HILTON COLLEGE
GRADE 12 TRIALS EXAMINATION
AUGUST 2018

PHYSICAL SCIENCE: PAPER 2

Time: 3 hours 200 marks

Examiner: Mr NC Robert
Moderator: Mr MJ Green

PLEASE READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This question paper consists of 15 pages, including an Answer sheet (Pg. 15) that can be detached. A green Data Sheet of 3 pages (i-iii) is provided separately. Please make sure that your question paper is complete.
2. **Write your laundry number on the Answer Sheet.**
3. Read the questions carefully.
4. ALL of the questions in this paper must be answered.
5. Question 1 consists of 10 multiple-choice questions. There is only one correct answer to each question. The questions are to be answered on the inside cover of your Answer Book. The letter that corresponds with your choice of the correct answer must be marked with a cross as shown in the example below:

A	B	C	D	Here the answer C has been marked.

6. **START EACH QUESTION ON A NEW PAGE.**
7. Use the data and formulae whenever necessary.
8. Number your answers in the same way as the questions are numbered.
9. Unless instructed otherwise it is NOT necessary to give state symbols (phase indicators) when asked to write a balanced chemical equation.
10. Show all necessary steps in calculations.
11. Where appropriate take your answers to 2 decimal places.
12. It is in your own interest to write legibly and to present your work neatly.

Question 1

Answer these questions on the multiple-choice Answer Sheet on the inside front cover of your Answer Book. Make a cross (X) in the box corresponding to the letter representing the answer that you consider to be the most correct.

1.1 The chemical formula for magnesium sulphite is:

A $Mg(SO_3)_2$
B $MgSO_4$
C Mg_3SO_2
D $MgSO_3$

1.2 Which one of the following best describes the particles and how the electrons are involved in the process of ionic bonding?

	Particles	Electrons
A	Non-metal ions only	Transferred
B	Metal ions and non-metal ions	Shared
C	Non-metal ions only	Shared
D	Metal ions and non-metal ions	Transferred

1.3 Which of the following gives the correct number of atoms in 10 g of NH_3 (g)?

A $\frac{10}{10} \times 6{,}02 \times 10^{23} \times 4$
B $\frac{10}{17} \times 4$
C $\frac{10}{17} \times 6{,}02 \times 10^{23} \times 4$
D $\frac{10}{17} \times 6{,}02 \times 10^{23}$

1.4 Which one of the following gives the approximate pH of an aqueous solution of sodium carbonate and the relevant hydrolysis equation?

	pH	Hydrolysis equation
A	Less than 7	$CO_3^{2-} + H_2O \rightleftharpoons HCO_3^- + OH^-$
B	Less than 7	$Na^+ + H_2O \rightleftharpoons NaOH + H^+$
C	Greater than 7	$CO_3^{2-} + H_2O \rightleftharpoons HCO_3^- + OH^-$
D	Greater than 7	$Na^+ + H_2O \rightleftharpoons NaOH + H^+$

1.5 A weak base is defined as one which …

A ionises almost completely in an aqueous solution.
B ionises partially in an aqueous solution.
C dissociates almost completely in an aqueous solution.
D dissociates partially in an aqueous solution.

1.6 1 mol of PCl_5 gas is heated in a closed container. 50% of the PCl_5 gas decomposes to set up the equilibrium represented by the balanced chemical equilibrium below.

$$PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$$

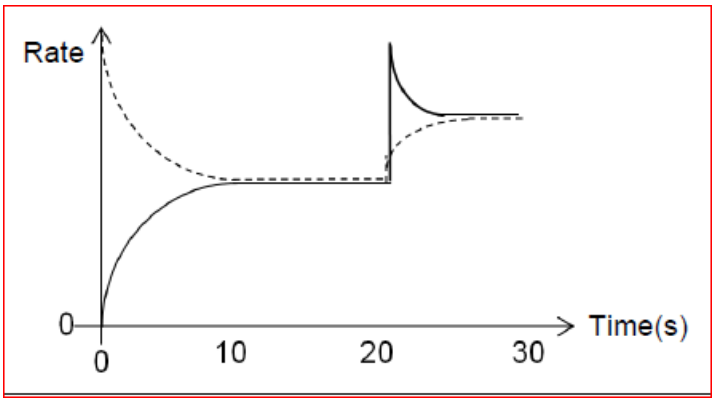
How many moles of gas are present in the container at equilibrium?

A 0,5
B 1,0
C 1,5
D 2,0

1.7 Gas X_2Y is introduced into the container, which is then sealed. The gas decomposes and the reaction reaches equilibrium. The balanced chemical equation for the reaction is:

$$2X_2Y(g) \rightleftharpoons 2X_2(g) + Y_2(g)$$

At t = 20 s, a change is made to the reaction in equilibrium. The graph below shows the changes in the **rates** of the forward and reverse reactions with time.



Which of the following gives the change made at t = 20 s?

A Using a catalyst
B Increase in pressure
C Decrease in temperature
D Decrease in pressure.

1.8 The balanced chemical equation for the spontaneous redox reaction of chlorine gas with an aqueous solution of potassium bromide is given below.

$$Cl_2(g) + 2KBr(aq) \longrightarrow 2KCl(aq) + Br_2(aq)$$

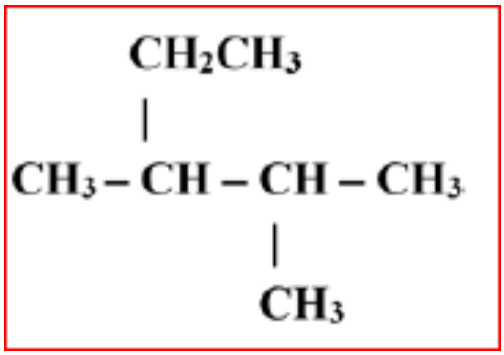
Which one of the following gives the formula of the oxidizing agent and reducing agent of this reaction?

	Oxidising agent	Reducing agent
A	Cl_2	Br_2
B	Cl_2	Br^-
C	K^+	Br_2
D	K^+	Br^-

1.9 Which one of the following organic compounds is an unsaturated hydrocarbon?

A C_2H_6
B C_3H_6
C CH_3COOH
D CH_4

1.10 The IUPAC name of the organic compound given below:



A 2-ethyl-3-methylbutane
B 3-ethyl-2-methylbutane
C 2-ethyl-1,1-dimethylpropane
D 2,3-dimethylpentane

[20]

Question 2 CHEMICAL BONDING AND QUANTITATIVE CHEMISTRY

2.1 Use only substances from the list below when answering Questions 2.1.1 to 2.1.7. The phase indicators (state symbols) represent the physical state of each of the substances at room temperature.
(Only write down the question number and the formula of the substance next to it. Substances may be used more than once.)

NaCl(s) N_2(g) Fe(s) NH_3(g) diamond(s) Ne(g)

Select one substance from the list that has:

2.1.1 Induced dipole (London) forces between its atoms. (1)

2.1.2 Induced dipole (London) forces between its molecules. (1)

2.1.3 A giant covalent network structure. (1)

2.1.4 Hydrogen bonding. (1)

2.1.5 Ionic bonds. (1)

2.1.6 Polar covalent bonds. (1)

2.1.7 Pure covalent bonds. (1)

2.2 Niaan prepares 200,00 cm^3 of a standard aqueous solution of magnesium nitrate ($Mg(NO_3)_2$ (aq)) of concentration 0,15 $mol.dm^{-3}$.

2.2.1 Identify the solvent used in Niaan's aqueous solution of magnesium nitrate. (1)

2.2.2 Name the type of Van der Waal's force of attraction between the solute and the solvent. (2)

2.2.3 Write down a balanced chemical equation for the dissociation of $Mg(NO_3)_2$ in water. Phase indicators (state symbols) **must** be shown. (4)

2.2.4 Calculate the number of moles of nitrate ions (NO_3^-) in the solution. (3)

Niaan now dissolves solid sodium nitrate ($NaNO_3$) in 200,00 cm^3 of 0,15 $mol.dm^{-3}$ magnesium nitrate solution. The total concentration of nitrate ions (NO_3^-) in the new solution is 0,50 $mol.dm^{-3}$. (Assume that there is no change in the volume of the solution.)

2.2.5 Calculate the mass of the sodium nitrate dissolved. (5)

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Question 3 ENERGY CHANGE AND REACTION RATES

3.1 Define the following terms:

3.1.1 *Heat of reaction.* (2)

3.1.2 *Activated complex.* (2)

3.2 According to the collision theory, in order for a chemical reaction to occur reactant particles must collide. State TWO requirements for an **effective** collision. (4)

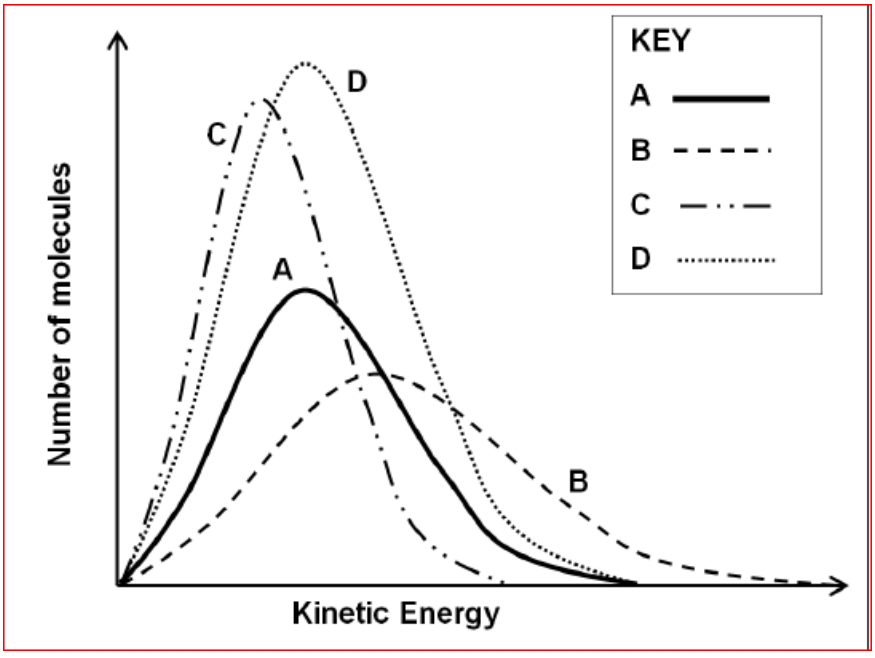
3.3 Excess dilute hydrochloric acid is added to a single large piece of zinc metal in an open test-tube.

3.3.1 Write a balanced chemical equation for the reaction which takes place in the test-tube. (3)

3.3.2 Other than using a suitable catalyst, state THREE different ways of increasing the rate of **this** particular reaction. Be specific in your answer! (6)

3.3.3 Explain in simple terms how a catalyst increases the rate of a chemical reaction. (2)

3.4 The Maxwell-Boltzmann curve labelled A shows the distribution of molecular energies in 0,5 mol of ozone gas (O_3) at STP.



3.4.1 Which of curves B, C or D represents 0,5 mol of ozone gas at a lower temperature? (1)

3.4.2 Which of curves B, C or D represents **1,0 mol** of ozone gas at STP? (1)

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Question 4 Chemical Equilibrium

4.1 Carbon monoxide and hydrogen react in a sealed container to produce methanol. The reaction reaches dynamic chemical equilibrium as shown by the balanced chemical equation below.

$$CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g) \quad \Delta H < 0$$

4.1.1 State Le Chatelier's principle. (2)

4.1.2 Define *yield.* (2)

4.1.3 What volume change must be made to the reaction container so that a high yield of methanol is obtained?
Explain by referring to Le Chatelier's principle. (4)

4.2 In an experiment, 9 mols of gas **P** is introduced into a container at a certain temperature. The container is then sealed and gas **P** decomposes to produce gas **Q** and gas **R.** The reaction taking place reaches dynamic chemical equilibrium for the first time after a period of 25 s.

The number of moles of each gas present with time over 35 s is given in the table below.

Time (s)	Number of moles of gas (mol)		
	Gas P	Gas Q	Gas R
0	9,00	0	0
5	7,40	2,40	0,80
10	6,30	4,05	1,35
15	5,60	5,10	1,70
20	5,20	5,70	1,90
25	5,00	6,00	2,00
30	5,00	6,00	2,00
35	5,00	6,00	2,00

4.2.1 (a) State what is meant by *dynamic chemical equilibrium.* (1)

(b) How can you tell from the data that the system has reached dynamic chemical equilibrium after a time period of 25 s? (1)

4.2.2 Complete the graph (detach answer sheet) by providing the information requested below.

(a) Write down a suitable heading for the graph on the lines provided above the graph on your ANSWER SHEET. (1)

(b) Write down a suitable label for the x-axis in the empty block provided on your ANSWER SHEET. (2)

(c) Determine the scale used on the y-axis and fill in the numbers in the empty blocks provided on your ANSWER SHEET. (1)

(d) Draw a best fit line graph, on the same set of axes, to represent the number of moles of gas **Q** over the period 0 to 35 s. Use of a SHARP, DARK PENCIL is recommended. (3)

4.2.3 Copy the equation given below for the decomposition of gas P and use the data and the graph to deduce the missing coefficients required to balance the chemical equation.

$$\underline{?}\ P \rightleftharpoons \underline{?}\ Q + \underline{?}\ R$$

(3)

4.2.4 Write an expression for the equilibrium constant (K_C) for this reaction. (2)

4.2.5 The volume of the container is 5 dm^3. Calculate the value of the equilibrium constant (K_c) at the temperature of the experiment. (5)

4.2.6 What information does the value of the equilibrium constant (K_c) give about the expected yield of products in this reaction? (1)

[28]

Question 5 Acid and Bases

The acid ionisation constant K_a for the ionisation of each of the hypothetical acids H_2X, HY and HZ in water at 25 ^{0}C is given in the table below.

Acid	K_a
H_2X	$2{,}8 \times 10^{-3}$
HY	$1{,}2 \times 10^{6}$
HZ	6×10^{-4}

5.1 State the difference between a strong acid and a weak acid. Give one example of each. (Choose from H_2X,HY or HZ) (4)

5.2 State the difference between a monoprotic and a polyprotic acid. Give one example of each. (Choose from H_2X,HY or HZ) (4)

5.3 Which acid, H_2X, HY or HZ, has the lowest pH in water? Justify your choice. Assume that the concentration of each acid is the same. (3)

5.4 Write down a balanced chemical equation to represent the ionisation of acid H_2X in water. (3)

5.5 25,0 cm^3 of acid HZ is neutralised in a titration by 32,4 cm^3 of 0,1 mol.dm^{-3} NaOH solution. An aqueous solution of the salt NaZ is produced in the reaction.

5.5.1 Write down a balanced chemical equation for the reaction of HZ with NaOH. (3)

5.5.2 Calculate the number of moles of NaOH which reacted. Give your answer Correct to 5 decimal places (or 3 significant figures). (3)

5.5.3 Calculate the concentration of acid HZ. (3)

5.5.4 Consider the equations given below for the dissociation of NaZ in water and for the ionization of water.

$$NaZ(s) \rightleftharpoons Na^+(aq) + Z^-(aq)$$
$$H_2O(\ell) \rightleftharpoons OH^-(aq) + H^+(aq)$$

Consider the interaction between the ions in the aqueous solution of the salt NaZ and hence predict whether the solution would have a pH of LESS THAN 7, EQUAL TO 7, OR GREATER THAN 7. Explain your answer fully. (5)

5.5.5 The indicators given in the table below are available for the titration.

INDICATOR	pH RANGE OF INDICATOR
bromothymol blue	6,0 – 7,6
phenolphthalein	8,4 – 10,0
methyl orange	3,1 – 4,4

(a) Select an indicator from the table which would be most suitable for the titration of HZ with NaOH in Question 5.5 (1)

(b) Briefly justify your choice of indicator with reference to your understanding of what is meant by the 'pH range of the indicator'. (2)

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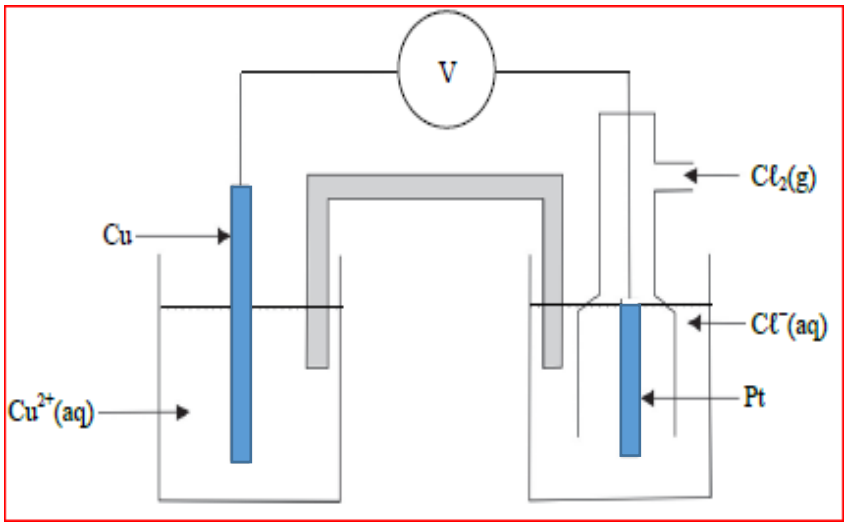
Question 6

A galvanic cell is constructed under standard conditions by connecting a copper half-cell and a chlorine half-cell using a salt bridge. In the chlorine half-cell, a platinum electrode is placed in the electrolyte. The diagram below represents this galvanic cell.



6.1 State the standard conditions that are applicable to this galvanic cell. (3)

6.2 Write down the chemical formula of a suitable electrolyte that could be used in the copper half-cell. (2)

6.3 For this galvanic cell, write down the following reactions taking place:

6.3.1 oxidation half-reaction (2)

6.3.2 reduction half-reaction. (2)

6.3.3 net cell reaction. (2)

6.4 Calculate the initial emf of this galvanic cell. (4)

6.5 Write down the cell notation for this cell. (4)

6.6 Explain why an electrode made from platinum is used in the chlorine half-cell. (2)

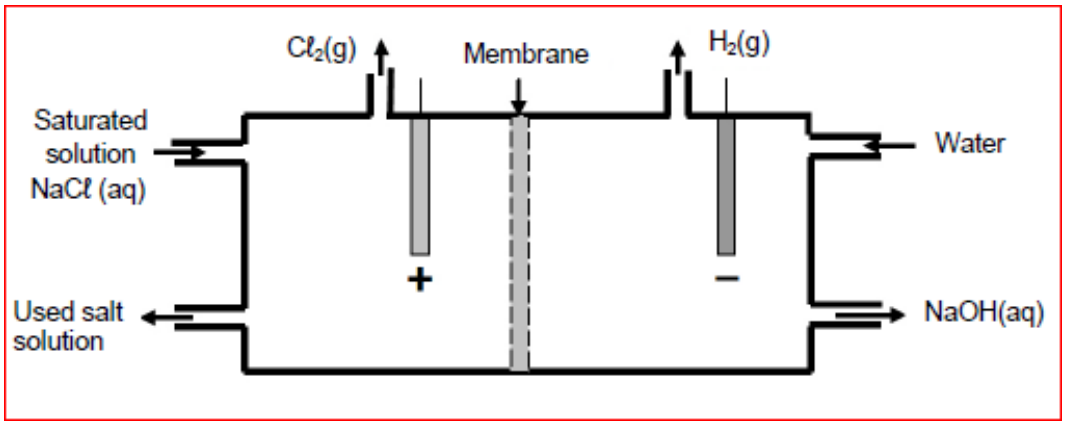
6.7 Identify a suitable electrolyte that can be used in the salt bridge. (2)

6.8 One of the functions of the salt bridge is to maintain the neutrality of the electrolytes in each half-cell. Explain in terms of the electrolyte used in the salt bridge, how it works to maintain this neutrality. (4)

[27]

Question 7

Chlorine gas is produced in industry by the electrolysis of a saturated solution of aqueous sodium chloride (NaCl(aq)). Other products of this process are hydrogen gas and sodium hydroxide. The diagram below illustrates a cell that can be used in this process.



7.1 Give another name for the aqueous solution of sodium chloride. (1)

7.2 State the main function of the membrane in the membrane cell. (2)

7.3 Write down the half-reaction that takes place at the cathode. (2)

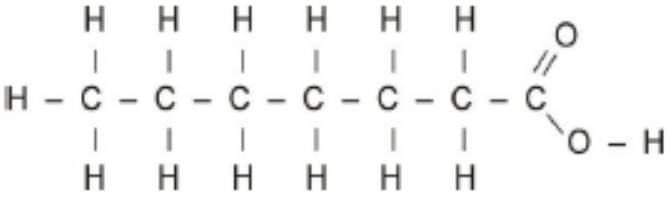
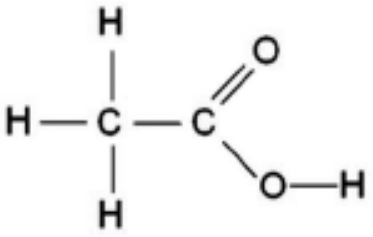
7.4 Use the relative strengths of the oxidising agents present to explain why sodium metal is NOT produced at the cathode in the membrane cell. (2)

7.5 A **constant** current of 4000 A is passed through a chlor-alkali cell for 2,5 minutes. Calculate the volume of chlorine gas produced, at STP, at the anode during this period of time. (7)

[14]

Question 8

Consider compounds **A** to **H** given in the table below before answering the questions which follow.

A	2-methylbuta-1,3-diene	**B**	C_5H_{12}
C		**D**	
E	Propan-1-ol	**F**	C_3H_6
G	$CH_3CHBrCH(CH_2CH_3)CH_2CH_2CH_3$	**H**	Propyl butanoate

8.1 Write down ONLY the letters **A** to **H** when answering the questions which follow.

8.1.1 Give ONE compound which is an alkane. (1)

8.1.2 Give TWO compounds which are unsaturated hydrocarbons. (2)

8.1.3 Give TWO compounds which are functional isomers of each other. (2)

8.2 Name the homologous series to which compound E belongs. (1)

8.3 Draw the structural formula of compound **A**. (4)

8.4 Write down the IUPAC name of compound **G.** (4)

8.5 Write down a balanced chemical equation, using structural formulae for the organic compounds, for the preparation of compound **H**. (Reaction conditions need not be given.) (6)

8.6 Draw the structural formula of a **branched** chain isomer of compound **B** and write down its IUPAC name. (4)

8.7 Compounds **D** and **E** have the same molar mass (60 $g.mol^{-1}$) yet compound **D** has a boiling point of 118 ^oC and compound **E** has a boiling point of 97 ^oC.

With reference to the relevant intermolecular forces, explain this difference in boiling point. (4)

[28]

Question 9

9.1 A student was given three colourless liquids that were labelled **X, Y** and **Z.** They were known to be ethanoic acid, methanol, and hex-1-ene, but the exact identity of each liquid was unknown. The student carried out various tests on liquids **X, Y** and **Z** and obtained the results shown in the table below.

	X	Y	Z
Solubility in water	Soluble	Insoluble	Soluble
Addition of bromine water, $Br_2(aq)$	No immediate colour change	Bromine water rapidly becomes colourless	No immediate colour change
Addition of sodium carbonate powder, $Na_2CO_3(s)$	No reaction	No reaction	Fizzing due to gas being given off

Identify each of compounds **X, Y** and **Z.** (3)

9.2 Write a balanced chemical equation using condensed structural formulae for the the reaction of propene with bromine. (3)

9.3 Write a balanced chemical equation using condensed structural formulae for the acid catalysed dehydration of butan-1-ol. (Reaction conditions need not be given.) (3)

[9]

Total: 200 marks

ANSWER SHEET

Laundry Number:_____

Question 4.2.2

HEADING: _____