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2020 Trial Examination

STUDENT NUMBER | | | | | | | | | Letter |

CHEMISTRY

Unit 3 – Written 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*
A	20	20	20
B	6	6	53
			Total 73

- Students are permitted to bring into the examination room: pens, pencils, highlighters, erasers, sharpeners, rulers, VCAA approved data book 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 16 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.

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.

Question 1

The formation of ammonia from hydrogen and nitrogen has a ΔH of −89.9 $kJmol^{-1}$. 24.7 $kJmol^{-1}$ needs to be provided to initiate the reaction. The values of ΔH and activation energy for the reverse reaction respectively would be;

A. 89.9 $kJmol^{-1}$, 65.2 $kJmol^{-1}$
B. 89.9 $kJmol^{-1}$, 114.6 $kJmol^{-1}$
C. −89.9 $kJmol^{-1}$, 114.6 $kJmol^{-1}$
D. −89.9 $kJmol^{-1}$, 65.2 $kJmol^{-1}$

Question 2

Calculate the heat of combustion in $kJmol^{-1}$ of decane if 1.200 L of decane at SLC produced 326.0 kJ of energy when undergoing complete combustion.

A. 9707
B. 271.7
C. 6085
D. 6737

Use the following information to answer Questions 3 and 4

Methane can be used in a fuel in internal combustion engines. However, there are problems with its use, such as, it is difficult to refuel and store the gas. Methane can also be used in a fuel cell using an acidic electrolyte.

Question 3

The half equation occurring at the negative electrode of a methane fuel cell is;

A. $CH_{4(g)} + H_2O_{(l)} \rightarrow CO_{2(g)} + 8H^+_{(aq)} + 8e^-$
B. $CH_{4(g)} + 4H_2O_{(l)} + 8e^- \rightarrow CO_{2(g)} + 8H^+_{(aq)}$
C. $O_{2(g)} + 4H^+_{(aq)} + 4e- \rightarrow 2H_2O_{(l)}$
D. $O_{2(g)} + 4H^+_{(aq)} \rightarrow 2H_2O_{(l)} + 4e-$

SECTION A – continued

Question 4
The advantage of using methane in a fuel cell rather than direct combustion is;

A. methane is able to react more quickly in a fuel cell and therefore provide more power.
B. less fuel is needed to obtain the same amount of energy output.
C. fuel cells are cheaper to produce than an internal combustion engine.
D. it is easier to store methane for a fuel cell than to store methane for an internal combustion engine.

Question 5
The electrolysis of a $NaCl_{(l)}$ would produce _____ at the negative electrode and _____ at the positive electrode.

A. $Na_{(l)}$, $Cl_{2(g)}$
B. $Cl_{2(g)}$, $Na_{(l)}$
C. $Cl_{2(g)}$, $H_{2(g)}$
D. $O_{2(g)}$, $H_{2(g)}$

Use the following information to answer Questions 6 and 7

A solution of $Fe(SCN)^{2+}$ is actually a mixture of chemicals due to the equilibrium

$Fe^{3+}_{(aq)} + SCN^{-}_{(aq)} \rightleftharpoons Fe(SCN)^{2+}_{(aq)}$.

$Fe(SCN)^{2+}$ is a dark red colour, while Fe^{3+} and SCN^- are colourless.

Question 6
When a student adds Fe^{3+} to the mixture;

A. the solution is lighter and the equilibrium shifts towards the products
B. **t**he concentration of Fe^{3+} increases and the equilibrium shifts so more SCN^- forms
C. the concentration of Fe^{3+} initially increases but then returns to the original value as the equilibrium shifts towards the products
D. the concentration of $Fe(SCN)^{2+}$ increases and the concentration of SCN^- decreases

Question 7
An equal volume of water is added to the mixture. When the mixture is viewed by looking down the opening of the test tube;

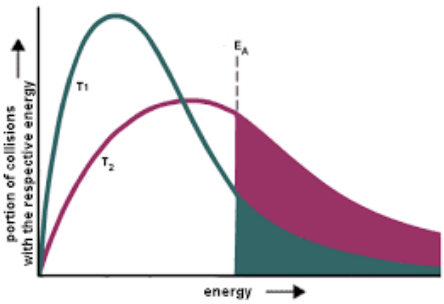
A. The solution is lighter as Fe^{3+} is colourless
B. The solution is lighter as more Fe^{3+} and SCN^- are produced
C. The solution is darker as the equilibrium has shifted towards the side with the greater mole of chemicals
D. The solution is neither darker or lighter as the concentration of all species remains unchanged

SECTION A – continued
TURN OVER

Question 8
1.00kg of calcium carbonate is completely decomposed in an open beaker according to;
$CaCO_{3(s)} \rightarrow CO_{2(g)} + CaO_{(s)}$ $\Delta H = +178$ kJ mol^{-1}
The final mass of the contents in the beaker in grams is;

A. 178
B. 440
C. 560
D. 1000

Question 9
The graph below shows the relationship between the energy of the particles and the relative number of particles. E_A represents the activation energy and the 2 lines represent different temperatures (T_1 and T_2).



It could be concluded that;

A. T_1 is greater than T_2
B. T_2 has a higher activation energy than T_1
C. The particles at T_2 are moving faster than the particles at T_1
D. A colliding particle at T_2 is more likely to react than a particle at T_1

Question 10
A solution of copper ions is undergoing electrolysis using copper electrodes. A student would observe;

A. the anode increasing in mass and the cathode decreasing in mass
B. the concentration of the copper ions staying constant
C. electrons flowing from the negative to the positive electrode
D. the pH of the solution decreasing

Question 11
A student applies a current of 2.50 A for 1 hour and 2.77g of metal is deposited at the cathode. The electrolyte must be;

A. Ag^{+}
B Mg^{2+}
C. Cr^{3+}
D. Sn^{4+}

SECTION A – continued

Question 12
Hydrogen has been suggested as a fuel that can reduce the output of greenhouse gases. To reduce greenhouse gases, the best source of hydrogen is obtained by;

A. separating hydrogen from coal seam gas
B. electrolysis of water using mains electricity
C. collecting hydrogen as a by-product from processes such as chlorine production
D. steam reforming of natural gas

Question 13
Nitrogen dioxide is in equilibrium with dinitrogen tetroxide according to

$$2NO_{2(g)} \rightleftharpoons N_2O_{4(g)}$$

0.25 mol of NO_2 is introduced into a evacuated 2 litre container. At equilibrium, 0.10 mol of N_2O_4 is present. The value of K is;

A. 0.0125 M
B. 15 M^{-1}
C. 2 M^{-1}
D. 80 M^{-1}

Question 14
The reaction between carbon monoxide and haemoglobin has a much higher equilibrium constant than the reaction between oxygen and haemoglobin. The patient is treated by providing pure oxygen. By doing this;

A. the reaction between oxygen and haemoglobin is driven to the right and the reaction between carbon monoxide and haemoglobin is driven to the left
B. K for the reaction between carbon monoxide and haemoglobin is decreased
C. the reaction between oxygen and haemoglobin is driven to the right and the reaction between carbon monoxide and haemoglobin is driven to the right
D. K for the reaction between oxygen and haemoglobin is increased

Question 15
Carbon can react with hydrogen to give benzene according to;
$6C_{(s)} + 3H_{2(g)} \rightarrow C_6H_{6(g)}$ $\Delta H = +49$ $kJmol^{-1}$
ΔH for the reaction $2C_6H_{6(g)} \rightarrow 12C_{(s)} + 6H_{2(g)}$ in $kJmol^{-1}$ would be;

A. +98
B −98
C. −49
D. +49

SECTION A – continued
TURN OVER

Question 16
The gas that occupies the largest volume at 25°C and 1.0 atm is;

A. 2.0 mol of CO_2
B 100 g of Neon
C. 2 x 10^{24} atoms of neon
D. 100 g of CO_2

Question 17
A suitable electrolyte for a hydrogen fuel cell would NOT be;

A. 1M $HCl_{(aq)}$
B. 1M $NaOH_{(aq)}$
C. $Na_2CO_{3(l)}$
D. $NaCl_{(l)}$

Question 18
In a hydrogen fuel cell,

A. a current is supplied and water is the only product
B. the electrodes are often porous and act as catalysts
C. the percentage energy conversion is greater than in an internal combustion engine so energy is produced at a faster rate.
D. it is difficult to store the hydrogen and oxygen gas as they are costly to compress

Question 19
The combustion of methanol (CH_3OH) can be safely carried out in a school laboratory. The rate of reaction can be reduced by;

A. reducing the amount of methanol burnt
B. increasing the temperature of the fuel
C. performing the reaction in a flat dish rather than in a test tube
D. mixing an equal amount of water with the methanol

Question 20
Biodiesel is sometimes referred to as being "carbon neutral" but this is not 100% true, mainly because;

A. farm land used for growing crops stops other more productive farming activities
B. carbon dioxide contributes to global warming regardless of where it comes from
C. energy is used to harvest and transport crops
D. biodiesel has a significantly lower energy content than petrodiesel

END OF SECTION A

SECTION B – Short-answer questions

Instructions for Section B

Questions must be written in blue or black pen and 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; unsimplified answers will not be given full marks.
- Show all workings 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 (9 marks)

The sales of electric vehicles are increasing worldwide. Most run using batteries such as Lithium-based, nickel metal hydride (NiMH), or zinc-air batteries. The initial cost of electric cars is greater than cars with an internal combustion engine but running costs are much lower.

a. The efficiency of an internal combustion engine is often about 25% while an electric car can have an efficiency of around 70%. By referring to the energy transformations involved, explain why electric cars are more efficient.

_____

_____

_____

2 marks

b. The fuel in internal combustion cars and batteries in electric cars can catch on fire during an accident

i. Write a balanced chemical equation for the combustion of octane (a major component of petrol).

_____

ii. Write half equations and a full equation for the reaction of lithium metal with water.

_____

_____

_____

1 + 3 = 4 marks

c. A zinc air battery is being investigated as a cheaper and lighter battery. When the cell is discharging, the reaction at the anode can be summarised as;

$Zn_{(s)} + 4OH^-_{(aq)} \rightarrow ZnO_{(s)} + H_2O_{(l)} + 2OH^-_{(aq)} + 2e^-$

The overall reaction is; $2Zn_{(s)} + O_{2(g)} \rightarrow 2ZnO_{(s)}$

i. Determine the equation for the reaction occurring at the cathode;

_____

ii. Why might zinc air batteries be more energy dense than other types of batteries?

_____

_____

iii. In order for the cell to be recharged, what characteristic must the products at the cathode and anode reaction have?

_____

1 + 1 + 1 = 3 marks

SECTION B - continued

Question 2 (6 marks)
Biodiesel is being used as an alternative to petrodiesel fuel.

Biodiesel can be produced by combining a fatty acid with methanol.

a. Write the semi-structural formula of the biodiesel molecule that is obtained from the reaction of myristic acid with methanol.

_____

1 mark

b. When 500.0g of petrodiesel reacts with excess oxygen, how much energy is produced?

_____

_____

1 mark

c. List 2 physical properties where petrodiesel and biodiesel differ and explain the difference by referring to the bonding involved in each fuel

i. Property 1

_____

ii. Explanation 1

_____

iii. Property 2

_____

iv. Explanation 2

_____

4 x 1 = 4 marks

SECTION B - continued
TURN OVER

Question 3 (12 marks)

It has been suggested that aluminium could be used as a fuel source by reacting it with water to produce hydrogen gas. The aluminium rods could be replaced when the vehicle is "refueled". The hydrogen gas produced could then be used in a fuel cell.

a. What is the advantage of producing hydrogen gas in this way?

_____

1 mark

b. The aluminium could be prepared using electrolysis.

i. Should the electrolyte be a molten liquid or aqueous solution? Why?

_____

_____

_____

ii. Write the half equation for the reaction occurring at the cathode?

_____

iii. A current of 20 000A is passed through an electrolyte for 20.0 minutes. What mass of aluminium, in kg, could theoretically be produced?

_____

_____

_____

2+1+3 = 6 marks

c. When the aluminium is reacted to form hydrogen from water, write half equations for the oxidation and reduction process.

i. Oxidation

_____

ii. Reduction

_____

1 + 1 = 2 marks

d. The fuel call uses a potassium hydroxide electrolyte.

i. Write the half equation for the reaction occurring at the positive electrode.

_____

ii. Ions move through the electrolyte. In what direction would the hydroxide ions move and why do they move in this direction?

_____

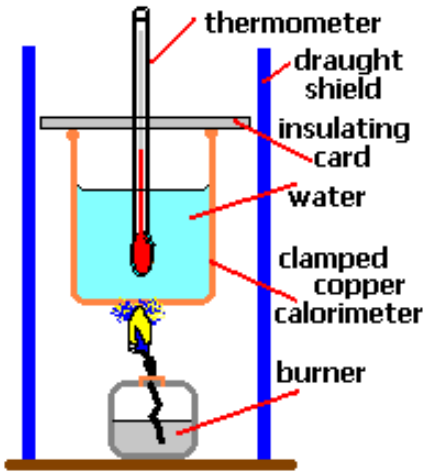
_____

1 + 2 = 3 marks

SECTION B - continued
TURN OVER

Question 4 (11 marks)

A student decides to determine the heat of combustion of ethanol using the experimental set-up as shown below.



Ethanol is placed in the burner and 150g of water is poured into the copper "calorimeter". The wick of the burner is lit and after 2.0 minutes, the mass of fuel has decreased by 0.873g and the temperature of the water has increased from 18.0°C to 41.5°C.

a. Write an equation to show the combustion of ethanol.

_____

1 mark

b. From the experimental data, determine the heat of combustion of ethanol in kJg^{-1}.

_____

_____

_____

2 marks

c. Compare your experimental value to the expected value and account for the difference between the two values.

_____

_____

_____

2 marks

SECTION B – **Question 4** - continued

d. The student now wants to experimentally determine the heat of combustion of octane. Why might they be advised not to do this?

_____

1 mark

e. Determine the volume of carbon dioxide and SLC that would be produced by the complete combustion of octane to produce 1.00×10^3 kJ of energy.

_____

_____

_____

_____

_____

4 marks

f. The volume of carbon dioxide produced by the complete combustion of ethanol to produce 1000 kJ of energy is greater than the volume of carbon dioxide produced by the complete combustion of octane to produce 1000 kJ of energy. In terms of reducing the effects of climate change why then might a car owner choose to run their car on ethanol rather than octane?

_____

_____

1 mark

SECTION B - continued
TURN OVER

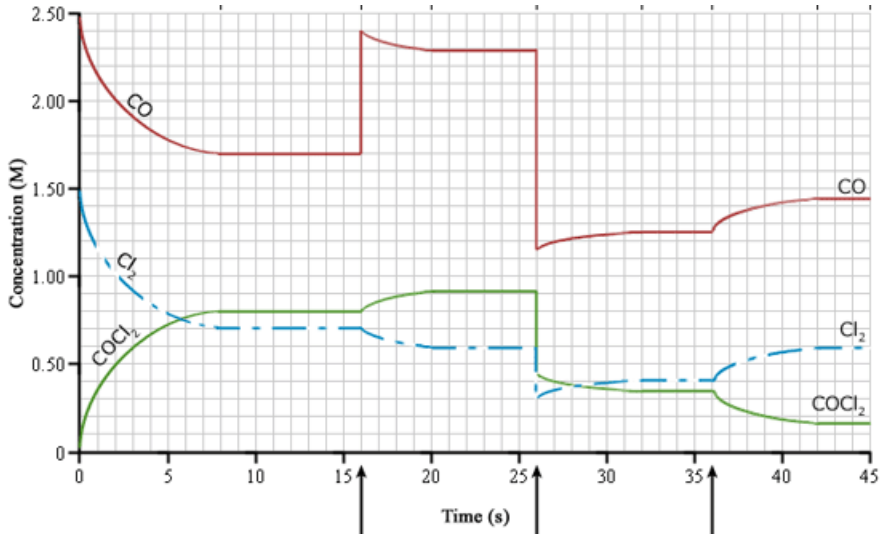
Question 5 (8 marks)

$COCl_2$ can be produced from the reaction of carbon monoxide and chlorine;

$CO_{(g)} + Cl_{2(g)} \rightleftharpoons COCl_{2(g)}$

Heat is generated during the reaction.

The graph below shows how the concentration of the gases can change when mixed and when conditions have changed,



a. What change has occurred at;

i. t = 16 seconds?_____

ii. t = 26 seconds?_____

iii. t = 36 seconds? _____

3 x 1 = 3 marks

b. Calculate the value of K at 15 seconds?

_____

_____

2 marks

c. Select **ONE** of the two reactants. Reactant selected _____

i. Describe why the chemical is so dangerous by referring to the chemistry involved.

_____

_____

ii. If you were carrying out this reaction, briefly describe one significant safety procedure that you would use (other than wear a laboratory coat and wear safety glasses).

_____

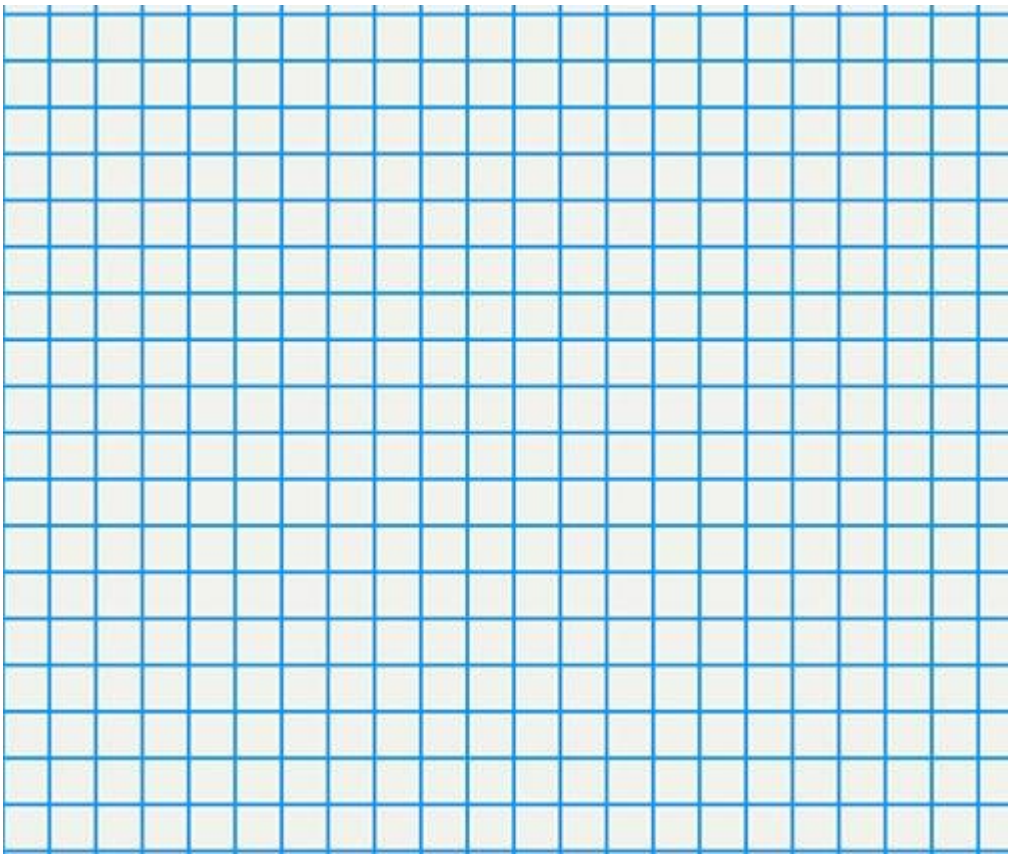
2 + 1 = 3 marks

SECTION B - continued

Question 6 (7 marks)

A key step in the production of sulfuric acid involves $2SO_{2(g)} + O_{2(g)} \rightarrow 2SO_{3(g)}$
The reaction has a ΔH of -196 $kJmol^{-1}$ and an activation energy of 54 $kJmol^{-1}$.

a. Sketch a labelled energy diagram to show how the enthalpy of the products compares to the enthalpy of the reactants. Include the activation energy.



2 marks

b. The reaction is often heated. What is the effect of heating the reaction mixture on the

i. rate of reaction

ii. extent of reaction.

2 marks

SECTION B – Question 6 - continued
TURN OVER

c. To increase the equilibrium yield, would you use a low or high pressure? Explain why by referring to LeChatelier's Principle.

_____

_____

_____

2 marks

d. What effect does heating have on the activation energy?

_____

1 mark

END OF QUESTION AND ANSWER BOOK