education

DEPARTMENT: EDUCATION
MPUMALANGA PROVINCE

NATIONAL SENIOR CERTIFICATE EXAMINATION

PHYSICAL SCIENCES: CHEMISTRY (P2)
FISIESE WETENSKAPPE: CHEMIE (V2)

SEPTEMBER 2015

GRADE / *GRAAD* 12

MEMORANDUM

MARKS / PUNTE: 150

TIME / TYD: 3 HOURS

This memorandum consists of 17 pages
Die memorandum bestaan uit 17 bladsye

GENERAL GUIDELINES

1 CALCULATIONS

1.1 **Marks will be awarded for:** correct formula, correct substitution, and correct answer with unit.

1.2 **NO marks** will be awarded if an **Incorrect or inappropriate formula is used**, even though there may be relevant symbols and applicable substitutions.

1.3 When an error is made during **substitution into a correct formula**, a mark will be awarded for the correct formula and for the correct substitutions, but **no further marks** will be given.

1.4 If **no formula** is given, but **all substitutions are correct**, a candidate will **forfeit one mark.**

Example:

No K_c expression, correct substitution

$K_C = \frac{(2)^2}{(2)(1)^3}$ ✓ = 2 ✓ $(\frac{2}{3})$

1.5 Marks are only awarded for a formula if a **calculation has been attempted** i.e. substitution have been made or a numerical answer given.

1.6 Marks can only be allocated for substitutions when values are substituted into formulae and not when listed before a calculation starts.

1.7 All calculations, when not specified in the question, must be done to two decimal places.

1.8 If a final answer to a calculation is correct, full marks will not automatically be awarded. Marks will always ensure that the correct/appropriate formula is used and that workings, including substitutions, are correct.

2 UNITS

2.1 Candidates will only be penalised once for the repeated use of an incorrect unit **within a question**.

2.2 Units are only required in the final answer to a calculation.

2.3 Marks are only awarded for an answer and not for a unit *per se.* Candidates will therefore forfeit the mark allocated for the answer in each of the following situations:

- Correct answer + wrong unit
- Wrong answer + correct unit
- Correct answer + no unit

2.4 Separate compound units with a multiplication dot, not a full stop, for example, mol·dm^{-3}. Accept mol.dm^{-3} (mol/dm^3) for marking purpose.

3 If one answer or calculation is required, but two are given by the candidate, only the first one will be marked, irrespective of which one is correct. If two answers are required, only the first two will be marked, etc.

3.1 When a chemical **FORMULA** is asked, and the **NAME** is given as answer the candidate forfeits the marks. The same rule applies when the **NAME** is asked and the **FORMULA** is given.

3.2 When redox half- reactions are to be written, the correct arrow should be used.

If the equation

$H_2S \rightarrow S + H^+ + 2e^-$ $(^2/_2)$

Is the correct answer, the marks must be given as follows:

$H_2S \rightleftharpoons S + H^+ + 2e^-$ $(^1/_2)$

$H_2S \leftarrow S + 2H^+ + 2e^-$ $(^0/_2)$

$S + 2H^+ + 2e^- \leftarrow H_2S$ $(^2/_2)$

$S + 2H^+ + 2e^- \rightleftharpoons H_2S$ $(^0/_2)$

3.4 One mark is forfeited when the charge of an ion is omitted per equation. (not for the charge on an electron)

3.6 The error carrying principle does not apply to chemical equations or half reactions. For example, if a learner writes the wrong oxidation/reduction half-reaction in the sub-question and carries the answer over to another sub-question (balancing of equations or calculation of E°_{cell}) then the learner must not be credited for this substitution.

3.7 In the structural formula of an organic molecule all hydrogen atoms must be shown. Marks must be deducted if hydrogen atoms are omitted.

When a structural formula is asked, marks must be deducted if the learner writes the condensed formula.

3.8 When an IUPAC name is asked and candidate omits the hyphen (e.g. instead of pent-1-ene or 1-pentene the candidate writes pent 1 ene or 1 pentene), marks must be forfeited.

3.9 When a chemical reaction is asked, marks are awarded for correct reactants, correct products and correct balancing.

If only a reactant(s) followed by an arrow, or only a product(s) preceded by an arrow, is/are written, marks may be awarded for the reactant(s) or products(s). if only a reactant(s) or only a product(s) are written, without an arrow, no marks are awarded for the reactants(s) or product(s).

Examples: $N_2 + 3H_2$ ✓ → $2NH_3$ ✓bal. ✓

$N_2 + H_2 \rightarrow$ ✓	$^1/_3$
$\rightarrow NH_3$ ✓	$^1/_3$
$N_2 + H_2$	$^0/_3$
NH_3	$^0/_3$

4 **POSITIVE MARKING**

4.1 **Sub-question to sub-question:**

When a certain variable is calculated in one sub-question (e.g. 3.1) and needs to be substituted in another (3.2 or 3.3), e.g. if the answer for 3.1 is incorrect and is substituted correctly in 3.2 or 3.3 **full marks** are to be awarded for the subsequent sub-question.

4.2 **A multi-step question:** if the candidate has to calculate, for example, current in the first and gets it wrong due to a substitution error, the mark for the substitution and the final answer will be forfeited.

5 NEGATIVE MARKING

Normally an incorrect answer cannot be correctly motivated if on a conceptual mistake. If the candidate is therefore required to motivate in QUESTION 3.2 the answer given to QUESTION 3.2. However, if the answer for e.g. 3.1 is based on a calculation, the motivation for the incorrect answer in 3.2 could be considered.

QUESTION 1 / *VRAAG 1*

1.1 C✓✓ (2)

1.2 B✓✓ (2)

1.3 B✓✓ (2)

1.4 A✓✓ (2)

1.5 D✓✓ (2)

1.6 D✓✓ (2)

1.7 B✓✓ (2)

1.8 C✓✓ (2)

1.9 C✓✓ (2)

1.10 D✓✓ (2)

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QUESTION 2 / *VRAAG 2*

2.1.1 C or / *of* G✓ (1)

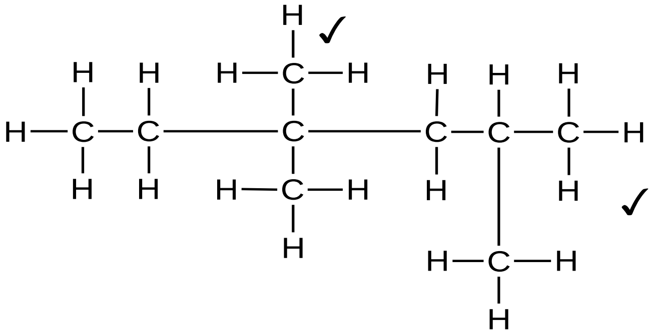
2.1.2 E✓ (1)

2.1.3 A✓ (1)

2.1.4 A & E✓✓ (2)

2.1.5 B✓ (1)

2.2.1 (2)



2.2.2 2,4,4-trimethyl✓hexane✓ / *2,4,4-trimetiel✓heksaan✓* (2)

2.3.1 Addition / *addisie* ✓ (1)

2.3.2 HBr ✓ (1)

2.4 Propanoic acid ✓ and ethanol ✓ / *propanoësuur* ✓ *en etanol* ✓ (2)

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QUESTION 3 / *VRAAG 3*

3.1 Organic molecules with the same molecular formula, ✓ but different structural formulae. ✓
Organiese molekules met dieselfde molekulêre formule ✓, *maar verskillende struktuurformules* ✓ (2)

3.2 Alkanes / *alkane* ✓ (1)

3.3.1 Boiling point / *kookpunt* ✓ (1)

3.3.2 Molecular structure / isomer / compound ✓
Molekulêre struktuur / isomeer / verbinding ✓ (1)

3.3.3 Increase in the number of branched chains result in decrease in the boiling point. ✓✓/straight chain alkanes have a higher boiling point compared to their corresponding branched chains.

'n Toename in die aantal vertakte kettings veroorsaak 'n afname in kookpunt / reguit kettings het 'n hoër kookpunt in vergelyking met hulle ooreenstemmende vertakte kettings ✓✓ (2)

3.4 Straight-chained molecules can get closer to one another than branched molecules, and have larger surface area in contact for intermolecular forces to form ✓ Therefore the Van der Waals forces / London forces are stronger. ✓ Hence more energy is required to overcome intermolecular forces between the straight chain molecules compared to branched chains. ✓thus a higher boiling point ✓

Reguitketting molekules kan nader aan mekaar beweeg as vertakte molekules, en het 'n groter oppervlakarea wat blootgestel is vir intermolekulêre kragte om te vorm. ✓ Daarom *is die Van der Waalskragte / Londonkragte sterker* ✓. *Daarom word meer energie benodig om die intermolekulêre kragte tussen reguitketting molekules te oorkom as tussen vertakte kettings* ✓ *en dus het dit 'n hoër kookpunt.* ✓

OR / OF

Branched chains form molecules that are more <u>spherical with fewer points of contact for intermolecular forces</u>. ✓Therefore the Van der Waals forces / London forces are weaker. ✓

Hence <u>less energy is required to overcome intermolecular forces between the branched chains compared to straight chains,</u> ✓thus a <u>lower boiling point</u>✓

Vertakte kettings vorm molekules <u>wat meer sferies is met minder kontakpunte vir intermolkulêre kragte</u>.✓Daarom *is die <u>Van der Waalskragte / Londonkragte swakker</u>✓.*

<u>Minder energie word benodig om die intermolekulêre kragte tussen vertakte molekules te oorkom</u> as tussen reguit kettings✓en dus het dit 'n <u>laer kookpunt</u>.✓ (4)

3.5 Alkanes are fuels and are highly flammable✓ - should avoid direct heating with an open flame/Work in a well-ventilated area/ use a fume hood ✓

Alkane is brandstowwe wat hoogs vlambaar ✓is en direkte kontak met 'n oop vlam moet vermy word. Werk in 'n goedgeventileerde vertrek / gebruik 'n dampkas.. ✓ (2)

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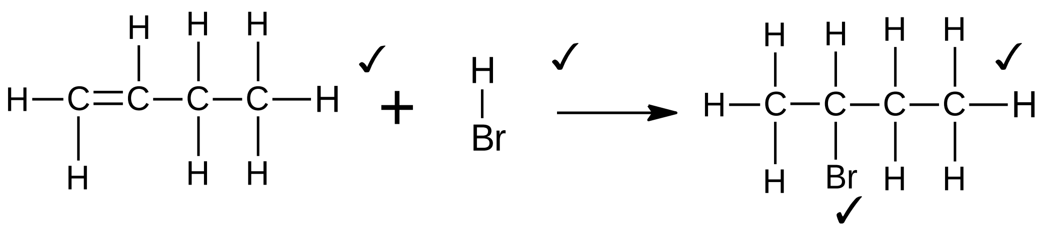
QUESTION 4 / *VRAAG 4*

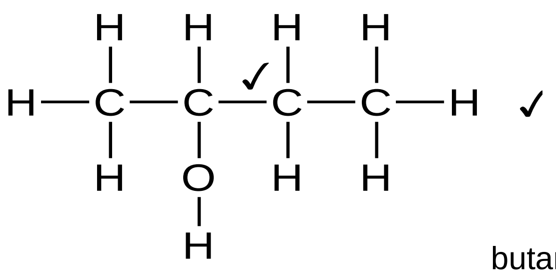
4.1



(4)

4.2 Hydrohalogenation /addition✓ / *hidrohalogenering / addisie*✓ (1)

4.3



butan-2-ol (2-butanol) ✓ (3)

4.4 hydrolysis / *hidrolise*✓ (1)

4.5.1 Water / H_2O ✓ (1)

4.5.2 H_2SO_4 / HCℓ / H_3PO_4✓ (1)

4.5.3 Hydration / *hidrasie* ✓ (accept addition / *aanvaar addisie*)✓ (1)

4.6.1 but-2-ene/2-butene ✓/ *but-2-een / 2-buteen*✓ (1)

4.6.2 Dehydrohalogenation / elimination✓
Dehidrohalogenering / eliminasie✓ (1)

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QUESTION 5 / *VRAAG 5*

5.1 2HCℓ(aq) + Mg(s) ✓→ MgCℓ$_2$(aq) + H_2(g) ✓✓ **[Do not penalise if phases are omitted]** (3)

5.2.1 Dependent: volume of gas / reaction rate✓.
Afhanklike: volume gas / reaksietempo✓ (1)

5.2.2 Independent: time✓
Onafhanklike: tyd✓ (1)

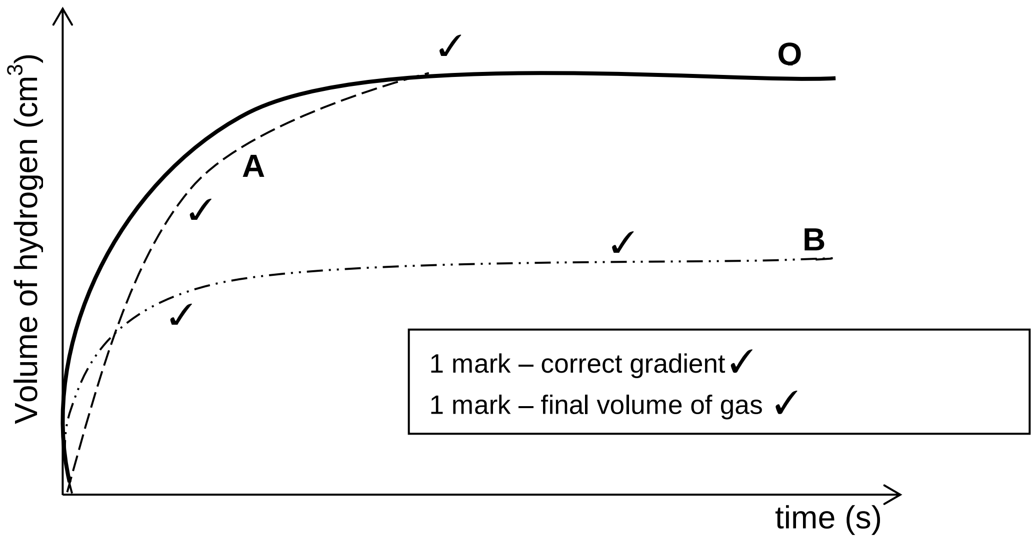
5.3 50 cm^3 ✓ (1)

5.4 Average rate = $\frac{\text{volume of gas produced}}{\text{Time}}$

$= \frac{42 - 0}{60 - 0}$ ✓

$= 0{,}7\ cm^3\cdot s^{-1}$✓ (2)

5.5



(4)

5.6 Catalyst / *katalisator* ✓ (1)

5.7 Mg is the limiting reactant. When magnesium is used up the reaction will stop / [HCℓ] stays constant ✓✓
Mg is die beperkende reaktant. Wanner magnesium opgebruik is sal die reaksie stop. /[HCℓ] bly konstant ✓✓ (2)

[15]

QUESTION 6 / *VRAAG 6*

6.1 Le Chatelier's principle: When the equilibrium in a closed system is disturbed, ✓ the system will re-instate a new equilibrium by favouring the reaction that will oppose the disturbance ✓
Le Chatelier se beginsel: Wanner die ewewig in 'n geslote sisteem versteur word ✓ *sal die sisteem 'n nuwe ewewig instel deur die reaksie te bevoordeel wat die versteuring teëwerk* ✓ (2)

6.2 $K_c = \frac{[CH_3COOC_2H_5][H_2O] ✓}{[CH_3COOH][C_2H_5OH] ✓}$ (2)

6.3 **<u>CALCULATIONS USING NUMBER OF MOLES</u>**

Mark allocation/*Puntetoekenning*

- Use of formula to calculate number of moles for ethanol and ethanoic acid $n = \frac{m}{M}$ ✓
- Divide by / *deel deur* 65 ✓
- Divide by / *deel deur* 46 ✓
- USING ratio / *Gebruik die verhouding*: 1:1:1:1 ✓
- Equilibrium: n(CH_3COOH) = n(C_2H_5OH) = 0,05 mol (initial - change) ✓
- Equilibrium: n($CH_3COOC_2H_5$) = n(H_2O) = 0,2 mol (initial + change) ✓
- Correct K_c expression (<u>formulae in square brackets</u>) ✓
- Final answer/*Finale antwoord*: 0,16 ✓

$$\text{n(ethanoic acid)} = \frac{\text{n}}{\text{M}} ✓$$

$$= \frac{15}{60} ✓$$

$$= 0{,}25 \text{ mol}$$

$$\text{n(ethanol)} = \frac{11.5}{46} ✓$$

$$= 0{,}25 \text{ mol}$$

	CH_3COOH	C_2H_5OH	$CH_3COOC_2H_5$	H_2O
Initial moles	0,25	0,25	0	0
Moles used/reacted	-0,20	-0,20	+0,20 ✓	+0,20
Moles at equilibrium	0,05✓	0,05	0,20 ✓	0,20
[..] at equilibrium ($mol\cdot dm^{-3}$) $C=\frac{n}{v}$	$\frac{0,05}{V}$	$\frac{0,05}{V}$	$\frac{0,20}{V}$	$\frac{0,20}{V}$

$$K_C = \frac{[CH_3COOC_2H_5][H_2O]}{[CH_3COOH][C_2H_5OH]}$$

$$K_C = \frac{\left(\frac{0.02}{V}\right)\left(\frac{0.02}{V}\right)}{\left(\frac{0.05}{V}\right)\left(\frac{0.05}{V}\right)} ✓$$

$$K_C = 0{,}16 ✓$$

<u>CALCULATIONS USING CONCENTRATION</u>

Mark allocation/*Puntetoekenning*

- Use of formula to calculate number of moles for ethanol and ethanoic acid $n = \frac{m}{M}$ ✓
- Divide by 65 ✓
- Divide by 46 ✓
- USING ratio: 1:1:1:1 ✓
- Equilibrium: $[CH_3COOH] = [C_2H_5OH] = \frac{0,05}{V}$ $mol\cdot dm^{-3}$ (initial - change) ✓
- Equilibrium: $[CH_3COOC_2H_5] = [H_2O] = \frac{0,20}{V}$ $mol\cdot dm^{-3}$ (initial + change) ✓
- Correct K_c expression (<u>formulae in square brackets</u>) ✓
- Final answer/*Finale antwoord*: 0,16 ✓

$$n(\text{ethanoic acid}) = \frac{n}{M} ✓$$

$$= \frac{15}{60} ✓$$

$$= 0{,}25 \text{ mol}$$

$$n(\text{ethanol}) = \frac{11.5}{46} ✓ = 0{,}25 \text{ mol}$$

	CH_3COOH	C_2H_5OH	$CH_3COOC_2H_5$	H_2O
Initial [ ]	$\frac{0,25}{V}$	$\frac{0,25}{V}$	0	0
[ ] used/reacted	$-\frac{0,20}{V}$	$-\frac{0,20}{V}$	$+\frac{0,20}{V}$ ✓	$+\frac{0,20}{V}$
Equilibrium [ ]	$\frac{0,05}{V}$✓	$\frac{0,05}{V}$	$\frac{0,20}{V}$ ✓	$\frac{0,20}{V}$

$$K_C = \frac{[CH_3COOC_2H_5][H_2O]}{[CH_3COOH][C_2H_5OH]}$$

$$K_C = \frac{\left(\frac{0.02}{V}\right)\left(\frac{0.02}{V}\right)}{\left(\frac{0.05}{V}\right)\left(\frac{0.05}{V}\right)} ✓$$

$$K_C = 0,16 ✓$$

(8)

6.4 $m = nM$

$m = (0,2)(18)$ ✓

$m = 3,6g$ ✓ (2)

6.5 The forward reaction will be favoured✓ to replace the water that has been removed to reinstate the equilibrium. ✓

Die voorwaartse reaksie sal bevoordeel word✓ om die water te vervang wat verwyder is, om 'n nuwe ewewig in te stel. ✓ (2)

6.6 Catalyst/dehydrating agent✓ / *Katalisator / dehidreermiddel*✓ (1)

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QUESTION 7 / *VRAAG 7*

7.1.1 A solution of which the concentration is exactly known and remains constant for a certain amount of time✓
'n Oplossing waarvan die konsentrasie presies bekend is en vir 'n geruime tyd konstant bly. ✓ (1)

7.1.2 **OPTION 1 / *OPSIE 1***

$M(KOH) = 56\ g \cdot mol^{-1}$
$m = cMV$✓
$= 0{,}2 \times 56 \times 0{,}3$✓
$= 3{,}36\ g$✓

OPTION 2 / *OPSIE 2*

$M(KOH) = 56\ g \cdot mol^{-1}$
$n = cV$
$= 0{,}2 \times 0{,}3$
$= 0{,}06$
$m = nM$ ✓
$= 0{,}06 \times 56$ ✓
$= 3{,}36\ g$✓ (3)

7.1.3 0,2 mol KOH yield / *lewer* 0,2 mol OH^- LEWER

$K_w = [H_3O^+][OH^-]$✓

$10^{-14} = [H_3O^+](0{,}2)$
$[H_3O^+] = 5 \times 10^{-14}$✓

$pH = -\log[H_3O^+]$✓
$= -\log(5 \times 10^{-14})$ ✓
$= 13{,}3$✓

7.1.4 Bromothymol blue;✓ H_2SO_4 is a strong acid and KOH is a strong base✓. The equivalence point will be at approximately pH = 7 which is the endpoint of bromothymol blue.
Broomtimolblou. H_2SO_4 is 'n sterk suur en KOH is 'n sterk basis✓. Die ekwivalente punt sal ongeveer by pH = 7 wees wat die endpunt van broomtimolblou is. (2)

7.1.5 **OPTION 1 / *OPSIE 1***

$$\left(\frac{n_a}{n_b}\right) = \left(\frac{C_aV_a}{C_bV_b}✓\right)$$
$$\left(\frac{1}{2}\right)✓ = \frac{C_a \times 20}{0{,}2 \times 15}\ ✓$$
$$C_a = 0{,}075\text{mol}\cdot\text{dm}^{-3}✓$$

OPTION 2 / *OPSIE 2*

$$n(NaOH) = cV\ ✓$$
$$= 0{,}2 \times 0{,}015$$
$$= 0{,}003\ mol$$
$$\frac{n(H_2SO_4)}{n(NaOH)} = \frac{1}{2}$$
$$n(H_2SO_4) = \frac{1}{2}(0{,}003)✓$$
$$= 0{,}0015\ mol$$
$$c = \frac{n}{V}$$
$$= \frac{0{,}0015}{0{,}020}✓$$
$$= 0{,}075\ mol\cdot dm^{-3}✓$$

(4)

7.2 Moles of MnO_4^-: $n = CV$✓

$$= \frac{15{,}70 \times 0{,}101}{1000}$$
$$= 1{,}5857 \times 10^{-3}\ \text{mol}✓$$

Moles of $C_2O_4^{2-}$ $= \frac{5}{2} \times 1{,}5875 \times 10^{-3}$

$$= 3{,}9643 \times 10^{-3}\ mol✓$$

$n(CaC_2O_4) = n(C_2O_4^{2-})$

$$m = nM$$

Mass of $CaC_2O_4 = 3{,}9643 \times 10^{-3} \times 128$✓

=0,50743g

Percentage of CaC_2O_4 = $\frac{0{,}50743}{0{,}803} \times 100$✓

$$= 63{,}19\%✓$$

(6)

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QUESTION 8 / *VRAAG 8*

8.1 Mg✓ → Mg^{2+} + $2e^-$✓ (2)

8.2 Mg + Pb^{2+} ✓→ Mg^{2+} + Pb✓ (✓balancing) (3)

8.3 $E^{\theta}_{cell} = E^{\theta}_{cathode} - E^{\theta}_{anode}$✓
$= -0.13$✓ $- (-2.36)$✓
$= 2.23V$✓ (4)

8.4 Decreases✓ (1)

8.5.1 Pt to Ag✓ (1)

8.5.2 Ag / silver✓ (1)

8.5.3 Anode: $2H_2O \rightarrow 4H^+ + O_2 + 4e^-$✓✓ (2)

8.5.4 Cathode: $2H_2O + 2e^- \rightarrow H_2 + 2OH^-$✓✓ (2)

[16]

QUESTION 9 / *VRAAG 9*

9.1 Lowers the melting point of the aluminium oxide/reduces energy used✓
Verlaag die smeltpunt van die aluminiumoksied / verminder energiegebruik✓ (1)

9.2 The ions must be mobile/ allow the movement of ions✓
Die ione moet vrylik kan beweeg✓ (1)

9.3 Red mud dams are a major problem in polluting groundwater/hydrogen fluoride fumes which are poisonous are produced. ✓
Rooi modderdamme is 'n groot probleem wat grondwater kan besoedel / warterstoffluorieddampe wat giftig is word gevorm✓ (1)

9.4 $2O^{2-} \rightarrow O_2 + 4e^-$✓✓ (2)

9.5 Making our resources last longer/lower energy costs/ It is much cheaper to recycle than manufacture it. ✓
Hulpbronne hou langer / laer energiekoste / goedkoper om te herwin as om te vervaardig✓ (1)

9.6 **OPTION 1 / *OPSIE 1***

$n(Al) = \frac{m}{M}$
$= \frac{8,1}{27}$
= 0,3 mol ✓
$n(O_2) = \frac{m}{M}$
$= \frac{8}{32}$
= 0,25 mol ✓

$\frac{n(A\ell_2O_3)}{n(A\ell)} = \frac{2}{4}$
$n(A\ell_2O_3) = \frac{2}{4} \times 0,3$ ✓
= 0,15 mol

$\frac{n(A\ell_2O_3)}{n(O_2)} = \frac{2}{3}$
$n(A\ell_2O_3) = \frac{2}{3} \times 0,25$ ✓

= 0,17 mol

Aℓ is the limiting reactant/ *Aℓ is die beperkende reagens* ✓

OPTION 2 / *OPSIE 2*

$n(Al) = \frac{m}{M}$
$= \frac{8,1}{27}$
= 0,3 mol ✓
$n(O_2) = \frac{m}{M}$
$= \frac{8}{32}$
= 0,25 mol ✓

Number of moles Aℓ reacting with O_2:

n(Aℓ) : n(O)
4 : 3
x : 0,25

$n(A\ell) = x = \frac{4}{3} \times 0,25$ ✓
= 0,33 mol ✓

Only 0,3 mol Aℓ is available, thus Aℓ is the limiting reagent. ✓

(5)

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QUESTION 10 / *VRAAG 10*

10.1.1 Oxygen / *suurstof*✓ (1)

10.1.2 V_2O_5/ vanadium pentoxide/ vanadium(V) oxide✓ (1)

10.1.3 Water/ H_2O✓ (1)

10.1.4 The reaction is very exothermic produces fumes(mist) of sulphuric acid that are difficult to precipitate✓
Die reaksie is baie eksotermies en veroorsaak 'n mis van swawelsuurdampe wat moeilik gepresipiteer kan word. ✓ (1)

10.1.5 $H_2S_2O_7(\ell) + H_2O(\ell) \rightarrow 2H_2SO_4(\ell)$ ✓✓ (2)

10.2 H_2SO_4/sulphuric acid / *swawelsuur*✓ (1)

10.3 $2NH_3 + H_2SO_4 \rightarrow (NH_4)_2SO_4$ ✓✓ (2)

[9]

TOTAL/*TOTAAL:* 150