KWAZULU-NATAL PROVINCE

EDUCATION
REPUBLIC OF SOUTH AFRICA

CURRICULUM GRADE 10 -12 DIRECTORATE

NCS (CAPS)

LEARNER SUPPORT DOCUMENT

GRADE 12

PHYSICAL SCIENCES WINTER REVISION DOCUMENT

2026 SOLUTIONS

This support document covers the following topics:

Vertical Projectile Motion

VERTICAL PROJECTILE MOTION

SOLUTIONS

MULTIPLE CHOICE QUESTIONS

1.1	B ✓✓	(2)
1.2	C ✓✓	(2)
1.3	D ✓✓	(2)
1.4	A ✓✓	(2)
1.5	C ✓✓	(2)
1.6	A ✓✓	(2)
1.7	B ✓✓	(2)

LONG QUESTIONS

QUESTION 2

2.1 $9,8\ m\cdot s^{-2}$ ✓ (1)

2.2.1 $\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ✓

$2 = v_i(0,125) + \frac{1}{2}(9,8)(0,125)^2$ ✓

$v_i = 15,39\ m.s^{-1}$

$v_f^2 = v_i^2 + 2a\Delta y$

$(15,39)^2 = (0)^2 + 2(9,8)(\Delta y)$ ✓

$\Delta y = 12,08\ m$

$h = 12,08 + 2$ ✓

$= 14,08\ m$ ✓ (5)

2.2.2 $\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ✓

$14,08$ ✓ $= 0(\Delta t) + \frac{1}{2}(9,8)(\Delta t)^2$ ✓

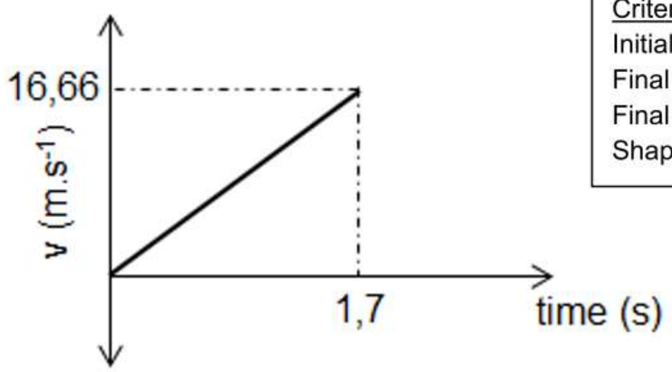
$\Delta t = 1,7\ s$ ✓ (4)

2.2.3 $v_f = v_i + a\Delta t$ ✓

$= 0 + (9.8)(1,7)$ ✓

$= 16,66\ m\cdot s^{-1}$ downwards ✓ (3)

2.3



Criteria
- Initial velocity = $0\ m\cdot s^{-1}$ ✓
- Final velocity = answer to 1.2.3 ✓
- Final time = answer to 1.2.2 ✓
- Shape: Straight line ✓

(4)

[17]

QUESTION 3

3.1 An object which has been given an initial velocity and then it moves under the influence of the gravitational force only. ✓✓ (2)

3.2 Distance = area under graph OR ½bh ✓

= ½ x 0,8✓ x 7,84✓ (4)

= 3,14 m ✓

3.3 0,2 seconds ✓ (1)

3.4

$F_{net} = \frac{\Delta p}{\Delta t}$

$F_{net} = \frac{m\Delta v}{\Delta t}$ ✓

$F_{net} = \frac{0,175(1,53 - 7,84)✓}{0,2✓}$

= - 5,52 N

= 5,52 N upwards ✓ (4)

3.5

$v_f = v_i + a\Delta t$ ✓

= 1,53 + (9,8)(0,7) ✓

= 8,39 $m \cdot s^{-1}$ ✓

$a = \frac{y_2 - y_1}{x_2 - x_1}$ ✓

$9,8 = \frac{v_f - 1,53}{1,7 - 1}$ ✓

V_f = 8,39 $m \cdot s^{-1}$ ✓ (3)

3.6 Equal to ✓ (1)

[15]

QUESTION 4

4.1 **BALL B**

$\Delta y = v_i\Delta t + ½ a\Delta t^2$ ✓

12 = 18Δt + ½ (-9,8)Δt^2 ✓

Δt = 0,88 s or 2,8 s

Select Δt = 0,88 s since Ball B is moving upwards when they meet at P

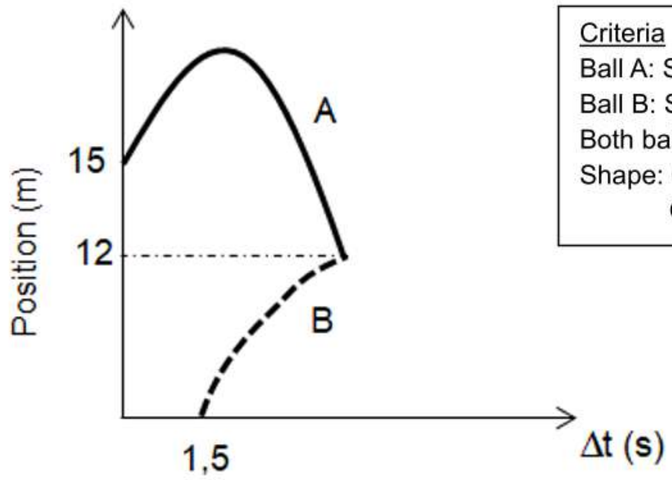
BALL A

$\Delta y = v_i\Delta t + ½ a\Delta t^2$

-3 ✓= v_i(0,88+1,5✓) + ½ (-9,8)$(0,88+1,5)^2$ ✓

vi = 10,4 $m \cdot s^{-1}$ upwards ✓ (6)

4.2



Criteria
Ball A: Start at 15 m ✓
Ball B: Start from x-axis at 1,5 s ✓
Both balls meet at 12 m ✓
Shape: Graph A ✓
Graph B ✓

(5)

[11]

QUESTION 5

5.1 Motion in which the only force acting is gravitational force.✓✓ (2)

5.2 No ✓ (1)

5.3.1 $\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ✓ (3)

$15 = 3,4(\Delta t) + \frac{1}{2}(9,8)(\Delta t)^2$ ✓

$\Delta t = 1,44$ s ✓

5.3.2 $\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ✓

$= 3,4(1,44) + \frac{1}{2}(0)(1,44)^2$ ✓

$= 4,896$ m

Height $= 15 - 4,896$ ✓

$= 10,1$ m ✓ (4)

5.4 $v_f = v_i + a\Delta t$ ✓

$0 = -7,2 + (9,8)\Delta t$ ✓

$\Delta t = 0,73$ s

$t_3 = 1,44 + 0,2 + 0,73$ ✓

$= 2,37$ s ✓ (4)

[14]

QUESTION 6

6.1.1 $v_f^2 = v_i^2 + 2a\Delta y$ ✓

$(0✓)^2 = v_i^2 + 2(-9,8)(\frac{1}{4}H)$ ✓

$v_i = \sqrt{4,9H}$ ✓ (4)

6.1.2 $v_f = v_i + a\Delta t$ ✓

$0 = v_i + (-9,8)(2,33 - T)$ ✓

$v_i = 22,834 - 9,8T$ ✓ (3)

6.2 $\sqrt{4,9H} = 22,834 - 9,8T$ ✓

$H = \frac{(22,834 - 9,8T)^2}{4,9}$ (1)

6.3 $\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ✓

$-H✓ = 5(T) + \frac{1}{2}(-9,8)(T)^2$ ✓

$H = 4,9T^2 - 5T$ ✓ (4)

6.4 $4,9T^2 - 5T ✓ = \frac{(22,834 - 9,8T)^2}{4,9}$ ✓

T = 1,76 s or T = 4,11 s (Reject 4,11s since T is less than 2,33 seconds)

T = 1,76 s ✓ (3)

[15]

QUESTION 7

7.1 Weight / Gravitational force ✓ (1)

7.2.1 $t = 0,67 - 0,64$ ✓

$= 0,03$ s ✓ (2)

7.2.2

$t = \frac{1,9 - 0,67}{2}$ ✓

$= 0,62$ s ✓ (2)

7.2.3 $v_f = v_i + a\Delta t$ ✓

$0 = v_i + (-9,8)(0,62)$ ✓

$v_i = 6,08\ m.s^{-1}$ ✓ (3)

7.2.4 $v_f^2 = v_i^2 + 2a\Delta y$ ✓

$(0)^2 = v_i^2 + 2(-9,8)(1,2)$ ✓

$v_i = 4,85\ m.s^{-1}$

$\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ✓

$1,2 = 4,85\Delta t + \frac{1}{2}(-9,8)\Delta t^2$ ✓

$\Delta t = 0,49\ s$

$t = 1,97 + 2 \times 0,49$ ✓

$= 2,95\ s$ ✓ (6)

[14]

QUESTION 8

8.1 An object that has been given an initial velocity and then moves under the influence of the gravitational force only. ✓✓ (2)

8.2.1

Upward as positive	Downward as positive
$v_f = v_i^2 + 2a\Delta y$ ✓ $(-29,36)^2$ ✓ $= v_i^2 + \underline{2(-9,8)(-33)}$ ✓ $v_i = 14,67\ m.s^{-1}$ ✓	$v_f^2 = v_i^2 + 2a\Delta y$ ✓ $(29,3)^2$ ✓ $= v_i^2 + 2(9,8)(33)$ ✓ $v_i = 14,67\ m.s^{-1}$ ✓

(4)

8.2.2

Upward as positive	Downward as positive
$v_f^2 = v_i^2 + 2a\Delta y$ ✓ $= \underline{(13,77)^2 + 2(-9,8)(-12)}$ ✓ $v_f = \underline{20,61\ m.s^{-1}, \text{downward}}$ ✓	$v_f^2 = v_i^2 + 2a\Delta y$ ✓ $= \underline{(-13,77)^2 + 2(9,8)(12)}$ ✓ $v_f = \underline{20,61\ m.s^{-1}, \text{downward}}$ ✓

(3)

8.3 **POSITIVE MARKING FROM QUESTION 8.2.1 & 8.2.2**

Time from roof to balcony

UPWARD AS POSITIVE	DOWNWARD AS POSITIVE
$vf = vi + a\Delta t$ ✓ $\underline{(-29,36) = 14,67 + (-9,8)\Delta t}$ ✓ $\Delta t = 4,49\ s$	$vf = vi + a\Delta t$ ✓ $\underline{(29,36) = -14,67 + 9,8\Delta t}$ ✓ $\Delta t = 4,49\ s$

Time from balcony to ground

UPWARD AS POSITIVE	DOWNWARD AS POSITIVE
$v_f = v_i + a\Delta t$ $\underline{(-20,61) = 13,77 + (-9,8)\Delta t}$ ✓ $\Delta t = 3,51\ s$	$v_f = v_i + a\Delta t$ $\underline{(20,61) = -13,77 + 9,8\Delta t}$ ✓ $\Delta t = 3,51\ s$

Contact time = $\underline{8,2 - (4,49 + 3,51)}$ ✓ $= 0,2\ s$

$F_{net} = \frac{m(vf - vi)}{\Delta t}$ ✓

$F_{net} = \frac{0,3(13,77 - (-29,36))}{0,2}$ ✓

$= 64,70\ N$, upwards ✓

(7)

[16]

QUESTION 9

9.1 An object which has been given an initial velocity and then moves under the influence of gravitational force only. ✓✓ (2)

9.2 $9,8\ m\cdot s^{-2}$ ✓ downwards✓ (2)

9.3.1

UPWARD AS POSITIVE	DOWNWARD AS POSITIVE
$v_f = v_i + a\Delta t$ ✓ $0 = 20 + (-9,8)\Delta t$ ✓ $\Delta t = 2,04\ s$ ✓	$v_f = v_i + a\Delta t$ ✓ $0 = -20 + (9,8)\Delta t$ ✓ $\Delta t = 2,04\ s$ ✓

(3)

9.3.2

OPTION 1 **POSITIVE MARKING FROM Q 9.3.1** $\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ✓ $= (20)(2,04) + \frac{1}{2}(-9,8)(2,04)^2$ ✓ $= 20,41\ m$ ✓	**OPTION 2** $v_f^2 = v_i^2 + 2a\Delta y$ ✓ $0^2 = 20^2 + 2(-9,8)\Delta y$ ✓ $\Delta y = 20,41\ m$ ✓
OPTION 3 **POSITIVE MARKING FROM Q 9.3.1** $\Delta y = \left(\frac{v_i + v_f}{2}\right)\Delta t$ ✓ $\Delta y = \left(\frac{20 + 0}{2}\right)(2,04)$ ✓ $\Delta y = 20,40\ m$ ✓	**OPTION 4** **POSITIVE MARKING FROM Q 9.3.1** maximum height $= \frac{1}{2}b\cdot h$ ✓ $= \frac{1}{2}(2,04)(20)$ ✓ $= 20,40\ m$ ✓

(3)

9.4.1

UPWARD AS POSITIVE	DOWNWARD AS POSITIVE
$v_f = v_i + a\Delta t$ ✓ $= 20 + (-9,8)(5)$ ✓ $= -29\ m\cdot s^{-1}$ $\therefore v_f = 29\ m\cdot s^{-1}$ ✓	$v_f = v_i + a\Delta t$ ✓ $= -20 + (9,8)(5)$ ✓ $= 29\ m\cdot s^{-1}$ ✓

(3)

9.4.2

OPTION 1 **UPWARDS AS POSITIVE** $\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ✓ $= (20)(5)$ ✓ $+ \frac{1}{2}(-9,8)(5)^2$ ✓ $= 22,50\ m$ ✓	**OPTION 1** **DOWNWARDS AS POSITIVE** $\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ✓ $= (-20)(5)$ ✓ $+ \frac{1}{2}(9,8)(5)^2$ ✓ $= 22,50\ m$ ✓
OPTION 2 **POSITIVE MARKING FROM Q 9.4.1** $\Delta y = \left(\frac{v_i + v_f}{2}\right)\Delta t$ $\Delta y = \left(\frac{20 + (-29)}{2}\right)(5)$ ✓ $\Delta y = 22,50\ m$ ✓	**OPTION 3** **POSITIVE MARKING FROM Q 9.4.1** $v_f^2 = v_i^2 + 2a\Delta y$ $(-29)^2 = 20^2 + 2(-9,8)\Delta y$ ✓ $\Delta y = 22,50\ m$ ✓

(4)

[17]

QUESTION 10

10.1 No✓

Not only gravitational force acts on the hot-air balloon/Acceleration of the balloon is zero/Net force acting on the hot-air balloon is zero.✓ (2)

10.2 $12\ m.s^{-1}$✓ upwards✓ (2)

10.3.1 **POSITIVE MARKING FROM QUESTION 10.2**

OPTION 1 UPWARD AS POSITIVE	OPTION 1 DOWNWARD AS POSITIVE
$v_f = v_i + a\Delta t$ ✓ $0 = 12 + (-9,8)\Delta t$ ✓ $\Delta t = 1,22\ s$ ✓	$v_f = v_i + a\Delta t$ ✓ $0 = -12 + (9,8)\Delta t$ ✓ $\Delta t = 1,22\ s$ ✓

(3)

10.3.2 **POSITIVE MARKING FROM QUESTION 10.2 and 10.3.1**

OPTION 1 **UPWARDS AS POSITIVE** **Max. height (camera) from where it was released** $\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ✓ $= (12)(1,22) + \frac{1}{2}(-9,8)(1,22)^2$ ✓ $= 7,35$ m **Height (hot-air balloon) after 1.22 s** $\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ $= (12)(1,22) + \frac{1}{2}(0)(1,22)^2$ ✓ $= 14,64$ m ∴ distance = 14,64 - 7.35 ✓ = 7,29 m ✓	**OPTION 1** **DOWNWARDS AS POSITIVE** **Max. height (camera) from where it was released** $\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ✓ $= (-12)(1,22) + \frac{1}{2}(9,8)(1,22)^2$ ✓ $= -7,35$ m **Height (hot-air balloon) after 1.22 s** $\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ $= (-12)(1,22) + \frac{1}{2}(0)(1,22)^2$ ✓ $= -14,64$ m ∴ distance = 14,64 - 7.35 ✓ = 7,29 m ✓
OPTION 2 **Max. hieght (camera) from where it was released** $\Delta y = \left(\frac{v_i + v_f}{2}\right)\Delta t$ ✓ $\Delta y = \left(\frac{12 + 0}{2}\right)(1,22)$ ✓ $\Delta y = 7,32$ m **Height (hot-air balloon) after 1.22 s** $\Delta y = v\Delta t$ $= (12)(1,22)$ ✓ $= 14,64$ m ∴ distance =14,64 - 7.32 ✓ = 7,32m ✓	**OPTION 3** **Max. hieght (camera) from where it was released** $v_f^2 = v_i^2 + 2a\Delta y$ ✓ $(0)^2 = 12^2 + 2(-9,8)\Delta y$ ✓ $\Delta y = 7,35$ m **Height (hot-air balloon) after 1.22 s** $\Delta y = v\Delta t$ $= (12)(1,22)$ ✓ $= 14,64$ m ∴ distance =14,64 - 7.35 ✓ = 7,29 m ✓

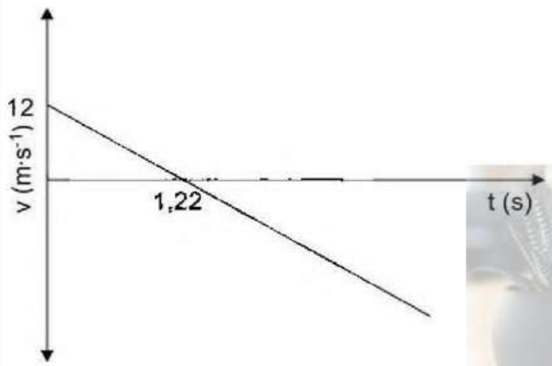
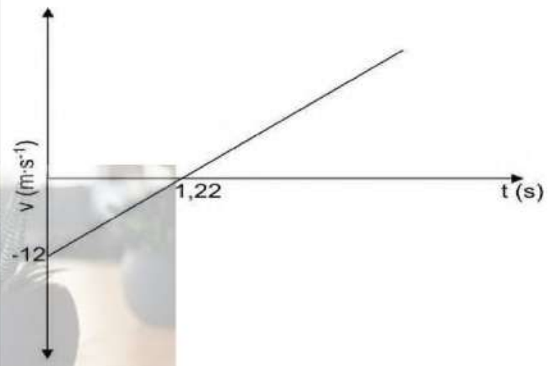
10.4 **POSITIVE MARKING FROM QUESTION 10.2**

UPWARDS AS POSITIVE Time taken by camera to reach the ground $\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ✓ -100 ✓ $= 12\Delta t + \frac{1}{2}(-9,8)\Delta t^2$ ✓ $\Delta t = 5,91$ s **Time taken by jogger** $\Delta x = v_i\Delta t + \frac{1}{2}a\Delta t^2$ 15 ✓ $= 3\Delta t + \frac{1}{2}(0)\Delta t^2$ ✓ $\Delta t = 5$ s 5,91 s > 5s ∴ the jogger will be able to catch the camera✓	**DOWNWARDS AS POSITIVE** Time taken by camera to reach the ground $\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ✓ 100 ✓ $= -12\Delta t + \frac{1}{2}(9,8)\Delta t^2$ ✓ $\Delta t = 5,91$ s **Time taken by jogger** $\Delta x = v_i\Delta t + \frac{1}{2}a\Delta t^2$ 15 ✓ $= 3\Delta t + \frac{1}{2}(0)\Delta t^2$ ✓ $\Delta t = 5$ s 5,91 s > 5s ∴ the jogger will be able to catch the camera✓	OPTION 1 UPWARDS AS P Time taken by ca $\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t$ -100 ✓= 12Δt + $\Delta t = 5,91$ s Time taken by jo $\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t$ 15 ✓= 3Δt + ½(0 $\Delta t = 5$ s 5,91 s > 5s ∴ the jogger will camera✓
OPTION 2 **UPWARDS AS POSITIVE** Time taken by camera to reach the ground	**OPTION 2** **DOWNWARDS AS POSITIVE** Time taken by camera to reach the ground	

$\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ✓ $-(100 + 7,35)$ ✓ $= (0)\Delta t + \frac{1}{2}(-9,8)\Delta t^2$ ✓ $\Delta t = 4,68$ s Total time = 4,68+1,22 = 5,90 Time taken by jogger to cover the 15 m $\Delta x = v_i\Delta t + \frac{1}{2}a\Delta t^2$ 15 ✓ $= 3\Delta t + \frac{1}{2}(0)\Delta t^2$ ✓ $\Delta t = 5$ s 5,90s > 5 s ∴ the jogger will be able to catch the camera ✓	$\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ✓ $(100+7.35)$ ✓ $= (0)\Delta t + \frac{1}{2}(9,8)\Delta t^2$ ✓ $\Delta t = 5,90$s Total time = 4,68+1,22 = 5,90 Time taken by jogger to cover the 15 m $\Delta x = v_i\Delta t + \frac{1}{2}a\Delta t^2$ 15 ✓ $= 3\Delta t + \frac{1}{2}(0)\Delta t^2$ ✓ $\Delta t = 5$ s 5,90 s > 5 s ∴ the jogger will be able to catch the camera ✓

(6)

10.5

UPWARD AS POSITIVE	DOWNWARD AS POSITIVE
	

Criteria
Initial velocity = 12 m·s^{-1} ✓
Time = 1,22s at max. height ✓
Shape: Straight line ✓

(3)

[21]

QUESTION 11

11.1 9,8 m·s^{-2} ✓ downwards ✓ (2)

11.2

UPWARD AS POSITIVE	DOWNWARD AS POSITIVE
$v_f^2 = v_i^2 + 2a\Delta y$ ✓ $(0)^2$ ✓ $= v_i^2 + 2(-9,8)(7)$ ✓ $v_i = 11,71$ m·s^{-1} ✓	$v_f^2 = v_i^2 + 2a\Delta y$ ✓ $(0)^2$ ✓ $= v_i^2 + 2(9,8)(-7)$ ✓ $v_i = 11,71$ m·s^{-1} ✓

(4)

11.3.1 **POSITIVE MARKING FROM QUESTION 11.2**

$E_{k(before)} = E_{K(after)} + E_{K(coverted)}$ ✓

$\frac{1}{2}mv^2 = \frac{1}{2}mv^2 + 344,1$

$\frac{1}{2}(1,5)v^2$ ✓ $= \frac{1}{2}(1,5)(11,71)^2 + 344,1$ ✓

$v = 24,41$ m·s-1 ✓

(4)

11.3.2 **POSITIVE MARKING FROM QUESTION 11.3.1**

UPWARD AS POSITIVE	DOWNWARD AS POSITIVE
$v_f = v_i + a\Delta t$ ✓ $-24,41 = -12 + (-9,8)\Delta t$ ✓ $\Delta t = 1,27$ s ✓	$v_f = v_i + a\Delta t$ ✓ $24,41 = 12 + (9,8)\Delta t$ ✓ $\Delta t = 1,27$ s ✓

(3)

[13]

Momentum/ Impulse

SOLUTIONS

QUESTION 1 MCQ

1.1 C✓✓ (2)

1.2 D✓✓ (2)

1.3 D✓✓ (2)

1.4 C✓✓ (2)

1.5 B✓✓ (2)

QUESTION 2

2.1 $p = mv$✓

$= (1300)(20)$ ✓

$= 26000\ kgm.s^{-1}$ left✓ (3)

2.2 $m_1v_{1i} + m_2v_{2i} = (m_1 + m_2)v_f$ ✓

$(1300)(20) + (2500)\ v_{2i}$ ✓$= (1300+2500)(-9)$✓

$v_{2i} = -28{,}08$

$v_{2i} = 28{,}08\ m.s^{-1}$✓ (4)

2.3 $F_{net}\Delta t = \Delta p$ ✓

$F_{net}(0{,}2)$✓$= 1300(-9-20)$ ✓

$F_{net} = -188500$

$F_{net} = 188500\ N$✓ (4)

2.4 $\sum E_{Ki} = ½\ mv_i^2 + ½\ mv_i^2$ ✓

$= ½(1300)(20)^2 + ½\ (2500)(-28{,}08)^2$ ✓

$= 984808\ J$

$\sum E_{Kf} = ½\ (m_1+m_2)v_f^2$

$= ½(1300+2500)(-9)^2$ ✓

$= 153900\ J$

$\sum E_{Ki} \neq \sum E_{Kf}$ ✓

∴ the collision is inelastic✓ (5)

QUESTION 3

3.1 The total linear momentum of an isolated system remains constant (is conserved) ✓✓ (2)

3.2 $m_1v_{1i} + m_2v_{2i} = (m_1 + m_2)v_f$ ✓

$(5)(4) + (2)(-1)$ ✓ $= (5+2)\ v_f$ ✓

$v_f = 2{,}54\ m.s^{-1}$ ✓ (4)

3.3 $F_{net}\,\Delta t = \Delta p$ ✓

$F_{net}(0{,}3)$ ✓ $= 7\ (0 - 2{,}57)$ ✓

$F_{net} = -59{,}97$

$F_{net} = 59{,}97\ N$ ✓ (4)

QUESTION 4

4.1 The total linear momentum of an isolated system remains constant (is conserved) ✓✓ (2)

4.2 $E_K = \frac{1}{2} mv^2$ ✓

$258750 = \frac{1}{2}(2300)v^2$ ✓

$v = 15\ m.s^{-1}$ ✓ (3)

4.3 $m_1v_{1i} + m_2v_{2i} = (m_1 + m_2)vf$ ✓

$m_T(20) + (2300 - m_T)(-10)$ ✓ $= (2300)(15)$ ✓

$m_T = 1916{,}67\ kg$ ✓ (4)

4.4 $\Delta p = m(v_f - v_i)$ ✓

$\Delta p = 1916{,}67(15 - 20)$ ✓

$\Delta p = -\ 9583{,}35$

$\Delta p = 9583{,}35\ kgm.s^{-1}$ ✓ (3)

[12]

QUESTION 5

5.1 The product of an object's mass and its velocity. ✓✓ (2)

5.2 **OPTION 1**

$F_{net}\,\Delta t = \Delta p$ ✓

$F_{net}(0{,}2)$ ✓ $= (5)\ (1{,}53 - 7{,}84\ )$ ✓

$F_{net} = -157{,}75$

$F_{net} = 157{,}75\ N$ ✓

OPTION 2

Gradient $= \frac{1{,}53 - 7{,}84}{1{,}0 - 0{,}8}$ ✓ (4)

$a = -31,55\ m.s^{-2}$

$F_{net} = ma$ ✓

$= (5)(-31,55)$ ✓

$= -157,75$

$= 157,75\ N$ ✓

5.3 Option 1

Inelastic ✓

- The velocity/speed before is greater than the velocity/speed after the collision ✓✓
- Total kinetic energy is not conserved ✓

Option 2

If calculation is given:

Total E_K before = ½ mv^2

$= ½(5)(7,84)^2$ ✓

$= 153,66\ J$

Total E_K after = ½ mv^2

$= ½(5)(1)^2$ ✓

$= 2,50\ J$

Total E_K before is not equal Total E_K after ✓ (4)

5.4

- The two balls will undergo the same Δp to stop. ✓
- The rubber ball will take longer to stop as is soft. F is inversely proportional to Δt if Δp is constant. ✓
- The force needed to stop the rubber ball is small enough for the glass not to break. ✓ (3)

Organic Molecules

SOLUTIONS

QUESTION 1

1.1	A ✓✓	(2)
1.2	B ✓✓	(2)
1.3	C ✓✓	(2)
1.4	A ✓✓	(2)
1.5	D ✓✓	(2)
1.6	B ✓✓	(2)
1.7	D ✓✓	(2)

[14]

QUESTION 2

2.1.1 A series of organic compounds that can be described by the same general formula. **OR** A series of organic compounds in which one member differs from the next by the CH_2 group. ✓✓ (2)

2.1.2 (a) Formyl group ✓ (1)

(b) Methanal ✓✓ (2)

2.1.3 (a) Homologous series / functional group / type of intermolecular forces / straight chain / atmospheric pressure ✓ (1)

(b) The boiling points of carboxylic acids increase with an increase in chain length/the number of carbon atoms/surface area/molecular mass ✓ (1)

(c) As the number of C atoms/chain length/molecular mass/surface area increases,

- The strength of intermolecular/London/dispersion forces increases. ✓
- More energy is required to overcome the intermolecular/London/dispersion forces. ✓

(2)

2.1.4 75 °C ✓ (1)

2.2
- Higher than ✓
- Compound B has two sites of hydrogen bonding between molecules and compound A has only one site of hydrogen bonding between molecules. ✓
- Intermolecular forces in compound B are stronger. ✓
- More energy is required to overcome the intermolecular forces in compound B. ✓ (4)

[14]

QUESTION 3

3.1 Compounds with one or more multiple bonds between C atoms in the hydrocarbon chain ✓✓ (2)

3.2.1 E ✓ (1)

3.3.2 F ✓ (1)

3.3 Ketones ✓
Aldehydes ✓ (2)

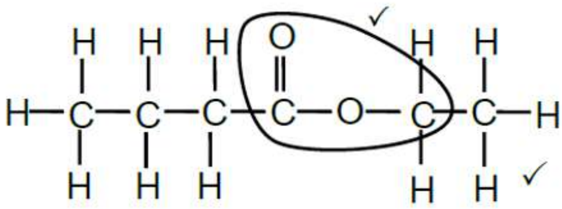
3.4 Tertiary ✓
The -OH is bonded to a C which is bonded to three other C atoms. ✓ (2)

3.5.1 3-ethyl-4-iodohexane ✓✓✓ (3)

3.5.2 2-methylpropan-1-ol / 2-methy-1-propanol / methyl-1-propanol ✓✓ (2)

3.6.1 Esterification / condensation ✓ (1)

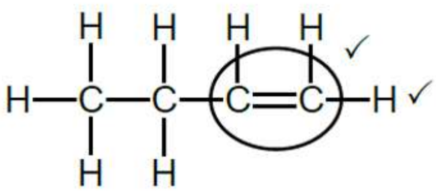
3.6.2



(2)

3.7.1 C_2H_4O ✓ (1)

3.7.2



(2)

[19]

QUESTION 4

4.1.1 D ✓ (1)

4.1.2 A ✓ (1)

4.1.3 E ✓ (1)

4.2 3,3-dibromo-4,4-dimethylhexane ✓✓✓ (3)

4.2.2 4,4-dimethylpent-2-yne OR 4,4-dimethyl-2-pentyne ✓✓✓ (3)

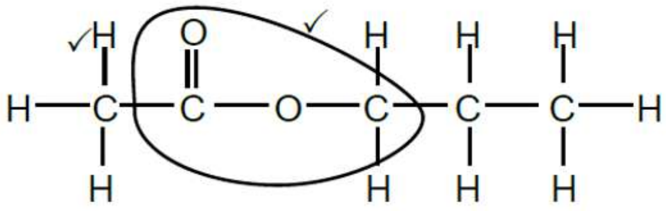
4.3.1 Compounds with the same molecular formula but different functional groups/homologous series. ✓✓ (2)

4.3.2 A and C ✓ (1)

4.4.1 H_2SO_4 / sulphuric acid ✓ (1)

4.4.2 Esterification / condensation ✓ (1)

4.4.3 (2)



4.4.4 Propan-1-ol OR 1-propanol ✓✓ (2)

[18]

QUESTION 5

5.1 The pressure exerted by a vapour at equilibrium with its liquid in a closed system ✓✓ (2)

5.2.1 146 (kPa) ✓ (1)

5.2.2 **Comparing compound C with compounds A and B**.

- **Structure:**

Compound C is more branched than compounds A and B / shorter chain length / smallest surface area. ✓

- **Intermolecular forces:**

Compound C has weaker intermolecular forces / London forces than A and B. ✓

- **Energy:**

Less energy is needed to overcome/break the intermolecular forces in compound C than in compounds A and B. ✓ (3)

5.3.1 E / butanal ✓ (1)

5.3.2

• Compound D/Propanoic acid has hydrogen bonding (dipole- dipole and London forces) between molecules. ✓

• Compound E/Butanal has dipole-dipole forces (and London forces) between molecules. ✓

• Intermolecular forces between molecules of compound D/propanoic acid are stronger than intermolecular forces between molecules of compound E/butanal. ✓

• More energy is needed to overcome/break intermolecular forces between molecules of compound D/propanoic acid than in compound E/butanal ✓

OR

• Compound D/Propanoic acid has hydrogen bonding (dipole-dipole and London forces) between molecules.

• Compound E/Butanal has dipole-dipole forces (and London forces) between molecules.

• Intermolecular forces between molecules of compound E/butanal are weaker than intermolecular forces between compound D/propanoic acid

• Lesser energy is needed to overcome/break intermolecular forces between molecules of compound E/butanal than in compound D/propanoic acid

(4)

[11]

QUESTION 6

6.1 The temperature at which the vapour pressure of a substance is equal to the vapour pressure. ✓ ✓ (2)

6.2 C ✓ (1)

6.3 **Compound A**

- Longer chain length / larger surface area over which the intermolecular forces act ✓
- Stronger intermolecular forces ✓ (3)

- More energy is needed to overcome / break the intermolecular forces ✓

OR

Compound B

- Shorter chain length / smaller surface area
- Weaker intermolecular forces
- Less energy is needed to break / overcome the intermolecular forces

6.4.1 75 °C ✓ (1)

6.4.2
- **Intermolecular forces:** C /butanol has stronger intermolecular forces than D /butanal. ✓
- **Energy:** More energy needed to overcome or break intermolecular forces. ✓

OR
- **Intermolecular forces:** D/butanal has weaker intermolecular forces than C/butanol
- **Energy:** Less energy is needed to overcome or break intermolecular forces.

OR
- **Intermolecular forces:** A is a more polar molecule than D increasing the intermolecular forces
- **Energy:** More energy is needed to overcome or break intermolecular forces

OR
- **Intermolecular forces:** Electron density of A is greater than that of D increasing the intermolecular forces
- **Energy:** More energy is needed to overcome or break intermolecular forces. (2)

6.5 Decreases ✓ (1)

[10]

QUESTION 7

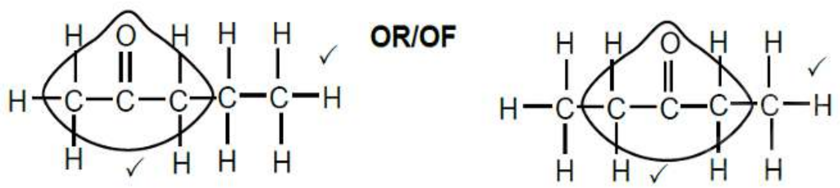
7.1 Organic compounds that consist of hydrogen and carbon only ✓✓ (2)

7.2.1 C and E ✓✓ (2)

7.2.2 D and H ✓ (1)

7.2.3 A ✓ (1)

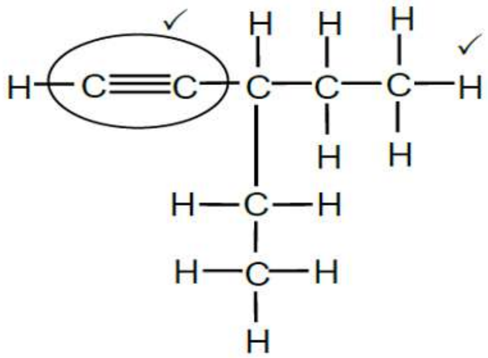
7.3.1



(2)

7.3.2 C_nH_{2n+2} ✓ (1)

7.3.3



(2)

7.4.1 3-ethyl-3-hexene OR 3-ethylhex-3-ene ✓✓✓ (3)

7.4.2 2,5-dichloro-2,4-dimethylhexane ✓✓✓ (3)

7.4.3 2,2-dimethylpropanal OR dimethylpropanal ✓✓ (2)

7.5 $C_7H_{16} + 11O_2 \rightarrow 7CO_2 + 8H_2O$ ✓✓✓ (3)

[22]

QUESTION 8

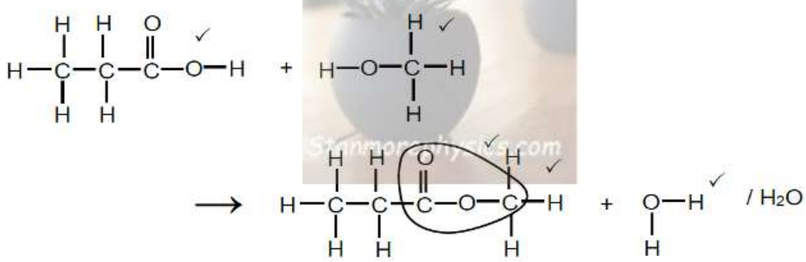
8.1.1 Sulphuric acid ✓ (1)

8.1.2 Esterification / condensation ✓ (1)

8.1.3
- Alcohol/methanol catches fire easily
- To heat evenly / increase temperature gradually
- Aclcohol / methanol will evaporate too quickly/is volatile

(Any two) ✓ ✓ (2)

8.1.4



(5)

8.1.5 Methyl propanoate ✓ ✓ (2)

8.2.1 Hydrogen / H_2 ✓ (1)

8.2.2 3,3-dimethylbut-1-ene OR 3,3-dimethyl-1-butene ✓ ✓ (2)

8.2.3 Elimination OR dehydrohalogenation ✓ (1)

8.2.4 H_2SO_4/H_3PO_4 OR sulphuric caid/phosphoric acid ✓ (1)

8.2.5 3,3-dimethylbutan-2-ol OR 3,3-dimethyl-2-butanol ✓ ✓ (2)

8.2.6 Addition / hydration ✓ (1)

8.2.7 Secondary ✓ (1)

[20]

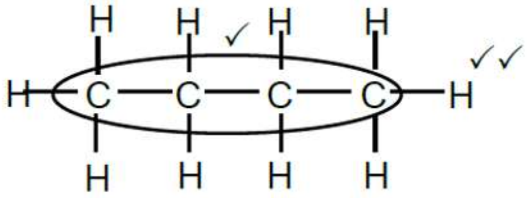
QUESTION 9

9.1 The chemical process/reaction in which longer chain hydrocarbon/alkane molecules/are broken down to shorter (more useful) molecules. ✓✓ (2)

9.2 Primary ✓

The halogen/bromine/functional group (-X) is bonded to a C atom that is bonded to one other C atom. ✓ (2)

9.3.1



(3)

9.3.2 C_8H_{18} ✓ (1)

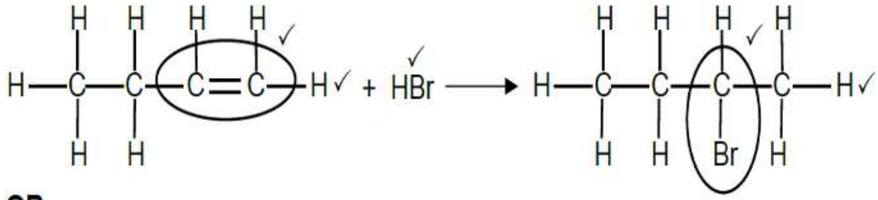
9.4.1 Br_2/Bromine ✓ (1)

9.4.2 Substitution ✓ (1)

9.4.3 UV/(Sun)light/Heat ✓ (1)

9.5 Dehydrohalogenation/Dehydrobromination ✓ (1)

9.6.1



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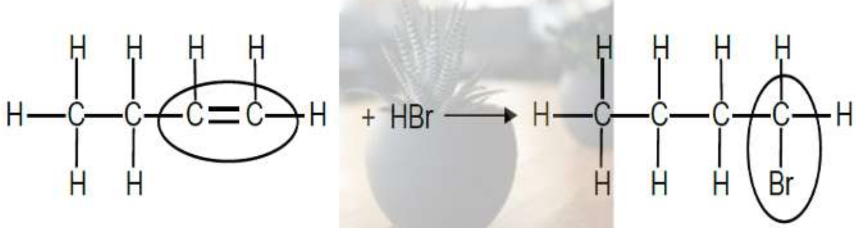
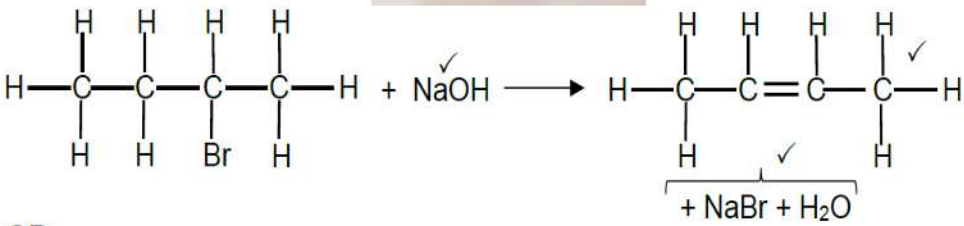


(5)

9.6.2



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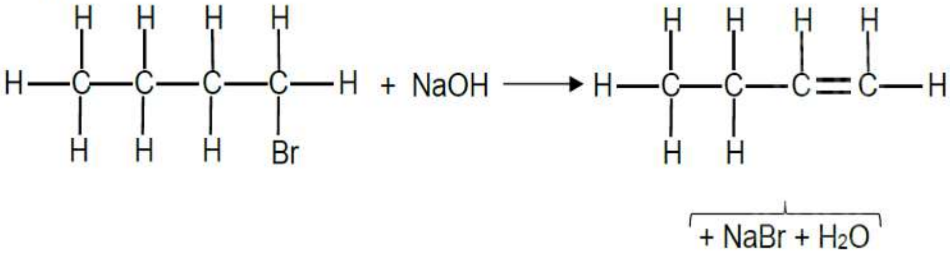


(3)

9.6.3 But-2-ene OR 2-butene OR but-1-ene OR 1-butene ✓ ✓ (2)

[22]

QUESTION 10

10.1.1 Hydrogenation (1)

10.1.2 Dehydration (1)

10.2 Butan-1-ol OR 1-butanol (2)

10.3.1

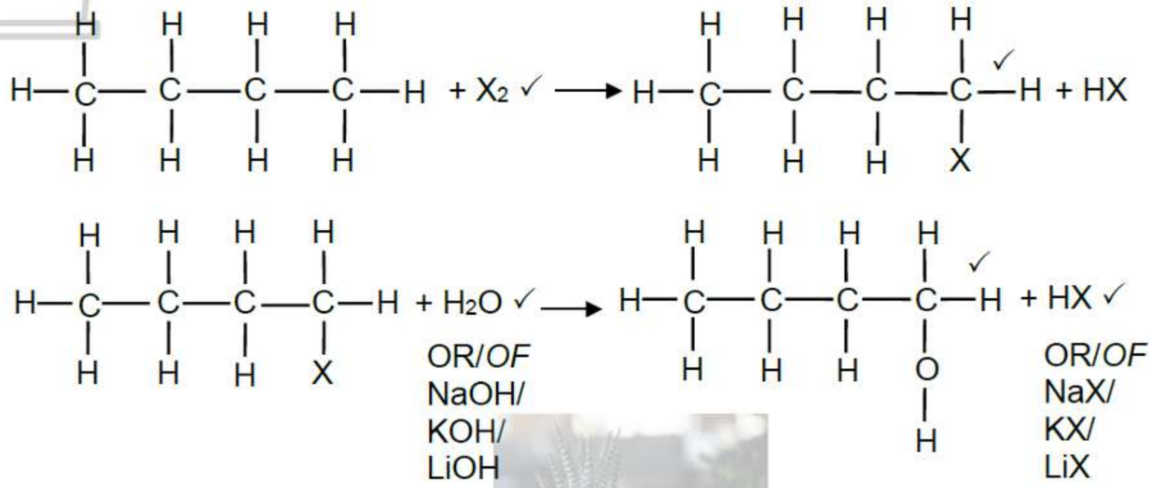
$CH_2CHCH_2CH_3$ ✓ + H_2O ✓ → $CH_3CHOHCH_2CH_3$ ✓ ✓

OR/*OF*

$CH_2{=}CHCH_2CH_3$ ✓ + H_2O ✓ → $CH_3CH(OH)CH_2CH_3$ ✓ ✓ (4)

10.3.2 Sulphuric acid / H_2SO_4 / Phosphoric acid / H_3PO_4. (1)

10.4



(5)

10.5 $2C_4H_{10}$ ✓ + $13O_2$ → $8CO_2$ + $10H_2O$ ✓ Balancing ✓ (3)

[18]

Work Energy and Power

SOLUTIONS

QUESTION 1 WEP

1.1. C✓✓ (2)
1.2. A✓✓ (2)
1.3. D✓✓ (2)
1.4. C✓✓ (2)
1.5. B✓✓ (2)

LONG QUESTIONS [10]

QUESTION 2

2.1. The total mechanical energy in an isolated system remain constant. ✓✓ (2)

2.2. Not conserved. ✓ the system is not isolated/ the net external force on the object is not zero✓ (2)

2.3.1. $(E_k + E_p)_Q = (E_k+E_p)_R$ ✓

$(\frac{1}{2}(20)v^2 + (20)(9,8)(0)$ ✓$= (\frac{1}{2}(20)(0)^2 + (30(9,8)(2)$ ✓

$V_Q = 2,8\ m{\cdot}s^{-1}$

$W_{net} = \Delta E_k$✓

$(80)(4)\cos\theta + (45)(4)\cos 180^0 = \frac{1}{2}(20)(2,8)^2 - (0)^2$✓

$\theta = 36,15^0$ ✓ (5)

2.3.2. $W_F = F\Delta x \cos\theta$ (3)

W_F= 980)(4) cos 36,15

W_F=258,392 J

$\therefore P = \frac{W}{\Delta t}$✓

$P = \frac{258,392}{2,86}$ ✓= 90,35 W✓

[12]

QUESTION 3

3.1. A force for which the work done in moving an object between two points is independent of the path taken ✓✓(2 or 0) (2)

3.2. $\text{Gradient} = \frac{\Delta Ek}{\Delta x}$ ✓

According to $W_{net} = \Delta E_k$

$\therefore \frac{\Delta Ek}{\Delta x} = \frac{Wnet}{\Delta t} = F_{net}$✓

(2)

3.2.1. $\text{Gradient} = \frac{160-24}{8-4}$ ✓ = 34 N✓ (2)

3.2.2.

OPTION 1

$F_{net} = F_A - f - F_{g\parallel}$✓

34 ✓ = 45-f- (8)(9,8) sin 25⁰✓

f = 22,13 N✓

OPTION 2

Wnc = ΔEk + ΔEp

$W_{FA} + W_f$= ΔEk + ΔEp } any one ✓

(45)(4) cos 0^0 + (f)(4) cos 180^0 ✓= (160-24) + (8) (9,8) 8sin 25^0) – (8)(9,8) (4sin 25 ^{0}) ✓

f = 22, 13 N ✓

OPTION 3

$W_{net} = \Delta E_k$

(45)(4) cos 0^0 + (f) (4) cos 180^0 + (8)(9,8) sin 25^0 (4) cos 180^0✓ = 160-24✓

f= 22,13 N ✓

3.3.3.

$E_k = \frac{1}{2} mv^2$

24 = ½ (8) v^2

V= 2,45 $m \cdot s^{-1}$

$\therefore P_{ave} = Fv_{ave}$ ✓

=(72)(2,45) ✓

= 176,5 W ✓

3.4. XY ✓, net force will decrease, when frictional force increases ✓. (2)

[17]

QUESTION 4

4.1. Ep = mgh = (90)(9,8)(37) ✓ = 32634 J

$E_k = \frac{1}{2} m v_f^2 = \frac{1}{2}(90)(2)^2$ ✓= 180 J

The pump must thus supply 32634 + 180 ✓ 2814 J of energy ✓ (4)

4.2. $P = \frac{W}{\Delta t}$ ✓

$P = \frac{32814}{60}$ ✓= 546,9 W ✓ (3)

4.3.1. No✓

4.3.2.
- 0,5 kW = 500 W, which is less than the required 546,9 W✓

The petrol pump will not be able to pump the water out at the same rate.✓ (2)

4.3.3.
- A windmill is environmentally friendly, and it costs less. ✓

The price of petrol is constantly increasing. ✓ (2)

[12]

QUESTION 5

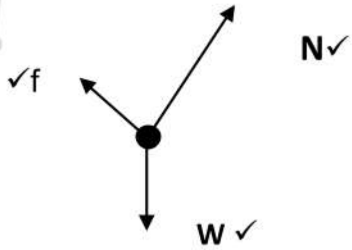
5.1. The net/total work done on an object is equal to the change in the objects kinetic energy. ✓✓ (2)

5.2. $W_{net} = \Delta E_k$

$(12)(7)\cos 0^0 = \Delta E_{k\,f} - 0$ ✓

$E_{kf} = 84$ J ✓ (3)

5.3.



(3)

5.4. $W_{net} = \Delta E_k$✓

$(3)(9,8)\sin 20^0 \Delta x \cos 0^0$✓ $+ 21\,\Delta x 180^0$ ✓ $= 0-84$✓

$\Delta x = 7,38$ m

7,68 >6,8m

The crate will pass point C ✓ (5)

[13]

QUESTION 6

6.1. A force is non- conservative if the work done by the force in moving the object between two points depends on the path taken. ✓✓ (2)

6.2. $W_{net} = \Delta K$

$(20)(9,8)(\sin 18^0)(15,6)\cos 180^0$✓$+(13,5)(15,6)\cos 180^0 + (96,8)(15,6)\cos 0^0$✓ $= ½\,(20)\,(v_f^2 - 0^2)$ ✓

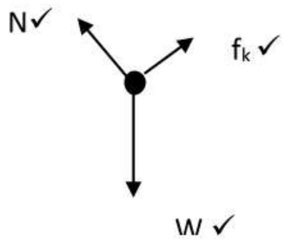
$v_f = 5,96\ m.s^{-1}$ ✓

6.3. $P_{ave} = Fv_{ave}$✓

$= (96,8 = \frac{0+5,96}{2})$✓

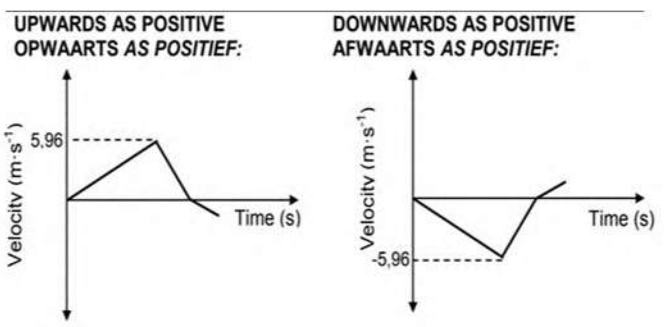
= 288,46 W ✓

6.4.



(3)

6.5.



[17]

QUESTION 7

7.1. The rate at which work is done✓✓

7.2.1. $W = F\Delta y\cos\theta$ ✓
$W_w = mg\Delta y\cos\theta$
$W_w = (125)(9,8)(6,8)(\cos180°)$✓
$= -8330$ J✓

7.2.2. $W = F\Delta y\cos\theta$
$W_{mp} = mg\Delta y\cos\theta$
$W_{mp} = (100)(9,8)(6,8)(\cos0°)$✓
$= 6664$ J✓

7.3. $W_{net} = \Delta E_k$✓
$W_{motor} + W_{mp} + W_w = \Delta E_k$
$W_{motor} + 6664 + (-8330)$ ✓ $= 0$✓
$W_{motor} = 1666$ J

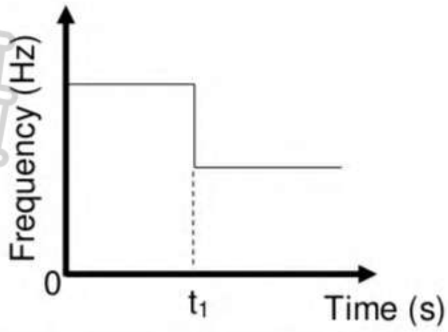
$P = \frac{W}{\Delta t}$✓ $= \frac{1666}{(1,7)(60)}$✓ $= 16,33$ W✓

Doppler Effect

DOPPLER EFFECT SOLUTIONS		
MULTIPLE CHOICE		
1.1	B✓✓	(2)
1.2	A✓✓	(2)
1.3	B✓✓	(2)
1.4	B✓✓	(2)
1.5	A✓✓	(2)
LONG QUESTIONS		
QUESTION 1		
1.1	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)
1.2	Graph B. ✓ The frequency recorded is lower than the emitted frequency. ✓	(2)
1.3	$f_L = \frac{v \pm v_L}{v \pm v_S} f_S$✓ $1100 = \frac{340}{340 - V_S} f_S$✓ $340f_s = 374000 – 110v_s$............ (1) $f_L = \frac{v \pm v_L}{v \pm v_S} f_S$ $900 = \frac{340}{340 + v_S} f_S$✓ $340f_s = 306000 + 900v_s$............... (2)	(5)

	equate equation 1 into equation 2 $347000 - 110v_s = 306000 + 900v_s$✓✓ $v_s = 34\ m{\cdot}s^{-1}$✓	
1.4.1	B ✓ Red shifted	(1)
1.4.2	High frequency ✓ Short wavelength ✓	(2)
		[12]
QUESTION 2		
2.1	Doppler effect ✓ The change in frequency (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. ✓✓	(3)
2.2	$v = f_L\ \lambda$ $340 = f_L \times 0{,}016$ ✓ $f_L = 21\ 250$ Hz $f_L = \frac{v \pm v_L}{v \pm v_S} f_S$ ✓ 21250 ✓ $= \frac{340}{340 - v_B} f_S$ ✓ $= 21250 - 62.5V_B$	(4)
2.3	$f_L = 21\ 250 - 62{,}5v_B + 850$ ✓ $= 22\ 100 - 62{,}5v_B$ $f_L = \frac{v \pm v_L}{v \pm v_S} f_S$ $22100 - 62.5v_B$ ✓ $= \frac{340 + v_B}{340}$ ✓ 21250 ✓ $= v_B = 6{,}8\ m{\cdot}s^{-1}$ ✓	(5)
QUESTION 3		
3.1	The 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)
3.2	AWAY FROM. ✓Detector records lower frequency. ✓	(2)
3.3	As the fire truck moves away from the detector, the wave fronts behind the truck become stretched out. ✓ The detector registers longer wavelength ✓and lower frequency✓	(3)
3.4.1	$v = f\lambda$ ✓	(3)

	340 = f x 0,34 ✓ f = 1000 Hz ✓	
3.4.2	$f_L = \frac{v \pm v_L}{v \pm v_S} f_S$ ✓ $f_L = \frac{340}{340 + 20}$ ✓✓ 1000 ✓ $f_L = 944.44\text{Hz}$ v = fλ✓ 340 = 944,44λ ✓ λ= 0,36 m ✓	(6)
3.5.1	Remains the same✓	(1)
3.5.2	Decreases✓	(1)
QUESTION 4		
4.1	It is the (apparent) change in frequency/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)
4.2	Towards / Away $f_L = \frac{v \pm v_L}{v \pm v_S} f_S$ ✓ Towards: $615 = \frac{v}{v - 26} f_S$ ✓ Away: $626 = \frac{v}{v + 26} f_S$ ✓ $\frac{615(v-26)}{v} = \frac{626(v+26)}{v}$ ✓ v = 333,33 m·s^{-1} ✓	(5)
4.3	$f_s = \frac{615(333{,}33-26)}{333{,}33}$ ✓ or $f_s = \frac{526(333{,}33+26)}{333{,}33}$ ✓ f_s = 567.03Hz f_s = 567.03Hz v= fλ ✓ 333,33 = 567,03λ ✓ λ = 0,59 m ✓	(4)

4.4	 ✓ axis ✓ shape ✓ t_1	(3)
QUESTION 5		
5.1	The change in frequency✓ (or pitch) (of the sound) detected by a listener because the source and the listener have different velocities relative to the medium of propagation. ✓	(2)
5.2	Towards	(1)
5.3	$f_L = \frac{v \pm v_L}{v \pm v_S} f_S$ ✓ $3148✓ = \frac{340+0}{340-v_S} f_S$ ✓ $\qquad 2073✓ = \frac{340-0}{340+vs} f_S$ ✓ $\frac{3148(340 - v_S)}{340 + 0} = \frac{2073(340 + v_S)}{340 - v_S}$ $v_S = 70 \text{ m·s}^{-1}$ ✓	(6)
5.4	$\Delta t = \frac{\Delta x}{v}$ $\Delta t = \frac{350}{70}$ ✓ $= 5\text{s}$✓	(2)
		[11]

Rates of Reaction

SOLUTIONS

1.1 C ✓✓

1.2 B ✓✓

1.3 D ✓✓

1.4 C ✓✓

1.5 A ✓✓

1.6 B ✓✓

1.7 A ✓✓

1.8 A ✓✓

A

QUESTION 2

2.1.1 The change in concentration of reactants or products per unit time. **(2)**
OR The change in mass of reactants or products per unit time.
OR The change in volume of reactants or products per unit time.
OR The change in moles of reactants or products per unit time.✓✓✓

2.2.1 Concentration of HCℓ ✓ **(1)**

2.2.2 Any ONE of the following: **(1)**

- Surface area of magnesium✓
- Volume of HCℓ
- Temperature
- Mass of magnesium
- Time intervals for measurement

2.3 P ✓ **(1)**

2.4 The higher the concentration of HCℓ ✓, the more H2 is produced.✓✓ (2)
OR The higher the concentration of HCℓ ✓, the higher the rate of the reaction.✓

2.5 $nH_2 = \frac{V}{Vm}$ ✓ (4)

$nH_2 = \frac{0,050}{22,4}$ ✓

n_{H2} = 0,00223 mol

Ratio Mg : H_2 = 1 : 1

0,00223 : 0,00223

$\therefore n_{H2} = \frac{m}{M}$

$0,00223 = \frac{m}{24}$✓

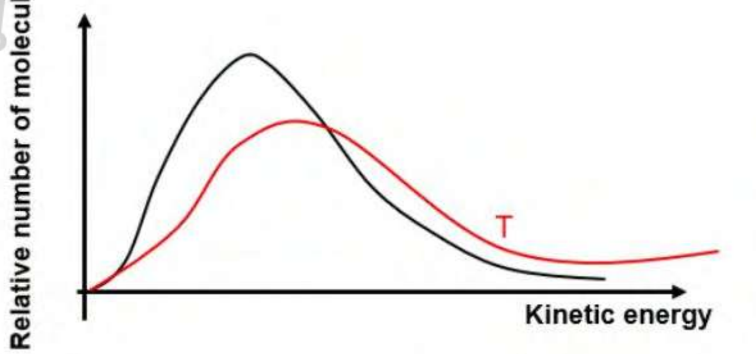
m = 0,05357 ≈ 0,05 g✓ Marking guideline/criteria

2.6.1 Steeper (gradient) (1)

2.6.2 (3)

- Increased surface area allows for more Mg-atoms to be exposed to the HCℓ solution per unit time. ✓✓
- More effective collisions per unit time/Frequency of effective collisions occur. ✓
- Rate of reaction increases.✓

2.7



17

QUESTION 3

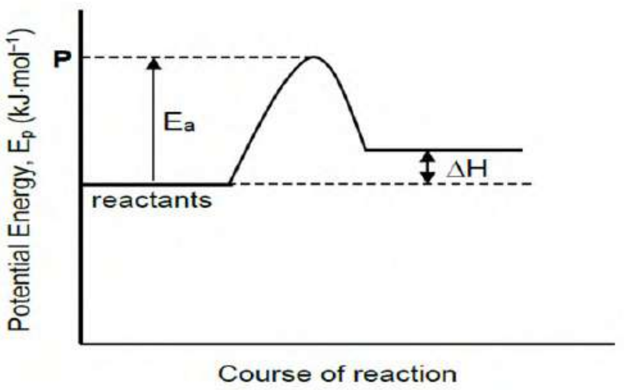
3.1.1 **4**NaNO → **2**Na_2O + **4**NO_2 + O_2 reac ✓ prod✓ bal✓ (3)

3.1.2 endothermic✓ (1)

3.1.3 A high energy unstable transition state between the reactants and the products✓✓ (2)

3.1.4 The net change ✓ of chemical potential energy ✓ of the system (2)

3.1.5 Draw the curve for an endothermic (coe from 12.1.2) reaction 1

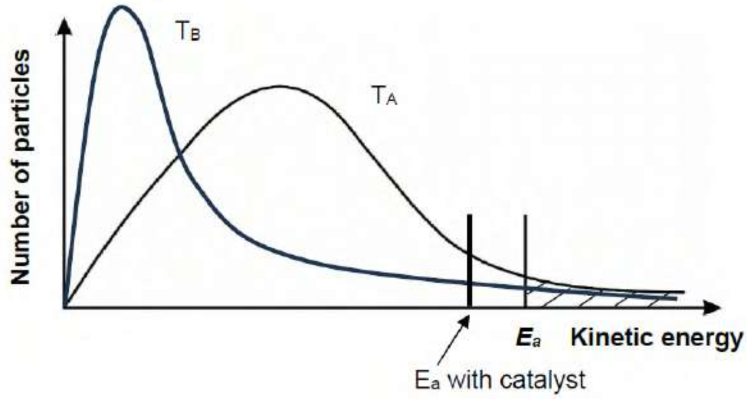


3.1.6 Correct labels for Ea ✓and ΔH✓ (2)

3.1.7 **P** on y-axis at peak position ✓ (1)

3.2.1 Maxwell-Boltzmann (distribution curve) ✓✓ (1)

3.2.2 Peak is higher and to the left of the original. ✓
Ends below original curve. ✓



3.2.3 Ea line shifts to the left.✓ (1)

3.2.4 INCORRECT ✓ (3)

EITHER There are more particles with Ek ≥ Ea. ✓
OR There will be the same number of collisions per unit time.
∴ there will be more effective collisions per unit time. ✓
OR There are not more particles.
The particles are not moving faster.

19

Question 4

4.1 Rate of change of concentration (of P) ✓✓. OR (2)

The change in concentration (of P) ✓ per unit time/per second. ✓

4.2 10 s✓Gradient (of the tangent) at 10 s is greater than that at 30 s. ✓ OR/OF 10 s✓The graph has a steeper slope at 10 s than at 30 s✓. (2)

4.3 0,27 mol·dm^{-3} (1)

4.4 At = 0 s: (5)

$c = \frac{n}{v}$ ✓

$0,27 = \frac{n}{2}$ ✓

n = 0,54 mol

At = 10 s

$c = \frac{n}{v}$

$0,15 = \frac{n}{2}$ ✓

n = 0,3 mole

rate = $\frac{0,30 - 0,54}{10 - 0}$ ✓

Rate = - 0,024 mol·s^{-1} / 0,024 mol·s^{-1} ✓

4.5 More molecules with sufficient / enough kinetic energy. ✓ More effective collisions per unit time. ✓ (2)

[13]

Question 5

5.1 temperature✓ (1)

5.2 Rate of reaction✓ (1)

5.3 Rate = gradient of graph (3)

Rate of reaction = $\frac{\Delta V}{\Delta t}$✓

= $\frac{60-0}{30-0}$✓

= 2 $cm^3 \cdot s^{-1}$✓

5.4 Less than✓ (1)

5.5 The rate of change (or gradient) is less✓ (1)

5.6 decrease✓ (1)

5.7 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)

5.8 n(Mg) = m/M = 20/24✓

= 0,833 moles

n (H_2SO_4) =c x V ✓

=1 x0,1 =0,1 moles

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

n(Mg) left = 0,83-0,1 moles✓

= 0,733 moles

thus mass of Mg = n x M

= 0,733 x 24 ✓

= 17,6 g✓

Alt. Method

24 g Mg ⎫ reacts with 1 mol H_2SO_4

∴ xg → 0,1 mol x = 2,4 g

mass left = 20-2,4⎫

= 17,6 g

5.9 A substance that increase the rate of a chemical reaction without undergoing✓✓ (2)

[13]

Question 6

6.1 Change in concentration ✓ of products/reactants per (unit) time. ✓ (2)

6.2.1 Rate of the reaction✓ (1)

6.2.2 Reaction rate increases with increase in concentration. ✓✓ (2)

6.3.1 Activation energy/(The boundary line for the) molecules with (adequate) kinetic energy to make effective collisions. ✓✓ (1)

6.3.2 B ✓ (1)

6.4 (4)

- At a higher temperature particles move faster/have a higher kinetic energy. ✓
- More molecules have enough/sufficient (kinetic) energy. ✓ OR
- More effective collisions per unit time/second./Increased frequency of effective collisions. ✓
- Reaction rate increases. ✓

6.5 Curve Y/it was obtained for the reaction where a catalyst was added. ✓ (1)

12

Question 7

7.1 Change in concentration ✓ of products/reactants per (unit) time. ✓ (2)

7.2 (2)

- Time✓
- Volume of gas✓/CO2/carbon dioxide

7.3 Experiment II (3)

- More (HCℓ) particles per unit volume./More particles with correct orientation. ✓
- More effective collisions per unit time./Higher frequency of effective collisions. ✓
- Higher reaction rate. ✓ OR

Experiment I:

- Less (HCℓ) particles per unit volume. ✓
- Less effective collisions per unit time./Lower frequency of effective collisions. ✓
- Lower reaction rate. ✓

7.4 Average rate $= -\frac{\Delta n}{\Delta t}$✓ (3)

$1,4x10 = -\frac{nf - 0,016}{2,5 - (-0)}$✓

$n[A\ell_2(CO_3)_3] = 0,005$ (mole) ✓

7.5 $n(CO_2) = 3n[A\ell_2(CO_3)_3$ (3)

$= 3(0,016)$ ✓

$= 0,048$ mole

$n(CO2) = \frac{V}{Vm}$

$V = (0,048)(24000)$✓

$V(CO_2) = 1152cm^3$ ($1.152\ dm^3$)✓

[13]

Question 8

.81 Change in concentration of products/reactants ✓ per (unit) time. ✓ (2)

8.2.1 Surface area/State of division ✓ (1)

8.2.2 Amount/mass of magnesium ✓/Concentration of HCℓ/acid/(Initial) temperature (1)

8.3 $\Delta m(Mg) = 2,6 - 0,2$✓ (5)

$=2,4g$

$n(\text{Mg used}) = \frac{m}{M}$ ✓

$= \frac{2,4}{24}$

$n(H_2) = n(Mg) = 0,1$ mol ✓

$V(H_2) = n.V_m = (0,1)(25)$ ✓

$= 2,5 dm^3$ ✓

(3)

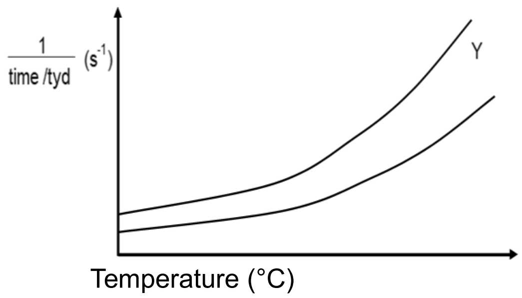
8.4 • Larger surface area/state of division. ✓

• More particles (per volume) with correct orientation. ✓

• More effective collisions per (unit) time. /Frequency of effective collisions increases. /More particles collide with sufficient kinetic energy & correct orientation per (unit) time. ✓

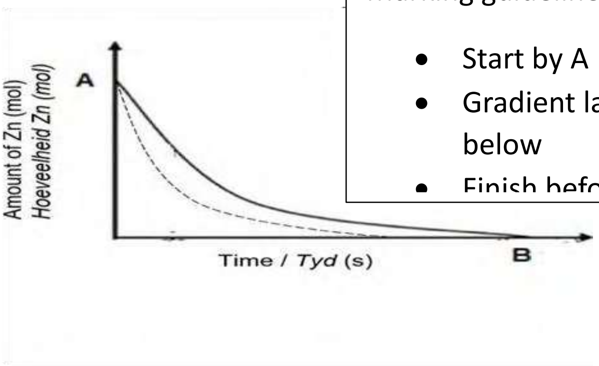
[17]

Question 9		
9.1	Exothermic, because H < 0/Energy is released✓	(1)
9.2	rate = $-\frac{\Delta m}{\Delta t}$ ✓ $= \frac{0.25-2}{30}$ ✓ = 0,06 ($g \cdot s^{-1}$) ✓ (0,0583 $g \cdot s^{-1}$)	(3)
9.3	Marking guidelines •Calculate: $m(CaCO_3)$ reacted / of $V(CO_2)$ produced/Substitute: 100 $g \cdot mol^{-1}$. •USE mole ratio: $n(CO_2) : n(CaCO_3) = 1 : 1$ •Final answer: 0,18 dm^3 (0,1792 dm^3) $m(CaCO_3) = \frac{40}{100} \times 2$ ✓ = 0,8 g $n(CaCO_3)$ reacted = $\frac{m}{M}$ $= \frac{0.8}{100}$ ✓ = 8 x 10^{-3} mol $n(CO_2) = n(CaCO_3)$ ✓ = 8 x 10^{-3} mol ↓ $V(CO_2)$ = 8 x 10^{-3} x 22,4 ✓ = 0,18 dm^3 ✓	(5)
9.4	**ANY ONE:**	(1)

	• Concentration (of acid) P ✓ • Size/mass of tablet/Identical tablet /Type of tablet. • State of division / Surface area.	
9.5	**Criteria for conclusion** Dependent [(reaction) rate/time] and independent (temperature) variables correctly identified.✓ ✓ Relationship between the independent and dependent variables correctly stated. **Examples** • Reaction rate ($\frac{1}{t}$) increases with increase in temperature. Time • Reaction rate ($\frac{1}{t}$) decreases with decrease in temperature. Time IF: Reaction rate is DIRECTLY proportional to temperature: max $= \frac{1}{2}$ • Time taken for reaction decreases when temperature increases • Time taken for reaction increases when temperature decreases.	(2)
9.6	Increase in temperature increases the average kinetic energy/molecules move faster. ✓ More molecules have enough/sufficient kinetic energy/More molecules have $E_k > E_a$. ✓ More effective collisions per unit time/second. /Frequency of effective collisions increases. ✓	(3)
9.7	**Marking guidelines** • For each value of temperature, the CURVE Y must be above the given CURVE.✓ • CURVE Y must have an increasing rate with an increase in temperature.✓ 	(2)
		18

Question 10		
10.1.1	Exothermic✓ Lower (potential) energy of the products than the reactants / More energy is released than absorbed/$\Delta H < 0$.✓	(2)
10.1.2	The number of particles with sufficient /enough kinetic energy (with a catalyst) **OR** $E_k \geq E_A$ (which can undergo effective collision.✓	(1)
10.1.3	$240,8 - 208,2$ ✓ $= 32,6\ kJ$ ✓	(2)
10.2.1	Decreases✓	(1)
10.2.2	Remain the same✓	(1)

10.2.3	Remain the same ✓	(1)
10.3.1	Concentration (sulfuric acid/ H_2SO_4)	(1)
10.3.2	• More (H_2SO_4) particles per unit volume.✓ • More effective collision per unit time. / Higher frequency of effective collisions.✓ • Higher reaction rate.✓ **OR** • Less (H_2SO_4) particles per unit volume. • Less effective collisions per unit time. / Lower frequency of effective collisions. Lower reaction rate.	(3)
10.3.3	$rate = \frac{\Delta V_{H_2}}{\Delta t}$ $40 = \frac{\Delta V_{H_2}}{2{,}6(60)}$ ✓ $V(H_2) = 6240\ cm^3$ $n(H_2) = \frac{V}{V_m}$ $= \frac{6\ 240}{27\ 000}$ ✓ $= 0{,}23 mol.$ $n(Al) = \frac{2}{3} n(H_2)$ $n(Al) = \frac{2}{3}(0{,}23)$ ✓ $= 0{,}15 mol$ $n(Al) = \frac{m}{M}$ $0{,}15 = \frac{m}{27}$ ✓ $m = 4{,}05 g$ $\%purity = \frac{4{,}05}{5}(100)$ ✓ $= 81\%$ ✓	(6)
		[18]
Question 11		
1.1	Reaction rate is the change in concentration of reactants or products per unit time. ✓✓	(2)
11.2	Concentration ✓	(1)
11.3	An increase in concentration will/will not increase the rate of reaction ✓✓	(2)
11.4	Surface Area ✓	(1)
11.5	$n = \frac{m}{M}$ ✓ $= \frac{6.5}{65}$ ✓ $= 0{,}1\ mol$ ✓	(3)
11.6	Convert: 0,08 mol to 5,2 g,	(5)

	Averate rate $= -\frac{\Delta m}{\Delta t}$ ✓ $0{,}15✓ = -\frac{0-5{,}2✓}{B-5✓}$ $B = 39{,}67$ s ✓	
11.7	 Marking guideline for graph • Start by A • Gradient larger/dotted line below • Finish before B	(3)
		[17]
Question 12		
12.1	Temperature	
12.2	**<u>NOTE</u>** Give the mark for <u>per unit time</u> only if in context of reaction rate. ✓ **<u>ANY ONE</u>** • <u>Change in concentration</u> ✓ of products/reactants <u>per (unit) time</u>. ✓ • <u>Change in amount/number of moles/volume/mass</u> of products or reactants <u>per (unit) time</u>. • <u>Amount/number of moles/volume/mass of products formed/reactants used</u> <u>per (unit) time</u>. • <u>Rate of change in concentration/amount/number of moles/volume/mass</u>.	(2)
12.3	14 (min)✓	(1)
12.4.1	Graph/ **B** ✓ **-** (Experiment **3)** has the highest (acid) concentration/more particles/higher number of moles. ✓	(2)
12.4.2	(Graph) **C** ✓ (Experiment 5) is at highest temperature/more particles with sufficient kinetic energy/HCℓ is at 35°C ✓	(2)
12.5.1	Speeds up the reaction. /Increases the reaction rate./Provides alternate pathway./Lowers the (net) activation energy. ✓	(1)
12.5.2	Equal to ✓	(1)
10.6	(Zn)= $\frac{m}{M}$✓ $= \frac{1{,}5}{65}$ ✓ = 0,023 mole rate= $-\frac{\Delta n}{\Delta t} = -\frac{0-0{,}023}{14-0}$ ✓= $1{,}63\times10^{-3}$ (mol.min^{-1}) ✓	(4)

Question 13		
13.1	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.	(1)
13.2.1	Temperature✓	(1)
13.2.2	Rate of reaction / Volume of gas (formed) per (unit) time ✓	(1)
13.3	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)
13.4	**marking criteria*:***	
Compare Exp.1 with Exp. 2:	The reaction in exp. 1 is faster in exp. 1 than in exp. 2 due to the higher acid concentration. ✓	(1)
	Therefore, the gradient of the graph representing exp. 1 is greater / steeper than that of exp. 2. / Graph of Exp. 1 reaches constant volume in shorter time than exp. 2. ✓	(1)
Compare Exp. 1 with Exp 3 & 4:	The reaction in exp. 3 is faster than that in exp. 1 due to the higher temperature.✓ The reaction in exp. 4 is faster than that in exp. 1 due to the higher temperature / larger surface area. ✓ *Graph A represents exp. 4 due to the greater mass of $CaCO_3$ - greater yield of CO_2 at a faster rate.* Therefore, the gradient of the graphs of exp. 3 & 4 are greater/steeper than that of exp. 1. / Graphs of Exp. 3 & 4 reaches constant volume in shorter time than exp. 1.✓	(1) (1) (1)
Final answer	C ✓	(1)
13.5	$n(CO_2) = \frac{V}{Vm} = \frac{4,5}{25,7}$ ✓ = 0,18 mol (0,175 mol) ✓ $n(CO_2) = n(CaCO_3)$ Ratio 1:1 $m(CaCO_3)$ =(0,18)(100) ✓ =18g (17,5g) $m(CaCO_3$ not reacted$)$*:* 25 – 18,00 ✓ = 7,00 g ✓ (7,49 g) (Accept range*:* 7,00 g – 7,5 g)	(5)

		[18]

Chemical Equilibrium

SOLUTIONS
CHEMICAL EQUILIBRIUM

Multiple choice

1.1 C✓✓
1.2 B✓✓
1.3 A✓✓
1.4 B✓✓
1.5 D✓✓ **[10]**

QUESTION 1

1.1.1 When the equilibrium in a closed system is disturbed, the system will re-instate a new equilibrium by favouring the reaction that will cancel/oppose the disturbance. ✓ ✓ (2)

1.1.2 (Mass) decreases. ✓ (1)

1.1.3
- Decrease in amount of OH^- ions/ concentration of OH^- ions, favours the reaction that increases the amount /concentration of OH^- ions. ✓ OR Acid/HCl/H^+ reacts with OH^- ions.
- The forward reaction is favoured✓OR The amount/concentration of the products increases. (2)

1.2.1 Endothermic ✓ (1)

1.2.2
- With an increase in the temperature the K_c value increases✓The concentration of the products increases. OR Concentration of reactants decreases. OR The forward reaction is favoured. ✓
- (According to Le Chatelier's principle) an increase in temperature favours the endothermic reaction. ✓ (3)

1.2.3 <u>**CALCULATING USING THE NUMBER OF MOLES**</u> (8)

<u>Marking Criteria:</u>

(a) Calculate number of moles NH_4HS $(\frac{70}{51})$ ✓ OR 1.37 moles
(b) <u>USING RATIO:</u> NH_4HS: NH_3: H_2S : = 1:1:1 ✓
(c) Calculate c(NH_3) and c(H_2S) at equilibrium (divide equilibrium moles by 3) ✓
(d) Correct K_c expression✓Substitute Kc = 18 x10- ✓
(e) $n(NH_4HS)_{eq} = n(NH_4HS)_{in} - n(NH_4HS)_{change}$✓Substitute 51 in n = $\frac{m}{M}$ P
(f) Correct final answer: m= 5,61 g✓

Range: 4,96g – 5,74g

<u>**OPTION 1**</u>

n= $\frac{m}{M}$

= $\frac{70}{51}$ ✓	$NH_4HS(s)$	$NH_{3(g)}$	$H_2S(g)$
Initial amount (mol)	1,37	0	0
Change (mol)	x	x	x ✓
Equilibrium amount (mol)	1,37-x	x	x
Equilibrium concentration(mol.dm^{-3})		$\frac{x}{3}$	$\frac{x}{3}$ ✓

$K_c = [NH_3][H_2S]$ ✓

$18 \times 10^{-2} = (\frac{x}{3})^2$

x= 1,27

$n(NH_4HS)_{aq}$= 1,37 – 1,27✓

= 0,1 mol

$m(NH_4HS)_{eq}$ = nM

= 0,1 x 51

= 5,1 g✓

Option 2

$n = \frac{m}{M}$

$= \frac{70}{51}$ ✓ $K_C = [NH_3][H_2S]$ ✓

$18 \times 10^{-2} = x^2$

X = 0,42✓

	$NH_4HS(s)$	$NH_{3(g)}$	$H_2S(g)$
Initial amount (mol)	1,37	0	0
Change (mol)	1,26	1,26	1,26 ✓
Equilibrium amount (mol)	0.11	1,26	1,26
Equilibrium concentration(mol.dm^{-3})		0,42	0,42 ✓

$m(NH_4HS)_{aq}$ = nM

= 0,11 x 51✓

= 5,61g ✓

OR $m(NH_4HS)_{change}$ = nM

= 1,26 x 51

= 64,26g

$m(NH_4HS)_{eq}$ =70 - 64,26

= 5,74 g

QUESTION 1

1.1.1 When the equilibrium in a closed system is disturbed, the system will re-instate a new equilibrium by favouring the reaction that will cancel/oppose the disturbance. ✓ ✓ (2)

1.1.2 (Mass) decreases. ✓ (1)

1.1.3
- Decrease in amount of OH^- ions/ concentration of OH^- ions, favoures the reaction that increases the amount /concentration of OH^- ions. ✓ OR Acid/HCl/H^+ reacts with OH^- ions.
- The forward reaction is favoured✓OR The amount/concentration of the products increases. (2)

1.2.1 Endothermic ✓ **(**1)

1.2.2
- With an increase in the temperature the K_c value increases✓The concentration of the products increases. OR Concentration of reactants decreases. OR The forward reaction is favoured. ✓
- (According to Le Chatelier's principle) an increase in temperature favours the endothermic reaction. ✓ (3)

1.2.3 <u>**CALCULATING USING THE NUMBER OF MOLES**</u> (8)

<u>Marking Criteria:</u>

(g) Calculate number of moles NH_4HS $(\frac{70}{51})$ ✓ OR 1.37 moles

(h) <u>**USING RATIO:**</u> NH_4HS: NH_3: H_2S : = 1:1:1 ✓

(i) Calculate $c(NH_3)$ and $c(H_2S)$ at equilibrium (divide equilibrium moles by 3) ✓

(j) Correct K_c expression✓Substitute Kc = 18 x10$^-$✓

(k) $n(NH_4HS)_{eq} = n(NH_4HS)_{in} – n(NH_4HS)_{change}$✓Substitute 51 in $n = \frac{m}{M}$ P

(l) Correct final answer: m= 5,61 g✓

Range: 4,96g – 5,74g

OPTION 1

n= $\frac{m}{M}$

$= \frac{70}{51}$ ✓	$NH_4HS(s)$	$NH_{3(g)}$	$H_2S(g)$
Initial amount (mol)	1,37	0	0
Change (mol)	x	x	x ✓
Equilibrium amount (mol)	1,37-x	x	x
Equilibrium concentration($mol.dm^{-3}$)		$\frac{x}{3}$	$\frac{x}{3}$ ✓

$K_c = [NH_3]\,[H_2S]$ ✓

$18 \times 10^{-2} = (\frac{x}{3})^2$

x= 1,27

$n(NH_4HS)_{aq}$= 1,37 – 1,27✓

= 0,1 mol

$m(NH_4HS)_{eq}$ = nM

= 0,1 x 51

= 5,1 g✓

Option 2

n= $\frac{m}{M}$

$= \frac{70}{51}$ ✓ $K_C = [NH_3][H_2S]$ ✓

$18 \times 10^{-2} = x^2$

X = 0,42✓

	$NH_4HS(s)$	$NH_{3(g)}$	$H_2S(g)$
Initial amount (mol)	1,37	0	0
Change (mol)	1,26	1,26	1,26 ✓
Equilibrium amount (mol)	0.11	1,26	1,26
Equilibrium concentration($mol.dm^{-3}$)		0,42	0,42 ✓

$m(NH_4HS)_{aq}$ = nM

= 0,11 x 51✓

= 5,61g ✓

OR $m(NH_4HS)_{change}$ = nM

= 1,26 x 51

= 64,26g

$m(NH_4HS)_{eq}$ =70 - 64,26

= 5,74 g

QUESTION 2

2.1 Add more reactants/increase the amount/mols/concentration of the reactants. ✓

OR

Remove some of the products/ decrease the amount/mols/concentration of the products.

OR

Decrease in pressure

2.2 **Marking criteria**

- Correct calculate 70.59% of 5= 3.53 ✓**Correct**
- Using the correct mol ratio ✓Calculating the quantity (mol) at equilibrium of all three substances ✓

- Using the Concentration of Q_2 at equilibrium and the number of mols of A_2 at equilibrium in the equation c = n/v to calculate the volume of the container. ✓✓
- Calculating the equilibrium concentrations of the reactants
- K_c expression✓
- Correct substitution of equilibrium concentrations into Kc expression
- K_c =5,09 ✓

	A_2Q	A_2	Q_2
Initial amount (mol)	5	0	0
Change (mol)	3,53	3,53	1,765 ✓
Equilibrium amount (mol)	1,47	3,53	1,765 ✓
Equilibrium concentration(mol.dm^{-3})	0,735	1,765	0,8825 ✓

$C = \frac{n}{v}$ ✓

$0.8825 = \frac{1,765}{v}$ ✓

$V = 2\ dm^3$

$K_c = \frac{[A_2]^2\ [Q_2]}{[A_2Q]^2}$ ✓

$= \frac{(1,764)^2(0,8825)}{(0,735)^2}$ ✓

$= 5,09$ ✓

2.3 The rates of the forward and reverse reaction do not increase equally. ✓ (1)

2.4 When the <u>equilibrium in a closed system is disturbed</u>, the system will re-instate a new equilibrium by favouring the reaction that will oppose the disturbance. ✓✓ (2)

2.5 GREATER THAN ✓ (1)

2.6 The rate of the forward reaction decreases less than the rate of the reverse reaction. ✓
The forward reaction is favoured.
Concentration of the products increases while the concentration of the reactants decreases. ✓✓ (3)

QUESTION 3

3.1 Yes, ✓ the concentrations of the reactants and products remain constant (2)

3.2.1 Concentration N_2 increases ✓✓OR N_2 was added ✓✓ (2)

3.2.2 Temperature was increased✓✓ (2)

3.3.1 Increase ✓ (1)

3.3.2 The concentrations of the reactants and products increased. ✓✓ (2)

3.3.3 The system will react to increase the pressure by forming more gas molecules. ✓OR A decrease in pressure favours a reaction producing more moles of gas. The reverse reaction will be favoured the concentration of NH_3 will decrease✓✓ (3)

3.4 t_1✓ and / t_2 ✓ (2)

3.5.1 **Option 1** (9)

$n(NH_3) = \frac{m}{M} = \frac{20,4}{17}$ = 1,2 mol OR give two marks in table for 1,2 mol

	N_2	H_2	NH_3
Mol ratio	1	3	2
Initial amount (mol)	5	5	0
Change (mol)	0,6	1,8	1,2✓
Equilibrium amount (mol)	4,4	3,2	1,2
Equilibrium concentration($mol.dm^{-3}$)	0,88	0,64	0,24 ✓

$K_c = \frac{[NH_3]^2}{[N_2][H2]^3}$✓ $= \frac{(0,24)^2}{(0,88)(0,64)^3}$✓ =0.25 ✓

3.5.2 The K_c value will remain the same. ✓Only temperature changes will influence the Kc value. ✓ (2)

QUESTION 4

4.1 (The stage in a chemical reaction when the) <u>rate of the forward reaction equals the rate of the reverse reaction.</u> ✓✓

OR

(The stage in a chemical reaction when the) <u>concentrations of reactants and products remain constant.</u> ✓✓ (2)

4.2 Exothermic✓

ΔH < 0 OR ΔH is negative ✓ (2)

4.3.1 Remains the same ✓ (1)

4.3.2 Decrease✓

• When the temperature is increased the reaction that will oppose this increase/decrease the temperature will be favoured.

OR

• The forward reaction is exothermic✓
• An increase in temperature favours the endothermic reaction. ✓
• The reverse reaction is favoured. ✓ (4)

4.4 Any THREE:

• Decrease temperature
• Increase pressure
• Increase concentration of both/any one of reactants.
• Remove SO_3 continuously

(3)

4.5 **CALCULATIONS USING MOLES**

Mark allocation:

• Change in $n(SO_3)$ = 0,2 (mol)
• Ratio $n(SO_2) : n(O_2) : n(SO_3)$ = 2 : 1: 2

- $n(SO_2)$ at equilibrium = initial + change
- $n(O_2)$ at equilibrium = initial + change
- Divide three equilibrium amounts by 2 (calculation of concentration)
- Kc expression
- Substitution into Kc expression
- Final answer = 0,21

OPTION 1

Amount of SO_3 reacted = 0,2 mol
n(SO_2 formed) = 0,2 mol
n(O_2 formed) = ½ n(SO_3 formed) = 0,1 mol
At equilibrium: $n(SO_2)$ = 0,6 + 0,2 = 0,8 mol
$n(O_2)$ = 0,5 + 0,1 = 0,6 mol

$$c(SO_3) = \frac{n}{V} = \frac{0,2}{2} = 0,1\ mol{\cdot}dm^{-3}$$
$$c(SO_2) = \frac{n}{V} = \frac{0,8}{2} = 0,4\ mol{\cdot}dm^{-3}$$
$$c(O_2) = \frac{n}{V} = \frac{0,6}{2} = 0,3\ mol{\cdot}dm^{-3}$$

✓ divide by/*gedeel deur* 2

$$K_c = \frac{[SO_3]^2}{[SO_2]^2[O_2]}\ ✓ = \frac{(0,1)^2}{(0,4)^2(0,3)}\ ✓ = 0,21\ ✓\ (0,208)$$

OPTION 2

	SO_2	O_2	SO_3	
Molar ratio/*Molverhouding*	2	1	2	
Initial quantity (mol) *Aanvanklike hoeveelheid (mol)*	0,6	0,5	0,4	
Change (mol)/*Verandering (mol)*	0,2	0,1	0,2 ✓	Ratio/*verhouding* ✓
Quantity at equilibrium (mol) *Hoeveelheid by ewewig (mol)*	0,8 ✓	0,6 ✓	0,2	
Concentration ($mol{\cdot}dm^{-3}$) *Konsentrasie ($mol{\cdot}dm^{-3}$)*	0,4	0,3	0,1	Divide by 2 *Gedeel deur 2* ✓

$$K_c = \frac{[SO_3]^2}{[SO_2]^2[O_2]}\ ✓ = \frac{(0,1)^2}{(0,4)^2(0,3)}\ ✓ = 0,21\ ✓\ (0,208)$$

(8)

[20]

QUESTION 5

5.1 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. ✓✓ (2)

5.2.1 NegativeP (1)

5.2.2 • Increase in temperature favours an endothermic reaction. ✓ ACCEPT: Decrease in temperature favours an exothermic.
• Reverse reaction is favoured./Concentration of reactants increases./ Concentration of products decreases✓• (Forward) reaction is exothermic.P

Accept: Reverse reaction is endothermic.

(3)

5.2.3 CALCULATIONS USING NUMBER OF MOLES

Marking criteria:

a) Initial n(P) and n(Q_2) and n(PQ) from table.
b) Change in n(P) = equilibrium n(P) – initial n(P).
c) USING ratio: P : Q_2 : PQ = 2 : 1 : 2
d) Equilibrium n(Q_2) = initial n(Q_2) + change in n(Q_2)
   Equilibrium n(PQ) = initial n(PQ) - change in n(PQ)
e) Divide equilibrium amounts of P and Q_2 and PQ by 2 dm^3.
f) Correct Kc expression (formulae in square brackets).
g) Substitution of equilibrium concentrations into Kc expression.
h) Final answer: 10,889

	P	Q_2	PQ	
Initial quantity (mol) *Aanvangshoeveelheid (mol)*	0,8	0,8	3,2	✓(a)
Change (mol) *Verandering (mol)*	0,4 ✓(b)	0,2	0,4	✓(c)
Quantity at equilibrium (mol)/ *Hoeveelheid by ewewig (mol)*	1,2	1,0	2,8	✓(d)
Equilibrium concentration ($mol{\cdot}dm^{-3}$) *Ewewigskonsentrasie ($mol{\cdot}dm^{-3}$)*	0,6	0,5	1,4	✓(e)

$$K_c = \frac{[PQ]^2}{[Q_2][P]^2} \checkmark (f)$$

$$= \frac{1{,}4^2}{(0{,}5)(0{,}6)^2} \checkmark (g)$$

$$= 10{,}89 \checkmark (h)$$

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)

5.2.4 Remains the same✓Only temperature can change Kc./Temperature remains constant. ✓

(2)

5.3.1 Increases✓ (1)

5.3.2 Decrease✓ (1)

[18]

QUESTION 6

6.1.1 Reversible ✓ (1)

6.1.2 Higher than ✓✓ (2)

6.1.3 Equal to (1)

6.2 A ✓At a given temperature the yield of NH_3 is the highest (in graph A) ✓Increase pressure favours reaction which produces less gas moles✓
Forward reaction is favoured P

(4)

6.3 Marking criteria:

(a) Calculating the initial number of moles of both reactants
(b) Calculating change in mols of I_2 (2,5 -1,45)
(c) Correct mole ratio
(d) Calculating the quantity(mol) at equilibrium of all H_2 and HI substances

(e) Substitute V = 1,5 dm^3 to determine concentration at equilibrium of all the substances.
(f) Kc expression
(g) Substitution into Kc expression
(h) Final answer 4,30

	H_2	I_2	HI	
Ratio	1	1	2	
Initial quantity (mol)	1,75	2,5 ✓	0	
Change (mol)	1,05	1,05 ✓	2,10	Using ratio ✓
Quantity at equilibrium (mol)	0,7	1,45	2,10 ✓	
Equilibrium concentration ($mol \cdot dm^{-3}$)	0,47	0,97	1,4	Divide by 1,5 ✓

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

$$\therefore \; = \frac{(1,4)^2}{(0,47)\,(0,97)} \checkmark$$

$$= 4,3 \checkmark$$

No K_c expression, correct substitution. 6/8

Wrong K_c expression 5/8

(8)

[16]

QUESTION 7

7.1 An open system is the one in which mass or energy can be transferred into or out of the system during a reaction. ✓✓

OR

An open system is the system that continuously interacts with its environment. ✓✓ (2)

7.2 Remains constant✓Carbon is a solid, concentration of solids = 1✓

(2)

7.3 Larger than✓

$K_c > 1$ ✓

(2)

7.4 **OPTION 1**

$n = \frac{m}{M}$

$= \frac{168}{28}$ ✓

$= 6$ mol

	CO_2	CO	
Initial quantity (mol) *Aanvangshoeveelheid (mol)*	x	0	
Change (mol) *Verandering (mol)*	3	6 ✓	ratio ✓ *verhouding*
Quantity at equilibrium (mol)/ *Hoeveelheid by ewewig (mol)*	x – 3 ✓	6	
Equilibrium concentration (mol·dm^{-3}) *Ewewigskonsentrasie (mol·dm^{-3})*	$\frac{x-3}{2}$	3	Divide by 2 ✓

$K_c = \frac{[CO]^2}{[CO_2]}$ ✓

14 ✓ $= \frac{(3)^2}{\frac{x-3}{2}}$ ✓

$\therefore$ x = 4,29 mol ✓

No K_c expression, correct substitution/*Geen K_c-uitdrukking, korrekte substitusie*: Max./*Maks.* $\frac{8}{9}$
Wrong K_c expression/*Verkeerde K_c-uitdrukking*: Max./*Maks.* $\frac{6}{9}$

OPTION 2

$n = \frac{m}{M}$

$= \frac{168}{28}$ ✓

$= 6$ mol

$c = \frac{n}{V}$

$= \frac{6}{2}$ Divide by/*Deel deur* 2 ✓

$= 3$ mol·dm^{-3}

	CO_2	CO	
Initial concentration (mol·dm^{-3}) *Aanvangskonsentrasie (mol·dm^{-3})*	x	0	
Change (mol·dm^{-3}) *Verandering* (mol·dm^{-3})	1,5	3 ✓	ratio ✓ *verhouding*
Equilibrium concentration (mol·dm^{-3}) *Ewewigskonsentrasie (mol·dm^{-3})*	x – 1,5 ✓	3	

$K_c = \frac{[CO]^2}{[CO_2]}$ ✓

14 ✓ $= \frac{[3]^2}{x-1,5}$ ✓

$\therefore$ x = 2,14 mol·dm^{-3}

No K_c expression, correct substitution/*Geen K_c-uitdrukking, korrekte substitusie*: Max./*Maks.* $\frac{8}{9}$
Wrong K_c expression/*Verkeerde K_c-uitdrukking*: Max./*Maks.* $\frac{6}{9}$

$n(CO_2) = cV$

$= (2,14)(2)$

$= 4,29$ mol ✓ (9)

7.5.1 Remains the same ✓ (1)

7.5.2 Decreases ✓ (1)

7.5.3 Increases ✓ (1)

[18]

QUESTION 8

8.1 To prevent gases from escaping✓✓ (2)

8.2.1 Higher than✓ (1)

8.2.2 Equal to ✓ (1)

8.3.1 NO_2(g) added ✓ (1)

8.3.2 Decrease in pressure ✓ (1)

8.4 Increases✓An increase in temperature favours the endothermic reaction. ✓
The forward reaction is endothermic. / The forward reaction is favoured. ✓ (3)

8.5

	N_2O_4	NO_2	
Initial quantity (mol) *Aanvangshoeveelheid (mol)*	0,92	0	
Change (mol) *Verandering (mol)*	0,19 ✓	0,38	ratio ✓ *verhouding*
Quantity at equilibrium (mol)/ *Hoeveelheid by ewewig (mol)*	0,73	0,38	✓
Equilibrium concentration ($mol{\cdot}dm^{-3}$) *Ewewigskonsentrasie ($mol{\cdot}dm^{-3}$)*	$\frac{0{,}73}{2} = 0{,}37$	$\frac{0{,}38}{2} = 0{,}19$	

Divide by / *gedeel deur* 2 ✓

$$K_c = \frac{[NO_2]^2}{[N_2O_4]} ✓$$

$$= \frac{(0{,}19)^2}{(0{,}37)} ✓$$

$$= 9{,}76 \times 10^{-2} ✓$$

No K_c expression, correct substitution / *Geen K_c-uitdrukking*, korrekte substitusie: Max. / *Maks.* $\frac{6}{7}$

Wrong K_c expression / *Verkeerde K_c-uitdrukking*: Max. / *Maks.* $\frac{4}{7}$

(7)

[16]

Acids and Bases

ACIDS AND BASES SOLUTIONS		
QUESTION 1		
1.1	A	(2)
1.2	B	(2)
1.3	D	(2)
1.4	C	(2)
1.5	B	(2)
		[10]
QUESTION 2		
2.1.1	An acid that ionises completely in water to form a high concentration of hydronium ions. ✓	(2)
2.1.2	No. ✓ It does not ionise completely ✓ (It ionises partially/ $[H_3O+] < [HF]$)	(2)
2.1.3	kw = $[H_3O^+][OH^-]$ = 1 x 10-14 ✓ 0, 018 x $[OH^-] = 1 \times 10^{-14}$ ✓ $[OH^-] = 5{,}56 \times 10^{-13}$ $mol.dm^{-3}$. ✓	

		(3)
2.2.1	An acid solution that contains a small amount of acid in proportion to the volume of water. ✓✓	(2)
2.2.2	Smaller than. ✓	(1)
2.2.3	pH= -log [H_3O^+] 12, 56 = - log [H_3O^+] ✓ (Or [H_3O^+] = $10^{-12,56}$) [H_3O^+] = 2, 75 x 10^{-13}mol.dm^{-3} [H_3O^+] [OH^-] = 1x10^{-14} 2, 27x10^{-13}x[OH^-] = 1x10^{-14} ✓ [OH^-] = 0, 0363 mol.dm-3 [NaOH] = [OH-] = 0, 0363 mol.dm^{-3}. n = c.v = 0, 0363 x 0, 037 ✓= 0, 0013431 mol. H_2SO_4: n = c.v = 0, 10 x 0, 012 ✓= 0, 0012 mol. Ratio: NaOH:H_2SO_4 is 2: 1 $n_{(NaOH)}$= 2 x 0, 0012 = 0, 0024 mol. ✓ Total n of NaOH = 0, 0013431 + 0, 0024 ✓= 0, 0037431 mol. m = n.M = 0, 0037431 x 40 ✓ m= 0, 15 g ✓	(8)
		[18]
QUESTION 3		
3.1	A base that dissociates completely in water to form a high concentration of hydrogen ions. ✓✓	(2)
3.2.1	n = c.V ✓= 0, 15 x 0, 02 ✓ n = 0, 003 mol. ✓	(3)
3.2.2	Ratio: HNO_3:$Ba(OH)_2$ is 1:2 $n_{(Ba(OH)2)}$ = 2 x 0, 003 = 0, 006 mol. ✓ HNO_3: c = $\frac{0,006}{0,025}$ ✓= 0, 24 mol.dm^{-3} [H_3O^+] = [HNO_3] = 0, 24 mol.dm^{-3} pH = - log [H_3O^+] ✓= - log (0, 24) ✓ = 0, 62 ✓	(5)
3.3	HNO_3: n = c.V = 0,4 x 0, 025 ✓ = 0, 01 mol. n of HNO_3 reacted: 0, 01 – 0, 006 ✓✓= 0, 004 mol. Ratio: HNO_3:**M**CO_3 $n_{(MCO3)}$ = ½ $n_{(HNO3)}$ = ½ x 0, 004 ✓= 0, 002 mol $m_{(MCO3)}$ = $\frac{85}{100}$ x 0, 198 ✓= 0, 168 g	

	m = n. M 0, 168 = 0, 002 x M ✓ M = 84 g.mol^{-1} Molar mass of M = 84 – 60 ✓= 24 g.mol^{-1} **M** is Magnesium (Mg) ✓	(8)
		[18]
QUESTION 4		
4.1.1	It ionises completely in water. ✓	(1)
4.1.2	NO_3^- (Nitrate ions) ✓	(1)
4.1.3	pH = - log [H_3O^+] ✓= - log (0, 3) ✓ = 0, 52 ✓	(3)
4.2.1	n = c.V ✓= 2 x 0, 1 ✓= 0, 2 mol. ✓	(3)
4.2.2	Burette ✓	(1)
4.2.3	B. ✓ Titration of a strong acid and a strong base. ✓✓	(3)
4.2.4	The number of moles of the acid in the flask remains the same. ✓	(1)
4.2.5	n = c.V ✓= 0, 2 x 0, 021 ✓= 0, 0042 mol. $n_{(HCl)}$ = $n_{(NaOH)}$ = 0, 0042 mol. ✓	(3)
4.2.6	$n_{(HCl\ reacted)}$ = 0, 2 – 0, 0042 ✓= 0, 1958 mol. Ratio: MgO:HCl is 1:2 n(MgO) = ½ 0, 1958 ✓= 0, 0979 mol m = n.M = 0, 0979 x 40 ✓= 3, 916 g % purity = $\frac{3,916}{4,5}$ x 100 ✓= 87, 02% ✓	(5)
		[21]
QUESTION 5		
5.1.1	An acid that donates two hydrogen ions. ✓✓	(2)
5.1.2	H_2O^2 ✓ and $(COO)_2^{2-}$ ✓	(2)
5.1.3	$HC_2O_4^-$ ✓	(1)
5.2	It ionises partially in water. ✓	(1)
5.3	n = c.V = 0, 2 x 0, 25 ✓= 0, 05 mol. m = n.M ✓ = 0, 05 x 90 ✓= 4, 5 g ✓	(4)
5.4.1	**Option 1** $(COOH)_2$: n = c.v ✓ = 0, 2 x 0, 025 ✓ = 0.005 mol. $n_{(NaOH)}$ = 2 x $n_{(C2O4H2)}$ = 2 x 0, 005 ✓= 0, 01 mol **Option 2** $\frac{c_a \times v_a}{c_b \times v_b} = \frac{n_a}{n_b}$ ✓ $\frac{0,2 \times 25 ✓}{c_b \times 36 ✓} = \frac{1}{2}$ ✓ Cb = 0, 28 mol.dm^{-3} ✓	

	NaOH: c = $\frac{n}{V}$ = $\frac{0,01}{0,036}$ ✓ c = 0, 28 $mol.dm^{-3}$ ✓		(5)
5.4.2	$(COO)_2^{2-}$ (aq) + $2H_2O$ (l) ✓ ⇌ $(COOH)_2$(aq) + $2OH^-$(aq) ✓ bal. ✓		(3)
			[18]