ALEXANDER ROAD HIGH SCHOOL

JUNE 2019 3 HOUR

PHYSICAL SCIENCE PAPER 2

EXAMINER: CO,MH,JA TOTAL = 150

GRADE 12

Instructions

- The question paper consists of 9 questions.
- Answer all the questions.
- Answer section A on the answer sheet provided AND section B on folio sheets.
- Rule off after each question in Section B.
- A non-programmable calculator may be used.
- Number the answers correctly according to the numbering system.
- Round off to two (2) decimal places where necessary.
- Formulas and a periodic table have been included at the end of the question paper

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SECTION A

- Answer on the answer sheet -

QUESTION 1: Multiple choice

Four possible options are provided as answers to the following questions. Each question has only 1 correct answer. Choose the correct answer and write the letter (A – D) next to the relevant question number (1.1 – 1.10) on the answer sheet.

1.1 Which ONE of the following molecules has the highest boiling point?

A. CO_2
B. NH_3
C. BF_3
D. CS_2

1.2 Concentrated nitric acid is added to 750 ml water at 25°C. Which ONE of the following combinations is correct with regards to the solution?

A	$K_w = 1 \times 10^{-14}$	$[H_3O^+] > 1 \times 10^{-7}$ M	$[OH^-] < 1 \times 10^{-7}$ M
B	$K_w = 1 \times 10^{-14}$	$[H_3O^+] = 1 \times 10^{-7}$ M	$[OH^-] = 0$ M
C	$K_w > 1 \times 10^{-14}$	$[H_3O^+] > 1 \times 10^{-7}$ M	$[OH^-] = 0$ M
D	$K_w < 1 \times 10^{-14}$	$[H_3O^+] < 1 \times 10^{-7}$ M	$[OH^-] > 1 \times 10^{-7}$ M

1.3 25,2 g of nitric acid (HNO_3) is dissolved in 20 cm^3 of water to make a concentred nitric acid solution. How much water must be added to the solution to dilute the concentration to 0,5 M?

A. 800 cm^3
B. 1 250 cm^3
C. 180 cm^3
D. 780 cm^3

1.4 Consider the following reactions:

$$(COOH)_{2(aq)} + H_2PO_4^-{}_{(aq)} \rightleftharpoons HC_2O_4^-{}_{(aq)} + H_3PO_{4(aq)} \qquad K_a > 1$$

$$H_3PO_{4(aq)} + (COO)_2^{2-}{}_{(aq)} \rightleftharpoons HC_2O_4^{2-}{}_{(aq)} + H_2PO_4^- \qquad K_a > 1$$

The strength of the acids in DESCENDING ORDER is…

A. $(COOH)_2;\ HC_2O_4^-;\ H_3PO_4$
B. $(COOH)_2;\ H_3PO_4;\ HC_2O_4^-$
C. $H_3PO_4;\ (COOH)_2;\ HC_2O_4^-$
D. $H_3PO_4;\ HC_2O_4^-;\ (COOH)_2$

1.5 A catalyst is a substance that increases the rate of a chemical reaction by …

A increasing the activation energy for the reaction.
B decreasing the activation energy for the reaction.
C increasing the average kinetic energy of the reacting particles.
D decreasing the average kinetic energy of the reacting particles.

1.6 Which of the following statements is true for a reaction in a state of dynamic chemical equilibrium?

A The limiting reagent has been used up.
B The forward and reverse reactions have stopped.
C The rates of the forward and reverse reactions are equal.
D The concentration of products equals the concentration of reactants.

1.7 A violet solution is prepared by dissolving cobalt chloride crystals in a mixture of ethanol and water. The violet colour is due to two different coloured cobalt(II) complex ions existing together in equilibrium in the solution as shown in the balanced chemical equation:

$$\underset{\text{BLUE}}{CoC\ell_4^{2-}} + 6H_2O \rightleftharpoons \underset{\text{PINK}}{Co(H_2O)_6^{2+}} + 4C\ell^- \qquad \Delta H < 0$$

What colour change will be observed when a few drops of concentrated hydrochloric acid are added to $1cm^3$ of the violet solution?

A The solution turns colourless

B The solution turns blue

C The solutions turns pink

D No colour change

1.8 An ideal ammeter is used to measure the current in a conductor. Which of the following describes the resistance of an ideal ammeter and the way the ammeter is connected to the conductor?

	Resistance	**Connection**
A	Zero	In series
B	Zero	In parallel
C	Infinite	In series
D	Infinite	In parallel

1.9 Chlorine gas is bubbled through a solution of Fe^{2+} ions. Consider the balanced chemical equation for the reaction given below.

$$2Fe^{2+}(aq) + C\ell_2(g) \rightarrow 2Fe^{3+}(aq) + 2C\ell^-(aq)$$

The symbol of the reducing agent in this reaction is:

A Fe^{2+}

B $C\ell_2$

C Fe^{3+}

D $C\ell^-$

1.10 Which one of the following correctly describes the process taking place at the cathode of an electrochemical cell and the electron transfer involved?

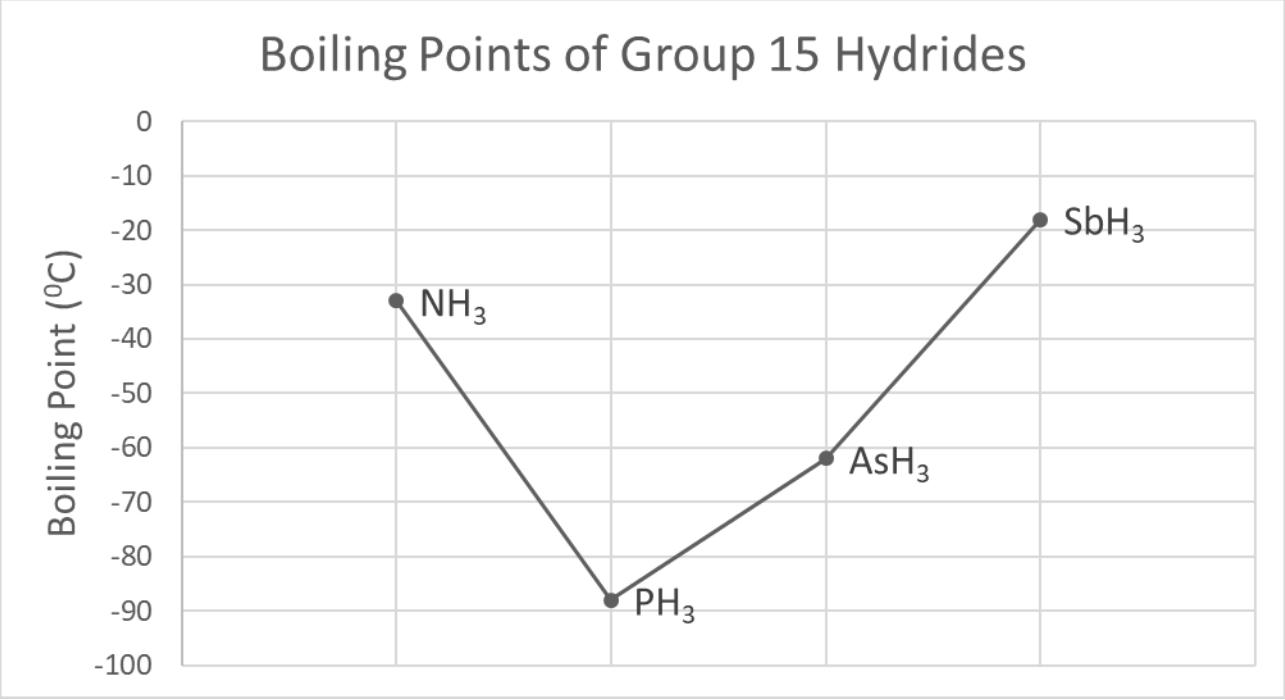
	Process	Electron transfer
A	Oxidation	Loss of electrons
B	Reduction	Loss of electrons
C	Oxidation	Gain of electrons
D	Reduction	Gain of electrons

[2 x 10 = 20]

SECTION B

QUESTION 2

Consider the graph below.



2.1 Define the term *boiling point*. (2)

2.2 Describe the trend in the boiling point from PH_3 to SbH_3. (1)

2.3 Use INTERMOLECULAR FORCES to explain the trend described in 2.2. (3)

2.4 Use INTERMOLECULAR FORCES to explain why NH_3 deviates from the trend described in 2.2. (3)

2.5 Explain, in terms of the POLARITY of the molecules, why NH_3 dissolves in water. (2)

2.6 How does the boiling point of NH_3 compare with that of HF? Write down MORE THAN, LESS THAN or EQUAL TO. Give a reason for your answer. (2)

[13]

QUESTION 3

Consider the following acids:

Name	Formula	K_a
Carbonic acid	H_2CO_3	$4,2 \times 10^{-7}$
Acetic acid	CH_3COOH	$1,8 \times 10^{-5}$

3.1 Define the term *acid*. (1)

3.2 Write down the NAME or FORMULA of the acid in the table which is the weakest. Give a reason for your answer. (2)

3.3 Acetic acid ionises in water according to the following balanced chemical equation:

$$CH_3COOH_{(l)} + H_2O_{(l)} \rightleftharpoons CH_3COO^-_{(aq)} + H_3O^+_{(aq)}$$

Write down the FORMULA of the two bases in this reaction. (2)

3.4 What do you call a substance, like H_2O, which can act as either an acid or a base? (1)

3.5 Write out a balanced chemical equation for the <u>reaction of potassium carbonate with water</u>. (3)

3.6 What is the name of the process described by the underlined sentence in question 3.5? (1)

3.7 A chemist dissolves some oxalic acid crystals ($(COOH)_{2\,(s)}$) in 250 cm^3 water. 25 cm^3 of the oxalic acid solution is titrated with 0,15 $mol.dm^{-3}$ NaOH. At the endpoint of the titration it was found that 40 cm^3 NaOH was used. The balanced chemical equation for the reaction is given below.

$$(COOH)_2 + 2\ NaOH \rightarrow 2\ Na_2COO + 2\ H_2O$$

3.7.1. Calculate the mass of oxalic acid crystals added to the 250 cm^3 water. (7)

3.7.2. Which indicator should the chemist use to accurately determine the endpoint of this titration? (1)

3.8 A solution of magnesium hydroxide ($Mg(OH)_2$) has a concentration of $3,5 \times 10^{-5}$ $mol.dm^{-3}$ at 25°C. What is the pH of the solution? (4)

3.9 The pH of a solution of calcium hydroxide ($Ca(OH)_2$) is 9,5. What is the hydroxide ion (OH^-) concentration? (2)

[24]

QUESTION 4

Learners use the reaction between IMPURE POWDERED calcium carbonate and excess hydrochloric acid to investigate reaction rate. The balanced equation for the reaction is:

$$CaCO_3(s) + 2HC\ell(aq) \rightarrow CaC\ell_2(aq) + H_2O(\ell) + CO_2(g)$$

They perform four experiments under different conditions of concentration, mass and temperature as shown in the table below. They use identical apparatus in the four experiments and measure the volume of gas released in each experiment.

	EXPERIMENT			
	1	**2**	**3**	**4**
Concentration of acid ($mol \cdot dm^{-3}$)	1	0,5	1	1
Mass of impure calcium carbonate (g)	15	15	15	25
Initial temperature of acid (°C)	30	30	40	40

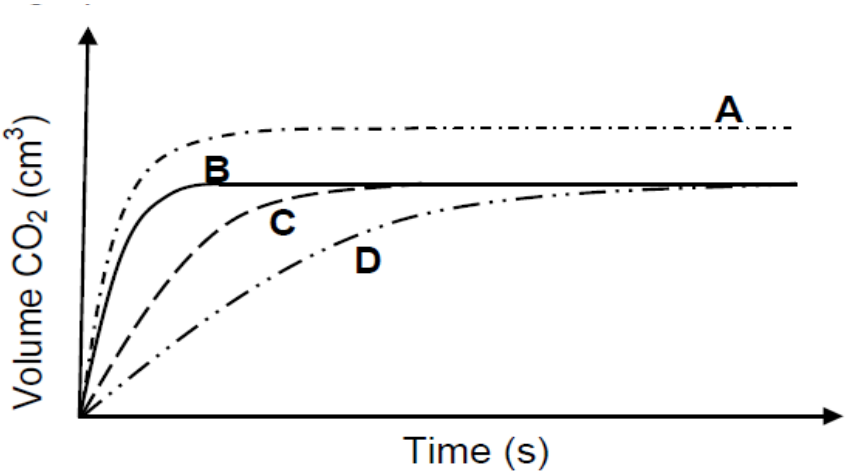
4.1 The results of experiment **1** and **2** are compared in the investigation.

Write down the:

4.1.1 dependant variable
4.1.2 independent variable
4.1.3 controlled variable (3 x 1)

4.2 Use the collision theory to explain why the reaction rate in experiment **3** will be higher than the reaction rate in experiment **1.** (3)

The learners obtain graphs **A, B, C** and **D** below from their results.



4.3 Which ONE of the graphs (**A, B, C** or **D**) represents experiment **3**? Fully explain the answer by comparing experiment **3** with experiment **1, 2** and **4.** (6)

4.4 When the reaction in experiment **3** reaches completion, the volume of gas formed is 400 cm^3. Assume that the molar gas volume at 40 °C is equal to 25,7 dm^3.

Calculate the mass of the impurities present in the calcium carbonate. (8)

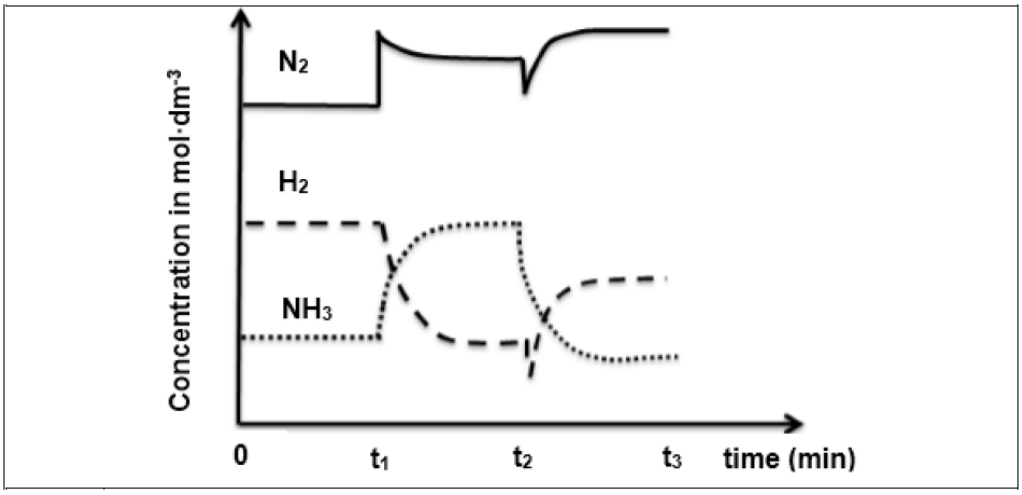
[20]

QUESTION 5

The reaction represented by the equation below reaches equilibrium in a closed container.

$$N_2(g) + 3H_2(g) \leftrightharpoons 2NH_3(g) \qquad \Delta H = -92\ kJ$$

5.1 Changes were made to the reaction conditions that affect equilibrium position. The graphs below represent the results obtained.



5.1 What does the gradient of the graphs represent? (1)

5.2 State Le Chatelier's Principle in words. (2)

5.3 What changes were made to the reaction conditions at each of the following times?

a) t_1 (1)

b) t_2 (1)

5.4 a) How would the K_c-value at t_3 compare to the K_c-value at t_1?

Only write INCREASE, DECREASE or STAY THE SAME. (1)

b) Give a reason for your answer in a). (1)

5.5 Use Le Chatelier's Principle to explain the shift in equilibrium because of the change that happened at t_2. (3)

5.6 How does the rate of the forward reaction compare to the rate of the reverse reaction just after t_1?

Write down HIGHER THAN, LOWER THAN or EQUAL TO. (1)

Equal number of moles of hydrogen gas and nitrogen gas are injected into a sealed 4 dm^3 container. When the reaction reaches equilibrium at 450°C, it is found that 40% of the original amount of hydrogen is ***left*** in the container. The value of K_c at 450°C is $1,5 \times 10^3$.

5.7 Give *two* conditions that is needed for equilibrium to be reached. (2)

5.8 Calculate the initial mass of hydrogen in the container. (10)

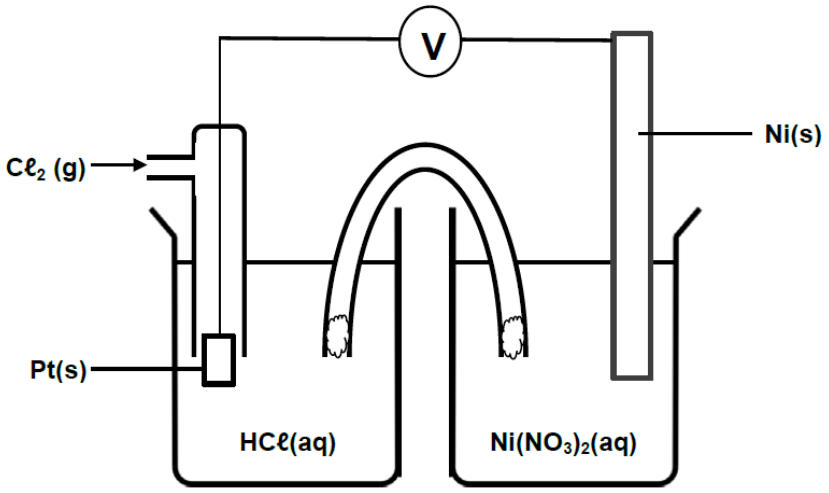
5.9 The temperature is increased to 500°C.

Explain how the K_c-value will be affected by this change. (3)

[26]

QUESTION 6

A galvanic cell is constructed using a standard $C\ell_2|C\ell^-$ half-cell and a standard $Ni|Ni^{2+}$ half-cell, as shown in the diagram below. The solution in the nickel half-cell is initially **pale green.**



6.1 The reduction half-reaction that occurs in this cell is shown below:

$$C\ell_2 + 2e^- \rightarrow 2C\ell^-$$

6.1.1 Define oxidising agent. (1)

6.1.2 With reference to the strengths of oxidising agents, explain why $C\ell_2$ is reduced instead of Ni^{2+}. (2)

6.2.1 Define anode. (2)

6.2.2 Identify the anode in this cell. (1)

6.3 Identify the positive electrode in this cell. (1)

6.4 Write the cell notation for this cell. State (phase) symbols and conditions need not be shown. (3)

6.5 The voltmeter is now replaced with a light bulb so that current flows.

6.5.1 Write down the half-reaction that occurs in the nickel half-cell. (1)

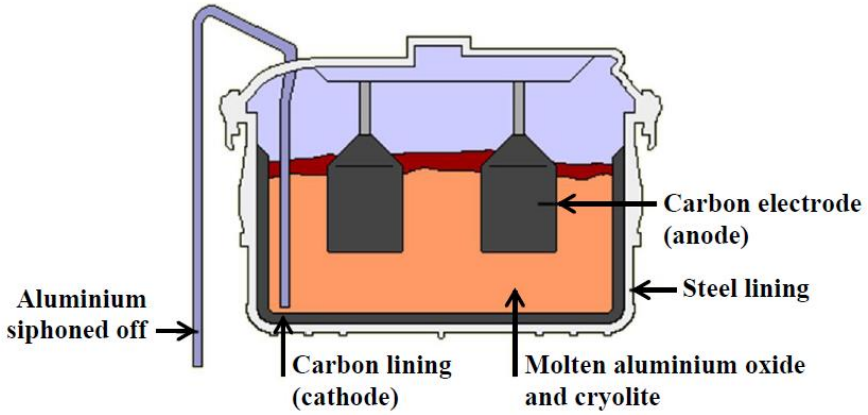
6.5.2 Hence, state ONE change that will be **observed** in the nickel half-cell after a significant amount of time has passed. (1)

6.5.3 One of the functions of the salt bridge is to maintain electrical neutrality. State ONE other function of the salt bridge. (1)

[13]

QUESTION 7

Aluminium is prepared on a large scale in industry by the electrolysis of molten aluminium oxide that is dissolved in molten cryolite at 950 °C. The electrolytic cell used in this process is shown in the diagram below.



[Source: PLATO learning (UK) Ltd]

7.1 State the energy conversion that takes place in this electrolytic cell. (1)

7.2 Write down the equation for the half-reaction that takes place at the cathode. (2)

7.3 Write down the equation for the half-reaction that takes place at the anode. (2)

7.4 The carbon electrodes in this cell constantly corrode and need to be replaced. Write down a balanced chemical equation for this occurence. (2)

Cryolite lowers the melting point of aluminium oxide from 2 000 °C to 950 °C.

7.5 State one way in which the use of cryolite is an advantage to the environment. (1)

7.6 Despite the use of cryolite, this process still consumes large quantities of electricity in order to achieve the required temperature of 950 °C. Thuli makes the following energy saving suggestion:

"*They should use the electrolysis of a concentrated aqueous solution of aluminium chloride at room temperature rather than molten aluminium oxide at 950 °C.*"

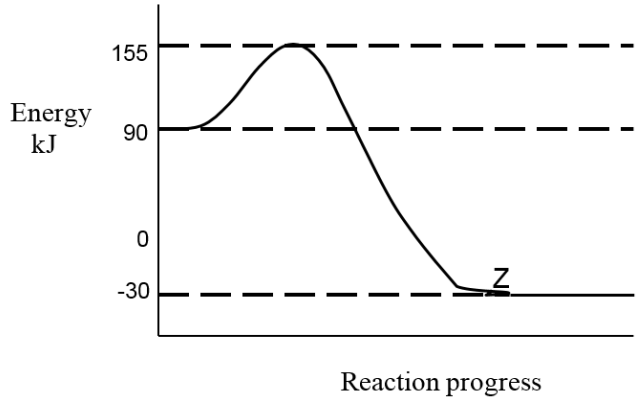
Consider the reaction taking place at the **cathode** in order to explain why Thuli's suggestion will not work. Write down the equation for a suitable half-reaction that supports your answer. (3)

[11]

QUESTION 8

The sketch below represents the potential energy graph for the reaction:

$$X(g) + Y(\ell) \rightarrow Z(aq)$$



Refer to the diagram and answer the following.

8.1 Define *activation energy*. (1)

8.2 What is the value of the activation energy in the graph above? (1)

8.3 How much energy was released when Z formed? (2)

8.4 Calculate the value of the heat of reaction (change in heat)? (2)

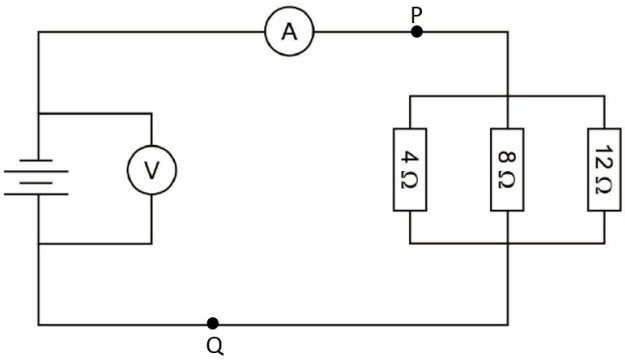
8.4 Is the **reverse** reaction EXOTHERMIC or ENDOTHERMIC? (1)

8.5 How will a catalyst influence any of the readings or calculated values for this graph? (1)

[8]

QUESTION 9

A circuit consists of a battery with an emf of **16,5 V** and an unknown internal resistance, three resistors, an ammeter and a voltmeter. The circuit is connected as shown in the diagram below. Ignore the resistance of the conductors.



The voltmeter measures a potential difference of **12 V**.

9.1.1 State *Ohm's Law*. (2)

9.1.2 Calculate the current in the 8 Ω resistor. (3)

9.1.3 Calculate the effective resistance of the resistors connected in parallel. (3)

9.1.4 Calculate the current measured by the ammeter. (2)

9.1.5 Calculate the internal resistance of the battery. (3)

9.1.6 If a 5Ω resistor is connected between points P and Q, what will happen to the reading on V ? Only write INCREASE, DECREASE or REMAIN THE SAME. Give a reason for your answer; no calculations need to be done. (2)

[15]

[TOTAL 150]