Student Name: _____

CHEMISTRY

Unit 4 – Written examination 2

2009 Trial Examination

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

QUESTION AND ANSWER BOOK

Structure of book

Section	*Number of questions*	*Number of questions to be answered*	*Number of marks*	*Suggested times (minutes)*
A	20	20	20	25
B	7	7	67	65
			Total 87	90

- Students are permitted to bring into the examination room: pens, pencils, highlighters, erasers, sharpeners, rulers, VCAA data booklet and a 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 book of 15 pages.

Instructions
- Print your name in the space provided on the top of this page.
- All written responses must be in English.

Students are NOT permitted to bring mobile phones and/or any other electronic communication devices into the examination room.

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SECTION A- Multiple-choice questions

Instructions for Section A
Answer **all** questions.
Choose the response that is **correct** or **best answers** the question.
A correct answer scores 1, an incorrect answer scores 0.
No mark will be given if more than one answer is completed for any question.
Marks will **not** be deducted for incorrect answers.

Questions 1, 2 and 3 refer to the following information

The rate of the reaction between bromine and methanoic acid is easy to study. The Br_2 has a deep red-brown colour, while most other reactants and products are colourless or lightly coloured.

$Br_2(aq) + HCOOH(aq) \rightarrow 2Br^-(aq) + 2H^+(aq) + CO_2(g)$

Question 1
The following measurements are made during a series of experiments between these two reactants

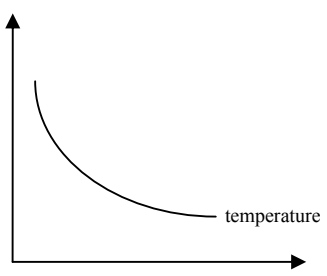
I the mass of the container
II the volume of gas evolved
III the pH of the solution

The rate of this reaction could be studied through the use of
A. I only
B. I or II only
C. II or III only
D. any of the above

Question 2
A cross is placed on a piece of cardboard and each reacting flask is placed over this cross. The rate of reaction
A. cannot be monitored in this way
B. is evident from the time it takes for the cross to be obscured
C. is evident from the time it takes for the cross to become visible
D. is obviously faster if the cross is obscured in a shorter time

Question 3
The quantity on the vertical axis of the graph below might be

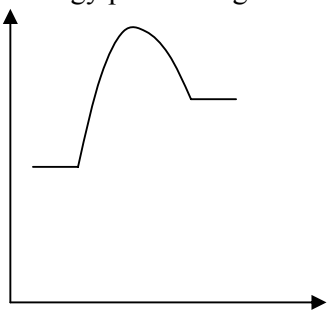
A. the volume of gas released in a given time
B. the mass of gas released in a given time
C. time taken for cross to be obscured
D. time taken for cross to become visible



SECTION A- continued

Questions 4, 5 and 6 refer to the following information

The energy profile diagram for the reaction $N_2O_4\,(g) \Leftrightarrow 2NO_2(g)$ is



At 100°C, the value of K is 0.80 M

Question 4
The yield of this reaction will be increased through the use of
A. high temperature and low pressure
B. low temperature and high pressure
C. low temperature and low pressure
D. a catalyst and high pressure

Question 5
A mixture of the two gases is at equilibrium. The pressure is increased. The temperature of the reactor will
A. not change
B. decrease because the reverse reaction is exothermic
C. increase because the reverse reaction is exothermic
D. increase because the forward reaction is exothermic

Question 6
Four flasks containing mixtures of the two gases are heated to 200°C. The concentrations of the N_2O_4 and NO_2 are given below. Which flask might be at equilibrium?

Flask	**$[N_2O_4]$**	**$[NO_2]$**
A.	0.77	1.30
B.	0.50	0.63
C.	1.30	0.77
D.	1.00	0.80

Question 7
In solution, the OCl^- hydrolyses according to the equation:

$$OCl^-(aq) + H_2O(l) \Leftrightarrow HOCl(aq) + OH^-(aq)$$

When a few drops of hydrochloric acid is added to an equilibrium solution of OCl^-, the
A. pH is unchanged
B. the final concentration of OH^- will be greater than before the addition
C. the final concentration of OH^- will be less than before the addition
D. the final concentration of OH^- will be unchanged

SECTION A – continued
TURN OVER

Question 8
Nitrogen reacts with oxygen in internal combustion reactions. The equation is

$N_2(g) + O_2(g) \Leftrightarrow 2NO(g)$

At 1500 ^{0}C, the value of K is 0.065.

What is the value of the equilibrium constant, at 1500ºC, for the reaction

$NO(g) \Leftrightarrow \frac{1}{2} N_2(g) + \frac{1}{2} O_2(g)$

A. -0.065
B. 3.92
C. 15.4
D. 65.0

Question 9
The contents of three beakers are
Beaker A 10 mL of 0.01 M HCl
Beaker B 1.0 L of 0.01 M CH_3COOH
Beaker C 1.0 L of 0.1 M HCN

A. All beakers will have the same pH
B. Beaker A will have the lowest pH
C. Beaker C will have the lowest pH
D. Beaker C will have the highest H_3O^+ concentration

Question 10
For the decomposition of NOCl, the reversible reaction is

$2NOCl(g) \Leftrightarrow 2NO(g) + Cl_2(g) \qquad K = 1.2 \times 10^{-5}$ M at 30ºC

At 30ºC in an equilibrium mixture
A. the [NOCl] will equal [NO]
B. the $[Cl_2]$ will be half the [NOCl]
C. the $[Cl_2]$ will be double [NOCl]
D. the [NOCl] will be many times greater than $[Cl_2]$

Question 11
Photovoltaic cells differ from most other sources of electrical energy because
A. they do not require a turbine turning in a magnetic field
B. the source of the energy is very expensive, making the process very expensive
C. they require more energy conversions hence they have low efficiency
D. the sun's energy is responsible for the turning of a turbine in a magnetic field

SECTION A - continued

Question 12
0.16 g of methane is burnt in a bomb calorimeter. The temperature changes from 12.8°C to 24.5°C. The calibration factor of the calorimeter is, in J^oC^{-1},
A. 0.76
B. 380
C. 760
D. 1520

Question 13
The equation for the combustion of hydrogen is:

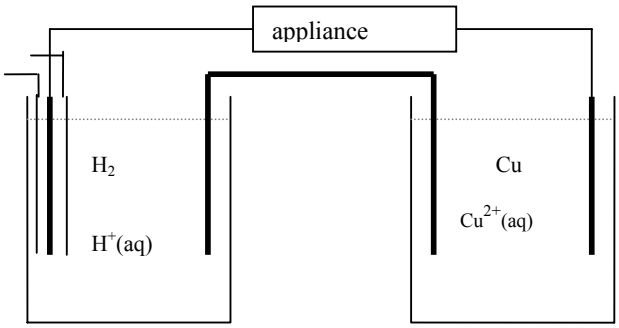
$2H_2(g) + O_2(g) \rightarrow 2H_2O(g) \quad \Delta H = -484 \text{ kJ mol}^{-1}$

The value of ΔH provided here
A. should be the same as that given in the VCAA chemistry data book
B. will be double that of the data book
C. will be half that of the data book
D. will be different to that of the data book, as the phases of the chemicals are different

Question 14
The fuel that produces the greatest amount of energy per gram during combustion is
A. ethanol
B. propane
C. octane
D. hydrogen

Questions 15 and 16 refer to the following information

An appliance is connected to a galvanic cell constructed from the materials shown in the diagram



Question 15
In this cell,

	Oxidant	Reductant	Positive electrode	Negative electrode
A.	H_2	Cu^{2+}	Cu	H_2
B.	Cu^{2+}	H_2	Cu	H_2
C.	H_2	Cu^{2+}	H_2	Cu
D.	Cu	H^+	Cu	H_2

SECTION A – continued
TURN OVER

Question 16
In this cell, the
A. reaction will stop when the copper electrode has been consumed in the reaction
B. electrons travel through the salt bridge to complete the circuit
C. electrons travel from the hydrogen electrode to the copper
D. electrons flow when the appliance is switched off

Question 17
When comparing the electrolysis of molten CuI_2 with that of a 1.0 M aqueous solution of CuI_2, which one of the following statements is correct?
A. The products at the anode and the cathode are the same in both cases.
B. The product at the cathode is the same in both cells but the products at the anode are different.
C. The product at the anode is the same in both cells but the products at the cathode are different.
D. The products at the cathodes of both cells are different as are the products at the anodes.

Question 18
A charge of 8042 coulomb is passed through a molten ionic solution. The product at the cathode could be
A. 0.166 mol of hydrogen gas
B. 0.0833 mol of magnesium metal
C. 0.0417 mol of sodium metal
D. 0.0278 mol of aluminium metal

Questions 19 and 20 refer to the following information.

The overall equation for the methane – oxygen fuel cell, operating in acid conditions, is

$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(l)$

Question 19
The half equation for the reaction occurring at the anode will be
A. $CH_4(g) + 2H_2O(l) + 8e^- \rightarrow CO_2(g) + 8H^+(aq)$
B. $CO_2(g) + 2H_2O(l) \rightarrow CH_4(g) + 2O_2(g)$
C. $O_2(g) + 4H^+(aq) + 4e^- \rightarrow 2H_2O(l)$
D. $CH_4(g) + 2H_2O(l) \rightarrow CO_2(g) + 8H^+ + 8e^-$

Question 20
A fuel cell is different from other types of galvanic cells because
A. it has a continuous flow of electrons
B. it is always rechargeable
C. it will keep running if reactants are supplied to it
D. it produces much higher voltages

END OF SECTION A

SECTION B – Short-answer questions

Instructions for Section B

Questions must be answered in the spaces provided in this book.
To obtain full marks for your responses you should

- give simplified answers with an appropriate number of significant figures to all numerical questions; simplified 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

Comment on the accuracy of each of the following statements.

a. In the reversible reaction;

$$A(g) + 2B(g) \Leftrightarrow C(g)$$

i. the concentration of B will always be twice that of A

_____

ii reactant A will run out before B

_____

_____

iii. a reaction will still occur if C is added to an empty reactor

_____

1 + 1 + 1 = 3 marks

b. 4.0 mole of electrons is passed through a series of molten ionic cells.

i. The same number of mole of any metal would be obtained at the cathode

_____

ii. The same number of mole of electrons passes through the anode as through the cathode.

_____

SECTION B - continued
TURN OVER

iii. 4.0 mol of chlorine gas would be obtained from NaCl molten solution.

_____

_____

1 + 1 + 1 = 3 marks

c. A fuel cell involving oxygen gas is operating.

i. The reaction at the anode will be $O_2(g) + 4H^+(aq) + 4e \rightarrow 2H_2O(l)$

_____

ii. Carbon dioxide gas will be one of the products of the cell.

_____

1 + 1 = 2 marks

d. An acid solution has a pH of 3.

i. the concentration of the acid is 0.001 M

_____

ii. the hydronium ion concentration is 0.001M

_____

1 + 1 = 2 marks

Total 10 marks

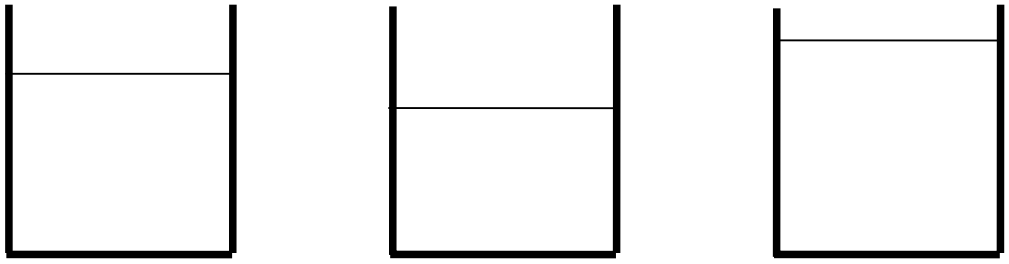
Question 2

Three students take turns using the same calorimeter to determine the ΔH value for the reaction between magnesium and hydrochloric acid.

Calibration

Group A uses 100 mL of water.
Group B uses 90 mL of water.
Group C think they are using 100 mL of water but in fact they have added 110 mL.

SECTION B – continued



A B C

Circle the correct answer where required in the following questions.

a. **i**. The calibration factor obtained by group B will be (compared to Group A)

lower the same higher

ii. Justify your answer

_____

1 + 1 = 2 marks

b. **i**. The ΔH values calculated by Group B will be (compared to Group A)

lower the same higher

ii. Justify your answer

_____

1 + 1 = 2 marks

c. **i**. The calibration factor obtained by Group C will be (compared to Group A)

lower the same higher

ii. Justify your answer

_____

1 + 1 = 2 marks

d. For the actual chemical reaction, Group C now measures the volume of water correctly. The ΔH values obtained by Group C will be (compared to Group A)

lower the same higher

1 mark

SECTION B - continued

TURN OVER

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Group A obtains a calibration factor of 455 J^oC^{-1}.

When 0.25 g of magnesium is added to 100 mL of 1.0 M HCl, the temperature rises from 24.6°C to 29.9°C.

e. Write a balanced equation for the reaction.

_____

1 mark

f. Calculate ΔH for the reaction.

_____

_____

2 marks

g. If 100 mL of 2.0 M HCl had been used, what impact would this have had on the value of ΔH obtained? Explain your answer.

_____

_____

2 marks

Total 12 marks

Question 3

Hydrogen peroxide is a clear liquid with a formula H_2O_2.
It is unstable and best stored in dark plastic containers in a refrigerator. Under such conditions, it has a shelf life of about two years.

a. **i**. Use half equations from the electrochemical series to derive the overall equation for the decomposition of H_2O_2

oxidation half equation _____

reduction half equation _____

overall equation _____

ii. The electrochemical series indicates that this is a spontaneous reaction. Why is it that the shelf life is over two years?

_____

SECTION B - continued

iii. Explain clearly, in terms of particle movement, why refrigeration in a dark container enhances shelf life.

_____

3 + 1 + 1 = 5 marks

b. When manganese dioxide, MnO_2 is added to the hydrogen peroxide, the reaction occurs more rapidly. If the products are filtered at the end of the reaction, the MnO_2 can be recovered and reused.

i. Explain the role of the MnO_2

_____

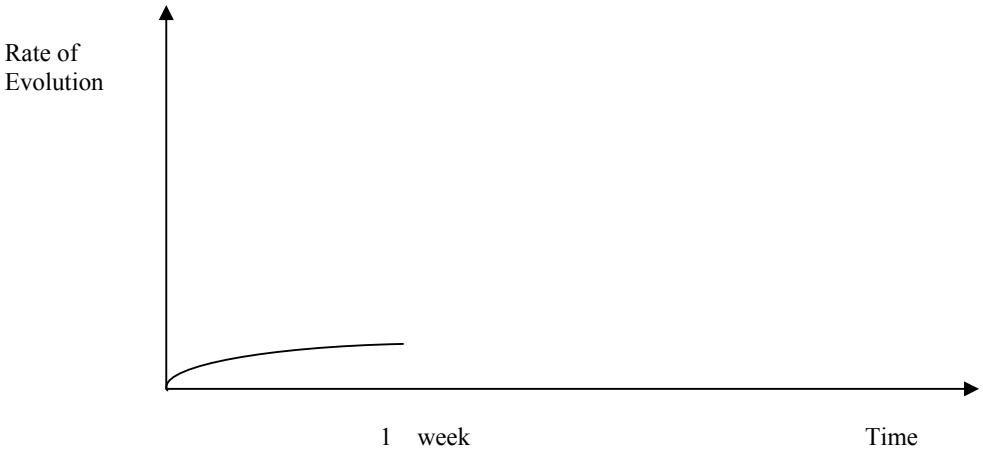
_____

ii. What compound do you think the MnO_2 has formed during the reaction?

_____

1 + 1 = 2 marks

c. The graph below shows the rate of gas evolution from a container of hydrogen peroxide. At the one week mark, a spatula of MnO_2 is added to the hydrogen peroxide. Sketch, on the graph, the impact on the rate of evolution of gas of the addition of the MnO_2.



1 mark

Total 8 marks

SECTION B - continued
TURN OVER

Question 4

One of the reactions occurring in the catalytic converter of a car is

$$2NO(g) + 2CO(g) \Leftrightarrow N_2(g) + 2CO_2(g) \quad \Delta H = +ve$$

The nitrogen monoxide and carbon monoxide are both converted to less harmful gases. This reaction can also be used in the laboratory as a source of nitrogen gas.

a. The closer the catalytic converter is to the engine, the higher the temperature it runs at. From an equilibrium point of view, is it desirable for the converter to be close to the engine or as far as possible from the engine? Explain your answer.

_____

_____

2 marks

b. Should the converter be run at high pressure? Explain your answer.

_____

_____

1 mark

c. A hole in the exhaust of a particular car is allowing air to enter the exhaust before the fumes reach the catalytic converter. What is the likely impact of air on this reaction?

_____

_____

2 marks

d. Write an expression for K for the reaction above.

1 mark

e. 0.30 mol of NO reacts with 0.44 mol of CO. At equilibrium, 0.12 mol of CO_2 has formed. What is the concentration of the other three gases?

NO _____ CO _____ N_2 _____

3 marks

Total 9 marks

SECTION B - continued

Question 5

Lithium is the key element to many new cells. One such example is the Lithium-Iron cell. It is of interest because the voltage produced is 1.5 volts, making it compatible with the conventional cells used in many common appliances. The Lithium-Iron cell can produce 2.5 times the capacity of an alkaline cell.

The overall equation for this cell is;

$$FeS_2 + 4Li \rightarrow Fe + 2Li_2S$$

Phases are not shown in this equation because an organic solvent is used.

a. Write half equations in the spaces provided and indicate the polarity of each electrode. (You should be able to use the likely oxidation state of lithium to deduce the oxidation states of the other elements)

	Half Equation	Polarity
anode	_____	_____
cathode	_____	_____

4 marks

b. Why do you think an organic solvent is used in these cells?

_____

1 mark

c. Why might a voltage of 1.5 volts be considered advantageous?

_____

1 mark

d. Like all cells, this one eventually goes 'flat'. In terms of the chemicals involved, why does this battery go flat?

_____

1 mark

e. The operating voltage of the cell is 1.40 volts.

i. How much energy is produced by this cell if it runs for 8.0 hours with a current of 3.50 amps?

_____

_____

SECTION B - continued
TURN OVER

ii. What mass of lithium would react in this time?

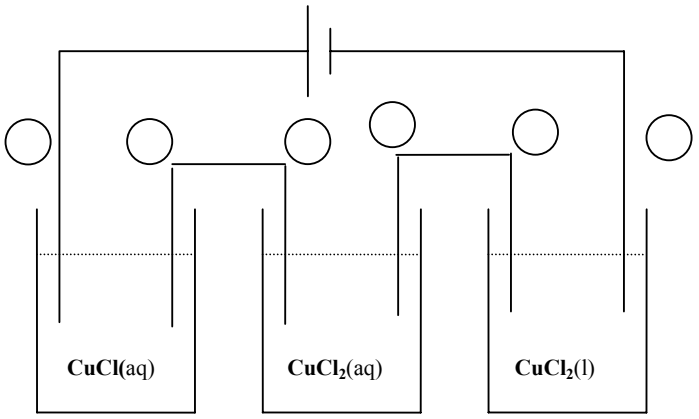
_____

_____

2 + 2 = 4 marks
Total 11 marks

Question 6

Three cells are connected in series to each other and to a power supply. The solutions in each are, respectively
CuCl(aq)
$CuCl_2$(aq)
$CuCl_2$(l)



a. Use the circles provided to indicate the polarity of each electrode.

3 marks

4.0 mol of electrons passes through the power supply.

b. **i**. How many mol of electrons passes through each cell?
CuCl(aq) _____
$CuCl_2$(aq) _____
$CuCl_2$(l) _____

ii. How many mol of chlorine gas is produced in each cell?
CuCl(aq) _____
$CuCl_2$(aq) _____
$CuCl_2$(l) _____

iii. How many mol of metal is produced in each cell?
CuCl(aq) _____
$CuCl_2$(aq) _____
$CuCl_2$(l) _____

SECTION B - continued

iv. The whole cell is enclosed in a 100 L container. What is the partial pressure of the chlorine gas produced if the cell is at 800ºC?

_____

_____

1 + 3 + 1 + 3 = 8 marks
Total 11 marks

Question 7

HCN and HCOOH are both weak acids.

100 mL of 0.1 M HCN is added to one beaker, 100 mL of 0.1 M HCOOH is added to a second beaker and 100 mL of 0.1 M HCl is added to a third beaker.

Calculate the pH of the three beakers.

_____

_____

_____

_____

_____

_____

6 marks

END OF QUESTION AND ANSWER BOOK