Neap:

Trial Examination 2011

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	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 2011 VCE Chemistry Unit 3 Written Examination.

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

A 0.10 g sample of gas *Y* occupies a volume of 469 mL.

If 0.20 g of sulfur dioxide (SO_2) gas occupies 440 mL at the same temperature and pressure, the formula of gas *Y* could be

A. CH

B. C_2H_6

C. C_2H_4

D. C_3H_6

Question 2

Using the appropriate catalysts and other reaction conditions, which of the following sets of reactants will produce ethanol as a product?

I $C_2H_6 + OH^-$

II $C_2H_4 + H_2O$

III $CH_3CH_2COOCH_3 + H_2O$

A. I only

B. II only

C. II and III only

D. I, II and III

Question 3

A number of actions taken during a gravimetric analysis can lead to inaccuracies in the calculated result.

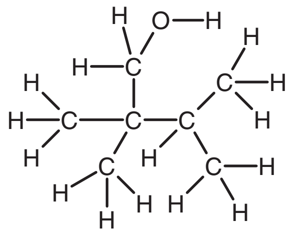
Which one of the following correctly shows the effects of these actions on the value of the calculated result compared to the actual value in a gravimetric analysis?

	Calculated result too high	Calculated result unchanged	Calculated result too low
A.	precipitate not fully dried before weighing	inadequate precipitating agent added	precipitate not washed before drying and weighing
B.	precipitate washed many times before drying	drying the precipitate at too high a temperature	inadequate precipitating agent added
C.	drying the precipitate at too high a temperature	some precipitate is lost in the drying and weighing	precipitate not fully dried before weighing
D.	precipitate not washed before drying and weighing	an excess of precipitating agent added	some precipitate is lost in the drying and weighing

Question 4

Organic compounds may be identified using various representations, including systematic names, semi-structural and structural formulas. Three such representation are shown below.

$HOCH_2C(CH_3)_2CH(CH_3)_2$



2,2,3-trimethylbutan-1-ol

The three representations above identify

A. the same compound.
B. different isomers of a compound.
C. members of a homologous series that are not isomers of each other.
D. three unrelated organic compounds.

Question 5

Which of the following occurs during the analysis of a sample using UV-visible spectroscopy?

A. absorption of energy by 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. absorption of light as electrons gain energy and move to an excited state

Question 6

In various forms of chemical analysis it is usual to rinse equipment with distilled or deionised water prior to use, or prior to rinsing with another solution.

Which of the following pieces of equipment should **not** be rinsed with water prior to its use?

A. the cell which holds the sample in an infrared spectral analysis of an alcohol
B. a standard flask used in a volumetric analysis of the acid content of vinegar
C. a conical flask used as the reaction vessel in a gravimetric analysis of salt in food
D. the cell used for the blank (solvent only) reading in a colorimetric analysis of aqueous copper(II) sulfate solutions

Question 7

In a research experiment, 1.5 mol of ammonia was mixed with 0.60 mol of oxygen gas in a sealed vessel and allowed to react completely according to the chemical equation:

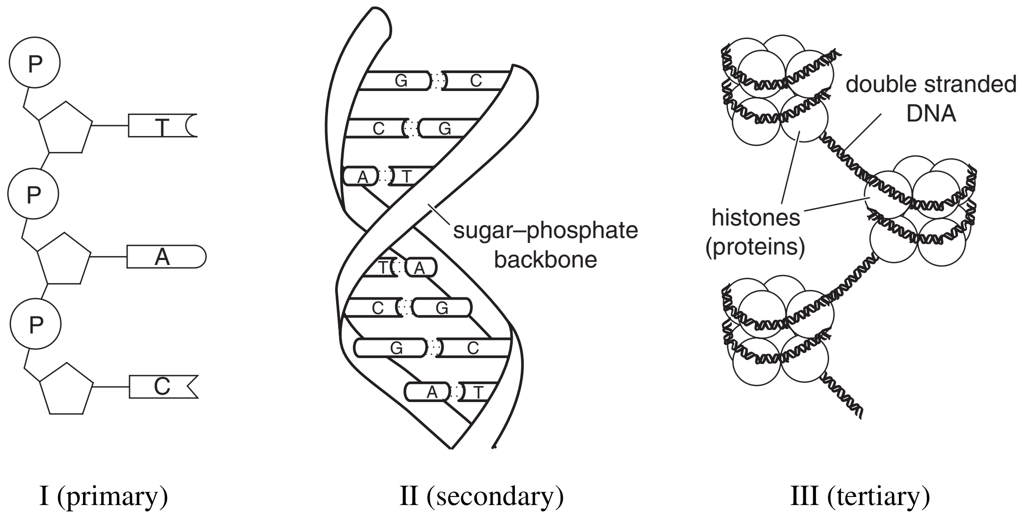
$$4NH_3(g) + 5O_2(g) \rightarrow 4NO(g) + 6H_2O(g)$$

After the reaction was complete, the total amount of gas (in mol) in the vessel would be expected to be

A. 1.0
B. 1.2
C. 2.2
D. 10

Question 8

The partially labelled sketches below show representations of various levels of structure of DNA.



Which of the following correctly lists the major type of bonding involved in each of the levels of structure shown above?

	I (primary)	II (secondary)	III (tertiary)
A.	covalent	hydrogen	ionic
B.	hydrogen	covalent	covalent
C.	ionic	hydrogen	hydrogen
D.	hydrogen	ionic	covalent

Question 9

The range of fragments produced when ethanoic acid is subjected to mass spectrometry includes

I CH_3^+

II COOH

III COH^+

IV the parent molecular ion

Which of these fragments will be displayed on the mass spectrum?

A. I and II only

B. II, III and IV only

C. I, III and IV only

D. I, II, III and IV

Question 10

Which of the spectral characteristics named below could **not** be used to distinguish between samples of propanoic acid and methyl ethanoate?

A. the number of peaks on the ^{1}H NMR spectra

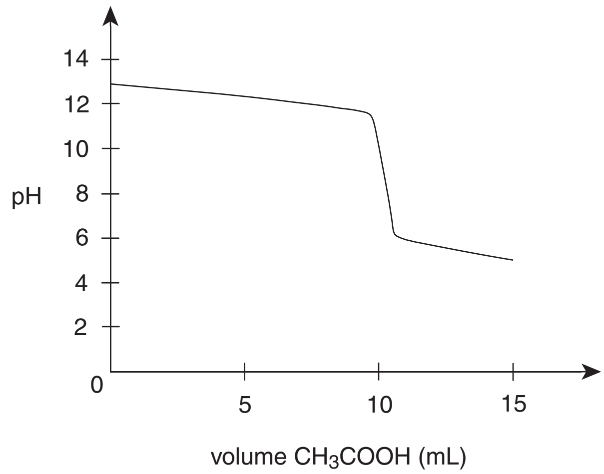
B. the region above wavenumber 1500 cm^{-1} on the infrared spectra

C. the major fragments detected on the mass spectra

D. the number of peaks on the ^{13}C NMR spectra

Question 11

The graph below shows the change in pH of a reaction solution during the titration of a 0.100 M NaOH solution with an ethanoic acid solution of unknown concentration. A student conducted the titration using methyl red indicator and recorded the volume of ethanoic acid solution at the endpoint when the solution changed from yellow to red.



The value calculated by the student for the concentration of the ethanoic acid solution using the titration results will be

A. higher than the true value because the endpoint of the titration occurred before the equivalence point was reached.

B. lower than the true value because the endpoint of the titration occurred before the equivalence point was reached.

C. higher than the true value because the endpoint of the titration occurred well after the equivalence point was reached.

D. lower than the true value because the endpoint of the titration occurred well after the equivalence point was reached.

Question 12

Which of the following species would be expected to be present in the highest concentration in a solution of the weak organic base methylamine?

A. OH^-

B. H_3O^+

C. CH_3NH_2

D. $CH_3NH_3^+$

The following information relates to Questions 13 and 14.

Creatine is an organic compound present in muscle tissue. With usual metabolic activity, creatine is converted to a similar compound, creatinine ($C_4H_7N_3O$), which has a normal blood concentration in the range of 0.06 to 0.13 millimolar. The concentration of creatinine in the blood is kept constant due to excretion of the substance by the kidneys.

Question 13

In a person with 5.6 litres of blood, the maximum mass (in grams) of creatinine that would be present in the body under normal circumstances is

A. 0.038
B. 0.082
C. 38
D. 82

Question 14

An increased level of creatinine in the blood is a sensitive indicator of kidney disease.

Which of the following statements is **not** a reasonable conclusion from the information given?

A. If a large amount of creatine is converted to creatinine in the body, a greater mass of creatinine would be excreted by the kidneys.
B. Muscle disease or damage to the muscles could result in a higher level of creatine in the blood than would normally occur.
C. When a person has kidney disease, blood concentration of creatinine would peak and then return to normal levels after a short time.
D. The level of creatinine in the blood not only indicates the existence of kidney disease but may also reveal its severity.

Question 15

Consider the redox reaction given by the equation:

$$2MnO_4^-(aq) + 3H_2SO_3(aq) \rightarrow 3SO_4^{2-}(aq) + 2MnO_2(s) + 4H^+(aq) + H_2O(l)$$

Which of the following shows a correct description for the chemical species involved in this reaction?

	Oxidant	Change in oxidation number of the sulfur	Change in oxidation number of the manganese
A.	MnO_4^-	+4 to +6	+8 to +4
B.	H_2SO_3	+4 to +6	+7 to +4
C.	H_2SO_3	+6 to +8	+8 to +4
D.	MnO_4^-	+4 to +6	+7 to +4

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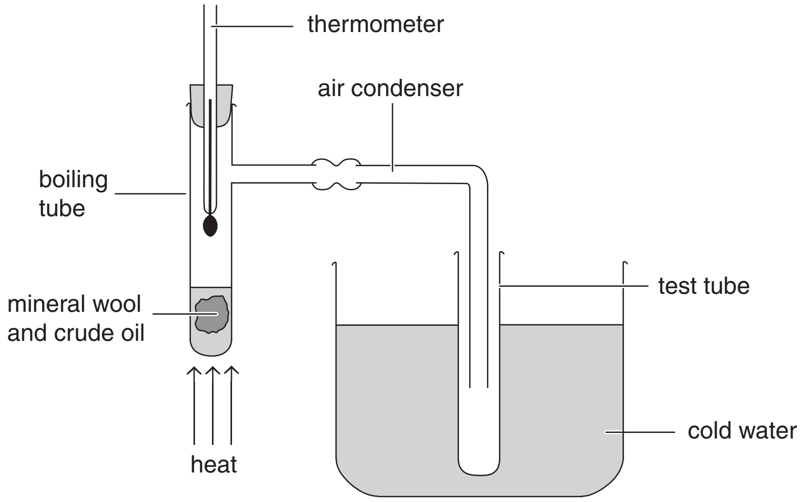
Question 16

The diagram below shows a laboratory experiment to separate the components of crude oil.



Which of the following statements about this distillation of crude oil are accurate?

I The products should consist of alkanes and alkenes in approximately the same proportions.

II The first component distilled will be a gas at room temperature.

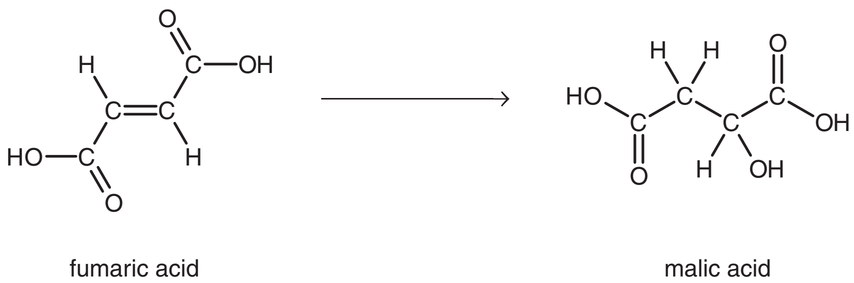
III By changing the test tube regularly, each fraction collected should consist of molecules of a single hydrocarbon compound.

IV The fractions collected later will have dispersion forces of greater strength than those of fractions collected earlier in the process.

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

Question 17

The enzyme, fumerase, catalyses the reaction which converts fumaric acid to malic acid, as shown below.

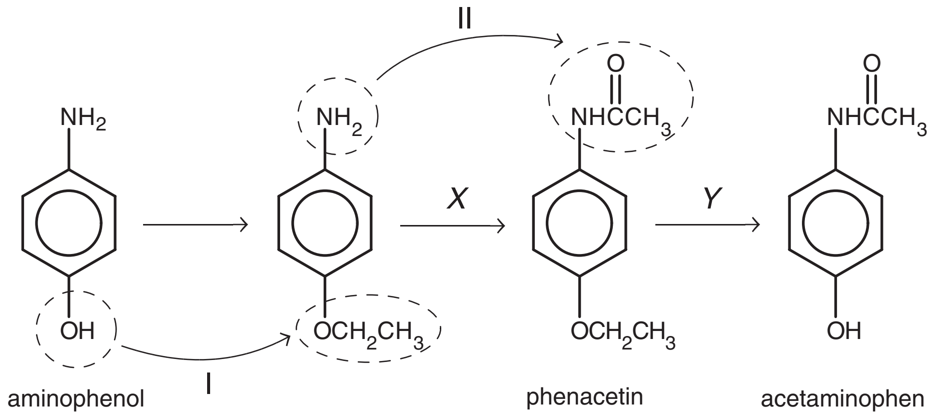


Considering the two acids shown in the conversion above, malic acid would be expected to

A. have greater solubility in water than fumaric acid.
B. be triprotic, while fumaric acid is diprotic.
C. react more readily with liquid bromine, $Br_2(l)$, than would fumaric acid.
D. show much stronger absorption of radiation of wavelength approximately 5900 nm than would fumaric acid.

The following information relates to Questions 18 to 20.

The compound phenacetin may be synthesised using a series of steps as illustrated in the reaction sequence below. Phenacetin was manufactured and marketed as a fever reducer and pain reliever. It was later found that the body converted phenacetin to acetaminophen. In addition, it was found that acetaminophen was as effective as phenacetin as a pain reliever and was less toxic. Acetaminophen is also known as paracetamol.



Question 18

The changes in the functional groups labelled I and II on the reaction sequence above are

	I	II
A.	hydroxyl to ether	amino to amide
B.	hydroxyl to ester	amide to amino
C.	hydroxyl to ether	amide to amino
D.	hydroxyl to ester	amino to amide

Question 19

Which of the following describes reagent *X* and reaction type *Y* which could be used to conduct the reaction sequence shown, assuming appropriate conditions and catalysts were used?

	reagent *X*	reaction *Y*
A.	ethanoic acid	substitution reaction
B.	ethanoic acid	hydrolysis reaction
C.	methanoic acid	substitution reaction
D.	methanoic acid	hydrolysis reaction

Question 20

During an experimental synthesis of phenacetin, 4.32 g of aminophenol (M = 109 g mol^{-1}) was reacted as shown in the sequence above and 3.51 g of phenacetin (M = 179 g mol^{-1}) was isolated from the reaction mixture.

The percentage yield of phenacetin for this experiment was closest to

A. 40
B. 50
C. 60
D. 70

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

An unknown organic compound was analysed to determine its identity. The compound contained only carbon, hydrogen and oxygen and did not contain any carbon-carbon double bonds. When completely oxidised in air, 8.20 g of the compound produced 8.19 g of water and 20.2 g of carbon dioxide.

a. **i.** Based on the mass of water produced by the oxidation, calculate the mass of hydrogen in the 8.20 g sample of the compound.

ii. Based on the mass of carbon dioxide produced by the oxidation, calculate the mass of carbon in the 8.20 g sample of the compound.

iii. Determine the mass of oxygen in the 8.20 g sample of the compound.

iv. Determine the empirical formula of the compound.

1 + 1 + 1 + 1 = 4 marks

b. The empirical and molecular formulas for the compound are the same. The infrared spectrum of the compound shows a sharp, prominent peak at a wavenumber close to 1700 cm^{-1}. The compound does not contain cyclic molecules.

i. Based on the given infrared spectral data, which bond type is present in a molecule of the compound?

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ii. Name one functional group which contains the bond type listed in **part b i**.

___

iii. Could the functional group named in **part b ii** be present in a molecule of the compound? Explain your choice.

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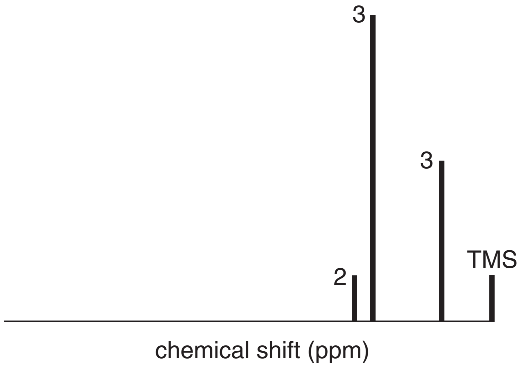
1 + 1 + 1 = 3 marks

c. A simplified diagram of the low resolution ^{1}H nuclear magnetic resonance spectrum for the compound is shown below. Numbers next to each peak show the relative areas under each peak.



What information about the structure of a molecule of the compound does the given NMR spectral data provide?

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2 marks

Total 9 marks

Question 2

A promising biochemical fuel is a biodiesel made from the triglyceride plant oils which have been used for deep-frying foods. This waste vegetable oil (WVO) is treated to hydrolyse the triglycerides to release the fatty acid molecules which are then reacted with an alcohol to produce the biodiesel. The reaction is known as transesterification and uses potassium hydroxide (KOH) as a catalyst.

a. The plant oils are used initially to cook food (containing water) at high temperatures. These conditions enable the ester linkages to be broken in some of the triglycerides of the oil, releasing free fatty acids. To calculate the amount of free fatty acids present in a sample of WVO, the following procedure was used:

A 2.00 mL sample of WVO was mixed with 20 mL of 2-propanol in a conical flask and titrated with a standardised 0.0100 M NaOH solution using phenolphthalein indicator. The endpoint was reached with a titre of 12.30 mL.

i. Suggest why it was necessary to mix the WVO sample with 2-propanol before the titration was conducted.

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ii. Calculate the amount (in mol) of NaOH needed to neutralise the free fatty acids in 2.00 mL of WVO.

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iii. The 0.0100 M NaOH solution was previously standardised using titration with a standard solution of an acid.

Give one reason why NaOH cannot be prepared as a primary standard.

____

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1 + 1 + 1 = 3 marks

b. In the transesterification reaction, 100.0 mL of WVO is mixed with 20.0 mL of ethanol and an appropriate volume of 10.0 M KOH solution is added. The amount of KOH needed to catalyse the transesterification reaction is 0.35 g per 100 mL of oil.

i. Calculate the volume of 10.0 M KOH solution needed to catalyse the transesterification of 100.0 mL of oil.

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ii. Using the formula RCOOH to represent a fatty acid, write an equation to show the formation of the biodiesel molecule when a fatty acid molecule reacts with ethanol. Symbols of state are not required.

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2 + 1 = 3 marks

c. To purify and extract the biodiesel after the transesterification reaction, a series of washing steps are used. Glycerol, a by-product of the transesterification reaction, is dissolved in the lower 'aqueous layer' together with unreacted ethanol and KOH. The biodiesel remains in the upper 'organic layer' during the washing procedure.

i. Explain why it is necessary to remove water and other contaminants from the biodiesel.

ii. In terms of structure and bonding, explain why glycerol dissolves in the 'aqueous layer'.

1 + 1 = 2 marks

d. Pure plant oils may also be used to produce biodiesel. To determine the identity of a pure plant oil, its iodine number is used. The iodine number is the number of grams of iodine that reacts with 100 g of oil.

Oil	**Iodine number**
olive oil	81
peanut oil	93
canola oil	99
sunflower oil	126

10 g of pure plant oil used to make a sample of biodiesel was shaken vigorously with 100.0 mL of solution containing 15.0 g of iodine. After the reaction was complete, 20.0 mL aliquots of the resultant solution were taken and titrated with 0.500 M sodium thiosulfate solution. The average titre was 16.04 mL. The reaction occurred according to the equation:

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

i. Calculate the amount, in mol, of iodine in the 20.0 mL aliquot.

ii. Calculate the mass of unreacted iodine in the 100.0 mL solution.

iii. Calculate the mass of iodine that reacted with 10 g of the pure plant oil.

iv. From the table, identify the pure plant oil.

2 + 2 + 1 + 1 = 6 marks
Total 14 marks

Question 3

DNA analysis is a powerful tool used widely in forensic science. When there is only a small piece of DNA available for analysis, scientists are able to make thousands of copies of the piece in a procedure known as the polymerase chain reaction (PCR). The PCR may be summarised by the steps shown below.

Step I Heat the DNA to 95°C.

Step II Lower the temperature to attach starting nucleotide sequences to each end of the DNA strands.

Step III Add a supply of the four nucleotides and an enzyme (polymerase) and raise the temperature to 72°C to begin the copying.

Step IV Repeat the cycle.

a. **i.** In Step I, why was the DNA sample heated to 95°C?

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ii. How could scientists be sure that Step I did not break the DNA strand itself into small pieces?

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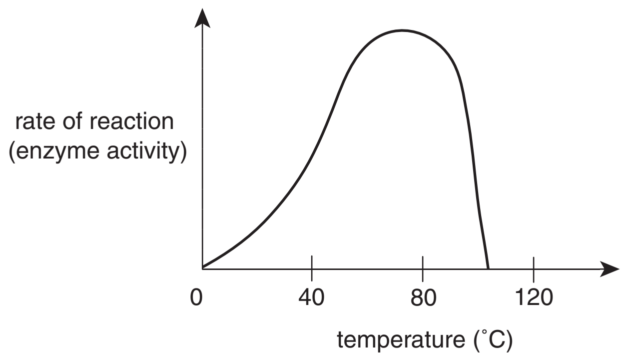
1 + 1 = 2 marks

b. The enzyme used in Step III is known as *Taq* polymerase and is extracted from the bacterium *Thermus aquaticus* which lives in hot springs. The effect of changing temperature on the activity of this enzyme is shown in the graph below:



Before the discovery of *Taq* polymerase, a DNA polymerase from *E.coli* (a bacterium which inhabits the human digestive system) was used in PCR.

Explain why using *Taq* polymerase, rather than the *E.Coli* polymerase, is a significant improvement to the PCR process.

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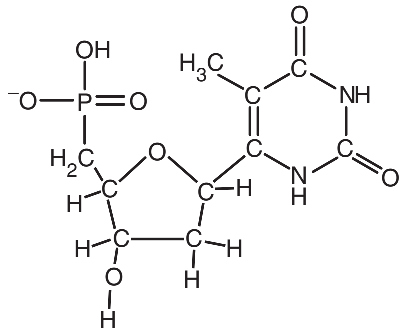
2 marks

c. In Step III, nucleotides are added. The diagram below **incorrectly** shows the structure of a nucleotide.



On the diagram above, circle one error in the structure and explain the nature of the error.

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____

2 marks

d. The most widely used DNA forensic technique is electrophoresis to create a DNA profile. Enzymes are used to cut the DNA at specific locations, producing thousands of DNA fragments of varying sizes. The DNA sample is applied into a well in a slab of gel submerged in an electrolyte solution. An electric current is passed through the gel. The bands produced in the gel by electrophoresis are made visible by various means. An example is shown below.

i. Would the end of the gel which has the well into which the DNA sample is loaded be connected to the positive or negative terminal during electrophoresis? Explain your choice.

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ii. One method used to enable the bands in the gel to be visualised is to attach short strands of complementary DNA which have been made with radioactive atoms. The bands in the gel then expose X-ray film.

Circle any of the radioactive isotopes below which could **not** be used to make the short radioactive strands of DNA. Explain your choice/s.

^{32}P	^{37}Cl	^{15}N	^{18}O	^{35}S	^{3}H

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2 + 2 = 4 marks
Total 10 marks

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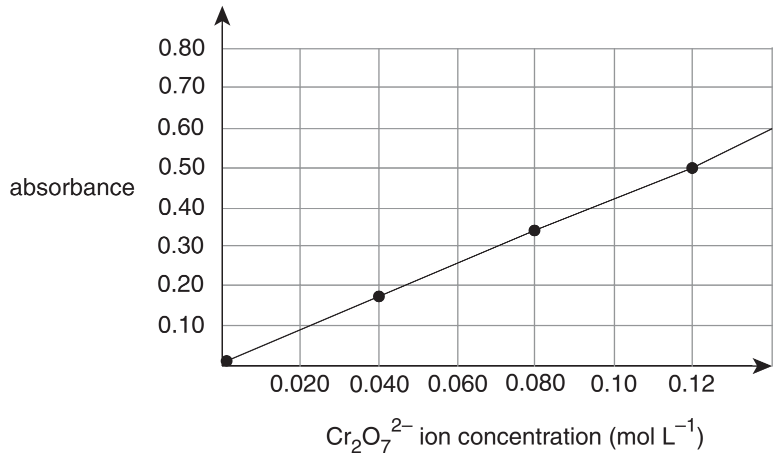
Question 4

UV-visible spectroscopy may be used to analyse the chromium content of stainless steel samples. The steel is first dissolved in acid. This converts any chromium present to chromium(III) ions, Cr^{3+}. The chromium(III) ions are then further oxidised to form the orange dichromate ion, $Cr_2O_7^{2-}$. The concentration of the dichromate ion is then determined using UV-visible spectroscopy.

a. Write an ionic equation for the oxidation of Cr^{3+} to $Cr_2O_7^{2-}$ in an acidic solution.

1 mark

b. In one analysis, a set of standard $Cr_2O_7^{2-}$ solutions was prepared. The absorbances of these standards were measured at a *suitable wavelength* and the following calibration line was obtained.



A 21 g sample of stainless steel was dissolved in acid and the $Cr^{3+}$was oxidised toy $Cr_2O_7^{2-}$ in the acidic solution. The solution was made up to a total volume of 150.0 mL. The absorbance of this solution was found to be 0.34.

i. State the concentration of dichromate ions in the 150.0 mL solution of dissolved stainless steel.

ii. Calculate the percentage by mass of chromium in the steel sample.

1 + 4 = 5 marks

c. Explain how the *suitable wavelength* used in this spectroscopic analysis would be selected.

1 mark
Total 7 marks

Question 5

An experiment was conducted to compare the products of the breakdown of the polysaccharide starch using enzyme and acid hydrolysis. The procedures used were as follows:

Enzyme hydrolysis (E H):

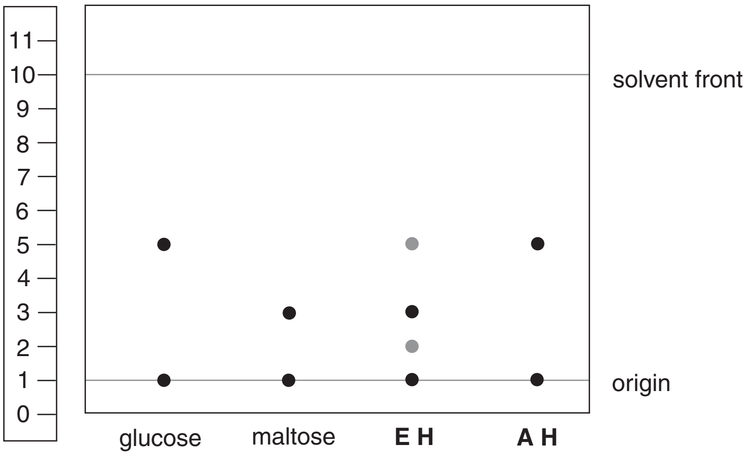
1.0 mL of enzyme solution was added to 5 mL of 1% starch solution and incubated at room temperature for 30 minutes.

Acid hydrolysis (A H):

0.5 mL of 4 M HCl was added to 5 mL of 1% starch solution and incubated in a boiling water bath. After 30 minutes incubation, phosphate buffer was added to neutralise the acid.

Samples of each of these hydrolysis products together with pure samples of glucose and maltose were spotted onto a thin layer chromatography (TLC) plate. The TLC plate was developed for three hours in an enclosed tank using a chloroform/ethanoic acid/water solvent.

The TLC plate was treated to allow visualisation and the resulting chromatogram is shown below:



a. **i.** Marking the origin is done *very lightly* with a *pencil*. Explain the reasons for each of these requirements.

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ii. Care must be taken to ensure that the origin of the TLC plate is above the level of the solvent. Explain why.

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2 + 1 = 3 marks

b. Calculate the R_f value of the glucose spot.

____

1 mark

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c. From the results of the experiment, what can be concluded about the products of the enzyme hydrolysis of starch compared to acid hydrolysis of starch?

2 marks

d. A student wanted to repeat the investigation using the polysaccharide glycogen but did not intend to use samples of glucose and maltose in this TLC analysis. Instead the student planned to compare the R_f values of the products of glycogen hydrolysis with those of starch hydrolysis.

Which of the following conditions should remain the same in both experiments to allow accurate identification of the hydrolysis products of glycogen?

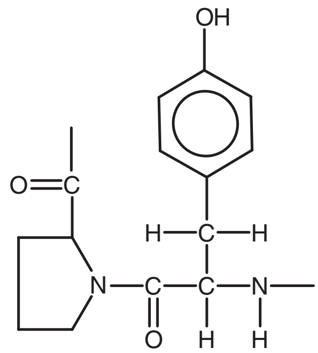
Conditions which must be the same for the two experiments	Tick your choices
distance travelled by solvent front	
stationary phase composition	
length of time running TLC	
composition of solvent mixture	

2 marks
Total 8 marks

Question 6

When the human immunodeficiency virus (HIV) infects a person, it takes control of the person's cells to produce more viruses. An enzyme in the virus, which allows this process to occur, has been identified by medical researchers. Scientists have analysed the structure of this enzyme and know the shape and configuration of its active site. Inhibitor drugs have been designed to bind to the enzyme's active site. These will prevent the virus from producing more viruses and allow the person's body to combat the infection.

a. The HIV enzyme is known to activate proteins by hydrolysing the peptide bond between the two particular amino acid residues, shown below:



i. Name the two amino acid residues shown in the protein segment above.

___

ii. Using an arrow, on the diagram above show where the peptide bond would be broken by the HIV enzyme.

1 + 1 = 2 marks

b. Most of the inhibitor drugs are based on the compound hydroxyethylamine which is known to bind to the HIV enzyme's active site.

Draw one possible structural formula for hydroxyethylamine, showing all bonds.

1 mark

c. Much of the inhibitor drug research involves modifying the structure of hydroxyethylamine to make it more soluble in water and to make it bind more strongly to the active site of the virus enzyme.

Explain how increased solubility in water will improve the drug's effectiveness.

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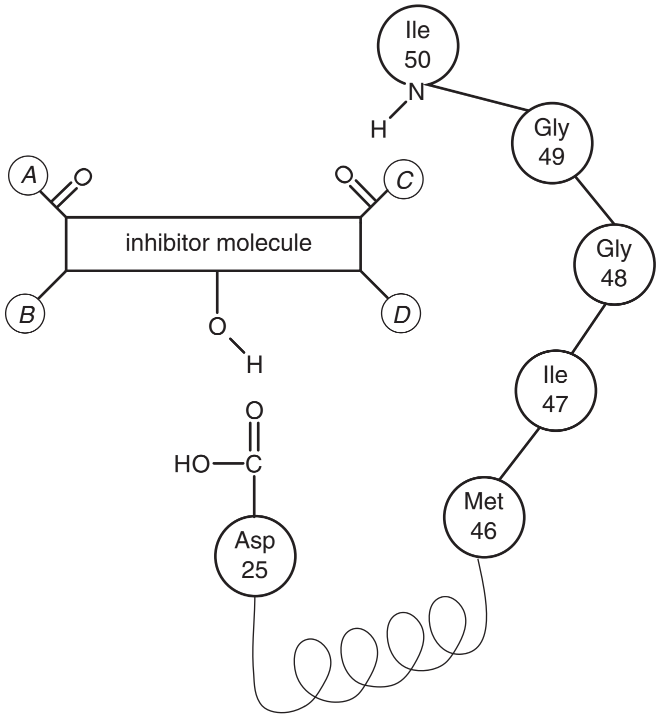
1 mark

d. A simplified image of part of the active site of the virus enzyme (with some of its amino acid residues numbered) is shown below. An inhibitor drug is depicted with some functional groups displayed and other groups labelled *A*, *B*, *C* and *D*.



Interaction occurs between the group of atoms labelled *D* on the drug with the side chain (not shown) of Ile47.

i. Give the systematic name of the amino acid isoleucine (Ile).

___

ii. Would you expect group *D* on the inhibitor drug to be largely polar or non-polar? Explain your choice.

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1 + 2 = 3 marks
Total 7 marks

END OF QUESTION AND ANSWER BOOKLET