Neap:

Trial Examination 2012

VCE Chemistry Unit 3

Written Examination

Question and Answer Booklet

Reading time: 15 minutes
Writing time: 1 hour 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	20	20	20	25
B Short-answer	5	5	55	65
			Total 75	Total 90

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 19 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 2012 VCE Chemistry Unit 3 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.

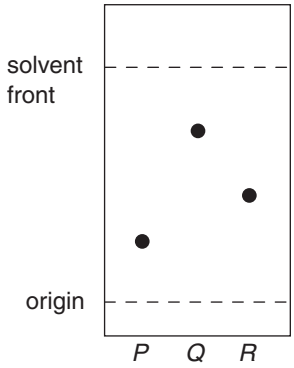
A correct answer scores 1, an incorrect answer scores 0.

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

Three components (*P*, *Q* and *R*) of a mixture were separated using thin layer chromatography (TLC). The results are shown below.



The same components are separated using column chromatography with the same stationary phase and solvent used in the TLC.

Which of the following correctly states the order of increasing retention times (R_t) for the column chromatography?

A. $P < R < Q$

B. $P < Q < R$

C. $Q < P < R$

D. $Q < R < P$

Question 2

Which of the indicators listed below would be the most suitable for use in a titration of a weak, monobasic base, with a strong, monoprotic acid?

A. Thymol blue

B. Phenolphthalein

C. Methyl red

D. Bromothymol blue

Question 3

Which of the following features do the polymers starch and cellulose have in common?

A. They are composed of carbon, hydrogen and nitrogen atoms only.

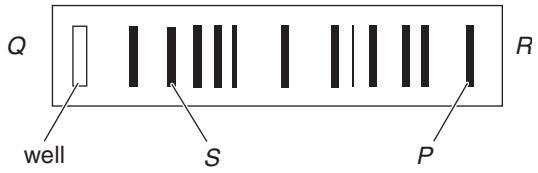
B. Ether linkages hold the constituent units to each other within the polymer chains.

C. Each polymer is formed by addition polymerisation of glucose molecules.

D. Polymerisation of 150 g of the monomer will produce 150 g of either polymer.

Question 4

Forensic science uses the technique of gel electrophoresis to separate DNA fragments. The diagram represents the result of such a separation.



The DNA fragments are loaded onto the gel in a small well.

Which of the following is correct concerning the electrophoresis process?

	End of gel connected to the positive terminal of power supply	Lower molecular mass fragment
A.	*Q*	*S*
B.	*Q*	*P*
C.	*R*	*S*
D.	*R*	*P*

Use the following information to answer Questions 5 and 6.

Fats and oils are composed of triglycerides. Triglycerides are formed by the reaction of glycerol with fatty acids. The iodine number of a fat or oil is used as a measure of its degree of unsaturation. Iodine number is expressed as the mass of iodine required to react with 100 g of the fat or oil.

Question 5

Under suitable conditions, 4.60 g of glycerol was reacted with excess linoleic acid to form a triglyceride of molar mass 878 g mol^{-1}.

Which of the following can be deduced from the information provided about this reaction?

A. The hydrolysis reactions will produce 2.70 g of water.
B. The condensation reactions will produce 2.70 g of water.
C. The hydrolysis reactions will produce 0.90 g of water.
D. The condensation reactions will produce 0.90 g of water.

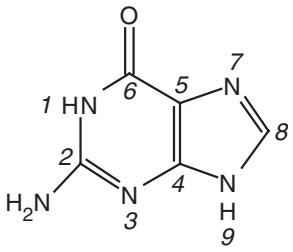
Question 6

The iodine number of the oil formed when glycerol reacts with excess linoleic acid is in the range

A. 0–50.
B. 51–100.
C. 101–150.
D. 151–200.

Question 7

The diagram below shows the structure of the guanine molecule with various positions numbered 1 to 9. The numbers in the following table refer to these numbered positions on the guanine structure.



Which of the following shows the position where the guanine molecule bonds to a deoxyribose molecule in the DNA polymer, and a position where the guanine hydrogen bonds to its complementary base pair in the double stranded DNA structure?

	Position of bond to the deoxyribose molecule	Position of hydrogen bond with the complementary base pair
A.	3	7
B.	3	1
C.	9	7
D.	9	1

Question 8

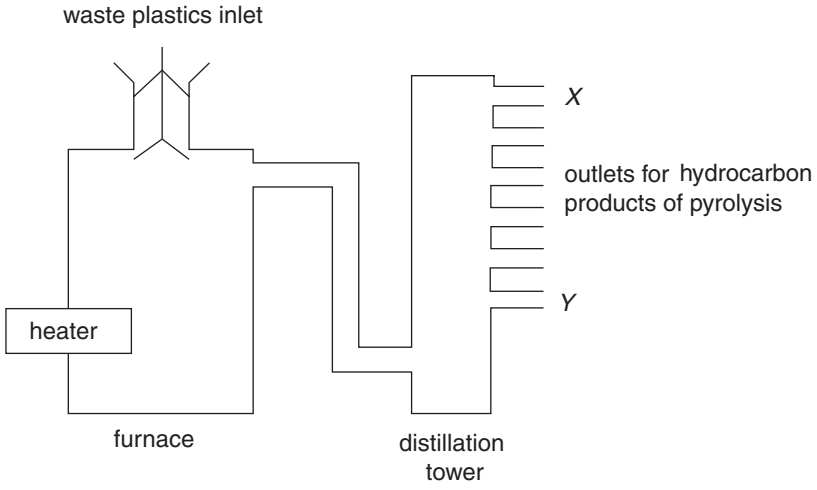
The concentration of copper ions in a blue-coloured copper(II) sulfate solution can be measured by UV-visible spectroscopy using a suitable wavelength. Copper ion concentration may also be determined using atomic spectroscopy. When the copper(II) sulfate solution is sprayed into a flame, a green colour is produced.

Which of the following is a correct pair of statements concerning the spectroscopic analysis of copper(II) sulfate samples?

	Wavelength of light to be used in UV-visible spectroscopy	Electron movement causing the green flame colour in atomic spectroscopy
A.	600 nm (orange)	Electrons moving from an excited state to the ground state
B.	450 nm (blue)	Electrons moving from an excited state to the ground state
C.	600 nm (orange)	Electrons moving from ground state to an excited state
D.	450 nm (blue)	Electrons moving from ground state to an excited state

Use the following information to answer Questions 9 and 10.

Waste plastics can be recycled using the process of pyrolysis. Heating the waste plastics to 600°C in a furnace in the absence of air causes the polymers to be broken down. The hydrocarbons generated can be reused after separation. The simplified diagram below shows the process.



Question 9

The process of pyrolysis is conducted in the absence of air because

A. better separation of the products from the polymers is achieved.

B. the strength of bonds to be broken is weaker in the presence of air.

C. unwanted products would form if air was admitted to the furnace.

D. a much higher temperature would be required to break the polymers in the presence of air.

Question 10

Which of the following statements about the separation process in the tower is **incorrect**?

A. The strength of the dispersion forces between the molecules collected at *X* is greater than those collected at *Y.*

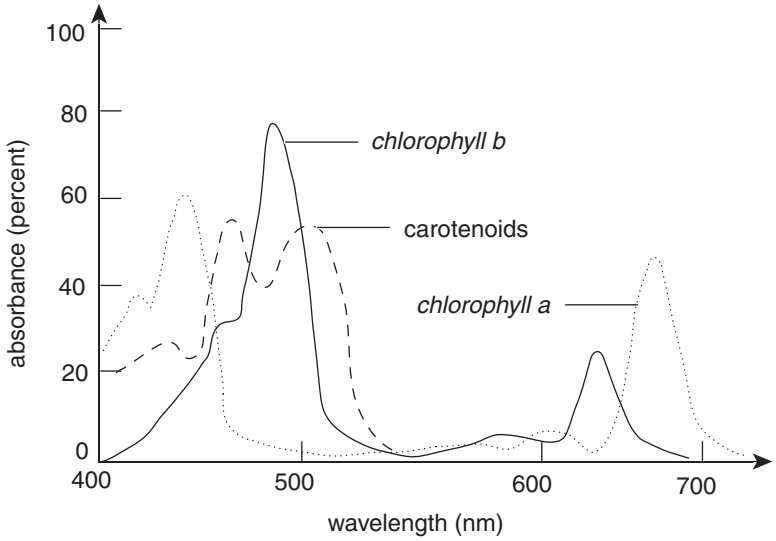
B. There is a gradual decrease in temperature in the tower with the temperature at the top being lower than the temperature at the bottom.

C. The product removed at *X* is likely to contain molecules of a number of different compounds.

D. Boiling points of compounds removed from the lowest part of the tower are higher than those of compounds removed higher in the tower.

Question 11

The photosynthetic pigments in plants fall into two categories: chlorophylls and carotenoids. Both pigment types are large, complex organic molecules with molar masses in the range 500–900 g mol^{-1}. In order to investigate the concentration of *chlorophyll b* in a plant extract, the pigments are first separated using chromatography, and then the separated pigments are subjected to analysis by UV-visible spectrometry. The graph below shows the absorption spectra of various photosynthetic pigments.



Which of the following shows the best combination of chromatographic technique and suitable wavelength for use in the UV-visible spectroscopic analysis of *chlorophyll b*?

	Chromatographic technique	Wavelength for UV-visible analysis
A.	HPLC	480 nm
B.	HPLC	630 nm
C.	GLC	480 nm
D.	GLC	630 nm

Question 12

When the compound CH_3CHO is added to water, an incomplete reaction occurs which produces some of another compound, $CH_3CH(OH)_2$. When the absorbance of a pure sample of each compound is measured at 290 nm, it is found that CH_3CHO absorbs strongly whereas $CH_3CH(OH)_2$ has no absorbance. In an experiment, some pure CH_3CHO is dissolved in water and the absorbance of the solution at 290 nm is read at regular intervals.

Consider the following statements:

I As the experiment progressed, the absorbance of the solution increased.

II The final three readings of the absorbance may have the same value.

III The initial absorbance reading was greater than zero.

Which of the following statements are consistent with the information provided?

A. I only

B. I and II only

C. II and III only

D. I, II and III

Use the following information to answer Questions 13 and 14.

The base sequence in a single strand of DNA can be represented by letters. I to III below show the base sequence for three single strand DNA fragments.

I GTAACGA

II ATCGTAT

III CGTTACG

Question 13

The base sequence of the complementary strand of DNA for fragment I is

A. TGCCATC

B. ACGGTAG

C. CATTGCT

D. AGCAATG

Question 14

Fragments I, II and III were used to produce double-stranded DNA. These pieces of DNA were then heated gradually in individual experiments.

The double-stranded DNA made from which fragment would be separated at the lowest temperature?

A. Fragment I

B. Fragment II

C. Fragment III

D. As each piece of DNA has the same number of base pairs, all will separate at the same temperature.

Use the following information to answer Questions 15 and 16.

The synthesis of aspirin ($C_9H_8O_4$; M = 180 g mol^{-1}) can be completed using the reaction shown:

$$2C_7H_6O_3(s) + C_4H_6O_3(l) \rightarrow 2C_9H_8O_4(s) + \text{Compound } Y$$

In a particular synthesis, 25.0 g of ethanoic anhydride ($C_4H_6O_3$; M = 102 g mol^{-1}) reacted with salicylic acid (M = 138 g mol^{-1}) to produce 88.3 g of aspirin.

Question 15

Compound *Y* can be identified as

A. an alkene.

B. water.

C. an alcohol.

D. a carboxylic acid.

Question 16

Which of the following statements about any reactant added in excess is correct?

A. Ethanoic anhydride must be in excess.

B. Salicylic acid must be in excess.

C. Both reactants must be completely used up in the synthesis.

D. There is not enough information provided to determine which reactant was added in excess.

Question 17

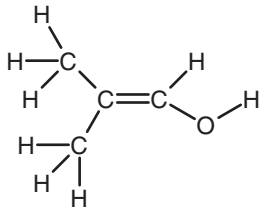
Which of the structures shown below is consistent with the formula, infrared (IR) and nuclear magnetic resonance (NMR) spectroscopic data provided?

Formula C_4H_8O

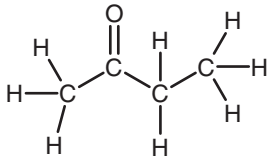
IR Sharp band near 1720 cm^{-1}

^1H NMR triplet, singlet and quartet peaks, with integration ratios 3:3:2 respectively

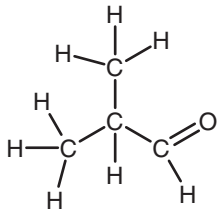
A.



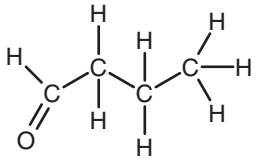
B.



C.



D.



Question 18

The enzyme creatine phosphokinase (CPK) is present in the cells of human heart muscle, skeletal muscle and the brain and can be used as a 'marker for disease'.

Consider the following statements about CPK:

I CPK would contain these elements: C, H, O, N, P and possibly S.

II A person suffering a heart attack would have elevated levels of CPK in the blood.

III Doctors could diagnose a heart attack solely on the evidence of CPK levels.

IV It is likely that there will be minor levels of CPK in the blood of a healthy person who is not suffering serious injury or disease.

Which of the following statements about CPK are accurate?

A. I and II only

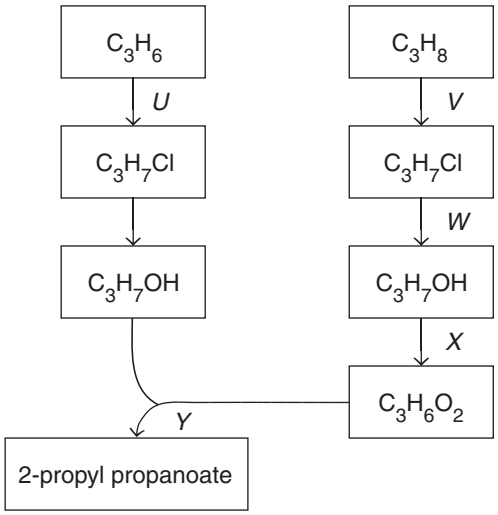
B. I and III only

C. II and IV only

D. II, III and IV only

Use the following information to answer Questions 19 and 20.

The diagram below represents a series of organic reactions used in the synthesis of a sample of 2-propyl propanoate.



Question 19

Which of the following represents suitable reagents and conditions to use in order to carry out reactions *U* and *X*?

	Reagents/conditions for reaction *U*	**Reagents/conditions for reaction *X***
A.	HCl	$Cr_2O_7^{2-}(aq)/H^+(aq)$
B.	HCl	$H_2O(l)/H^+(aq)$
C.	Cl_2/300°C	$Cr_2O_7^{2-}(aq)/H^+(aq)$
D.	Cl_2/300°C	$H_2O(l)/H^+(aq)$

Question 20

Reactions *V*, *X* and *Y* represent which types of reactions?

	Reaction *V*	**Reaction *X***	**Reaction *Y***
A.	substitution	oxidation	esterification
B.	substitution	condensation	oxidation
C.	chlorination	oxidation	oxidation
D.	chlorination	condensation	esterification

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

The compound ethanol has many important applications in industry and society, including being used in alcoholic drinks and as a biochemical fuel.

a. With the aid of a balanced chemical equation, outline how ethanol is produced as a biochemical fuel.

_____

_____

_____

2 marks

b. Ethanol is produced industrially using ethene as a reactant.

Write the chemical equation for the formation of ethanol from ethene. Symbols of state are not required, but reaction conditions must be specified.

_____

_____

2 marks

c. The ethanol concentration of a liquid is usually determined in the laboratory using redox volumetric analysis. Other forms of analysis may also be used.

i. In the iodoform reaction, a precipitate of triiodomethane (CHI_3) forms when ethanol is heated with a solution of potassium iodide and a few drops of sodium hypochlorite.

Construct a flow chart showing the main steps in determining the ethanol concentration of a solution by gravimetric analysis using the iodoform reaction.

_____

_____

_____

_____

_____

_____

_____

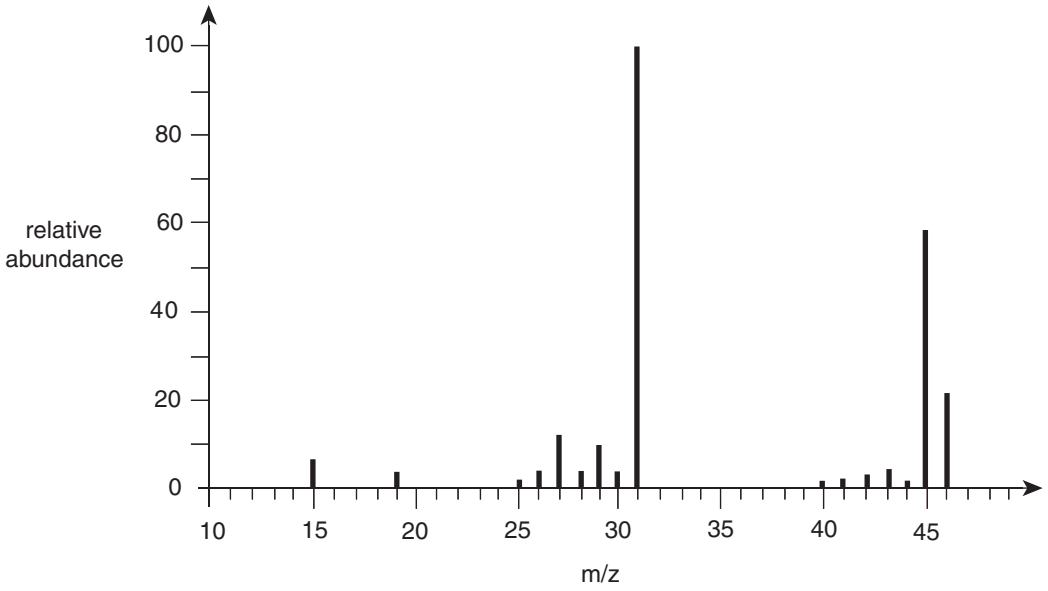
ii. Which of the following forms of analysis could be used to determine the ethanol concentration of a sample? (Indicate your choice or choices by placing a tick next to each appropriate analytical technique.)

Analytical technique	Tick if appropriate for ethanol concentration determination
mass spectroscopy	
UV-visible spectroscopy	
NMR spectroscopy	
thin layer chromatography	
gas chromatography	

2 + 1 = 3 marks

d. The ethanol molecule is isomeric with the compound dimethyl ether, CH_3OCH_3.

The mass spectrum of ethanol is shown below.



i. Write the formula of the chemical species which accounts for the peak at m/z of 31.

_____

ii. What feature would be present in the mass spectra of both ethanol and dimethyl ether?

_____

_____

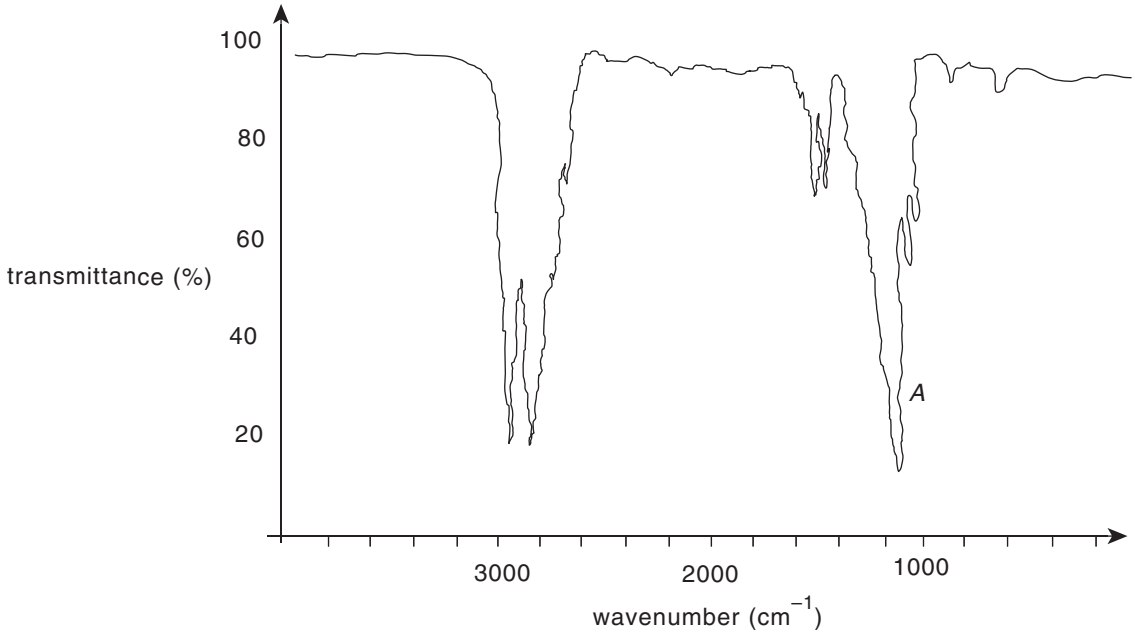
iii. State one way in which the mass spectrum of dimethyl ether would differ from that of ethanol.

_____

_____

1 + 1 + 1 = 3 marks

e. Using an aluminium oxide catalyst, ethanol can be dehydrated to produce different products, depending on the temperature of the reaction. At 360°C, ethene is produced. At 260°C, the reaction produces diethyl ether ($C_2H_5OC_2H_5$). These two compounds can be distinguished by examining their infrared (IR) spectra. The IR spectrum of diethyl ether is shown below.



i. Which bond corresponds to the absorption characteristic marked *A* on the IR spectrum above?

_____

ii. Which feature is missing from the IR spectrum of diethyl ether which would be present in the IR spectrum of ethene?

_____

_____

1 + 1 = 2 marks
Total 12 marks

Question 2

One important aspect in the design and synthesis of medicines is to determine the structure of the proteins which are being targeted. A crucial part of this process is establishing the amino acid sequence of the protein.

a. To determine the amount of each of the amino acids in a protein, a sample of the protein is initially heated with 6 M hydrochloric acid to 110°C for 24 hours. This acid digestion method breaks the linkages between the amino acid units in the protein chain.

i. Name the general type of reaction used in this process of breaking linkages in the polymer chain.

_____

ii. The amino acid alanine is present in the resultant solution when a particular protein undergoes acid digestion.

Draw the structure of alanine, showing all bonds, as it would appear in the resultant solution.

1 + 2 = 3 marks

b. The acid digestion of proteins described is more efficient when smaller peptides are utilised. The enzyme trypsin can be used to break long protein chains into smaller lengths, as shown in the table below.

Enzyme	Location of cleavage of the protein chain
Trypsin	Linkage on carboxyl side of Lys or Arg

i. For the polypeptide represented below, how many peptides would be produced if trypsin digestion was used?

H_2N – Ala – Trp – Arg – His – Cys – Lys – Trp – Lys – Ser – Phe – Asn – Gly – COOH

_____

ii. In terms of the structure of the enzyme trypsin, explain why the linkage on the carboxyl side of Lys is cleaved by the enzyme but **not** the linkage on the amine side of Lys.

_____

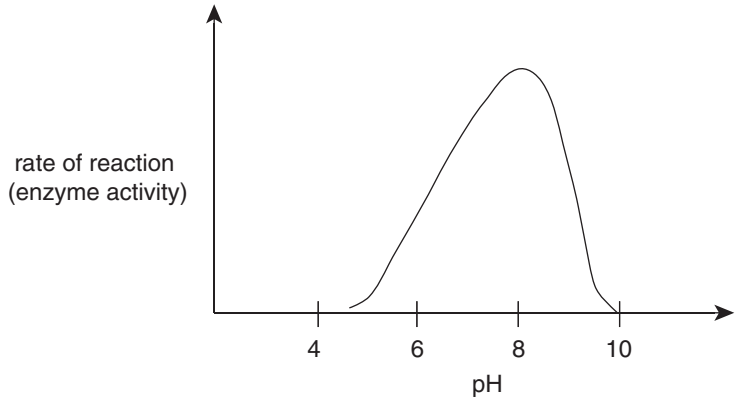
_____

_____

_____

_____

iii. The variation in enzyme activity of trypsin with pH is shown below.



Why does changing the pH from the optimum affect the activity of the enzyme?

_____

_____

_____

_____

iv. Chemical industries which supply trypsin to laboratories recommend that the enzyme be stored at temperatures below –20°C and at pH 3.

Explain why these precautions are necessary.

_____

_____

_____

1 + 2 + 2 + 1 = 6 marks

c. After the linkages in a polypeptide have been broken, the individual amino acids can be separated by column chromatography. A non-polar stationary phase is used in conjunction with a polar mobile phase.

i. Which of the amino acids listed below would have the longest retention time in this column chromatography? Circle your choice.

Aspartic acid Isoleucine Serine

ii. Explain your choice in part **i**.

_____

_____

_____

_____

1 + 2 = 3 marks
Total 12 marks

Question 3

A chemical industry involved in applying protective metal coatings produces large volumes of waste liquid containing $Cr^{3+}(aq)$ and $CrO_4^{2-}(aq)$ ions. These ions must be removed before disposal of the waste liquid as they pose human health and environmental hazards. The $CrO_4^{2-}(aq)$ ions are first converted to $Cr^{3+}(aq)$ ions. All $Cr^{3+}(aq)$ ions are then removed from the liquid by precipitation.

a. **i.** To ensure the efficient use of chemicals, the concentration of $CrO_4^{2-}(aq)$ ions in the waste liquid is determined by a redox titration with hydrogen peroxide (H_2O_2) solution. The reaction occurs according to the equation:

$$2CrO_4^{2-}(aq) + 10H^+(aq) + 3H_2O_2(aq) \rightarrow 2Cr^{3+}(aq) + 8H_2O(l) + 3O_2(g)$$

Write the partial redox equation for the reduction reaction.

_____

ii. 25.0 mL aliquots of the waste liquid were titrated with 0.0341 M hydrogen peroxide solution. The average titre was 18.95 mL.

Calculate the molarity of CrO_4^{2-} ions in the waste liquid.

_____

_____

_____

_____

1 + 3 = 4 marks

b. The initial concentration of $Cr^{3+}(aq)$ ions in the waste liquid was 1.5×10^{-3} M.

5.0×10^3 L of the waste liquid was treated to convert $CrO_4^{2-}(aq)$ ions to $Cr^{3+}(aq)$ ions. All of the Cr^{3+} ions in the 5.0×10^3 L waste were then precipitated according to the equation:

$$Cr^{3+}(aq) + 3OH^-(aq) \rightarrow Cr(OH)_3(s)$$

Calculate the mass of $Cr(OH)_3$ produced from the 5.0×10^3 L of waste liquid.

_____

_____

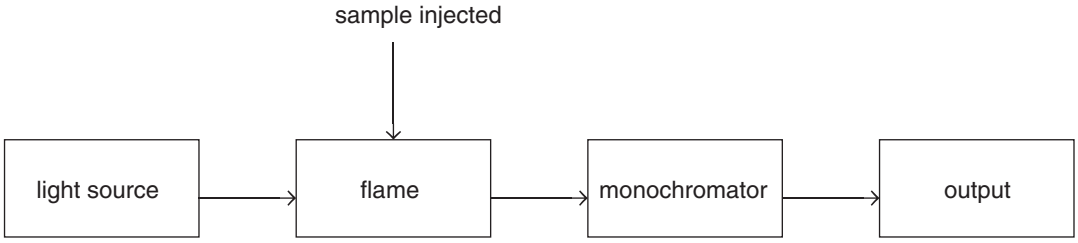
_____

_____

_____

3 marks

c. Environmental protection agencies use atomic absorption spectroscopy (AAS) to determine the concentration of chromium ions in a city's water supply. The main components of the AAS instrument are shown below.



i. Suggest a reason why these analyses are conducted using AAS rather than by the gravimetric and volumetric methods outlined in parts **a** and **b**.

_____

_____

_____

ii. The water contains numerous other metal ions.

Why will these other ions not interfere with the analysis of chromium ions by AAS?

_____

_____

iii. Explain what happens to the chromium ions when the water sample is injected into the flame.

_____

_____

_____

iv. Calibration of the AAS instrument revealed the following relationship:

$$\text{Molarity of chromium ions} = \text{Absorbance} \times 1.52 \times 10^{-5}$$

One water sample contained 0.060 mg L^{-1} chromium ions.

What absorbance reading would be expected for this sample?

_____

_____

_____

1 + 1 + 1 + 2 = 5 marks
Total 12 marks

Question 4

Compound *A* is an ester composed of 48.6% carbon and 8.1% hydrogen by mass.

a. **i.** Determine the empirical formula of Compound *A*.

_____

_____

_____

_____

_____

ii. When 5.33 g of Compound *A* is vaporised, it occupies 2.22 L at 100°C and 1.00×10^5 Pa.
Determine the molecular formula of compound *A*.

_____

_____

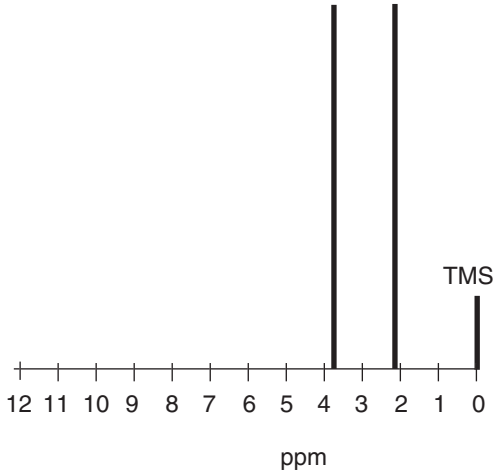
_____

_____

_____

2 + 3 = 5 marks

b. The proton NMR spectrum of Compound *A* is shown below.



i. The outputs at 2.1 ppm and 3.7 ppm are both singlets.
What information does this provide about the structure of Compound *A*?

_____

_____

ii. The relative peak area for the outputs is 1:1.
What information does this provide about the structure of Compound *A*?

_____

_____

1 + 1 = 2 marks

c. The ester linkage in Compound *A* can be broken by boiling in alkaline conditions:

$$\text{Compound } A + \text{NaOH} \rightarrow CH_3COONa + \text{Compound } B$$

The properties of some of the compounds involved are shown in the table below.

Compound	Appearance at room temperature	Melting point (°C)	Solubility in 100 g of water at 20°C	Electrical conductivity of aqueous solution
A	liquid	–98	less than 1 g	negligible
CH_3COONa	white solid	324	46 g	high
B	liquid	–97.5	totally miscible	negligible

i. In terms of structure and bonding, account for the difference in solubilities of Compound *A* and Compound *B*.

_____

_____

_____

_____

ii. In terms of structure and bonding, account for the difference in electrical conductivity of aqueous solutions of CH_3COONa and Compound *B*.

_____

_____

_____

_____

2 + 2 = 4 marks
Total 11 marks

Question 5

Limestone is composed largely of calcium carbonate, $CaCO_3$. The percentage by mass of $CaCO_3$ in a limestone sample was determined by adding 40.00 mL of a 1.003 M HCl solution to 1.69 g of the crushed limestone. The resulting solution was heated to drive off the evolved carbon dioxide. The amount of remaining, unreacted HCl was determined by titration with a 0.5011 M NaOH solution. A titre of 14.2 mL was required.

a. Write an equation to represent the reaction of the $CaCO_3$ with HCl solution.

_____

2 marks

b. **i.** Calculate the amount (in mol) of HCl reacting with the NaOH solution.

_____

_____

ii. Calculate the amount (in mol) of HCl reacting with the $CaCO_3$ in the limestone sample.

_____

_____

_____

iii. The percentage by mass of $CaCO_3$ in the limestone sample may be determined using the expression shown below.

$$\%\ CaCO_3 \text{ in the limestone sample} = 0.5 \times n(\text{HCl reacting}) \times 100.1 \times \frac{100}{1.69}$$

What does the figure of 100.1 in this expression represent?

_____

1 + 2 + 1 = 4 marks

c. Explain why it was necessary to drive off the evolved carbon dioxide before conducting the titration.

_____

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1 mark

d. Explain why the indirect titration method was used in this analysis rather than the direct titration of the $CaCO_3$ with HCl.

_____

_____

1 mark

Total 8 marks

END OF QUESTION AND ANSWER BOOKLET