Neap:

Trial Examination 2010

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 18 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 2010 VCE Chemistry Unit 3 Written Examination.

Copyright © 2010 Neap ABN 49 910 906 643 96–106 Pelham St Carlton VIC 3053 Tel: (03) 8341 8341 Fax: (03) 8341 8300 TEVCHEMU3_QA_2010.FM

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

Niacin, also known as Vitamin B3, is a water soluble vitamin that is important to a range of metabolic processes. Niacin contains 58.5% carbon, 4.1% hydrogen, 11.4% nitrogen and 26.0% oxygen.

The empirical formula of niacin is

A. CHNO

B. $C_3H_4N_2O$

C. $C_6H_5NO_2$

D. $C_5H_{11}NO_3$

Question 2

A sample of butane is reacted with chlorine gas in the presence of ultraviolet light.

How many compounds, each with a different structural formula, and a molar mass of 92.5 g mol^{-1} can be formed?

A. 3

B. 4

C. 5

D. 6

Question 3

Some diseases are caused by viruses which often have a key protein responsible for controlling the course of the infection. Knowing the structure of the protein allows drugs to be designed which will inhibit the protein and reduce the effects of the disease.

Which one of the following actions is least likely to be taken when designing an organic compound which will inhibit the protein?

A. Synthesising derivatives of compounds which are known to bind tightly to regions of the active site of the protein.

B. Determining energetically favourable interactions between various functional groups and the catalytic region of the protein.

C. Investigating the structure of the protein using infrared spectroscopy to achieve a three dimensional view of its active site.

D. Modifying a known inhibitor using functional group characteristics to achieve a more precise interaction with the protein.

Question 4

Unsaturated fats are reacted with hydrogen gas using a metal catalyst to produce saturated fats. To produce a saturated fat, 7.50 g of hydrogen gas was reacted with 1.25 mol of unsaturated fat.

Assuming the unsaturated fat is a triglyceride containing only one type of fatty acid, which of the following fatty acids was the constituent of the unsaturated fat?

A. linoleic acid
B. arachidonic acid
C. linolenic acid
D. palmitoleic acid

Question 5

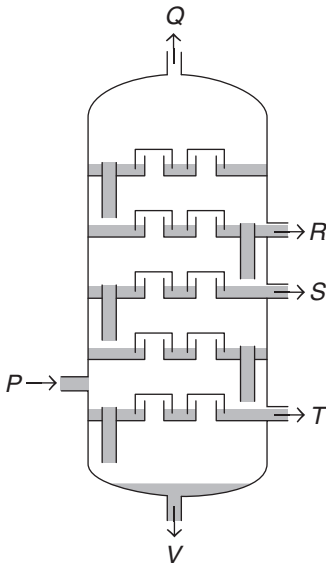
When a solution of $KMnO_4$ is reduced by H_2O_2 solution under acidic conditions, the products include oxygen gas and a solution of Mn^{2+} ions.

The number of mole of hydrogen ions for each 5 mole of H_2O_2 in this reaction is

A. 5
B. 6
C. 7
D. 8

Question 6

The diagram below shows a fractionating tower similar to the structure used in the fractional distillation of crude oil. The input at *P* is crude oil.

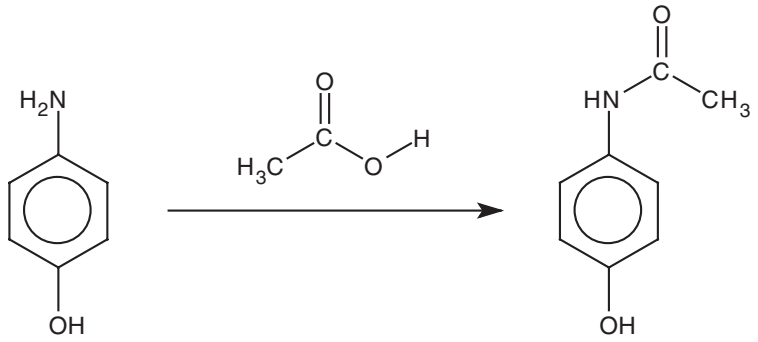


Which of the following statements is **correct**?

A. The dispersion forces between molecules of the fractions at *Q* are weaker than those at *T*.
B. Fractions at *Q*, *R*, *S* and *T* are likely to be gases when removed from the column.
C. All compounds in the fractionating tower are initially converted into gases before separation.
D. Each fraction at *R*, *S* and *T* will consist of a single hydrocarbon compound with molecular masses in this order: $R < S < T$.

Questions 7 to 9 refer to the following information.

Paracetamol is a pain relieving and fever reducing drug used for temporary relief from headaches and muscular pain. It may be prepared by reacting 4-aminophenol with ethanoic acid, as shown in the reaction sequence below.



Question 7

The reaction of 4-aminophenol to produce paracetamol involves

A. a condensation reaction converting an amine functional group to an amide functional group.

B. a condensation reaction converting an amine functional group to an ester functional group.

C. a hydrolysis reaction converting an amine functional group to an amide functional group.

D. a hydrolysis reaction converting an amine functional group to an ester functional group.

Question 8

When 1.12 g of 4-aminophenol was added to an excess of ethanoic acid solution, 1.04 g of paracetamol was recovered.

The percentage yield for this experiment was

A. 24%

B. 55%

C. 67%

D. 93%

Question 9

When 4-aminophenol is converted to paracetamol, which of the following would **not** be expected to increase?

A. the molecular mass of the organic molecule

B. the number of peaks on the ^{1}H nuclear magnetic resonance spectrum of the molecule

C. the number of peaks on the ^{13}C nuclear magnetic resonance spectrum of the molecule

D. the strength of the molecule when acting as a base

Question 10

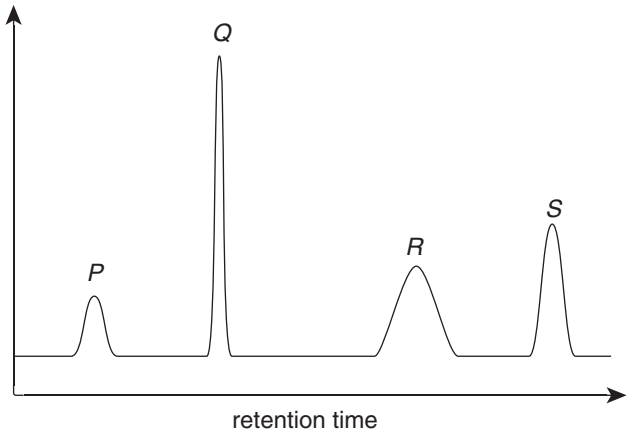
A carboxylic acid has the molecular formula $C_4H_8O_2$.

The number of different carboxylic acid structures which can be drawn for this compound is

A. 1
B. 2
C. 3
D. 4

Questions 11 and 12 refer to the following information.

The chromatogram below shows the amino acid components of a mixture separated by high pressure liquid chromatography.



Question 11

Which of the following is a reasonable conclusion from the data presented in the chromatogram?

A. The amount of each component in the mixture is given by the height of each peak.
B. Component *P* has the lowest concentration and would be eluted last from the column.
C. If separated using thin layer chromatography, component *S* would have the highest R_f value.
D. Component *Q* has a greater attraction to the mobile phase than component *S*.

Question 12

The range of changes which can be made to the conditions of the chromatography includes:

I increasing the column temperature
II decreasing the solvent pressure
III increasing the polarity of the solvent
IV decreasing the particle size of the stationary phase

Which actions will increase the retention times for all components?

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

Question 13

The following tests were performed on organic compound X:

- Mixing with $Br_2(aq)$ produces a colourless solution
- Reaction with CH_3COOH in the presence of H_2SO_4 yields a sweet-smelling product
- Oxidation using MnO_4^-/H^+ produces a solution which reacts with NaOH(aq)

Which of the following is least likely to be Compound X?

A. $CH_3CH{=}CHCOOH$

B. $HOCH_2CH_2CH{=}CHCH_3$

C. $HOCH_2CH{=}CHCH_2COOH$

D. $CH_3CH{=}CHCH_2OH$

Questions 14 and 15 refer to the following information.

The amount of phosphate ions (PO_4^{3-}) present in a sample of soluble fertiliser was determined by gravimetric analysis. 1.624 g of the fertiliser was dissolved in a flask using 100.0 mL of water. The phosphate ions in a 20.00 mL aliquot were then precipitated as $MgNH_4PO_4$ (M = 137.3 g mol^{-1}). The precipitate was filtered, washed with distilled water, allowed to dry and weighed to a constant mass of 0.0147g.

Question 14

The percentage (by mass) of phosphorus in the fertiliser is closest to

A. 0.2

B. 0.4

C. 1.0

D. 2.0

Question 15

The following actions may occur in a similar gravimetric analysis:

I The mass of the fertiliser was wrongly recorded and should have been 1.642 g.

II The precipitate was not washed thoroughly with distilled water.

III Insufficient precipitating agent was added to the dissolved fertiliser.

IV The flask was not completely dry before the 100.0 mL of water was added.

Which of the actions listed would produce a calculated result which was higher than the actual percentage of phosphorus?

A. I only

B. I and II only

C. II and III only

D. II, III and IV only

Question 16

This question concerns the following situations:

I Using the protein hormone insulin to regulate blood sugar levels of a person with a diabetic disorder.

II Monitoring the levels of administered chemical agents in the blood which prevent blood clotting in heart attack patients.

III Determining the level of cellular enzymes in the blood of a patient.

IV Finding the required amount of digestive enzymes to be added to the diet to aid digestion in a person lacking the relevant proteins.

Which of the situations listed above (I to IV) are examples of using 'proteins as markers for disease'?

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

Question 17

20.0 mL of a 0.0030 M solution of a weak, monobasic base is mixed with exactly 20.0 mL of a 0.0030 M solution of a strong, monoprotic acid.

The resulting mixture is most likely to be

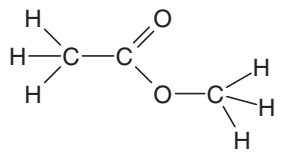
A. yellow in the presence of phenol red indicator, and red in the presence of thymol blue indicator.
B. orange in the presence of phenol red indicator, and orange in the presence of thymol blue indicator.
C. red in the presence of phenol red indicator, and yellow in the presence of thymol blue indicator.
D. yellow in the presence of phenol red indicator, and yellow in the presence of thymol blue indicator.

Question 18

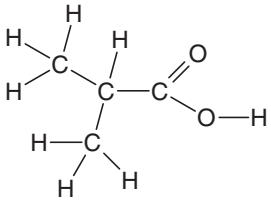
The infrared spectrum of an unknown compound shows distinct absorption peaks in the 1700–1750 cm^{-1} and 2500–3000 cm^{-1} regions. The ^1H NMR spectrum of the compound shows three peaks, a triplet, a quartet and a single peak.

Which of the following molecules is consistent with the spectral data provided?

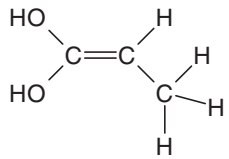
A.



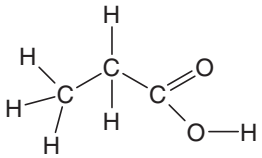
B.



C.

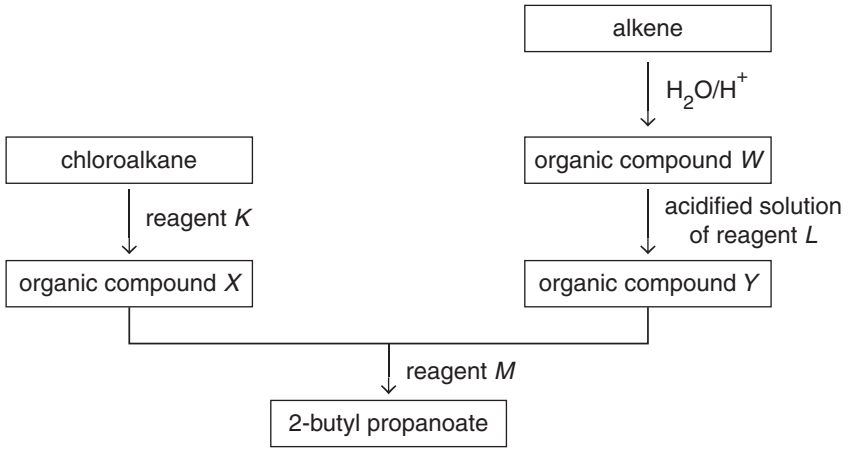


D.



Questions 19 and 20 refer to the following information.

The diagram below shows a sequence of reactions involving a number of organic compounds.



Question 19

Which of the following correctly identifies, in order, the organic compounds labelled *W*, *X* and *Y*?

A. 1-butanol, 2-propanol and butanoic acid

B. 1-propanol, 2-butanol and propanoic acid

C. 2-butanol, 1-propanol and butanoic acid

D. 2-propanol, 1-butanol and propanoic acid

Question 20

The reagents labelled *K*, *L* and *M* could be, in order,

A. KOH, $KMnO_4$ and H_2SO_4.

B. H_2O, $K_2Cr_2O_7$ and H_2SO_4.

C. KOH, $KMnO_4$ and H_2O.

D. H_2O, $KMnO_4$ and H_2O.

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

Alkanols are organic chemicals which are used in a range of important biofuel applications.

a. The fermentation of plant material by microorganisms produces the alkanol ethanol, primarily for alcoholic drinks and use as a biochemical fuel.

i. Write a balanced equation for the production of ethanol by the fermentation of glucose.

_____

ii. Biochemical fuels are classified as 'carbon neutral', which means that they do not increase the amount of carbon dioxide in the atmosphere over time.

Explain why they are carbon neutral.

_____

_____

_____

iii. Describe one other advantage (in addition to their carbon neutral nature) of using biochemical fuels such as ethanol.

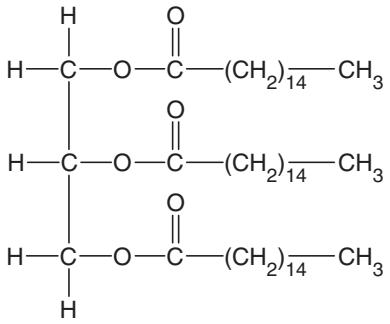
_____

_____

1 + 1 + 1 = 3 marks

b. Another biochemical fuel, biodiesel, is produced by reacting a fatty acid with an alkanol.

i. Give the semi-structural formula of the biodiesel compound produced when the alkanol methanol is reacted with the fatty acid derived from the triglyceride shown below.



_____

ii. Indicate the solubility of the biodiesel compound in water and organic solvents (such as petrol) by ticking one box in each row of the table below.

	Soluble	**Not soluble**
Solubility of biodiesel in water		
Solubility of biodiesel in organic solvents		

iii. Explain why biodiesel has the solubility characteristics shown in the table above.

_____

_____

_____

_____

1 + 1 + 1 = 3 marks
Total 6 marks

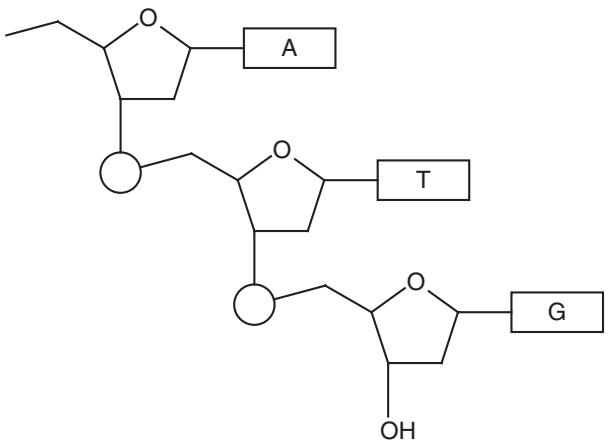
Question 2

Various techniques have been used to study the composition and structure of DNA.

a. Chemicals have been used to cut the DNA molecule in particular locations to determine the base sequence.

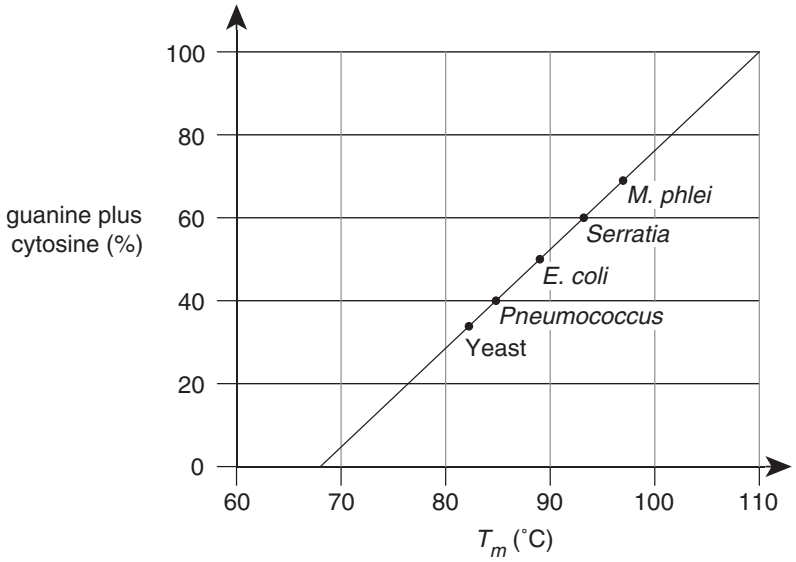
i. Using a strong acid, the bonds between purine bases and deoxyribose will be cleaved. On the diagram of DNA below, use an arrow to indicate a point of cleavage and label this arrow 'acid'.

ii. The enzyme pancreatic endonuclease splits the phosphodiester bridges at the 3′ carbon of deoxyribose. On the diagram of DNA below, use an arrow to indicate a point of cleavage and label this arrow 'enzyme'.



1 + 1 = 2 marks

b. When double-stranded DNA is heated slowly, the double helix unravels to a random coil configuration over a narrow temperature range. The midpoint temperature of this process is known as the melting temperature (T_m). The graph below shows the T_m of various samples of DNA (taken from different living things) as a function of the base composition.



i. With reference to the structure of DNA, explain the trend depicted in the graph.

_____

_____

_____

_____

_____

ii. In a sample of double-stranded DNA from *E. coli* which contains 3000 base pairs, how many adenine and thymine molecules in total would be present in a single strand of its DNA?

_____

_____

2 + 2 = 4 marks

c. In a cell, DNA strands are bonded tightly to proteins known as histones. These proteins contain a high proportion of the amino acids lysine and arginine. In the acidic environment of the DNA molecule, the side chain groups of these amino acids are charged.

Name the type of strong bonding that exists between histones and the DNA molecule, and explain how this bonding occurs between them.

_____

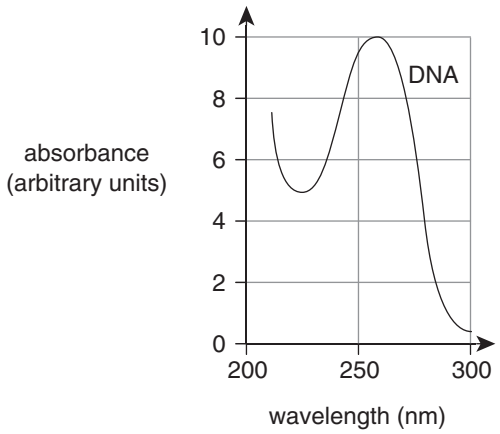
_____

_____

_____

2 marks

d. The nitrogenous bases found in DNA are responsible for the strong absorption of ultraviolet radiation by DNA, as depicted in the UV absorbance spectrum below.



However, the tight packing of the bases in the high molecular mass DNA molecule produces an absorbance which is about 40% less than that expected from adding up the individual absorbances of the bases. As the DNA double helix unravels, this effect progressively disappears until the expected value is reached.

Describe how ultraviolet spectroscopy could be used to measure the level of unwinding of the double helix structure in a sample of DNA.

_____

_____

_____

_____

_____

_____

_____

3 marks
Total 11 marks

Question 3

The percentage of iron in steel can be determined by volumetric analysis.

A sample of steel is dissolved in acid and iron(II) ions form according to the equation:

$$Fe(s) + 2H^+(aq) \rightarrow Fe^{2+}(aq) + H_2(g)$$

This solution is titrated with standardised potassium permanganate solution according to the equation:

$$5Fe^{2+}(aq) + 8H^+(aq) + MnO_4^-(aq) \rightarrow Mn^{2+}(aq) + 5Fe^{3+}(aq) + 4H_2O(l)$$

In one analysis, 0.981 g of steel was dissolved in excess acid in a volume of 100.0 mL (solution *A*). From the resulting solution, 10.00 mL aliquots were titrated with 0.0184 M potassium permanganate. An average titre of 17.91 mL was recorded.

a. A standard solution of oxalic acid ($C_2H_2O_4$) could be used to standardise the potassium permanganate solution before the titration.

Describe how 500.0 mL of a standard 0.0200 M solution of oxalic acid is made using crystals of the compound.

_____

_____

_____

_____

_____

_____

3 marks

b. **i.** Calculate the amount (in mol) of iron(II) ions in solution *A*.

_____

_____

_____

_____

ii. Determine the percentage of iron in the sample of steel.

_____

_____

3 + 2 = 5 marks

c. Calculate the volume of hydrogen gas (in mL), at 20°C and 770 mmHg, produced when the steel sample was dissolved in the acid.

_____

_____

_____

_____

2 marks

d. The percentage of iron in the steel sample could be determined quickly and accurately using Atomic Absorption Spectroscopy (AAS).

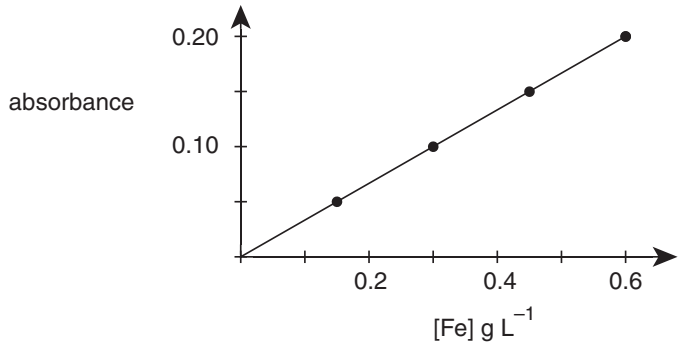
i. A key component of the AAS instrument is a cathode lamp.

Explain the function of this lamp.

_____

_____

ii. In conducting an analysis of the iron in the steel sample using AAS, a series of iron standards were prepared and the calibration curve shown below was obtained at a suitable wavelength.



A 10.0 mL sample of solution *A* is to be analysed for its iron content using the calibration curve shown.

By what factor must the sample be diluted in order to use the curve?

_____

_____

_____

1 + 2 = 3 marks

e. Steel contains some chromium. When the sample of steel is dissolved in acid, Cr^{2+} ions form.

i. Would the presence of the chromium in the steel affect the calculated percentage of iron in the sample of steel using the titration procedure? Explain your choice.

_____

_____

_____

ii. Would the presence of the chromium in the steel affect the calculated percentage of iron in the sample of steel using the AAS procedure? Explain your choice.

_____

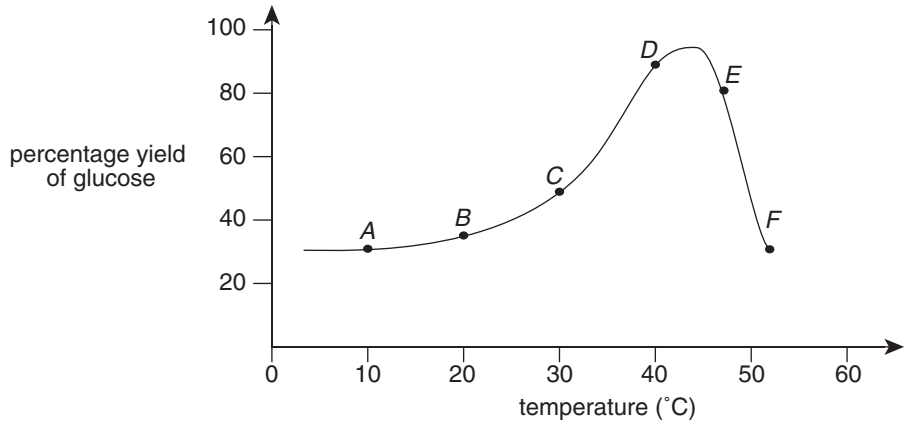
_____

_____

1 + 1 = 2 marks
Total 15 marks

Question 4

The enzyme amylase breaks down starch into glucose and maltose. An experiment was performed to determine the effect of temperature on the activity of the enzyme. Equivalent amounts of amylase were mixed with six starch solutions of equal concentrations in separate test tubes labelled *A* to *F*. Each of the starch-amylase mixtures was held at a different temperature throughout the experiment. The percentage yield of glucose was measured in each mixture after incubation for 20 minutes and the results are displayed in the graph below.



a. **i.** Explain why the percentage yield of glucose is low in test tube *A*.

_____

_____

_____

ii. After the experiment was completed, test tubes *A* and *F* with their contents were placed in another water bath and held at 40°C for a further 20 minutes.

In the table below, predict the overall percentage yield of glucose in each test tube after the further 20 minutes.

Test tube	Predicted percentage yield of glucose
A	
F	

iii. Explain your choice for test tube *F* in part **a. ii.**

_____

_____

_____

_____

1 + 2 + 2 = 5 marks

b. Maltose is a disaccharide consisting of two glucose molecules linked together.

i. Name the functional group in the glucose molecules involved in the formation of the linkage.

_____

ii. Name the type of linkage which occurs between the two glucose molecules to form maltose.

_____

1 +1 = 2 marks

c. Starch is a polysaccharide formed by the polymerisation of glucose molecules.
Calculate the molar mass of a sample of starch formed from 2000 glucose molecules.

_____

_____

_____

2 marks
Total 9 marks

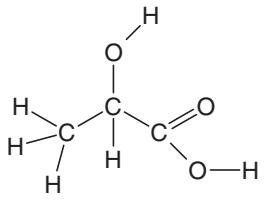
Question 5

Malic acid, $C_4H_6O_5$, is a weak diprotic acid found in grapes and apples, especially in unripe fruit.
The ^1H NMR spectrum of the malic acid molecule shows four peaks.

a. Draw a structural diagram of the malic acid molecule consistent with the information provided.

1 mark

b. During the production of wine from grapes, malic acid may undergo a fermentation process activated by bacteria. The products of this reaction are lactic acid and carbon dioxide. The structural formula of lactic acid is shown below.



i. Give the systematic name for lactic acid.

_____

ii. Write a balanced half-equation for the reduction reaction occurring during malic acid fermentation to produce lactic acid.

_____

_____

1 + 1 = 2 marks

c. Lactic acid occurs normally in human blood at a concentration of 45–190 mg L^{-1}. Calculate the minimum number of lactic acid molecules expected to be found in 1.0 L of blood.

_____

_____

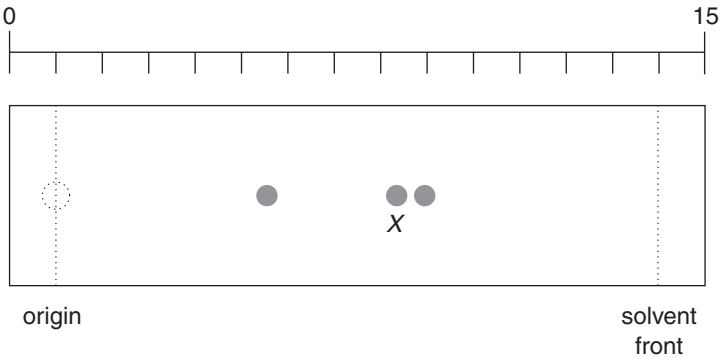
2 marks
Total 5 marks

Question 6

The table below lists five amino acids, together with their molar masses, isoelectric points and R_f values when separated by paper chromatography using solvent *S*.

Amino acid	Molar mass (g mol^{-1})	Isoelectric point	R_f using solvent S
alanine	89	6.0	0.55
arginine	174	10.8	0.60
glutamic acid	147	3.2	0.33
lysine	146	9.7	0.55
serine	105	5.7	0.34

a. A small sample of a mixture of some of these amino acids was placed at the origin of a piece of chromatography paper, and a chromatogram was developed using solvent *S*. The chromatogram obtained is shown below.



i. Amino acids are colourless.

Explain how the locations of the spots shown on the chromatogram would be determined.

_____

_____

_____

ii. Identify the amino acid labelled as spot *X* on the chromatogram.

_____

_____

_____

iii. Using a chromatographic technique, how could the identity of the amino acid at spot *X* be confirmed?

_____

_____

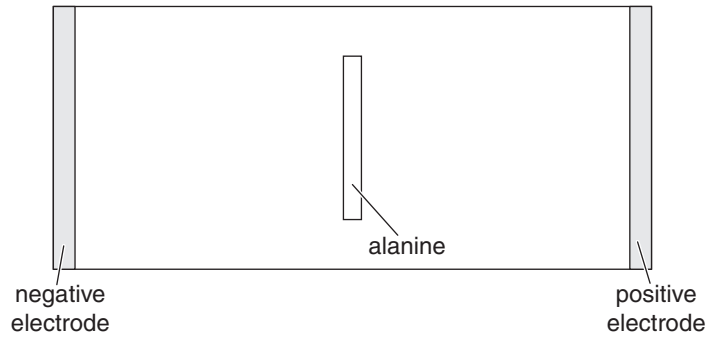
_____

1 + 2 + 1 = 4 marks

b. Separation and identification of the amino acids in a sample may also be made using gel electrophoresis. In this technique, charged substances are separated according to the different rates at which they move through a polyacrylamide gel when a potential difference is applied. The gel is moistened with a buffer solution so that the gel remains at a particular pH. At a particular pH some amino acids will be positively charged, some negatively charged and some will be zwitterions, the name given to an ion which carries both a positive and a negative charge. The isoelectric point of an amino acid is the pH at which its zwitterion forms. A mixture of three amino acids, alanine, glutamic acid and serine, is separated by gel electrophoresis in a buffer solution at pH 6.0.

i. Draw the structure, showing all bonds, of the amino acid alanine in its zwitterion state.

ii. On the diagram of the electrophoresis gel shown below, draw a possible finished gel after the amino acids have been separated, clearly labelling the locations of the glutamic acid and serine amino acids.



1 + 2 = 3 marks

c. **i.** Draw the structural formula of a dipeptide produced from the reaction of glutamic acid and serine.

ii. Circle the peptide (amide) functional group in the dipeptide drawn in part **i**.

1 + 1 = 2 marks
Total 9 marks

END OF QUESTION AND ANSWER BOOKLET

