INSIGHT

Trial Exam Paper

2011

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	9	9	56
			Total 76

- 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 19 pages, with a removable data sheet.
- An answer sheet for multiple-choice questions.

Instructions

- Remove the data sheet from this book during reading time.
- 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.

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 chosen for any question.

Question 1

20.00 mL of 0.10 M sodium hydroxide is placed in a volumetric flask and titrated with 0.10 M ethanoic acid. The volume of ethanoic acid required to react completely with the sodium hydroxide and the approximate pH at the equivalence point would be closest to

	Volume of ethanoic acid required (mL)	**pH at equivalence point**
A.	less than 20.00 mL	7
B.	less than 20.00 mL	greater than 7
C.	20.00 mL	7
D.	20.00 mL	greater than 7

Question 2

For which of the following titrations between 0.10 M reactants will phenolphthalein be a suitable choice for indicator?

I $C_2H_5COOH(aq) + NaOH(aq) \rightarrow C_2H_5COONa(aq) + H_2O(l)$

II $NaOH + NH_4^+ \rightarrow Na^+(aq) + NH_3(g) + H_2O(l)$

III $KOH(aq) + HCl(aq) \rightarrow KCl(aq) + H_2O(l)$

IV $NH_4^+(aq) + Cl^-(aq) \rightarrow NH_4Cl(aq)$

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

Question 3

Caffeine, $C_8H_{10}N_4O_2$ (molar mass 194 g mol^{-1}), is the stimulant found in coffee and a number of soft drinks. A 270 mL cup of coffee is found to contain 420 mg of caffeine.
What mass, in g, of nitrogen originating from caffeine, will be present in 1.00 L of coffee?

A. 0.121
B. 0.289
C. 0.450
D. 1.56

Question 4

A dipeptide is produced by a reaction between 10.0 g each of the amino acids cysteine (M = 121.2 g mol^{-1}) and glycine (M = 75.1 g mol^{-1}). The mass, in g, of water eliminated in the reaction is

A. 0.0825

B. 1.49

C. 2.39

D. 2.98

Question 5

The initial reaction that occurs when a car airbag is triggered to inflate is

$$2NaN_3(s) \rightarrow 2Na(s) + 3N_2(g)$$

When two moles of NaN_3 reacts, the total volume, in L, of gas produced by this reaction, as measured at 32°C and 100 kPa, is closest to

A. 7.98

B. 33.8

C. 50.7

D. 76.0

Question 6

In a particular solvent used for thin-layer chromatography (TLC), compounds A and B have R_f values, as shown in the table below.

Compound	**R_f value**
A	0.46
B	0.15

In one analysis, compound A travels 3.5 cm from the origin. The origin is marked at 0.7 cm from the bottom of the plate.
The distance, in cm, travelled by compound B from the origin will be

A. 0.91

B. 1.14

C. 1.84

D. 4.2

Question 7

Which of the following analytical techniques is **least** likely to be used as part of a series of analyses performed to identify an unknown organic compound and determine its concentration in a mixture?

A. gas liquid chromatography

B. mass spectrometry

C. infrared spectroscopy

D. atomic absorption spectroscopy

Question 8

When a sample absorbs radiowaves during NMR spectroscopy

A. electrons in atoms are promoted to higher energy levels.
B. nucleons are promoted to higher energy spin states.
C. molecules move to higher vibrational energy levels.
D. molecules are ionised.

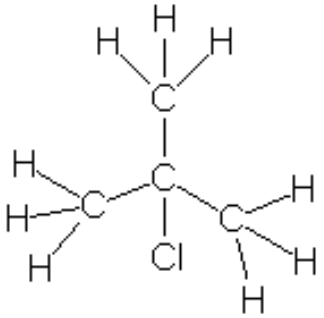
Question 9

The concentration of copper ions in ground water is to be analysed using atomic absorption spectroscopy. A sample of the water is sprayed into a flame and a light is passed through.

A. A zinc lamp should be used and the intensity of the light will be greater after passing through the sample in the flame.
B. A zinc lamp should be used and the intensity of the light will reduce after passing through the sample in the flame.
C. A copper lamp should be used and the intensity of the light will be greater after passing through the sample in the flame.
D. A copper lamp should be used and the intensity of the light will reduce after passing through the sample in the flame.

Question 10

What is the correct systematic name for the following compound?



A. 2-methyl-chloropropane
B. 2-methyl-chlorobutane
C. 2-chloro-2-methylpropane
D. 2-chloro-2-methylbutane

Question 11

For which of the following molecular formulae are there four possible isomers?

I C_3H_7Cl
II C_4H_9Cl
III $C_3H_6Cl_2$

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

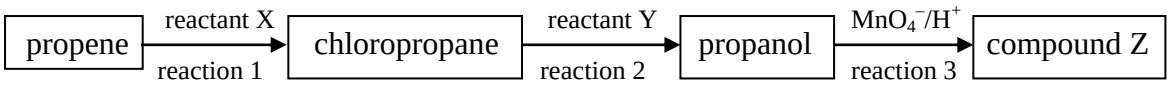
Question 12

Which of the following amino acids will have the highest pH when dissolved in solution?

A. aspartic acid
B. histidine
C. lysine
D. methionine

Questions 13 and 14 refer to the following information.

Propene can be converted into other types of carbon compounds according to the following flow chart.



Question 13

What could compounds X, Y and Z be, respectively?

A. Cl_2, NaOH, propanoic acid
B. Cl_2, H_2O, propene
C. HCl, NaOH, propanoic acid
D. HCl, H_2O, propene

Question 14

Reactions 1, 2, and 3 can be described, respectively, as

A. addition, substitution, oxidation.
B. addition, oxidation, condensation.
C. substitution, condensation, oxidation.
D. substitution, substitution, oxidation.

Question 15

Which of the following amino acids is **most** likely to form covalent bonds at the tertiary structure level of a protein?

A. asparagine
B. isoleucine
C. cysteine
D. serine

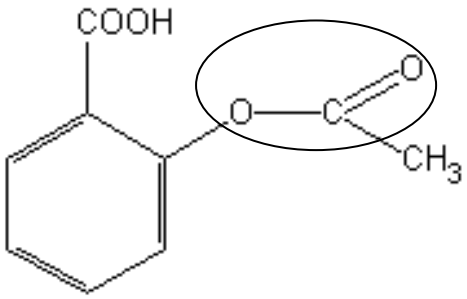
Question 16

A tripeptide consists of three different amino acids: A, B and C. What is the maximum number of possible tripepetides that can be formed?

A. 3
B. 4
C. 5
D. 6

Question 17

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



What is the molar mass of aspirin and the name of the circled linkage?

A. 180 g mol^{-1}, ester
B. 176 g mol^{-1}, ester
C. 180 g mol^{-1}, ether
D. 176 g mol^{-1}, ether

Questions 18 and 19 refer to the following information.

The percentage by mass of sodium ions in the form of sodium chloride in a particular brand of gravy powder was determined using gravimetric analysis. A 2.67 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 0.187 g.

Question 18

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

A. 0.033%
B. 1.12%
C. 2.24%
D. 2.85%

Question 19

The percentage by mass of sodium chloride calculated by a student is higher than that stated on the label on the gravy powder packaging. This may be due to

I incomplete precipitation of the chloride ions.
II inadequate washing of the precipitate.
III the precipitate was not dried to constant mass.
IV co-precipitation of another, unknown anion with the silver ions.

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

Question 20

The activity of a particular enzyme is reduced at temperatures above 40°C. Which of the following best describes this observation?

A. Hydrogen bonds in the primary structure are broken.
B. Amide linkages are broken.
C. Covalent bonds in the tertiary structure are broken.
D. Hydrogen bonds in the secondary and tertiary structures are broken.

END OF SECTION A
TURN OVER

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

The amount of vitamin C ($C_6H_8O_6$) in a new brand of fruit juice is to be determined.
A 25.00 mL sample of juice is diluted to 250.0 mL with pure water in a volumetric flask.
20.00 mL aliquots of the diluted juice are then placed in a conical flask and titrated against a solution containing 1.80×10^{-4} mol L^{-1} I_3^- ions.

The reaction is

$$C_6H_8O_6(aq) + I_3^-(aq) \rightarrow C_6H_6O_6(aq) + 2H^+(aq) + 3I^-(aq)$$

The half-reaction for the reduction of $I_3^-(aq)$ to $I^-(aq)$ is

$$I_3^-(aq) + 2e^- \rightarrow 3I^-(aq)$$

Four titrations are carried out and the volumes of the I_3^- titres are recorded in the table below.

Titration number	1	2	3	4
Volume of I_3^- solution (mL)	16.87	16.15	17.03	16.93

a. Write a balanced half-equation, including states, for the oxidation of vitamin C.

_____

_____

2 marks

b. Calculate the average volume, in mL, of the concordant titres of the $I_3^-(aq)$ solution.

_____

_____

1 mark

c. Calculate the amount, in mol, of vitamin C present in each 20.00 mL aliquot.

2 marks

d. Calculate the concentration, in mol L^{-1}, of vitamin C in the original (i.e., undiluted) sample of fruit juice.

2 marks

e. Express your answer to **part d** in g L^{-1}.

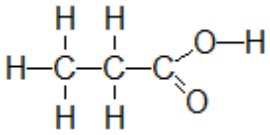
2 marks

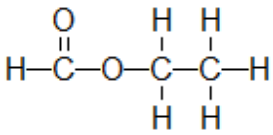
Total 2 + 1 + 2 + 2 + 2 = 9 marks

Question 2

A molecule with the formula $C_3H_6O_2$ is thought to have one of the following structures.

molecule A **or** **molecule B**





The molecule is first subjected to infrared (IR) spectroscopy.

a. Explain how this analysis will help in identifying which of these is the correct structure.

_____

_____

_____

_____

2 marks

The molecule is subjected to further analysis using nuclear magnetic resonance (NMR) spectroscopy.

b. How many different carbon environments are present in each molecule?

Molecule A: _____

Molecule B: _____

2 marks

c. The ^1H NMR spectrum of the analysed molecule shows three peaks in addition to the TMS calibration peak. The peaks have relative areas of 1, 2 and 3. Draw the grouping of atoms in molecule A that could give rise to the peak with a relative area of 3.

1 mark

d. The peaks in the ^{1}H NMR spectrum have distinctive splitting patterns. One peak is a singlet, one is a triplet and another is a quartet. Draw the groupings of atoms in molecule B that would give rise to the singlet and quartet splitting patterns.

2 marks

e. A further test showed that the molecule being tested reacted with a base. Identify whether the molecule is A or B and give the name of the molecule.

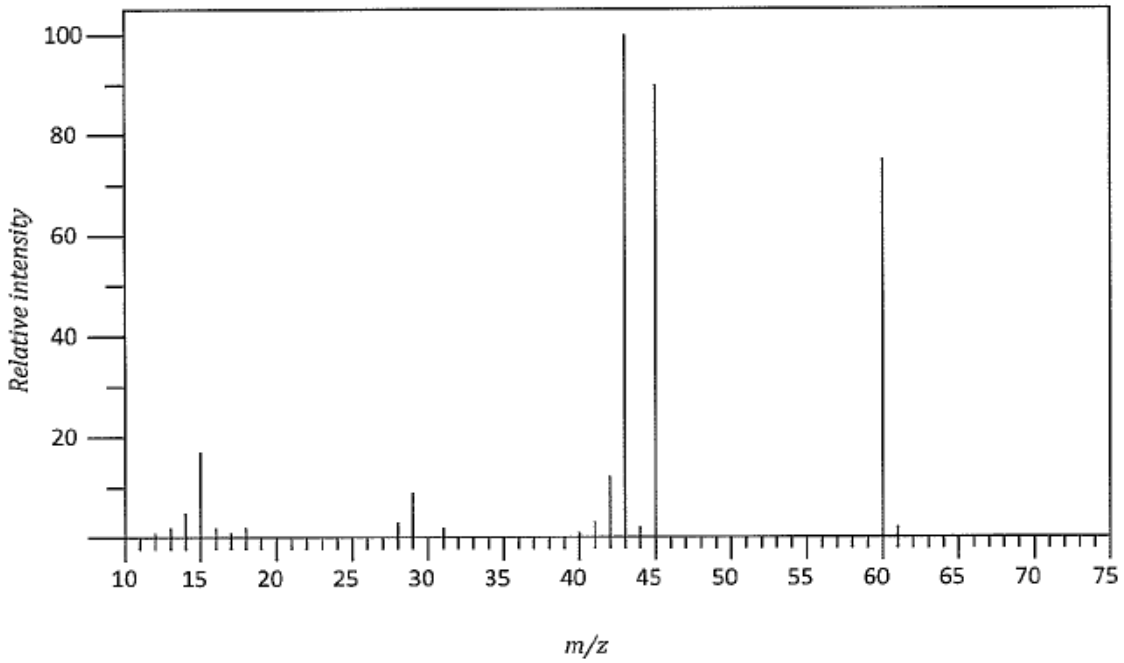
_____

2 marks

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

Question 3

The mass spectrum of ethanoic acid is shown below.



a. **i.** On the spectrum above, circle the peak that is caused by the parent molecular ion.

1 mark

ii. Write an equation showing the formation of the parent ion in the mass spectrometer.

_____

1 mark

b. What fragment must have been lost from ethanoic acid to account for the peak at m/z 45?

_____

1 mark

c. Write an equation showing the formation of the fragment at m/z 15 from the parent ion.

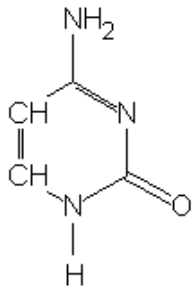
_____

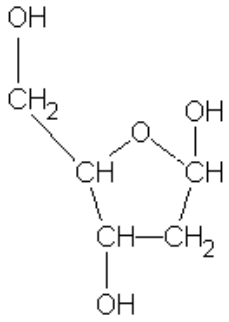
1 mark

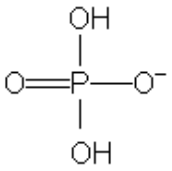
Total 2 + 1 + 1 = 4 marks

Question 4

Shown below are some of the components of a nucleotide that is the building block of a single strand of DNA.







a. **i.** Circle only the atoms on the components that will form bonds with the other components to form a single nucleotide.

2 marks

ii. Name the type of bonding that holds the three components of the nucleotide together.

_____

1 mark

b. Strand A is a segment of double-stranded DNA in which 35% of the bases are of the type given in **part a.** Strand B is a segment of double-stranded DNA in which only 10% of the bases are of this type. Which strand would be **least** readily separated by heating? Give an explanation for your answer.

_____

_____

_____

2 marks

Total 3 + 2= 5 marks

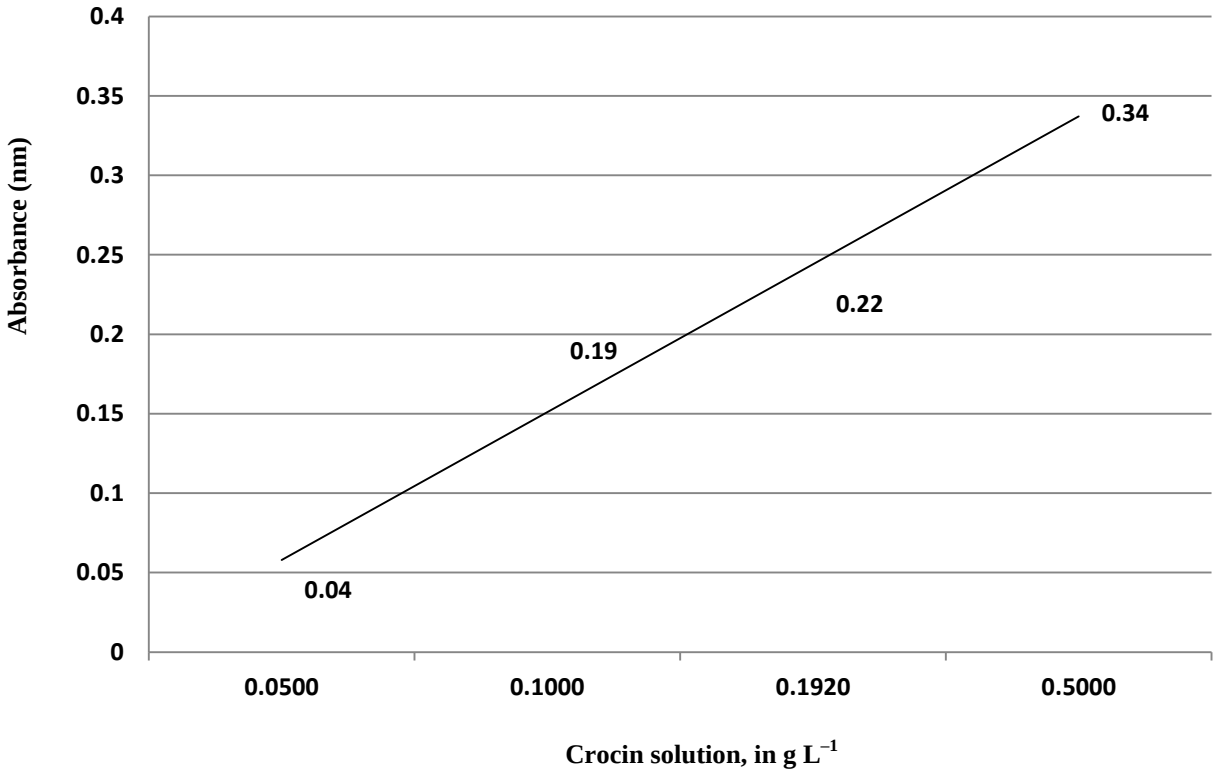
Question 5

Saffron is a spice that is highly valued for its colour and aroma. The chemical responsible for its rich golden colour is crocin ($C_{44}H_{64}O_{24}$; molar mass = 977 g mol^{-1}). UV-visible spectroscopy is used to analyse the crocin content of a batch of saffron.

A stock solution of crocin is prepared by dissolving 0.500 g of crocin in 250.0 mL of water. The stock solution is then diluted to make the following three standard solutions.

Standard solution	Crocin solution, in g L^{-1}
standard 1	1.00×10^{-2}
standard 2	5.00×10^{-2}
standard 3	1.00×10^{-1}

The absorbances of the standard solutions are measured at an appropriate wavelength and the following calibration line is obtained.



Crocin solution, in g L^{-1} (x-axis)	Absorbance (y-axis)
0.0500	0.04
0.100	0.19
0.192	0.22
0.500	0.34

a. Calculate the concentration, in mol L^{-1}, of crocin in the stock solution.

_____

_____

_____

_____

2 marks

b. The crocin in a dried 4.875 g sample of saffron is extracted into solution. The solution is filtered and made up to 100 mL in a volumetric flask. 10.0 mL of this solution is then further diluted to 250 mL. The absorbance of the diluted solution at the same wavelength as that used in the calibration was found to be 0.22.

i. Calculate the crocin content of the diluted solution, in g L^{-1}.

_____

1 mark

ii. Calculate the percentage by mass of crocin in the saffron sample.

_____

_____

_____

_____

2 marks

Total 2 + 3 = 5 marks

Question 6

a. Draw the structure of one dipeptide that could result from the linking of asparagine and alanine.

2 marks

b. Would you expect a solution of the dipeptide you drew in **part a** dissolved in water to be acidic, basic or neutral? Give a reason for your answer.

_____

_____

_____

2 marks

Total 2 + 2 = 4 marks

Question 7

a. Ethanol can be added to petrol to reduce our reliance on fossil fuels as the energy source for vehicles. It is produced primarily by the fermentation of glucose in plant grains.

i. Write a balanced chemical equation to show how glucose is produced by plants.

_____

1 mark

ii. Write a balanced chemical equation to show the fermentation of glucose to ethanol.

_____

1 mark

iii. Write a balanced chemical equation to show the combustion of ethanol for the release of energy.

_____

1 mark

b. Biodiesel is another biochemical fuel that can be produced by a reaction between methanol and the fatty acids obtained from triglycerides in plant oils.

i. Name the type of organic molecule that would result from the reaction between methanol and a fatty acid.

_____

1 mark

ii. Give the formula of the other molecule that would be produced in this reaction.

_____

1 mark

iii. One type of biodiesel that is produced from fatty acids has the formula $C_{15}H_{29}COOH$. How many double bonds does this molecule have?

_____

1 mark

Total 3 + 3 = 6 marks

Question 8

A low molecular mass unbranched alkane is subjected to the sequence of chemical reactions below.

- The alkane is added to a sample of chlorine gas and placed under ultraviolet light. Two compounds, A and B, are formed, each with a molar mass of 92.5 g mol^{-1}.
- One of these compounds is isolated and allowed to react with sodium hydroxide to form compound C, which is then heated with a solution containing acidified dichromate ions and reacted completely to form compound D.
- Compound D is reacted with sodium carbonate crystals to produce a gas.

a. Give the systematic names of compounds A and B.

Compound A: _____

Compound B: _____

2 marks

b. Draw the structure of compound C below and give the systematic name of the compound.

2 marks

c. Write redox half-equations for the reaction that produces compound D. The dichromate ions, $Cr_2O_7^{2-}$, are converted to Cr^{3+} ions.

Oxidation reaction:

_____

_____

Reduction reaction:

_____

_____

2 marks

Total 2 + 2 + 2 = 6 marks

Question 9

Methanol and ethanol can both form solutions by dissolving in water.

a. **i.** Draw the structure of a methanol molecule.

1 mark

ii. Explain how methanol is able to form bonds with and dissolve in water.

_____

_____

2 marks

b. The different boiling points of methanol, ethanol and water are listed in the table below.

Molecule	Boiling point (°C)
methanol	64.5
ethanol	78.3
water	100.0

i. Explain, in terms of intermolecular forces, why the boiling point of ethanol is higher than that of methanol.

_____

_____

_____

1 mark

ii. Give the name of the process that could be carried out to separate and collect the methanol and ethanol from the water, based on their different boiling points.

_____

1 mark

iii. Briefly describe how you would obtain a pure sample of methanol from the mixture using this process.

_____

_____

_____

2 marks

c. Give the name of the process that could be used to determine the concentration of methanol and ethanol in the water.

_____

1 mark

Total 3 + 4 + 1 = 8 marks

END OF QUESTION AND ANSWER BOOK