INSIGHT

Trial Exam Paper

2009

CHEMISTRY

Written examination 2

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	60
			Total 80

- 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 complete for any question.

Question 1

The following equilibrium is established in a 2.0 L vessel:

$$2N_2(g) + O_2(g) \rightleftharpoons 2N_2O(g)$$

Which one of the following sets of conditions would be expected to push the equilibrium furthest to the right?

	Addition of chemical	Volume of reaction vessel
A.	nitrogen gas	increased
B.	nitrogen gas	decreased
C.	argon gas	increased
D.	argon gas	decreased

Question 2

Small amounts of hydrogen gas and iodine gas are added to an empty reaction vessel, in which they react according to the equation

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$$

Which one of the following actions will increase both the reaction rate and the amount of $H_2(g)$ in the mixture at equilibrium?

A. adding a catalyst and decreasing the volume of the reaction vessel
B. adding $I_2(g)$ and decreasing the volume of the reaction vessel
C. adding a catalyst and removing some HI(g)
D. adding some HI and decreasing the volume of the reaction vessel

Question 3

A number of factors will increase the rate of a reaction. The factors that cause an increase in reaction rate solely as the result of an increase in the frequency of collisions between particles are

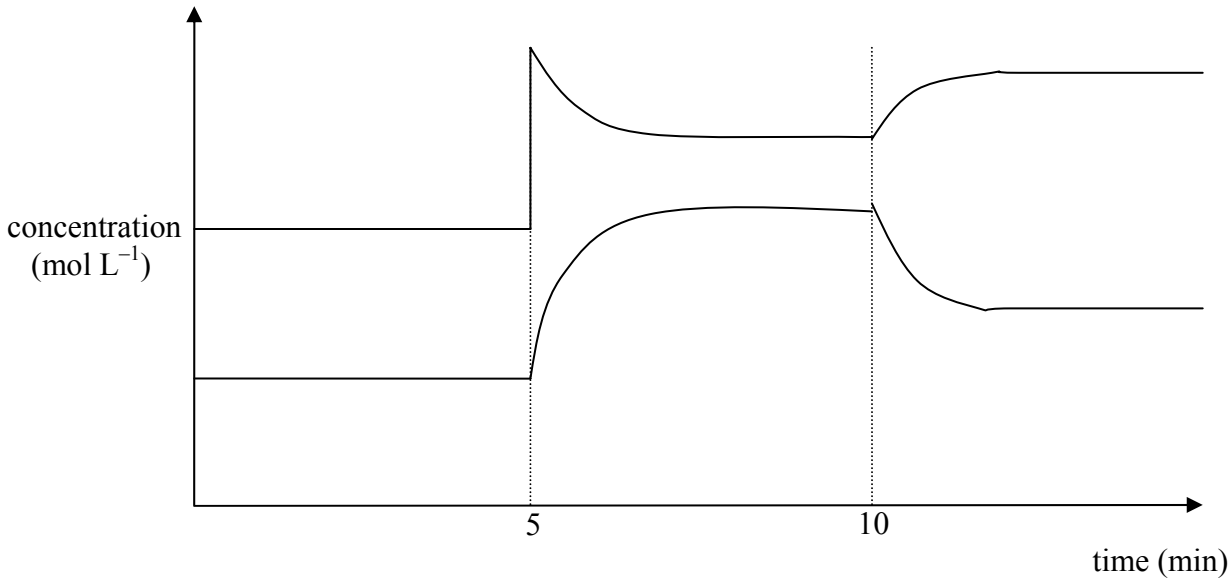
I adding a catalyst.
II increased temperature.
III increased concentration of reactants.
IV increased surface area of reactants.

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

Question 4

Consider the graph below of the equilibrium system

$2NO_2(g) \rightleftharpoons N_2O_4(g)$



Which one of the following could correctly describe the changes made to the mixture at 5 minutes and 10 minutes?

	5 minutes	**10 minutes**
A.	addition of NO_2	volume increase
B.	addition of NO_2	temperature decrease
C.	addition of N_2O_4	volume increase
D.	addition of N_2O_4	temperature decrease

Question 5

Nitric oxide (NO) is a significant air pollutant produced as a byproduct when the internal combustion engines of cars reach high temperatures. The reaction is

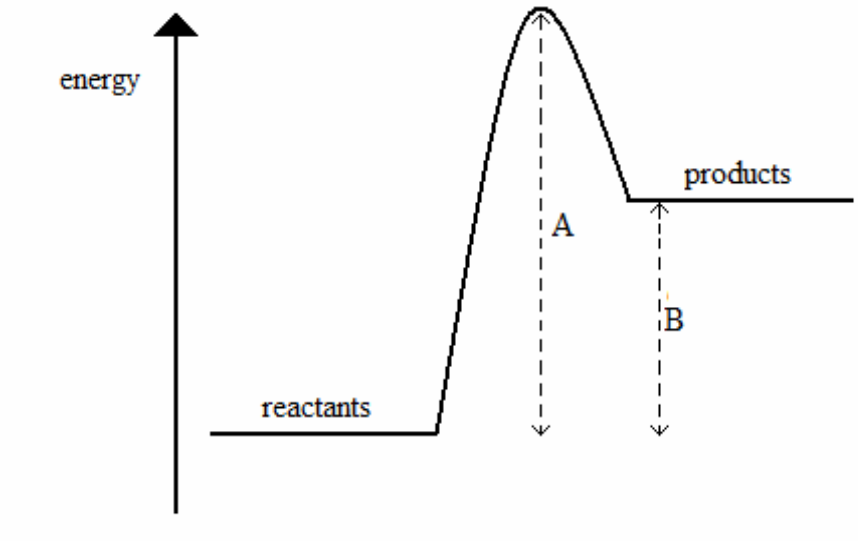
$N_2 + O_2 \rightleftharpoons 2NO$

This reaction is most likely to be

A. endothermic with a $\Delta H > 0$.
B. exothermic with a $\Delta H > 0$.
C. endothermic with a $\Delta H < 0$.
D. exothermic with a $\Delta H < 0$.

Question 6

The energy changes for a particular reaction can be represented by the profile shown.



The reverse reaction is

A. exothermic with an activation energy that is equal to A.
B. exothermic with an activation energy that is equal to A–B.
C. endothermic with an activation energy that is equal to A.
D. endothermic with an activation energy that is equal to A–B.

Question 7

Consider the following reactions:

$$NaOH(aq) + HCl(aq) \rightarrow NaCl(aq) + H_2O(l) \qquad \Delta H_1$$
$$NaOH(aq) + NH_4Cl(aq) \rightarrow NH_3(aq) + H_2O(l) \qquad \Delta H_2$$
$$HCl(aq) + NH_3(aq) \rightarrow NH_4Cl(aq) \qquad \Delta H_3$$

The value of ΔH_3 will be equal to

A. $-\Delta H_1$
B. $-\Delta H_2$
C. $\Delta H_1 - \Delta H_2$
D. $\Delta H_1 + \Delta H_2$

Question 8

Separate samples of 1.0 M solutions of HCl and CH_3COOH are diluted by a factor of ten. The change in pH units

A. will be greater for HCl than for CH_3COOH.
B. will be greater for CH_3COOH than for HCl.
C. will be the same for HCl and CH_3COOH.
D. cannot be determined for CH_3COOH.

Questions 9 and 10 refer to the following information.

Nitrogen gas and oxygen gas can react according to the following equation:

$$2N_2(g) + O_2(g) \rightleftharpoons 2N_2O(g)$$

Question 9

Three different flasks, X, Y and Z, contain a mixture of N_2, O_2 and N_2O at equilibrium. The concentrations, in mol L^{-1}, of these components in each flask is shown below.

Flask	**$[N_2(g)]$**	**$[O_2(g)]$**	**$[N_2O(g)]$**
X	0.30	0.40	0.15
Y	0.60	0.10	0.15
Z	0.20	0.35	0.15

Which one of the flasks is at a different temperature compared to the other two?

A. X
B. Y
C. Z
D. Unable to be determined from the information given.

Question 10

A volume of 1.0 mol of gaseous N_2O is placed in an empty 2.0 L container. Once equilibrium is reached, 0.60 mol of N_2O remains. The equilibrium concentrations, in mol L^{-1}, of N_2 and O_2 are

	$[N_2(g)]$	**$[O_2(g)]$**
A.	0.20	0.10
B.	0.20	0.20
C.	0.30	0.15
D.	0.40	0.20

Question 11

Liquid ethanoic acid can react with ethanol to form the ester ethyl ethanoate, according to the following equation:

$$CH_3COOH(l) + CH_3CH_2OH(l) \rightleftharpoons CH_3COOCH_2CH_3(l) + H_2O(l)$$

At 25°C, the value of the equilibrium constant is 4.0.

What is the value of the equilibrium constant for the reaction below?

$$3CH_3COOCH_2CH_3(l) + 3H_2O(l) \rightleftharpoons 3CH_3COOH(l) + 3CH_3CH_2OH(l)$$

A. 0.016
B. 0.083
C. –4.0
D. 64

Question 12

The self-ionisation constant of pure water at 15°C is 4.51×10^{-15} M^2. The hydroxide ion concentration and pH will be

	$[OH^-]$	**pH**
A.	1.0×10^{-7} M	7.17
B.	1.0×10^{-7} M	7.00
C.	6.7×10^{-8} M	7.17
D.	6.7×10^{-8} M	7.00

Question 13

A student conducted an experiment to determine the heat content of a dry biscuit. When a 3.5 g sample was combusted in a bomb calorimeter the temperature of the water inside the calorimeter rose from 16.0°C to 28.7°C. The calibration factor of the calorimeter was 2.95 kJ $°C^{-1}$.

The heat content of the biscuit, in kJ g^{-1}, is

A. 10.7
B. 13.5
C. 24.2
D. 37.5

Question 14

Which of the following processes will have a ΔH value with an opposite sign to the other three?

A. $CH_4(g) + O_2(g) \rightarrow CO_2(g) + H_2O(g)$

B. $N_2(g) \rightarrow N_2(l)$

C. $H_2O(s) \rightarrow H_2O(l)$

D. $Mg(l) + Cl_2(g) \rightarrow MgCl_2(l)$

Question 15

The ability of secondary cells to be recharged is best explained by the fact that

A. the products of the discharge reaction come into contact with each other.

B. the products of the discharge reaction do not migrate away from the electrodes.

C. the polarity of the electrodes can be reversed.

D. the products of the discharge reaction move away from the electrodes used in the discharging reaction.

Question 16

To heat a 350 g block of copper by 35.0°C, 4.76 kJ of energy is required. The specific heat capacity of copper, in J g^{-1} $°C^{-1}$ is

A. 3.89×10^{-4}

B. 0.389

C. 3.89

D. 389

Question 17

Which of the following compounds would have the same product at the anodes but a different product at the cathodes when comparing the electrolysis of its molten state with the electrolysis of the compound in a 1.0 M aqueous solution?

A. sodium fluoride

B. zinc chloride

C. lead iodide

D. potassium bromide

Question 18

Silver metal is electroplated onto a copper ring, using a silver anode and a solution containing $Ag^+(aq)$ ions. During this process

A. $Ag^+(aq)$ ions move towards the anode.

B. the concentration of $Ag^+(aq)$ ions in the solution increases.

C. the concentration of $Ag^+(aq)$ ions in the solution decreases.

D. the anode decreases in mass.

Question 19

Which of the following energy sources has the highest energy content per gram of fuel?

A. brown coal
B. natural gas
C. nuclear fuel (uranium)
D. biochemical fuels

Question 20

Which of the following **cannot** be predicted correctly using the electrochemical series?

A. Cu(s) and I_2(s) will react at a very fast rate.
B. Ag(s) can react with Br(l).
C. In order to produce K(s), a molten reactant containing K^+(l) ions must be used.
D. A solution of H_2O_2(aq) can decompose to O_2(g) and H_2(g).

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

A 3.5 g piece of calcium carbonate was added to an excess volume of 1.0 M nitric acid.

The volume of carbon dioxide gas, at STP, produced during the reaction was measured and recorded.

a. Write an equation for the reaction between calcium carbonate and nitric acid.

_____

_____

2 marks

b. On the axes below, sketch the expected shape of the graph of volume of carbon dioxide against time for this experiment.

2 marks

c. In a second experiment, another 3.5 g piece of calcium carbonate was added to the same volume of **heated** 1.0 M nitric acid. Explain why this second reaction will occur at a faster rate than the first.

_____

_____

_____

1 mark
Total 2 + 2 + 1 = 5 marks

Question 2

a. 1-propanol is used to calibrate a bomb calorimeter. 1.86 g of 1-propanol is reacted with excess oxygen in the bomb calorimeter, causing the temperature of the surrounding water to increase from 22.4°C to 63.5°C.

Calculate the calibration factor of the bomb calorimeter, in kJ $°C^{-1}$.

_____

_____

_____

_____

_____

_____

3 marks

b. A second bomb calorimeter of the same size and same manufacturer as the first is calibrated electrically. A charge of 3.55 A was passed through the heating element in the calorimeter at a voltage of 6.40 V for 4.00 minutes. The temperature of the surrounding water increased from 22.3°C to 25.6°C.

Calculate the calibration factor of this bomb calorimeter, in kJ $°C^{-1}$.

_____

_____

_____

_____

2 marks

c. Assuming the calculations were carried out correctly, give two reasons for any difference between the two calculated calibration factors.

_____

_____

_____

_____

2 marks
Total 3 + 2 + 2 = 7 marks

Question 3

Solutions of equal concentrations of three different acids were compared. The acids were

I hydrochloric acid
II hydrofluoric acid
III hypochlorous acid

a. Which one of these three acids would have the highest pH? Give a reason for your answer.

_____

_____

2 marks

b. Calculate the pH of a 1.0 M solution of the weakest acid as identified in **Question 3a**.

_____

_____

_____

2 marks

c. Calculate the percentage ionisation of the weakest acid in a 1.0 M solution as identified in **Question 3a**.

_____

_____

2 marks

d. A volume of 100 mL of acid I is mixed with 100 mL of acid III. Will the resultant solution have a pH that is higher, lower or the same as the original solution of acid I? Give a reason for your answer.

_____

_____

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

Question 4

Nitric oxide can be produced from nitrogen and oxygen according to the equation

$N_2(g) + O_2(g) \rightleftharpoons 2NO(g)$ ΔH is positive

Initially, a mixture of 0.10 M N_2, 0.050 M O_2 and 0.10 M NO was allowed to reach equilibrium in a 2.0 L vessel. Once equilibrium was established, it was found that the amount of NO had increased by 0.040 mol.

a. Calculate the value of the equilibrium constant for this reaction.

4 marks

b. The same reaction is repeated in a 4.0 L vessel. What would be the effect on the value of the equilibrium constant? Give an explanation for your answer.

1 mark

c. The same reaction is repeated at a much higher temperature. What would be the effect on the value of the equilibrium constant? Give an explanation for your answer.

2 marks
Total 4 + 1 + 2 = 7 marks

Question 5

In VCE Chemistry Unit 4, you were required to investigate the industrial production of a chemical selected from ammonia, ethene, sulfuric acid or nitric acid. Choose one of these chemicals and circle it in the list below.

ammonia ethene sulfuric acid nitric acid

a. Write a balanced chemical equation for a reaction in the production process of which your chosen chemical is a product.

_____

_____

1 mark

b. **i.** Give the name or formula of **one** waste chemical formed during the production of the chemical you have chosen.

_____

1 mark

ii. Describe **one** way in which this waste chemical is safely managed or disposed of.

_____

_____

1 mark

c. Write the chemical formula of **one** useful product formed from the chemical you have chosen.

_____

1 mark
Total 1 + 2 + 1 = 4 marks

Question 6

Water can be electrolysed according to the reaction

$$2H_2O(l) \rightarrow 2H_2(g) + O_2(g)$$

a. **i.** Write a balanced equation for the reaction that occurs at the anode.

_____

1 mark

ii. Write a balanced equation for the reaction that occurs at the cathode.

_____

1 mark

A student wishes to electrolyse some water by setting up an electrolytic cell.

b. **i.** Circle the best solution below for the student to choose for the electrolyte in the cell.

deionised water sodium sulfate copper sulfate sodium iodide

1 mark

ii. Give an explanation for your choice.

_____

_____

_____

2 marks

c. An electrolytic cell is used for the extraction of copper metal from a solution of $CuCl_2$ and operates for 1.50 hours at a constant current of 18.5 A.

i. Calculate the quantity of electricity, in coulomb, that passes through the cell.

_____

_____

_____

1 mark

ii. Assuming that 80.0% of the electricity passing through the cell is used in the electrolysis of $CuCl_2$, calculate the mass, in grams, of copper produced in this time.

_____

_____

_____

_____

_____

_____

4 marks
Total 2 + 3 + 5 = 10 marks

Question 7

The $H^+(aq)/H_2(g)$ half-cell is the standard half-cell used to obtain the E^o values listed in the electrochemical series.

a. **i.** Sketch and label a diagram of this half-cell.

1 mark

ii. State the pH of the solution of $H^+(aq)$ ions required when this half-cell is used as a standard half-cell.

_____

1 mark

b. A galvanic cell consists of the following half-cells set up under standard conditions.

Half-cell 1: The $H^+(aq)/H_2(g)$ half cell described above.

Half-cell 2: An inert electrode in a solution containing $Cr^{2+}(aq)$ and $Cr^{3+}(aq)$ ions.

After some time, the pH in half-cell 1 has increased.

i. Which chemical species is the strongest oxidant in this galvanic cell? Give an explanation for your answer.

_____

_____

_____

_____

2 marks

ii. Give the equation for the half-reaction that takes place at the anode in this cell.

_____

1 mark

c. A second galvanic cell consists of the following half-cells set up under standard conditions.

Half-cell 1: An electrode of X(s) in a solution containing $X^{2+}(aq)$ ions.

Half-cell 2: An inert electrode in a solution containing $Cr^{2+}(aq)$ and $Cr^{3+}(aq)$ ions.

The direction of electron flow is from the X(s) electrode towards the inert electrode.

i. Give the equation for the half-reaction that takes place at the cathode in this cell.

_____

1 mark

ii. Would you expect the standard E^o value of $X^{2+}(aq) + 2e^- \rightarrow X(s)$ to have a positive or negative value? Give an explanation for your answer.

_____

_____

_____

_____

2 marks

d. A nickel–metal hydride battery is a rechargeable galvanic cell used in laptop computers. A hydrogen-absorbing metal alloy is used for the negative electrode and NiO(OH)(s) is used for the positive electrode. When the cell is generating electricity the overall cell reaction is

$H(\text{absorbed on M}) + NiO(OH)(s) \rightarrow Ni(OH)_2(s)$

The reaction at the negative electrode when the cell is generating electricity is

$H(\text{absorbed on M}) + OH^-(aq) \rightarrow H_2O(l) + e^-$

i. Write the equation for the half-reaction that takes place at the cathode when the cell is discharging.

_____

1 mark

ii. Write the equation for the half-reaction that takes place at the electrode connected to the positive terminal of the power supply when the cell is recharging.

_____

1 mark
Total 2 + 3 + 3 + 2 = 10 marks

Question 8

The solid oxide fuel cell (ZAFC) is a leading candidate for high-power applications, including large-scale electricity generating stations. The fuel cell has the following features:

- a ceramic solid as its electrolyte, in which oxide ions, O^{2-}, are able to move.
- an anode reaction of $H_2(g) + O^{2-}(\text{in ceramic}) \rightarrow H_2O(l) + 2e^-$
- hydrogen gas and oxygen gas are the reactants.
- water is the only product.

a. Give a reason why the electrolyte in any fuel cell must contain an ion that is free to move.

_____

_____

1 mark

b. Give an equation for the reaction that takes place at the cathode of this cell. States are not required.

_____

_____

1 mark

c. What distinguishes a fuel cell from other types of galvanic cells, such as primary and secondary cells?

_____

_____

1 mark

d. A particular cell operates at 0.650 V, delivering a current of 0.600 A for 3.00 hours.

i. Calculate the energy, in J, that would be provided by the cell in this time.

_____

_____

_____

1 mark

ii. Calculate the charge, in coulomb, produced by the cell.

_____

_____

_____

1 mark

e. Describe **one** disadvantage of a fuel cell, such as the solid ceramic fuel cell, over a coal-fired power station.

_____

1 mark

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

Question 9

Butane (C_4H_{10}) is commonly used as a fuel in portable camping stoves.

a. Determine the heat content of butane, in kJ g^{-1}.

_____

_____

_____

1 mark

b. Calculate the mass, in grams, of butane required to heat a 500 mL container of water from 16.0°C to 100°C.

_____

_____

_____

_____

_____

2 marks
Total 1 + 2 = 3 marks

END OF QUESTION AND ANSWER BOOK