Province of the
EASTERN CAPE
EDUCATION

Iphondo leMpuma Kapa: Isebe leMfundo
Provinsie van die Oos Kaap: Departement van Onderwys
Porafensie Ya Kapa Botjahabela: Lefapha la Thuto

NATIONAL
SENIOR CERTIFICATE

GRADE 11

NOVEMBER 2025

PHYSICAL SCIENCES P2
(CHEMISTRY)

MARKS: **150**

TIME: **3 hours**

This question paper consists of 21 pages, including 4 data sheets.

INSTRUCTIONS AND INFORMATION

1. Write your name and surname in the appropriate space 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 sub questions, e.g. between QUESTION 2.1 and QUESTION 2.2.
6. You may use a non-programmable calculator.
7. You may use appropriate mathematical instruments.
8. Show ALL formulae and substitutions in ALL calculations.
9. Round off your FINAL numerical answers to a minimum of TWO decimal places.
10. Give brief motivations, discussions, etc. where required.
11. You are advised to use the attached DATA SHEETS.
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 numbers (1.1 to 1.10) in the ANSWER BOOK, for example 1.11 E.

1.1 Which ONE of the following molecules contains a dative covalent bond?

A H_2O

B NH_3

C BF_3

D NH_4^+ (2)

1.2 Consider the chemical bonds shown below:

C – C	C = C	C ≡ C

Which ONE of the following combinations regarding the bond length and bond energy is CORRECT?

SHORTEST BOND LENGTH		HIGHEST BOND ENERGY
A	C – C	C – C
B	C = C	C = C
C	C ≡ C	C ≡ C
D	C – C	C ≡ C

(2)

1.3 Which ONE of the following substances have ION DIPOLE FORCES between its molecules?

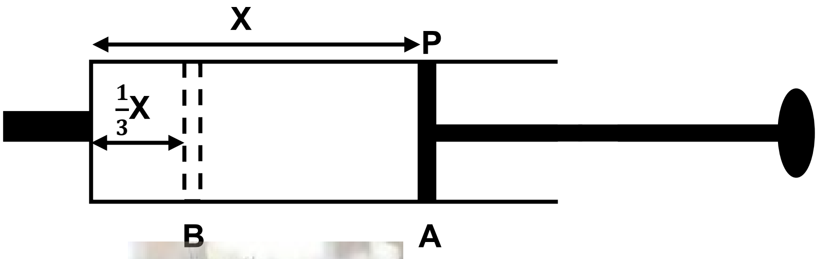
A H_2O (ℓ)

B CO_2 (g)

C NaCℓ (aq)

D NaCℓ (s) (2)

1.4 The diagram below shows a gas syringe containing a certain gas. When the plunger is at position **A** the volume occupied by the gas is **X** and exerts a pressure **P**. When the plunger moves to position **B** the volume occupied by the gas is $\frac{1}{3}$ **X**.



What is the DIFFERENCE in pressure exerted by the gas between points **A** and **B**?

A 3 **P**

B $\frac{2}{3}$ **P**

C $\frac{1}{3}$ **P**

D 2 **P** (2)

1.5 Consider the following statement regarding the activated complex during a chemical reaction:

(I) The activation energy must be overcome to reach the activated complex.

(II) It is the unstable transition state from reactants to products.

(III) It is the energy released or absorbed during a chemical reaction.

Which of the above statement(s) is/are CORRECT about the activated complex?

A **II** and **III** only

B **II** only

C **I** and **II** only

D **I** only (2)

1.6 Consider the balanced equation:

$$Na_2CO_3\ (aq)\ +\ 2\ HC\ell\ (aq)\ \rightarrow\ 2\ NaC\ell\ (aq) + H_2O\ (\ell) + CO_2\ (g)$$

1 mol of Na_2CO_3 reacts with 1 mol of $HC\ell$ to yield 0,2 mol of CO_2.

Which ONE of the following combinations is CORRECT regarding the reaction?

	Limiting reagent	**% yield of CO_2**
A	Na_2CO_3	40%
B	Na_2CO_3	20%
C	$HC\ell$	40%
D	$HC\ell$	20%

(2)

1.7 Consider the incomplete equation below:

$$H_2\mathbf{Y} + 2\ NaOH \rightarrow Na_2\mathbf{Y} + 2\ H_2O$$

The formula of **Y** is …

A $C\ell^-$

B SO_4^{2-}

C NO_3^-

D PO_4^{3-} (2)

1.8 Consider the following equation:

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

The bases in the above reaction are …

A $(COOH)_2$ and H_2O

B $(COO)_2^{2-}$ and H_3O^+

C H_2O and $(COO)_2^{2-}$

D $(COOH)_2$ and $(COO)_2^{2-}$ (2)

1.9 Consider the reaction below:

$$5\ Zn + 2\ MnO_4^- + 16\ H^+ \rightarrow 5\ Zn^{2+} + 2\ Mn^{2+} + 8\ H_2O$$

The reducing agent in the above reaction is …

A Zn

B MnO_4^-

C H^+

D Mn^{2+} (2)

1.10 How many electrons are needed to reduce 2 mol of H_2O to 2 mol of OH^- and 1 mol of H_2?

A 2

B 3

C 4

D 5 (2)

[20]

QUESTION 2 (Start on a new page.)

Consider the following substances (**A**–**D**) in the table below:

SUBSTANCE	CHEMICAL FORMULA
A	$HOC\ell$
B	NF_3
C	H_2S
D	HCN

2.1 Define the term *chemical bond*. (2)

2.2 Draw the Lewis structures for the following molecules.

2.2.1 $HOC\ell$ (2)

2.2.2 HCN (2)

2.3 Write down the name of the molecular shape for:

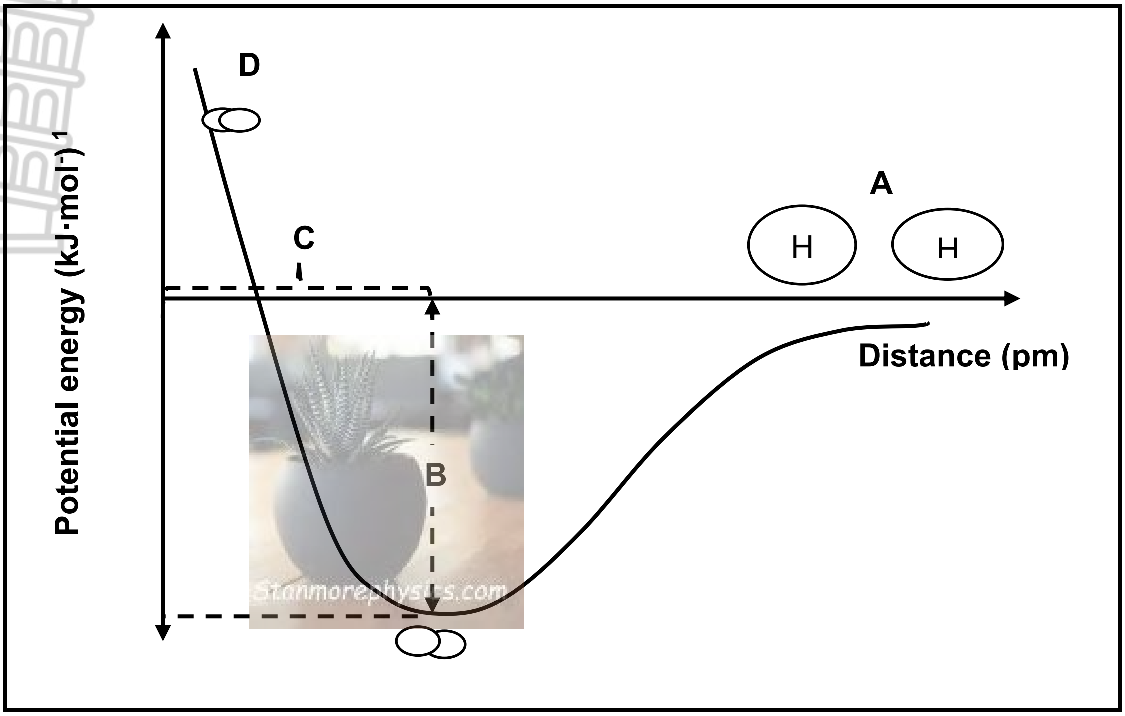
2.3.1 H_2S (1)

2.3.2 NF_3 (1)

2.4 Is NF_3 a POLAR or NON-POLAR molecule?

Fully explain the answer. (4)

2.5 Two hydrogen atoms form a bond according to the energy profile graph shown below.



Use the letters **A**, **B**, **C** or **D** as it appears on the graph above to identify the following:

2.5.1 Bond energy (1)

2.5.2 Point when repulsive forces are stronger than the attractive forces (1)

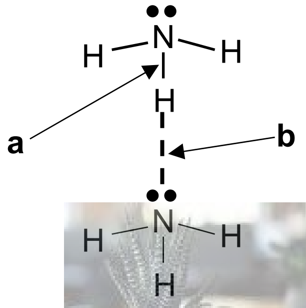
2.5.3 Explain the formation of H_2 from the graph.

Refer to the electrostatic force between the protons and electrons and energy involved. (2)

[16]

QUESTION 3 (Start on a new page.)

3.1 The diagram below is used to demonstrate the differences between intermolecular forces and intramolecular forces (chemical bonds) between two NH_3 molecules.



3.1.1 Write down the name of the predominant intermolecular force that is represented by letter **(b)** in the diagram above. (1)

3.1.2 Write down TWO requirements for the formation of the force named in QUESTION 3.1.1. (2)

3.1.3 Write down the name of bond labelled **(a).** (1)

3.1.4 Which ONE (**a** or **b**) requires the highest amount of energy to break/overcome its forces? (1)

3.2 Consider the boiling points of the hydrogen halides on group 16 as shown on the table below.

Hydrogen halides		**Boiling point (°C)**
A	H_2S	- 60
B	H_2Se	- 41
C	H_2Te	- 2

3.2.1 Define the term *boiling point*. (2)

3.2.2 Write down the phase of the hydrogen halides at room temperature. (1)

3.2.3 Explain the trend observed in the boiling points of the hydrogen halides by referring to the molecular size and energy involved. (3)

3.2.4 Which hydrogen halide (H_2S, H_2Se or H_2Te) will have the lowest vapour pressure at a certain temperature?

Give a reason for the answer. (2)

3.2.5 How will the boiling point of HF compare to that of H_2S?

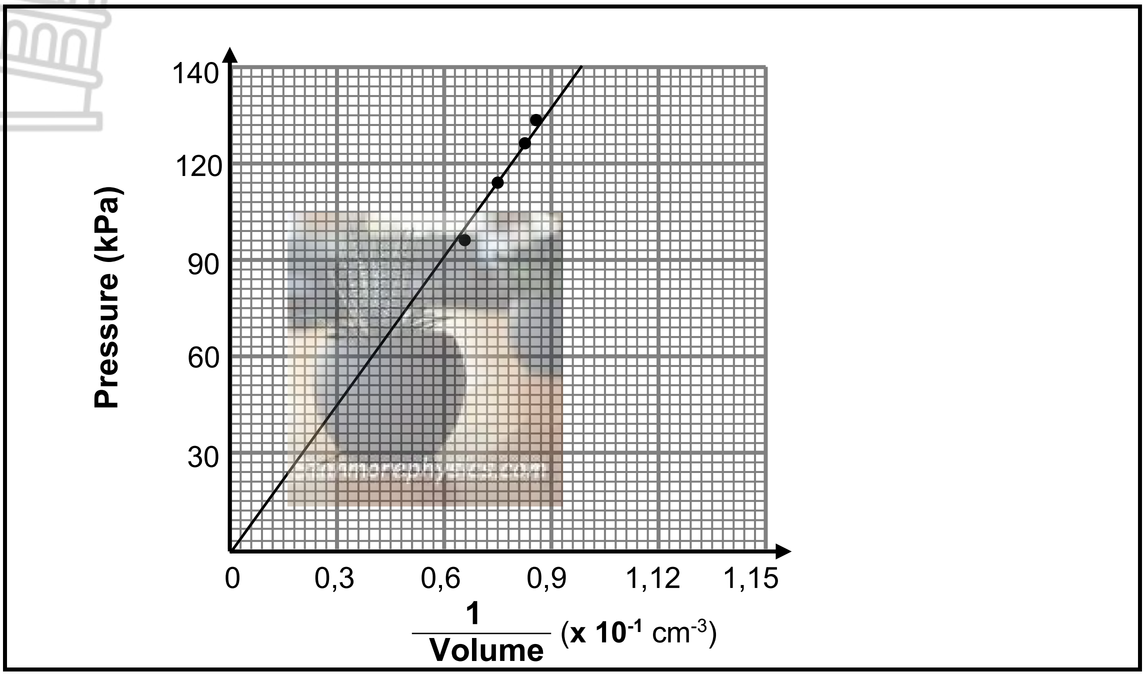
Choose from HIGHER THAN, LOWER THAN or EQUAL TO. (1)

3.2.6 Explain the answer in QUESTION 3.2.5 by referring to type of intermolecular forces and energy involved. (4)

[18]

QUESTION 4 (Start on a new page.)

A group of learners investigated the relationship between the pressure and volume of a certain gas. The graph of the pressure versus inverse of volume was obtained from the data in the investigation.



4.1 Name the gas law that is investigated. (1)

4.2 From the investigation write down:

4.2.1 An investigative question for this investigation (2)

4.2.2 TWO controlled variables for this investigation (2)

4.3 Explain the relationship observed between pressure and volume by referring to the kinetic molecular theory. (3)

4.4 Determine the volume that the gas occupied at 96 kPa. (2)

4.5 Calculate the volume occupied by the gas at 252 kPa. (4)

4.6 It is observed that the gas does not obey the gas law named in QUESTION 4.1 at very high pressure. Explain this observation. (3)

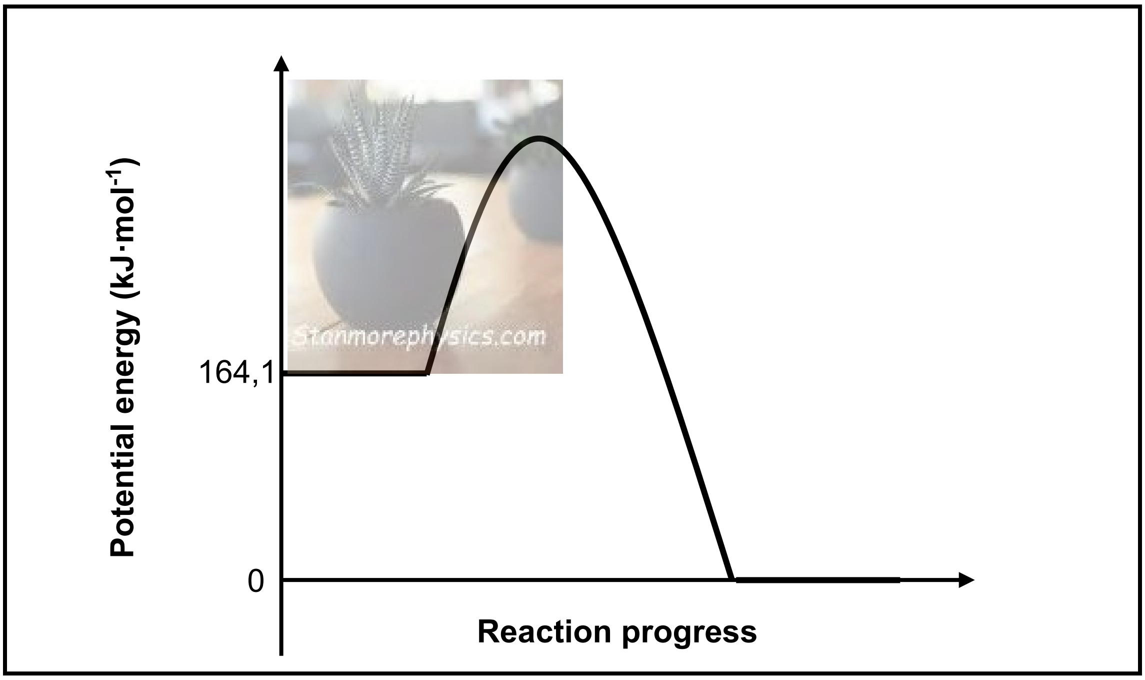
[17]

QUESTION 5 (Start on a new page.)

Consider the balanced equation that shows the decomposition of nitrogen oxide (N_2O) into nitrogen (N_2) and oxygen (O_2) molecules.

$$2\ N_2O\ (g) \rightarrow 2\ N_2\ (g) + O_2\ (g)$$

The energy profile graph is drawn for the decomposition of N_2O.



5.1 Define the term *heat of reaction.* (2)

5.2 Is the above reaction ENDOTHERMIC or EXOTHERMIC?

Give a reason for the answer. (2)

5.3 Calculate the heat of reaction. (2)

5.4 The energy that is released from the formation of N_2 and O_2 molecules are 405,30 $kJ \cdot mol^{-1}$.

Calculate the activation energy for this reaction. (3)

5.5 Redraw the energy profile graph in your ANSWER BOOK.

Draw on the same set of axes the effect that a catalyst would have on the energy profile graph.

Indicate the graph of the catalyst with a dotted line. (2)

[11]

QUESTION 6 (Start on a new page.)

A certain organic compound ($C_xH_yO_z$) is composed of 54,54 g of carbon; 9,1 g of hydrogen and 36,36 g of oxygen and has a molecular mass of 88 g·mol^{-1}.

6.1 Define the term *molar mass.* (2)

6.2 Determine by calculation, the molecular formula of the organic compound ($C_xH_yO_z$) (7)

6.3 A bottle in a laboratory contains an unknown **metal** hydroxide (**M**OH). A lab technician dissolves 1,826 g of the metal hydroxide to make a 100 cm^3 solution. Upon analysis it was found that the concentration of the metal hydroxide is 0,326 mol·dm^{-3}.

6.3.1 Define the term *concentration.* (2)

6.3.2 Determine by calculation, the name of the metal hydroxide. (5)

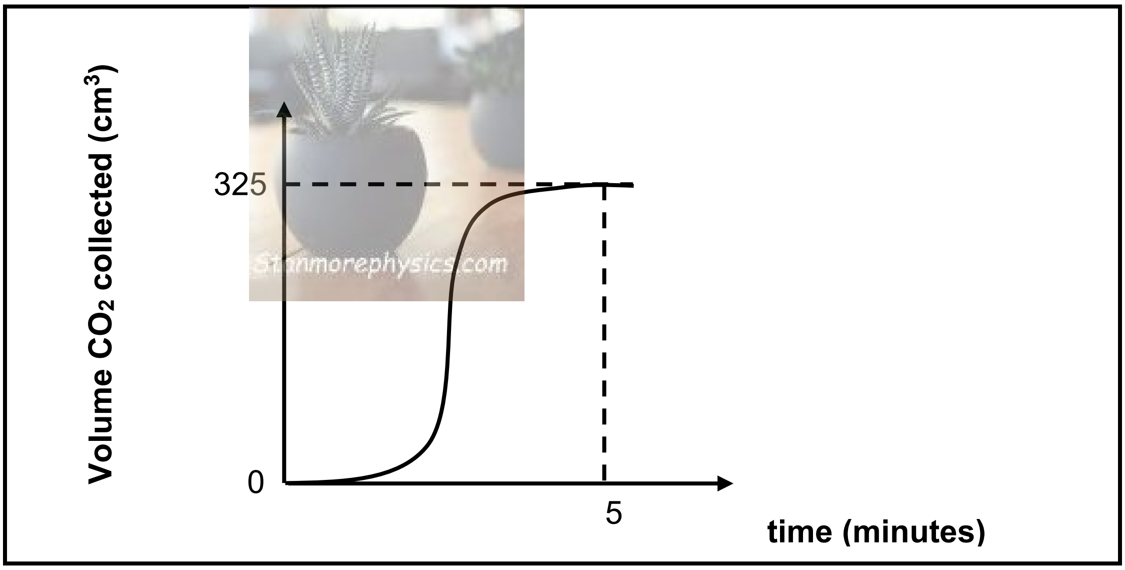
[16]

QUESTION 7 (Start on a new page.)

Learners crushed eggshells to determine the percentage of calcium carbonate that are found in a 1,5 g sample. The crushed eggshells are allowed to react with EXCESS hydrochloric acid. The balanced equation for the reaction:

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

The calcium carbonate reacted completely in 5 minutes. The graph below shows the carbon dioxide gas that was collected at STP.



7.1 Define the term *limiting reagent.* (2)

Calculate the:

7.2 Mass of calcium carbonate contained in the 1,5 g sample of eggshells (5)

7.3 Percentage purity of calcium carbonate in 1,5 g of eggshells (2)

7.4 Number of molecules of HCℓ that reacted with calcium carbonate (4)

7.5 How does the carbon dioxide gas produced after 8 min compare to the carbon dioxide gas produced at 5 min?

Write down only HIGHER THAN, SMALLER THAN or EQUAL TO.

Give a reason for the answer. (2)

[15]

QUESTION 8 (Start on a new page.)

Consider the reactions below:

$$HSO_4^- (aq) + H_2O (\ell) \rightarrow H_3O^+(aq) + SO_4^{2-} (aq)$$

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

8.2 From the reaction above, write down the:

8.2.1 Formulae of the TWO substances that can act as ampholytes (2)

8.2.2 Conjugate base of HSO_4^- (1)

8.3 500 cm^3 of NaOH are added to 500 cm^3 of HNO_3 with a concentration of 0,25 mol·dm^{-3}. The temperature of the reaction mixture rises during the reaction. The pH of the final solution is 2,8. The balanced equation is shown below.

$$NaOH (aq) + HNO_3 (aq) \rightarrow NaNO_3 (aq) + H_2O(\ell)$$

8.3.1 Describe the term *acid base indicator*. (2)

8.3.2 Write down the colour when bromothymol blue is added to HNO_3 solution. (1)

8.3.3 Is the reaction above EXOTHERMIC or ENDOTHERMIC? Give a reason for the answer. (2)

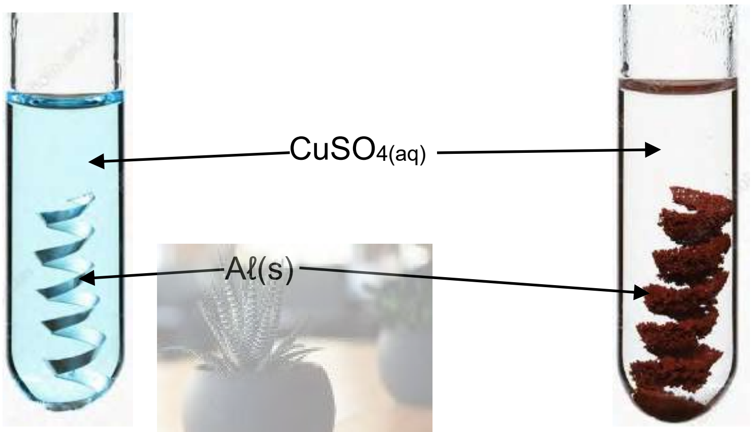
8.3.4 Calculate the concentration of H_3O^+ in the final solution. (3)

8.3.5 Calculate the initial concentration of NaOH solution. (7)

[20]

QUESTION 9 (Start on a new page.)

A clean piece of aluminium metal strip is placed in a copper sulphate ($CuSO_4$) solution. The reaction was observed again after 2 hours.



At the start

After 2 hours

After 2 hours it was observed that the blue solution turned colourless and the shiny metallic aluminium turned brown.

The net ionic balanced equation for the reaction is given below:

$$2\,A\ell\,(s) + 3\,Cu^{2+}(aq) \rightarrow 3\,Cu\,(s) + 2\,A\ell^{3+}(aq)$$

9.1 Explain the term *oxidation* in terms of oxidation number. (2)

9.2 Write down the chemical symbol of a substance that is …

9.2.1 oxidised. (2)

9.2.2 the oxidising agent. (2)

9.3 Will the oxidation number of the sulphate ion INCREASE, DECREASE or REMAIN THE SAME during this reaction?

Give a reason for the answer. (2)

9.4 Acidified potassium dichromate ($K_2Cr_2O_7$) is an orange solution due to the presence of the dichromate ions ($Cr_2O_7^{2-}$).

9.4.1 Determine the oxidation number of chromium (Cr) in $Cr_2O_7^{2-}$. (2)

When iron sulphate solution ($FeSO_4$) is added to acidified potassium dichromate ($K_2Cr_2O_7$) solution, the solution changes colour from orange to green after a few seconds. During this reaction Fe^{2+} ions were oxidised to Fe^{3+} and $Cr_2O_7^{2-}$ is reduced to Cr^{3+}

9.4.2 Will the concentration of the potassium dichromate INCREASE, DECREASE or REMAINS THE SAME as the reaction proceeds?

Explain the answer by referring to the relevant half-reaction. (4)

9.4.3 Write down the balance net ionic equation for this reaction. (3)

[17]

TOTAL: 150

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DATA FOR PHYSICAL SCIENCES GRADE 11
PAPER 2 (CHEMISTRY)

GEGEWENS VIR FISIESE WETENSKAPPE GRAAD 11
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 teen 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 se konstante	N_A	$6{,}02 \times 10^{23}\ mol^{-1}$

TABLE 2: FORMULAE/TABEL 2: FORMULES

$p_1V_1 = p_2V_2$	$n = \frac{m}{M}$	$K_w = [H_3O^+][OH^-] = 1x10^{-14}$ at/by 298 K
$n = \frac{N}{N_A}$ **OR/*OF***	$n = \frac{V}{V_M}$	$pH = -log[H_3O^+]$
$c = \frac{n}{V}$ **OR/*OF*** $c = \frac{m}{MV}$	$\frac{c_aV_a}{c_bV_b} = \frac{n_a}{n_b}$	

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

KEY/ *SLEUTEL*

Atoomgetal
Atomic number → 29

Elektronegatiwiteit
Electronegativity → 1,9

Simbool
Symbol → Cu

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

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

Increasing oxidising ability/*Toenemende oksiderende vermoë*

Half-reactions/*Halfreaksies*			E^{θ} (V)
$F_2(g) + 2e^-$	⇌	$2F^-$	+ 2,87
$Co^{3+} + e^-$	⇌	Co^{2+}	+ 1,81
$H_2O_2 + 2H^+ + 2e^-$	⇌	$2H_2O$	+ 1,77
$MnO_4^- + 8H^+ + 5e^-$	⇌	$Mn^{2+} + 4H_2O$	+ 1,51
$Cℓ_2(g) + 2e^-$	⇌	$2Cℓ^-$	+ 1,36
$Cr_2O_7^{2-} + 14H^+ + 6e^-$	⇌	$2Cr^{3+} + 7H_2O$	+ 1,33
$O_2(g) + 4H^+ + 4e^-$	⇌	$2H_2O$	+ 1,23
$MnO_2 + 4H^+ + 2e^-$	⇌	$Mn^{2+} + 2H_2O$	+ 1,23
$Pt^{2+} + 2e^-$	⇌	Pt	+ 1,20
$Br_2(ℓ) + 2e^-$	⇌	$2Br^-$	+ 1,07
$NO_3^- + 4H^+ + 3e^-$	⇌	$NO(g) + 2H_2O$	+ 0,96
$Hg^{2+} + 2e^-$	⇌	$Hg(ℓ)$	+ 0,85
$Ag^+ + e^-$	⇌	Ag	+ 0,80
$NO_3^- + 2H^+ + e^-$	⇌	$NO_2(g) + H_2O$	+ 0,80
$Fe^{3+} + e^-$	⇌	Fe^{2+}	+ 0,77
$O_2(g) + 2H^+ + 2e^-$	⇌	H_2O_2	+ 0,68
$I_2 + 2e^-$	⇌	$2I^-$	+ 0,54
$Cu^+ + e^-$	⇌	Cu	+ 0,52
$SO_2 + 4H^+ + 4e^-$	⇌	$S + 2H_2O$	+ 0,45
$2H_2O + O_2 + 4e^-$	⇌	$4OH^-$	+ 0,40
$Cu^{2+} + 2e^-$	⇌	Cu	+ 0,34
$SO_4^{2-} + 4H^+ + 2e^-$	⇌	$SO_2(g) + 2H_2O$	+ 0,17
$Cu^{2+} + e^-$	⇌	Cu^+	+ 0,16
$Sn^{4+} + 2e^-$	⇌	Sn^{2+}	+ 0,15
$S + 2H^+ + 2e^-$	⇌	$H_2S(g)$	+ 0,14
$2H^+ + 2e^-$	**⇌**	**$H_2(g)$**	**0,00**
$Fe^{3+} + 3e^-$	⇌	Fe	– 0,06
$Pb^{2+} + 2e^-$	⇌	Pb	– 0,13
$Sn^{2+} + 2e^-$	⇌	Sn	– 0,14
$Ni^{2+} + 2e^-$	⇌	Ni	– 0,27
$Co^{2+} + 2e^-$	⇌	Co	– 0,28
$Cd^{2+} + 2e^-$	⇌	Cd	– 0,40
$Cr^{3+} + e^-$	⇌	Cr^{2+}	– 0,41
$Fe^{2+} + 2e^-$	⇌	Fe	– 0,44
$Cr^{3+} + 3e^-$	⇌	Cr	– 0,74
$Zn^{2+} + 2e^-$	⇌	Zn	– 0,76
$2H_2O + 2e^-$	⇌	$H_2(g) + 2OH^-$	– 0,83
$Cr^{2+} + 2e^-$	⇌	Cr	– 0,91
$Mn^{2+} + 2e^-$	⇌	Mn	– 1,18
$Aℓ^{3+} + 3e^-$	⇌	$Aℓ$	– 1,66
$Mg^{2+} + 2e^-$	⇌	Mg	– 2,36
$Na^+ + e^-$	⇌	Na	– 2,71
$Ca^{2+} + 2e^-$	⇌	Ca	– 2,87
$Sr^{2+} + 2e^-$	⇌	Sr	– 2,89
$Ba^{2+} + 2e^-$	⇌	Ba	– 2,90
$Cs^+ + e^-$	⇌	Cs	– 2,92
$K^+ + e^-$	⇌	K	– 2,93
$Li^+ + e^-$	⇌	Li	– 3,05

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

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Porafensie Ya Kapa Botjahabela: Lefapha la Thuto

NATIONAL SENIOR CERTIFICATE/ *NASIONALE SENIOR SERTIFIKAAT*

GRADE/*GRAAD* 11

NOVEMBER 2025

PHYSICAL SCIENCES: CHEMISTRY P2 MARKING GUIDELINE/ *FISIESE WETENSKAPPE: CHEMIE V2 NASIENRIGLYN*

MARKS/*PUNTE*: **150**

This marking guideline consists of 16 pages./
Hierdie nasienriglyn bestaan uit 16 bladsye.

QUESTION 1/*VRAAG 1*

1.1	D ✓✓	(2)
1.2	C ✓✓	(2)
1.3	C ✓✓	(2)
1.4	D ✓✓	(2)
1.5	C ✓✓	(2)
1.6	C ✓✓	(2)
1.7	B ✓✓	(2)
1.8	C ✓✓	(2)
1.9	A ✓✓	(2)
1.10	A ✓✓	(2)
		[20]

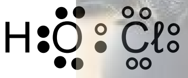
QUESTION 2/*VRAAG 2*

2.1

Marking criteria/Nasienriglyne
If any of the underlined key words/phrases in the **correct context** are omitted: - 1 mark per word/phrase.
Indien enige van die sleutelwoorde/frases in die korrekte konteks weggelaat word: - 1 punt per word/frase.

A chemical bond is a mutual attraction between two atoms resulting from the simultaneous attraction between their nuclei and the outer electrons.✓✓
'n Chemiese binding is 'n wedersydse aantrekkingskrag tussen twee atome wat voortspruit uit die gelyktydige aantrekkingskrag tussen hul kerne en die buitenste elektrone. (2)

2.2 2.2.1



$H:\overset{\cdot\cdot}{\underset{\cdot\cdot}{O}}:\overset{\circ\circ}{\underset{\circ\circ}{C\ell}}{:}$ ✓✓ (2)

2.2.2

$H:C\,\vdots\vdots\,N{:}$ ✓✓ (2)

2.3 2.3.1 Bent/ Angular ✓
Gebuig/ Hoekig (1)

2.3.2 Trigonal – pyramidal ✓
Trigonaal – piramidaal (1)

2.4 Polar ✓

- F is more electronegative than N / F attracts the bond electrons more towards itself / ΔEN = 4,0 – 3,0 = 1✓
- N-F bond is polar ✓
- NF_3 molecular geometry is assymetrical. ✓

Polêr

- *F is meer elektronegatief as N / F trek die bindingselektrone meer na homself toe / ΔEN = 4,0 – 3,0 = 1*
- *N-F-binding is polêr*
- *NF_3 molekulêre geometrie is assimmetries* (4)

2.5 2.5.1 **B** ✓ (1)

2.5.2 **D** ✓ (1)

2.5.3
- As the two H atoms approaches each other, the electrons of the one H atom is attracted to the nucleus (protons) of the other H atom. ✓ The protons repel and electrons repel from the two H atoms.
- Attractive forces are greater than the repulsive forces, therefore the potential energy of the system decreases until it reaches the minimum value (most stable state) ✓

- *Soos die twee H-atome nader aan mekaar kom, word die elektrone van die een H-atoom na die kern (protone) van die ander H-atoom aangetrek. Die protone stoot mekaar af en die elektrone stoot die twee H-atome af.*
- *Aantrekkingskragte is groter as die afstotingskragte, daarom neem die potensiële energie van die stelsel af totdat dit die minimum waarde bereik (mees stabiele staat)* (2)

[16]

QUESTION 3/*VRAAG 3*

3.1 3.1.1 Hydrogen bond / *Waterstofbinding* ✓ (1)

3.1.2
- A hydrogen atom covalently bonded to a highly electronegative atom. ✓
- A lone pair of electrons on a nearby highly electronegative atom. ✓

- *'n Waterstofatoom wat kovalent verbind aan 'n hoë elektronegatiewe atoom.*
- *'n Alleen elektronpaar op 'n nabygeleë hoë elektronegatiewe atoom.* (2)

3.1.3 (Polar) covalent bond/(*Polêre) kovalente binding* ✓ (1)

3.1.4 a ✓ (1)

3.2.1

> **<u>Marking criteria/Nasienriglyne</u>**
> If any of the underlined key words/phrases in the **correct context** are omitted: - 1 mark per word/phrase.
> *Indien enige van die sleutelwoorde/frases in die korrekte konteks weggelaat word: - 1 punt per word/frase.*

The <u>temperature</u> at which the <u>vapour pressure</u> of a substance <u>equals</u> the <u>atmospheric pressure</u> ✓✓

Die <u>temperatuur</u> waarby die <u>dampdruk</u> van 'n stof <u>gelyk</u> is aan die <u>atmosferiese</u> <u>druk</u> (2)

3.2.2 Gas ✓ (1)

3.2.3

> **<u>MARKING CRITERIA/*NASIENKRITERIA*</u>**
> - State the increase in molecular size from H_2S – H_2Te
> - State the relationship between molecular size and London forces correctly.
> - Refer to the energy involved.
>
> - *Noem die toename in molekulêre grootte van H_2S – H_2Te*
> - *Stel die verwantskap tussen molekulêre grootte en London kragte korrek.*
> - *Verwys na die energie betrokke.*

- From H_2S to H_2Te the molecular size increases. ✓
- As the molecular size increases so does the London forces. ✓
- More energy is needed to overcome the intermolecular forces from H_2S to H_2Te ✓

- *Van H_2S na H_2Te neem die molekulêre grootte toe*
- *Soos die molekulêre grootte toeneem, neem die London-kragte ook toe.*
- *Meer energie is nodig om die intermolekulêre kragte van H_2S na H_2Te te oorkom* (3)

3.2.4 H_2Te ✓

It has the highest boiling point. / *Dit het die hoogste kookpunt*. ✓ (2)

3.2.5 HIGHER THAN/*HOËR AS* ✓ (1)

3.2.6 **Marking criteria/*Nasienkriteria***

- State the dipole-dipole forces in H_2S ✓
- State the hydrogen bonds in HF ✓
- Compare strength of intermolecular forces between these two molecules ✓
- Refer to the energy involved ✓

- *Noem die dipool-dipoolkragte in H_2S*
- *Noem die waterstofbindings in HF*
- *Vergelyk die sterkte van intermolekulêre kragte tussen hierdie twee molekules*
- *Verwys na die energie wat betrokke is*

- HF has Hydrogen bonds ✓
- H_2S has dipole-dipole forces ✓
- Hydrogen bonds are stronger than dipole dipole forces ✓
- More energy is needed to overcome the intermolecular forces in HF ✓

- *HF het waterstofbindings*
- *H_2S het dipool-dipoolkragte*
- *Waterstofbindings is sterker as dipool-dipoolkragte*
- *Meer energie word benodig om die intermolekulêre kragte in HF te oorkom*

OR/*OF*

- HF has hydrogen bonds ✓
- H_2S has dipole-dipole forces ✓
- Dipole dipole forces are weaker than hydrogen bonds ✓
- Less energy is needed to overcome the intermolecular forces in H_2S ✓

- *HF het waterstofbindings*
- *H2S het dipool-dipoolkragte*
- *Dipool-dipoolkragte is swakker as waterstofbindings*
- *Minder energie word benodig om die intermolekulêre kragte in H_2S te oorkom* (4)

[18]

QUESTION 4/*VRAAG 4*

4.1 Boyle's law/*Boyle se wet* ✓ (1)

4.2 4.2.1

Criteria for investigative question/*Nasienkriteria vir ondersoekendevraag*

The independent and dependent variables are stated ✓
Die onafhanklike en afhanklike veranderlike korrek gestel
Ask a question about the relationship between the independent and dependent variables ✓
Vra 'n vraag rondom die verwantskap tussen onafhanklike en afhanklike veranderlike

How does the pressure of a gas affects the volume? ✓✓
Hoe beïnvloed die druk van 'n gas die volume?

OR/*OF*

What is the relationship between pressure and volume of the gas? ✓✓
Wat is die verwantskap tussen druk en volume van die gas? (2)

4.2.2 Temperature ✓and amount of gas ✓
Temperatuur en hoeveelheid gas (2)

4.3 **When volume is decreased**

- The same number of gas particles are now occupy a smaller volume. ✓
- Particles collide with each other and walls of the container more frequently. ✓
- More frequent collisions mean greater pressure**.** ✓

Wanneer die volume afneem

- *Dieselfde aantal gasdeeltjies beset nou 'n kleiner volume.*
- *Deeltjies bots meer gereeld met mekaar en teen die wande van die houer.*
- *Meer gereelde botsings beteken groter druk.*

OR/*OF*

When the volume is increased

- The same number of gas particles are occupy a larger volume. ✓
- Particles collide with each other and walls of the container less frequently. ✓
- Less frequent collisions mean a decrease in pressure.✓

Wanneer die volume toeneem

- *Dieselfde aantal gasdeeltjies beset 'n groter volume.*
- *Deeltjies bots minder gereeld met mekaar en teen die wande van die houer.*
- *Minder gereelde botsings beteken 'n afname in druk.* (3)

4.4 $V = 1 / 0{,}66 \times 10^{-1}$ ✓ $= 15{,}15 \text{ cm}^3$ ✓ (2)

4.5 **Positive marking from QUESTION 4.4/*Positiewe nasien vanaf VRAAG 4.4***

$p_1V_1 = p_2V_2$ ✓

$(96)(15{,}15)$ ✓ $= (252)V_2$ ✓

$V_2 = 5{,}77 \text{ cm}^3$ ✓

NOTE:
For any other pressure values used from the table:
1) Then no positive marking from QUESTION 4.4.
2) Learners must use the reciprocal value of volume in their substitution.

LET WEL:
Vir enige ander drukwaardes wat uit die tabel gebruik word:
1) Dan geen positiewe nasien vanaf VRAAG 4.4 nie
2) Leerders moet die omgekeerde waarde van volume in hul vervanging gebruik.

(4)

4.6 At very high pressure, the volume of the gas particles increases. ✓
At very high pressure the volume of the gas becomes significant and the space inside the container becomes significantly less. ✓
The volume measured is higher than predicted by the ideal gas law ✓

Teen baie hoë druk neem die volume van die gas deeltjies toe.
Teen baie hoë druk word die volume van die gas beduidend en die ruimte binne die houer word aansienlik minder.
Die gemete volume is hoër as wat deur die ideale gaswet voorspel word. (3)

[17]

QUESTION 5/*VRAAG 5*

5.1 Heat of reaction is the energy absorbed or released per mole in a chemical reaction. ✓✓
Reaksiewarmte is die energie wat per mol in 'n chemiese reaksie geabsorbeer of vrygestel word. (2)

5.2 EXOTHERMIC REACTION/*EKSOTERMIESE REAKSIE* ✓
More energy is released than the energy absorbed. ✓
Meer energie word vrygestel as die energie wat geabsorbeer word.

OR/*OF*

Heat/Enthalpy of the products is less than heat/enthalpy of the reactants. ✓
Die warmte/entalpie van die produkte is minder as die warmte/entalpie van die reaktante

OR/*OF*

$\Delta H < 0$ ✓ (2)

5.3 ΔH reaction/*reaksie* = ∑ H products/*produkte* - ∑ H reactant/*reaktanse*

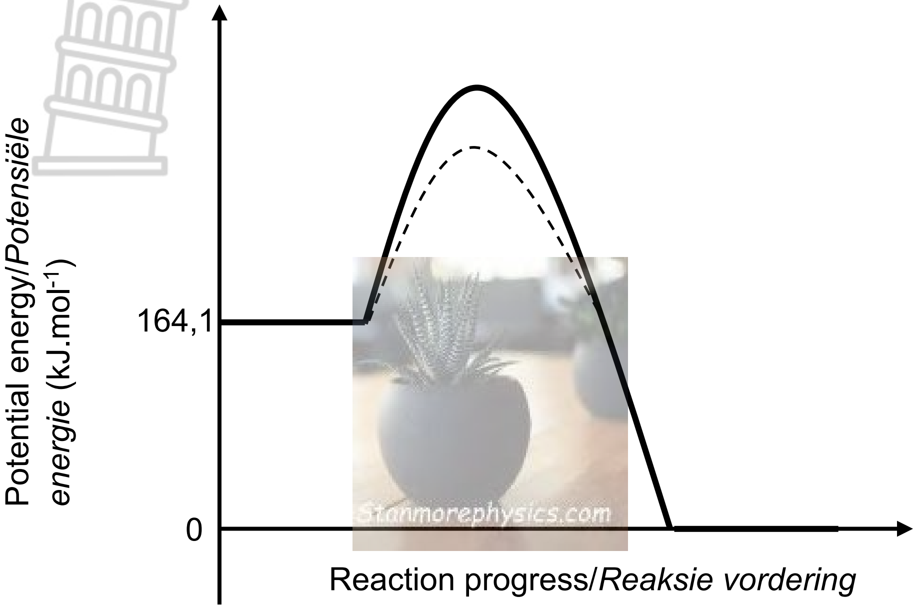
ΔH reaction/*reaksie* = 0 – (164,1) ✓

ΔH reaction/*reasksie* = – 164,1 kJ·mol^{-1} ✓ (2)

5.4 $E_a = 405,30 - 164,1$ ✓✓

$E_a = 241,20\ kJ\cdot mol^{-1}$ ✓ (3)

5.5



Marking criteria/*Nasienkriteria*

- Peak of the catalyst is lower. ✓
  Die piek van die katalisator is laer.
- Graphs start at the E_a and ends horizontally to H_r ✓
  Grafieke begin by die Ea en eindig horisontaal by H_r

(2)
[11]

QUESTION 6 / *VRAAG 6*

6.1 The mass of one mole of a substance. ✓✓ **(2 or 0)**
Die massa van een mol van 'n stof. ***(2 of 0)*** (2)

6.2 **Marking criteria:**

a. Calculation of moles of carbon ✓
b. Calculation of moles of hydrogen ✓
c. Calculation of moles of oxygen ✓
d. Dividing by smallest number of moles ✓
e. Empirical formula ✓
f. Dividing M(molecular mass) by M(empirical mass) ✓
g. Correct molecular formula ($C_4H_8O_2$) ✓

Nasienkriteria

a. Berekening van mol koolstof
b. Berekening van mol waterstof
c. Berekening van mol suurstof
d. Deel deur die kleinste aantal mol
e. Empiriese formule
f. Deel M(Molekulêre massa) deur M(empiriese massa)
g. Korrekte molekulêre formule ($C_4H_8O_2$)

$$\begin{array}{ccccc} n(C) & & n(H) & & n(O) \\ \frac{54{,}54}{12}\ (a)\ ✓ & : & \frac{9{,}1}{1}\ (b)\ ✓ & : & \frac{36{,}36}{16}\ (c)\ ✓ \end{array}$$

Simplest ratio/ *Vereenvoudigste verhouding*

$$\frac{5{,}545}{2{,}2725} : \frac{9{,}100}{2{,}2725} : \frac{2{,}2725}{2{,}2725} \quad (d)\ ✓$$

2 : 4 : 1

Empirical formula / *Empiriese formule*: C_2H_4O (e) ✓

$M_r(C_2H_4O) = 2(12) + 4(1) + 16 = 44$

$$n = \frac{M(molecular\ mass)}{M(formula\ mass)} = \frac{88}{44} = 2 \quad (f)\ ✓$$

Molecular formula / *Molekulêre formule*: $C_4H_8O_2$ (g) ✓ (7)

6.3 6.3.1 The amount of solute per litre of solution. ✓✓
Die hoeveelheid opgeloste stof per liter oplossing. (2)

6.3.2

OPTION 1/*OPSIE 1*	**OPTION 2/*OPSIE 2***
n = cV n = (0,326)(0,1) ✓ n = 0,0326 mol M = m / n ✓ M = (1,826) / 0,0326 ✓ M = 56 $g \cdot mol^{-1}$ **M** + 16 + 1 = 56 ✓ M = K^+ MOH = Potassium hydroxide/*Kalium hidroksied* ✓	c = m / MV ✓ 0,326 = 1,826 / M (0,1) ✓✓ M = = 56 $g \cdot mol^{-1}$ **M** + 16 + 1 = 56 ✓ M = K^+ MOH = Potassium hydroxide/*Kalium hidroksied* ✓

(5)

[16]

QUESTION 7/*VRAAG 7*

7.1 The substance that is completely used up during a chemical reaction. ✓✓
Die stof wat volledig tydens 'n chemiese reaksie opgebruik word. (2)

7.2

Marking Criteria

a) Substitution into $n = V/V_m$
b) Use of mol ratio $CaCO_3 : CO_2$
c) Formula $n = m/M$
d) Substitution into $n = m/M$
e) Final answer

Nasienkriteria

a) Vervanging in $n = V / V_m$
b) Gebruik van mol verhouding $CaCO_3 : CO_2$
c) Formule $n = m/M$
d) Vervanging in $n = m/M$
e) Finale antwoord

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

$= \frac{0,325}{22,4}$ (a) ✓

$= 0,0145$ mol

$CaCO_3 : CO_2$
1 : 1
$n(CaCO_3) = 0,0145$ mol (b) ✓

$n = \frac{m}{M}$ (c) ✓

$0,0145 = \frac{m}{M}$

$m = (0,0145)(100)$ (d) ✓

$m = 1,45$ (e) ✓ (5)

7.3 % purity $= \frac{\text{mass } CaCO_3}{\text{mass of sample}} \times 100$

$= \frac{1,45}{1,5} \times 100$ ✓

$= 96,67$ % ✓ (2)

7.4

Marking Criteria

- a) Use of mol ratio $CaCO_3 : HCℓ$
- b) Formula n = N / N_A
- c) Substitution into n = N / N_A
- d) Final answer

Nasienkriteria

- *a) Gebruik van mol verhouding $CaCO_3 : HCℓ$*
- *b) Formule n = N / N_A*
- *c) Vervanging in n = N / N_A*
- *d) Finale antwoord*

$CaCO_3$: HCℓ
1 : 2

n (HCℓ) = 2(0,0145) (a) ✓
= 0,029 mol

$n = \frac{N}{N_A}$ (b) ✓

N = 0,029 x 6,02 x 10^{23} (c) ✓

N = 1,7458 x 10^{22} particles of / *deeltjie van* HCℓ (d) ✓ (4)

7.5 Equal to ✓

After calcium carbonate completely reacted (at 5 min) there was no more CO_2 produced ✓

Gelyk aan

Nadat kalsiumkarbonaat volledig gereageer het (na 5 min) is daar geen verdere CO_2 geproduseer nie (2)

[15]

QUESTION 8/*VRAAG 8*

8.1

> **Marking criteria/Nasienriglyne**
> If any of the underlined key words/phrases in the **correct context** are omitted: - 1 mark per word/phrase.
> *Indien enige van die sleutelwoorde/frases in die korrekte konteks weggelaat word: - 1 punt per word/frase.*

An acid is a substance that produces hydrogen ions (H^+)/hydronium ions (H_3O^+) when it dissolves in water. ✓✓
'n Suur is 'n stof wat waterstofione (H^+)/hidroniumione (H_3O^+) produseer wanneer dit in water oplos. (2)

8.2 8.2.1 HSO_4^- ✓and/*en* H_2O ✓ (2)

8.2.2 SO_4^{2-}✓ (1)

8.3 8.3.1 An acid-base indicator is a weak acid, or a weak base, which color changes as the H^+ ion concentration or the OH^- ion concentration in a solution changes. ✓✓
'n Suur-basis-indikator is 'n swak suur, of 'n swak basis, waarvan die kleur verander soos die H^+-ioonkonsentrasie of die OH^--ioonkonsentrasie in 'n oplossing verander. (2)

8.3.2 Yellow/*Geel* ✓ (1)

8.3.3 Exothermic / Eksotermies ✓
It gives off heat / temperature rises / *Dit gee hitte af / temperatuur styg* ✓ (2)

8.3.4
$$pH = -\log[H_3O^+] ✓$$
$$2{,}8 ✓ = -\log[H_3O^+]$$
$$[H_3O^+] = 10^{-2{,}8}$$
$$[H_3O^+] = 1{,}58 \times 10^{-3}\ mol{\cdot}dm^{-3} ✓$$
(3)

8.3.5

POSITIVE MARKING FROM QUESTION 8.3.4/*POSITIEWE NASIEN VANAF VRAAG 8.3.4*

MARKING CRITERIA

a. Calculating $n(HNO_3)$ initial by substituting to $n = cV$
b. Calculating $n(HNO_3)$ excess by substituting to $n = cV$
c. Calculating $n(HNO_3)$ reacted
d. Use of a molar ratio of NaOH : HNO_3
e. Formula $c = n/V$
f. Substitution in $c = n/V$
g. Final answer

Nasienkriteria

a. Bereken aanvangs $n(HNO_3)$ deur te vervang in $n = cV$
b. Bereken oormaat $n(HNO_3)$ deur te vervang in $n = cV$
c. Bereken $n(HNO_3)$ wat gereageer het
d. Gebruik mol verhouding NaOH : HNO_3
e. Formule $c = n/V$
f. Vervang in $c = n/V$
g. Finale antwoord

$n(HNO_3)_{\text{initial}} = cV$
$= (0,25)(0,5)$ (a) ✓
$= 0,125$ mol

$n(HNO_3)$ excess/*oormaat* $= cV$
$= (1,58 \times 10^{-3})(1)$ (b) ✓
$= 1,58 \times 10^{-3}$ mol

Reaction: $HNO_3 + NaOH \rightarrow NaNO_3 + H_2O$

$n(HNO_3)_{\text{reacted}} = n(HNO_3)$ initial/*aanvangs* $- \ n(HNO_3)$ excess/*oormaat*

$= 0,125 - 1,58 \times 10^{-3}$ (c) ✓
$= 0,123$ mol

NaOH : HNO_3
1 : 1
N (NaOH) = n (HNO_3) = 0,123 mol (d) ✓

$[NaOH]_{initial} = \frac{n}{V}$ (e) ✓

$= \frac{0,123}{0,5}$ (f) ✓
$= 0,246 \text{ mol·dm}^{-3}$ (g)✓

(7)
[20]

QUESTION 9/*VRAAG 9*

9.1 It is a number that shows the number of electrons an atom has gained, lost, or shared in a chemical compound, compared to its elemental state. ✓✓
Dit is 'n getal wat die aantal elektrone aandui wat 'n atoom in 'n chemiese verbinding verkry, verloor of gedeel het, in vergelyking met sy elementêre toestand. (2)

9.2 9.2.1 Aℓ ✓✓ (2)

9.2.2 Cu^{2+}✓✓ (2)

9.3 REMAIN THE SAME/*BLY DIESELFDE* ✓

It is the spectator ion/*Dit is 'n toeskouer ioon* ✓ (2)

9.4 9.4.1 $Cr_2O_7^{2-}$
$2x + 7(-2) = -2$ ✓
$x = +6$ ✓ (2)

9.4.2 Decreases/*Neem af* ✓

$Cr_2O_7^{2-} + 14H^+ + 6e^- \rightarrow 2Cr^{3+} + 7H_2O$✓✓
$Cr_2O_7^{2-}$ were reduced to/*was gereduseer na* Cr^{3+} ✓ (4)

9.4.3 **MARKING CRITERIA**
a) balancing electrons by multiplying oxidation half reaction by 6✓
b) correct balanced net reaction (1mark reactants and 1 mark products) ✓✓

NASIENKRITERIA
a) balansering van elektrone deur die oksidasiehalfreaksie met 6 te vermenigvuldig
b) *korrekte gebalanseerde netto reaksie (1 punt reaktanse en 1 punt produkte)*

$Cr_2O_7^{2-} + 14H^+ + 6e^- \rightarrow 2Cr^{3+} + 7H_2O$

$6\ (Fe^{2+} \rightarrow Fe^{3+} + e^-)$ ✓

$Cr_2O_7^{2-} + 6Fe^{2+} + 14H^+$ ✓ $\rightarrow 2Cr^{3+} + 6Fe^{3+} + 7H_2O$ ✓ (3)
[17]

TOTAL/TOTAAL: 150