Insight Publications

INSIGHT
Trial Exam Paper

2006
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*	*Suggested times (minutes)*
A	20	20	20	26
B	8	8	59	64
			Total 79	90

- Students are permitted to bring the following items into the examination: pens, pencils, highlighters, erasers, sharpeners and rulers, an approved graphics calculator with the memory cleared and/or a 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 separate data sheet and a separate answer sheet for multiple-choice questions.

Instructions
- Write your **name** in the box provided.
- Remove the data sheet.
- 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 multiple-choice questions.
Choose the response that is **correct** or that **best answers** the question.
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 completed for any question.

Question 1

The compound in which nitrogen has the lowest oxidation number is

A. NO_2
B. NO_3^-
C. N_2O
D. HNO_3

Question 2

A 3.45 g sample of baby food is analysed for sodium chloride content. The sample is dissolved in water and filtered, then excess silver nitrate is added to the baby food solution to react according to the equation

$$NaCl(aq) + AgNO_3(aq) \rightarrow AgCl(s) + NaNO_3(aq)$$

The precipitate is washed, dried and weighed and found to have a mass of 0.45 g. The percentage, by mass, of sodium chloride in the baby food is closest to

A. 18%
B. 13%
C. 5%
D. 0.8%

Question 3

The amount, in mol, of chloride ions present in 4.55 g of magnesium chloride is

A. 0.0477
B. 0.0761
C. 0.0955
D. 0.152

Question 4

A 4.00 g sample of a hydrocarbon contains 3.27 g of carbon. The empirical formula of the hydrocarbon is

A. CH
B. CH_2
C. CH_4
D. C_3H_8

Question 5

Propane gas undergoes combustion in oxygen according to the following equation.

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

The maximum volume, in litres, of oxygen that would be required to react with 100 g of propane at STP is

A. 50.9 L
B. 55.6 L
C. 255 L
D. 279 L

Question 6

500 mL of 0.100 M NaOH is added to an amount of water at 25°C. The pH of the resultant solution is 12. The volume of water used is

A. 0.45 L
B. 0.50 L
C. 4.5 L
D. 5.0 L

Question 7

50 mL of 0.0100 M hydrochloric acid and 50 mL of 0.0100 M sulfuric acid are mixed together. The pH of the resultant solution is

A. 1.8
B. 2.0
C. 2.8
D. 3.0

Question 8

The self-ionisation constant of pure water at 55°C is 7.29×10^{-14} M^2. The hydroxide ion concentration and pH will be, respectively,

A. 1.0×10^{-7} M and 6.57
B. 1.0×10^{-7} M and 7.00
C. 2.7×10^{-7} M and 6.57
D. 2.7×10^{-7} M and 7.00

Question 9

Which of the following analytical techniques would be used to identify a metal deficiency in the blood?

A. flame tests
B. high-performance liquid chromatography
C. gas-liquid chromatography
D. atomic absorption spectroscopy

Question 10

The process of addition polymerisation is used to produce an unbranched polyethene molecule containing 3300 carbon atoms. The number of water molecules eliminated in this process would be closest to

A. 0
B. 2
C. 1650
D. 3300

Questions 11 and 12 refer to the following information.

Excess hydrochloric acid (HCl) is added to a sample of aluminium (Al) and allowed to react according to the chemical equation

$$2Al(s) + 6HCl(aq) \rightarrow 2AlCl_3(aq) + 3H_2(g)$$

250 mL of hydrogen gas is then collected at 23°C and 1.0 atm.

Question 11

The amount of hydrogen gas collected, in mol, would be closest to

A. 97
B. 0.13
C. 1.0×10^{-2}
D. 1.0×10^{-4}

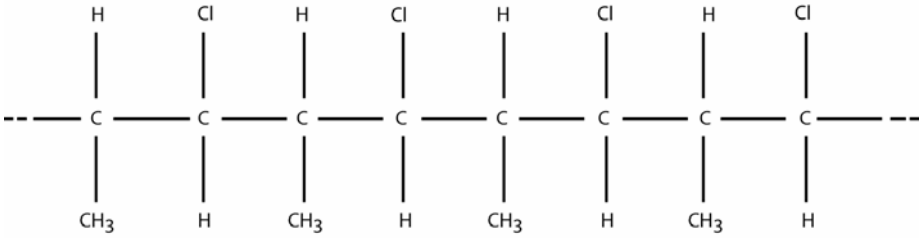
Question 12

The mass of aluminium, in grams, that reacts with the hydrochloric acid is closest to

A. 0.14
B. 0.18
C. 0.27
D. 0.41

Question 13

Consider the polymer



The semi-structural formula of the monomer that underwent addition polymerisation to form this polymer is

A. CH_2CHCl

B. $CH_3CH_2CH_2Cl$

C. CH_2CClCH_3

D. $CH_3CHCHCl$

Question 14

Consider the equilibrium

$$2HI(g) \leftrightharpoons H_2(g) + I_2(g); \qquad K = 6.3\times10^{-3}\ \text{M at 500 K}$$

A volume of 500 mL of a reaction mixture at equilibrium at 500 K contains 0.13 mol of H_2 and 0.80 mol of HI. The concentration of I_2, in M, will be

A. 0.031

B. 0.039

C. 0.062

D. 0.12

Question 15

Hydrocarbon molecules obtained from crude oil by fractional distillation can undergo catalytic cracking to produce smaller hydrocarbons. Which of the following is **not** a possible product of the catalytic cracking of octane?

A. propene

B. carbon dioxide

C. hydrogen

D. ethane

Question 16

How many different structural isomers exist with the molecular formula C_4H_9OH?

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

Question 17

Consider the reaction represented by the chemical equation

$$PCl_5(g) \leftrightharpoons PCl_3(g) + Cl_2(g); \qquad K_1 = 0.040 \text{ M at } 250°C$$

The equilibrium constant for the reaction represented by the chemical equation

$$2Cl_2(g) + 2PCl_3(g) \leftrightharpoons 2PCl_5(g)$$

at the same temperature would be closest to

A. 6.3×10^2
B. 25
C. 13
D. 1.6×10^{-3}

Question 18

An aqueous mixture of two substances (X and Y) is subjected to paper chromatography. Component X of the sample bonded more strongly to the stationary phase than component Y.

Which of the following statements is correct?

A. Component X has a higher R_f value than component Y.
B. If the same mixture was subjected to high-performance liquid chromatography (HPLC), component X would have a higher retention time than component Y.
C. The relative R_f values of X and Y cannot be compared unless the distance travelled by the solvent front is known.
D. Component Y has undergone stronger adsorption to the stationary phase than component X.

Question 19

Consider the reaction represented by the chemical equation

$$2CO(g) + O_2(g) \leftrightharpoons 2CO_2(g); \qquad \Delta H = -564 \text{ kJmol}^{-1}$$

Which of the following changes will decrease the amount of CO_2 in the reaction mixture?

A. adding more CO to the reaction vessel
B. adding an inert gas to the reaction vessel
C. decreasing the temperature of the reaction mixture
D. doubling the volume of the reaction vessel

Question 20

50 mL of 1.0 M HCl is added to 1.5 g of calcium carbonate chips.

Which of the following will **not** increase the initial rate of this reaction?

A. grinding the calcium carbonate chips into powder before adding the HCl
B. adding 100 mL of 1.0 M HCl in place of 50 mL of 1.0 M HCl
C. adding 50 mL of 2.0 M HCl in place of 50 mL of 1.0 M HCl
D. heating the HCl before adding it to the calcium carbonate

END OF SECTION A
TURN OVER

SECTION B – Short-answer questions

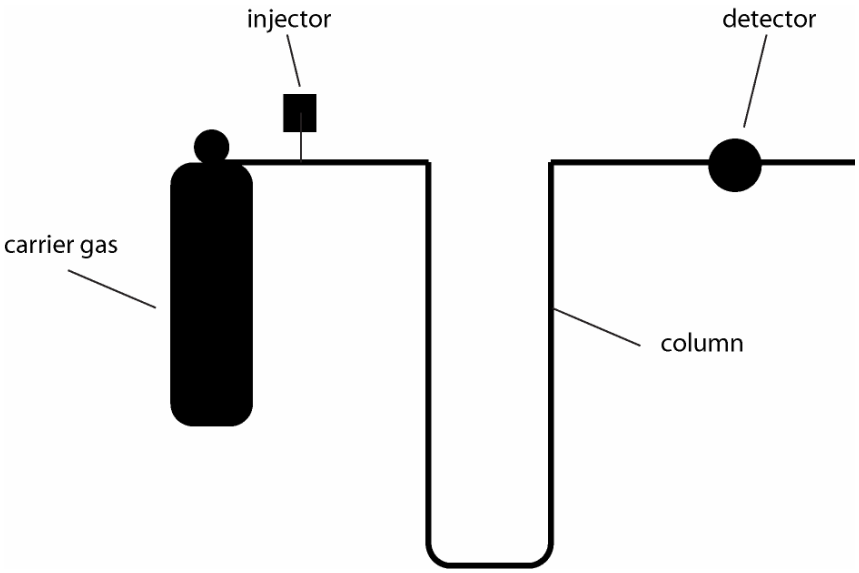
Instructions for Section B

Answer **all** the questions in the spaces provided.
To receive **full marks** for your responses you should

- give simplified answers with an appropriate number of significant figures to all numerical questions; answers that have not been simplified will not be awarded 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.
- ensure chemical equations are balanced and that the formulas for individual substances include an indication of state; for example, $H_2(g)$; NaCl(s).

CONTINUED ON NEXT PAGE

Question 1



Shown above is a simplified diagram of a gas-liquid chromatograph used to analyse a mixture of methanol (CH_3OH), ethanol (C_2H_5OH) and propanol (C_3H_7OH).

a. **i.** What property shared by these compounds makes the mixture suitable for analysis using a gas chromatograph?

_____

1 mark

ii. Explain how this gas chromatograph is able to separate different components in a mixture.

_____

_____

_____

_____

_____

3 marks

b. **i**. Place the three components in expected order from longest retention time (R_t) value to shortest.

_____

_____

1 mark

ii. Briefly explain your answer.

_____

_____

_____

1 mark

c. What effect would lengthening the column have on the R_t values of the components?

_____

_____

1 mark

Total 7 marks

Question 2

A newly released wine is tested for its alcohol (CH_3CH_2OH) content. A 25.00 mL sample is diluted to 250 mL in a volumetric flask. A 20.00 mL aliquot is taken from the diluted wine in the volumetric flask sample and titrated against a 0.100 M solution of $K_2Cr_2O_7$. The titration is then repeated carefully three more times. The table below gives the complete set of titres obtained.

	Titre (mL)
First titre	22.48
Second titre	22.46
Third titre	22.49
Fourth titre	23.14

The equation for the reaction is

$$3CH_3CH_2OH(aq) + 2Cr_2O_7^{2-}(aq) + 16H^+(aq) \rightarrow 4Cr^{3+}(aq) + 3CH_3COOH(aq) + 11H_2O(l)$$

a. Examine the titres given and calculate the average titre, in millilitres, that would be used to calculate the ethanol concentration in the wine.

_____

_____

1 mark

b. Calculate the number of moles of $Cr_2O_7^{2-}$ used in the titration.

_____

_____

_____

1 mark

c. Calculate the number of moles of CH_3CH_2OH present in the 20.00 mL aliquot of diluted wine.

_____

_____

_____

1 mark

d. Calculate the alcohol concentration of the diluted wine.

_____

_____

_____

1 mark

e. Calculate the concentration of alcohol, in mol L^{-1}, of the original sample of wine.

_____

_____

_____

1 mark

f. There are a number of possible sources of experimental error when carrying out a titration. Several are listed in the table below. Indicate the effect each error would have on the final result by placing a tick in the appropriate box.

Experimental error	Calculated concentration of wine higher than it should be	Calculated concentration of wine lower than it should be
i. Distilled water is used for the final rinse of the burette.		
ii. The titration is continued past the endpoint.		
iii. Distilled water is used for the final rinse of the 20.00 mL pipette.		

3 marks

Total 8 marks

Question 3

a. Give concise explanations for each of the following.

i. Carbon monoxide levels as low as 200 ppm (parts per million) can cause significant carbon monoxide poisoning.

_____

_____

_____

2 marks

ii. Purple light, rather than green light, is used as the light source in the colorimetric analysis of a green solution of chlorophyll.

_____

_____

_____

2 marks

iii. Sodium produces a yellow colour when heated in a flame, whereas copper produces a green colour.

_____

_____

_____

_____

2 marks

b. Write balanced chemical equations to demonstrate the following processes.

i. The oxidation of manganese (II) ions (Mn^{2+}) to permanganate ions (MnO_4^-).

_____

_____

2 marks

ii. Sulfuric acid acting as a dehydrating agent.

_____

_____

1 mark

iii. The thermal cracking of pentane to produce ethene and one other product.

_____

_____

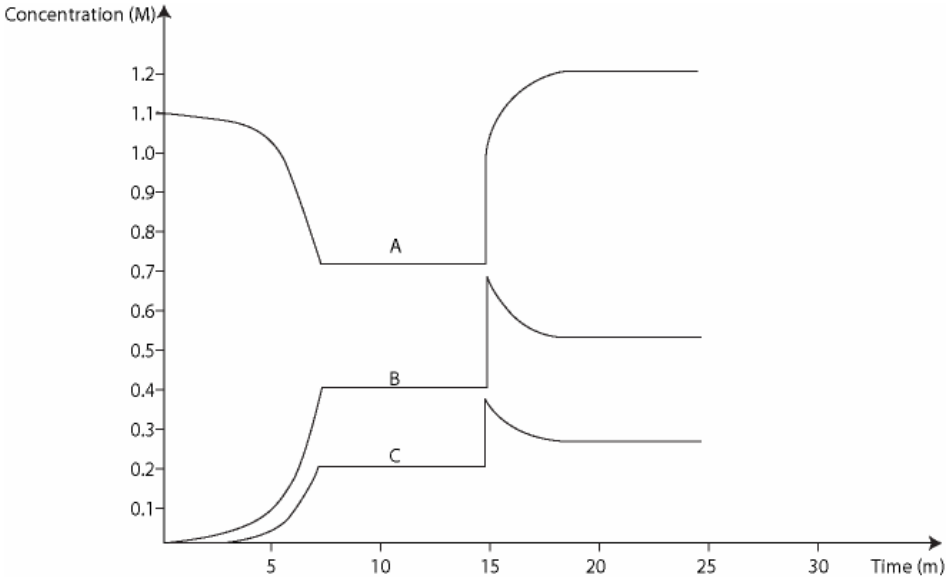
1 mark

Total 10 marks

Question 4

Consider the equilibrium

$2CO(g) + O_2(g) \leftrightharpoons 2CO_2(g)$; $\Delta H = -564$ kJ mol^{-1}



a. What change occurred at the 5-minute mark?

_____

_____

1 mark

b. Identify components A, B and C by writing the formula of each in the space provided.

A = _____

B = _____

C = _____

3 marks

c. Write an expression for the equilibrium constant for this reaction.

1 mark

d. Calculate the value of the equilibrium constant at the 10-minute mark.

1 mark

e. **i.** What change was made to the equilibrium mixture at the 15-minute mark?

_____

_____

1 mark

ii. Briefly explain why the system responded to this change in the manner shown.

_____

_____

_____

1 mark

f. At the 25-minute mark the temperature of the reaction mixture was decreased.

i. State Le Chatelier's principle.

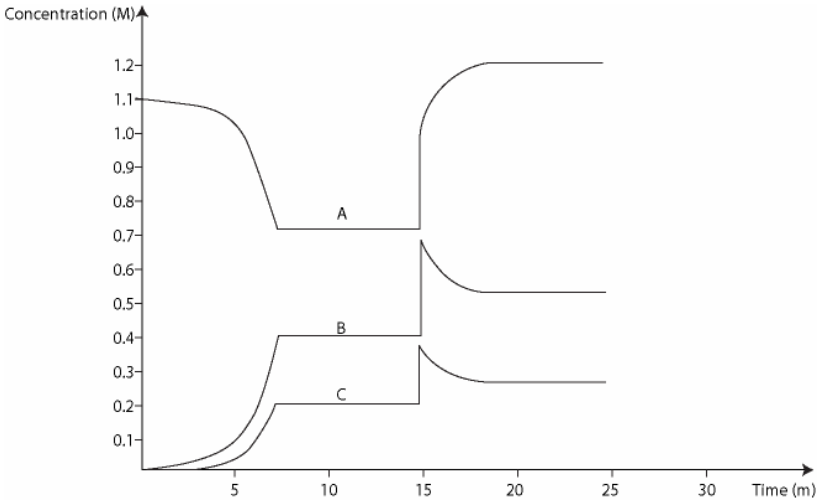
_____

_____

_____

1 mark

ii. Indicate, by continuing each line on the graph, what effect the temperature decrease will have on the concentration of each species.



2 marks

Total 11 marks

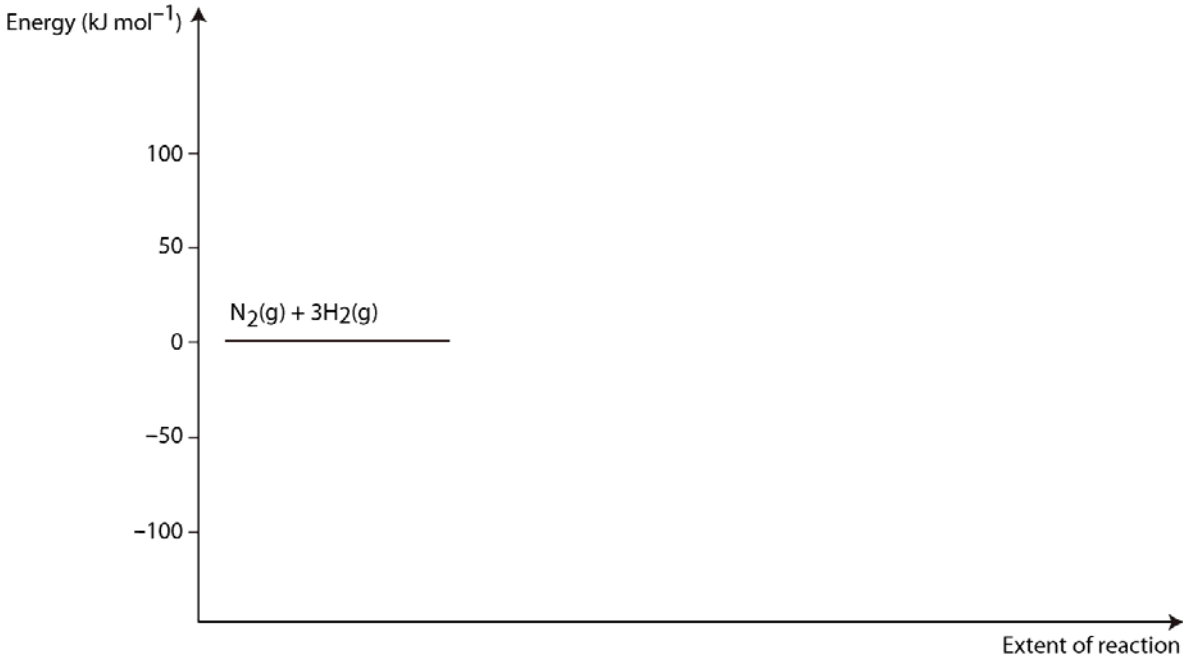
SECTION B – continued
TURN OVER

Question 5

The Haber process uses nitrogen and hydrogen gas to produce ammonia. The equation for this reaction is given below.

$N_2(g) + 3H_2(g) \leftrightharpoons 2NH_3(g)$; $\Delta H = -91$ kJ mol^{-1}

a. Complete the energy profile on the graph below to represent the energy changes over the course of this reaction. Clearly label the activation energy and ΔH.



3 marks

b. During the industrial production of ammonia, a fast reaction rate is highly desired. A catalyst is added and high temperatures are used.

i. Explain why adding a catalyst increases the reaction rate.

_____

_____

1 mark

ii. Explain why increasing the temperature increases the reaction rate.

_____

_____

_____

_____

2 marks

Total 6 marks

Question 6

Methanoic acid (HCOOH), which is present in some ant stings, is a weak acid in water.

a. Explain the meaning of the term 'weak acid'.

_____

_____

1 mark

b. Write an equation that demonstrates the ionisation of methanoic acid in water.

_____

_____

1 mark

c. Methanoic acid has an acidity constant of 1.8×10^{-4} at 25°C. Calculate the pH of a 0.100 M solution of methanoic acid.

3 marks

Total 5 marks

Question 7

Ethyl ethanoate is the ester responsible for the apple smell in many synthetic food items. The laboratory production of ethyl ethanoate from a sample of ethene gas follows a series of steps.

Step 1: Conversion of ethene to ethanol

a. **i.** Write a balanced equation for this reaction.

_____

_____

1 mark

ii. This can be classified as what type of reaction?

_____

1 mark

Step 2: Conversion of some of the ethanol to ethanoic acid

b. Give the name or formula of an oxidising agent suitable for this reaction that is used in the laboratory.

_____

1 mark

Step 3: Reaction between ethanol and ethanoic acid to produce ethyl ethanoate

c. **i.** Draw a full structural formula of ethyl ethanoate.

1 mark

ii. Give the name or formula of a laboratory catalyst suitable for this reaction.

_____

1 mark

iii. This can be classified as what type of reaction?

_____

1 mark

Total 6 marks

Question 8

Part of the contact process used for the industrial production of sulfuric acid from mined sulfur is the oxidation of sulfur dioxide in the converter.

a. Write a balanced chemical equation for this reaction.

_____

_____

1 mark

b. Name the catalyst used in this process.

_____

1 mark

c. The temperature in the converter is between 400°C and 500°C despite the fact that a higher temperature would deliver a faster reaction rate. Explain why a higher temperature is not used.

_____

_____

_____

_____

2 marks

d. It is desirable in this process to maximise contact between the catalyst and the reactant. Explain how this is achieved.

_____

_____

_____

1 mark

e. If the reaction occurred under high pressure, this would also increase the equilibrium yield. Give a reason why higher pressures are not used in industry.

_____

_____

1 mark

Total 6 marks

END OF QUESTION AND ANSWER BOOK