Neap:

Trial Examination 2009

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	6	6	50	65
			Total 70	Total 90

Students are permitted to bring into the examination room: pens, pencils, highlighters, erasers, sharpeners, 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 17 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 2009 VCE Chemistry Unit 3 Written Examination.

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Neap:

Trial Examination 2009

VCE Chemistry Unit 3

Written Examination

Multiple-choice Answer Sheet

Student's Name: _____

Teacher's Name: _____

Instructions

Use a **pencil** for **all** entries. If you make a mistake, **erase** the incorrect answer – **do not** cross it out.
Marks will **not** be deducted for incorrect answers.
No mark will be given if more than **one** answer is completed for any question.

All answers must be completed like **this** example: [A] [B] [C] [D]

Use pencil only

1	A	B	C	D
2	A	B	C	D
3	A	B	C	D
4	A	B	C	D
5	A	B	C	D
6	A	B	C	D
7	A	B	C	D
8	A	B	C	D
9	A	B	C	D
10	A	B	C	D

11	A	B	C	D
12	A	B	C	D
13	A	B	C	D
14	A	B	C	D
15	A	B	C	D
16	A	B	C	D
17	A	B	C	D
18	A	B	C	D
19	A	B	C	D
20	A	B	C	D

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 mark will be given if more than one answer is completed for any question.

Question 1

When performing a gravimetric analysis experiment to determine the salt content of a dried soup sample a student obtained a result that was lower than expected.

A possible explanation for this incorrect result is that

A. the precipitate was not fully dried before weighing.

B. the precipitate was not washed prior to drying and weighing.

C. insufficient precipitating agent was added.

D. other ions were present in the soup sample that also reacted with the precipitating agent.

Question 2

The fatty acid, erucic acid, is found in a variety of plants, particularly in members of the *Brassica* family such as broccoli. It has the molecular formula $C_{22}H_{42}O_2$.

Based on its molecular formula it can be concluded that erucic acid is

A. a saturated fatty acid.

B. a monounsaturated fatty acid.

C. a polyunsaturated fatty acid.

D. an essential fatty acid.

Question 3

Glucocorticoid is a member of a class of compounds known as corticosteroids and is used in the treatment of itching, swelling and redness of the skin. It is a large and complex molecule of formula $C_{22}H_{29}FO_4$.

The analytical instrument **least** useful in determining the structure of glucocorticoid is the

A. infrared spectrometer.

B. ^1H nuclear magnetic resonance spectrometer.

C. mass spectrometer.

D. high performance liquid chromatograph.

Question 4

Which of the following organic compounds does **not** contain only five carbon atoms per molecule?

A. 2-methylpentan-3-ol

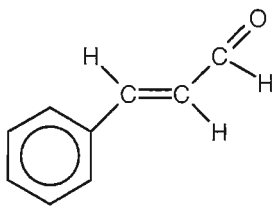
B. methyl butanoate

C. pentanoic acid

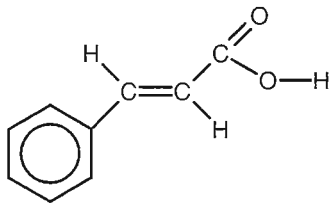
D. 2,2-dimethylpropanoic acid

Questions 5 to 7 refer to the following information.

Cinnamaldehyde (C_9H_8O) is the active ingredient in the spice cinnamon, and gives this spice its characteristic flavour and scent. It is derived from the bark of the cinnamon tree and has the structural formula shown below. When ingested into the human body, cinnamaldehyde is converted to cinnamic acid, which is excreted from the body in urine. The structural formula of cinnamic acid is also shown below.



cinnamaldehyde



cinnamic acid

Question 5

The concentration of cinnamaldehyde in a commercial solution used in baking is 32 mg L^{-1}.

This concentration is equivalent to

A. 0.32 g L^{-1}

B. 0.0024 M

C. 0.0032% m/V

D. 3.2 mg mL^{-1}

Question 6

In the conversion of cinnamaldehyde to cinnamic acid the cinnamaldehyde is acting as

A. an acid.

B. a base.

C. an oxidant.

D. a reductant.

Question 7

The key difference between the infrared spectra of cinnamaldehyde and cinnamic acid is that cinnamic acid

A. has a sharp absorbance peak at close to 1700 cm^{-1} but cinnamaldehyde does not.

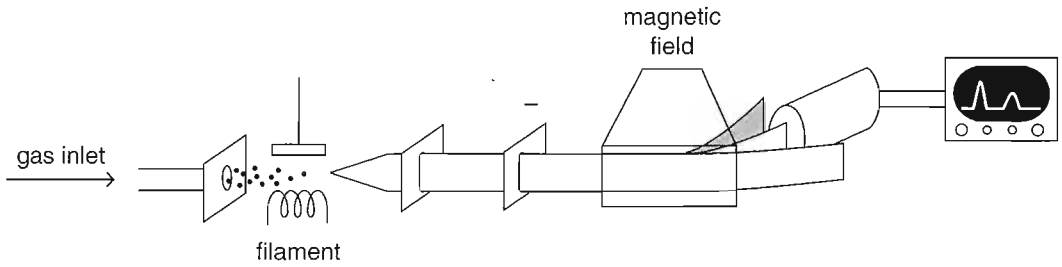
B. has a broad absorbance peak at around 3100–3300 cm^{-1} but cinnamaldehyde does not.

C. has many more peaks in the 'fingerprint region' below 1400 cm^{-1} than cinnamaldehyde does.

D. has no significant peak around 1620 cm^{-1} while cinnamic acid does.

Question 8

The schematic diagram below represents a mass spectrometer.



The roles of the filament and magnetic field respectively are to

A. atomise the gas sample by bombarding it with an electron beam and then separate the particles such that those with the highest mass-to-charge ratio (m/z) bend the least.

B. atomise the gas sample by bombarding it with an electron beam and then separate the particles such that those with the highest mass-to-charge ratio (m/z) bend the most.

C. ionise the gas sample by removing one or more electrons with an electron beam and then separate the particles such that those with the highest mass-to-charge ratio (m/z) bend the least.

D. ionise the gas sample by removing one or more electrons with an electron beam and then separate the particles such that those with the highest mass-to-charge ratio (m/z) bend the most.

Question 9

Consider a section of double-stranded DNA.

If A represents the number of adenine base units in the section of DNA, T the number of thymine base units, C the number of cytosine base units, and G the number of guanine base units, which of the following expressions is correct?

A. $\frac{A}{G} = 1$

B. $\frac{A + T}{G + C} = 1$

C. $\frac{A - T}{G - C} = 1$

D. $\frac{A + C}{T + G} = 1$

Question 10

A sample containing an isomer of butene is reacted with chlorine in the presence of a suitable catalyst.

Which of the following is **not** a possible product of the reaction?

A. 1,2-dichlorobutane

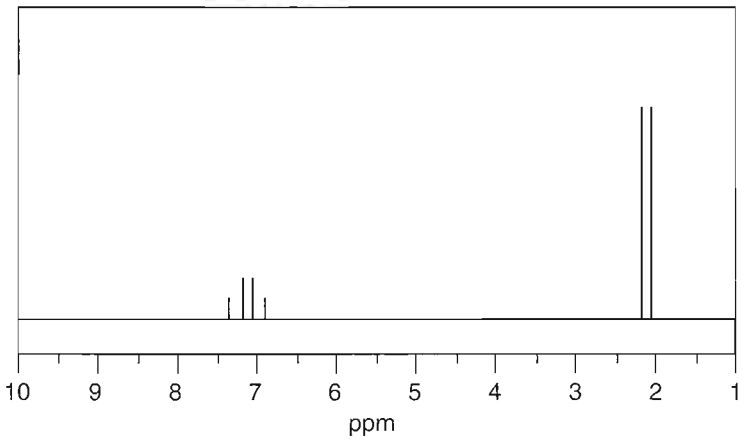
B. 1,3-dichlorobutane

C. 2,3-dichlorobutane

D. 1,2-dichloro-2-methylpropane

Question 11

The high resolution ^1H NMR spectrum of a molecule is shown below.



The molecule is most likely to be

A. chloroethane.

B. chloroethene.

C. 1,1-dichloroethane.

D. 1,2-dichloroethane.

Question 12

20.00 mL of 0.10 M HCl is pipetted into a conical flask and the solution is titrated with a 0.10 M NH_3 solution.

A suitable choice of indicator for this titration and the colour change observed at the endpoint would be

A. methyl red changing from red to yellow.

B. methyl red changing from yellow to red.

C. thymol blue changing from red to yellow.

D. thymol blue changing from yellow to red.

Question 13

Each of the following statements refers to a number.

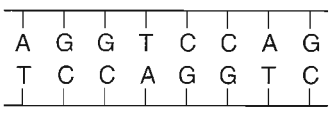
For which of the statements is that number less than 20?

A. The number of different alpha-amino acids used in the synthesis of proteins.

B. The number of sugar-phosphate bonds forming when twenty nucleotides undergo condensation reactions to form a section of DNA.

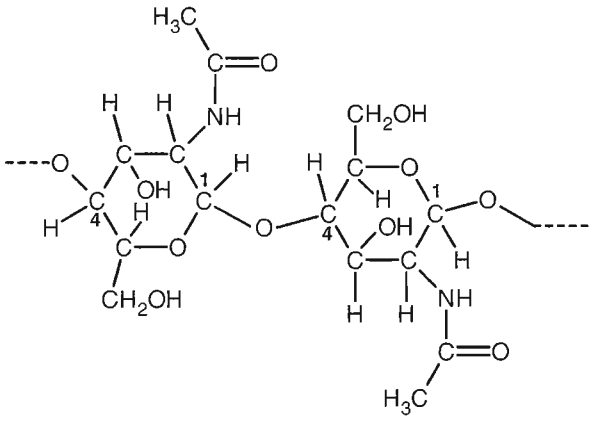
C. The minimum number of nucleotides needed to encode the instructions for a segment of protein containing seven amino acids.

D. The total number of hydrogen bonds formed between the strands of DNA shown in the diagram below. (The letters A, C, T and G represent the bases adenine, cytosine, thymine and guanine respectively, and the horizontal lines represent a sugar-phosphate backbone.)



Question 14

Chitin is a long-chain polymer of *N*-acetylglucosamine ($C_8H_{15}O_6N$) and is the structural material found in the shells of crabs, lobsters and many insects. The *N*-acetylglucosamine monomers combine in a very similar way to that of glucose molecules in cellulose, with a link occurring between the C_1 and C_4 atoms of the six-membered rings, as shown below.



Given that a particular chitin macromolecule is made up of 317 monomer units, it can be described as

A. an addition polymer with a molar mass of 70 057 g mol^{-1}.

B. a condensation polymer with a molar mass of 70 057 g mol^{-1}.

C. an addition polymer with a molar mass of 64 369 g mol^{-1}.

D. a condensation polymer with a molar mass of 64 369 g mol^{-1}.

Question 15

0.351 g of a compound was found to occupy a volume of 334 mL at a pressure of 780 mmHg and a temperature of 30°C.

Which of the following is the compound most likely to be?

A. methane

B. ethyne

C. carbon dioxide

D. beryllium oxide

Question 16

DNA fingerprinting using gel electrophoresis is a powerful tool used by law agencies around the world.

Which of the following statements about this technique is **incorrect**?

A. The entire sequence of base pairs in a suspect's DNA sample must be compared with that of a crime scene sample to ensure that the samples have a high likelihood of matching.

B. If the DNA obtained from a sample is insufficient for analysis it can be replicated using the polymerase chain reaction (PCR) process.

C. An individual will produce a different pattern of bands on their DNA profile depending on which restriction enzymes are used in the procedure.

D. Once DNA fragments have been separated using gel electrophoresis they must be further treated before a fingerprint can be developed for sample comparison.

Question 17

In which of the following reactions would you expect more than two products to form?

A. the condensation of methanol and ethanoic acid

B. the acid catalysed hydrolysis of but-2-ene

C. the chlorination of ethane in the presence of sunlight

D. the catalysed addition of hydrogen bromide to ethene

Question 18

Benzene typically undergoes

A. combustion and substitution reactions.

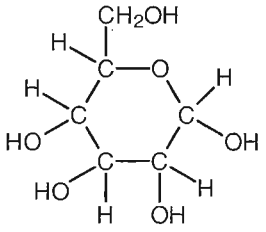
B. combustion and addition reactions.

C. condensation and substitution reactions.

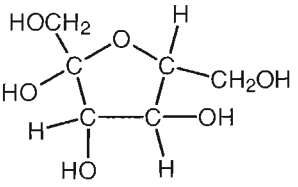
D. condensation and addition reactions.

Question 19

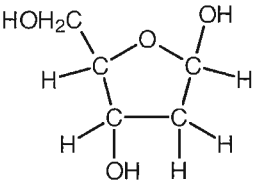
The structural formulas for four sugar molecules (identified only as *W* to *Z*) are shown below.



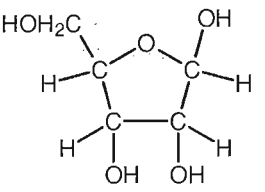
W



X



Y



Z

Which of the following correctly identifies the sugar molecules which could be produced by the hydrolysis of starch and the hydrolysis of a DNA nucleotide respectively?

A. *W* and *Y*

B. *W* and *Z*

C. *X* and *Y*

D. *X* and *Z*

Question 20

A compound known to be one of the four nitrogen bases found in DNA has the following percentage mass composition: 43.2% carbon, 4.50% hydrogen, 37.8% nitrogen and 14.5% oxygen.

The nitrogen base is

A. adenine.

B. thymine.

C. guanine.

D. cytosine.

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

a. Selenium dioxide (SeO_2) is an important reagent in organic syntheses, as it is both an oxidant and weakly acidic. In a certain reaction, 0.142 g of selenium dioxide reacted with exactly 25.52 mL of 0.100 M chromium(II) sulfate, $CrSO_4$. In the reaction, the $Cr^{2+}(aq)$ ions were oxidised to $Cr^{3+}(aq)$.

To what oxidation state was the Se^{4+} converted in this reaction?

3 marks

b. Selenium dioxide reacts readily with water to form the weak, diprotic acid selenous acid, H_2SeO_3. The reaction of 25.00 mL of 0.0500 M selenous acid with a solution of 0.100 M sodium hydroxide can be represented by the equation:

$$H_2SeO_3(aq) + 2NaOH(aq) \rightarrow Na_2SeO_3(aq) + 2H_2O(l)$$

i. Calculate the volume of 0.100 M NaOH solution required to completely react with the selenous acid.

ii. The pH of the resultant solution at the equivalence point is 11.4.

Given that the acid and base have completely reacted with each other, explain why the pH of the final solution is greater than 7.

2 + 1 = 3 marks

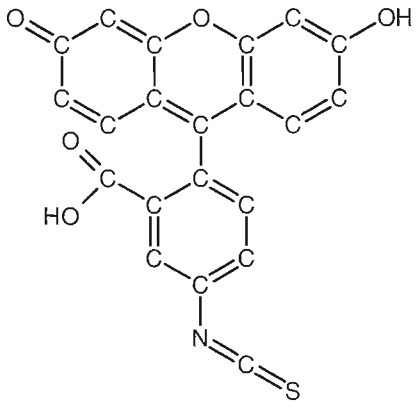
Total 6 marks

Question 2

Fluorescent molecules are those which absorb light energy to excite electrons, and then rapidly release this energy as specific wavelengths of light. The light emitted is often in the ultraviolet or blue end of the spectrum, which makes these molecules useful in laundry 'whiteners' and in dyes. Fluorescein isothiocyanate (FITC) is such a molecule. It is widely used in monitoring medical conditions, as it attaches to certain proteins inside living cells and so allows for extremely accurate measurements of protein concentration within cells.

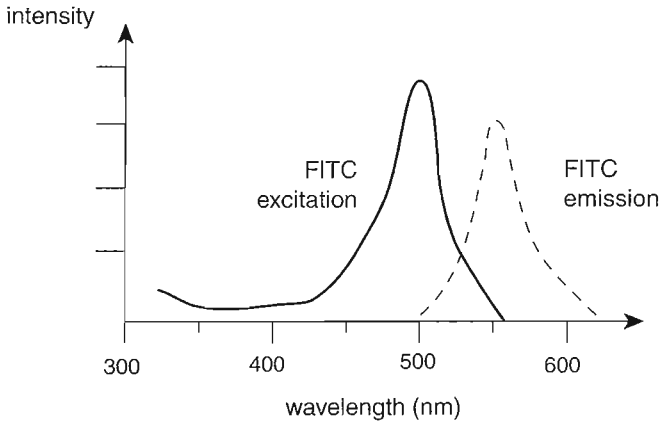
a. The structural formula of FITC ($C_{21}H_{11}NO_5S$) is shown below. (Note that nine hydrogen atoms have been omitted to simplify the diagram.)

On the structure below, circle and name two different functional groups present in FITC.

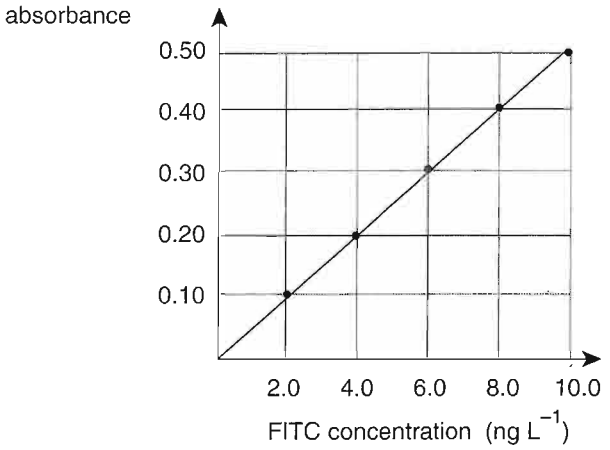


2 marks

b. The UV-visible spectrum of FITC is shown below.



In order to measure the concentration of FITC in a blood sample, a series of standard solutions of known FITC concentration were prepared and their absorbances recorded using a UV-visible spectrophotometer. The results are shown in the graph below.



A small quantity of FITC solution was injected into a patient's vein. In just 20 seconds the presence of the FITC in the blood supply to the patient's retina was detected. At this point, precisely 2.00 mL of fluid was drawn from the eye of the patient. The sample was then treated to release all proteins from within the cells. The mixture was diluted to 200.0 mL and a quantity was placed into a silica cell for testing in the UV-visible spectrophotometer.

i. From the list below, circle the wavelength that would be the best setting for the UV-visible spectrophotometer used to determine the FITC concentration in the sample.

wavelengths: 400 nm 450 nm 500 nm 550 nm 600 nm

ii. Explain why an absorbance reading was recorded for pure solvent with no FITC present when the standard curve was being prepared.

iii. The absorbance reading of the diluted sample was 0.34.

Use this reading and the standard curve to determine the concentration (in ng L^{-1}) of FITC in the original fluid sample taken from the eye.

iv. Calculate the number of molecules of FITC present in the 2.00 mL sample of fluid from the eye.

1 + 1 + 1 + 2 = 5 marks
Total 7 marks

Question 3

Propene reacts with water in the presence of a phosphoric acid catalyst to produce two product molecules, both of formula C_3H_8O. Both have very similar infrared spectra with a broad peak at around 3300 cm^{-1}.

a. **i.** Name the type of reaction that has occurred to generate these products.

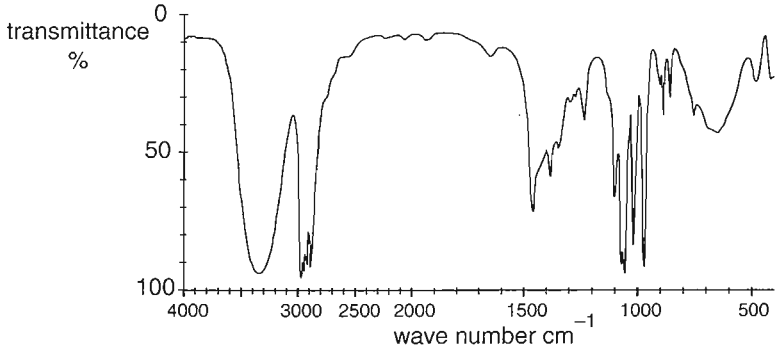
_____

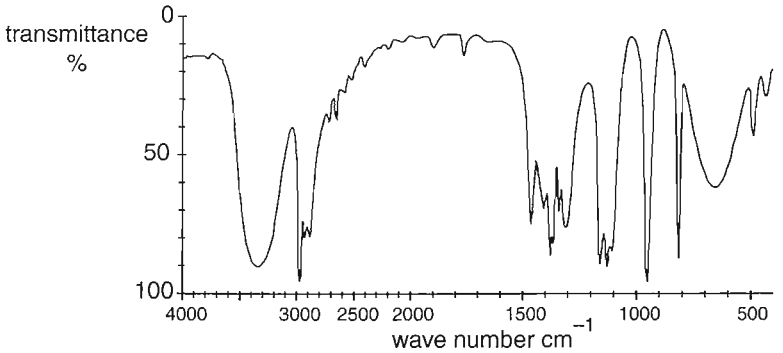
ii. Name and draw the structural formulas for each of these two possible product molecules, showing all bonds.

Structure A	Structure B
Name: _____	Name: _____

1 + 2 = 3 marks

b. The infrared spectra of the two molecules are shown below.





Why are their spectra so similar at wave numbers above 1500 cm^{-1}?

_____

_____

_____

2 marks

c. The mass spectrum of one of the molecular products has a significant peak at a mass-to-charge ratio (m/z) of 29.

Write the chemical formula of the fragment that would generate this peak, and state which parent molecule (structure A or B as drawn in part a ii) it originates from.

_____

_____

2 marks

d. State the number of peaks that would be observed in the ^{13}C NMR spectrum of:

i. structure A.

_____

ii. structure B.

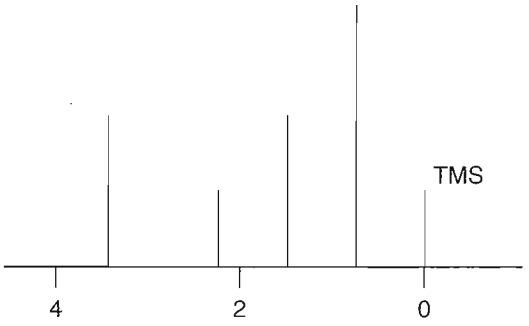
_____

1 + 1 = 2 marks

e. The low resolution ^{1}H NMR spectrum of one of the product molecules is provided below.

On the set of axes provided, draw the high resolution ^{1}H NMR spectrum of the same molecule, clearly showing the number of peaks into which each signal would be split.

low resolution ^{1}H NMR spectrum



high resolution ^{1}H NMR spectrum

2 marks

Total 11 marks

Question 4

Sulfur dioxide is a serious atmospheric pollutant and a significant contributor to acid rain. The amount of SO_2 in a given volume of air can be determined by passing the air through a solution containing excess hydrogen peroxide, H_2O_2, with which it reacts according to the equation:

$$SO_2(g) + H_2O_2(aq) \rightarrow H_2SO_4(aq)$$

The amount of unreacted H_2O_2 can then be determined by titrating the solution with a standardised potassium permanganate solution according to the equation:

$$2MnO_4^-(aq) + 6H^+(aq) + 5H_2O_2(aq) \rightarrow 2Mn^{2+}(aq) + 5O_2(g) + 8H_2O(l)$$

In one such analysis, 3.0 m^3 of air vented from a sulfuric acid manufacturing plant was bubbled through 50.0 mL of 0.0879 M H_2O_2 solution. The excess H_2O_2 remaining in solution was then titrated with 0.0250 M $KMnO_4$ solution and a titre of 23.90 mL was required to reach endpoint.

a. H_2O_2 may act as an acid, an oxidant and a reductant.

In which of these ways is the H_2O_2 acting in its reaction with SO_2?

1 mark

b. **i.** Calculate the amount (in mol) of MnO_4^- required to reach endpoint.

ii. Calculate the amount (in mol) of H_2O_2 in excess after the SO_2 was bubbled through the solution.

iii. Calculate the amount (in mol) of H_2O_2 in the initial 50.0 mL of H_2O_2 solution.

iv. Thus, calculate the amount (in mol) of H_2O_2 consumed in the reaction with the SO_2.

v. Calculate the mass of SO_2 present in the sample of air.

vi. Given that 1 m^3 of air at sea level has a mass of approximately 1200 g, calculate the concentration of SO_2 in the sample of air in parts per million.

1 + 1 + 1 + 1 + 2 + 2 = 8 marks
Total 9 marks

Question 5

The element zinc consists of five naturally occurring isotopes with the following relative isotopic masses and percentage abundances.

Symbol	Relative isotopic mass	Percentage abundance
^{64}Zn	63.93	48.89
^{66}Zn	65.93	27.81
^{67}Zn	66.93	4.11
^{68}Zn	67.93	18.57
^{70}Zn	69.93	0.62

a. Use these data to determine the relative atomic mass of zinc to two decimal places (working must be shown to obtain full marks).

2 marks

b. The element zinc is required in plants for the production of the amino acid tryptophan, a component of many proteins.

i. Write the molecular formula of the tryptophan molecule.

ii. Draw the structure of the amino acid tryptophan as it would exist in a solution of pH 11.

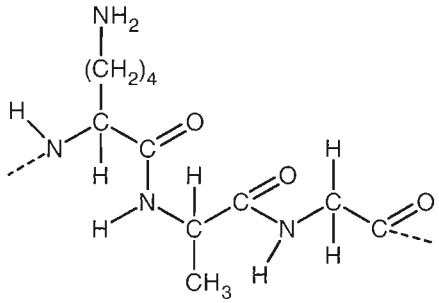
1 + 1 = 2 marks

c. An important class of proteins are the enzymes. Zinc is involved in a large number of enzyme systems in the human body, and is essential for normal growth and development. A deficiency of zinc in the diet can cause a decrease in appetite, which can contribute to eating disorders such as anorexia nervosa. Sufferers of this condition severely limit their dietary intake (including zinc) and so the problem is compounded.

i. What is the role of enzymes in the human body?

ii. The zinc-containing enzyme, carbonic anhydrase, plays an important role in the transport of carbon dioxide in the bloodstream. A small section of this protein is shown below.

Circle a peptide link in this structure.



iii. In common with other enzymes, carbonic anhydrase operates best within a narrow range of temperature and pH.

Explain why changes in temperature and pH will often alter the functioning of enzymes.

1 + 1 + 2 = 4 marks

d. Name the spectroscopic method which is most useful for the analysis of the zinc content of foods.

1 mark

Total 9 marks

Question 6

The drug zanamivir was the first medicine produced for the treatment of the viral disease influenza. It was developed by Australian scientists who identified the three-dimensional structure of a key protein (neuraminidase) in the influenza virus. This protein enables many more viruses to be released into a person infected with influenza. The chemical zanamivar was synthesised so that it inhibited the functioning of neuraminidase. This inhibitor was marketed under the name Relenza.

a. Why is it important for drug design success that the three-dimensional structure of the protein being targeted by the drug is known?

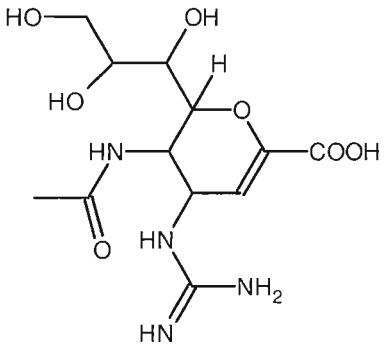
1 mark

b. Relenza was taken by inhaling a mist through the nose. The zanamivir was absorbed directly into the bloodstream across the membranes of the nose.

Suggest why the zanamivir could not be taken through the mouth like many other drugs.

1 mark

c. The structure of zanamivir is shown below.



i. On the diagram above circle and name one functional group which could act as a base.

ii. Scientists had to ensure that the drug was water soluble. Based on its structure, explain why zanamivir is likely to be soluble in water.

1 + 1 = 2 marks

d. The first influenza medicine which could be taken by mouth was also a neuraminidase inhibitor, oseltamivir, marketed under the trade name Tamiflu. Tamiflu is called a pro-drug, because it is inactive until it is *hydrolysed* by the liver to produce the active drug.

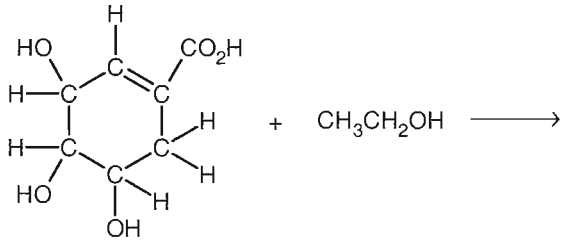
i. What is meant by the term *hydrolysed*?

_____

_____

ii. Oseltamivir can be chemically synthesised by an esterification reaction between shikimic acid (shown below) and ethanol.

Complete the equation below by drawing the organic product of this esterification reaction, and giving the molecular formula of the inorganic product.



1 + 3 = 4 marks
Total 8 marks

END OF QUESTION AND ANSWER BOOKLET