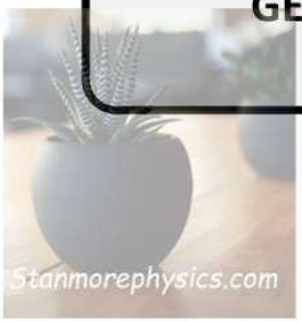
education

DEPARTMENT: EDUCATION
MPUMALANGA PROVINCE

GERT SIBANDE DISTRICT



GRADE 12

PHYSICAL SCIENCES TOPIC TEST

TOPIC: CHEMICAL EQUILIBRIUM

MAY 2023

MARKS: 50

TIME: 1 hour

This question paper consists of 9 pages including the data sheet

INSTRUCTIONS AND INFORMATION

1. This question paper consists of FOUR questions. Answer ALL the questions in the ANSWER BOOK.
2. Start EACH question on a NEW page in the ANSWER BOOK.
3. Number the answers correctly according to the numbering system used in this question paper.
4. Leave ONE line between two sub questions, for example between QUESTION 2.1 and QUESTION 2.2.
5. You may use a non-programmable calculator.
6. You are advised to use the attached DATA SHEETS.
7. Show ALL formulae and substitutions in ALL calculations.
8. Round off your final numerical answers to a minimum of TWO decimal places.
9. Write neatly and legibly.

QUESTION 1

Various options are provided as possible answers to the following questions. Choose the answer and write only the letter (A-D) next to the question number (1.1- 1.5) in your answer sheet, eg. 1.6 A.

1.1 A certain chemical reaction reaches equilibrium at 25 ^{0}C. The equilibrium constant Kc, for this reaction at this temperature is $1,0x10^{-4}$. Which of the following statements regarding this reaction at equilibrium is CORRECT?

A The concentration of the products is equal to that of reactants.

B The concentration of the products is higher than that of reactants.

C The concentration of the products is lower than that of reactants.

D The rate of the forward reaction is lower than the rate of the reverse reaction. (2)

1.2 A catalyst is added to a reaction mixture at equilibrium.

Which one of the following statements about the effect of catalyst is FALSE?

A The rate of the forward reaction increases.

B The rate of the reverse reaction increases.

C The equilibrium position shifts to the right.

D The equilibrium position remains unchanged. (2)

1.3 A hypothetical reaction reaches equilibrium at 10ºC in a closed container according to the following balanced equation:

$$A_{(g)} + B_{(g)} \rightleftharpoons AB_{(g)} \qquad \Delta H < 0$$

The temperature is now increased to 25ºC. Which ONE of the following is correct as the reaction approaches a new equilibrium?

	REACTION RATE	YIELD OF PRODUCTS
A	Increases	Remains the same
B	Increases	Decreases
C	Increases	Increases
D	Decreases	Decreases

(2)

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

$$C\ell_{2(g)} + H_2O_{(\ell)} \rightleftharpoons C\ell^-_{(aq)} + C\ell O^-_{(aq)} + 2H^+_{(aq)}$$

Which ONE of the following reagents will favour the reaction when added?

A Hydrogen

B Sodium chloride

C Hydrogen chloride

D Sodium hydroxide (2)

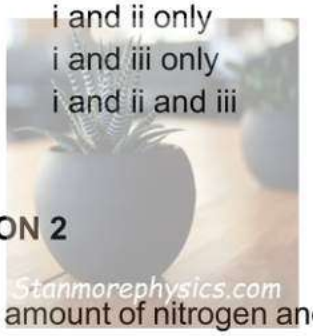
1.5 The balanced equation for three reactions at equilibrium in a closed container are given below.

i. $C_2H_{4(g)} + H_{2(g)} \rightleftharpoons C_2H_{6(g)}$
ii. $Fe_3O_{4(s)} + 4H_{2(g)} \rightleftharpoons 3Fe_{(s)} + 4H_2O_{(g)}$
iii. $SO_{3(g)} + NO_{(g)} \rightleftharpoons NO_{2(g)} + SO_{2(g)}$

In which reaction(s) will the equilibrium position shift when the volume of the reaction vessel is decreased at a constant temperature?

A i only
B i and ii only
C i and iii only
D i and ii and iii (2)

[10]



QUESTION 2

A certain amount of nitrogen and hydrogen were reacted in a container to produce ammonia as shown by the chemical equation below.
The reaction was allowed to reach equilibrium.

$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$ $\Delta H<O$

2.1 Define the term chemical equilibrium. (2)

2.2 The container was then warmed to a higher temperature.

How did this change influence the following at equilibrium?

Only write down INCREASED, DECREASED or REMAINSED THE SAME.

2.2.1 The amount of H_2. (1)

2.2.2 The value of K_C. (1)

2.3 Use Le Chatelier's principle to explain the answer to the QUESTION 2.2.2. (3)

2.4 Some ammonia (NH_3) was removed from the reaction container.
How did this change affect the concentration of N_2? Only write down INCREASED, DECREASED or REMAINED THE SAME. (1)

[8]

QUESTION 3

A heterogeneous reaction below took place in a 1000 cm^3 sealed flask.

$$C\ (s) + O_2\ (g) \rightleftharpoons CO_2\ (g)$$

The reaction mixture initially contained 3.8 g of Carbon (C) and unknown mass of oxygen (O_2). When the equilibrium was reached, there were 0,292 mole of carbon.

3.1 Give a reason why the above reaction is referred to as heterogeneous reaction. (1)

3.2 If the equilibrium constant (K_c) at 400°C was 0.145, calculate the initial mass of oxygen (O_2) placed in the flask. (9)

3.3 When one of the conditions affecting the equilibrium was increased, the K_c value also increased.

3.3.1 State Le chatelier's principle. (2)

3.3.2 Which condition was changed? (1)

3.3.3 Is the forward reaction exothermic or endothermic?
Use Le Chatelier's principle to explain the answer. (4)

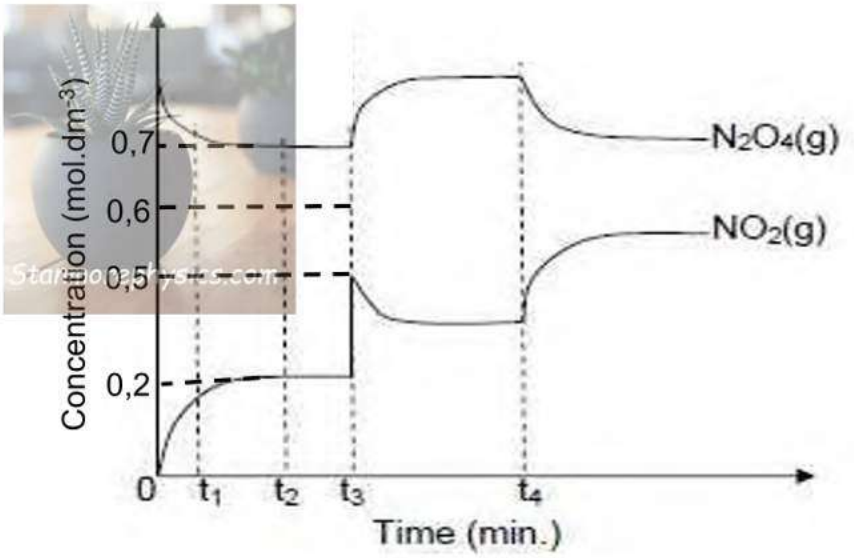
[17]

QUESTION 4

A sample of N_2O_4 gas is sealed in a container and heated. The N_2O_4 gas decomposes to NO_2 gas and the reaction reaches equilibrium according to the following balanced equation:

$$N_2O_{4(g)} \rightleftharpoons 2NO_{2(g)} \qquad \Delta H > 0$$

The graph below shows how the concentration of the two gases change as a result of the changes made to the reaction conditions.



4.1 How does the rate of the forward reaction compare to that of reverse reaction at the following times?
Only write HIGHER THAN, LOWER THAN or EQUALTO.

4.1.1 t_1 (1)

4.1.2 t_2 (1)

4.2 What change is made to one of the reaction conditions at time t_3?
In this instance, the equilibrium constant for the reaction does not change. (1)

4.3 Use Le chatelier's principle to explain the effect of the change in QUESTION 4.2 until a new equilibrium is established. (3)

4.4 Calculate the equilibrium constant (K_c) when the reaction reached the equilibrium for the FIRST time. (3)

4.5 A catalyst is added to the equilibrium system in the above reaction. How is this change influence the following at equilibrium?
Only write down INCREASES, DECREASES or REMAINES THE SAME.

4.5.1 The amount of $_2O_4(g)$? (1)

4.5.2 The time taken to set up equilibrium? (1)

4.6 The plunger is then pushed into the container and the volume of the container decreases, causing an increase in the pressure of the system.

4.6.1 How does this change influence the amount of NO_2 at equilibrium? Only write down INCREASES, DECREASES or REMAINES THE SAME. (1)

4.6.2 Use Le Chatelier's principle to explain the answer in QUESTION 4.6.1. (3)

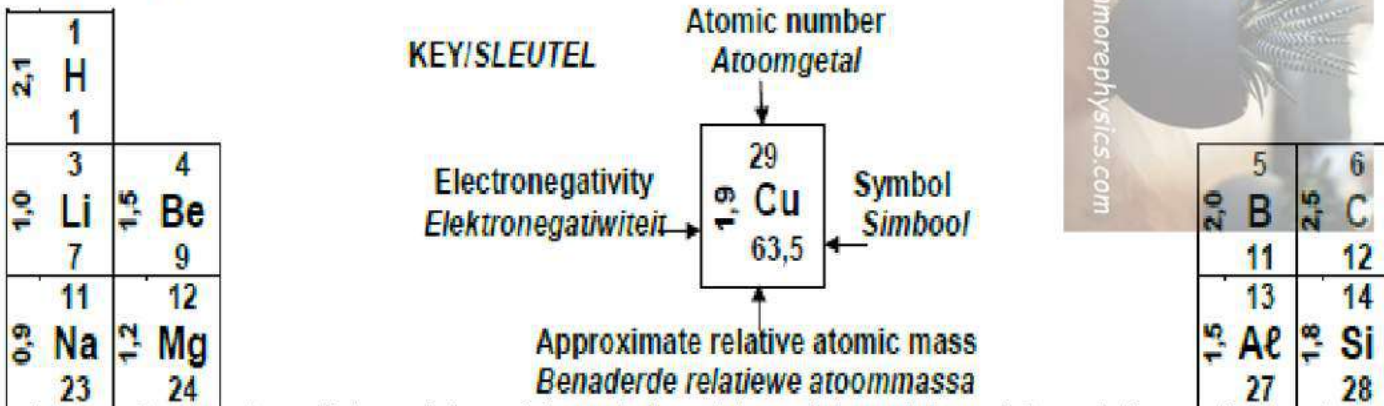
[15]

TOTAL: 50

TABLE OF FORMULAE

$n = \frac{m}{M}$	$n = \frac{N}{N_A}$
$n = \frac{V}{V_m}$	$c = \frac{n}{V}$ OR $C = \frac{m}{MV}$

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



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)
2,1 H 1																	2 He 4
1,0 Li 7	1,5 Be 9											2,0 B 11	2,5 C 12	3,0 N 14	3,5 O 16	4,0 F 19	10 Ne 20
0,9 Na 23	1,2 Mg 24											1,5 Aℓ 27	1,8 Si 28	2,1 P 31	2,5 S 32	3,0 Cℓ 35,5	18 Ar 40
0,8 K 39	1,0 Ca 40	1,3 Sc 45	1,5 Ti 48	1,6 V 51	1,6 Cr 52	1,5 Mn 55	1,8 Fe 56	1,8 Co 59	1,8 Ni 59	1,9 Cu 63,5	1,6 Zn 65	1,6 Ga 70	1,8 Ge 73	2,0 As 75	2,4 Se 79	2,8 Br 80	36 Kr 84
0,8 Rb 86	1,0 Sr 88	1,2 Y 89	1,4 Zr 91	Nb 92	1,8 Mo 96	1,9 Tc	2,2 Ru 101	2,2 Rh 103	2,2 Pd 106	1,9 Ag 108	1,7 Cd 112	1,7 In 115	1,8 Sn 119	1,9 Sb 122	2,1 Te 128	2,5 I 127	54 Xe 131
0,7 Cs 133	0,9 Ba 137	La 139	1,6 Hf 179	Ta 181	W 184	Re 186	Os 190	Ir 192	Pt 195	Au 197	Hg 201	1,8 Tℓ 204	1,8 Pb 207	1,9 Bi 209	2,0 Po	2,5 At	Rn
0,7 Fr	0,9 Ra 226	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

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TOPIC: CHEMICAL EQUILIBRIUM
MAY 2023

MARKING GUIDELINES

MARKS: 50

This question paper consists of 5 pages

QUESTION 1

1.1 C✓✓ (2)

1.2 C✓✓ (2)

1.3 B✓✓ (2)

1.4 D✓✓ (2)

1.5 A✓✓ (2)

[10]

QUESTION 2

2.1 Is the dynamic equilibrium when the rate of the forward reaction equals the rate of the reverse reaction. ✓✓ **[2 or 0 MARK]** (2)

2.2.1 INCREASED✓ (1)

2.2.2 DECREASED✓ (1)

2.3 The system re-instates a new equilibrium by favouring a reaction that decreases temperature. ✓
The reverse reaction is favoured ✓ because it is endothermic that decreases temperature.✓ (3)

2.4 DECREASED✓ (1)

[8]

QUESTION 3

3.1 All reactants and products are not in the same phase. ✓

OR: C is in solid state while O_2 and CO_2 are in gaseous state. (1)

3.2 **OPTION 1: USING (THE TABLE OF) NUMBER OF MOLES**

$$n(C)\ \text{initial} = \frac{m}{M} = \frac{3,8}{12} = 0,317\ \text{mol}$$ ✓

Reaction	C	O_2 ⇌	CO_2
Initial mole	0,317	X	0
Change in mole	-0,025	-0,025	+0,025 ✓
Equilibrium mole	0,292	X – 0,025	0,025 ✓
Equilibrium concentration ($Mol.dm^{-3}$)	0,292 ÷ 1 = 0,292	X – 0,025 ÷1 = X – 0,025	0,025 ÷ 1 = 0,025 ✓

$$K_c = \frac{[CO2]}{[O2]}$$ ✓

$$0,145 = \frac{(0,025)}{(x - 0,025)}$$ ✓

X = 0,197mol ✓

$m(O_2) = nM$

$m(O_2) = 0,197 \times 32$ ✓ = 6,317 g ✓

$$K_c = \frac{[CO2]}{[O2]}$$

$$0,145 = \frac{(0,025)}{[O2]}$$

$[O2] = 0,172\ mol.dm^{-2}$

$0,172 = x - 0,025$

X = 0,197 mol

OPTION 2: USING (THE TABLE OF) CONCENTRATION

$C_{(C)}$ initial = $= \frac{m}{MV} = \frac{3,8}{12X1}$ = 0,317 moldm^{-3}✓

$C_{(C)}$ equim $= \frac{n}{V} = \frac{0,292}{1}$ = 0,292 moldm^{-3}✓

Reaction	C	O2 ⇌	CO_2
C(C) initial	0,317	X	0
Change in concentration	-0,025	-0,025	+0,025✓
Equilibrium concentration (Mol.dm^{-3})	0,292	X – 0,025	0,025✓

$K_c = \frac{[CO_2]}{[O_2]}$ ✓

$0,145 = \frac{(0,025)}{(x-0,025)}$ ✓

X = 0,197 moldm^{-3}✓

$C_{(O_2)} = \frac{m}{MV}$

$0,197 = \frac{m}{32\ X1}$ ✓

$m(O_2)$ = 6, 304 g✓

(9)

3.3.1 when equilibrium in a closed system is disturbed, the system will re-instate a new equilibrium by favouring a reaction that will oppose/cancel the disturbance. ✓✓ **[2 or O Mark]** (2)

3.3.2 Temperature✓ (1)

3.3.3 Endothermic.✓

Kc value increases as the concentration of products increases.✓.

(According to Le chatelier's principle), increase in temperature favours endothermic reaction which causes temperature decrease.✓

Forward reaction is favoured as it causes increase in concentration of the products.✓ (4)

[17]

QUESTION 4

4.1.1 HIGHER THAN✓ (1)

4.1.2 EQUAL TO ✓ (1)

4.2 NO_2 added/ [NO_2] increased✓ (1)

4.3 (According to Le chatelier's principle), the system re-instate a new equilibrium by favouring a reaction that decreases/uses up NO_2✓
The reverse reaction is favoured,✓ as this is a reaction that decreases the concentration/amount of NO_2 and increases the concentration of N_2O_4✓ (3)

4.4 $K_c = \frac{[NO_2]^2}{[N_2O_4]}$ ✓

$K_c = \frac{(0,2)^2}{(0,7)}$ ✓

$K_c = 0,057$✓

(3)

4.5.1 REMAINES THE SAME✓ (1)

4.5.2 DECREASES✓ (1)

4.6.1 DECREASES✓ (1)

4.6.2 The system reacts/ re-instate a new equilibrium by favouring a reaction that leads to lowering of pressure (according to Le chatelier's principle).✓
Reverse reaction is favoured✓ because it occurs by decrease in number of moles and it attempts to decrease pressure.✓ (3)

[15]

TOTAL: 50