KWAZULU-NATAL PROVINCE
EDUCATION
REPUBLIC OF SOUTH AFRICA

NATIONAL SENIOR CERTIFICATE

GRADE 12

PHYSICAL SCIENCES P2 (CHEMISTRY)

COMMON TEST

JUNE 2023

MARKS : 150

TIME : 3 Hours

This question paper consists of 14 pages and 2 data sheets.

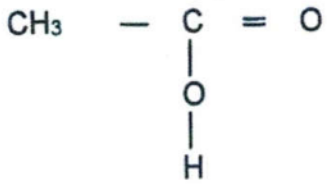
INSTRUCTIONS AND INFORMATION

1. Write your centre number and examination number in the appropriate spaces on the ANSWER BOOK.
2. This question paper consists of NINE 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 subquestions, for example between QUESTION 2.1 and QUESTION 2.2.
6. You may use a non-programmable calculator.
7. You may use appropriate mathematical instruments.
8. You are advised to use the attached DATA SHEETS.
9. Show ALL formulae and substitutions in ALL calculations.
10. Round off your final numerical answers to a minimum of TWO decimal places.
11. Give brief motivations, discussions et cetera where required.
12. Write neatly and legibly.

QUESTION 1: MULTIPLE-CHOICE QUESTIONS

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 (1.1-1.10) in the ANSWER BOOK, for example 1.11 D.

1.1 What is the homologous series to which the following compound belongs?



A Ketones

B Alcohols

C Haloalkanes

D Carboxyllic acids (2)

1.2 Which ONE of the following is a tertiary alcohol?

A Pentan-1- ol

B Pentan-2-ol

C 2 – methylbutan – 2 - ol

D 3 – methylbutan – 2 - ol (2)

1.3 Which of the following statements would apply to organic compounds that belong to the same homologous series? They have the same . . .

I boiling points.
II functional group.
III molecular formula.

A II only

B I and II only

C II and III only

D I, II and III (2)

1.4 Which ONE of the following statements is TRUE for the reaction of an UNSATURATED HYDROCARBON with bromine water?

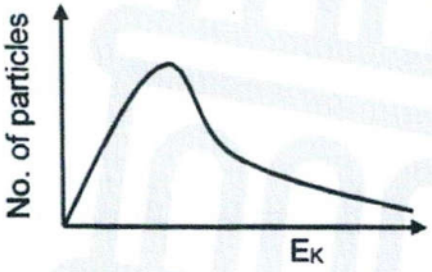
A The reaction is slow.

B The bromine water decolourises quickly.

C The reaction is a substitution reaction.

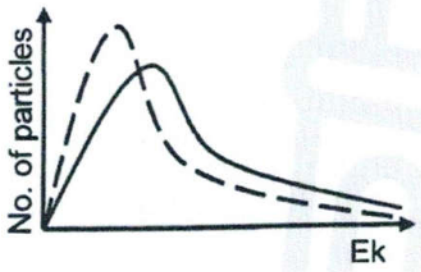
D Ultraviolet light is needed for this reaction. (2)

1.5 The Maxwell–Boltzmann distribution curve for a reaction mixture is shown below:

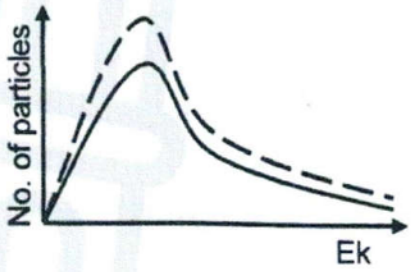


The TEMPERATURE of the reaction mixture is now DECREASED. Which one of the following graphs shows the new distribution curve as a **dotted line**?

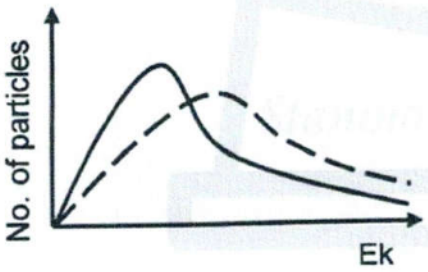
A



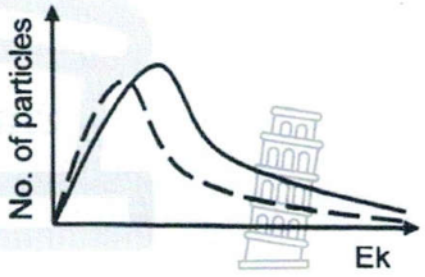
B



C



D

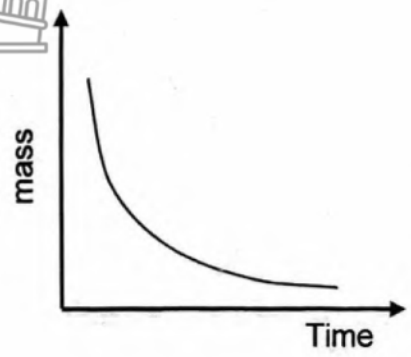


(2)

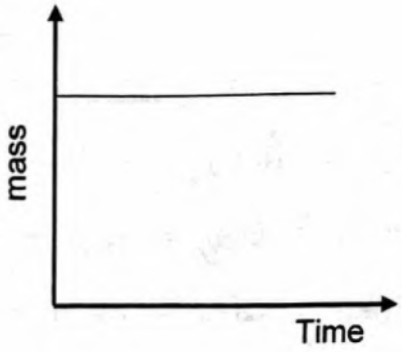
1.6 The mass of a catalyst was determined at intervals during a reaction.

Which ONE of the following graphs best represents the mass of the catalyst with time?

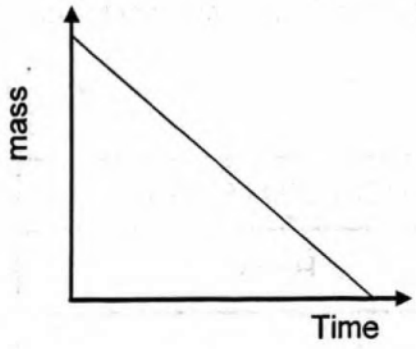
A



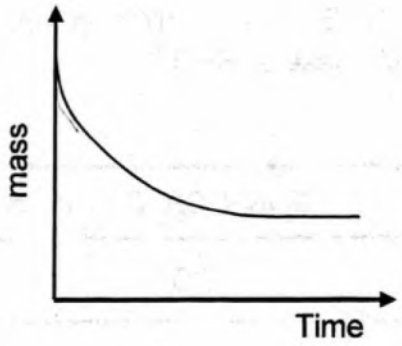
B



C



D



(2)

1.7 Each of the reactions represented below is at equilibrium in a closed container.

In which ONE of these reactions will an INCREASE IN PRESSURE (by decreasing the volume) at constant temperature favour the formation of products?

A $N_2O_4(g) \rightleftharpoons 2\,NO_2(g)$

B $PC\ell_5(g) \rightleftharpoons PC\ell_3(g) + C\ell_2(g)$

C $N_2(g) + 3\,H_2(g) \rightleftharpoons 2\,NH_3(g)$

D $NO_2(g) + CO(g) \rightleftharpoons NO(g) + CO_2(g)$

(2)

1.8 The expression for the equilibrium constant (Kc) for a hypothetical reaction is given as follows:

$$K_c = \frac{[R]\ [S]^2}{[P]^3}$$

Which ONE of the following balanced equations represents the hypothetical reaction?

A $3P(s) \rightleftharpoons R(g) + 2S(g)$

B $3P(\ell) \rightleftharpoons R(aq) + 2\,S(aq)$

C $3P(aq) + Q(s) \rightleftharpoons R(g) + S_2(g)$

D $3P(aq) + Q(s) \rightleftharpoons R(aq) + 2S(g)$ (2)

1.9 Which ONE of the following pairs represents the conjugate acid and the conjugate base of HPO_4^{2-} ?

	CONJUGATE ACID	CONJUGATE BASE
A	PO_4^{3-}	$H_2PO_4^-$
B	$H_2PO_4^-$	PO_4^{3-}
C	$H_2PO_4^-$	H_3PO_4
D	$H_2PO_4^{2-}$	PO_4^{2-}

(2)

1.10 CH_3COOH is a weak acid. Which ONE of the following statements is correct for a 0,01 $mol{\cdot}dm^{-3}$ aqueous solution of CH_3COOH?

A There are more hydronium ions than acetate ions.

B There are fewer acetate ions than unionized CH_3COOH.

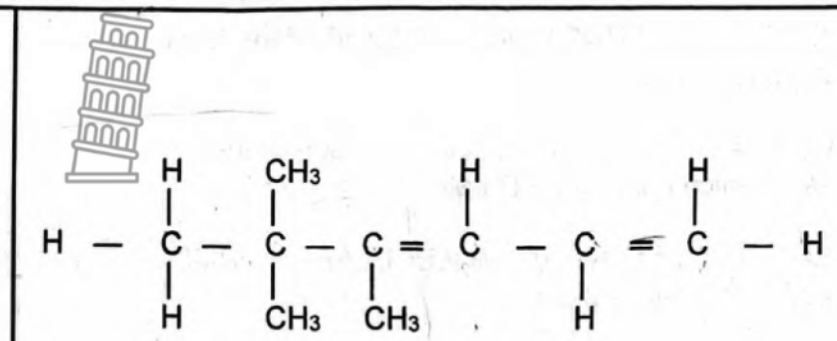
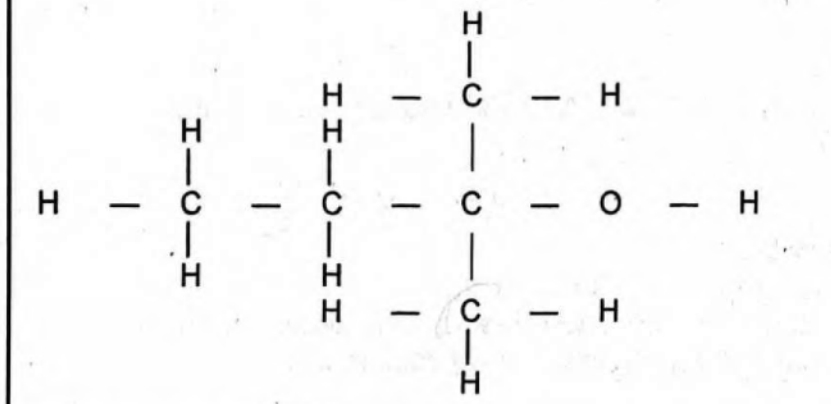
C There are more hydronium ions than unionized CH_3COOH.

D There are equal quantities of unionized CH_3COOH, hydronium ions and acetate ions.

(2)
[20]

QUESTION 2 (Start on a new page.)

The letters **A** to **F** in the table below represent six organic compounds.

A			
B			
C	CH_3CO_2H	**D**	$CH_3CO_2C_2H_5$
E	C_3H_8O	**F**	2 – bromobutane

Use the information in the table to answer the questions that follow.

2.1 Write down the IUPAC name of:

2.1.1 Compound A. (3)

2.1.2 Compound B. (3)

2.2 Write down the letter that represents:

2.2.1 A haloalkane. (1)

2.2.2 A compound that belongs to the same homologous series as compound B. (1)

2.3 Compound D is produced when compound C is reacted with a primary alcohol.

2.3.1 Define the term *functional group.* (2)

2.3.2 Write down the NAME of the FUNCTIONAL GROUP of the homologous series to which compound C belongs. (1)

2.3.3 Write down the structural formula of the functional group of the homologous series to which compound D belongs. (2)

2.3.4 Write a balanced equation using MOLECULAR FORMULAE to represent the reaction that takes place. (5)

2.3.5 Write down the NAME or FORMULA of the substance that can be used to accelerate the above reaction. (1)

2.3.6 Write down the IUPAC name of the primary alcohol used in this reaction. (2)

2.4 Define the term *functional isomer.* (2)

2.5 Write down the STRUCTURAL FORMULA of the straight chain FUNCTIONAL ISOMER of compound D. (2)

[25]

QUESTION 3 (Start on a new page.)

3.1 X and Y are two saturated hydrocarbons with the same molecular formula. Both X and Y have 4 carbons each. X has a lower boiling point than Y

3.1.1 Define *boiling point.* (2)

3.1.2 Fully explain the difference in the boiling points of these two compounds. (3)

3.1.3 Write down the STRUCTURAL FORMULA for compound X. (2)

3.2 In an experiment the boiling points of alcohols are compared to that of the carboxylic acids. The boiling point of pentan – 1 – ol is found to be 138 °C.

3.2.1 Write down the IUPAC name of the carboxylic acid that must be used in this experiment to ensure that the comparison is fair.
Give a reason for the answer. (3)

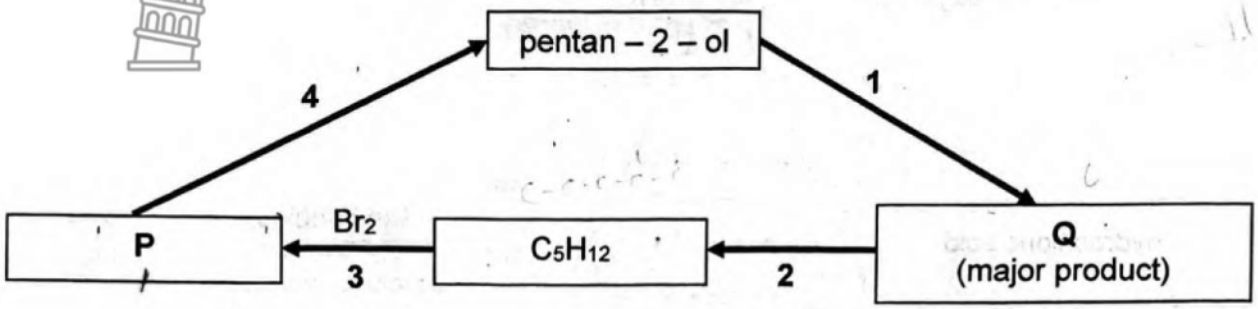
3.2.2 Will the boiling point of the carboxylic acid be LESS THAN, EQUAL TO or GREATER THAN 138 °C? (1)

3.2.3 Fully explain the answer to QUESTION 3.2.2. (3)

[14]

QUESTION 4 (Start on a new page.)

In the flow diagram below, **1, 2, 3,** and **4** represent organic reactions. P and Q represent organic compounds. Q is a HYDROCARBON.



4.1 Consider REACTION **1**:

4.1.1 Name the type of reaction that takes place. Choose from SUBSTITUTION, ELIMINATION or ADDITION. (1)

4.1.2 Write down the structural formula of Q. (2)

4.1.3 Apart from heat, state one other reaction condition (2)

4.2 REACTION **2** is an example of an addition reaction.

4.2.1 Write down the TYPE of addition reaction represented here. (1)

4.2.2 Write down the NAME or FORMULA of the inorganic reactant required for this reaction. (1)

4.2.3 Name ONE reaction condition for reaction **2**. (1)

4.3 Bromine is used as an inorganic reactant in REACTION **3**.

4.3.1 Name the type of reaction that takes place. (1)

4.3.2 State the reaction condition for this reaction. (1)

4.3.3 Write down the structural formula of compound P. (2)

4.4 Consider REACTION **4**:

4.4.1 Apart from heat, state one other reaction condition. (1)

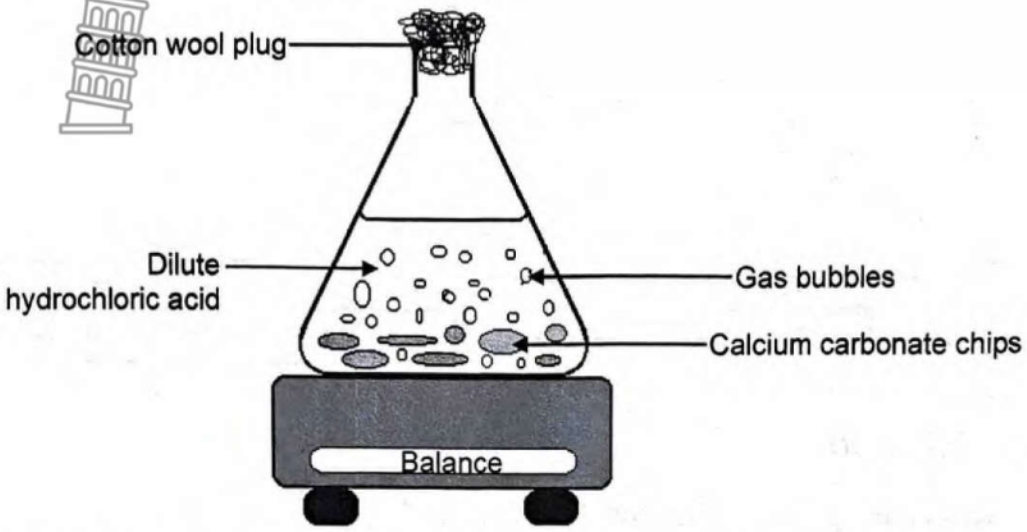
4.4.2 Using condensed structural formula, write a balanced equation to represent the reaction that takes place. (3)

4.5 Compound P can be converted directly to compound Q in an elimination reaction. Write down the TYPE of elimination reaction taking place. (1)

[17]

QUESTION 5 (Start on a new page)

Calcium carbonate chips are added to excess dilute hydrochloric acid solution in a flask placed on a balance as illustrated below.



The cotton wool plug placed in the mouth of the flask prevents spillage of reactants and products, while simultaneously allowing the formed gas to escape. The balanced equation for the reaction that takes place is:

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

The mass of the flask and its contents is recorded in intervals of 30 seconds. The results obtained are shown in the table below.

Time in seconds (s)	Mass of the flask and its contents in grams (g)
0	217,50
30	215,00
60	212,95
90	211,05
120	209,20
150	207,40
180	X
210	203,95
240	203,95
270	Y

5.1 Define *reaction rate.* (2)

5.2 Write down the evidence from the table that suggests that the rate of the above reaction DECREASES with time. (2)

5.3 Use the collision theory to explain why the rate of the reaction decreases with time. Assume that the temperature remains constant. (3)

5.4 How will an increase in the volume of the hydrochloric acid used affect the rate of this reaction? Choose from INCREASES, DECREASES or REMAINS THE SAME (1)

5.5 The average rate of the reaction for the first 180s is $6,58 \times 10^{-2}$ g.s^{-1}. Calculate the value of X in the table. (4)

5.6 Write down the mass, in grams, represented by Y. Give a reason for the answer. (2)

5.7 Calculate the total volume of carbon dioxide gas produced during the above reaction at S.T.P. (6)

5.8 It is observed that when a catalyst is added to the above reaction, the reaction reaches completion in a shorter time.
Use the collision theory to explain the observation. (3)

5.9 The $CaCO_3$ chips are replaced with an equal mass of $CaCO_3$ powder. How will each of the following be affected by this change? (Choose from INCREASES, DECREASES or REMAINS THE SAME)

5.9.1 The mass in grams represented by Y. (1)

5.9.2 Time taken to reach the mass represented by X. (1)

[25]

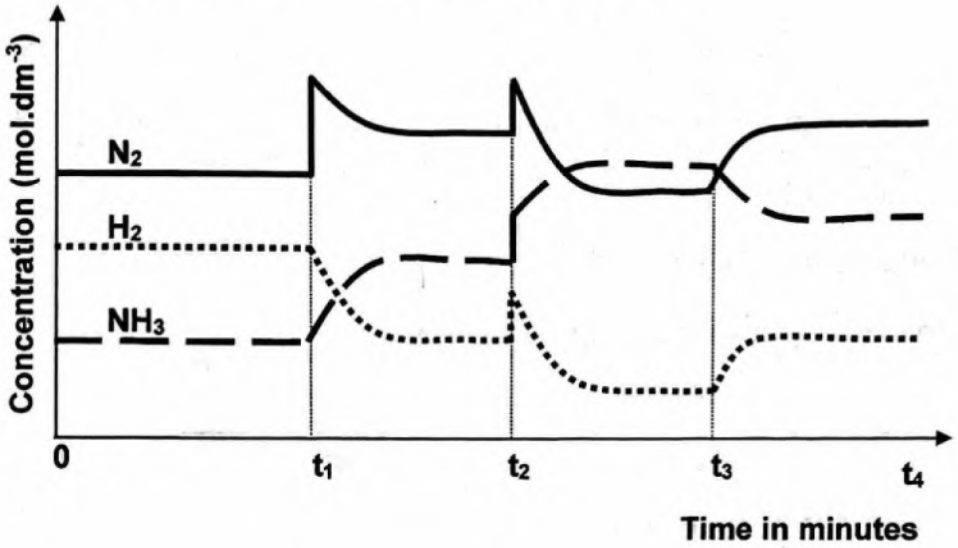
QUESTION 6 (Start on a new page)

6.1 An investigation is performed to determine the effect of TEMPERATURE, PRESSURE and CONCENTRATION on equilibrium in the production of ammonia in a sealed container. The volume of the container is kept constant.

The balanced equation below represents the reaction that takes place in the sealed container.

$$N_2(g) + 3\ H_2(g) \rightleftharpoons 2\ NH_3(g) \qquad \Delta H < 0$$

The graph below represents the results obtained:



6.1.1 What information about the reaction does the graph provide between **0** and t_1? (2)

6.1.2 Will the Kc value for this reaction between **0** and t_1 be GREATER THAN 1, EQUAL TO 1 or LESS THAN 1? (1)

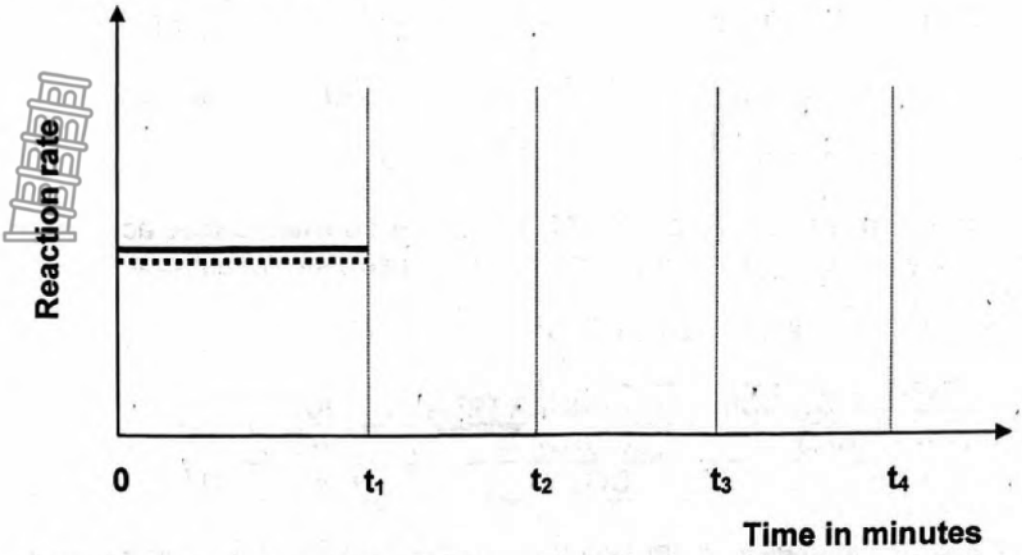
6.1.3 At which time, t_1, t_2 **or** t_3 was the concentration of a reactant increased? Give a reason for the answer. (2)

6.1.4 State Le Chatelier's principle. (2)

6.1.5 Which ONE of the factors, TEMPERATURE, PRESSURE or CONCENTRATION was changed at t_3? (1)

6.1.6 Was the factor identified in QUESTION 6.1.5 INCREASED or DECREASED?
Explain the answer by referring to Le Chatelier's principle. (4)

6.1.7 A partial graph of reaction rate versus time is drawn below. The dotted line represents the reverse reaction



Copy the above graph in your answer book. Complete the graph for each of the time periods period till t_4. Use the solid line for the forward reaction rate and the dotted line for the reverse reaction rate. (5)

6.2 The equation below represents the reversible reaction that takes place when sulphur dioxide gas, SO_2, and oxygen gas, O_2, are allowed to react in a sealed container.

$$2\ SO_2(g) + O_2(g) \rightleftharpoons 2\ SO_3(g) \qquad \Delta H < 0$$

6.2.1 Write down the meaning of the term *reversible reaction*. (2)

6.2.2 The activation energy for the FORWARD reaction is compared to the activation energy of the REVERSE reaction. Which reaction, FORWARD or REVERSE, will have a higher activation energy? (1)

6.3 A hypothetical reaction is represented by the balanced equation below:

$$2\ X(g) + Y(g) \rightleftharpoons 2\ C(g)$$

2,5 moles of X (g) were mixed with 1,75 moles of Y (g) in a sealed 2 dm^3 container. The reaction reaches equilibrium at T °C. At equilibrium the concentration of C (g) was 0,5 $mol.dm^{-3}$.
Calculate the value of the equilibrium constant, Kc. (7)
[27]

QUESTION 7 (Start on a new page.)

7.1 Sulphuric acid, H_2SO_4, ionizes in water in TWO steps as follows:

STEP I: $H_2SO_4(aq) + H_2O(\ell) \rightleftharpoons HSO_4^-(aq) + H_3O^+(aq)$

STEP II: $HSO_4^-(aq) + H_2O(\ell) \rightleftharpoons SO_4^{2-}(aq) + H_3O^+(aq)$

7.1.1 Define an *acid* in terms of the *Arrhenius theory*. (2)

7.1.2 Write down the NAME or FORMULA of the substance that acts as an ampholyte in the above equations. Give a reason for the answer. (2)

7.2 The Ka value for TWO acids are as follows:

NAME OF ACID	FORMULA OF ACID	Ka VALUE
Oxalic Acid	$(COOH)_2$	$5,6 \times 10^{-2}$
Carbonic Acid	H_2CO_3	$4,3 \times 10^{-2}$

7.2.1 Oxalic acid ionizes in water according to the following balanced equation:

$$(COOH)_2(aq) + 2\,H_2O(\ell) \rightleftharpoons (COO)_2^{2-}(aq) + 2\,H_3O^+(aq)$$

Write down the formula of the TWO BASES in this reaction. (2)

7.2.2 Which ONE, oxalic acid or carbonic acid, will have a higher conductivity? Explain the answer by referring to the information in the table. (3)

7.3 Water is added to a 0,01 $mol.dm^{-3}$ solution of hydrochloric acid. How does the addition of the water affect each of the following? (Choose from: INCREASES, DECREASES or REMAINS THE SAME).

7.3.1 The strength of the solution of the hydrochloric acid. (1)

7.3.2 The concentration of the solution of the hydrochloric acid. Give a reason for the answer. (2)

7.4 A solution of sodium hydrogen carbonate, ($NaHCO_3$) of volume 250 cm^3, is prepared by dissolving x g of sodium hydrogen carbonate in sufficient distilled water in a volumetric flask.

20 cm^3 of the prepared sodium hydrogen carbonate solution neutralises 12,58 cm^3 of a sulphuric acid(H_2SO_4) solution of 0,29 $mol.dm^{-3}$.

The balanced equation for the reaction is:

$$H_2SO_4(aq) + 2\,NaHCO_3(aq) \rightarrow Na_2SO_4(aq) + 2\,H_2O(\ell) + CO_2(g)$$

7.4.1 Define the *equivalence point of a titration.* (2)

7.4.2 Calculate the concentration of the $NaHCO_3$ solution that neutralised the H_2SO_4 solution. (4)

7.4.3 Calculate x, the mass of sodium hydrogen carbonate used to prepare the initial solution of sodium hydrogen carbonate. (4)

[22]

[150]

DATA FOR PHYSICAL SCIENCES GRADE 12
PAPER 2 (CHEMISTRY)

TABLE 1: PHYSICAL CONSTANTS

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 electron*	E	$-1{,}6 \times 10^{-19}$ C
Avogadro's constant *Avogadro-konstante*	N_A	$6{,}02 \times 10^{23}$ mol^{-1}

TABLE 2: FORMULAE

$n = \frac{m}{M}$	$n = \frac{N}{N_A}$
$c = \frac{n}{V}$ 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	

TABLE 3: THE PERIODIC TABLE OF ELEMENTS

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 He 4
2,1 H 1												2,0 B 11	2,5 C 12	3,0 N 14	3,5 O 16	4,0 F 19	10 Ne 20
1,0 Li 7	1,5 Be 9											1,5 Aℓ 27	1,8 Si 28	2,1 P 31	2,5 S 32	3,0 Cℓ 35,5	18 Ar 40
0,9 Na 23	1,2 Mg 24											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 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	1,7 In 115	1,8 Sn 119	1,9 Sb 122	2,1 Te 128	2,5 I 127	54 Xe 131
0,8 Rb 86	1,0 Sr 88	1,2 Y 89	1,4 Zr 91	41 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 Tℓ 204	1,8 Pb 207	1,9 Bi 209	2,0 Po	2,5 At	86 Rn
0,7 Cs 133	0,9 Ba 137	57 La 139	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						
0,7 Fr	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

KEY/*SLEUTEL*

- **Atomic number** *Atoomgetal*
- **Electronegativity** *Elektronegatiwiteit*
- **Symbol** *Simbool*
- **Approximate relative atomic mass** *Benaderde relatiewe atoommassa*

KWAZULU-NATAL PROVINCE
EDUCATION
REPUBLIC OF SOUTH AFRICA

GRADE 12

NATIONAL SENIOR CERTIFICATE

PHYSICAL SCIENCES P2 (CHEMISTRY)

JUNE 2023

COMMON TEST

MARKING GUIDELINES

MARKS: 150

This memorandum consists of 11 pages.

QUESTION 1

1.1 D ✓✓ (2)

1.2 C ✓✓ (2)

1.3 A ✓✓ (2)

1.4 B ✓✓ (2)

1.5 A ✓✓ (2)

1.6 B ✓✓ (2)

1.7 C ✓✓ (2)

1.8 D ✓✓ (2)

1.9 B ✓✓ (2)

1.10 B ✓✓ (2)

[20]

QUESTION 2

2.1.1 4,5,5 – trimethylhexa – 1,3 - diene

REMOVED

Marking criteria:
- correct stem i.e. hexadiene✓
- all substituents trimethyl correctly identified✓
- IUPAC name completely correct including numbering, sequence and hyphen and commas✓

(3)

2.1.2 2 – methylbutan – 2 – ol **OR** 2 – methyl -2-butanol

Marking criteria:
- correct stem i.e. butanol✓
- substituent methyl correctly identified✓
- IUPAC name completely correct including numbering, sequence and hyphen and commas✓

(3)

2.2.1 F✓ (1)

2.2.2 E✓ (1)

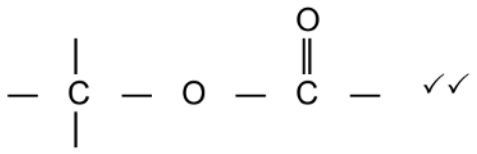
2.3.1 A bond/an atom/a group of atoms that determine(s) the (physical and) chemical properties of a group of organic compounds.

Marking criteria:
If any one of the underlined key phrases in the correct context is omitted, deduct 1 mark

(2)

2.3.2 carboxyl✓✓ (1)

2.3.3



✓✓

Marking criteria:
Whole structure correct
2 or zero

(2)

2.3.4 $C_2H_4O_2$ ✓ + C_2H_6O ✓ → $C_4H_8O_2$ ✓ + H_2O ✓ balancing ✓

Marking criteria:
- 1 for each correct reactant and product
- 1 for correct balancing
- If structural formulae are used Max 4/5
- Any additional reactant or product: -1 mark

(5)

2.3.5 Sulphuric acid/H_2SO_4 ✓ (1)

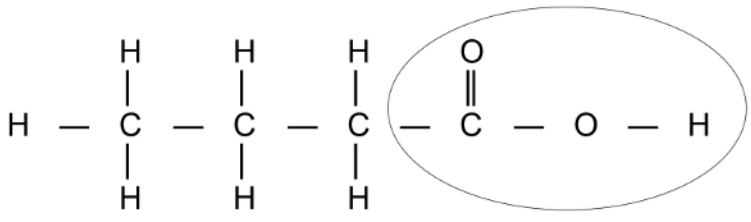
2.3.6 ethanol✓✓ (2)

2.4 Compounds with the same molecular formula ✓ but different functional groups/homologous series. ✓

Marking criteria:
If any one of the underlined key phrases in the correct context is omitted, deduct 1 mark

(2)

2.5



Marking criteria:
- Only Functional group correctly drawn✓ ½
- Whole structure correct ✓ 2/2

(2)

[25]

QUESTION 3

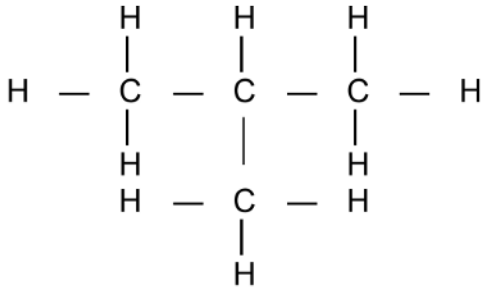
3.1.1 The temperature at which the vapour pressure of a substance equals atmospheric pressure ✓✓

Marking criteria:
If any one of the underlined key phrases in the correct context is omitted, deduct 1 mark

(2)

3.1.2 Compound X / methylpropane Is branched / has a smaller surface area / is less spherical while compound Y / butane has a straight chain / is unbranched / has a bigger surface area / is more spherical✓
The intermolecular forces in compound Y are stronger than the intermolecular forces in comnpound X. ✓
More energy is required to overcome the intermolecular forces in compound Y. ✓ (3)

3.1.3



Marking criteria:
- 3 carbons in the longest chain✓
- substituent methyl on the second carbon and everything else correct✓

(2)

3.2.1 Butanoic acid ✓✓
The compounds must be of comparable molecular mass OR butanoic acid has the same molecular mass as pentan – 1 - ol✓

OR

Pentanoic acid ✓✓
The compounds must be of comparable chain length OR butanoic acid has the same chain length as pentan – 1 - ol✓ (3)

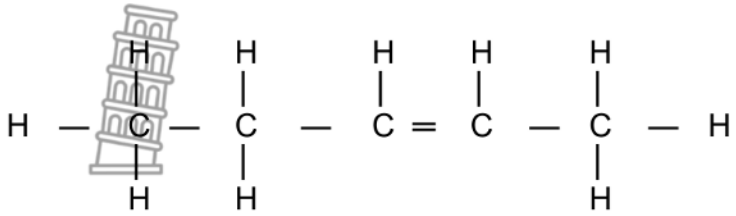
3.2.2 GREATER THAN✓ (1)

3.2.3 The carboxylic acid has 2 sites for hydrogen bonding while the alcohol has only 1 site for hydrogen bonding. ✓
The intermolecular forces will therefore be stronger between the molecules of the carboxylic acid. ✓
More energy will therefore be required to overcome the intermolecular forces between the molecules of the acid. ✓ (3)
[14]

QUESTION 4

4.1.1 Elimination. ✓ (1)

4.1.2



Marking criteria:
- Double bond on second carbon✓ ½
- Whole structure correct ✓ 2/2

(2)

4.1.3 concentrated sulphuric acid ✓✓ (If concentrated is not mentioned, then 1/2) (2)

4.2.1 Hydrogenation✓ (1)

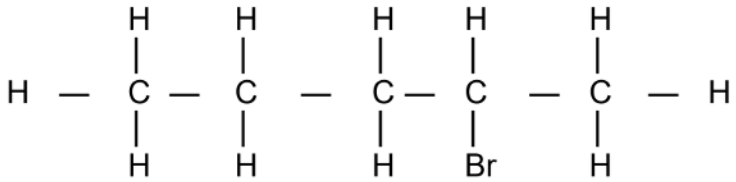
4.2.2 Hydrogen/H_2✓ (1)

4.2.3 Platinum/Pt catalyst✓ (1)

4.3.1 Halogenation/bromination/substitution✓ (1)

4.3.2 Require uv light. Or heat✓ (1)

4.3.3



Marking criteria:
- Br on second carbon✓ ½
- Whole structure correct ✓ 2/2

(2)

4.4.1 Dilute strong base/KOH/NaOH/H_2O✓ (1)

4.4.2 $CH_3CH_2CH_2CHBrCH_3 + KOH \rightarrow CH_3CH_2CH_2CHOHCH_3 + KBr$ **OR**
$CH_3CH_2CH_2CHBrCH_3 + NaOH \rightarrow CH_3CH_2CH_2CHOHCH_3 + NaBr$ **OR**
$CH_3CH_2CH_2CHBrCH_3 + H_2O \rightarrow CH_3CH_2CH_2CHOHCH_3 + HBr$

Marking criteria:
- Correct reactants✓
- Correct products✓
- Balancing✓

(3)

4.5 Dehydrohalogenation/dehydrobromination✓ (1)
[17]

QUESTION 5

5.1

Marking criteria:
Give the mark for per unit time only if in context of reaction rate.

ANY ONE
- Change in concentration ✓of products/reactants per (unit) time. ✓
- Change in amount/number of moles/volume/mass✓ of products or reactants per (unit) time. ✓
- Amount/number of moles/volume/mass of products formed/reactants used per (unit) time. ✓✓
- Rate of change in concentration/amount of moles/number of moles/volume/mass. ✓✓ (2 or 0) (2)

5.2 Change in the mass of the flask and contents✓ decreases per unit time / per second / every 30 seconds. ✓ (2)

5.3 Mass of $CaCO_3$ decreases or is used up. ✓
A decrease in the exposed surface area. ✓
The number of effective collisions per unit time decreases. ✓

OR

HCl is used up. ✓
Concentration of the HCl decreases. ✓
The number of effective collisions per unit time decreases. ✓ (3)

NOTE: If no mention made of $CaCO_3$ or HCl used up, award 2 marks to second bullet.

5.4 REMAINS THE SAME. ✓ (1)

5.5

$$\text{Average rate} = -\frac{\Delta m}{\Delta t}$$

$$6{,}58 \times 10^{-2} \checkmark = -\frac{X - 217{,}50}{180 - 0} \checkmark \checkmark$$

$$X = 205{,}66 \text{ g} \checkmark$$

Marking criteria:
- Substitute rate✓
- Substitute Δm✓
- Δt✓
- Final answer✓

(4)

5.6 203,95 g ✓
Reaction has reached completion. ✓ (2)

5.7 **Marking criteria:**

- Calculate mass of pure CO_2✓
- Formula: $n = \frac{m}{M}$
- Correct substitution of 44 ($\frac{13{,}55}{44}$ ✓) in the above formula
- Formula $n(CO_2)_{produced} = \frac{V}{V_m}$

✓Either equation

- Substitute n = 0,31 ✓
- Substitute V_m = 22,4 ✓
- Final answer = 6.944 dm^3 ✓

$m(CO_2)$ = 217,50 - 203,95 ✓ = 13,55 g

$n(CO_2) = \frac{m}{M}$

$= \frac{13{,}55}{44}$ ✓

= 0,31 mols

✓Either equation

$n(CO_2)_{produced} = \frac{V}{V_m}$

$0{,}31$✓ $= \frac{V}{22{,}4}$ ✓

V = 6,944 dm^3 (6,90)✓ (6)

5.8 A catalyst provides an alternate pathway of lower activation energy / lowers the activation energy✓
More molecules will therefore have sufficient energy✓
The number of effective collisions per unit time increases ✓ (3)

5.9.1 REMAINS THE SAME✓ (1)

5.9.2 DECREASES✓ (1)

[25]

QUESTION 6

6.1.1 The reaction is in a state of (dynamic) equilibrium. ✓✓
OR The rate of forward reaction equals the rate of reverse reaction.
OR The concentrations of the reactants and products remain constant.

Note
IF: Forward reaction equals reverse reaction. $^{1}/_{2}$ (2)

6.1.2 Less than✓ (1)

6.1.3 **t_1**✓
The concentration of N_2 was increased./graph shows an increase in concentration of N_2✓ (2)

6.1.4

Marking criteria:
If any one of the underlined key phrases in the correct context is omitted, deduct 1 mark.

When the equilibrium in a closed system is disturbed, the system will re-instate a new equilibrium by favouring the reaction that will cancel/oppose the disturbance. ✓✓ (2)

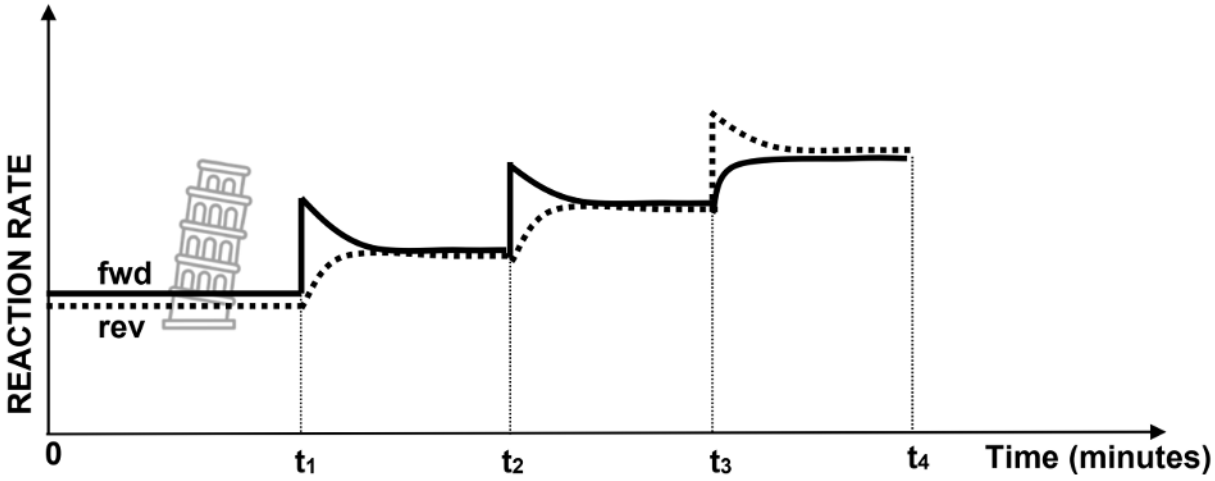
6.1.5 temperature✓ (1)

6.1.6 INCREASED✓
According to the graph the concentration of the reactants increases OR the concentration of the products decreases. ✓
Therefore the reverse reaction / endothermic reaction is favoured. ✓
(According to Le Chatelier's Principle) an increase in temperature favours the endothermic reaction. ✓ (4)

6.1.7

MARKING CRITERIA

- At t_1, forward reaction is favoured (vertical upward climb of solid line) ✓
- At t_2, forward reaction is favoured (vertical upward climb of solid line) ✓
- At t_3, reverse reaction is favoured (vertical upward climb of broken line) ✓
- Vertical upward increase in rates at t_2, t_3 and t_4. ✓
- Equilibrium rate at t_4 .> equilibrium rate at t_3 > equilibrium rate at t_2✓



(5)

6.2.1 Products can be converted back to reactants. ✓✓ (2)

6.2.2 REVERSE✓ (1)

6.3

Marking criteria:

- Change in no. of mol of C =1✓
- Using the correct ratio✓
- Subtraction: initial mol X – change in mol of X AND initial mol Y – change in mol of Y. ✓
- Equilibrium mol of X and Y; divide by 2✓
- Correct Kc expression (formulae in square brackets) ✓
- Substitution of equilibrium concentrations into Kc expression. ✓
- Final answer 0,71✓

	X	Y	C	
Ratio	2	1	2	
Initial quantity (mol)	2,5	1,75	0	
Change (mol)	1	0,5 ✓	1✓	Using ratio ✓
Quantity at equilibrium (mol)	1,5	1,25	1	✓
Equilibrium concentration (mol·dm^{-3})	0,75	0,625	0,5	✓ Divide by 2

$$K_c = \frac{[C]^2}{[X]^2[Y]} \checkmark$$

$$\therefore = \frac{[0,5]^2}{[0,75]^2[0,625]} \checkmark$$

$$= 0,71 \checkmark$$

No K_c expression, correct substitution. $^6/_7$
Wrong K_c expression $^4/_7$

(7)

[27]

QUESTION 7

7.1.1 acids produce hydrogen ions (H^+/H_3O^+/hydronium ions) in aqueous solutions. ✓✓

Marking criteria:
If any one of the underlined key phrases in the correct context is omitted, deduct 1 mark. (2)

7.1.2 Hydrogen sulphate ion/ HSO_4^- ✓
Acts as an acid and a base✓ (2)

7.2.1 H_2O✓
$(COO)_2^{2-}$ ✓ (2)

7.2.2 Oxalic acid. ✓
Has a higher Ka value. ✓
Ionises to a greater extent / more completely. OR has a higher ion concentration. ✓ (3)

7.3.1 REMAINS THE SAME✓ (1)

7.3.2 DECREASES✓ The volume increases while number of moles is constant /
The number of moles of acid decreases in proportion to the volume of water ✓ (2)

7.4.1 The point at which the acid has completely reacted with the base /
The point at which the base has completely reacted with the acid ✓✓ (2)

7.4.2

Marking criteria:

- Formula $\frac{C_A V_A}{C_B V_B} = \frac{n_A}{n_B}$ / n = cV✓
- Substitute for C_A, V_A and V_B in the above formula/cV✓
- Ratio $n_A : n_B$✓
- Final answer: 0,365 mol.dm^{-3}✓

$\frac{C_A V_A}{C_B V_B} = \frac{n_A}{n_B}$ ✓

$\frac{0,29 \times 12,58}{C_B \times 20}$ ✓ $= \frac{1}{2}$ ✓

C_B = 0,365 mol.dm^{-3} ✓

OR

$n(NaHCO_3) = 2\, n(H_2SO_4)$

$= 2\, cV$✓

$= 2(0,29)(0,01258)$

$= 7,2964 \times 10^{-3}$ mols

$c(NaHCO_3) = \frac{n}{V}$ ✓

$= \frac{7,2964 \times 10^{-3}}{0,02}$ ✓

$= 0,365$ mol.dm^{-3} ✓

(4)

7.4.3 **POSITIVE MARKING FROM QUESTION 7.4.2**

Marking criteria:

- Any Formula: n = CV / m = nM / m = CMV Formula: m = nM✓
- Substitute 0,365 from 7.3.1 and 0,25✓
- Substitute M = 84✓ in any of the above formulae
- Final answer: 7,665 g ✓

OPTION1

$n(NaHCO_3)$ in 250cm^3 = cV✓

= (0,365)(0,25) ✓

= 0,09125 mols

$m(NaHCO_3)$ in 250cm^3 = nM

= 0,09125 x 84✓

= 7,67 g✓

OPTION2

m = CMV✓

= (0,365) (0,25) ✓ (84) ✓

= 7,67 g✓

(4)

[22]

TOTAL: 150