Western Cape Government

Education

METRO SOUTH EDUCATION DISTRICT

CURRICULUM AND
ASSESSMENT POLICY
STATEMENT

GRADE 12

PHYSICAL SCIENCES: CHEMISTRY (P2)

SEPTEMBER 2015

MARKS: 150

TIME: 3 hours

This question paper consists of 16 pages and 4 data sheets.

INSTRUCTIONS AND INFORMATION

1. Write your examination number and centre number in the appropriate spaces on the ANSWER BOOK.
2. This question paper consists of TEN 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

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) on one page of your ANSWER FOLIO'S.

1.1 Which of the following is the molecular formula of a compound that belongs to the same homologous series as but-2-yne.

A C_6H_6

B C_6H_{10}

C C_6H_{12}

D C_6H_{14}.

(2)

1.2 Which one of the following statements is INCORRECT?

A Sunflower oil undergoes hydrogenation to form margarine

B Alkynes are more reactive than alkenes

C Alkynes will discolour a bromine solution without the assistance of UV-light

D Alkanes only undergo addition reactions and alkenes undergo elimination reactions. (2)

1.3 Which one of the following organic compounds will have the LOWEST boiling point?

A Propanoic acid

B Propan-1-ol

C Propan-2-ol

D Propanal.

(2)

1.4 Consider the reaction 2 $SO_3(g) \rightarrow 2\ SO_2(g) + O_2(g)$ $\Delta H = 198\ kJ \cdot mol^{-1}$

Which one of the following is TRUE for this reaction?

When 2 moles of $SO_2(g)$ are formed …

A 198 kJ of energy are absorbed

B 198 kJ of energy are released

C 396 kJ of energy are absorbed

D 396 kJ of energy are released. (2)

1.5 Which ONE of the following is a primary nutrient needed by plants?

A N

B C

C Mg

D Na (2)

1.6 The presence of dissolved fertilisers which are rich in nitrates and phosphates can lead to …

A eutrophication

B pollution

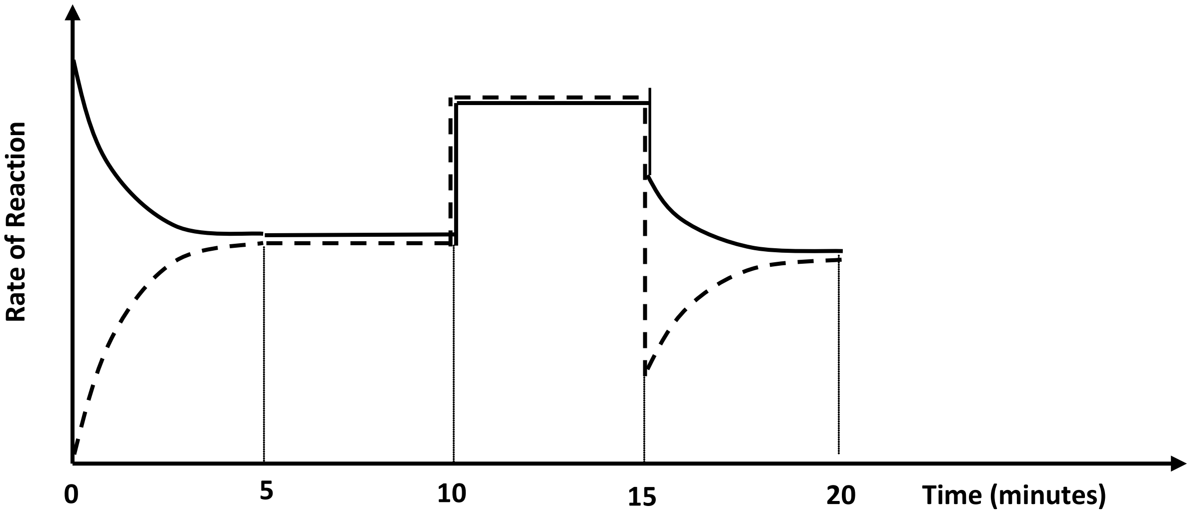
C soil erosion

D climate change. (2)

1.7 The graphs represent the change in the rate of reaction versus time for the reversible reaction that took place when an amount of hydrogen (H_2) gas and iodine (I_2) gas was sealed off in a container.

The equation for the reaction is: $H_2(g) + I_2(g) \rightleftharpoons 2HI(g) \quad \Delta H < 0$

Equilibrium was first established after 5 minutes.



What change in the conditions was made at **15 minutes** to change the rate of the reaction as indicated on the graph?

A A catalyst was added.

B The temperature was increased.

C The temperature was decreased.

D The external pressure on the reaction mixture was decreased. (2)

1.8 Which one of the following weak acids, each of concentration of 0,1 mol·dm^{-3}, will have the HIGHEST pH-value?

	Acid	**K_a-value**
A	H_2S (aq)	1,0x10^{-7}
B	H_2CO_3 (aq)	4,2x10^{-7}
C	H_2SO_3 (aq)	1,2x10^{-2}
D	$(COOH)_2$ (aq)	5,6x10^{-2}

(2)

1.9 The following equations represent two hypothetical half reactions. The reduction potentials are also provided:

$$X_2 + 2e^- \rightleftarrows 2X^- \qquad + 1,09\ V$$

$$Y^+ + e^- \rightleftarrows Y \qquad - 2,8\ V$$

Which one of the following substances from these hypothetical half-reactions has the greatest tendency to donate electrons?

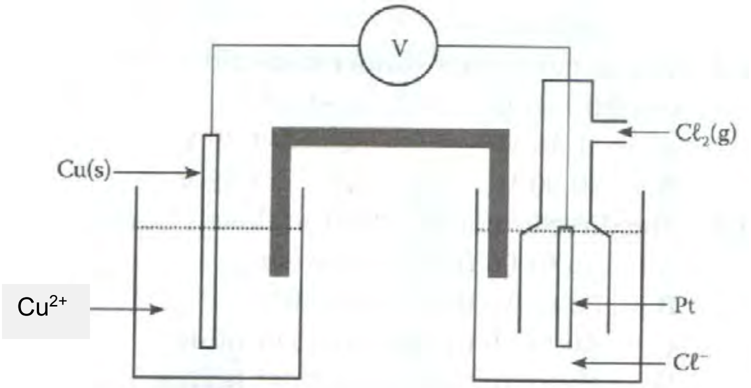
A X^-

B X_2

C Y

D Y^+. (2)

1.10 Consider the following electrochemical cell:



The correct cell notation for the above cell operating under standard conditions is:

A $Cu / Cu^{2+} // Cl^- / Cl_2$

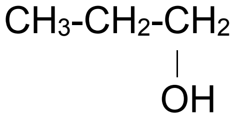
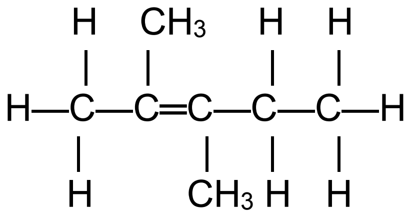
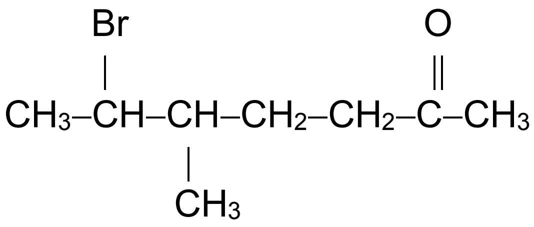
B $Pt / Cl^- // Cu^{2+} / Cu$

C $Cu^{2+} / Cu // Cl^- / Cl_2 / Pt$

D $Cu / Cu^{2+} // Cl_2 / Cl^- / Pt$ (2)

[20]

QUESTION 2

A hexanoic acid	**B**  $CH_3\text{-}CH_2\text{-}\underset{\underset{OH}{\vert}}{CH_2}$
C  $H-\overset{H}{\overset{\vert}{\underset{\underset{H}{\vert}}{C}}}-\overset{CH_3}{\overset{\vert}{C}}=\underset{\underset{CH_3}{\vert}}{C}-\overset{H}{\overset{\vert}{\underset{\underset{H}{\vert}}{C}}}-\overset{H}{\overset{\vert}{\underset{\underset{H}{\vert}}{C}}}-H$	**D**  $CH_3-\overset{Br}{\overset{\vert}{CH}}-\underset{\underset{CH_3}{\vert}}{CH}-CH_2-CH_2-\overset{O}{\overset{\Vert}{C}}-CH_3$
E $CH_3CH_2CH_2CHO$	**F** $CHCCH_3$

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

Use the information in the table (where applicable) to answer the questions that follow:

2.1 Write down only the LETTER that represents a compound that:
(a compound may be used more than once or not at all)

2.1.1 is an unsaturated compound. (1)

2.1.2 has a hydroxyl group as a functional group. (1)

2.2 Write down the

2.2.1 IUPAC name of compound C. (2)

2.2.2 IUPAC name of compound D. (2)

2.2.3 structural formula of compound F. (1)

2.3 Consider the term ISOMERS:

2.3.1 Which compound in the table is a **functional** isomer of ethyl butanoate? (1)

2.3.2 Draw the structural formula of a **chain** isomer of compound E. (2)

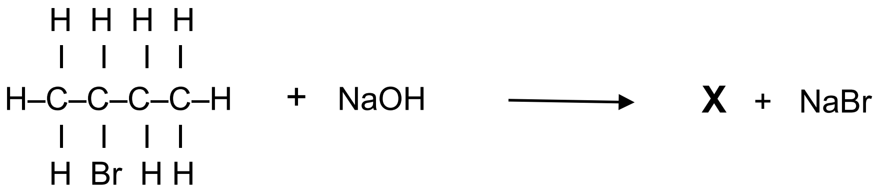
2.4 Draw the structural formula for the organic compound formed when Compounds A and B react in the presence of concentrated sulphuric acid. (3)

[13]

QUESTION 3

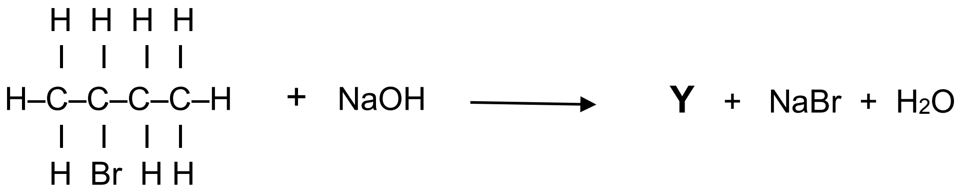
Consider the following reactions of organic compounds:

Reaction 1:



$$\begin{array}{c} H\quad H\quad H\quad H \\ |\quad\ |\quad\ |\quad\ | \\ H-C-C-C-C-H \\ |\quad\ |\quad\ |\quad\ | \\ H\quad Br\ \ H\quad H \end{array} + NaOH \longrightarrow \mathbf{X} + NaBr$$

Reaction 2:



$$\begin{array}{c} H\quad H\quad H\quad H \\ |\quad\ |\quad\ |\quad\ | \\ H-C-C-C-C-H \\ |\quad\ |\quad\ |\quad\ | \\ H\quad Br\ \ H\quad H \end{array} + NaOH \longrightarrow \mathbf{Y} + NaBr + H_2O$$

Reaction 3: $CH_3CH_2CH_2CH_2CH_2CH_3 \xrightarrow{\text{heat, catalyst}} CH_2CH_2 + \mathbf{Z} + CH_3CH_3$

Reaction 1 uses a dilute solution of NaOH while Reaction 2 uses a concentrated solution of NaOH dissolved in hot ethanol.

3.1 Consider reaction 1:

3.1.1 X is the major product formed. Draw the structural formula of X. (2)

3.1.2 Name the type of reaction. (1)

3.2 Consider reaction 2:

3.2.1 Draw the structural formula of the major product, Y. (2)

3.2.2 Name the type of reaction. (1)

3.3 Consider reaction 3:

3.3.1 Name the type of elimination reaction. (1)

3.3.2 Give the condensed formula of product Z. (2)

3.4 Compound Z is a monomer of a polymer used to make plastic bags:

3.4.1 Write down the NAME and CONDENSED STRUCTURAL FORMULA of this polymer. (3)

3.4.1 Describe the type of polymerisation that forms the polymer in QUESTION 3.4.1. (2)

[14]

QUESTION 4

4.1 Alkanes are primarily used as fuels. Consider the energy values of various compounds:

Fuel	Energy in kJ·mol^{-1}	Energy in kJ·g^{-1}
coal	394	33
petrol (C_8H_{18})	5 510	48
butane	2 636	45
methane	890	?

4.1.1 Write a balanced equation for the complete combustion of butane using molecular formulae. (3)

4.1.2 Make use of a calculation and determine which fuel releases more energy per unit mass (g): *butane* or *methane*. (3)

4.1.3 Give one reason why coal is used as a fuel of choice in many Industries despite its relatively low energy per mol ratio. (1)

4.2 Consider the boiling points of the following alkanes:

Alkane	Boiling point (^{O}C)	Molecular Mass (g.mol^{-1})
Propane	- 42	44
Methylpropane	- 11,7	58
Butane	- 0,5	58
Pentane	36	72

4.2.1 Explain why the boiling point of pentane is higher than that of butane. Refer to *structure*, *strength of intermolecular forces* (IMF's) and *energy* in your answer. (3)

4.2.2 Methylpropane is an isomer of butane. Explain why its boiling point is lower than that of butane despite having the same molecular mass. (2)

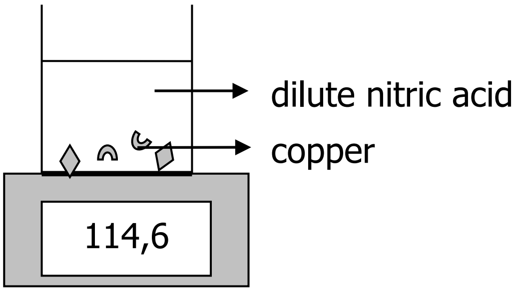
4.2.3 Why is it important, when comparing the boiling points of butane and methylpropane, that the compounds have identical (very similar) molecular mass? (1)

4.2.4 Which compound in the above table has the highest vapour pressure? (1)

[14]

QUESTION 5

Sarah wants to investigate the rate at which a reaction proceeds and places a beaker containing dilute nitric acid on a sensitive balance in a fume cupboard. She drops a few pieces of copper metal into the beaker. Mass readings of the beaker and contents are recorded every 15s, from the moment the copper metal is dropped into the acid until there is no more copper metal present.



The following results are obtained:

time (s)	mass of beaker and contents (g)	decrease in mass (g)
0	114,6	0,0
15	114,0	0,6
30	112,4	2,2
45	110,4	4,2
60	109,4	5,2
75	108,7	5,9
90	108,4	6,2
105	108,3	6,3
120	108,3	6,3
135	108,3	6,3
150	108,3	6,3

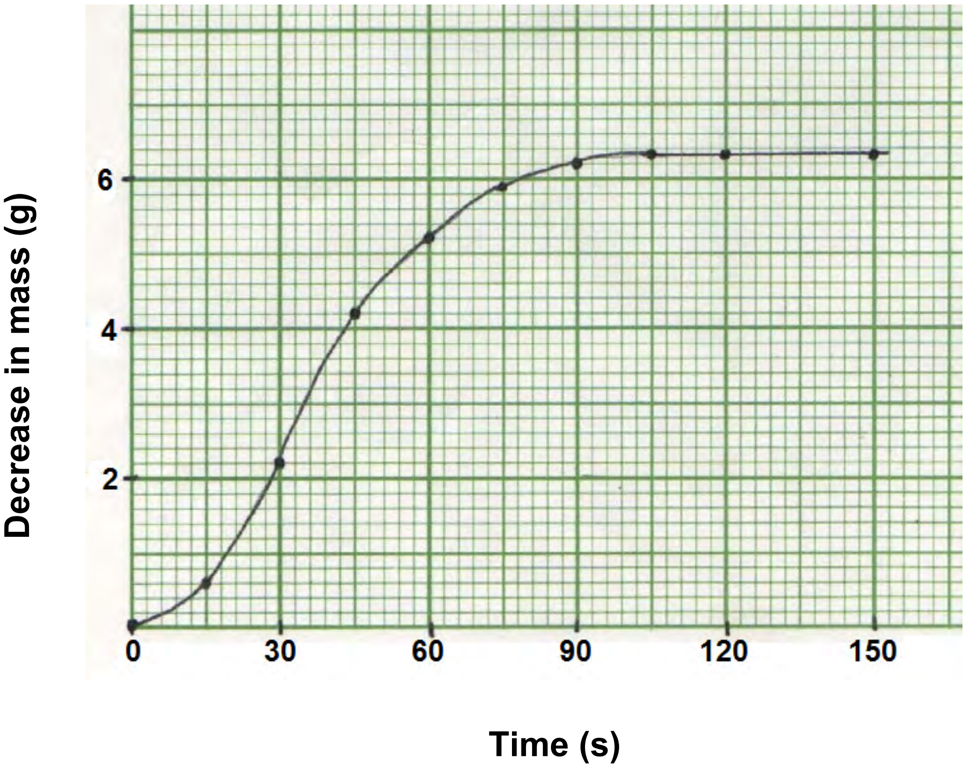
The reaction that occurs is represented by the following equation:

$$Cu(s) + 4HNO_3(aq) \rightarrow Cu(NO_3)_2(aq) + 4NO(g) + 2H_2O(l) \quad \Delta H > 0$$

5.1 Give a reason why the mass of the beaker and contents DECREASES. (1)

5.2 Use the values in the table and calculate the average rate in $g \cdot s^{-1}$ for the whole150 s of the reaction. (3)

Consider the graph below of *Decrease in mass* versus *Time*:



5.3 Give a reason for the shape of the graph from 105 s to 120 s. (1)

5.4 Give a reason why...

5.4.1 the rate of reaction INCREASES between 0 s and 30 s. (1)

5.4.2 the rate of reaction DECREASES between 45 s and 105 s. (1)

5.5 Explain your answer to QUESTION 5.4.2 in terms of the collision theory. (2)

5.6 Calculate the mass of copper used in the reaction. (4)

[13]

QUESTION 6

The rapidly increasing human population is resulting in an ever-increasing demand for food. To meet this demand, farmers apply fertiliser to the same cultivated land each year.

6.1 Explain why farmers have to apply fertiliser to the same land EACH YEAR. (1)

6.2 Write down ONE negative impact that over-fertilisation can have on humans. (2)

6.3 Sulphuric acid is an important substance used in the manufacture of fertilisers.

The equation below represents one of the steps in the industrial preparation of sulphuric acid:

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

6.3.1 Name the industrial process used to prepare sulphuric acid. (1)

6.3.2 Write down the NAME or FORMULA of the catalyst used. (1)

6.3.3 Sulphur trioxide (SO_3) is dissolved in oleum to make concentrated sulphuric acid. Write down the formula of oleum. (1)

6.3.4 Write down the FORMULA of the fertiliser formed when sulphuric acid reacts with ammonia. (2)

6.3.5 Sulphuric acid also plays a role in turning phosphates into superphosphates.

(a) Explain why this process is necessary? (1)

(b) Name one natural (organic) source of phosphates. (1)

6.4 The reaction represented in QUESTION 6.3 reaches equilibrium at 350 ^{O}C in a 2 dm^3 closed container. On analysis, it is found to contain 0,8 mol SO_2, 0,5 mol O_2 and 0,6 mol SO_3.

6.4.1 Explain what is meant by the term "*equilibrium*". (2)

6.4.2 How must the pressure in the container be changed to increase the yield of SO_3? Write only INCREASED or DECREASED. (1)

6.4.3 Explain your answer to QUESTION 6.4.2 in terms of Le Chatelier's Principle. (2)

6.4.4 The temperature is now increased to 500 ^{O}C and the reaction is allowed to reach equilibrium again at the new temperature. On analysis, it is found that 0,3 mol of SO_2 is present in the container. Calculate the equilibrium constant at 500 ^{O}C. (7)

6.4.5 At which temperature will the Kc value will be greater: 350 ^{O}C or 500 ^{O}C? (1)

[23]

QUESTION 7

Anhydrous oxalic acid is an example of a diprotic acid and thus ionises in two steps as represented by the equations below:

I: $(COOH)_2\ (aq) + H_2O\ (l) \rightleftharpoons H_3O^+\ (aq) + H(COO)_2^-\ (aq)$

II: $H(COO)_2^-\ (aq) + H_2O\ (l) \rightleftharpoons H_3O^+\ (aq) + (COO)_2^{2-}\ (aq)$

7.1 Write down:

7.1.1 what is meant by a diprotic acid ? (1)

7.1.2 the FORMULAE of each of the TWO bases in reaction II. (2)

7.1.3 the FORMULA of the substance that acts as an ampholyte in reactions I and II. (1)

7.2 "*Oxalic acid is a weak acid and thus will always form a dilute solution.*"

7.2.1 Is a weak acid always a dilute acid? (1)

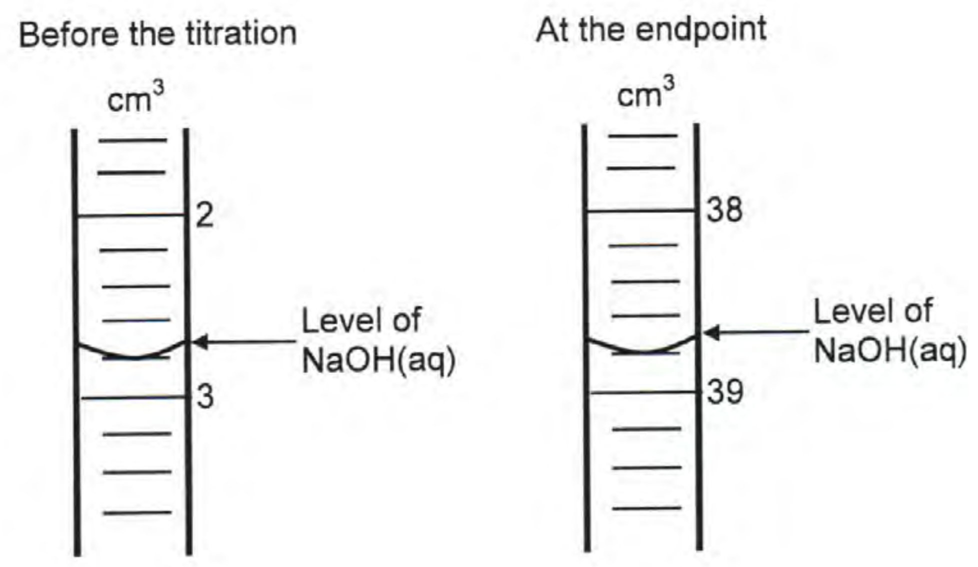
7.2.2 Explain your answer to QUESTION 7.2.1 (2)

7.3 A standard solution of $(COOH)_2$ of concentration 0,2 $mol·dm^{-3}$ is prepared by dissolving a certain amount of hydrous oxalic acid, $(COOH)_2•2H_2O$, in water in a 250 cm^3 volumetric flask. Calculate the mass of oxalic acid needed to prepare the standard solution. (4)

7.4 During a titration 25 cm^3 of the standard solution of $(COOH)_2$ prepared in QUESTION 7.3 is neutralised by a sodium hydroxide solution from a burette. The balanced equation for the reaction is:

$$(COOH)_2\,(aq) \;+\; 2\,NaOH\,(aq) \;\rightarrow\; (COONa)_2\,(aq) \;+\; 2\,H_2O\,(l)$$

The diagrams below show the burette readings before the titration commenced and at the endpoint respectively.



7.4.1 Explain what is meant by the endpoint of a titration? (1)

7.4.2 Which indicator is most suitable for this titration? Choose from: *phenolphthalein / bromothymol blue / methyl orange*. (1)

7.4.3 Use the burette readings and calculate the concentration of the sodium hydroxide solution. (5)

7.4.4 What will be the pH of the solution at the endpoint? Write only *less than 7 / equal to 7 / greater than 7.* (1)

7.4.5 Write down a balanced equation that explains your answer to QUESTION 7.4.4. (3)

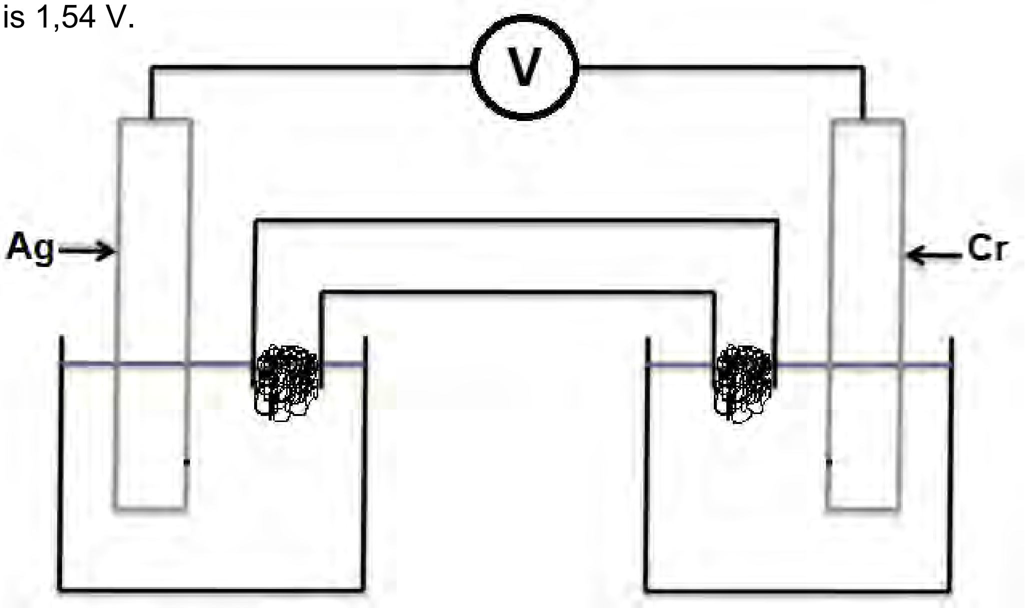
7.4.6 Use the answer obtained in QUESTION 7.4.3 to calculate the pH of the sodium hydroxide solution. (4)

[26]

QUESTION 8

Consider the electrochemical cells below:

In the first electrochemical cell, the Cr/Cr^{3+} half-cell is connected to a Ag/Ag^{+} half-cell. Both electrolytes are nitrates under standard conditions. The initial reading on the voltmeter is 1,54 V.



8.1 What type of electrochemical cell is this? (1)

8.2 State the standard conditions under which this cell operates. (2)

8.3 Write down the half-reaction that occurs at the anode. (2)

8.4 Write down the nett ionic cell reaction (make use of half-reactions.) (2)

8.5 How will the initial reading on the voltmeter change if…

8.5.1 a larger Cr plate is used? (1)
8.5.2 the Ag^{+} solution concentration is doubled? (1)
8.5.3 the Ag/Ag^{+} half-cell is replaced with an Sr/Sr^{2+} half-cell? (1)

Write only **INCREASE**, **DECREASE** or **NO CHANGE**.

8.6 The Ag/Ag^{+} half-cell is now replaced with an unknown electrode X in its electrolyte. When operating under standard conditions, the initial reading on the voltmeter is 1,08 V. After delivering current for a while, it is noticed that the Cr electrode has DECREASED in mass.

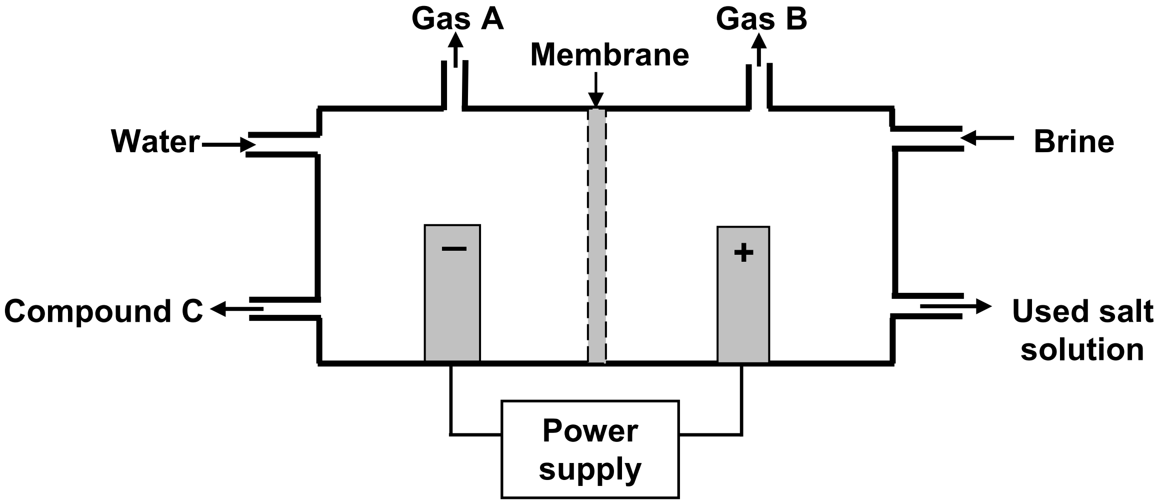
8.6.1 Which electrode is the anode: Cr or X? (2)

8.6.2 Identify metal X by calculating the standard reduction potential for X. (5)

[17]

QUESTION 9

The simplified diagram of a membrane cell used in the chlor-alkali industry is shown below. Gas **A**, gas **B** and compound **C** are the three major products formed during this process.



9.1 What is *brine*? (1)

9.2 Identify the gas B produced by the positive terminal. (2)

9.3 Consider the following standard reduction potentials:

$Na^+ + e^- \rightleftharpoons Na(s)$ $E^\ominus = -2,71\ V$

$2H_2O + 2e^- \rightleftharpoons H_2(g) + 2OH^-$ $E^\ominus = -0,83\ V$

$Cl_2(g) + 2e^- \rightleftharpoons 2Cl^-$ $E^\ominus = 1,36\ V$

9.3.1 Explain why H_2O is reduced instead of Na^+. (2)

9.3.2 Write down the FORMULA of compound C. (2)

9.4 What is the function of the membrane? (1)

9.5 Does the power supply provide AC or DC current? (1)

9.6 Give a reason for your choice in QUESTION 9.5. (1)

[10]

TOTAL: 150

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*

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

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**

TABLE 4A: STANDARD REDUCTION POTENTIALS
TABEL 4A: STANDAARD-REDUKSIEPOTENSIALE

Half-reactions/*Halfreaksies*			E^{θ} (V)
$F_2(g) + 2e^-$	$\rightleftharpoons$	$2F^-$	+ 2,87
$Co^{3+} + e^-$	$\rightleftharpoons$	Co^{2+}	+ 1,81
$H_2O_2 + 2H^+ + 2e^-$	$\rightleftharpoons$	$2H_2O$	+1,77
$MnO_4^- + 8H^+ + 5e^-$	$\rightleftharpoons$	$Mn^{2+} + 4H_2O$	+ 1,51
$C\ell_2(g) + 2e^-$	$\rightleftharpoons$	$2C\ell^-$	+ 1,36
$Cr_2O_7^{2-} + 14H^+ + 6e^-$	$\rightleftharpoons$	$2Cr^{3+} + 7H_2O$	+ 1,33
$O_2(g) + 4H^+ + 4e^-$	$\rightleftharpoons$	$2H_2O$	+ 1,23
$MnO_2 + 4H^+ + 2e^-$	$\rightleftharpoons$	$Mn^{2+} + 2H_2O$	+ 1,23
$Pt^{2+} + 2e^-$	$\rightleftharpoons$	Pt	+ 1,20
$Br_2(\ell) + 2e^-$	$\rightleftharpoons$	$2Br^-$	+ 1,07
$NO_3^- + 4H^+ + 3e^-$	$\rightleftharpoons$	$NO(g) + 2H_2O$	+ 0,96
$Hg^{2+} + 2e^-$	$\rightleftharpoons$	$Hg(\ell)$	+ 0,85
$Ag^+ + e^-$	$\rightleftharpoons$	Ag	+ 0,80
$NO_3^- + 2H^+ + e^-$	$\rightleftharpoons$	$NO_2(g) + H_2O$	+ 0,80
$Fe^{3+} + e^-$	$\rightleftharpoons$	Fe^{2+}	+ 0,77
$O_2(g) + 2H^+ + 2e^-$	$\rightleftharpoons$	H_2O_2	+ 0,68
$I_2 + 2e^-$	$\rightleftharpoons$	$2I^-$	+ 0,54
$Cu^+ + e^-$	$\rightleftharpoons$	Cu	+ 0,52
$SO_2 + 4H^+ + 4e^-$	$\rightleftharpoons$	$S + 2H_2O$	+ 0,45
$2H_2O + O_2 + 4e^-$	$\rightleftharpoons$	$4OH^-$	+ 0,40
$Cu^{2+} + 2e^-$	$\rightleftharpoons$	Cu	+ 0,34
$SO_4^{2-} + 4H^+ + 2e^-$	$\rightleftharpoons$	$SO_2(g) + 2H_2O$	+ 0,17
$Cu^{2+} + e^-$	$\rightleftharpoons$	Cu^+	+ 0,16
$Sn^{4+} + 2e^-$	$\rightleftharpoons$	Sn^{2+}	+ 0,15
$S + 2H^+ + 2e^-$	$\rightleftharpoons$	$H_2S(g)$	+ 0,14
$\mathbf{2H^+ + 2e^-}$	$\rightleftharpoons$	$\mathbf{H_2(g)}$	**0,00**
$Fe^{3+} + 3e^-$	$\rightleftharpoons$	Fe	– 0,06
$Pb^{2+} + 2e^-$	$\rightleftharpoons$	Pb	– 0,13
$Sn^{2+} + 2e^-$	$\rightleftharpoons$	Sn	– 0,14
$Ni^{2+} + 2e^-$	$\rightleftharpoons$	Ni	– 0,27
$Co^{2+} + 2e^-$	$\rightleftharpoons$	Co	– 0,28
$Cd^{2+} + 2e^-$	$\rightleftharpoons$	Cd	– 0,40
$Cr^{3+} + e^-$	$\rightleftharpoons$	Cr^{2+}	– 0,41
$Fe^{2+} + 2e^-$	$\rightleftharpoons$	Fe	– 0,44
$Cr^{3+} + 3e^-$	$\rightleftharpoons$	Cr	– 0,74
$Zn^{2+} + 2e^-$	$\rightleftharpoons$	Zn	– 0,76
$2H_2O + 2e^-$	$\rightleftharpoons$	$H_2(g) + 2OH^-$	– 0,83
$Cr^{2+} + 2e^-$	$\rightleftharpoons$	Cr	– 0,91
$Mn^{2+} + 2e^-$	$\rightleftharpoons$	Mn	– 1,18
$A\ell^{3+} + 3e^-$	$\rightleftharpoons$	$A\ell$	– 1,66
$Mg^{2+} + 2e^-$	$\rightleftharpoons$	Mg	– 2,36
$Na^+ + e^-$	$\rightleftharpoons$	Na	– 2,71
$Ca^{2+} + 2e^-$	$\rightleftharpoons$	Ca	– 2,87
$Sr^{2+} + 2e^-$	$\rightleftharpoons$	Sr	– 2,89
$Ba^{2+} + 2e^-$	$\rightleftharpoons$	Ba	– 2,90
$Cs^+ + e^-$	$\rightleftharpoons$	Cs	- 2,92
$K^+ + e^-$	$\rightleftharpoons$	K	– 2,93
$Li^+ + e^-$	$\rightleftharpoons$	Li	– 3,05

Increasing oxidising ability/*Toenemende oksiderende vermoë* ↑

Increasing reducing ability/*Toenemende reduserende vermoë* ↓

TABLE 4B: STANDARD REDUCTION POTENTIALS
TABEL 4B: STANDAARD-REDUKSIEPOTENSIALE

Increasing oxidising ability/*Toenemende oksiderende vermoë*

Increasing reducing ability/*Toenemende reduserende vermoë*

Half-reactions/*Halfreaksies*			**E^{θ} (V)**
$Li^+ + e^-$	$\rightleftharpoons$	Li	– 3,05
$K^+ + e^-$	$\rightleftharpoons$	K	– 2,93
$Cs^+ + e^-$	$\rightleftharpoons$	Cs	– 2,92
$Ba^{2+} + 2e^-$	$\rightleftharpoons$	Ba	– 2,90
$Sr^{2+} + 2e^-$	$\rightleftharpoons$	Sr	– 2,89
$Ca^{2+} + 2e^-$	$\rightleftharpoons$	Ca	– 2,87
$Na^+ + e^-$	$\rightleftharpoons$	Na	– 2,71
$Mg^{2+} + 2e^-$	$\rightleftharpoons$	Mg	– 2,36
$A\ell^{3+} + 3e^-$	$\rightleftharpoons$	$A\ell$	– 1,66
$Mn^{2+} + 2e^-$	$\rightleftharpoons$	Mn	– 1,18
$Cr^{2+} + 2e^-$	$\rightleftharpoons$	Cr	– 0,91
$2H_2O + 2e^-$	$\rightleftharpoons$	$H_2(g) + 2OH^-$	– 0,83
$Zn^{2+} + 2e^-$	$\rightleftharpoons$	Zn	– 0,76
$Cr^{3+} + 3e^-$	$\rightleftharpoons$	Cr	– 0,74
$Fe^{2+} + 2e^-$	$\rightleftharpoons$	Fe	– 0,44
$Cr^{3+} + e^-$	$\rightleftharpoons$	Cr^{2+}	– 0,41
$Cd^{2+} + 2e^-$	$\rightleftharpoons$	Cd	– 0,40
$Co^{2+} + 2e^-$	$\rightleftharpoons$	Co	– 0,28
$Ni^{2+} + 2e^-$	$\rightleftharpoons$	Ni	– 0,27
$Sn^{2+} + 2e^-$	$\rightleftharpoons$	Sn	– 0,14
$Pb^{2+} + 2e^-$	$\rightleftharpoons$	Pb	– 0,13
$Fe^{3+} + 3e^-$	$\rightleftharpoons$	Fe	– 0,06
$\mathbf{2H^+ + 2e^-}$	$\rightleftharpoons$	$\mathbf{H_2(g)}$	**0,00**
$S + 2H^+ + 2e^-$	$\rightleftharpoons$	$H_2S(g)$	+ 0,14
$Sn^{4+} + 2e^-$	$\rightleftharpoons$	Sn^{2+}	+ 0,15
$Cu^{2+} + e^-$	$\rightleftharpoons$	Cu^+	+ 0,16
$SO_4^{2-} + 4H^+ + 2e^-$	$\rightleftharpoons$	$SO_2(g) + 2H_2O$	+ 0,17
$Cu^{2+} + 2e^-$	$\rightleftharpoons$	Cu	+ 0,34
$2H_2O + O_2 + 4e^-$	$\rightleftharpoons$	$4OH^-$	+ 0,40
$SO_2 + 4H^+ + 4e^-$	$\rightleftharpoons$	$S + 2H_2O$	+ 0,45
$Cu^+ + e^-$	$\rightleftharpoons$	Cu	+ 0,52
$I_2 + 2e^-$	$\rightleftharpoons$	$2I^-$	+ 0,54
$O_2(g) + 2H^+ + 2e^-$	$\rightleftharpoons$	H_2O_2	+ 0,68
$Fe^{3+} + e^-$	$\rightleftharpoons$	Fe^{2+}	+ 0,77
$NO_3^- + 2H^+ + e^-$	$\rightleftharpoons$	$NO_2(g) + H_2O$	+ 0,80
$Ag^+ + e^-$	$\rightleftharpoons$	Ag	+ 0,80
$Hg^{2+} + 2e^-$	$\rightleftharpoons$	$Hg(\ell)$	+ 0,85
$NO_3^- + 4H^+ + 3e^-$	$\rightleftharpoons$	$NO(g) + 2H_2O$	+ 0,96
$Br_2(\ell) + 2e^-$	$\rightleftharpoons$	$2Br^-$	+ 1,07
$Pt^{2+} + 2\,e^-$	$\rightleftharpoons$	Pt	+ 1,20
$MnO_2 + 4H^+ + 2e^-$	$\rightleftharpoons$	$Mn^{2+} + 2H_2O$	+ 1,23
$O_2(g) + 4H^+ + 4e^-$	$\rightleftharpoons$	$2H_2O$	+ 1,23
$Cr_2O_7^{2-} + 14H^+ + 6e^-$	$\rightleftharpoons$	$2Cr^{3+} + 7H_2O$	+ 1,33
$C\ell_2(g) + 2e^-$	$\rightleftharpoons$	$2C\ell^-$	+ 1,36
$MnO_4^- + 8H^+ + 5e^-$	$\rightleftharpoons$	$Mn^{2+} + 4H_2O$	+ 1,51
$H_2O_2 + 2H^+ +2\,e^-$	$\rightleftharpoons$	$2H_2O$	+1,77
$Co^{3+} + e^-$	$\rightleftharpoons$	Co^{2+}	+ 1,81
$F_2(g) + 2e^-$	$\rightleftharpoons$	$2F^-$	+ 2,87