HILLCREST HIGH SCHOOL
PHYSICAL SCIENCE
GRADE 12
PAPER 2 - Chemistry

JUNE 2021
TIME: 1½ HRS

Total 60

Instructions

1. Answer ALL the questions.

2. This question paper consists of TWO sections:

3. SECTION A (6)
   SECTION B (54)

   Answer SECTIONS A and B in the ANSWER BOOK.

4. Non-programmable calculators may be used.

5. Appropriate mathematical instruments may be used.

6. Number the answers correctly according to the numbering system used in this question paper.

7. Data sheets and a periodic table are attached for your use.

8. Give brief motivations, discussions, et cetera where required.

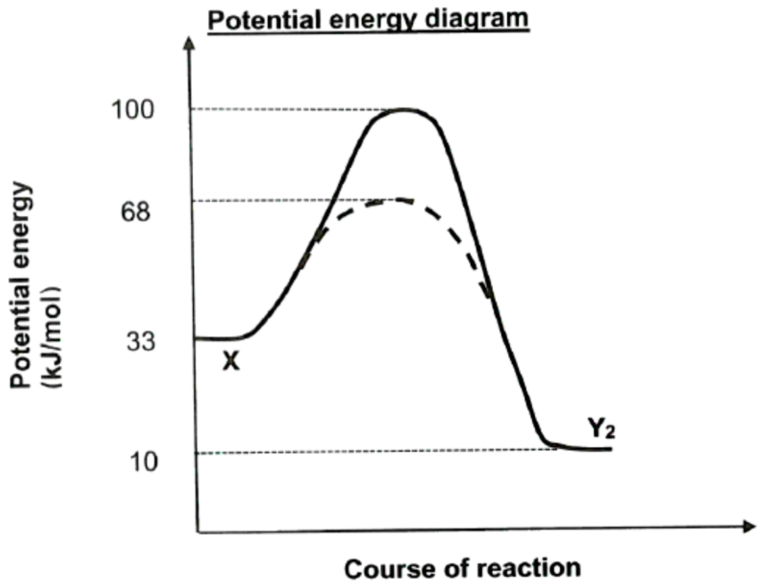
9. Numbers must be rounded off to **two decimal** places

SECTION A: QUESTION 1 (Multiple-choice)

Four options are provided as possible answers to the following questions. Each question has only ONE correct answer. Write only the letter (A- D) next to the question number (1.1 – 1.3) on your ANSWER BOOK.

1.1 The potential energy diagram shown is for the hypothetical reversible reaction shown below:

$$X(g) \leftrightarrows Y_2(g)$$



The value of ΔH (in kJ/mol) for the catalysed forward reaction is equal to …

A 23
B -23
C 58
D -58

1.2 One of the stages in the industrial preparation of iron from its ore is represented below:

$$Fe_2O_3\ (s) + 3CO\ (g) \rightarrow 2Fe\ (l) + 3CO_2\ (g)$$

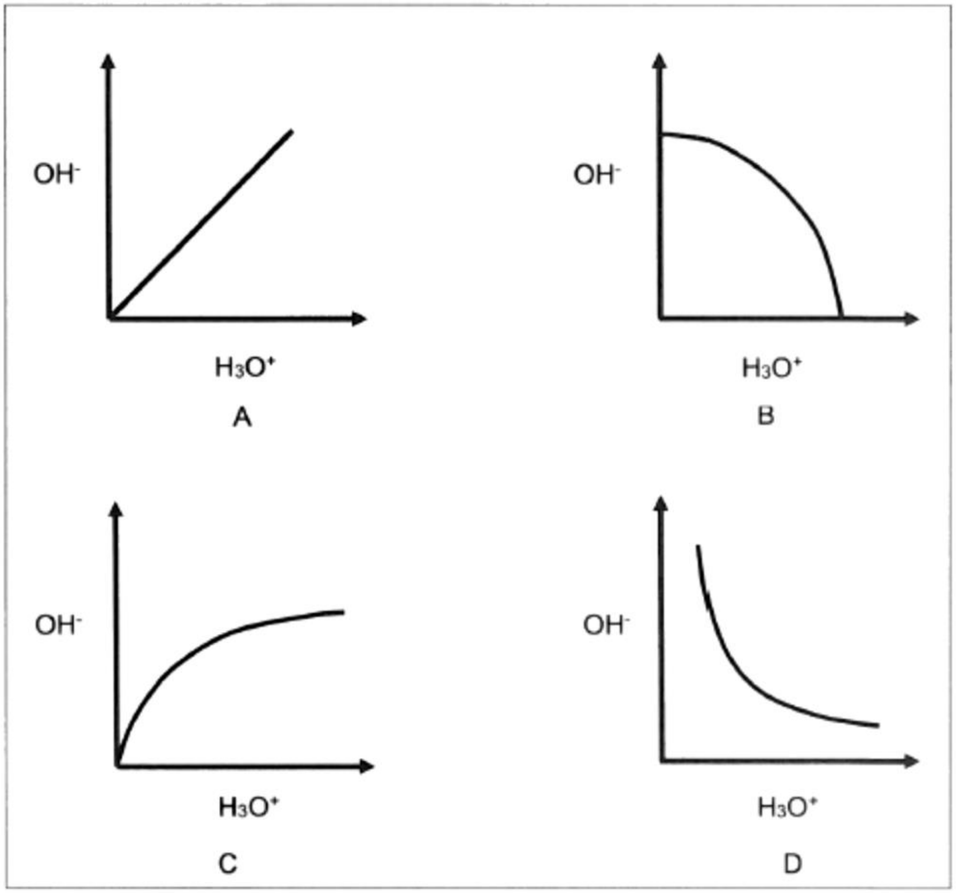
The following changes are made to the system:

I. Fe_2O_3 is added
II. CO_2 is removed
III. CO is removed

Which of the changes mentioned above will favour the **forward** reaction?

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

1.3 The relationship between [H_3O^+] and [OH^-] in an aqueous solution at constant temperature is best represented by …



[3x2 = 6]

SECTION B

Question 1

Compounds **A** to **E**, indicated in the table below, are used to determine the factors which influence boiling point.

Investigation	Compound		Molecular mass ($g{\cdot}mol^{-1}$)	Boiling point (°C)
I	A	2,2-dimethyl propane	72	9
	B	2-methyl butane	72	27
	C	pentane	72	36
II	D	$CH_3CH_2CH_2CH_2OH$	74	117
	E	$CH_3CH_2CH_2CHO$	72	75

1.1 Compounds **A**, **B** and **C** are structural isomers.

1.1.1 Define the term *structural isomer*. (2)

1.1.2 Which type of structural isomerism is illustrated by these compounds? (1)

1.2 Consider the boiling points of the compounds in **investigation I**.
Which one of compounds **A** or **C** will have the highest vapour pressure at a certain temperature? (1)

1.3 To which homologous series does compound **E** belong? (1)

1.4 Consider **investigation II**. Refer to the type of intermolecular forces in each of the compounds to explain why the boiling point of compound **D** is higher than that of compound **E**. (3)

[8]

Question 2

Consider the TWO incomplete organic reactions below:

I: 2-bromobutane + dilute NaOH $\rightarrow$

II: Compound **P** + H_2 $\rightarrow$ $CH_3CH(CH_3)CH_3$

2.1 For reaction **I** write down the:

2.1.1 Type of reaction taking place (1)

2.1.2 IUPAC name of the organic product formed (2)

2.2 For reaction **II** write down the:

2.2.1 NAME of the catalyst used (1)

2.2.2 Structural formula for compound **P** (2)

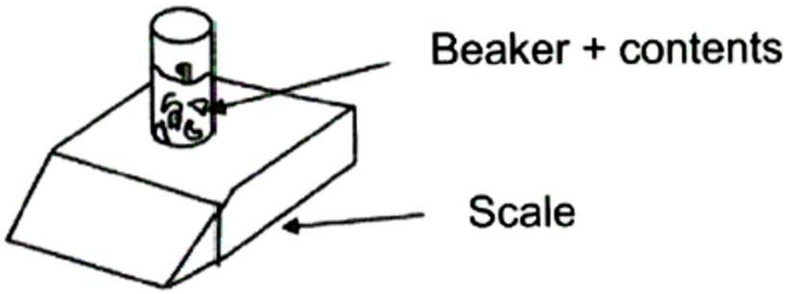
[6]

Question 3

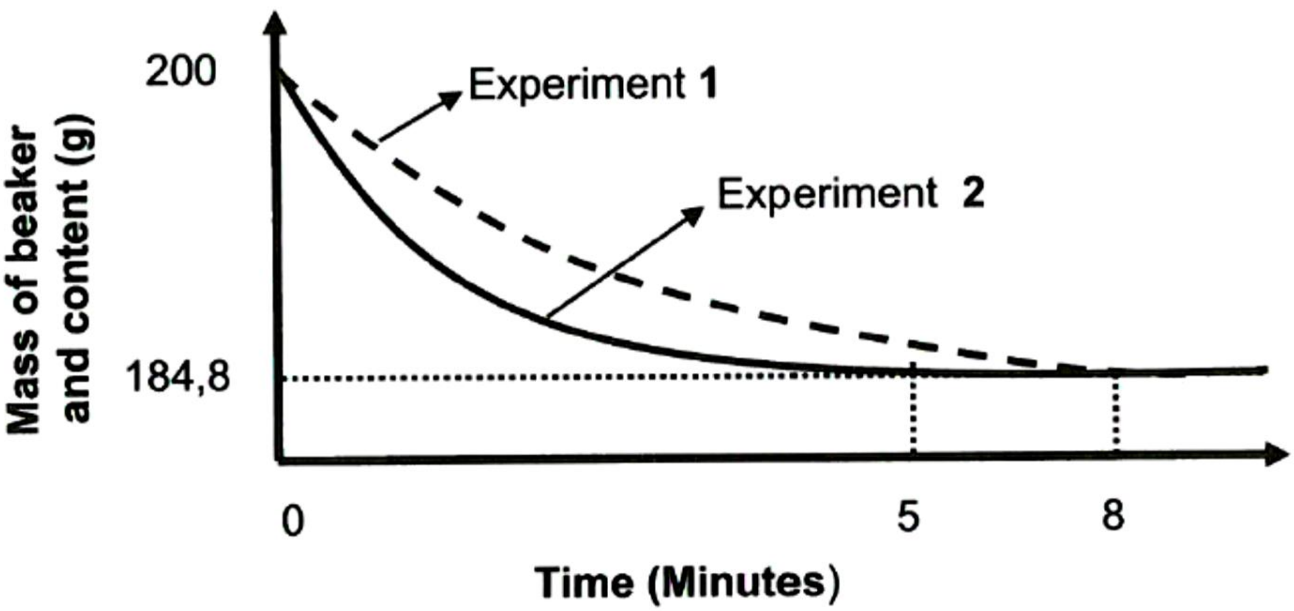
A factor influencing the rate of a chemical reaction is investigated by carrying out experiments **1** and **2** in which the following reaction takes place:

$$CaCO_3\ (s) + 2HCl\ (aq) \rightarrow CaCl_2\ (aq) + H_2O\ (l) + CO_2\ (g)$$

In one of the experiments, chunks of calcium carbonate ($CaCO_3$) are used, while in the other powdered calcium carbonate of the same mass is used. The calcium carbonate is added to EXCESS hydrochloric acid solution (HCl) in open flasks. Each flask is placed on a mass scale as shown in the diagram below:



The graph below shows the changes in mass of the beaker and its contents during the reaction in experiments **1** and **2**.



3.1 Calculate the average rate of reaction in $g.min^{-1}$ for experiment **2**. (3)

3.2 Calculate the mass of calcium carbonate that was used in experiment **1**. (6)

3.3.1 Identify which reaction used the powdered calcium carbonate.
Write down only EXPERIMENT **1** or EXPERIMENT **2**. (1)

3.3.2 Explain your answer to QUESTION 3.3.1 using the collision theory. (2)

[12]

Question 4

4.1 The industrial preparation of hydrogen gas is represented below:

$$CH_4 (g) + H_2O (g) \rightarrow CO (g) + 3H_2 (g) \qquad \Delta H > 0$$

The reaction reaches equilibrium at 1000ºC in a closed container.

4.1.1 State *Le Chatelier's principle*. (2)

4.1.2 How will an increase in pressure at 1000ºC (by decreasing the volume) affect the yield of hydrogen gas?
Write down only INCREASES, DECREASES or NO EFFECT. (1)

4.2 Study the reversible reaction represented by the balanced equation below:

$$H_2(g) + CO_2(g) \leftrightarrows CO(g) + H_2O(g)$$

Initially **x** moles of $H_2(g)$ is mixed with 0,3 moles of $CO_2(g)$ in a sealed 10 dm^3 container.
When equilibrium is reached at a certain temperature, it is found that 0,2 moles of $H_2O(g)$ is present.
The equilibrium constant, K_c, for the reaction at this temperature is 4.

4.2.1 Calculate the initial number of moles of $H_2(g)$, **x**, that was in the container. (8)

4.2.2 The reaction is now carried out at a much higher temperature. It is found that K_c decreases at this higher temperature. Is this reaction EXOTHERMIC or ENDOTHERMIC? Explain your answer. (3)

[14]

Question 5

A group of learners perform a titration to determine **x** number of moles of water of crystallisation in hydrated oxalic acid ($C_2O_4H_2.\mathbf{x}H_2O$).

They first prepared a solution of hydrated oxalic acid, by adding 7,56 g of hydrated oxalic acid to water and made a volume of 250 cm^3 solution.

During a titration, 25 cm^3 of the solution of hydrated oxalic acid was neutralised by exactly 24 cm^3 of a 0,5 $mol.dm^{-3}$ solution of sodium hydroxide according to the balanced equation:

$$C_2O_4H_2 . xH_2O (aq) + 2NaOH (aq) \rightarrow C_2O_4Na_2 (aq) + (x+2)H_2O (l)$$

<u>Note</u>: Water of crystallisation does not react with the base.

5.1 Define a *strong base*. (2)

5.2 Calculate the pH of the 0,5 $mol.dm^{-3}$ solution of sodium hydroxide. (5)

5.3 Determine the value of **x** by calculation. (7)

[14]

Total 60

DATA FOR PHYSICAL SCIENCES GRADE 12
PAPER 2 (CHEMISTRY)

GEGEWENS VIR FISIESE WETENSKAPPE GRAAD 12
VRAESTEL 2 (CHEMIE)

TABLE 1: PHYSICAL CONSTANTS/*TABEL 1: FISIESE KONSTANTES*

NAME/*NAAM*	SYMBOL/*SIMBOOL*	VALUE/*WAARDE*
Standard pressure *Standaarddruk*	p^{θ}	$1{,}013 \times 10^{5}$ Pa
Molar gas volume at STP *Molêre gasvolume by STD*	V_m	$22{,}4\ dm^{3}\cdot mol^{-1}$
Standard temperature *Standaardtemperatuur*	T^{θ}	273 K
Charge on electron *Lading op elektron*	e	$-1{,}6 \times 10^{-19}$ C
Avogadro's constant *Avogadro-konstante*	N_A	$6{,}02 \times 10^{23}\ mol^{-1}$

TABLE 2: FORMULAE/*TABEL 2: FORMULES*

$n = \frac{m}{M}$	$n = \frac{N}{N_A}$
$c = \frac{n}{V}$ or/*of* $c = \frac{m}{MV}$	$n = \frac{V}{V_m}$
$\frac{c_a V_a}{c_b V_b} = \frac{n_a}{n_b}$	$pH = -\log[H_3O^+]$
$K_w = [H_3O^+][OH^-] = 1 \times 10^{-14}$ at/*by* 298 K	
$E^{\theta}_{cell} = E^{\theta}_{cathode} - E^{\theta}_{anode}$ / $E^{\theta}_{sel} = E^{\theta}_{katode} - E^{\theta}_{anode}$ or/*of* $E^{\theta}_{cell} = E^{\theta}_{reduction} - E^{\theta}_{oxidation}$ / $E^{\theta}_{sel} = E^{\theta}_{reduksie} - E^{\theta}_{oksidasie}$ or/*of* $E^{\theta}_{cell} = E^{\theta}_{oxidising\ agent} - E^{\theta}_{reducing\ agent}$ / $E^{\theta}_{sel} = E^{\theta}_{oksideermiddel} - E^{\theta}_{reduseermiddel}$	

TABLE 3: THE PERIODIC TABLE OF ELEMENTS
TABEL 3: DIE PERIODIEKE TABEL VAN ELEMENTE

KEY/*SLEUTEL*

Atomic number / *Atoomgetal*	29
Electronegativity / *Elektronegatiwiteit*	1,9
Symbol / *Simbool*	Cu
Approximate relative atomic mass / *Benaderde relatiewe atoommassa*	63,5

1 (I)	2 (II)	3	4	5	6	7	8	9	10	11	12	13 (III)	14 (IV)	15 (V)	16 (VI)	17 (VII)	18 (VIII)
1 2,1 H 1																	2 He 4
3 1,0 Li 7	4 1,5 Be 9											5 2,0 B 11	6 2,5 C 12	7 3,0 N 14	8 3,5 O 16	9 4,0 F 19	10 Ne 20
11 0,9 Na 23	12 1,2 Mg 24											13 1,5 Aℓ 27	14 1,8 Si 28	15 2,1 P 31	16 2,5 S 32	17 3,0 Cℓ 35,5	18 Ar 40
19 0,8 K 39	20 1,0 Ca 40	21 1,3 Sc 45	22 1,5 Ti 48	23 1,6 V 51	24 1,6 Cr 52	25 1,5 Mn 55	26 1,8 Fe 56	27 1,8 Co 59	28 1,8 Ni 59	29 1,9 Cu 63,5	30 1,6 Zn 65	31 1,6 Ga 70	32 1,8 Ge 73	33 2,0 As 75	34 2,4 Se 79	35 2,8 Br 80	36 Kr 84
37 0,8 Rb 86	38 1,0 Sr 88	39 1,2 Y 89	40 1,4 Zr 91	41 Nb 92	42 1,8 Mo 96	43 1,9 Tc	44 2,2 Ru 101	45 2,2 Rh 103	46 2,2 Pd 106	47 1,9 Ag 108	48 1,7 Cd 112	49 1,7 In 115	50 1,8 Sn 119	51 1,9 Sb 122	52 2,1 Te 128	53 2,5 I 127	54 Xe 131
55 0,7 Cs 133	56 0,9 Ba 137	57 La 139	72 1,6 Hf 179	73 Ta 181	74 W 184	75 Re 186	76 Os 190	77 Ir 192	78 Pt 195	79 Au 197	80 Hg 201	81 1,8 Tℓ 204	82 1,8 Pb 207	83 1,9 Bi 209	84 2,0 Po	85 2,5 At	86 Rn
87 0,7 Fr	88 0,9 Ra 226	89 Ac															

58 Ce 140	59 Pr 141	60 Nd 144	61 Pm	62 Sm 150	63 Eu 152	64 Gd 157	65 Tb 159	66 Dy 163	67 Ho 165	68 Er 167	69 Tm 169	70 Yb 173	71 Lu 175
90 Th 232	91 Pa	92 U 238	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr