Neap:

Trial Examination 2014

VCE Chemistry Units 3&4

Written Examination

Question and Answer Booklet

Reading time: 15 minutes
Writing time: 2 hours 30 minutes

Student's Name: _____

Teacher's Name: _____

Structure of Booklet

Section	Number of questions	Number of questions to be answered	Marks	Suggested time (minutes)
A Multiple-choice	30	30	30	40
B Short-answer	8	8	90	110
			Total 120	Total 150

Students are permitted to bring into the examination room: pens, pencils, highlighters, erasers, sharpeners, and one scientific calculator.
Students are NOT permitted to bring into the examination room: blank sheets of paper and/or white out liquid/tape.

Materials supplied

Question and Answer Booklet of 26 pages.
Data Booklet of 11 pages.
Answer Sheet for multiple-choice questions.

Instructions

Please ensure that you write **your name** and your **teacher's name** in the space provided on this booklet and in the space provided on the answer sheet for multiple-choice questions.
All written responses must be in English.

At the end of the examination

Place the answer sheet for multiple-choice questions inside the front cover of this booklet and hand them in.

Students are NOT permitted to bring mobile phones and/or any other electronic communication devices into the examination room.

Students are advised that this is a trial examination only and cannot in any way guarantee the content or the format of the 2014 VCE Chemistry Units 3&4 Written Examination.

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SECTION A: MULTIPLE-CHOICE QUESTIONS

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.

Question 1

Two water-soluble food dyes are analysed by thin-layer chromatography (TLC) using an organic solvent.

Which one of the following statements is correct?

A. Running the TLC plate for a longer time would increase the R_f value for each spot.

B. Repeating the TLC analysis with a different solvent will not change the R_f values.

C. Increasing the time of the TLC analysis will increase the distance between the spots.

D. The most polar food dye will travel the furthest during the TLC analysis.

Use the following information to answer Questions 2 and 3.

When a purple-coloured solution of MnO_4^- ions is mixed with a pale green-coloured solution of Fe^{2+} ions, the products include Mn^{2+} and Fe^{3+} ions.

Question 2

If 10 mol of Fe^{3+} ions are formed in a particular chemical reaction, which one of the following options shows the correct number of mole of the reactants and products in this reaction?

A. 4 mol $MnO_4^-(aq)$ and 8 mol $H^+(aq)$

B. 2 mol $Mn^{2+}(aq)$ and 2 mol $H_2O(l)$

C. 4 mol $H^+(aq)$ and 2 mol $Mn^{2+}(aq)$

D. 2 mol $MnO_4^-(aq)$ and 8 mol $H_2O(l)$

Question 3

Consider the following statements in regards to the reaction described above:

I As Fe^{2+} loses electrons, it is the reductant in the reaction.

II MnO_4^- is the oxidant and so it undergoes reduction.

III Fe^{2+} is reduced because the oxidation number of Fe increases.

IV The oxidation number of Mn changes from +7 to +2 and so it is oxidised.

Which of the above statements about this reaction are correct?

A. I and II only

B. I, II and III only

C. II and III only

D. III and IV only

Question 4

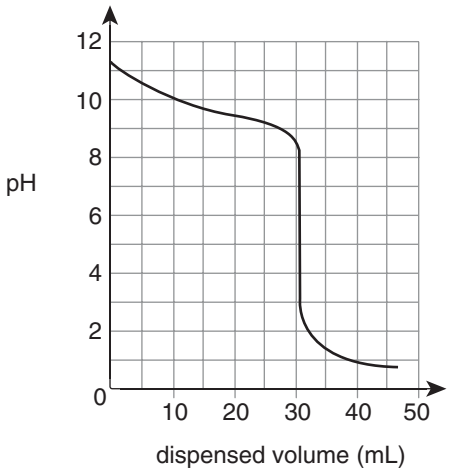
Serotonin is a compound found in the human brain. A molecule of serotonin contains 10 carbon atoms and 12 hydrogen atoms, which together are 75% of the molecule by mass.

What is the molar mass of serotonin in g mol^{-1}?

A. 160
B. 176
C. 324
D. More information is required to calculate the molar mass of serotonin.

Use the following information to answer Questions 5 and 6.

The graph below shows the pH changes during an acid–base titration.



Question 5

Which solutions were used during the titration?

A. weak acid and weak base
B. weak acid and strong base
C. strong acid and weak base
D. strong acid and strong base

Question 6

Which indicator would be most suitable to detect the endpoint of the neutralisation?

A. phenolphthalein
B. thymol blue
C. phenol red
D. methyl red

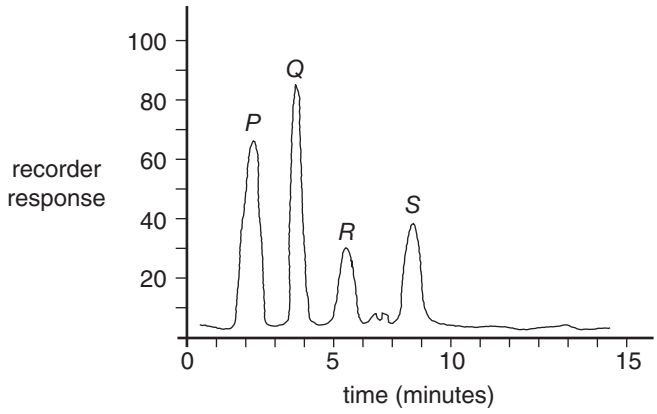
Question 7

Which of the following descriptions of reactions and their products is **incorrect**?

A. 1-chloropropane undergoes a substitution reaction with NaOH(aq) to form 1-propanol.
B. Methanol and butanoic acid react in the presence of concentrated sulfuric acid to form methyl butanoate.
C. But-2-ene reacts undergoes an addition reaction with chlorine gas in the presence of a catalyst to form 2,2-dichlorobutane.
D. Ethanoic acid reacts with ammonia in aqueous solution to produce ammonium ethanoate.

Use the following information to answer Questions 8 and 9.

Analysis of a mixture of carbon-based compounds (*P*, *Q*, *R* and *S*) by HPLC produced the chromatogram shown below.



Question 8

Which of the following statements is **incorrect**?

A. Component *Q* has a longer retention time than component *P*.

B. Component *P* has more attraction to the stationary phase than component *R*.

C. Component *R* travelled through the column at a different rate to component *S*.

D. Component *S* was adsorbed to the stationary phase for a longer time than component *Q*.

Question 9

Consider the following alternatives:

I using a different mobile phase

II increasing the temperature at which the column operated

III reducing the amount of solvent in the sample

Which of the above changes to the procedure used for the analysis would change the area under each peak?

A. I only

B. I and II only

C. III only

D. II and III only

Question 10

When a sample of 1-pentanol is heated with concentrated sulfuric acid a dehydration reaction occurs.

Which of the following shows the molecular formula of the organic product of this dehydration reaction?

A. C_5H_{12}

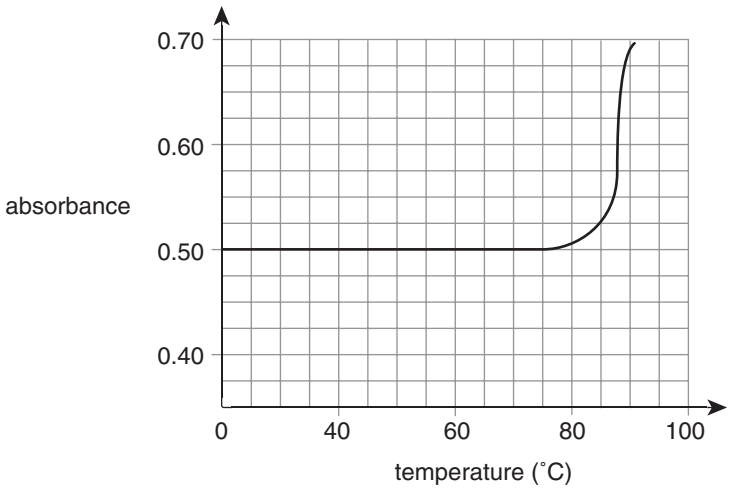
B. C_5H_{10}

C. C_5H_9O

D. C_5H_8

Use the following information to answer Questions 11–13.

When double-stranded DNA is heated slowly the individual strands separate from each other over a narrow temperature range. The midpoint temperature (T_m) of this separation is known as the melting temperature. During this transition from double helix to random coil arrangement, the absorbance at 260 nm of a particular DNA sample increases as shown in the graph below.



Question 11

What is the melting temperature of the DNA sample?

A. 50°C
B. 73°C
C. 87°C
D. 92°C

Question 12

Which level of structure of DNA, if any, would be disrupted during heating to determine the melting temperature of a DNA sample?

A. primary only
B. secondary only
C. both primary and secondary
D. neither primary nor secondary

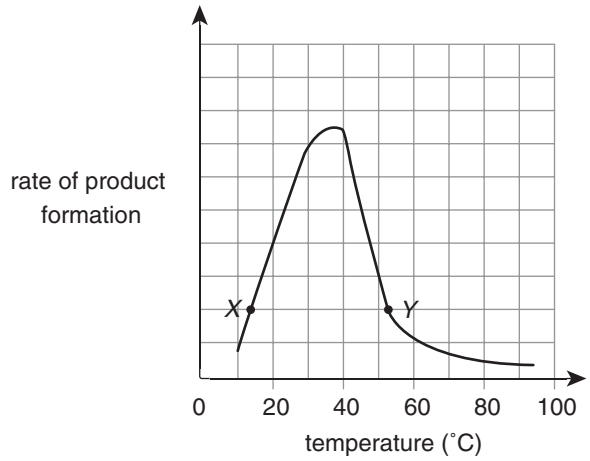
Question 13

Which of the following nitrogenous bases in the DNA sample contribute most to a high melting temperature value?

A. adenine and guanine
B. thymine and cytosine
C. adenine and thymine
D. cytosine and guanine

Question 14

The effect of temperature on the activity of a particular plant enzyme is shown in the graph below. The points *X* and *Y* on the graph have the same enzyme activity but at different temperatures.



Consider the following statements in relation to the graph above:

I The active site of many enzyme molecules has been destroyed.

II The secondary and tertiary structures of the enzyme have been disrupted.

Which of the above statements could be used to explain the activity of the enzyme at **both** points *X* and *Y*?

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

Use the following information to answer Questions 15 and 16.

3.60 mol of hydrogen chloride and 2.00 mol of oxygen were introduced into an evacuated 2.5 L vessel. Reaction occurred according to the equation:

$$4HCl(g) + O_2(g) \rightleftharpoons 2H_2O(g) + 2Cl_2(g) \qquad \Delta H = -112 \text{ kJ mol}^{-1}$$

At equilibrium the vessel contained 0.600 mol of chlorine.

Question 15

As the system first approaches equilibrium, which of the following would be decreasing in value?

A. ratio of concentration of products to reactants
B. pressure
C. temperature
D. rate of the backward reaction

Question 16

The concentrations (in M) of hydrogen chloride and oxygen at equilibrium are, respectively,

A. 3.00 and 1.40
B. 1.20 and 0.56
C. 2.40 and 1.70
D. 0.96 and 0.68

Question 17

The two solutions listed below were prepared.

I 0.00030 M HCl(aq)

II 0.30 M HOCl(aq)

Which of the solutions would turn red if a few drops of methyl red indicator were added?

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

Question 18

What are the products of the electrolysis of 1.0 M nickel sulfate solution using copper electrodes?

	Anode	**Cathode**
A.	copper ions	nickel metal
B.	oxygen gas	nickel metal
C.	oxygen gas	hydrogen gas
D.	copper ions	hydrogen gas

Question 19

Consider the following formulas:

I $[H_3O^+]^2$

II $[OH^-] \times 10^{-pH}$

III $[H_2O]$ × value of K for the self-ionisation reaction of water

Which of the above could be used to determine the self-ionisation constant (K_w) of pure water at a particular temperature?

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

Question 20

You are provided with the following information in addition to that found in the Data Booklet:

$$H_2O(s) \rightarrow H_2O(l) \qquad \Delta H = +6.00 \text{ kJ mol}^{-1}$$

$$H_2O(l) \rightarrow H_2O(g) \qquad \Delta H = +44.0 \text{ kJ mol}^{-1}$$

The energy (in kJ) required to convert 1.0 mol of ice at 0°C to 1.0 mol of steam at 100°C is closest to

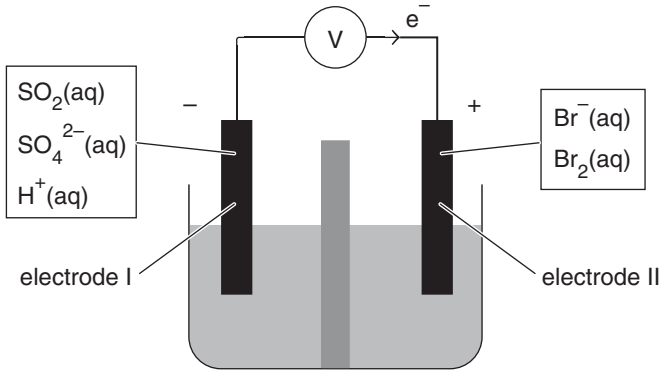
A. 15
B. 50
C. 60
D. 7500

Use the following information to answer Questions 21 and 22.

The chemical reaction represented below proceeds readily and rapidly in aqueous solution at room temperature.

$$Br_2(aq) + SO_2(aq) + 2H_2O(l) \rightarrow 2Br^-(aq) + 4H^+(aq) + SO_4^{2-}(aq)$$

It is proposed that a galvanic cell be constructed using this reaction, as shown below.



Question 21

When this cell is operating, electrode I will be the

A. anode, at which SO_2 undergoes oxidation.

B. anode, at which Br_2 undergoes oxidation.

C. cathode, at which SO_2 undergoes reduction.

D. cathode, at which Br_2 undergoes reduction.

Question 22

When the cell is operating, the pH close to electrode I would initially be expected to

A. increase.

B. decrease.

C. remain unchanged.

D. fluctuate rapidly.

Question 23

The self-ionisation reaction of water is endothermic.

If the temperature of pure water is decreased, how do the values of the pH and K_w change?

A. both values increase

B. both values decrease

C. pH increases and K_w decreases

D. pH decreases and K_w increases

Question 24

Which one of the following is a feature of a galvanic cell but **not** of an electrolytic cell?

A. Reduction occurs at the cathode, i.e. the positive electrode.

B. Oxidation and reduction reactions occur simultaneously at the electrodes.

C. Positively charged ions travel towards the anode where oxidation occurs.

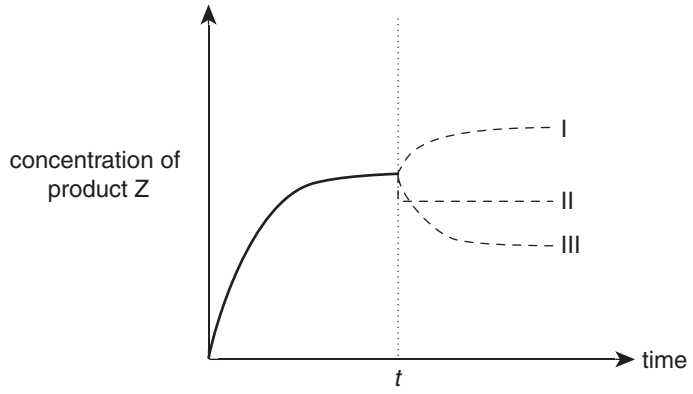
D. Loss of mass of the anode is matched by an equivalent gain of mass of the cathode.

Question 25

The gases X and Y react in a sealed container and reach equilibrium according to the following equation:

$$X(g) + Y(g) \rightleftharpoons Z(g)$$

At time *t* an effective catalyst for the reaction is introduced into the container. Three possible results of this introduction are shown on the graph below.



Which of the lines on the graph above best represents the concentration of product Z after time *t*?

A. graph I
B. graph II
C. graph III
D. none of graphs I, II or III

Question 26

Natural gas is used in some power stations to generate electricity for large cities. The gas can also be used as the energy source in a fuel cell.

Which of the following comparisons of these two energy sources is correct?

	Lower cost of a unit of electrical energy generated	**Higher efficiency in generating electrical energy**
A.	power station	power station
B.	power station	fuel cell
C.	fuel cell	power station
D.	fuel cell	fuel cell

Question 27

Which of the following comparisons of fuel cells, primary cells and secondary cells is **incorrect**?

A. In both fuel cells and secondary cells the electrodes act as catalysts, while in primary cells they do not.
B. Fuels cells must be continually provided with reactants, while primary and secondary cells contain a store of reactants.
C. Secondary cells are able to be recharged, while primary cells must be discarded when their reactants are depleted.
D. In all three cell types, chemical energy is converted to electrical energy.

Use the following information to answer Questions 28 and 29.

The following table lists a selection of standard redox potentials.

Half-reaction	E^0/V
$AuCl_4^-(aq) + 3e^- \rightarrow Au(s) + 4Cl^-(aq)$	+0.99
$Cd^{2+}(aq) + 2e^- \rightarrow Cd(s)$	–0.40
$MnO_2(s) + 4H^+(aq) + 2e^- \rightarrow Mn^{2+}(aq) + 2H_2O(l)$	+1.51
$NO_3^-(aq) + 4H^+(aq) + 3e^- \rightarrow NO(g) + 2H_2O(l)$	+0.96

Question 28

From the table above, the strongest oxidant and the strongest reductant are, respectively,

A. $MnO_2(s)$ and $Cd(s)$

B. $Cd^{2+}(aq)$ and $Mn^{2+}(aq)$

C. $Cd(s)$ and $MnO_2(s)$

D. $Mn^{2+}(aq)$ and $Cd^{2+}(aq)$

Question 29

Which set of the following chemical species is likely to produce a significant, spontaneous reaction when mixed?

A. $Mn^{2+}(aq)$ and $AuCl_4^-(aq)$

B. $Cd^{2+}(aq)$ and $NO(g)$

C. $NO(g)$ and $AuCl_4^-(aq)$

D. $NO_3^-(aq)$, $H^+(aq)$ and $Cd(s)$

Question 30

It is predicted from the electrochemical series that the voltage of the galvanic cell reaction shown below is 1.76 V.

$$2VO_2^+(aq) + 4H^+(aq) + Zn(s) \rightarrow 2VO^{2+}(aq) + 2H_2O(l) + Zn^{2+}(aq)$$

When the galvanic cell was constructed, the actual voltage was 1.89 V.

What is the most likely explanation for this discrepancy?

A. The rate of a chemical reaction cannot be predicted from the electrochemical series.

B. The conditions used to set up the galvanic cell were not standard conditions.

C. Voltage predictions from the electrochemical series have a margin of error of 5–10%.

D. A highly purified sample of zinc metal was used in the galvanic cell.

SECTION B: SHORT-ANSWER QUESTIONS

Instructions for Section B

Answer **all** questions in the spaces provided.

To obtain full marks for your responses you should

- give simplified answers with an appropriate number of significant figures to all numerical questions; 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.
- make sure chemical equations are balanced and that the formulas for individual substances include an indication of state, for example $H_2(g)$; NaCl(s).

Question 1 (11 marks)

a. i. Sucrose is a disaccharide molecule made by the reaction of a glucose molecule with a fructose molecule. Glucose has a six-membered ring structure.

Using information from the Data Booklet, draw the structure of a fructose molecule. 1 mark

ii. Glucose molecules (M = 180 g mol^{-1}) are polymerised in plants to produce the carbohydrate starch.

Calculate the molar mass of a starch polymer formed from 2000 glucose molecules. 2 marks

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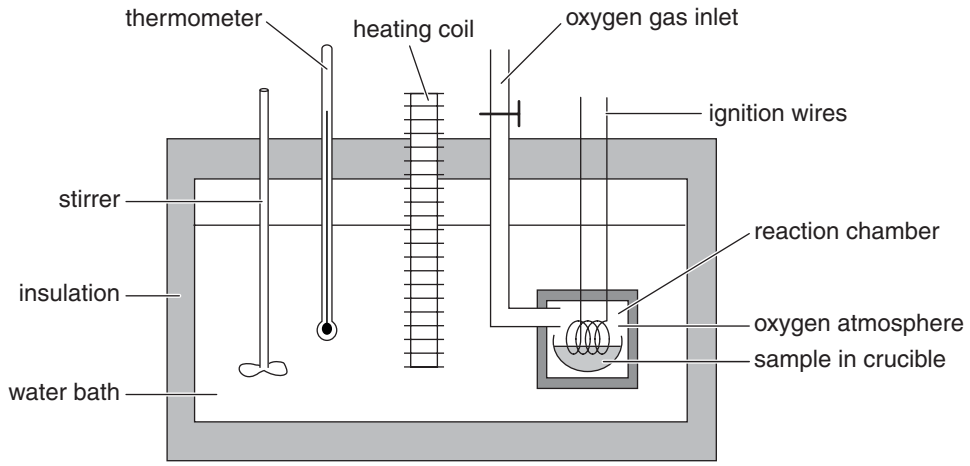
b. The energy released when a compound is oxidised can be measured using a bomb calorimeter. A simplified diagram of the device is shown below.



i. Explain the role of the insulation in the calorimeter. 1 mark

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ii. The calorimeter may be calibrated using the combustion of benzoic acid ($C_7H_6O_2$), which is known to have a molar heat of combustion of 3227 kJ mol^{-1}.

Write a balanced thermochemical equation for the complete combustion of solid benzoic acid. 2 marks

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iii. If the calorimeter is calibrated using combustion of benzoic acid, which feature shown in the diagram of the calorimeter is not needed? Explain your choice. 2 marks

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iv. When 0.142 g of sucrose (M = 342 g mol^{-1}) was burnt completely in a bomb calorimeter, the temperature increased from 21.73°C to 23.41°C.

Calculate the energy released when 1 mole of sucrose undergoes complete combustion, given that the calibration factor of the calorimeter is 1.387 kJ $°C^{-1}$. 3 marks

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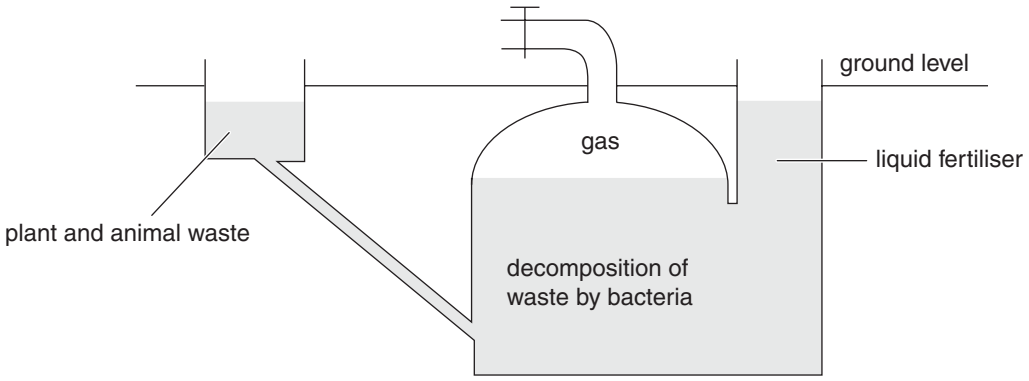
Question 2 (15 marks)

Biogas is a biochemical fuel which can be produced by the bacterial decomposition of animal and plant waste in a simple digester, as shown in the diagram below.



a. As with fermentation, the decomposition in the digester occurs in the absence of oxygen.

Why is this necessary? 1 mark

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b. Farmers can produce enough biogas for their farming energy needs, as well as for heating and cooking purposes, using small-scale digesters.

Give one benefit of using biogas in this situation rather than natural gas. 1 mark

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c. The composition of a particular sample of biogas is shown in the table below.

Component gas	CH_4	CO_2	CO	N_2
% by volume	65	26	5	4

Both methane and carbon monoxide (CO) can be used as a fuel. You are provided with the following information, in addition to that found in the Data Booklet.

$$2CO(g) + O_2(g) \rightarrow 2CO_2(g) \quad \Delta H = -466 \text{ kJ mol}^{-1}$$

Calculate the energy released when 1.0 L of biogas (at SLC) is burnt. 4 marks

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d. Depending on the type of waste used in the digester, the biogas product may have as much as 5% by volume hydrogen sulfide (H_2S) gas.

Some of the properties of hydrogen sulfide are listed in the table below.

Boiling point	–60°C
Odour	extremely offensive
Toxicity	• 20 ppm: severe irritation • 400 ppm: can cause death • 5000 ppm: rapidly fatal
Redox properties	powerful reductant
Acid/base properties	• $K_{a1} = 8.9 \times 10^{-8}$ M • $K_{a2} = 1.2 \times 10^{-10}$ M
Combustion	In excess oxygen: $2H_2S(g) + 3O_2(g) \rightarrow 2SO_2(g) + 2H_2O(g)$

i. Explain why burning biogas containing high levels of hydrogen sulfide may be harmful to the environment. 1 mark

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ii. Give a safety phase which is applicable to help limit the risks associated with using hydrogen sulfide. 1 mark

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_____

iii. Write an expression for the acidity constant K_{a2} for the second ionisation of hydrogen sulfide. 1 mark

_____

iv. Many metal cations can be precipitated as a metal sulfide when reacted with hydrogen sulfide. The hydrogen sulfide provides sulfide ions according to the equation:

$$H_2S(aq) + 2H_2O(l) \rightleftharpoons 2H_3O^+(aq) + S^{2-}(aq)$$

A high concentration of sulfide ions is needed for a successful precipitation of the metal sulfide.

In terms of Le Chatelier's principle, explain why ammonia (NH_3) solution is often added to ensure complete precipitation. 2 marks

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v. When a 10.0 L sample of biogas (at 17°C and 1 atmosphere) containing hydrogen sulfide was bubbled though a solution of excess silver ions, 1.540 g of silver sulfide (Ag_2S) was precipitated according to the equation:

$$H_2S(g) + 2Ag^+(aq) \rightarrow Ag_2S(s) + 2H^+(aq)$$

Calculate the percentage by volume of hydrogen sulfide in the biogas. 4 marks

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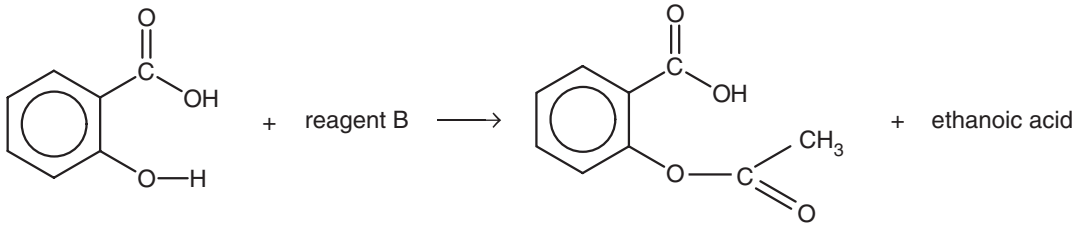
Question 3 (10 marks)

Aspirin (acetylsalicylic acid) can be synthesised in the laboratory using the following chemical reaction:



salicylic acid
(M = 138 g mol^{-1})

aspirin
(M = 180 g mol^{-1})

a. Showing all bonds, draw the structural formula of reagent B in this reaction. 1 mark

b. Both aspirin and salicylic acid are white powders. When synthesised in the laboratory, aspirin may be contaminated with some unreacted salicylic acid. In aqueous solution, salicylic acid reacts with iron(III) nitrate ($Fe(NO_3)_3(aq)$) to produce a highly coloured, violet compound. Aspirin shows no such reaction.

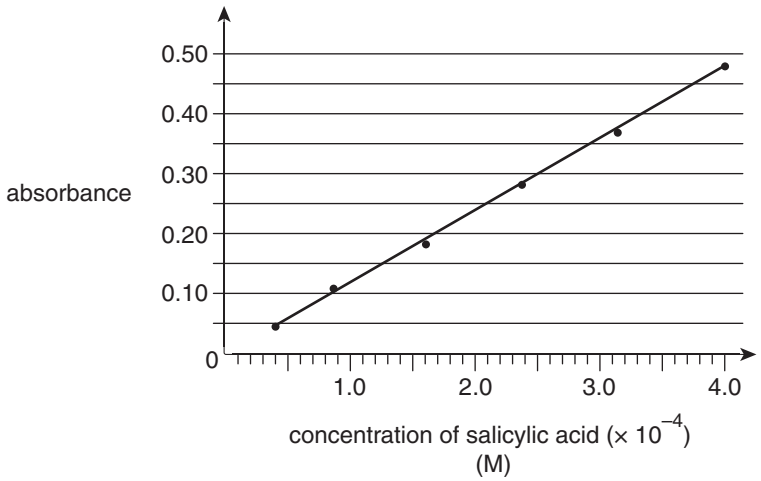
Using spectrophotometry, the percentage purity of a sample of aspirin was determined using the following steps:

Step I: A stock solution was made by dissolving salicylic acid in pure water and then making it up to 1000 mL, to produce a 0.00200 M solution.

Step II: A series of standard solutions of salicylic acid were made by pipetting set volumes of the stock solution into separate volumetric flasks, adding 0.02 M $Fe(NO_3)_3$ solution to a final volume of 50.0 mL in each flask.

Step III: The absorbance of each standard solution at 530 nm was recorded and the results were plotted to produce a calibration graph (shown below).

Step IV: A 0.298 g sample of impure aspirin prepared in the laboratory synthesis was dissolved in pure water and then made up to 100.0 mL. An aliquot of 5.00 mL of this solution was placed into a volumetric flask, 0.02 M $Fe(NO_3)_3$ solution was added to a final volume of 50.0 mL and its absorbance at 530 nm was recorded.



i. How would 530 nm be chosen as the wavelength used to read the absorbances in this experiment? 2 marks

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ii. What volume of the stock solution was used to make the 50.0 mL standard solution of concentration 1.60×10^{-4} M? 1 mark

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iii. The absorbance of the solution made in step IV is 0.15.
Calculate the mass of salicylic acid present in the 0.298 g sample of impure aspirin. 4 marks

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iv. Calculate the percentage by mass of aspirin in the sample. 2 marks

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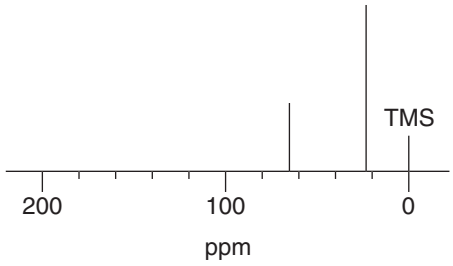
Question 4 (14 marks)

Infrared, NMR and mass spectrometers are powerful analytical instruments which enable the identity and structure of organic compounds to be determined quickly.

a. The ^{13}C NMR spectrum of an isomer of propanol is shown below.



State the systematic name of the propanol isomer which generated the ^{13}C NMR spectrum shown above. 1 mark

_____

b. **i.** Using semistructural formulas, write equations for the two reaction sequences which can be used to produce propan-1-ol from propane. *(States are not required.)* 2 marks

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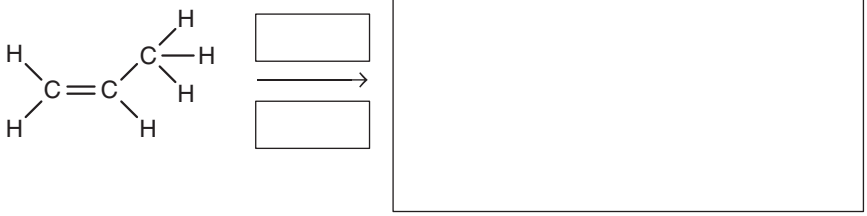
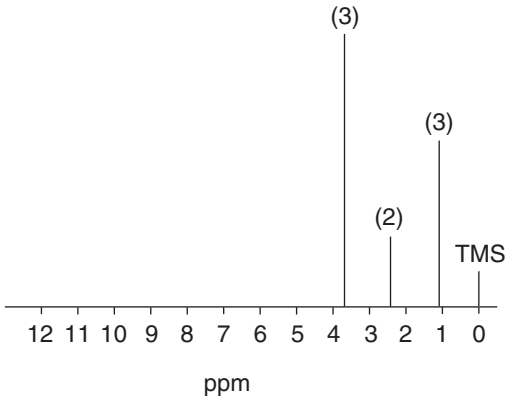
_____

ii. Complete the equation below for the reaction which can produce propan-2-ol from propene. Include a structural formula for propan-2-ol, and formulas for the two inorganic reagents needed. 3 marks



c. A low resolution ^{1}H NMR spectrum of a compound being analysed is shown below. The area under each peak is indicated by the numeral in brackets above the peaks.



i. Which of the following is most likely to be the compound being analysed? Explain your choice, including explanations for why you excluded the two incorrect choices. 3 marks

I: $CH_3CH_2CH_2CH_3$ II: $CH_3CH_2COOCH_3$ III: CH_3CH_2COOH

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ii. Explain the peak-splitting pattern expected for the peak at chemical shift 1.1 on the high-resolution ^{1}H NMR spectrum. 2 marks

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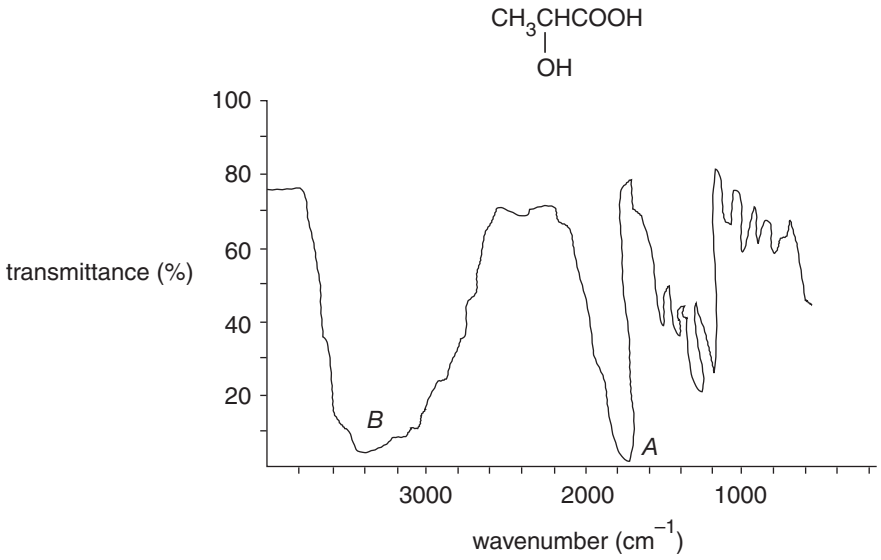
d. The structural formula and the infrared spectrum of a compound are shown below.



i. Give the systematic name of the compound. 1 mark

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ii. Explain why trough *B* is so broad. 2 marks

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Question 5 (15 marks)

Applications of equilibrium occur in natural systems and in the industrial production of chemicals.

a. The human body contains several buffers which prevent the pH of fluids from changing appreciably in different situations. A buffer is an equilibrium mixture of a weak acid and its conjugate base. An example of this is shown by the following equation:

$$H_2PO_4^-(aq) \rightarrow HPO_4^{2-}(aq) + H^+(aq) \qquad K_a(H_2PO_4^-) = 6.4 \times 10^{-8}\ M$$

i. In 5.0×10^2 mL of an aqueous solution, there is 0.250 mol each of $H_2PO_4^-$ and HPO_4^{2-} in equilibrium.

Using the value of the acidity constant, calculate the pH of the solution. 3 marks

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ii. 0.005 mol of HCl is now added to the 500 mL solution described in part **i**.
If all of the added HCl was used up when equilibrium was again established, calculate the new concentrations of $H_2PO_4^-$ and HPO_4^{2-}. 2 marks

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iii. Using the value of the acidity constant, calculate the pH of the solution in part **ii**. 2 marks

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iv. Calculate the change in pH which occurs if 0.005 mol of HCl is added to 500 mL of pure water. 2 marks

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v. Considering your answers to parts **i**, **iii** and **iv**, how effective is the $H_2PO_4^-/HPO_4^{2-}$ buffer in controlling pH changes? 1 mark

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b. Hydrogen gas is produced industrially by the steam reforming reaction:

$$CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g) \qquad \Delta H = +207 \text{ kJ mol}^{-1}$$

i. Which conditions of temperature will give the highest yield of hydrogen gas? Explain your choice. 2 marks

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ii. Discuss factors (other than yield) which may be considered by the industrial manufacturer before the conditions of temperature to be used for industrial production are chosen. 2 marks

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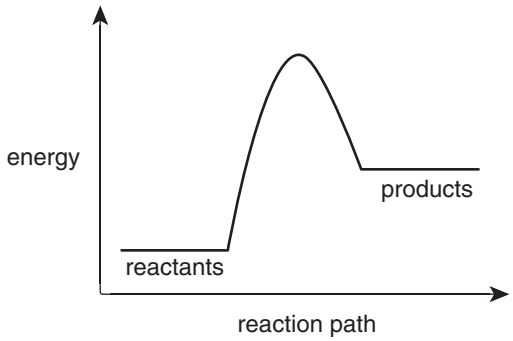
iii. The energy profile for the reaction is shown below.



Identify the **one** correct statement in the table shown below by ticking the appropriate box. 1 mark

1.	The activation energy (E_A) for the reverse reaction is larger than the E_A for the forward reaction.	
2.	There is more chemical energy in the reactants than in the products.	
3.	The enthalpy change for the reverse reaction is equal to the activation energy for the forward reaction.	
4.	For the forward reaction, more energy is taken in from the surroundings than is released to the surroundings.	
5.	Increasing the temperature of the reverse reaction will decrease the activation energy for that reaction.	
6.	The equilibrium constant for the forward reaction must be numerically larger than the equilibrium constant for the reverse reaction.	

Question 6 (10 marks)

a. The number of carbon–carbon double bonds in a long-chain carboxylic acid was determined by volumetric analysis using the following steps:

Step 1: 1.069 g of the long-chain carboxylic acid is added to a flask containing 50.0 mL of 0.591 M I_2 solution.

Step 2: The flask is shaken vigorously and then the contents are allowed to settle.

Step 3: From the aqueous layer, a 10.00 mL aliquot is taken and titrated with 0.224 M sodium thiosulfate solution using the reaction represented below.

$$I_2(aq) + 2S_2O_3^{2-}(aq) \rightarrow 2I^-(aq) + S_4O_6^{2-}(aq)$$

Step 4: The endpoint was reached using a titre of 17.85 mL of sodium thiosulfate solution.

i. Name the type of chemical reaction which occurs between the long-chain carboxylic acid and iodine. 1 mark

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ii. Calculate the amount (in mol) of iodine in the flask in step 1. 1 mark

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iii. Calculate the amount (in mol) of iodine reacting during the titration. 2 marks

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iv. Calculate the amount (in mol) of iodine reacting with the 1.069 g sample of carboxylic acid. 2 marks

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v. If the molar mass of the long-chain carboxylic acid is 328 g mol^{-1}, calculate the number of double bonds in each molecule. 2 marks

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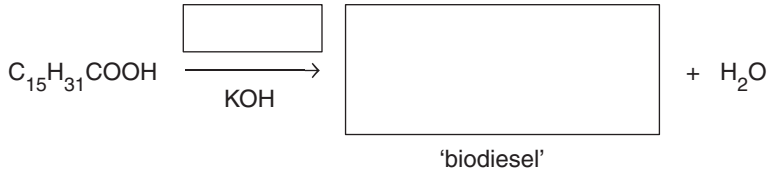
b. Palmitic acid is a long-chain carboxylic acids, also known as a 'fatty' acid. Palmitic acid is used to form biodiesel, a sustainable replacement for the diesel fuel derived from crude oil.

Complete the following equation which shows the formation of a biodiesel (a methyl ester) based on palmitic acid. 2 marks



Question 7 (6 marks)

Electrolysis is used in the industrial production of the organic chemical adiponitrile ($NC(CH_2)_4CN$). Production involves the half-equation shown below.

$$2CH_2{=}CHCN + 2H^+ + 2e^- \rightarrow NC(CH_2)_4CN$$

a. A particular manufacturing plant produces 2000 kg of adiponitrile in 24 hours.

Calculate the constant current required for this production. 3 marks

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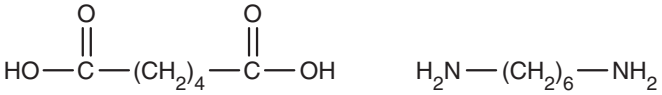
b. Adiponitrile can also be synthesised from the amino acid glutamic acid.

Draw the structure of the glutamic acid molecule as it would be found in a solution of pH 12. 2 marks

c. Adiponitrile is chemically reduced by hydrogen to form hexane-1,6-diamine, one of the two reactants used to produce the polymer nylon. The other reactant is a dioic acid. Both reactants are shown below. Nylon is produced by the formation of amide bonds between the two monomers.



Draw the organic molecule which forms when the two monomers react to produce one amide bond. 1 mark

Question 8 (9 marks)

A series of experiments was undertaken to investigate the factors affecting the rate of the reaction of hydrochloric acid with magnesium:

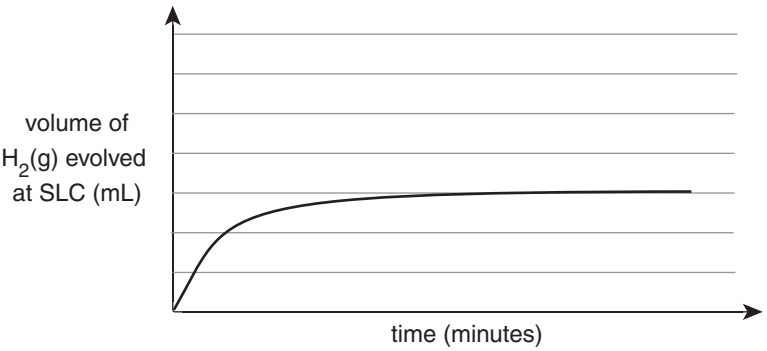
$$2HCl(aq) + Mg(s) \rightarrow MgCl_2(aq) + H_2(g)$$

Flasks containing hydrochloric acid were set up under the conditions shown in Table 1.

Table 1

Flask	Concentration of HCl(aq) (M)	Volume of HCl(aq) (mL)	Temperature of HCl(aq) (°C)
A	0.15	50.0	20
B	0.20	50.0	20
C	0.20	50.0	30
D	0.15	100.0	20

Each experiment was initiated by adding 0.080 g of cleaned magnesium ribbon. The volume of the hydrogen gas produced was measured at SLC at set intervals. The result of the experiment for Flask A is shown in the graph below.



a. Calculate the amount (in mol) of hydronium ions present in flask A after the investigation was complete. 3 marks

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b. **i.** On the axes above, sketch the expected results for Flask B and label it 'B'. 1 mark

ii. On the axes above, sketch the expected results for Flask C and label it 'C'. 1 mark

c. To investigate the effect of the surface area of a solid reactant on the rate of the same reaction, a further three flasks were set up as shown in Table 2. Each experiment was conducted as described earlier except that the magnesium was in the form shown in Table 2.

Table 2

Flask	Concentration of HCl(aq) (M)	Volume of HCl(aq) (mL)	Temperature of HCl(aq) (°C)	Mass of magnesium
E	0.15	100	20	0.080 g of Mg powder
F	0.15	50	30	0.080 g of Mg cube
G	0.20	50	20	0.20 g of Mg powder

Which flask in Table 2 would provide the most informative results on the effect of surface area on the rate of reaction when analysed in conjunction with the results from Table 1? Explain your choice. 2 marks

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d. The number of successful collisions between the reactant particles is less than 1% of the total number of collisions.

Give **two** reasons why the vast majority of collisions between reactant particles do not produce a reaction. 2 marks

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END OF QUESTION AND ANSWER BOOKLET

