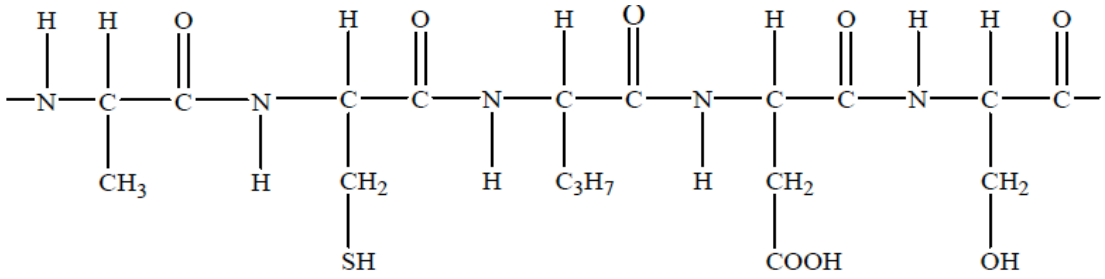
b) In some reports, DMAA has also been called 2-amino-4-methylhexane and incorrectly described as an amino acid supplement. Explain why DMMA is not an amino acid. **1 mark**

c) Give the systematic name of the amino acid, alanine. **1 mark**

d) Give the structural formula, showing all bonds, of the amino acid, aspartic acid, in solution at pH 11. **1 mark**

e) Describe, how a tripeptide is formed from its smaller units. **2 marks**

f) A section of a polypeptide is represented below **3 marks**

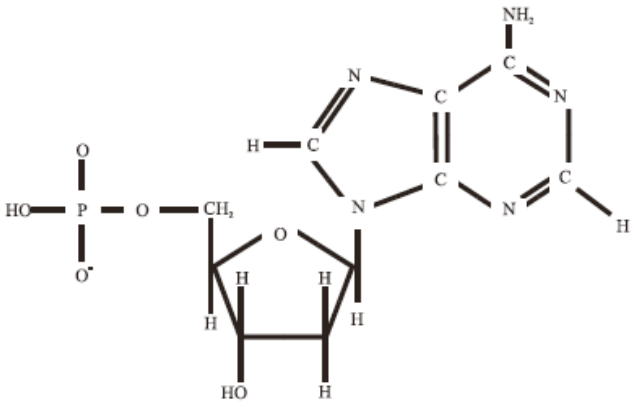


i. Circle a bond which maintains the primary structure of a protein.

ii. Place a hash sign (#) next to two 'different' atoms between which bonding responsible for maintaining the secondary structure of a protein occurs.

iii. Draw a rectangle around the atom commonly associated with the tertiary structure of a protein.

g) The structure of a nucleotide is represented below **4 marks**



i. Name the three species which combined to form this nucleotide.

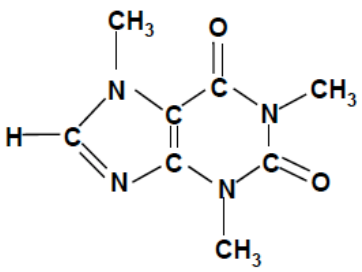
ii. Circle the groups of atoms where reaction occurs when this nucleotide becomes part of the primary structure of DNA.

iii. Use hash signs (#) to show where bonding occurs between this nucleotide and its complement in the secondary structure of DNA.

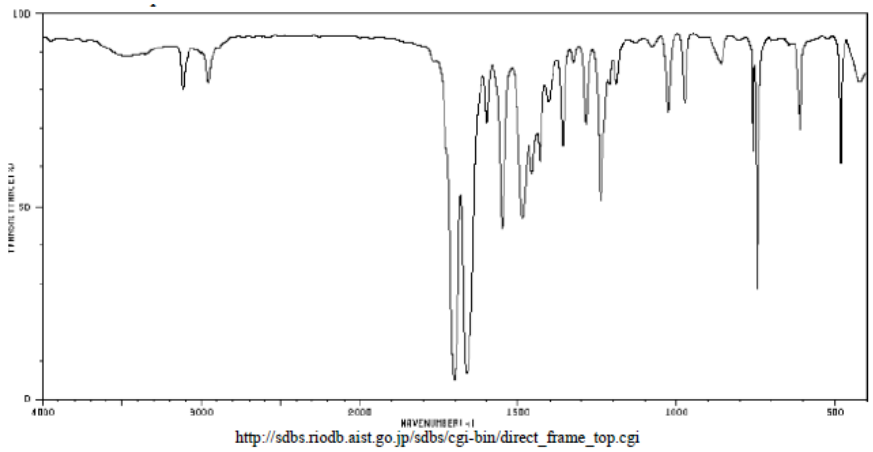
h) Other than the total number of nucleotides in each strand of the double helix of DNA, what is the key factor in the overall strength of attraction between the strands?
Explain your answer. **1 mark**

Question 5 (13 marks)

The Oxford Dictionary defines alkaloids as 'any of a class of nitrogenous organic compounds of plant origin which have pronounced psychological actions on humans'. Caffeine, which acts as a central system stimulant, is an alkaloid.
The structure of caffeine molecules is represented below.

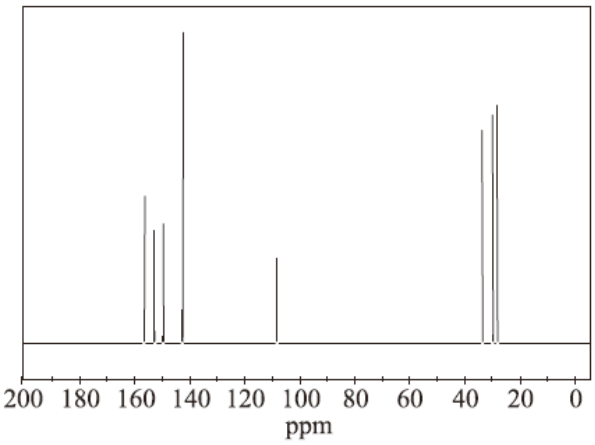


a) The IR spectrum of caffeine is shown below.



Explain the presence of **two** distinct strong peaks around 1650-1700 cm^{-1}. **2 mark**

b) The ^{13}C NMR spectrum of caffeine is shown below.

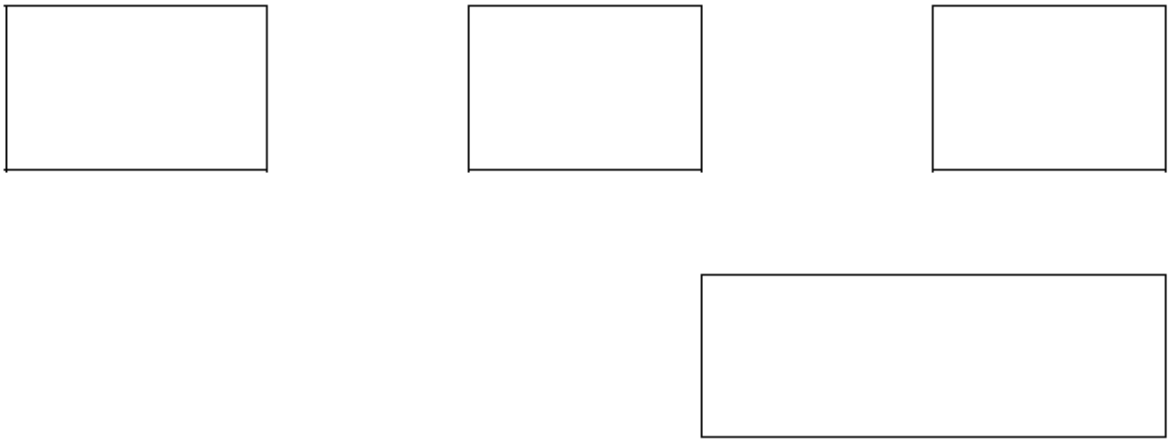


Explain the presence of eight peaks on the spectrum and why they all occur at different chemical shifts. **2 marks**

Decaffeination is the process of removing caffeine from coffee beans, cocoa, tea leaves and other caffeine containing materials. In one method of decaffeination, coffee beans are steamed for 30 minutes and then rinsed with ethyl ethanoate for about 10 hours. The solvent is then drained away and the beans are steamed for another 10 hours to remove any remaining solvent.

c) The ethyl ethanoate used in this process is produced synthetically from ethane. Using semistructural formulae, use the boxes below to show an organic reaction pathway, including essential inorganic reactants and catalysts for the production of ethylethanoate from ethene.

5 marks



d) Write a balanced chemical equation for the production of ethyl ethanoate.
This is an equilibrium reaction. **1 mark**

e) The ΔH value for the correctly balanced equation for the production of ethyl ethanoate is +17.5 kJ mol^{-1}.

i. Give two advantages of heating the reaction mixture in a water bath. **2 marks**

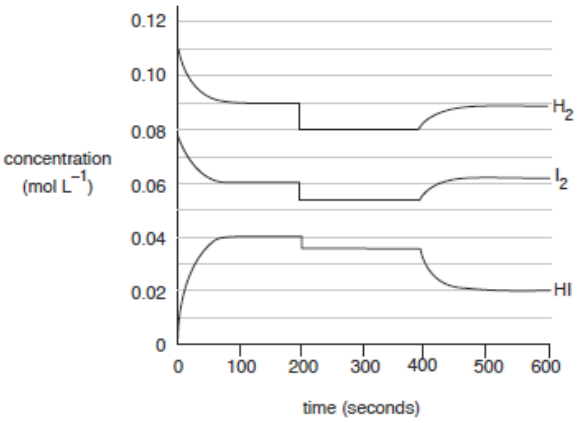
ii. Why would the reaction mixture **not** be heated using a Bunsen burner? **1 mark**

Question 6 (18 marks)

When $H_2(g)$ and $I_2(g)$ are placed in a sealed container, equilibrium will establish according to the following equation:

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$$

The results of an experiment using this equilibrium system are shown in the graph below.



During the time interval 0 to 200 seconds, the temperature of the system was kept constant by removing heat from the container.

a) Explain how it can be demonstrated that chemical reactions are still occurring during a state of equilibrium by introducing into this system a trace amount of the radioactive isotope of hydrogen known as deuterium. **2 marks**

b) Calculate the equilibrium constant for the equilibrium, which occurred in the time interval 0 to 200 seconds. **3 marks**

c) At t = 200 seconds, a change was made to the volume of the reaction vessel.
Outline what change was made, and indicate the magnitude of the change. **2 marks**

d) **i.** Circle one of the following to indicate the value of *K* at 560 seconds compared to the value of *K* at 260 seconds. **1 mark**

lower unchanged higher

ii. Without any calculation, explain the reasoning for your choice in part **d. i.** **2 marks**

e.) The experiment was repeated under identical conditions except that a suitable catalyst was used.

By drawing a line on the graph on the previous page, show the effect of the catalyst on the concentration of HI in the interval 0 to 200 seconds. **1 mark**

f) The formation of nitrogen(II) oxide, NO, and nitrogen(IV) oxide, NO2, from nitrogen and oxygen can be described by the chemical equations at 900 K.

$$N_2(g) + O_2(g) \rightleftharpoons 2NO(g) \qquad K_1 = 6.7\times10^{-10} \qquad \Delta H_1 = 180\ \text{kJ mol}^{-1}$$

$$N_2(g) + 2O_2(g) \rightleftharpoons 2NO_2(g) \qquad K_2 = 3.1\times10^{-9}\ \text{M}^{-1} \qquad \Delta H_2 = 66\ \text{kJ mol}^{-1}$$

i. Using the data provided, calculate the value of the heat of reaction, ΔH, for the following reaction. **1 mark**

$$2NO(g) + O_2(g) \rightleftharpoons 2NO_2(g)$$

ii. Write an expression for the equilibrium constant for this reaction. **1 mark**

iii. Determine the value of this equilibrium constant at 900 K using the data provided. **2 marks**

iv. Explain why the rates of reaction for the formation of nitrogen(II) oxide and nitrogen(IV) oxide from nitrogen and oxygen would be slow. **1 mark**

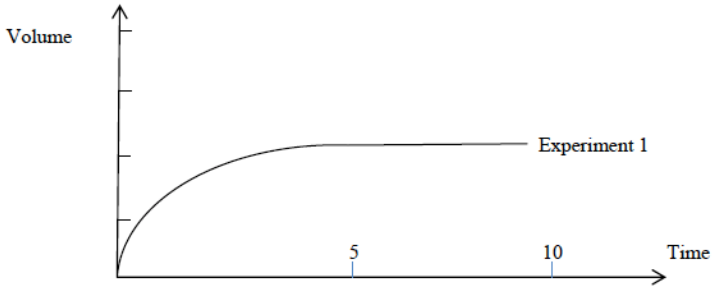
v. The activation energy for the forward reaction is 220 kJ mol^{-1}. On the grid below draw a labelled energy potential diagram for this reaction (**f i**.), showing the activation energies for the forward and reverse reactions and the change in enthalpy. **2 marks**

Question 7 (6 marks)

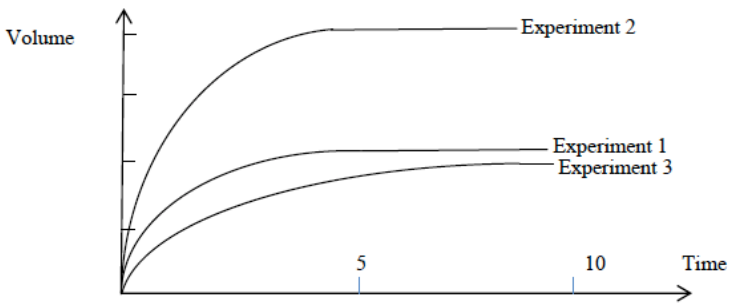
The equation for the reaction between magnesium and hydrochloric acid is

$$Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$$

An experiment is conducted where 1.0 g of magnesium is added to excess hydrochloric acid at 25°C and the volume of hydrogen gas evolved is monitored. The volume of gas produced is shown on the graph below.



Two further experiments are conducted and the hydrogen gas evolved is shown on the graph below.



a) Suggest a change that was made to the original experiment that would have led to the hydrogen production being as shown in experiment 2. **1 mark**

b) Suggest three possible changes to experiment 1 that might have led to the hydrogen production being as shown in experiment 3. **3 marks**

c) List two other methods that could be used to monitor the rate of this reaction. **2 marks**

Question 8 (11 marks)

Fred wanted to experiment with the production of biodiesel, and find out whether or not it was a viable alternative to butane in camping stoves. He had a source of stearic acid from canola oil, which he reacted with methanol, using potassium hydroxide as a catalyst, to form the biodiesel.

a) Draw the structural formula of the biodiesel molecule formed. **1 mark**

b) Name the linkage formed in the biodiesel molecule. **1 mark**

c) Write the equation for complete combustion of the biodiesel molecule. **1mark**

Fred used a bomb calorimeter to combust a small amount of the biodiesel. The calibration factor for the bomb calorimeter was previously found to be 1175 $J^{\circ} C^{-1}$, after heating the calorimeter for 50 s. When the 0.50 g of the biodiesel was combusted in excess oxygen, the temperature of the calorimeter rose from 19.21 $^{\circ}$C to 35.04 $^{\circ}$C.

d) Find the molar enthalpy of combustion of the biodiesel in kJ mol^{-1}. **4 marks**

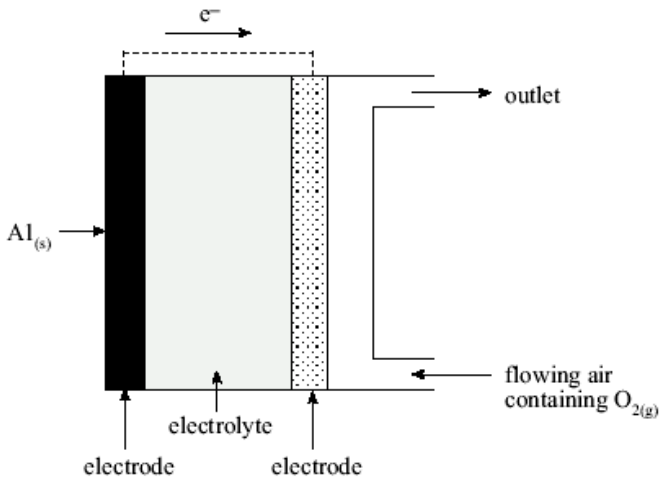
e) Calculate the amount of energy, which would be released when 10 g of butane undergoes complete combustion. **2 marks**

f) Does 10 g of butane release more or less energy than 10 g of Fred's biodiesel? **1 mark**

g) Other than the amount of energy released, what other factor may be important in the determination of whether or not the biodiesel produced by Fred is better for use in a camping stove than butane. **1 mark**

Question 9 (8 marks)

Electrochemical cells are being developed as possible alternatives to the combustion of fossil fuels to power motor vehicles. One electrochemical cell, the aluminium–air battery, is represented in the diagram below:



It is an alkaline cell with the following overall cell reaction:

$$4Al(s) + 3O_2(g) + 6H_2O(l) \rightarrow 4Al^{3+}(aq) + 12OH^-(aq)$$

a) Write the equation for the reaction at **electrode A.** **1 mark**

b) Write the equation for the reaction at **electrode B.** **1 mark**

c) Write the electronic configuration, in terms of subshells, for aluminium. **1 mark**

d) State whether the aluminium is acting as the anode or the cathode, and give a reason for your answer. **1 mark**

e) State the main form of energy produced in this type of electrochemical cell. **1 mark**

f) State *one* reason why the use of an aluminium–air battery may be considered as a desirable alternative to the combustion of fossil fuels to power motor vehicles. **1 mark**

g) Explain why the aluminium–air battery cannot be classified as a fuel cell. **1 mark**

h) State one advantage and one disadvantage of a fuel cell over a conventional primary cell. **2 marks**

End of Section B
End of Trial Exam