Insight Publications

INSIGHT

Trial Exam Paper

2008

CHEMISTRY

Written examination 1

STUDENT NAME:

QUESTION AND ANSWER BOOK

Reading time: 15 minutes
Writing time: 1 hour 30 minutes

Structure of book

Section	*Number of questions*	*Number of questions to be answered*	*Number of marks*
A	20	20	20
B	6	6	47
			Total 67

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

Materials provided
- The question and answer book of 22 pages.
- An answer sheet for multiple-choice questions.
- A data book of 11 pages.

Instructions
- Write your **name** in the box provided.
- You must answer the questions in English.

At the end of the examination
- Place the multiple-choice answer sheet inside the front cover of this question and answer book.

Students are NOT permitted to bring mobile phones or any other electronic devices into the 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 the multiple-choice questions.
Choose the response that is **correct** or that **best answers** the questions.
1 mark will be awarded for a correct answer; no marks will be awarded for an incorrect answer.
Marks are **not** deducted for incorrect answers
No marks will be awarded if more than one answer is complete for any question.

Question 1

The combination of analytical techniques best suited to the separation and identification of esters used as flavourings in ice-cream is

A. UV-visible spectroscopy and nuclear magnetic resonance (NMR) spectroscopy.
B. thin-layer chromatography and infra-red (IR) spectroscopy.
C. high-performance liquid chromatography (HPLC) and NMR spectroscopy.
D. gas chromatography (GC) and UV-visible spectroscopy.

Questions 2 and 3 refer to the following information.

The percentage by mass of sodium ions in the form of sodium chloride in a particular brand of dry biscuit was determined using gravimetric analysis. A 3.65 g sample of the biscuits was ground into a powder, dissolved in water and filtered. Excess silver nitrate was added to the remaining solution to precipitate the chloride ions as silver chloride. The precipitate was collected, washed and dried. Its mass was found to be 0.241 g.

Question 2

The percentage by mass of sodium ions in the biscuit is closest to

A. 0.0387%
B. 1.06%
C. 1.47%
D. 2.69%

Question 3

The calculated percentage by mass of sodium chloride is lower than stated on the label on the packaging. This may be due to

A. incomplete precipitation of the chloride ions.
B. inadequate washing of the precipitate.
C. the precipitate not being dried to constant mass.
D. co-precipitation of another, unknown anion with the silver ions.

Question 4

100 g of propane gas combusts according to the equation

$$C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(g)$$

The volume of carbon dioxide produced, in L, at 5.00°C and 0.500 atm is

A. 5.59
B. 104
C. 311
D. 3.15×10^4

Question 5

Consider the equation

$$\_\_Al(s) + \_\_Cu^{2+}(aq) \rightarrow \_\_Al^{3+}(aq) + \_\_Cu(s)$$

The coefficients required in front of each species to balance the equation are, in order

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

Question 6

A volume of 180 mL of 1.0 M HCl is added to 100 mL of 1.0 M NaOH. The pH of the resultant solution is closest to

A. 0.3
B. 0.4
C. 0.5
D. 1.1

Question 7

Different quantities of sulfur trioxide (SO_3) are listed below. Which one contains the **greatest** number of molecules?

A. 8×10^2 g
B. 8 × 102 L at SLC
C. 8×10^{23} molecules
D. 8 mol

Question 8

7.33 g of lanthanum (La) combines with oxygen to give 8.60 g of an oxide. The empirical formula of the oxide is

A. La_2O_3

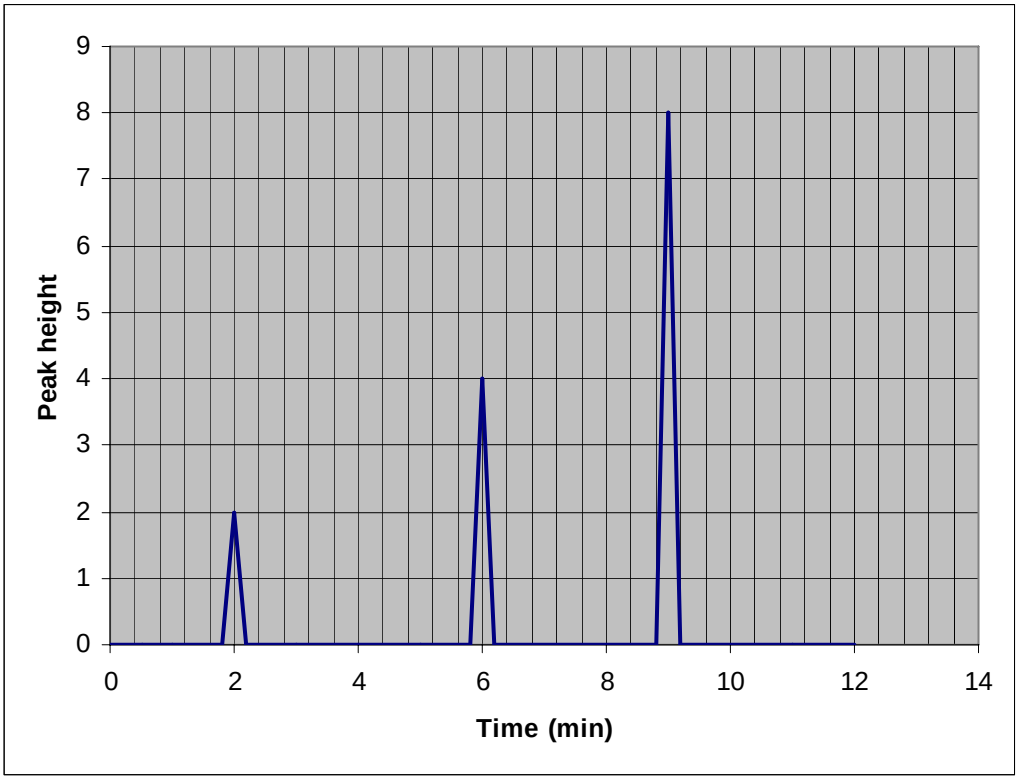
B. LaO_5

C. LaO_{10}

D. La_3O_2

Question 9

A mixture of gases collected from a car exhaust was analysed using gas chromatography. The carrier gas used is also recorded by the detector and known to have a retention time under these conditions of approximately 2 minutes. The following chromatogram was obtained.



Which of the following can be reasonably concluded from the chromatogram?

A. There are at least two components in the mixture of approximately the same amount.

B. There are at least two components in the mixture with one component present in twice the amount of the other.

C. There are at least three components in the mixture of approximately the same amount.

D. There are at least three components in the mixture with one present in twice the amount than the others.

Question 10

The structures of 2-chloropropane and propan-2-ol are analysed separately using low resolution nuclear magnetic resonance spectroscopy (NMR). Which of the following statements best describes the ^{1}H NMR spectra produced for each of the molecules?

A. The spectra for 2-chloropropane and propan-2-ol are identical in appearance.

B. The spectra for 2-chloropropane and propan-2-ol each have two main peaks.

C. The spectrum for 2-chloropropane has two main peaks whereas the spectrum for propan-2-ol has three main peaks.

D. The spectrum for 2-chloropropane has three main peaks whereas the spectrum for propan-2-ol has four main peaks.

Question 11

Which one of the following compounds will include absorption bands in the infra-red spectrum at about 1700 cm^{-1} and 2600 cm^{-1}?

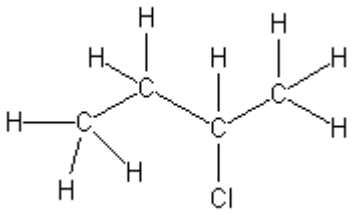
A. pentane

B. pentan-2-ol

C. pentanoic acid

D. pent-2-ene

Question 12



The systematic name for the molecule with the structure shown is

A. 1-methyl, 2-chloropropane

B. 2-chloro, 3-methylpropane

C. 3-chlorobutane

D. 2-chlorobutane

Questions 13 and 14 refer to the following reactions.

Reaction 1 $CH_2CH_2(g) + H_2O(g) \rightarrow X$

Reaction 2 $CH_3CH_3(g) + Y \rightarrow CH_3CH_2Cl(g) + HCl(g)$

Reaction 3 $CH_3CH_2CH_2Cl(aq) + OH^-(aq) \rightarrow Z + Cl^-(aq)$

Question 13

Which of the following shows the formulas of species X, Y and Z?

	Species X	**Species Y**	**Species Z**
A	CH_2CHOH	HCl	$CH_3CHOHCH_3$
B	CH_3CH_2OH	HCl	$CH_3CH_2CH_2OH$
C	CH_3CH_2OH	Cl_2	$CH_3CH_2CH_2OH$
D	CH_3CH_2OH	Cl_2	$CH_3CHOHCH_3$

Question 14

Which of the following correctly identifies each reaction type?

	Reaction 1	**Reaction 2**	**Reaction 3**
A	addition	substitution	substitution
B	addition	condensation	oxidation
C	addition	substitution	oxidation
D	substitution	condensation	substitution

Question 15

Which of the following is not considered a biochemical fuel?

A. ethanol
B. biodiesel
C. vegetable oils
D. natural gas

Question 16

The mass, in grams, of one molecule of ethanol is closest to

A. 7.48×10^{-23}
B. 7.64×10^{-23}
C. 46.0
D. 1.31×10^{22}

Question 17

Which of the following statements about the tertiary structure of proteins is **not** correct?

A. Changing the tertiary structure of a protein will always cause a change in its secondary and primary structures.

B. The three-dimensional structure of a protein is determined by its tertiary structure.

C. The tertiary structure of a protein is determined by interactions between different Z groups (side chains).

D. Changing the tertiary structure of an enzyme will always cause a change in its ability to catalyse a specific chemical reaction.

Question 18

Which of the following statements is **not** correct in describing the action of enzymes?

A. Enzymes generally operate at much lower pressures than inorganic catalysts.

B. Enzymes can catalyse only a small number of reactions each whereas an inorganic catalyst can catalyse a wider range of reactions.

C. Enzyme activity is destroyed at high temperatures whereas many inorganic catalysts require high temperatures to work.

D. Enzymes increase the rate of a reaction to a much greater extent than inorganic catalysts.

Question 19

Electrophoresis is useful for separating fragments of deoxyribonucleic acid (DNA) because all DNA fragments carry a

A. negative charge and, hence, are attracted to the positive electrode, and smaller fragments travel faster than larger fragments.

B. negative charge and, hence, are attracted to the positive electrode, and larger fragments travel faster than smaller fragments.

C. positive charge and, hence, are attracted to the negative electrode, and smaller fragments travel faster than larger fragments.

D. positive charge and, hence, are attracted to the negative electrode, and larger fragments travel faster than smaller fragments.

Question 20

When a molecule absorbs radio waves during nuclear magnetic resonance spectroscopy (NMR) this is most likely to lead to

A. the molecule moving to a higher vibrational energy level.

B. a deflection in the path taken by the molecule when it is travelling at high speeds.

C. an electron being promoted from a lower energy level to a higher energy level.

D. a change in the spin state of nucleons.

END OF SECTION A

SECTION B – Short-answer questions

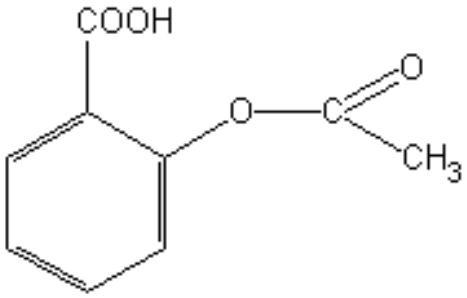
Instructions for Section B

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 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

Acetylsalicylic acid, or aspirin, is a drug commonly used as an analgesic (painkiller), to reduce fever and as an anti-inflammatory. The structure of aspirin is shown below.



Aspirin can be produced in the laboratory by a number of different synthetic pathways. In one pathway, salicylic acid reacts via a condensation reaction with ethanoic acid to produce aspirin and water.

1a. In the space below, draw the structures of salicylic acid and ethanoic acid.

A student wishes to analyse the aspirin content in a particular brand of headache tablets. Five headache tablets are dissolved in 25.00 mL of 1.00 M sodium hydroxide in a 250.0 mL volumetric flask and the mixture is heated. The reaction occurring is:

$$CH_3COOC_6H_4COOH(s) + 2NaOH(aq) \rightarrow CH_3COONa(aq) + HOC_6H_4COONa(aq) + H_2O(l)$$

The mixture is then made up to 250 mL with water and several 25.00 mL aliquots are transferred to conical flasks and titrated with 0.100 M hydrochloric acid, using phenolphthalein as the indicator. The reaction occurring is:

$$NaOH(aq) + HCl(aq) \rightarrow NaCl(aq) + H_2O(l)$$

Titre volumes of 6.62 mL, 6.41 mL, 6.38 mL and 6.40 mL are obtained.

1b. Calculate the amount, in mol, of hydrochloric acid in the average titre.

_____

_____

_____

_____

2 marks

1c. Calculate the amount of sodium hydroxide in excess in the volumetric flask after the reaction with aspirin.

_____

_____

_____

_____

_____

_____

2 marks

1d. Calculate the amount, in mol, of aspirin in the volumetric flask and, hence, the average mass of aspirin in one headache tablet. Ensure your answer is expressed to the correct number of significant figures.

4 marks

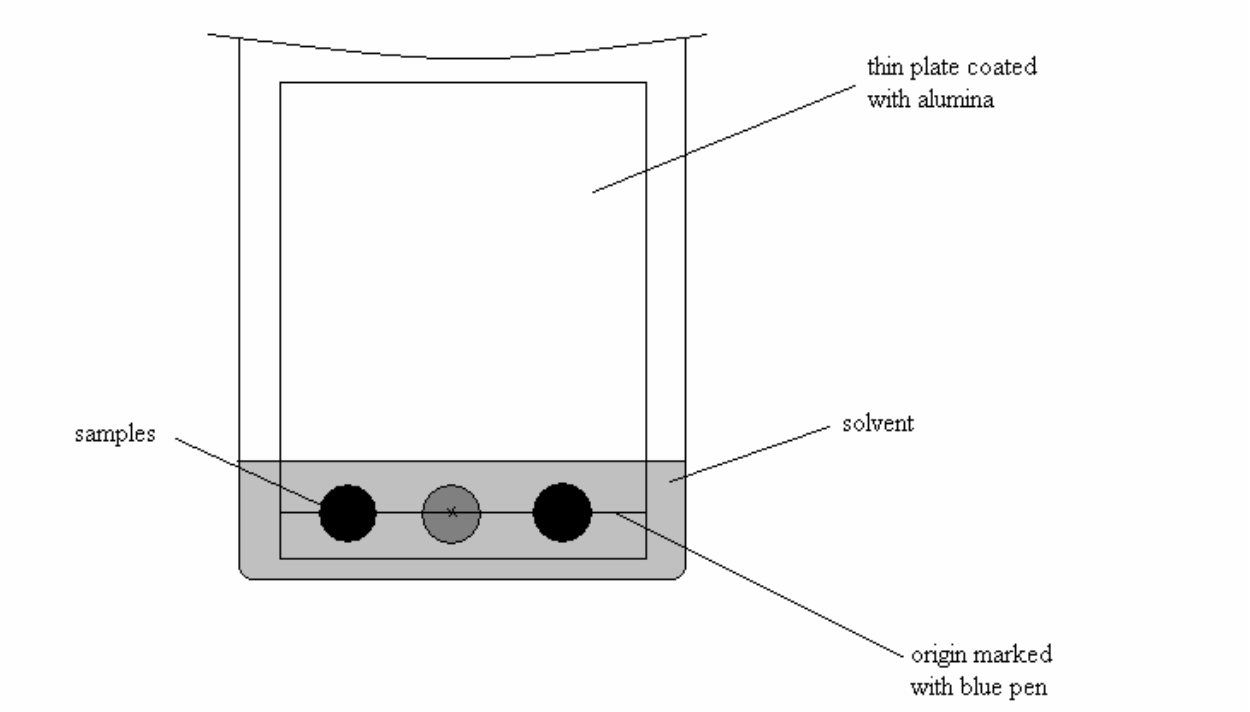
1e. Describe a rinsing error that could be made during the experiment that would result in the mass of aspirin in the tablet being calculated as higher than it should be.

1 mark

Total 2 + 2 + 2 + 4 + 1 = 11 marks

Question 2

2a. Some students use thin-layer chromatography to try to identify an unknown food colouring in a green icy pole. One student uses a blue pen to mark an origin on the plate, applies a large spot of an icy pole sample and two known food colouring standards onto the origin, and places the plate in the solvent, as shown below.



Identify two experimental errors made by this student and describe their likely effect on the experiment.

Error 1 _____

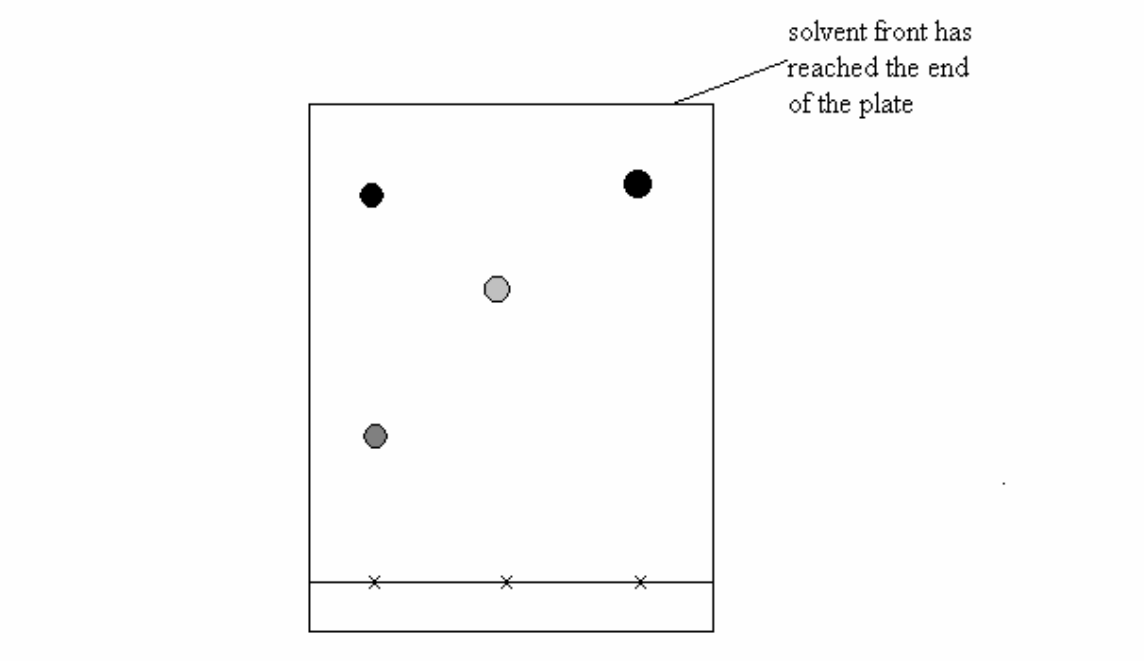
Likely effect _____

Error 2 _____

Likely effect _____

2 marks

2b. A second student begins the experiment with a correct initial set-up and allows the solvent to move up the plate. The diagram below shows the appearance of the plate after it was removed from the solvent.



Explain why this student is unable to calculate accurate R_f values for the components in the mixture.

_____

1 mark

2c. Briefly explain why the components of a mixture separate in thin-layer chromatography.

_____

_____

_____

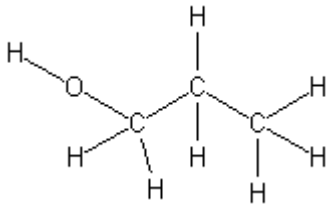
_____

2 marks

Total 2 + 1 + 2 = 5 marks

Question 3

3a. Consider the compound represented by the structure shown below.



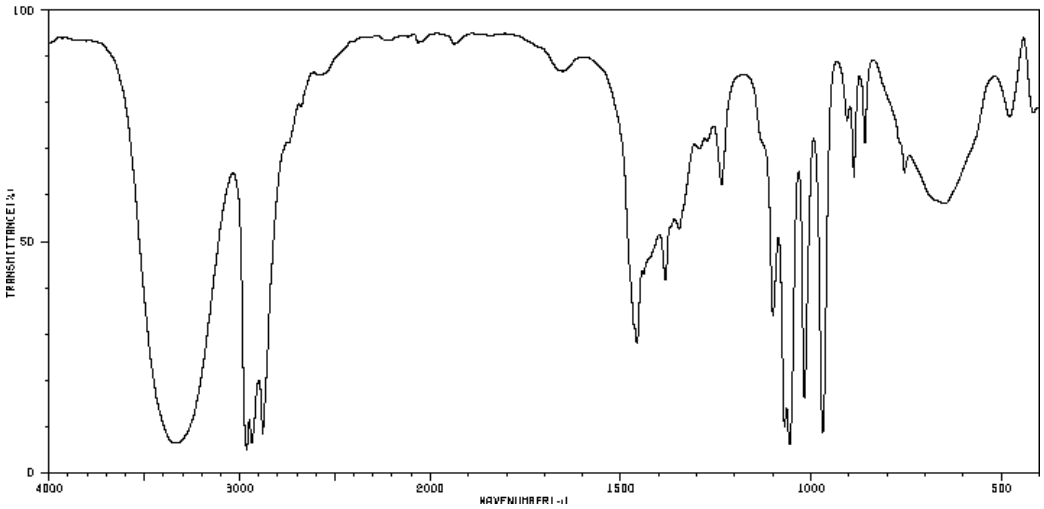
Give the name of this compound.

_____

1 mark

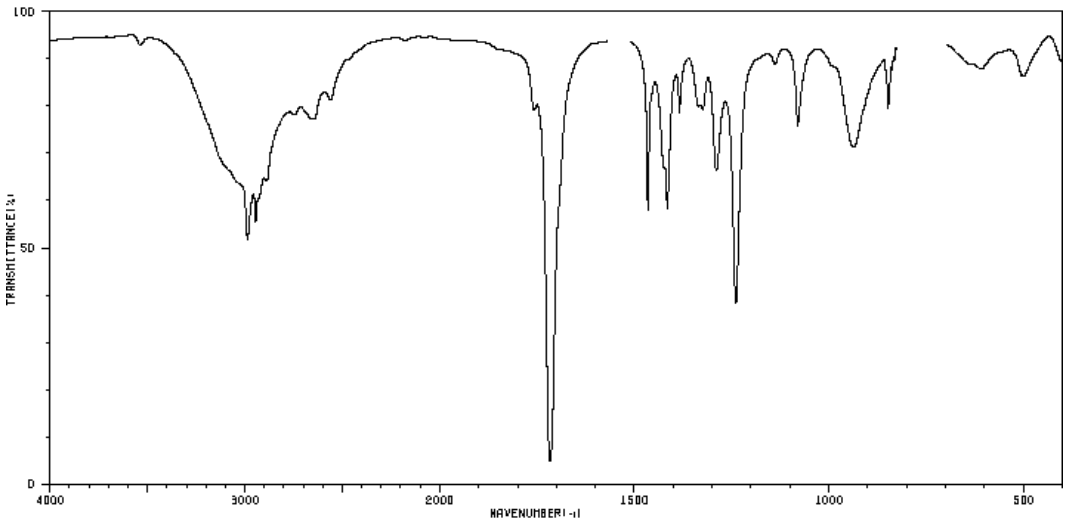
3b. **i.** Consider the two infra-red spectra below.

Spectrum A



SDBSWeb: http://riodb01.ibase.aist.go.jp/sdbs/ (National Institute of Advanced Industrial Science and Technology, accessed 11/03/2008)

Spectrum B



SDBSWeb: http://riodb01.ibase.aist.go.jp/sdbs/ (National Institute of Advanced Industrial Science and Technology, accessed 11/03/2008)

Which of the spectra, A or B, is most likely to be the spectrum of the compound with the structural formula shown above? Explain how you arrived at your answer.

_____

_____

_____

2 marks

3c. How many peaks, in addition to the TMS signal, would you expect to see in the ^{13}C NMR spectrum of this compound? Give a reason for your answer.

_____

_____

_____

2 marks

3d. All types of spectroscopy use a part of the electromagnetic spectrum. One spectroscopic technique is used in the analysis of sodium chloride in potato chips. This technique uses radiation from the visible part of the electromagnetic spectrum to give quantitative information.

i. Name the spectroscopic technique used in this analysis.

_____

1 mark

ii. Identify the type of lamp that should be used in this analysis. Give a reason for your answer.

_____

_____

2 marks

Total 1 + 2 + 2 + 3 = 8 marks

Question 4

Consider the reactions below.

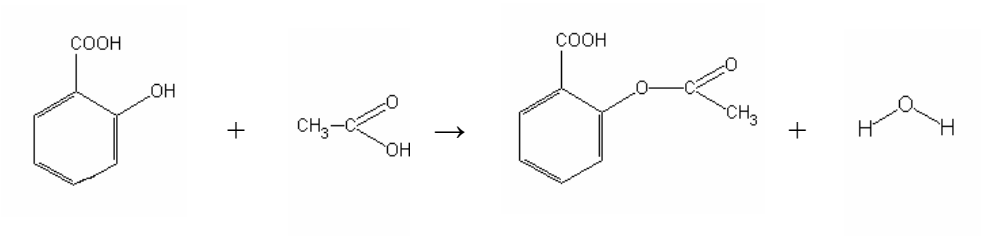
A $C_6H_{12}O_6(aq) \rightarrow 2CH_3CH_2OH(aq) + 2CO_2(g)$

B $C_3H_8O_3(aq) + 3C_{18}H_{36}O_2(aq) \rightarrow C_{57}H_{110}O_6(aq) + 3H_2O(l)$

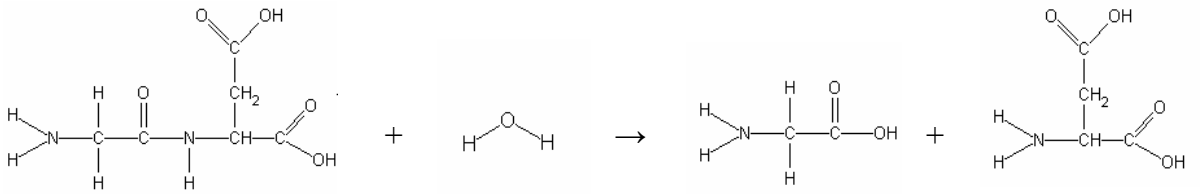
C $C_3H_8O_3(aq) + 3C_{18}H_{34}O_2(aq) \rightarrow C_{57}H_{104}O_6(aq) + 3H_2O(l)$

D $CH_2CH_2(g) + H_2O(g) \rightarrow CH_3CH_2OH$

E



F



G $4C_6H_{12}O_6(aq) \rightarrow 2C_{12}H_{22}O_{10}(aq) + 2H_2O(l)$

H $CH_3CH_2CH_2Br(aq) + NH_3(g) \rightarrow CH_3CH_2CH_2NH_2(aq) + HBr(g)$

Using the letters A–H, indicate which one or more of the reactions represented by the equations above fits the descriptions below. The equations can appear more than once.

4a. An addition reaction

_____

1 mark

4b. Involves a reaction between hydroxy and carboxy functional groups

_____

1 mark

4c. Is catalysed by enzymes in yeast

_____

1 mark

4d. Involves an unsaturated fatty acid

_____

1 mark

4e. A condensation reaction

_____

1 mark

4f. A substitution reaction

_____

1 mark

Total 1 + 1 + 1 + 1 + 1 + 1 = 6 marks

Question 5

5a. Draw the structural formula for propyl ethanoate. Clearly show all bonds.

1 mark

5b. Design a reaction pathway for the synthesis of propyl ethanoate from propane and ethene. Include all relevant chemical equations.

6 marks

5c. Fractional distillation can be used to separate different organic compounds and hydrocarbons.

i. State the physical property used to separate different components in fractional distillation.

1 mark

ii. Describe one structural feature of hydrocarbons that influence their separation using fractional distillation.

_____

_____

1 mark

Total 1 + 6 + 2 = 9 marks

Question 6

Deoxyribonucleic acid (DNA) provides the genetic code for all living things. Its structure codes for particular sequences of amino acids, which link together to form proteins.

6a. Draw the structure of a single nucleotide that includes the base cytosine.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

2 marks

6b. Describe the secondary structure of a DNA polymer.

_____

_____

_____

2 marks

6c. A section of one strand of DNA codes for a protein that includes the amino acids cysteine, alanine and serine, in that order. Draw the structure of this section of the protein.

1 mark

6d. Describe how the Z group of cysteine may contribute to the tertiary structure of the protein.

_____

_____

1 mark

6e. Draw the structure of glutamic acid as it would appear in a solution of pH 12.

1 mark

6f. Give one example of how the presence of a protein can be used as a marker for disease.

_____

1 mark

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

END OF QUESTION AND ANSWER BOOK