Basic Education

KwaZulu-Natal Department of Basic Education
REPUBLIC OF SOUTH AFRICA

PHYSICAL SCIENCES: CHEMISTRY (P2)

COMMON TEST

JUNE 2015

NATIONAL SENIOR CERTIFICATE

GRADE 12

MARKS : 75

TIME : 1½ Hours

This question paper consists of 9 pages, 2 Data Sheets and a special answer sheet for question 5.4.

INSTRUCTIONS AND INFORMATION TO CANDIDATES

1. Write your name on the **ANSWER BOOK**.
2. This 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 subsections, 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.

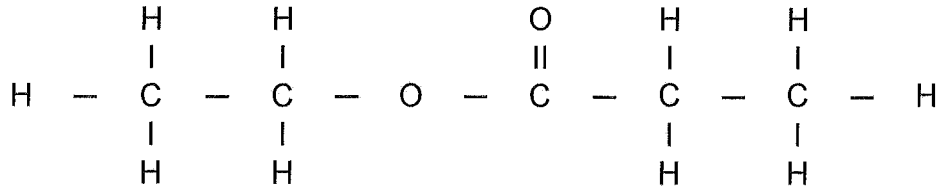
QUESTION 1: MULTIPLE – CHOICE QUESTIONS

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 – 1.10) in the ANSWER BOOK, for example 1.11 D.

1.1 The monomer of polyethene is . . .

A polyethene.
B propene.
C ethene.
D ethane. (2)

1.2 Consider the structural formula of an organic compound given below:



The above organic compound is the product of the reaction between . . .

A ethanol and ethanoic acid
B propanol and propanic acid
C ethanol and propanoic acid
D propanol and ethanoic acid (2)

1.3 The expression for the equilibrium constant (K_C) of a hypothetical reaction is given as follows:

$$K_C = \frac{[D]^2[C]}{[A]^3}$$

Which ONE of the following equations for a reaction at equilibrium matches the above expression?

A $3A(aq) + B(s) \rightleftharpoons C(aq) + 2D(aq)$
B $3A(aq) + B(s) \rightleftharpoons C(g) + D_2(g)$
C $3A(\ell) \rightleftharpoons C(aq) + 2D(aq)$
D $3A(s) \rightleftharpoons C(g) + 2D(g)$ (2)

1.4 Study the following reaction at equilibrium in a closed container:

$$H_2(g) + C\ell_2(g) \rightleftharpoons 2HC\ell(g)$$

If the pressure is increased by decreasing the volume of the container, then ...

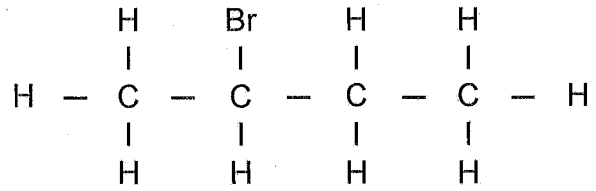
A the $H_2(g)$ and $C\ell_2(g)$ are completely used up.
B a greater number of moles of $H_2(g)$ are used up.
C the number of moles of $HC\ell(g)$ produced increases.
D the amount of reactants and products remain unchanged. (2)

1.5 Which ONE of the following solutions has the lowest concentration of hydrogen (H^+) ions?

A 25 cm^3 of a 1 $mol.dm^{-3}$ solution of HCℓ.
B 25 cm^3 of a 1 $mol.dm^{-3}$ solution of H_2SO_4.
C 25 cm^3 of a 1 $mol.dm^{-3}$ solution of H_3PO_4.
D 25 cm^3 of a 1 $mol.dm^{-3}$ solution of CH_3COOH. (2)
[10]

QUESTION 2 (Start on a new page.)

Consider the following representation of organic molecules **A** to **F** listed in the table below:

A	
B	3 – bromo – 2 – chloro – 2 – methylpentane
C	$(CH_3)_2CHCH_2CH(CH_3)CH_2CH_3$
D	$CH_3CCCH(C_2H_5)CH_2CH_3$
E	4 – methylpentan – 2 – one

2.1 Write down the letter that represents:

2.1.1 a saturated hydrocarbon. (1)

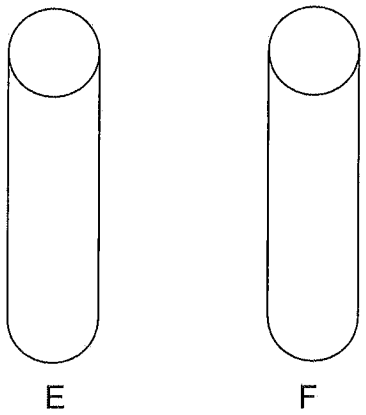
2.1.2 a compound whose functional group is a carbonyl group bonded to two carbon atoms. (1)

2.2 Write down the IUPAC name for the major product formed when compound A is dissolved in a concentrated solution of sodium hydroxide in pure ethanol and is strongly heated under reflux. (2)

2.3 Write down the structural formula of compound B. (2)
[6]

QUESTION 3 (Start on a new page.)

In an attempt to compare the boiling points of alcohols with carboxylic acids, a group of learners heated equal amounts of the alcohol and carboxylic in TWO separate test tubes, E and F.



The learners, however forgot to record which test tube contained the alcohol and which the carboxylic acid.

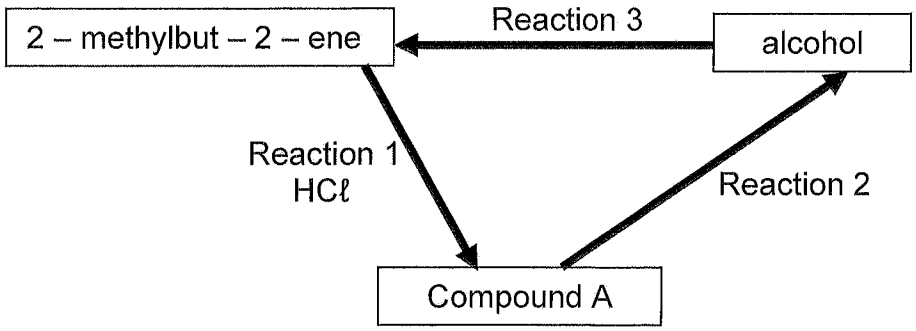
The learners observed that the compound in test tube F boiled first.

3.1 Define *boiling point*. (2)

3.2 The learners concluded that test tube E contained the carboxylic acid? Are the learners correct? (Write YES or NO). Explain, with reference to intermolecular forces and energy. (3)
[5]

QUESTION 4 (Start on a new page.)

Consider the reactions shown in the flow diagram below:



For each type of reaction given below write down whether it represents Reaction 1, Reaction 2 or Reaction 3:

4.1 substitution (1)

4.2 addition (1)

4.3 hydrolysis (1)

4.4 dehydration (1)
[4]

QUESTION 5 (Start on a new page.)

The decomposition of an aqueous solution of hydrogen peroxide can be accelerated by a catalyst.

$$H_2O_2(aq) \rightarrow H_2O(g) + O_2(g)$$

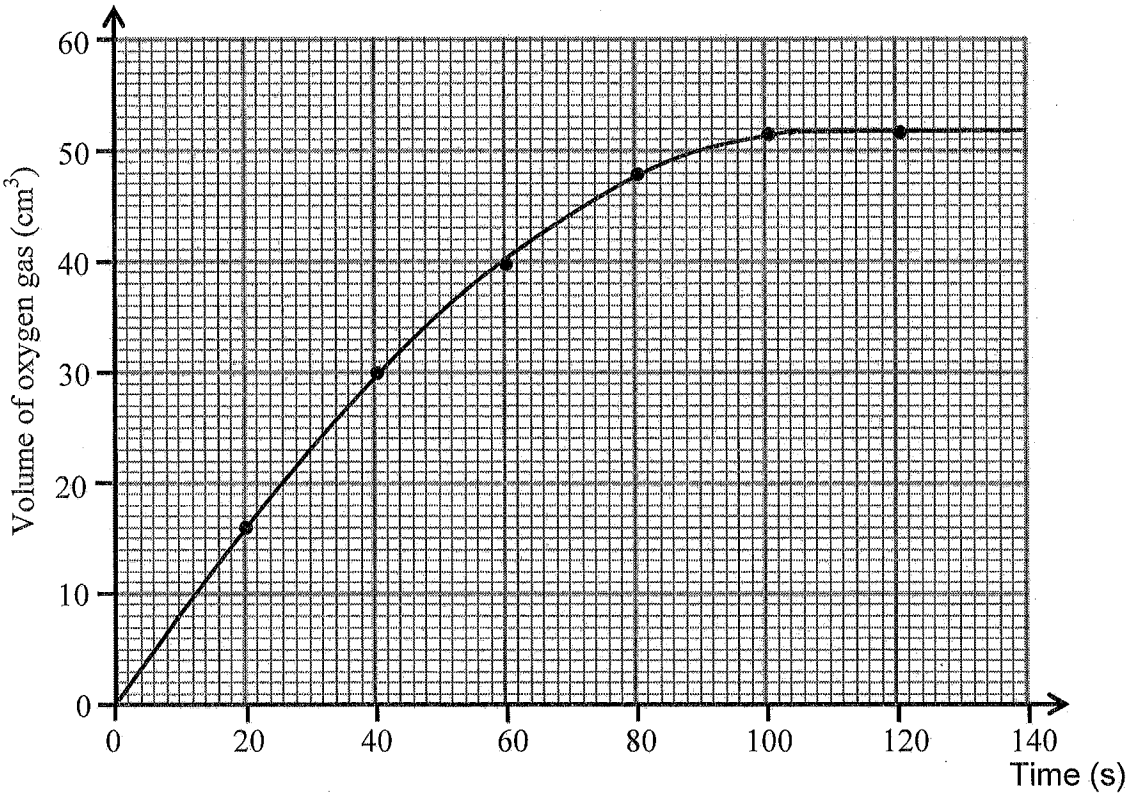
A group of learners conduct an investigation to determine which solid metal oxide, (P or Q), is a better catalyst for the decomposition of an aqueous solution of hydrogen peroxide.
They measure 50 cm^3 of the hydrogen peroxide solution into two conical flasks and add 0,80 g of the solid metal oxide. The volume of oxygen produced is then measured.

	$V(H_2O_2)$ in cm^3	catalyst used	mass of catalyst
Investigation 1	50	P	0,80 g
Investigation 2	50	Q	0,80 g

5.1 Identify the dependant variable. (1)

5.2 Name ONE factor that must be controlled to ensure that the comparison above is fair. (1)

5.3 The graph drawn below represents the results obtained from investigation 1.



5.3.1 What does the horizontal section of the graph represent? (1)

5.3.2 Calculate the average rate of the reaction between 0 s and 80 s. (3)

The above graph has been re-copied on the last page of the question paper (AS A SPECIAL ANSWER SHEET). QUESTION 5.4 MUST BE ANSWERED ON THIS SPECIAL ANSWER SHEET.

5.4 The learners found that Q is a better catalyst than P for this reaction. Draw a sketch graph that will be obtained for investigation 2. Label this graph Q.

REMEMBER TO DETACH THIS SPECIAL ANSWER SHEET AND HAND IN WITH YOUR ANSWER BOOK. (3)

5.5 Explain, by referring to the collision theory, how the use of a catalyst can accelerate the decomposition of an aqueous solution of hydrogen peroxide. (3)

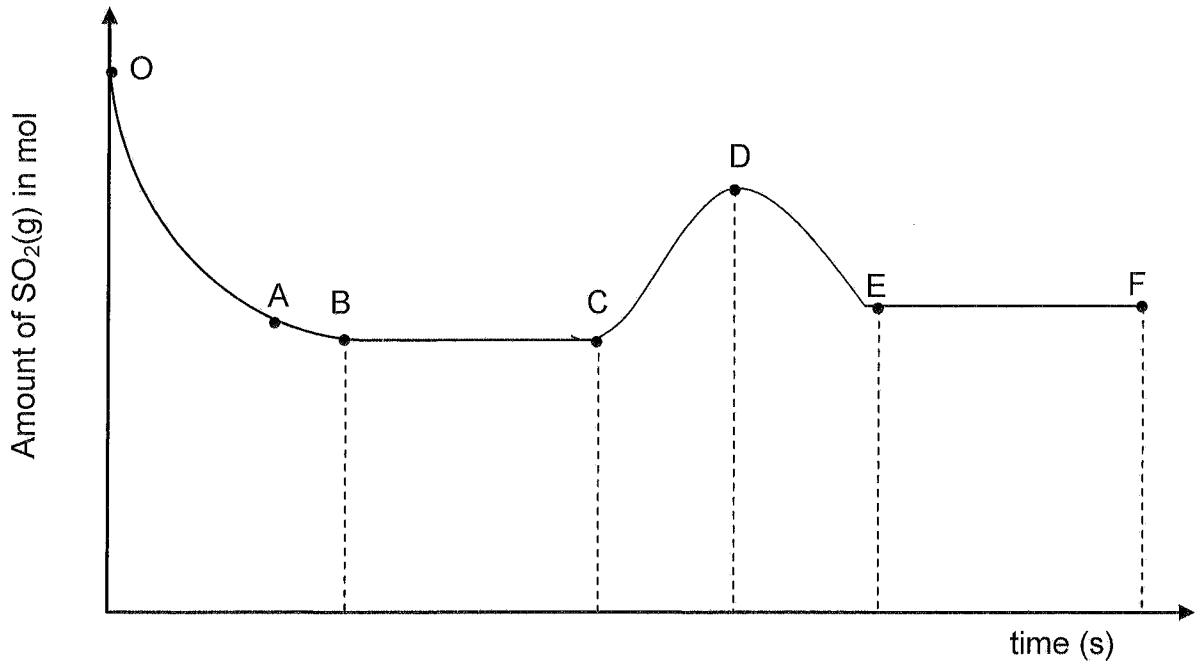
[12]

QUESTION 6 (Start on a new page.)

Consider the following reaction which occurs in a sealed container:

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

A graph of amount of $SO_2(g)$ was plotted against time as shown below.



6.1 When answering the following questions, write down only GREATER THAN, LESS THAN or EQUAL TO.

- During the time interval O – A, the rate of the forward reaction is **6.1.1** rate of the reverse reaction. (1)
- During the time interval B – C, the rate of the forward reaction is **6.1.2** rate of the reverse reaction. (1)
- During the time interval C – D, the rate of the forward reaction is **6.1.3** rate of the reverse reaction. (1)

6.2 The changes in the graph from C to E are due to changes in the temperature of the reaction vessel.
Was the temperature at point C increased or decreased?
Explain, by referring to Le Chatelier's Principle. (3)

6.3 How does the Kc value at point C compare to that at point E? (Write down EQUAL TO, GREATER THAN or LESS THAN).
Give a reason for your answer. (3)

6.4 Initially 8 moles of $SO_2(g)$, 5 moles of $O_2(g)$ and an unknown quantity (x moles) of $SO_3(g)$ were placed in a sealed container of volume 2 dm^3 and allowed to react at a certain temperature.

When equilibrium was established it was found that the equilibrium concentration of $SO_2(g)$ was 1,5 $mol.dm^{-3}$.

Calculate, x, the initial number of moles of $SO_3(g)$ in the container.

The Kc value for the reaction at this temperature is 6.

(7)
[16]

QUESTION 7 (Start on a new page.)

7.1 Sodium hydroxide is classified as a base according to the Arrhenius theory.

Write down the chemical formula of the ion responsible for the basic properties of sodium hydroxide. (1)

7.2 Sulphuric acid reacts with water in two steps as represented by the equations below:

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

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

7.2.1 A learner suggests that $HSO_4^-(aq)$ is an ampholyte. Give a reason to support the learner's suggestion. (2)

7.2.2 Write down the NAME of the conjugate base of the hydrogen sulphate ion. (1)

7.3 0,27 g of an IMPURE sample of anhydrous oxalic acid ($H_2C_2O_4$), was dissolved in enough water to make a solution of volume 75,00 cm^3.
The entire oxalic acid solution was then titrated against a sodium hydroxide solution of concentration 0,08 $mol.dm^{-3}$. The titration required 50,12 cm^3 of the NaOH solution to reach end point.

The reaction is shown below:

$$H_2C_2O_4 + 2NaOH \rightarrow Na_2C_2O_4 + 2H_2O$$

7.3.1 Define end point of a titration. (1)

7.3.2 Will the pH of the solution at the end point be EQUAL TO 7, LESS THAN 7 or GREATER THAN 7? Explain, with reference to the reactions of salts. (3)

7.3.3 Calculate the mass of impurities in the given sample of anhydrous oxalic acid. (7)

7.4 A solution is prepared by dissolving 2,54 g magnesium hydroxide, $Mg(OH)_2$, in water to make a solution of volume 250,00 cm^3.
Calculate the pH of this solution. (7)

[22]

TOTAL: 75

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* $E^\theta_{cell} = E^\theta_{oxidising\ agent} - E^\theta_{reducing\ agent}$ / $E^\theta_{sel} = E^\theta_{oksideermiddel} - E^\theta_{reduseermiddel}$	

NSC – Grade 12

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

Cell format: atomic number, symbol, approximate relative atomic mass (electronegativity)

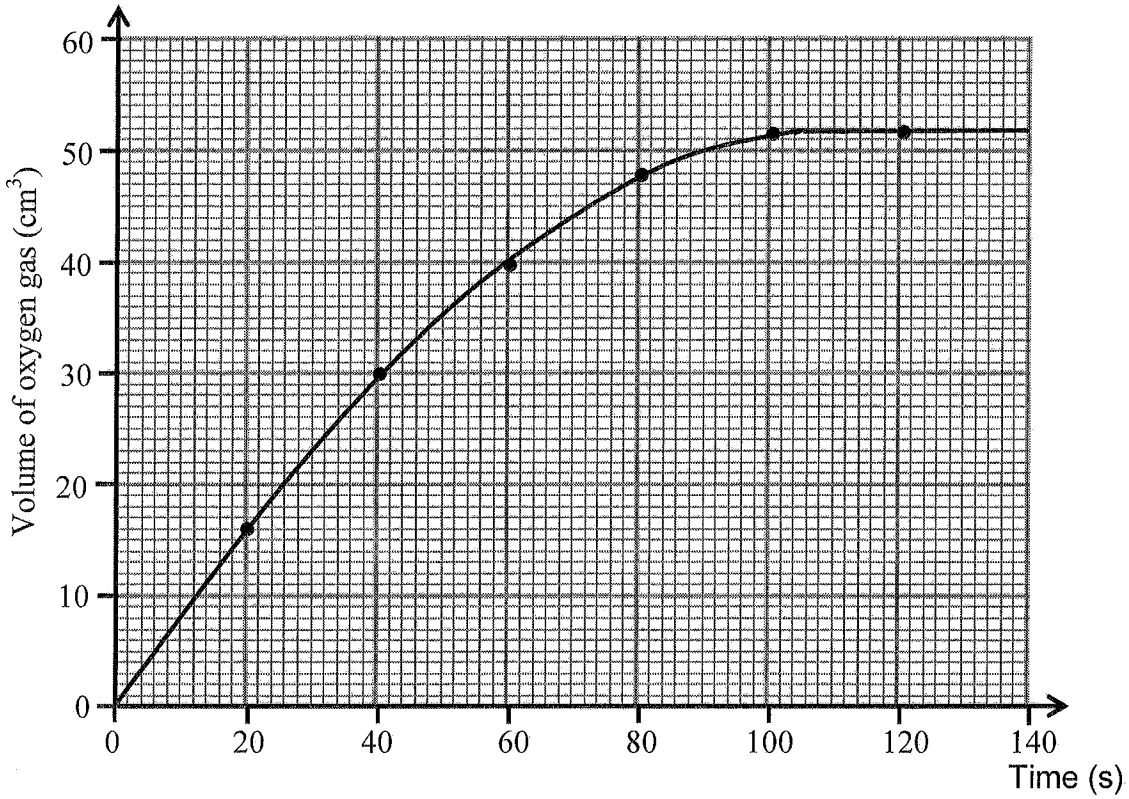
1 (I)	2 (II)	3	4	5	6	7	8	9	10	11	12	13 (III)	14 (IV)	15 (V)	16 (VI)	17 (VII)	18 (VIII)
1 H 1 (2,1)																	2 He 4
3 Li 7 (1,0)	4 Be 9 (1,5)											5 B 11 (2,0)	6 C 12 (2,5)	7 N 14 (3,0)	8 O 16 (3,5)	9 F 19 (4,0)	10 Ne 20
11 Na 23 (0,9)	12 Mg 24 (1,2)											13 Aℓ 27 (1,5)	14 Si 28 (1,8)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

SPECIAL ANSWER SHEET FOR QUESTION 5.4

GRAPH FOR QUESTION 5.4



REMEMBER TO DETACH THIS PAGE AND HAND IN WITH YOUR ANSWER BOOKLET.

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PHYSICAL SCIENCES: CHEMISTRY (P2)

COMMON TEST

JUNE 2015

MEMORANDUM

NATIONAL SENIOR CERTIFICATE

GRADE 12

MARKS : 75

TIME : 1½ Hours

This memorandum consists of 6 pages.

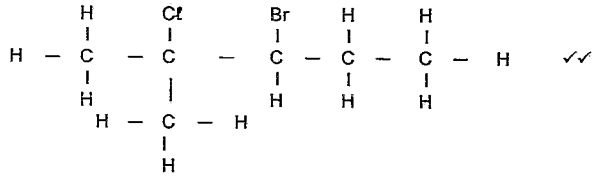
SECTION A

QUESTION 1

1.1 C✓✓ (2)
1.2 C✓✓ (2)
1.3 A✓✓ (2)
1.4 D✓✓ (2)
1.5 D✓✓ (2)
[10]

QUESTION 2

2.1.1 C ✓ (1)
2.1.2 E ✓ (1)
2.2 but-2-ene ✓✓ (2)
2.3



(2)
[6]

QUESTION 3

3.1 Temperature at which the vapour pressure of a liquid equals the atmospheric pressure. ✓✓ (2)
3.2 Yes✓
Although both alcohol and carboxylic have strong hydrogen bonding, the carboxylic acid has 2 sites for hydrogen bonding and therefore has stronger intermolecular forces. ✓ The alcohol has only 1 site ✓
More energy is required to overcome the intermolecular forces therefore carboxylic acid have a higher boiling point. (3)
[5]

QUESTION 4

4.1.1 reaction 2✓ (1)
4.1.2 reaction 1✓ (1)
4.1.3 reaction 2✓ (1)
4.1.4 reaction 3✓ (1)
[4]

QUESTION 5

5.1 rate of reaction✓ / volume of O_2 produced per unit time ✓ (1)

5.2 surface area/state of division of the catalyst or✓
Temperature of the solution✓ or
Concentration of the solution✓ (any 1) (1)

5.3.1 reaction complete/reactants completely used up✓ (Accept: maximum volume of O_2 produced) ✓ (1)

5.3.2

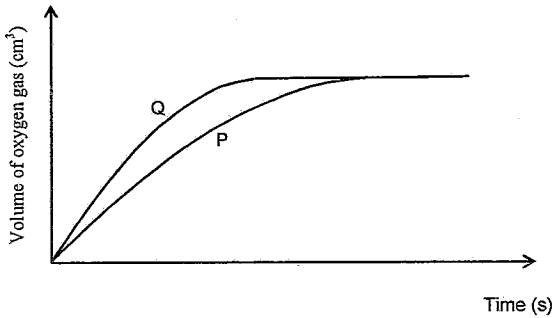
$$\text{rate of reaction} = \frac{\Delta \text{volume } (O_2)}{\Delta \text{time}} \checkmark$$

$$= \frac{48 - 0}{80 - 0} \checkmark$$

$$= 0{,}6\ cm^3.s^{-1}. \checkmark$$

(3)

5.4



For Q: greater gradient✓ and reaches completion before P✓ Same volume of O_2 produced✓ (3)

5.5 The catalyst provides an alternate pathway of lower activation energy. ✓
More particles will have enough/sufficient energy to be converted to activated complex✓
The number of effective collisions increases per unit time✓ (3)

[12]

QUESTION 6

6.1.1 greater than✓ (1)

6.1.2 equal to ✓ (1)

6.1.3 less than✓ (1)

6.2 increased✓
Amount of SO_2 increased implies reverse reaction favoured✓
According to LCP an increase in temperature favours the endothermic reaction✓ (3)

6.3 Greater than✓
lowest temperature promotes the formation of product✓. Reactants lowest/products highest✓ OR

More reactants ✓ than products in the reaction vessel at C. ✓ (3)

6.4

	$SO_2(g)$	$O_2(g)$	$SO_3(g)$
Mol ratio	2	1	2
$n_{(initial)}$ (mol)	8	5	x ✓
$n_{(change)}$ (mol)	-5	-2,5	+5 ✓ ratio
$n_{(equilibrium)}$ (mol)	n = cV = 1,5 x 2 = 3✓	2,5	x + 5
$c_{(equilibrium)}$ (mol.dm^{-3})	1,5	1,25	$\frac{(x+5)}{2}$ ✓

$$K_c = \frac{[SO_3]^2}{[O_2].[SO_2]^2} \checkmark$$

$$6 = \frac{(\frac{(x+5)}{2})^2}{(1{,}5)^2(1{,}25)} \checkmark$$

$$x = 3{,}216 \text{ mol} \checkmark$$

(7)

[16]

QUESTION 7

7.1 OH^- (1)

7.2.1 It has the ability to act as an acid in one reaction(donate a proton) ✓and as a base in another reaction(accept a proton) ✓ (2)

7.2.2 Sulphate ion ✓ (1)

7.3.1 Point at which acid and base have completely reacted with each other and the indicator changes colour✓ (1)

7.3.2 greater than 7✓
Sodium oxalate is salt of a weak acid and undergoes hydrolysis ✓to produce hydroxide ions. ✓ (Accept $C_2O_4^{2-} + H_2O \rightleftharpoons HC_2O_4^- + OH^-$) ✓ (3)

7.3.3 $\frac{c_A\ V_A}{c_B\ V_B} = \frac{n_A}{n_B}$ ✓

$\frac{c_A \times 75}{0,08 \times 50,12} = \frac{1}{2}$ ✓

$C_A = 0,027$ mol. dm^{-3}

$n = cV$

$= 0,027 \times 0,075$ ✓

$= 0,002025$ mol

$m = nM$

$= 0,002025 \times 90$ ✓

$= 0,18$ g

Mass of impurities = 0,27 - 0,18 (for subtraction✓)
= 0,09 g✓ (7)

7.4 $Mg(OH)_2 \rightarrow Mg^{2+} + 2OH^-$

$n(OH^-) = 2n(Mg(OH)_2)$✓

$= 2(\frac{m}{M})$

$= 2(\frac{2,54}{58})$✓

$= 0,0876$ mol

$c(OH^-) = nV$

$= \frac{0,0876}{0,25}$ ✓

$= 0,350$ mol.dm^{-3}

If learner did not use $n(OH^-) = 2n(Mg(OH)_2$, then max 5 out of 7 marks

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

$[H_3O^+] = 1 \times 10^{-14} / 0,350$

$[H_3O^+] = 2,857 \times 10^{-14}$ mol.dm^{-3}✓

$pH = -\log[H_3O^+]$✓

$= -\log 2,857 \times 10^{-14}$✓

$= 13,544$✓

OR

$pOH = -\log[OH^-]$✓

$= -\log 0,350$✓

$= 0,456$

$pH = 14 - 0,456$✓

$= 13,544$✓ (7)

[22]

TOTAL MARKS: [75]