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SECONDARY SCHOOL IMPROVEMENT PROGRAMME (SSIP) 2016



GRADE 12

SUBJECT: PHYSICAL SCIENCES

**LEARNER HOMEWORK SOLUTIONS
SESSION 6 TO 8**

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SESSION 6: DOPPLER EFFECT

SECTION A: HOMEWORK SOLUTIONS

QUESTION 1: 10 minutes (Taken from Senior Certificate June 2015 Paper 1)

1.1 The apparent change in frequency of the sound detected by a listener because the sound source and the listener have different velocities relative to the medium of sound propagation. ✓ ✓ (2)

1.2

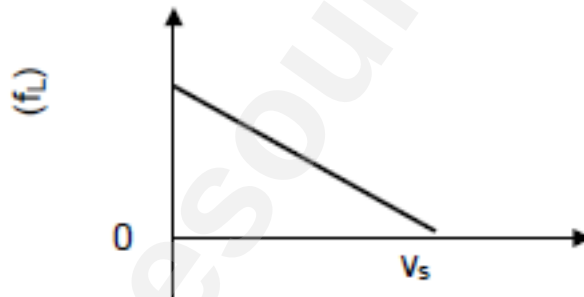
$$f_L = \frac{v \pm v_L}{v \pm v_s} \cdot f_s \quad \checkmark$$

$$825 \checkmark = \frac{v}{v - v_s} \cdot 800 \checkmark$$

$$1,03125(v-10) \checkmark = v$$

$$v = 330 \text{ m} \cdot \text{s}^{-1} \checkmark \quad (5)$$

1.3 Straight line with a negative gradient / frequency decreases (linearly) ✓ ✓



(2)
[9]

QUESTION 2: 15 minutes (Taken from Mpumalanga Prep Exam 2015)

2.1 $10 \times 10^{-4} \text{ s} \checkmark$ / $1 \times 10^{-3} \text{ s} \checkmark$ / $0,001 \text{ s} \checkmark$ (1)

2.2 POSITIVE MARKING FROM QUESTION 2.1

$$T = \frac{1}{f} \checkmark \quad \text{OR } f = \text{number of wavetime}$$

$$f = 10,001 \checkmark = 0,252,5 \times 10^{-4}$$

$$= 1000 \text{ Hz} \checkmark = 1000 \text{ Hz} \quad (3)$$

- 2.3 The change in frequency (or pitch) of the sound detected by a listener✓
because the sound source and the listener have different velocities✓
relative to the medium of sound propagation. (2)

2.4 **POSITIVE MARKING FROM QUESTION 2.2**

$$f_L = \frac{v \pm v_L}{v \pm v_s} \cdot f_s \quad \checkmark$$

$$1000 \checkmark = \frac{340}{340 - v_s} \checkmark \cdot 800 \checkmark$$

$$v_s = 68 \text{ m} \cdot \text{s}^{-1} \quad \checkmark \quad (5)$$

- 2.5 Decreases✓. $f \propto \frac{1}{\lambda}$ ✓, if velocity stays constant✓ ($v = f\lambda$) (3)
[14]

SECTION B: TYPICAL EXAM QUESTIONS SOLUTIONS

QUESTION 1: 15 minutes

(Taken from NSC Nov 2014 Paper 1)

- 1.1.1 An (apparent) change in observed/detected frequency (pitch).
(wavelength)✓ as a result of the relative motion between a source
and an observer✓ (listener). (2)

- 1.1.2 Towards ✓
Observed/detected frequency is greater than the actual frequency. ✓ (2)

- 1.1.3 $f_L = \frac{v \pm v_L}{v \pm v_s} \cdot f_s \quad \checkmark \text{ OR } f_L = \frac{v}{v - v_s} \cdot f_s$
- $$1200 \checkmark = \frac{343}{343 - v_s} \cdot 1130 \checkmark$$
- $$v_s = 20,01 \text{ m} \cdot \text{s}^{-1} \checkmark$$
- Accept (19,42 – 20,01 m·s⁻¹) (5)

- 1.2 The star is approaching the earth. ✓
OR
The earth and the star are approaching (moving towards) each other. ✓

The spectral lines in diagram 2 are shifted towards the blue end/blue
shifted. ✓ (2)

QUESTION 2: 15 minutes

(Taken from NSC Nov 2015 Paper 1)

2.1.1 Frequency (of sound detected by the listener (observer))✓ (1)

2.1.2 The apparent change in frequency or pitch of sound (detected (by a listener) because the sound source and the listener have different velocities relative to the medium of sound propagation.✓ ✓ (2)

2.1.3 Away ✓
Detected frequency of source decreases✓ (2)

2.1.4

OPTION 1/OPSIE 1

EXPERIMENT/EKSPERIMENT 2

$$f_L = \frac{v \pm v_L}{v \pm v_s} f_s \text{ OR/OF } f_L = \frac{v}{v + v_s} f_s \quad \checkmark$$

$$874 \checkmark = \frac{v}{v + 10} \checkmark (900) \quad \checkmark$$

$$v = 336,15 \text{ m} \cdot \text{s}^{-1} \checkmark \quad (\text{Accept/Aanvaar : } 336,15 \text{ m} \cdot \text{s}^{-1} - 323,33 \text{ m} \cdot \text{s}^{-1})$$

EXPERIMENT/EKSPERIMENT 3

$$f_L = \frac{v \pm v_L}{v \pm v_s} f_s \text{ OR/OF } f_L = \frac{v}{v + v_s} f_s \quad \checkmark$$

$$850 \checkmark = \frac{v}{v + 20} \checkmark (900) \quad \checkmark$$

$$v = 340 \text{ m} \cdot \text{s}^{-1} \checkmark \quad (\text{Accept/Aanvaar : } 313,33 \text{ m} \cdot \text{s}^{-1} - 340 \text{ m} \cdot \text{s}^{-1})$$

EXPERIMENT 4/EKSPERIMENT 4

$$f_L = \frac{v \pm v_L}{v \pm v_s} f_s \text{ OR/OF } f_L = \frac{v}{v + v_s} f_s \quad \checkmark$$

$$827 \checkmark = \frac{v}{v + 30} \checkmark (900) \quad \checkmark$$

$$v = 339,86 \text{ m} \cdot \text{s}^{-1} \checkmark \quad (\text{Accept/Aanvaar : } 339,86 \text{ m} \cdot \text{s}^{-1} - 345 \text{ m} \cdot \text{s}^{-1})$$

OPTION 2/OPSIE 2

$$f_L = \frac{V \pm V_L}{V \pm V_S} f_s \quad \text{OR/OF} \quad f_L = \frac{V}{V + V_S} f_s \quad \checkmark$$

Experiment/Eksperiment 2 and/en 3

$$\frac{874(v + 10)}{v} \checkmark = \frac{850(v + 20)}{v} \checkmark$$

$$874v + 8740 = 850v + 1700$$

$$\therefore v = 344,17 \text{ m} \cdot \text{s}^{-1} \quad \checkmark$$

✓ both frequencies / beide frekwensies

(5)

2.2 Away from the earth ✓

(1)

[11]

QUESTION 3: 15 minutes

(Taken from NSC Feb/March 2015 Paper 1)

3.1.1 $v = f\lambda$ ✓

$$\lambda = \frac{340}{520}$$

$$= 0,65 \text{ m} \quad \checkmark$$

(2)

3.1.2

$$f_L = \frac{v \pm v_L}{v \pm v_s} f_s \checkmark$$

$$f_L = \frac{340}{(340-15)} (520) \checkmark$$

$$f_L = 544 \text{ Hz}$$

$$v = f\lambda$$

$$\lambda = \frac{340}{544} \checkmark$$

$$= 0,63\text{m} \checkmark$$

(6)

3.2 The wavelength in QUESTION 3.1.2 is shorter because the waves are compressed as they approach the observer. ✓✓ (2)

3.3 The red shift occurs when the spectrum of a distant star moving away from the earth is shifted toward the red end of the spectrum. ✓✓ (2)

[12]**QUESTION 4: 15 minutes***Taken from Gauteng Prep Exam 2014 Paper 1)*

4.1.1

$$\Sigma E_{m56m} = \Sigma E_{m18m}$$

$$(E_P + E_K)_{56m} = (E_P + E_K)_{18m} \checkmark$$

$$mgh + 0 = mgh + \frac{1}{2}mv^2$$

$$9,8(56) \checkmark = 9,8(18) + \frac{1}{2}v^2 \checkmark$$

$$v = 27,29 \text{ m} \cdot \text{s}^{-1} \checkmark$$

(4)

4.1.2

$$f_L = \frac{v \pm v_L}{v \pm v_s} f_s$$

OR/OF

$$f_L = \frac{v}{v - v_s} f_s \checkmark$$

$$\checkmark f_L = \left(\frac{340}{340 - 27,29} \right) 497 \times 10^3 \checkmark$$

$$f_L = 5,4 \times 10^5 \text{ Hz} \checkmark$$

(4)

4.1.3 The phone is moving away from Keenan who is stationary, the phone is increasing the distance between each wavefront and therefore the wavelength increases ✓. This causes the frequency to decrease ✓ since $f \propto \frac{1}{\lambda}$ for the same speed of sound ✓ (3)

4.1.4 higher ✓ (1)
[12]

SESSION 7: RATES OF REACTION

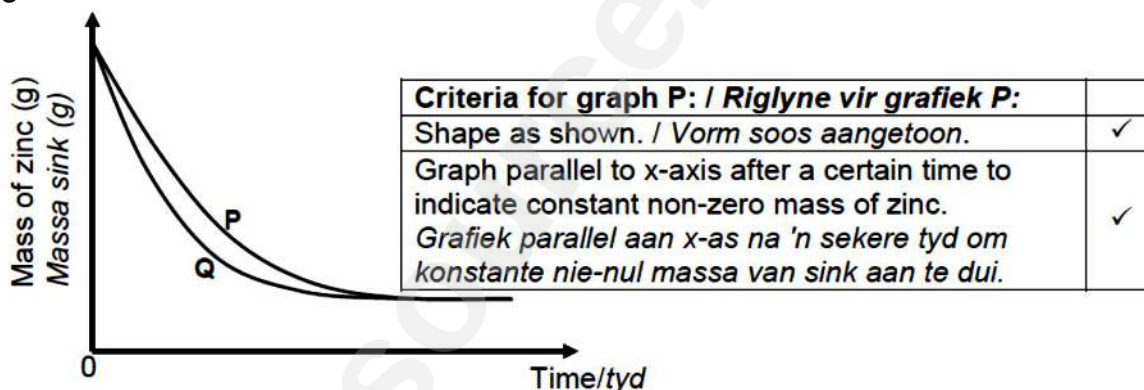
SECTION A: HOMEWORK SOLUTIONS

QUESTION 1: 20 minutes (Taken from NSC Exemplar 2014 Paper 2)

1.1 Hydrochloric acid / HCl ✓ (1)

1.2 Hydrogen gas escapes from the flask ✓ (1)

1.3



(2)

1.4

Criteria for graph Q / Riglyne vir grafiek Q:	
Steeper gradient than Graph P. / Steiler gradiënt as Grafiek P.	✓
Joins parallel section of Graph P after a shorter time.	
Verbind met die parallelle deel van Grafiek P na 'n korter tyd.	

(1)

1.5 At a higher temperature:

- More molecules have sufficient kinetic energy / kinetic energy equal to or greater than the activation energy. ✓

- More effective collisions per unit time / second. ✓ (2)

1.6

$$c(\text{HCl}) = \frac{n}{V} \checkmark$$

$$\therefore 0,2 = \frac{n}{0,1} \checkmark$$

$$\therefore n(\text{HCl}) = 0,02 \text{ mol}$$

$$n(\text{Zn}) = \frac{1}{2}n(\text{HCl}) = 0,01 \text{ mol} \checkmark$$

$$\begin{aligned} m(\text{Zn reacted / gereageer}) &= nM \checkmark \\ &= (0,01)(65) \checkmark \\ &= 0,65 \text{ g} \end{aligned}$$

Mass of Zn initially in flask / Massa Zn aanvanklik in fles:

$$0,65 + 0,12 = 0,77 \text{ g} \checkmark$$

(6)
[13]

QUESTION 2: 20 minutes

(Taken from NSC Feb/March 2014 Paper 2)

2.1 Rate of change of concentration (of P). $\checkmark\checkmark$

OR

The change in concentration (of P) $\checkmark$ per unit time/per second. $\checkmark$ (2)

2.2 10 s $\checkmark$

Gradient (of the tangent) at 10 s is greater than that at 30 s. $\checkmark$

OR

10 s

The graph has a steeper slope at 10 s than at 30 s. (2)

2.3 $0,27 \text{ mol} \cdot \text{dm}^{-3} \checkmark$

(1)

2.4

OPTION 1/OPSIE 1

At $t = 0$ s:
 $n = cV$ ✓
 $= (0,27)(2)$ ✓
 $= 0,54 \text{ mol}$

At $t = 10$ s
 $n = cV$
 $= (0,15)(2)$ ✓
 $= 0,3 \text{ mol}$

Rate/Tempo = $\frac{0,30 - 0,54}{10 - 0}$ ✓
 $= -0,024 \text{ mol} \cdot \text{s}^{-1} / 0,024 \text{ mol} \cdot \text{s}^{-1}$ ✓

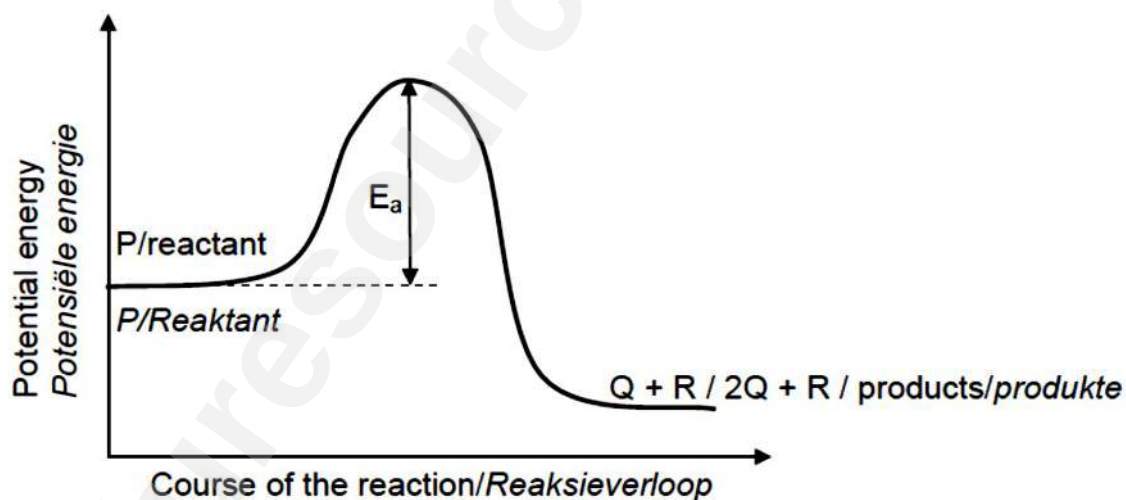
OPTION 2/OPSIE 2

Rate/Tempo = $\frac{0,15 - 0,27}{10 - 0}$ ✓
 $= -0,012 \text{ mol} \cdot \text{dm}^{-3} \cdot \text{s}^{-1}$ ✓

Rate/Tempo = $(-0,012)(2)$ ✓✓
 $= -0,024 \text{ mol} \cdot \text{s}^{-1} / 0,024 \text{ mol} \cdot \text{s}^{-1}$ ✓

(6)

2.5



Marking criteria/ Nasienriglyne:	
Correct shape as shown./Korrekte vorm soos getoon.	✓
Reactants and products correctly indicated. Reaktanse en produkte korrek aangetoon.	✓
Activation energy indicated as shown. Aktiveringsenergie aangedui soos getoon.	✓

(3)

2.6 More molecules with sufficient / enough kinetic energy. ✓

More effective collisions per unit time. ✓

(2)
[16]

SECTION B: TYPICAL EXAM QUESTIONS SOLUTIONS

QUESTION 1: 25 minutes

(Taken from GAUT PREP EXAM 2014 Paper 2)

- 1.1 temperature ✓ (1)
- 1.2 rate of reaction ✓ (1)
- 1.3 Rate = gradient of graph ✓ = $60-0/30-0$ ✓ = $2 \text{ cm}^3 \cdot \text{s}^{-1}$ ✓ (3)
- 1.4 less than ✓ (1)
- 1.5 The rate of change (or gradient) is less ✓ (1)
- 1.6 decrease ✓ (1)
- 1.7 As the surface area increases, there are more particles available for reacting. ✓ Thus there will be more collisions per second, and thus a greater number of effective collisions per second ✓ and thus the reaction rate will increase. ✓ (3)

1.8

$$\begin{aligned} n(\text{Mg}) &= m/M \\ &= 20/24 \checkmark \\ &= 0,833 \text{ moles} \end{aligned}$$

$$\begin{aligned} n(\text{H}_2\text{SO}_4) &= c \times V \\ &= 1 \times 0,1 \\ &= 0,1 \text{ moles} \end{aligned}$$

0,1 moles of Mg will react with 0,1 moles of sulphuric acid ✓

$$n_{\text{Mg}} \text{ left} = 0,83-0,1 \text{ moles} \checkmark = 0,733 \text{ moles}$$

$$\text{thus mass of Mg} = n \times M = 0,733 \times 24 \checkmark = 17,6 \text{ g} \checkmark$$

Alt. Method

24 g Mg ✓ reacts with 1 mol H_2SO_4

$$\therefore x \text{ g} \rightarrow \checkmark 0,1 \text{ mol}$$

$$x = 2,4 \text{ g} \checkmark$$

$$\text{mass left} = 20-2,4 \checkmark$$

$$= 17,6 \text{ g} \checkmark$$

Option 1

- ✓ mass → mole
- ✓ relationship
- ✓ $x \text{ g} - 0,1 \text{ mole}$
- ✓ subtraction } to obtain 2,4 g
- ✓ answer

Option 2

- ✓ mole → mole
- ✓ relationship
- ✓ subtraction
- ✓ substitution
- ✓ answer

(5)

- 1.9 A substance that increase the rate of a chemical reaction without undergoing permanent change. ✓✓ (2)
[18]

QUESTION 2: 20 minutes (Taken from NSC Feb/March 2015 Paper 2)

- 2.1 Exothermic ✓
Temperature increases during reaction. $T_i < T_f$ ✓ (2)
- 2.2 Larger surface area in experiment 2. ✓
OR
Smaller surface area in experiment 1. ✓ (1)
- 2.3 More than one independent variable. ✓
OR
Different concentrations and state of division. ✓ (1)
- 2.4 Faster than ✓
A catalyst was used in experiment 5. ✓ .
• A catalyst provides an alternative pathway of lower activation energy. ✓
• More molecules have sufficient/enough kinetic energy. ✓
OR
More molecules have kinetic energy equal to or greater than the activation energy.
• More effective collisions per unit time. /Rate or frequency of effective collisions increases. ✓ (5)
- 2.5

$$n(\text{Zn}) = \frac{n}{M} \checkmark$$

$$= \frac{1,2}{65} \checkmark$$

$$= 0,018 \text{ mol}$$

$$n(\text{HCl reacted/gereageer}) = 2(0,018) \checkmark = 0,037 \text{ mol}$$

$$\text{rate/tempo} = \frac{\Delta n}{\Delta t}$$

$$= \frac{0,037 \checkmark}{8 \checkmark} \text{ OR/OF } = \frac{-0,037}{8}$$

$$= 4,63 \times 10^{-3} \text{ mol} \cdot \text{s}^{-1} \text{ OR/OF } - 4,63 \times 10^{-3} \text{ mol} \cdot \text{s}^{-1} \checkmark$$

Accept range/aanvaar gebied: $0,004615 - 0,00463 \text{ mol} \cdot \text{s}^{-1}$

Marking criteria/Nasienriglyne:

- Formula/Formule: $n = \frac{n}{M}$
- Substitute/Vervang 65
- Use ratio/Gebruik verhouding 1 : 2
- Substitute mole acid in rate equation/Vervang mol suur in tempovergelyking
- Substitute time in rate equation/Vervang tyd in tempovergelyking
- Final answer/Finale antwoord: 0,004615 – 0,00463 mol·s⁻¹

(6)
[15]

QUESTION 3: 20 minutes*(Taken from NSC Nov 2014 Paper 2)***3.1 ONLY ANY ONE OF:**

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

3.2.1 Temperature✓ (1)

3.2.2 Rate of reaction / Volume of gas (formed) per (unit) time ✓ (1)

3.3 Larger mass / amount / surface area. ✓
More effective collisions per (unit) time. / Frequency of effective collisions increase./ More particles collide with sufficient kinetic energy & correct orientation per (unit) time. ✓✓ (3)

3.4

Marking criteria / Nasienriglyne:

Compare Exp. 1 with Exp. 2: Vergelyk Eksp. 1 met Eksp. 2:	The reaction in <u>exp. 1</u> is faster in <u>exp. 1</u> than in <u>exp. 2</u> due to the <u>higher acid concentration</u> . <i>Die reaksie in <u>eksp. 1</u> is vinniger as dié in <u>eksp. 2</u> as gevolg van die <u>hoër suurkonsentrasie</u>.</i>	✓
	Therefore the <u>gradient</u> of the graph representing <u>exp. 1</u> is <u>greater / steeper</u> than that of <u>exp. 2</u> . / Graph of Exp. 1 reaches constant volume in shorter time than exp. 2. <i>Dus is die <u>gradiënt</u> van die grafiek wat <u>eksp. 1</u> voorstel, <u>groter/steiler</u> as dié vir <u>eksp. 2</u>. / Grafiek van exp. 1 bereik konstante volume in korter tyd as dié vir eksp. 2.</i>	✓
Compare Exp. 1 with Exp 3 & 4: Vergelyk Eksp. 1 met Eksp. 3 & 4:	The reaction in <u>exp. 3</u> is faster than that in <u>exp. 1</u> due to the <u>higher temperature</u> . <i>Die reaksie in <u>eks. 3</u> is vinniger as dié in <u>eksp. 1</u> as gevolg van die <u>hoër temperatuur</u>.</i>	✓
	The reaction in <u>exp. 4</u> is faster than that in <u>exp. 1</u> due to the <u>higher temperature / larger surface area</u> . <i>Die reaksie in <u>eks. 4</u> is vinniger as dié in <u>eksp. 1</u> as gevolg van die <u>hoër temperatuur / groter reaksieoppervlak</u>.</i> OR/OF <i>Graph <u>A</u> represents <u>exp. 4</u> due to the greater mass of CaCO_3 - greater yield of CO_2 at a faster rate.</i> <i>Grafiek <u>A</u> stel <u>eksp. 4</u> voor as gevolg van die groter massa CaCO_3 - groter opbrengs CO_2 teen vinniger tempo.</i>	✓
	Therefore the <u>gradient</u> of the graphs of <u>exp. 3 & 4</u> are <u>greater/steeper</u> than that of <u>exp. 1</u> . / Graphs of Exp. 3 & 4 reaches constant volume in shorter time than exp. 1. <i>Dus is die <u>gradiënte</u> van die grafieke vir <u>eksp. 3 & 4</u> is <u>groter/steiler</u> as dié in <u>eksp. 1</u>. / Grafieke van exp. 3 & 4 bereik konstante volume in korter tyd as dié vir eksp. 1.</i>	✓
Final answer Finale antwoord	C	✓

Notes/Aantekeninge

- Compare exp. 1 with exp. 2 / Vergelyk eksp. 1 met eksp. 2:
 - Factor & rate / Faktor & tempo.
 - Gradient / volume CO_2 per time / gradient / volume CO_2 per tyd.
- Compare exp. 1 with exp. 3 / Vergelyk eksp. 1 met eksp. 3:
 - Factor & rate / Faktor & tempo.
- Compare exp. 1 with exp. 4 / Vergelyk eksp. 1 met eksp. 4:
 - Factor & rate / Faktor & tempo.
- Compare gradient / volume CO_2 per time of exp 1 with that of exp. 3 & 4
Vergelyk gradient/volume CO_2 per tyd van eksp 1 met die van eksp. 3 & 4
- Final answer / finale antwoord: C

(6)

3.5

Marking criteria / Nasienriglyne:

- Divide volume by / Deel volume deur: 25,7 ✓
- Use ratio / Gebruik verhouding: $n(\text{CO}_2) = n(\text{CaCO}_3) = 1:1$ ✓
- Substitute / Vervang 100 in $n = \frac{m}{M}$. ✓
- Subtraction / Aftrekking. ✓
- Final answer / Finale antwoord: 7,00 g to/tot 7,5 g ✓

OPTION 1 / OPSIE 1

$$n(\text{CO}_2) = \frac{V}{V_m}$$

$$= \frac{4,5}{25,7} \checkmark$$

$$= 0,18 \text{ mol (0,175 mol)}$$

$$n(\text{CaCO}_3) = n(\text{CO}_2) = 0,18 \text{ mol} \checkmark$$

$$n(\text{CaCO}_3) = \frac{m}{M}$$

$$0,18 = \frac{m}{100} \checkmark$$

$$\therefore m = 18 \text{ g (17,5 g)}$$

$$m(\text{CaCO}_3 \text{ not reacted/nie gereageer nie}):$$

$$25 - 18 \checkmark = 7,00 \text{ g} \checkmark \quad (7,49 \text{ g})$$

(Accept range: 7,00 g – 7,5 g)
(Aanvaar gebied: 7,00 g – 7,5 g)

OPTION 2 / OPSIE 2Calculate mass of CO_2 :Bereken massa CO_2 :

$$n(\text{CO}_2) = \frac{V}{V_m}$$

$$= \frac{4,5}{25,7} \checkmark$$

$$= 0,18 \text{ mol (0,175 mol)}$$

$$n(\text{CO}_2) = \frac{m}{M}$$

$$0,18 = \frac{m}{44}$$

$$\therefore m(\text{CO}_2) = 7,92 \text{ g (7,7043 g)}$$

$$m(\text{CaCO}_3 \text{ needed / benodig}) = \frac{7,92}{44} \times 100 \checkmark$$

$$= 18 \text{ g (17,5 g)}$$

$$m(\text{CaCO}_3 \text{ not reacted/nie gereageer nie}):$$

$$25 - 18,00 \checkmark = 7,00 \text{ g} \checkmark \quad (7,49 \text{ g})$$

(Accept range: 7,00 g – 7,5 g)
(Aanvaar gebied: 7,00 g – 7,5 g)

OPTION 3 / OPSIE 3

$$25,7 \text{ dm}^3 : 1 \text{ mol}$$

$$4,5 \text{ dm}^3 : 0,18 \text{ mol} \checkmark$$

$$100 \text{ g} \checkmark : 1 \text{ mol}$$

$$x : 0,18 \text{ mol} \checkmark$$

$$x = 18 \text{ g}$$

$$m(\text{CaCO}_3 \text{ not reacted/nie gereageer nie}):$$

$$25 - 18 \checkmark = 7,00 \text{ g} \checkmark$$

(Accept range: 7,00 g – 7,5 g)
(Aanvaar gebied: 7,00 g – 7,5 g)

OPTION 4 / OPSIE 4

$$100 \text{ g CaCO}_3 \rightarrow 25,7 \text{ dm}^3 \text{ CO}_2 \checkmark \checkmark$$

$$x \text{ g} \rightarrow 4,5 \text{ dm}^3 \text{ CO}_2 \checkmark$$

$$\therefore x = 17,51 \text{ g}$$

$$\text{Mass not reacted/Massa nie gereageer nie}$$

$$= 25 - 17,51 \checkmark$$

$$= 7,49 \text{ g} \checkmark$$

(Accept range: 7,00 g – 7,5 g)
(Aanvaar gebied: 7,00 g – 7,5 g)

(5)
[18]

SESSION 8: CHEMICAL EQUILIBRIUM

SECTION A: HOMEWORK SOLUTIONS

QUESTION 1: 20 minutes

(Taken from NCS Nov 2015 Paper 2)

1.1 Equal to ✓

(1)

1.2

$$K_c = \frac{[X_3]^2}{[X_2]^3} \checkmark$$

$$= \frac{(0,226)^2}{(0,06)^3} \checkmark$$

$$= 236,46 \checkmark$$

No K_c expression, correct substitution / *Geen K_c - uitdrukking, korrekte substitusie:* Max./Maks. $\frac{3}{4}$

Wrong K_c expression / *Verkeerde K_c -uitdrukking* Max./Maks. $\frac{0}{4}$

If one or more exponents are omitted in substitution step but correct answer obtained: Max $\frac{3}{4}$

Indien een of meer eksponente uitgelaat by substitusie stap, maar korrekte antwoord verkry: Maks $\frac{3}{4}$

(4)

1.3.1 increases ✓

(1)

1.3.2 The increase in $[X_3]$ is opposed. / Change is opposed. ✓The reverse reaction is favoured. / X_3 is used / $[X_3]$ decreases. ✓

(2)

1.4 Higher than ✓

(1)

1.5 Exothermic ✓

☐ The concentration of the product/ $X_3(g)$ is lower / the concentration of the reactant / $X_2(g)$ is higher. ✓

☐ The increase in temperature favoured the reverse reaction. ✓

☐ According to Le Chatelier's principle an increase in temperature favours the endothermic reaction. ✓

OR

Exothermic ✓

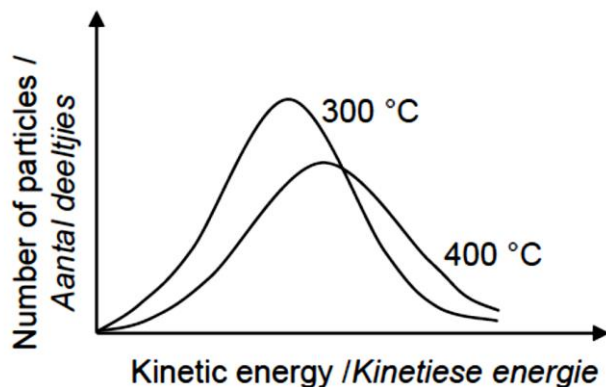
☐ $[X_3]$ decreases and $[X_2]$ increases. ✓

☐ K_c decreases if temperature increases. ✓

☐ Decrease in temperature favoured the forward reaction. ✓

(4)

1.6



Marking criteria/Nasienriglyne	
Peak of curve at 400 °C lower than at 300 °C and shifted to the right. <i>Piek van kurwe by 400 °C laer as by 300 °C en skuif na regs.</i>	✓
Curve at 400 °C has larger area at the higher E_k . <i>Kurwe by 400 °C het groter oppervlak by hoë E_k.</i>	✓

(2)
[15]

SECTION B: TYPICAL EXAM QUESTIONS SOLUTIONS

QUESTION 1: 25 minutes

(Taken from NSC Feb/Mar 2013 Paper 2)

1.1 Exothermic ✓

 ΔH is negative./less than zero. ✓

(2)

1.2

1.2.1 Greater than/Greater at t_1 than at t_2 . ✓

Larger/Steeper gradients/slopes. ✓

OR

Smaller at t_2 than at t_1 . ✓

Smaller/less steep gradients/slopes. ✓

(2)

1.2.2 Equal to ✓

(1)

1.2.3 CALCULATIONS USING NUMBER OF MOLES

Mark allocation

- Initial amount of reactants: $n(\text{HCl}) = 1 \text{ mol}$ & $n(\text{O}_2) = 0,3 \text{ mol}$ ✓
- Equilibrium: $n(\text{O}_2) = 0,1 \text{ mol}$ ✓
- USING ratio: 4 : 1 : 2 : 2 ✓
- Equilibrium: $n(\text{HCl}) = 0,2 \text{ mol}$ (initial – change) ✓
- Equilibrium: $n(\text{H}_2\text{O}) = n(\text{Cl}_2) = 0,4 \text{ mol}$ (initial + change) ✓
- Divide by volume (5 dm^3) ✓
- Correct K_c expression (formulae in square brackets) ✓
- Substitution of concentrations ✓
- Final answer: 800 ✓

Option 1:

From graph:

Initially $n(\text{HCl}) = 1 \text{ mol}$ & $n(\text{O}_2) = 0,3 \text{ mol}$ ✓At equilibrium $n(\text{O}_2) = 0,1 \text{ mol}$ ✓Ratio: ✓ $n(\text{HCl}) \text{ reacted} = 4n(\text{O}_2) \text{ reacted}$ $n(\text{H}_2\text{O}) \text{ formed} = n(\text{Cl}_2) \text{ formed} = 2n(\text{O}_2) \text{ reacted}$ $= 2(0,2) = 0,4 \text{ mol}$

At equilibrium:

 $n(\text{HCl}) = 0,2 \text{ mol}/(\text{initial} - \text{change})$ ✓ $n(\text{H}_2\text{O}) = n(\text{Cl}_2) = 0,4 \text{ mol} (\text{initial} + \text{change})$ ✓

Equilibrium concentration:

$$c(\text{HCl}) = \frac{n}{V} = \frac{0,2}{5} = 0,04 \text{ mol} \cdot \text{dm}^{-3}$$

$$c(\text{O}_2) = \frac{n}{V} = \frac{0,1}{5} = 0,02 \text{ mol} \cdot \text{dm}^{-3}$$

$$c(\text{H}_2\text{O}) = \frac{n}{V} = \frac{0,4}{5} = 0,08 \text{ mol} \cdot \text{dm}^{-3}$$

$$c(\text{Cl}_2) = \frac{n}{V} = \frac{0,4}{5} = 0,08 \text{ mol} \cdot \text{dm}^{-3}$$

Divide by 5 ✓

$$K_C = \frac{[\text{H}_2\text{O}]^2 [\text{Cl}_2]^2}{[\text{HCl}]^4 [\text{O}_2]} \checkmark \therefore \frac{(0,08)^2 (0,08)^2}{(0,04)^4 (0,02)} \checkmark = 800 \checkmark$$

Option 2

	HCl	O ₂	H ₂ O	Cl ₂
Initial quantity (mol)	1	0,3 ✓	0	0
Change (mol)	-0,8	-0,2	+ 0,4	+ 0,4
Quantity at equilibrium (mol)/	0,2 ✓	0,1 ✓	0,4	0,4 ✓
Equilibrium concentration (mol·dm ⁻³)	$\frac{0,2}{5}$ (0,04)	$\frac{0,1}{5}$ (0,02)	$\frac{0,4}{5}$ (0,08)	$\frac{0,4}{5}$ (0,08)

ratio ✓

Divide by 5 ✓

$$K_C = \frac{[\text{H}_2\text{O}]^2 [\text{Cl}_2]^2}{[\text{HCl}]^4 [\text{O}_2]} \checkmark \therefore \frac{(0,08)^2 (0,08)^2}{(0,04)^4 (0,02)} \checkmark = 800 \checkmark$$

(9)

- 1.3 Decreases ✓
 - Higher temperature favours the endothermic reaction. ✓
 The reverse reaction is favoured. ✓
 Less products/more reactants. ✓ (4)
- 1.4
 1.4.1 Decreases ✓ (1)
 1.4.2 Remains the same ✓ (1)
 1.4.3 Decreases ✓ (1)
[21]

QUESTION 2: 20 minutes (Taken from NSC Feb/March 2015 Paper 2)

- 2.1 A reaction is reversible when products can be converted back to reactants. ✓ (1)
 2.2 no change ✓ (1)
- 2.3.1 temperature decreases ✓ (1)
 2.3.2 Decrease in temperature decreases the rate of both forward and reverse reactions. ✓
 Decrease in temperature favours the exothermic reaction. ✓
 The rate of the reverse (exothermic) reaction is faster or the reverse reaction is favoured./The rate of the forward (endothermic) reaction is slower. ✓ (3)

2.4

Mark criteria/Nasienriglyne:

- Correct K_c expression (formulae in square brackets). ✓
 Korrekte K_c uitdrukking (formules in vierkanthakies).
- Divide equilibrium moles by 2 dm^3 . ✓
 Deel aantal mol by ewewig deur 2 dm^3 .
- At equilibrium: $[\text{H}_2] = [\text{I}_2] = x$ /By ewewig: $[\text{H}_2] = [\text{I}_2]$ ✓
- Substitution of concentrations into K_c expression. ✓
 Vervanging van konsentrasies in K_c -uitdrukking.
- Substitution of K_c value. ✓
 Vervanging van K_c -waarde.
- Final answer/Finale antwoord: $2,83 \times 10^{-3} \text{ mol} \cdot \text{dm}^{-3}$ ✓

OPTION 1/OPSIE 1

At equilibrium/by ewewig: $[\text{H}_2] = [\text{I}_2]$ ✓

$$K_c = \frac{[\text{H}_2][\text{I}_2]}{[\text{HI}]^2} \checkmark$$

$$\therefore 0,02 \checkmark = \frac{(x)(x)}{\left(\frac{0,04}{2}\right)^2} \checkmark \quad \begin{array}{l} \text{Divide by } 2 \text{ dm}^3 \checkmark \\ \text{Deel deur } 2 \text{ dm}^3 \end{array}$$

$$\therefore x = [\text{H}_2] = 2,83 \times 10^{-3} \text{ mol} \cdot \text{dm}^{-3} \checkmark \quad (0,0028 \text{ mol} \cdot \text{dm}^{-3})$$

OPTION 2/OPSIE 2

	HI	H ₂	I ₂	
Initial quantity (mol) <i>Aanvangshoeveelheid (mol)</i>	x	0	0	
Change (mol) <i>Verandering (mol)</i>	x - 0,04	$\frac{x - 0,04}{2}$	$\frac{x - 0,04}{2}$	ratio ✓ verhouding
Quantity at equilibrium (mol)/ <i>Hoeveelheid by ewewig (mol)</i>	0,04	$\frac{x - 0,04}{2}$	$\frac{x - 0,04}{2}$	
Equilibrium concentration (mol·dm ⁻³) <i>Ewewigskonsentrasie (mol·dm⁻³)</i>	0,02	$\frac{x - 0,04}{4}$	$\frac{x - 0,04}{4}$	Divide by 2 dm ³ Deel deur 2 di

$$K_c = \frac{[H_2][I_2]}{[HI]^2} \checkmark$$

$$\therefore 0,02 \checkmark = \frac{\left(\frac{x - 0,04}{4}\right)\left(\frac{x - 0,04}{4}\right)}{(0,02)^2} \checkmark$$

$$\therefore x = 0,05$$

$$\begin{aligned} [H_2] &= \frac{x - 0,04}{2} \\ &= \frac{0,05 - 0,04}{2} \\ &= 2,83 \times 10^{-3} \text{ mol·dm}^{-3} \checkmark \end{aligned}$$

No K_c expression, correct substitution/Geen K_c-uitdrukking, korrekte substitusie: Max./Maks. $\frac{5}{6}$

Wrong K_c expression/Verkeerde K_c-uitdrukking: Max./Maks. $\frac{2}{6}$

(6)

2.5

$$\begin{aligned} K_c &= \frac{1}{0,02} \\ &= 50 \checkmark \end{aligned}$$

(1)

2.6 increases

(1)

[14]

QUESTION 3: 20 minutes

(Taken from NSC November 2014 Paper 2)

3.1 The stage in a chemical reaction when the rate of forward reaction equals the rate of reverse reaction. ✓

OR

The stage in a chemical reaction when the concentrations of reactants and products remain constant. ✓

(1)

3.2 Note that there are 6 OPTIONS as answers for this question.

CALCULATIONS USING NUMBER OF MOLES
BEREKENINGE WAT GETAL MOL GEBRUIK

Mark allocation / Puntetoekenning:

- Correct K_c expression (formulae in square brackets). ✓
 Korrekte K_c uitdrukking (formules in vierkanthakies).
- Substitution of concentrations into K_c expression. ✓
 Vervanging van konsentrasies in K_c -uitdrukking.
- Substitution of K_c value / Vervanging van K_c -waarde. ✓
- Equilibrium concentration of both NO_2 & N_2O_4 multiplied by $0,08 \text{ dm}^3$. ✓
 Ewewigskonsentrasie van beide NO_2 & N_2O_4 vermenigvuldig met $0,08 \text{ dm}^3$
- Change in $n(N_2O_4)$ = equilibrium $n(N_2O_4)$ – initial $n(N_2O_4)$ ✓
 Verandering in $n(N_2O_4)$ = ewewig $n(N_2O_4)$ – aanvanklike $n(N_2O_4)$
- **USING** ratio / **GEBRUIK** verhouding: $NO_2 : N_2O_4 = 2 : 1$ ✓
- Initial $n(NO_2)$ = equilibrium $n(NO_2)$ + change $n(NO_2)$. ✓
 Aanvanklike $n(NO_2)$ = ewewig $n(NO_2)$ + verandering $n(NO_2)$.
- Final answer / Finale antwoord: 1,11 (mol) ✓
 Accept range/Aanvaar gebied: 1,11 – 1,12 (mol)

OPTION 1 / OPSIE 1

$$K_c = \frac{[N_2O_4]}{[NO_2]^2} \checkmark$$

$$171 \checkmark = \frac{[N_2O_4]}{(0,2)^2} \checkmark$$

$$\therefore [N_2O_4] = 171 \times (0,2)^2 \\ = 6,84 \text{ mol} \cdot \text{dm}^{-3}$$

No K_c expression, correct substitution / Geen K_c -uitdrukking, korrekte substitusie: Max./Maks. $\frac{7}{8}$

Wrong K_c expression / Verkeerde K_c -uitdrukking: Max./Maks. $\frac{5}{8}$

	NO_2	N_2O_4
Initial quantity (mol) Aanvangshoeveelheid (mol)	1,11 ✓	0
Change (mol) Verandering (mol)	1,094	0,55 ✓
Quantity at equilibrium (mol)/ Hoeveelheid by ewewig (mol)	0,016	0,55
Equilibrium concentration ($\text{mol} \cdot \text{dm}^{-3}$) Ewewigskonsentrasie ($\text{mol} \cdot \text{dm}^{-3}$)	0,2	6,84

ratio ✓
verhouding

$\times 0,08 \checkmark$

(8)

OPTION 2 / OPSIE 2

$$K_c = \frac{[N_2O_4]}{[NO_2]^2} \checkmark$$

$$171 \checkmark = \frac{[N_2O_4]}{(0,2)^2} \checkmark$$

$$\therefore [N_2O_4] = 171 \times (0,2)^2 \\ = 6,84 \text{ mol} \cdot \text{dm}^{-3}$$

No K_c expression, correct substitution / *Geen K_c -uitdrukking, korrekte substitusie*: Max./Maks. $\frac{7}{8}$

Wrong K_c expression / *Verkeerde K_c -uitdrukking*: Max./Maks. $\frac{5}{8}$

Equilibrium moles / Ewewigsmol:

$$\left. \begin{aligned} n(N_2O_4) &= (6,84)(0,080) \\ &= 0,55 \text{ mol} \\ n(NO_2) &= (0,2)(0,080) \\ &= 0,016 \text{ mol} \end{aligned} \right\} \checkmark \times 0,08 \text{ dm}^3$$

$$n(N_2O_4 \text{ formed/gevorm}) = 0,55 - 0 = 0,55 \text{ mol} \checkmark$$

Ratio / Verhouding:

$$n(NO_2 \text{ reacted / gereageer}) = 2n(N_2O_4 \text{ formed/gevorm}) = 2(0,55) = 1,094 \text{ mol} \checkmark$$

$$\text{Initial / Aanvanklike } n(NO_2) = 0,016 + 1,094 \checkmark = 1,11 \text{ (mol)} \checkmark$$

(8)

OPTION 3 / OPSIE 3

	NO ₂	N ₂ O ₄	
Initial quantity (mol) <i>Aanvangshoeveelheid (mol)</i>	2x + 0,016	0	
Change (mol) <i>Verandering (mol)</i>	2x	x ✓	ratio ✓ verhouding
Quantity at equilibrium (mol)/ <i>Hoeveelheid by ewewig (mol)</i>	0,016	x	
Equilibrium concentration (mol·dm ⁻³) <i>Ewewigskonsentrasie (mol·dm⁻³)</i>	0,2	$\frac{x}{0,08}$	x 0,08 & ÷ 0,08 ✓

$$K_c = \frac{[N_2O_4]}{[NO_2]^2} \checkmark$$

$$171 \checkmark = \frac{\frac{x}{0,08}}{(0,2)^2} \checkmark$$

$$\therefore x = 0,5472$$

$$\therefore n(\text{initial/aanvanklik}) = 2(0,5472) + 0,016 \\ = 1,11 \text{ mol} \checkmark$$

No K_c expression, correct substitution / *Geen K_c -uitdrukking, korrekte substitusie*: Max./Maks. $\frac{7}{8}$

Wrong K_c expression / *Verkeerde K_c -uitdrukking*: Max./Maks. $\frac{5}{8}$

(8)

OPTION 4 / OPSIE 4

	NO ₂	N ₂ O ₄	
Initial quantity (mol) <i>Aanvangshoeveelheid (mol)</i>	x	0	
Change (mol) <i>Verandering (mol)</i>	x - 0,016	$\frac{x - 0,016}{2}$ ✓	ratio ✓ verhouding
Quantity at equilibrium (mol)/ <i>Hoeveelheid by ewewig (mol)</i>	0,016	$\frac{x - 0,016}{2}$	
Equilibrium concentration (mol·dm ⁻³) <i>Ewewigskonsentrasie (mol·dm⁻³)</i>	0,2	$\frac{x - 0,016}{0,16}$	x 0,08 & ÷ 0,08 ✓

$$K_c = \frac{[N_2O_4]}{[NO_2]^2} \checkmark$$

$$171 \checkmark = \frac{x - 0,016}{(0,2)^2} \checkmark$$

$$\therefore x = 1,11 \text{ mol} \checkmark$$

No K_c expression, correct substitution/Geen K_c-uitdrukking, korrekte substitusie: Max./Maks. $\frac{7}{8}$

Wrong K_c expression/Verkeerde K_c-uitdrukking: Max./Maks. $\frac{5}{8}$

(8)

CALCULATIONS USING CONCENTRATION
BEREKENINGE WAT KONSENTRASIE GEBRUIK

Mark allocation / Puntetoekenning:

- Correct K_c expression (formulae in square brackets). ✓
Korrekte K_c uitdrukking (formules in vierkanthakies).
- Substitution of concentrations into K_c expression. ✓
Vervanging van konsentrasies in K_c-uitdrukking.
- Substitution of K_c value. / Vervanging van K_c-waarde. ✓
- Change in [N₂O₄] = equilibrium [N₂O₄] – initial [N₂O₄]. ✓
Verandering in [N₂O₄] = ewewig [N₂O₄] – aanvanklike [N₂O₄].
- **USING** ratio/**GEBRUIK** verhouding: NO₂ : N₂O₄ = 2 : 1 ✓
- Initial [NO₂] = equilibrium [NO₂] + change in [NO₂]. ✓
Aanvanklike [NO₂] = ewewigs [NO₂] + verandering in [NO₂].
- Equilibrium concentration of [NO₂] multiplied by 0,08 dm³. ✓
Ewewigskonsentrasie van [NO₂] vermenigvuldig met 0,08 dm³.
- Final answer/*Finale antwoord*: 1,11 (mol) ✓
Accept range/*Aanvaar gebied*: 1,11 – 1,12 (mol)

OPTION 5 / OPSIE 5

$$K_c = \frac{[N_2O_4]}{[NO_2]^2} \checkmark$$

$$171 \checkmark = \frac{[N_2O_4]}{(0,2)^2} \checkmark$$

$$\therefore [N_2O_4] = 171 \times (0,2)^2 \\ = 6,84 \text{ mol} \cdot \text{dm}^{-3}$$

No K_c expression, correct substitution/Geen K_c -uitdrukking, korrekte substitusie: Max./Maks. $\frac{7}{8}$

Wrong K_c expression/Verkeerde K_c -uitdrukking: Max./Maks. $\frac{5}{8}$

	NO_2	N_2O_4
Initial concentration ($\text{mol} \cdot \text{dm}^{-3}$) <i>Aanvangskonsentrasie ($\text{mol} \cdot \text{dm}^{-3}$)</i>	13,88	0
Change ($\text{mol} \cdot \text{dm}^{-3}$) <i>Verandering ($\text{mol} \cdot \text{dm}^{-3}$)</i>	13,68	6,84 ✓
Equilibrium concentration ($\text{mol} \cdot \text{dm}^{-3}$) <i>Ewewigskonsentrasie ($\text{mol} \cdot \text{dm}^{-3}$)</i>	0,2	6,84

ratio ✓
verhouding

$$n(NO_2) = cV = (13,88)(0,08) \checkmark = 1,11 \text{ mol} \checkmark$$

(8)

OPTION 6 / OPSIE 6

	NO_2	N_2O_4
Initial concentration ($\text{mol} \cdot \text{dm}^{-3}$) <i>Aanvangskonsentrasie ($\text{mol} \cdot \text{dm}^{-3}$)</i>	x	0
Change ($\text{mol} \cdot \text{dm}^{-3}$) <i>Verandering ($\text{mol} \cdot \text{dm}^{-3}$)</i>	x - 0,2	$\frac{x - 0,2}{2} \checkmark$
Equilibrium concentration ($\text{mol} \cdot \text{dm}^{-3}$) <i>Ewewigskonsentrasie ($\text{mol} \cdot \text{dm}^{-3}$)</i>	0,2	$\frac{x - 0,2}{2}$

ratio ✓
verhouding

$$K_c = \frac{[N_2O_4]}{[NO_2]^2} \checkmark$$

$$171 \checkmark = \frac{\frac{x - 0,2}{2}}{(0,2)^2} \checkmark$$

$$\therefore x = 13,88 \text{ mol} \cdot \text{dm}^{-3}$$

No K_c expression, correct substitution/Geen K_c -uitdrukking, korrekte substitusie: Max./Maks. $\frac{7}{8}$

Wrong K_c expression/Verkeerde K_c -uitdrukking: Max./Maks. $\frac{5}{8}$

$$n(NO_2) = cV = (13,88)(0,08) \checkmark = 1,11 \text{ mol} \checkmark$$

(8)

3.3.1 Concentration (of the gases) increases. / Molecules become more condensed or move closer to each other. ✓ (1)

3.3.2 Increase in pressure favours the reaction that leads to smaller number of moles / volume of gas. ✓

- Forward reaction is favoured ✓
- Number of moles/amount of N_2O_4 / colourless gas increases. ✓

OR

Number of moles/amount of NO_2 / brown gas decreases. ✓ (3)

3.4.1 darker ✓ (1)

3.4.2 decreases ✓ (1)

[16]