Basic Education

KwaZulu-Natal Department of Education
REPUBLIC OF SOUTH AFRICA

PHYSICAL SCIENCES P2 (CHEMISTRY)

COMMON TEST

JUNE 2016

NATIONAL SENIOR CERTIFICATE

GRADE 12

MARKS: 100

TIME: 2 hour

This question paper consists of 10 pages, 2 pages of data sheets and a graph sheet.

INSTRUCTIONS AND INFORMATION

1. Write your name and other information in the appropriate spaces on the ANSWER BOOK.
2. The question paper consists of SEVEN questions. Answer ALL the questions in the ANSWER BOOK.
3. Start EACH question on a NEW page in the ANSWER BOOK.
4. Number the answers correctly according to the numbering system used in this question paper.
5. Leave one line between two sub-questions, for example between QUESTION 2.1 and QUESTION 2.2.
6. You may use a non-programmable pocket calculator.
7. You are advised to use the attached DATA SHEETS.
8. Show ALL formulae and substitutions in ALL calculations.
9. Round off your final numerical answers to a minimum of TWO decimal places where applicable.
10. Give brief motivations, discussions, et cetera where required.
11. For Question 5.6 a graph sheet is provided. Submit the graph sheet together with your answer book.
12. Write neatly and legibly.

QUESTION 1: MULTIPLE-CHOICE QUESTIONS

Four options are provided as possible answers to the following questions. Each question has only ONE correct answer. Write only the letter A, B, C or D next to the question number (1.1 – 1.5) in your ANSWER BOOK.

1.1 Which one of the following salts, when dissolved in water, will give a solution with a pH less than 7?

A K_2SO_4
B $KC\ell$
C $NH_4C\ell$
D CH_3COONa (2)

1.2 Consider the following reaction:

$$Mg(s) + 2HC\ell(aq) \rightarrow H_2(g) + MgC\ell_2(aq)$$

The rate of the reaction increases when more magnesium is added.
This change is caused by the ...

A increase in surface area
B addition of a catalyst
C increase in concentration of reactants
D change in nature of the reactants (2)

1.3 The following equilibrium constant expression is given for a particular reaction.

$$Kc = \frac{[H_2O]^4\,[CO_2]^3}{[C_3H_8]\,[O_2]^5}$$

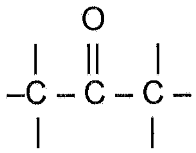
For which one of the following reactions is the above K_c expression correct?

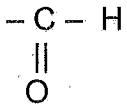
A $C_3H_8(g) + 5O_2(g) \rightleftharpoons 4H_2O(l) + 3CO_2(g)$
B $4H_2O(g) + 3CO_2(g) \rightleftharpoons C_3H_8(g) + 5O_2(g)$
C $2C_3H_8(g) + 7O_2(g) \rightleftharpoons 8H_2O(g) + 6CO_2(g)$
D $C_3H_8(g) + 5O_2(g) \rightleftharpoons 4H_2O(g) + 3CO_2(g)$ (2)

1.4 Which of the following organic compounds has the molecular formula $C_5H_{10}O_2$?

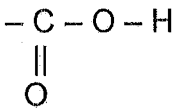
A ethyl ethanoate
B butyl ethanoate
C ethyl propanoate
D propyl butanoate (2)

1.5 The functional group of heptanoic acid is:

A 

B 

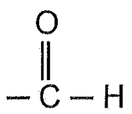
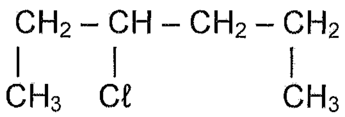
C R – O – H

D 

(2)
[10]

QUESTION 2 (Start on a new page.)

Consider the following representation of organic molecules **A** to **E** listed in the table below to answer the following questions:

A		**B**	CH_3CH_2OH
C		**D**	4-methylpentanoic acid
E	pentanoic acid		

2.1 Write down the

2.1.1 IUPAC name of compound **B**. (1)

2.1.2 IUPAC name of compound **C**. (2)

2.1.3 STRUCTURAL FORMULA of the substituent (side chain) of compound **D**. (1)

2.1.4 IUPAC NAME of the simplest molecule of which **A** is the functional group. (1)

2.2 Compound **B** reacts with **E**. Write down the

2.2.1 Structural formula of the organic product formed. (2)

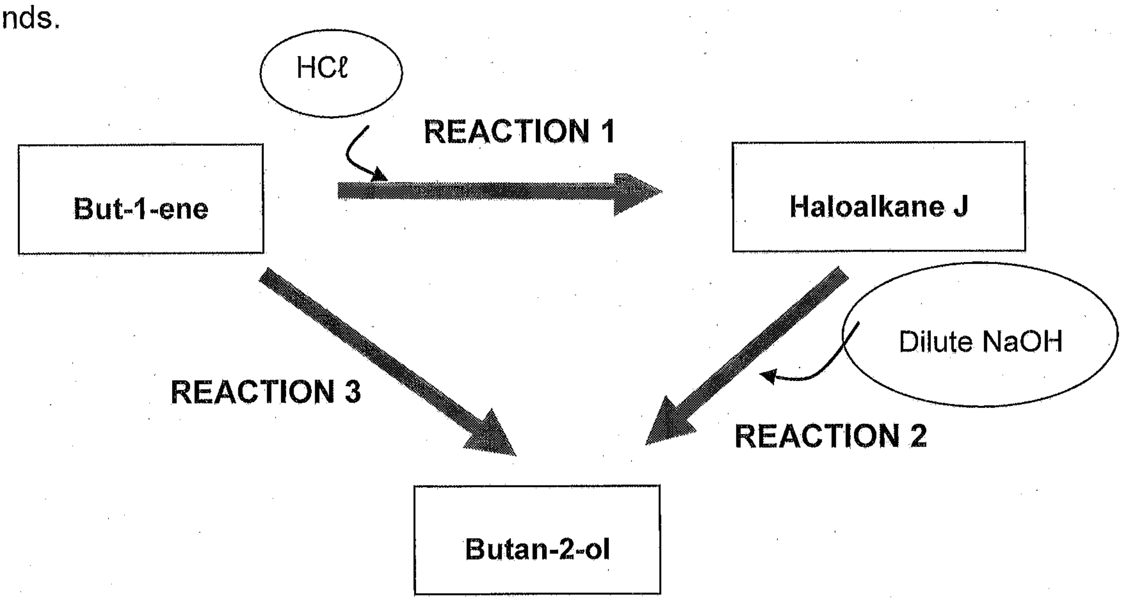
2.2.2 IUPAC name of the organic product formed. (2)

2.2.3 Name or formula of the catalyst used in this reaction. (1)

[10]

QUESTION 3 (Start on a new page.)

The diagram below shows the conversion of certain organic compounds to other organic compounds.



3.1 Write down the IUPAC name of Haloalkane J. (2)

3.2 Use STRUCTURAL FORMULAE and write down the balanced equation for Reaction 3. (4)

3.3 Explain why **no** H_2O must be present during Reaction 1. (2)

3.4 A learner wanted to convert Haloalkane J to Butan-2-ol (reaction 2). However, instead of using dilute NaOH, the learner used a concentrated NaOH solution in ethanol.

Write down the:

3.4.1 structural formula of the major organic product formed. (2)

3.4.2 formula(e) of any inorganic product(s) formed. (1)

3.5 Susan is given Butan-2-ol, concentrated H_2SO_4 and Cl_2 gas. Explain how she could use these chemicals to produce 2,3-dichlorobutane. (4)
[15]

QUESTION 4 (Start on a new page.)

Haloalkanes can be made from alcohols. The following tables provide the boiling points of some haloalkanes and alcohols.

TABLE 1

Name	Formula	Boiling point (°C)
chloromethane	CH_3Cl	-24,1
dichloromethane	CH_2Cl_2	40,1
trichloromethane	$CHCl_3$	61,8
tetrachloromethane	CCl_4	76,6

TABLE 2

Name	Formula	Boiling point (°C)
fluoromethane	CH_3F	-78,3
chloromethane	CH_3Cl	-24,1
bromomethane	CH_3Br	-5,3
iodomethane	CH_3I	42,5

TABLE 3

Name	Condensed Formula	Boiling point (°C)
propan-1-ol	C_3H_7OH	98
propane-1,2-diol	$CH_3CHOHCH_2OH$	189
propane-1,2,3-triol	$CH_2OHCHOHCH_2OH$	290

4.1 Define the boiling point of a liquid. (2)

4.2 Is chloromethane a solid, a liquid, or a gas at 25°C? (1)

4.3 Describe and explain the trend in the boiling points illustrated by

4.3.1 Table 2. (3)

4.3.2 Table 3. (3)

4.4 Identify the compound in **Table 1** that has

4.4.1 the lowest vapour pressure. (1)

4.4.2 the highest melting point. (1)

[11]

QUESTION 5 (Start on a new page.)

Sodium thiosulfate reacts with dilute hydrochloric acid to produce a sulfur precipitate.

$$Na_2S_2O_3(aq) + 2HCl(aq) \rightarrow 2NaCl(aq) + S(s) + SO_2(g) + H_2O(l)$$

The formation of the precipitate is used to measure the rate of this reaction.
An investigation was conducted to determine the relationship between concentration and reaction rate.

Water was added to different volumes of the same $Na_2S_2O_3$ solution as indicated in the table below.
Each flask is placed on a dark cross against a white background, and the time taken for the cross to disappear is recorded for each experiment. The results are indicated in the table below.

	Exp no. 1	**Exp no. 2**	**Exp no. 3**	**Exp no. 4**	**Exp no. 5**
Volume HCℓ (cm^3)	20	20	20	20	20
Volume $Na_2S_2O_3$ (cm^3)	25	20	15	10	5
Volume of H_2O (cm^3)	0	5	10	15	20
Concentration of $Na_2S_2O_3$ ($mol.dm^{-3}$)	0,5	0,4	0,3	0,2	
Time (s)	20	28	32	50	100
$\frac{1}{time}$ **(s^{-1})**	0,050	0,036	0,031	0,020	0,010

5.1 Define *reaction rate.* (2)

5.2 Identify TWO variables that must be controlled in this investigation. (2)

5.3 Why was H_2O added to the $Na_2S_2O_3$ in each experiment? (1)

5.4 Calculate the concentration of the $Na_2S_2O_3$ in experiment 5. (3)

5.5 Explain why $\frac{1}{time}$ is taken to be the reaction rate for each experiment. (3)

5.6 Use the graph paper provided to draw a graph of reaction rate against concentration. (4)

5.7 State the mathematical relationship between reaction rate and concentration. (1)

5.8 Explain the relationship in question 5.7 in terms of the molecular collision theory. (3)

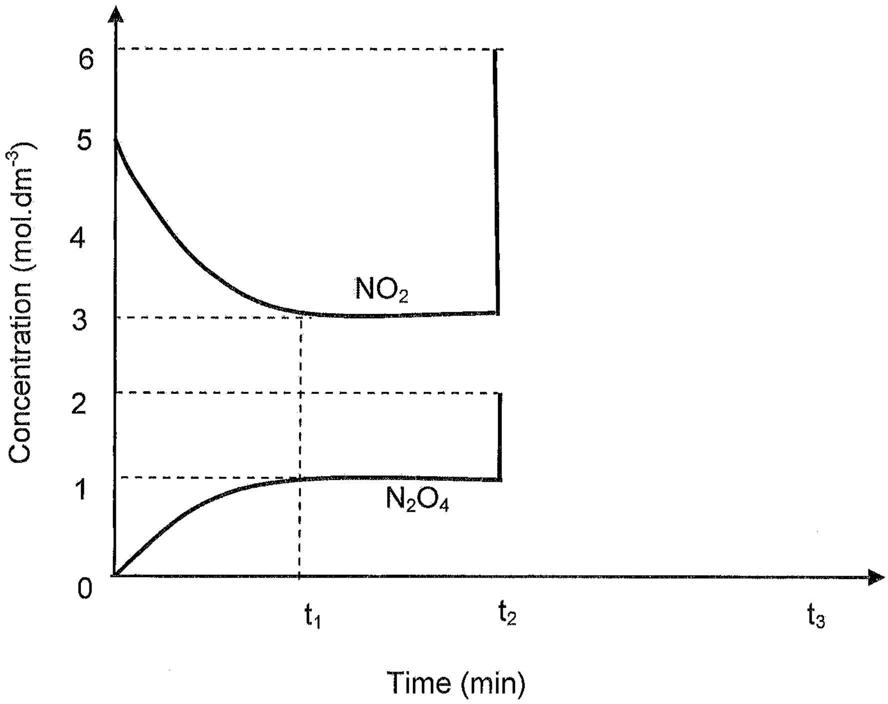
[19]

QUESTION 6 (Start on a new page.)

5 moles of $NO_2(g)$ is injected into a 2 dm^3 container at 330 K. The container is then sealed. An equilibrium position is attained after time t_1. The following reaction takes place:

$$\underset{\text{(Brown)}}{2NO_2(g)} \rightleftharpoons \underset{\text{(Colourless)}}{N_2O_4(g)}$$

The concentration-time graph for the two gases is drawn below.



6.1 Calculate the equilibrium constant (K_c) at 330 K. (3)

6.2 Identify the external change that was made at time t_2. (1)

6.3 State what colour change occurs in the container from t_1 to t_2. (1)

6.4 Use Le Chatelier's Principle to explain the colour change in question 6.3.
A new equilibrium position is attained at time t_3. (3)

6.5 Comment on the colour of the gas mixture after time t_3. (1)

6.6 Calculate the concentration of the N_2O_4 at this new equilibrium position, if the change in QUESTION 6.2 was the only change made to the system. (8)

[17]

QUESTION 7 (Start on a new page.)

5,3 g of sodium carbonate (Na_2CO_3) is dissolved in excess pure water.

7.1 Write down the:

7.1.1 balanced reaction for the hydrolysis of the sodium carbonate in water. (3)

7.1.2 conjugate acid-base pairs in QUESTION 7.1.1. (2)

7.2 The sodium carbonate solution is now neutralized by 200,00 cm^3 of a solution of an acid HZ according to the equation:

$$Na_2CO_3(g) + 2HZ(g) \rightarrow 2NaZ(aq) + CO_2(g) + H_2O(\ell)$$

Calculate the concentration of the HZ solution. (7)

7.3 NaOH is a strong base. Solid NaOH pellets are dissolved in water to make a standard solution of concentration 0,20 $mol{\cdot}dm^{-3}$.

7.3.1 Define a **standard solution**. (2)

7.3.2 Calculate the pH of this solution at 25°C. (4)

[18]

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*

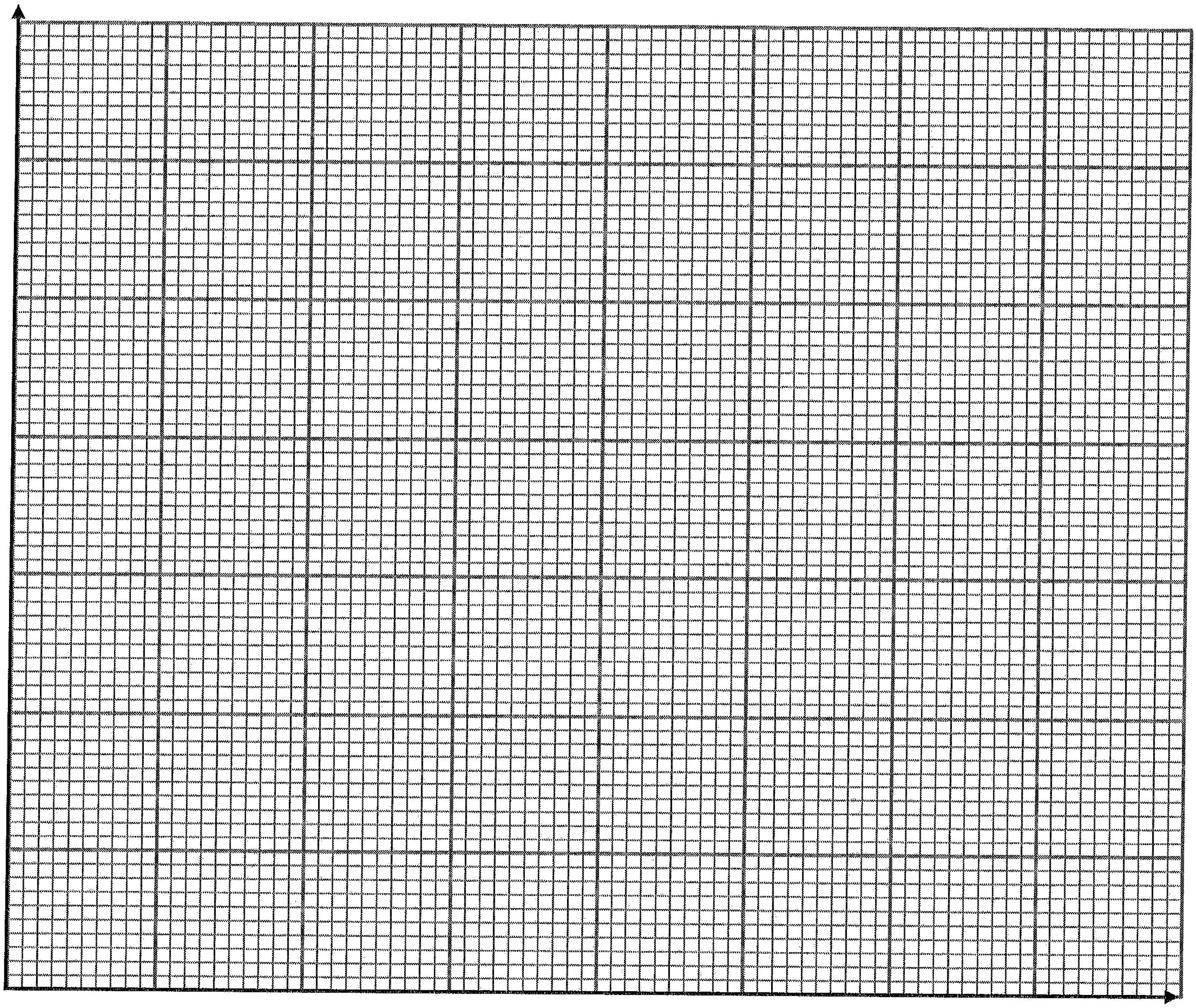
Atomic number / *Atoomgetal*	29
Symbol / *Simbool*	Cu
Electronegativity / *Elektronegatiwiteit*	1,9
Approximate relative atomic mass / *Benaderde relatiewe atoommassa*	63,5

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

NAME: ___________________________________

QUESTION 5.6



Basic Education

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REPUBLIC OF SOUTH AFRICA

PHYSICAL SCIENCES P2 (CHEMISTRY)

COMMON TEST

JUNE 2016

AMENDED

MEMORANDUM

NATIONAL SENIOR CERTIFICATE

GRADE 12

MARKS: 100

TIME : 2 hour

This memorandum consists of 8 pages

QUESTION 1

1.1 C ✓✓

1.2 A ✓✓

1.3 D ✓✓

1.4 C ✓✓

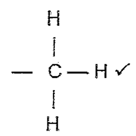
1.5 D ✓✓ **[10]**

QUESTION 2

2.1.1 ethanol ✓ (1)

2.1.2 3 – chlorohexane ✓✓ (2)

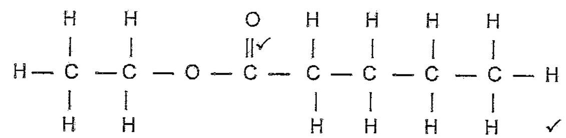
2.1.3



(1)

2.1.4 methanal ✓ (1)

2.2.1



(2)

(1 mark for functional group; 1 mark for rest of structure)

2.2.2 ethyl✓ pentanoate ✓ (2)

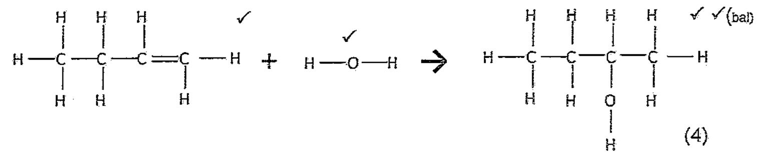
2.2.3 sulfuric acid or H_2SO_4 ✓ (1)

[10]

QUESTION 3

3.1 2-chlorobutane ✓✓ (2)

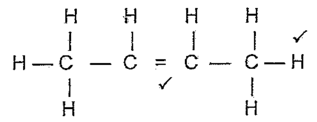
3.2



(4)

3.3 H_2O will react with but - 1- ene ✓, using HCl as a catalyst. ✓ (2)

3.4.1



(2)

3.4.2 NaCl + H — O — H ✓ (1)

3.5 Strongly heat butan-2-ol ✓ using H_2SO_4 as a catalyst ✓, to form but-2-ene. React but-2-ene with chlorine✓ to form 2,3-dichlorobutane. ✓ (4)

OR

$CH_3CH(OH)CH_2CH_3$✓ $\xrightarrow[\text{heat}]{H_2SO_4 ✓}$ $CH_3CH{=}CHCH_3$ Δ

$CH_3CH{=}CHCH_3 + Cl_2$✓ $\rightarrow CH_3CHClCHClCH_3$✓

(Accept structural formulae) [15]

QUESTION 4

4.1 The temperature at which the vapour pressure of a liquid equals atmospheric pressure. ✓✓ (2)

4.2 Gas. ✓ (1)

4.3.1 The boiling point of a one carbon haloalkane increases ✓as the atomic size

of the halogen increases ✓. The strength of the van der Waals forces increases✓. (3)

OR

The boiling point of a one carbon haloalkane increases✓as molecular weight increases ✓, hence the strength of the van der Waals forces also increases✓.

4.3.2 For the same length carbon chain, the more OH groups present ✓, the higher the boiling point ✓. More H bonds can form ✓. (3)

4.4.1 tetrachloromethane / carbon tetrachloride or CCl_4 ✓ (1)

4.4.2 tetrachloromethane / carbon tetrachloride or CCl_4 ✓ (1)

[11]

QUESTION 5

5.1 the change in concentration of reactants (or products) per unit time. ✓✓ OR the amount of reactant used / product formed per unit time. (2)

5.2 Volume of HCℓ
Concentration of HCℓ
Temperature **(any 2)** ✓✓ (2)
Total volume of solution

5.3 To change the concentration of $Na_2S_2O_3$, OR To dilute the $Na_2S_2O_3$. ✓ (1)

5.4 $C_1 V_1 = C_2 V_2$ ✓
$0{,}5 \times 5 = C_2 \times 25$ ✓
$\therefore C_2 = 0{,}1\ mol.dm^{-3}$ ✓ (3)

5.5 Since the same amount of S is formed in each case✓,

Reaction rate = $\dfrac{\text{amount of S formed}}{\text{time}}$ ✓

∴ reaction rate is inversely proportional to time. ✓ (3)

5.6

Criteria	Marks
Both axes labelled correctly with concentration on x axes	✓
3 points correctly plotted	✓
The other 2 points correctly plotted	✓
Line of best fit through the origin	✓

(4)

5.7 Reaction rate is directly proportional to concentration. ✓ (1)

5.8 An increase in concentration increases the number of particles in a given volume ✓. There would be more collisions per second ✓. Therefore reaction rate increases ✓. (3)

OR

Increase in the concentration increases the fraction of particles that are correctly orientated✓. This increases the number of effective collisions per unit time✓. Hence reaction rate increases✓.

[19]

QUESTION 6

6.1 $K_c = \frac{[N_2O_4]}{[NO_2]^2}$ ✓

$= \frac{1}{3^2}$ ✓

$= \frac{1}{9}$ ✓ (3)

6.2 An increase in pressure. ✓(OR Decrease in volume) (1)

6.3 and 6.4 **FOR QUESTIONS 6.3 and 6.4, award 4 marks across the board. (4)**

6.5 The colour remains constant / unchanged. ✓ (1)

6.6 Positive marking from 6.1 Mark independently of Question 6.2

	$2NO_2$	N_2O_4	
Initial number of mole (mol)	6	2	✓
Number of moles used/formed (mol)	-2x	+ x	✓
Number of moles at equilibrium(mol)	6 – 2x	2 + x	✓
Equilibrium concentration ($mol\cdot dm^{-3}$)	6 – 2x	2 + x	✓

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

$\frac{1}{9}$ ✓ $= \frac{2 + x}{(6 - 2x)^2}$ ✓

x = 0,59

$\therefore [N_2O_4] = 2 + 0,59$ ✓
$= 2,59$ ✓

OR

	$2NO_2$	N_2O_4	
Initial concentration ($mol\cdot dm^{-3}$)	6	2	✓
Amounts / Concentration used/formed	-2x	+ x	✓
Concentration at equilibrium($mol\cdot dm^{-3}$)	6 – 2x ✓	2 + x ✓	

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

$\frac{1}{9}$ ✓ $= \frac{2 + x}{(6 - 2x)^2}$ ✓

x = 0,59

$\therefore [N_2O_4] = 2 + 0,59$ ✓
$= 2,59\ mol.dm^{-3}$ ✓

(8)
[17]

QUESTION 7

7.1.1 $CO_3^{2-} + H_2O$ ✓ $\rightleftharpoons$ $HCO_3^- + OH^-$ ✓ (✓ balancing) (3)

OR $Na_2CO_3 + H_2O \rightleftharpoons NaHCO_3 + NaOH$

7.1.2 CO_3^{2-} and HCO_3^- ✓

H_2O and OH^- ✓ (2)

ACCEPT: Na_2CO_3 and $NaHCO_3$

H_2O and NaOH

7.2 $n(Na_2CO_3) = \frac{m}{M}$ ✓

$= \frac{5,3}{106}$ ✓

$= 0,05$ mol ✓

$n(HZ) = 2 \times n(Na_2CO_3)$ ✓

$= 0,1$ mol

$c(HZ) = \frac{n}{V}$ ✓

$= \frac{2 \times 0,05}{0,2}$ ✓

$= 0,5\ mol.dm^{-3}$ ✓ (7)

OR

$C_B = m/MV_B$ ✓ $= 5,2/(106 \times V_B)$ ✓ $= 0,05/V_B$

$C_AV_A/C_BV_B = na/nb$ ✓

$C_A \times 0,2$ ✓$/[(0,05/V_B)x(VB)]$ ✓ $= 2$ ✓

$C_A = 0,5\ mol.dm^{-3}$ ✓

7.3.1 A solution whose concentration is known ✓✓ (and will remain constant for a period of time). (2)

7.3.2 $[OH^-] = 0,2\ mol.dm^{-3}$

$[OH^-][H_3O^+] = 1 \times 10^{-14}$ ✓

$[H_3O^+] = \frac{1 \times 10^{-14}}{0,2 ✓}$

$= 5 \times 10^{-14}\ mol.dm^{-3}$

pH $= -\log [H_3O^+]$ ✓

$= -\log (5 \times 10^{-14})$

$= 13,3$ ✓

OR

pOH $= -\log [OH^-]$ ✓

$= -\log (0,2)$ ✓

$= 0,7$

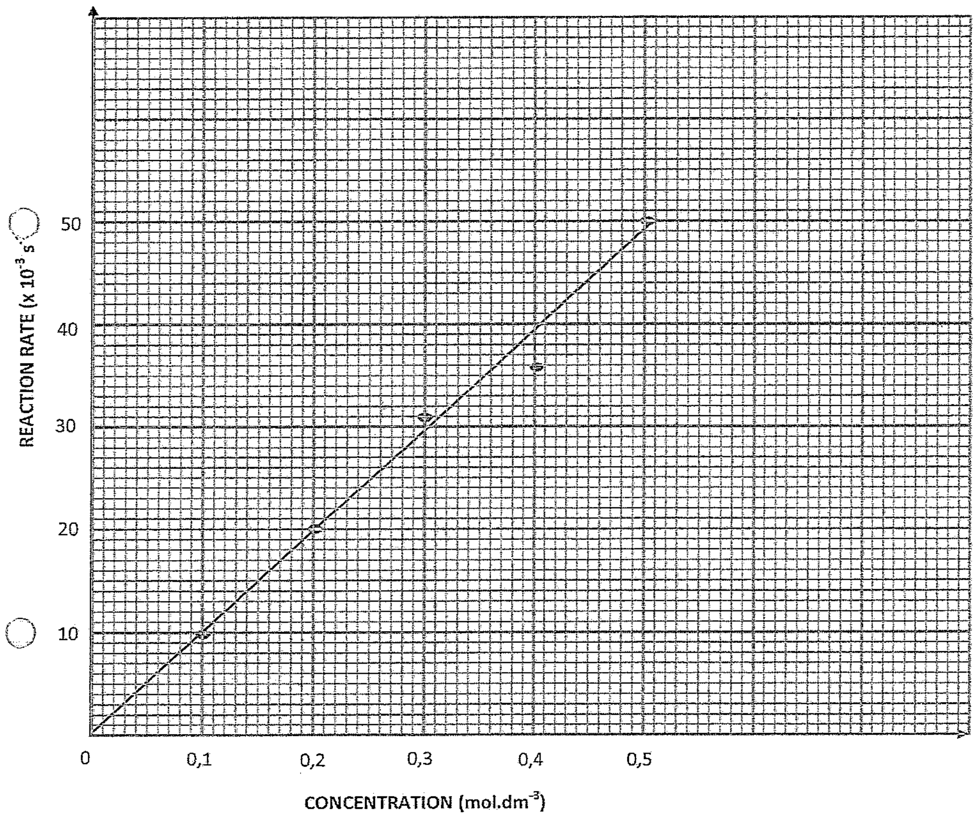
pH $= 14 - pOH$ ✓

$= 14 - 0,7$

$= 13,3$ ✓ (4)

[18]

QUESTION 5.6


REACTION RATE (x 10^{-3} s^{-1})
50
40
30
20
10
0
0,1
0,2
0,3
0,4
0,5
CONCENTRATION (mol.dm^{-3})