



# JENN

Training and Consultancy

The path to enlightened education



Province of the  
**EASTERN CAPE**  
EDUCATION

**SUBJECT: PHYSICAL SCIENCES**

**GRADE 12**

**LAST PUSH 2024**

**SOLUTION MANUAL**

**Topics**

**PAPER 1**

**PAPER 2**



# 1 Newton's laws

## QUESTION 1

- 1.1.1 When a resultant/net force acts on an object, the object will accelerate in the direction of the force at an acceleration directly proportional to the force ✓ and inversely proportional to the mass of the object. ✓ (2)

- 1.1.2 (3)



Accept the following symbols/Aanvaar die volgende simbole		
F	F <sub>applied</sub> /Force applied/ Toegepaste krag/F <sub>A</sub>	✓
F <sub>g</sub>	w / F <sub>w</sub> / weight /gewig	✓
T	F <sub>T</sub> / Tension/Spanning	✓

- 1.1.3 (3)

Option 1

$$\begin{aligned}
 f_k &= \mu_k N \checkmark \\
 &= \mu_k mg \\
 &= 0,3 \times 5 \times 9,8 \checkmark \\
 &= 14,7 \text{ N } \checkmark
 \end{aligned}$$

Option 2

$$\begin{aligned}
 N &= mg \\
 &= 5 \times 9,8 \\
 &= 49 \\
 f_k &= \mu_k N \checkmark \\
 &= 0,3 \times 49 \checkmark \\
 &= 14,7 \text{ N } \checkmark
 \end{aligned}$$

1.1.4

Direction of motion as positive

(6)

$$\begin{aligned}
 F_{\text{net}} &= ma \quad \checkmark \\
 F + F_g + T &= ma \\
 120 - 10 \times 9,8 - T &= 10a \\
 22 - T &= 10a \\
 F_{\text{net}} &= ma \\
 T - f_k &= ma \\
 T - 14,7 &= 5a \\
 a &= 0,487 \\
 T - 14,7 &= 5(0,487) \quad \checkmark \\
 T &= 17,13 \text{ N} \quad \checkmark \\
 \text{OR} \\
 T &= 22 - 10a \\
 &= 22 - 10(0,487) \\
 &= 17,13 \text{ N}
 \end{aligned}$$

1.2

1.2.1 Each body in the universe attracts every other body with a force that is directly proportional to the product of their masses and inversely proportional to the square of the distance between their centres. (2)

1.2.2 (4)

$$F_{\text{planet/planeet}} = \frac{1}{2} F_{\text{earth/aarde}} \quad \checkmark$$

$$G \frac{M_m 2M_e}{(X)^2} = \frac{1}{2} G \frac{M_m M_e}{R^2} \quad \checkmark$$

$$4R^2 = (X)^2$$

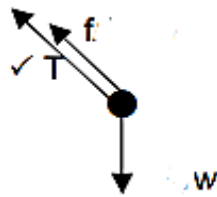
$$2R = X \quad \checkmark$$

[20]

## QUESTION 2

2.1 The force that opposes the motion of an object and which act parallel to the surface (2)

2.2



(3)

2.3

2.3.1

$$\begin{aligned} f_{k(\max)} &= \mu_k F_N \checkmark \\ &= 0,15(3)(9,8)(\cos 30^\circ) \checkmark \\ &= 3,82 \text{ N} \checkmark \end{aligned}$$

(3)

2.3.2

Right/downwards as positive

(6)

$$\begin{aligned} \text{5 kg block: } F_{\text{net}} &= ma \checkmark \\ T + f &= ma \\ T - (8) &= 5a \checkmark \end{aligned}$$

[1]

$$\begin{aligned} \text{3 kg block: } T + f + F_{g/y} &= ma \\ -T - 3,82 + (3)(9,8)\sin 30^\circ &= 3a \checkmark \\ -T + 10,88 &= 3a \end{aligned}$$

[2]

Substitute 2 into 1:

$$a = 0,36 \text{ m}\cdot\text{s}^{-2}$$

Substitute a into 1:

$$\begin{aligned} T - 8 &= (5)(0,36) \checkmark \\ T &= 9,8 \text{ N} \checkmark \end{aligned}$$

[14]

### QUESTION 3

3.1

When object **A** exert a force on body **B**, object **B** SIMULTANEOUSLY exert an oppositely directed force of equal magnitude on object **A**.  $\checkmark\checkmark$

(3)

3.2

**For crate B**

(6)

$$F_{\text{net}} = ma \checkmark$$

$$F_{A \text{ on } B} - f_k = ma$$

$$F_{A \text{ on } B} - 25,3 = (30)(2,3) \checkmark$$

$$F_{A \text{ on } B} - 25,3 = 69$$

$$F_{A \text{ on } B} = 94,3 \text{ N to the right} \checkmark$$

**Newton's third law**

$$F_{B \text{ on } A} = -F_{A \text{ on } B} \checkmark$$

$$F_{B \text{ on } A} = -94,3 \text{ N}$$

$$F_{B \text{ on } A} = 94,3 \text{ N to the left} \checkmark\checkmark$$

3.3

3.3.1 When a net force acts on object, the object will accelerate in the direction of the force and acceleration is directly proportional to the force and inversely proportional to the mass of the object. ✓✓ (2)

3.3.2 (4)

Option 1	Option 2
<u>For trolley N</u> $F_{\text{net}} = ma$ ✓ $F - T - f_k = ma$ $180 - T - 8.58\sqrt{} = (130) (1.09) \sqrt{} ✓$ $T = 27.72\text{N}\sqrt{} ✓$	<u>For trolley M</u> $F_{\text{net}} = ma$ ✓ $T + F_x - f_k = ma$ $T + 60\cos 28 - 6.4\sqrt{} = (70) (1.09) \sqrt{} ✓$ $T = 27.72\text{N}\sqrt{} ✓$

3.4 Decreases✓ (1)

3.5 (3)

- There will be vertical component of the applied force, this vertical component will tend Lift the trolley from the floor. ✓
- The normal force will decrease. ✓
- Hence frictional force decreases. ✓

[19]

## 2 Projectile motion

### QUESTION 1

1.1 Projectile in an object upon which the only force acting is the force of gravity. ✓ (2)  
✓

1.2  $9.8 \text{ m.s}^{-2} \sqrt{} \text{ downwards } \sqrt{} (2)$

1.3  $\Delta y = v_i \Delta t + \frac{1}{2} a \Delta t^2 \sqrt{} (3)$   
 $\Delta y = (9.8)(1.02) + \frac{1}{2}(-9.8)(1.02^2) \sqrt{} ✓$   
 $\Delta y = 41.88 \text{ m downwards } \sqrt{} ✓$

#### 1.4 OPTION 1

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

$$\Delta y = (9.8)(4.08) \sqrt{} ✓$$

$$+ \frac{1}{2}(-9.8)(4.08^2) \sqrt{} ✓$$

$$\Delta y = -41.58 \text{ m}$$

$$\Delta y = 41.88 \text{ m downwards } \sqrt{} ✓$$

#### OPTION 2

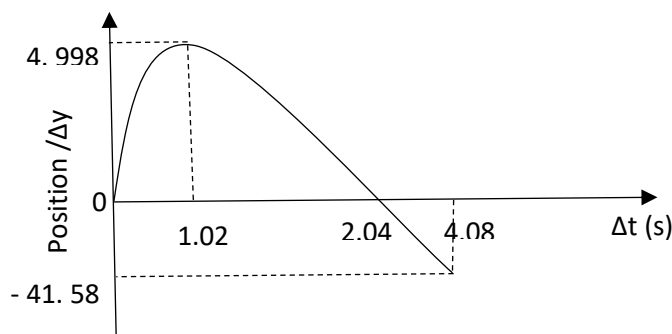
$$\Delta y = v_i \Delta t + \frac{1}{2} a \Delta t^2 \sqrt{} ✓$$

$$\Delta y = (9.8)(2.04) \sqrt{} + \frac{1}{2}(-9.8)(2.04^2) \sqrt{} ✓ (4)$$

$$\Delta y = -41.58 \text{ m}$$

$$\Delta y = 41.88 \text{ m downwards } \sqrt{} ✓$$

1.5



(4)

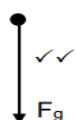
CRITERIA	MARKS
Graph starting from zero (0 m)	✓
Correct shape	✓
Position for maximum height (4,998 m) at 1.02 s	✓
Final position (41.58 m) at 4.08 s	✓

## QUESTION 2

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

2.2  $3,43 \text{ m}\cdot\text{s}^{-1}$ . ✓ penalise if there is no unit (1)

2.3



NOTE: ACCEPTED LABELS/ AANVAARDE BYSKRIFTE		MARK/ PUNT
w	$F_g/F_w$ /weight/0,49N/gravitational force	✓✓

(2)

### Notes:/Notas:

- Mark awarded for label and arrow. / Ken punt toe vir byskrif en pyl.
- Do not penalise for length of arrows, drawing is not to scale. / Moenie penaliseer vir lengte van pyle, nie op skaal geteken nie.
- Any other additional force(s) Max.  $\frac{1}{2}$  / Enige ander addisionele kragte Max.  $\frac{1}{2}$
- If force(s) do not make contact with body. Max.  $\frac{1}{2}$  / Indien krag nie kontak maak met kol nie Maks  $\frac{1}{2}$
- If no arrows indicated and all forces correctly drawn deduct 1 mark. / Indien geen pyle nie maar alle kragte korrek getrek is, trek een punt af

2.4.1

**OPTION/OPSIE 1**

$$\begin{aligned}\text{Gradient/Gradiënt} &= \text{acceleration/versnelling} = \frac{\Delta y}{\Delta x} \\ &= \frac{3,92 - 0}{0,4} \checkmark \\ &= 9,8 \text{ m.s}^{-2} \checkmark\end{aligned}$$

(3)

**OPTION/OPSIE 2**

$$\begin{aligned}\text{Gradient/Gradiënt} &= \text{acceleration/versnelling} = \frac{\Delta y}{\Delta x} \\ &= \frac{3,43 - 0}{0,77 - 0,42} \checkmark \\ &= 9,8 \text{ m.s}^{-2} \checkmark\end{aligned}$$

**OPTION/OPSIE 3**

$$\begin{aligned}v_f &= v_i + a\Delta t \\ 3,92 \checkmark &= 0 + a(0,40) \checkmark \\ a &= 9,8 \text{ m.s}^{-2} \checkmark\end{aligned}$$

any equation of motion can be used

**Option 4**

If learner uses the values for the collision during the 0,02 seconds when the ball is in contact with the ground.

$$\begin{aligned}v_f &= v_i + a\Delta t \\ -3,43 \checkmark &= +3,92 + a(0,02) \checkmark \\ a &= -367,5 \text{ m.s}^{-2}\end{aligned}$$

Answer will be  $367,5 \text{ m.s}^{-2} \checkmark$

Give learner the credit if following this path and doing the correct steps and calculations.

**OPTION/OPSIE 1**

Height/Hoogte = area under the graph/ *area onder die grafiek*

$$= \frac{1}{2} bh \checkmark$$

$$= \frac{1}{2} \times 0,4 \times 3,92 \checkmark \checkmark$$

$$= 0,784 \text{ m} \checkmark$$

Do not penalise if formula is not given

**OPTION/OPSIE 2**

$$y = v_i t + \frac{1}{2} gt^2 \checkmark$$

$$= 0 \checkmark + \frac{1}{2} (9,8)(0,4)^2 \checkmark$$

$$= 0,784 \text{ m} \checkmark$$

**OPTION/OPSIE 3**

(4)

**Downwards as positive/Afwaarts as positief**

$$v_f^2 = v_i^2 + 2ay \checkmark$$

$$3,92^2 \checkmark = 0 + 2 \times (9,8)y \checkmark$$

$$y = 0,784 \text{ m (downwards/afwaarts)} \checkmark$$

**OPTION/OPSIE 4**

**Downwards as negative/Afwaarts as negatief**

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

$$(-3,92)^2 \checkmark = (0)^2 + 2(-9,8) \Delta y \checkmark$$

$$\therefore \Delta y = -0,784 \text{ m}$$

$$\therefore \Delta y = 0,784 \text{ m downwards/afwaarts}$$

The height from which the ball was dropped = 0,784 m. ✓

*Die hoogte waarvan dan die bal laat val is = 0,784 m.*

**OPTION/OPSIE 5**

$$y = \left( \frac{v_f + v_i}{2} \right) t \checkmark$$

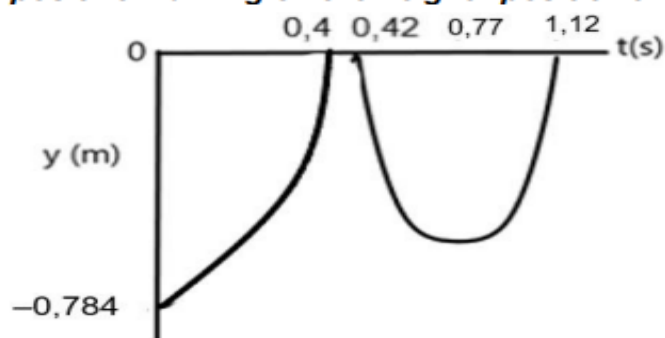
$$= \left( \frac{3,92 + 0}{2} \right) \checkmark 0,4 \checkmark$$

$$= 0,784 \text{ m} \checkmark$$



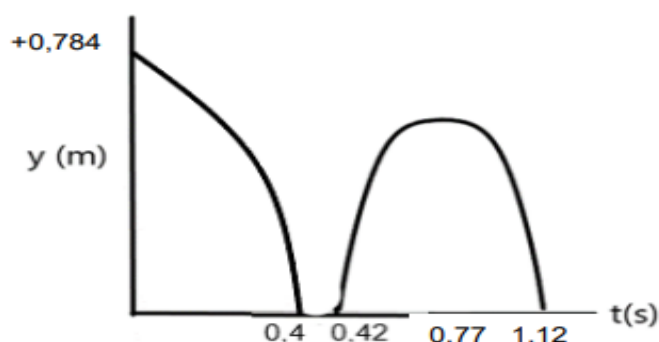
2.5

(Downwards taken as positive)/(afwaarts geneem as positief)  
positive marking on the height / positiewe nasien vir die hoogte



OR/OF

(Downward taken as negative)/(Afwaarts geneem as negatief)  
positive marking on the height / positiewe nasien vir die hoogte



Marking Criteria/Nasienriglyne	Mark/Punt
Graph starting from the maximum height (0,784 m) <i>Grafiek begin vanaf maksimum hoogte (0,784 m)</i>	✓
Time taken to reach the ground indicated <i>Tyd geneem om grond te bereik aangedui</i>	✓
Correct shape of the graph/Korrekte vorm van grafiek	✓
Ground taken as zero/Grond geneem as nulverwysing	✓

(4)

### 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/ is in free fall. ✓✓

(2)

#### 3.2.1 OPTION 1

UPWARDS AS POSITIVE

$$v_f = v_i + a\Delta t \checkmark$$

$$0 = (15) + (-9.8)(\Delta t) \checkmark$$

$$\Delta t = 1.53 \text{ s} \checkmark$$

#### OPTION 2

UPWARDS AS POSITIVE

$$v_f = v_i + a\Delta t \checkmark$$

$$0 = (-15) + (9.8)(\Delta t) \checkmark$$

$$\Delta t = 1.53 \text{ s} \checkmark$$

(3)

**DOWNWARDS AS POSITIVE**

$$v_f = v_i + a\Delta t \checkmark$$

$$0 = (-15) + (9.8)(\Delta t) \checkmark$$

$$\Delta t = 1.53 \text{ s} \checkmark$$

**OPTION 3****UPWARDS AS POSITIVE**

$$v_f = v_i + a\Delta t \checkmark$$

$$(-15) = (15) + (-9.8)(\Delta t) \checkmark$$

$$\Delta t = 3.06 \text{ s}$$

$$\Delta t_{up} = 1.53 \text{ s} \checkmark$$

**DOWNWARDS AS POSITIVE**

$$v_f = v_i + a\Delta t \checkmark$$

$$(15) = (-15) + (9.8)(\Delta t) \checkmark$$

$$\Delta t = 3.06 \text{ s}$$

$$\Delta t_{up} = 1.53 \text{ s} \checkmark$$

**3.2.2 OPTION 1****UPWARDS AS POSITIVE**

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

$$= (15)(1.53)$$

$$+ \frac{1}{2}(-9.8)(1.53)^2 \checkmark$$

$$\Delta y = 11.58 \text{ m}$$

$$\text{Height} = 11.58 + 30 \checkmark$$

$$= 41.48 \checkmark$$

**DOWNWARDS AS POSITIVE**

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

$$= (-15)(1.53)$$

$$+ \frac{1}{2}(9.8)(1.53) \checkmark$$

$$\Delta y = -11.58 \text{ m}$$

$$\text{Height} = 11.58 + 30 \checkmark$$

$$= 41.48 \checkmark$$

**DOWNWARDS AS POSITIVE**

$$v_f = v_i + a\Delta t \checkmark$$

$$0 = (15) + (-9.8)(\Delta t) \checkmark$$

$$\Delta t = 1.53 \text{ s} \checkmark$$

**OPTION 3****UPWARDS AS POSITIVE**

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

$$0 = (15)(\Delta t) + \frac{1}{2}(-9.8)(\Delta t)^2 \checkmark$$

$$\Delta t = 3.06 \text{ s}$$

$$\Delta t_{up} = 1.53 \text{ s} \checkmark$$

**UPWARDS AS POSITIVE**

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

$$0 = (-15)(\Delta t) + \frac{1}{2}(9.8)(\Delta t)^2 \checkmark$$

$$\Delta t = 3.06 \text{ s}$$

$$\Delta t_{up} = 1.53 \text{ s} \checkmark$$

**OPTION 2****UPWARDS AS POSITIVE**

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

$$0 = (15)^2 + (-9.8)\Delta y \checkmark$$

$$\Delta y = 11.58 \text{ m}$$

$$\text{Height} = 11.58 + 30 \checkmark$$

$$= 41.48 \checkmark$$

**DOWNWARDS AS POSITIVE**

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

$$0 = (-15)^2 + (9.8)\Delta y \checkmark$$

$$\Delta y = -11.58 \text{ m}$$

$$\text{Height} = 11.58 + 30 \checkmark$$

$$= 41.48 \checkmark$$

(4)

**3.3 Take  $y_c$  as height of disc above ground at meeting point**

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

$$y_c - 30 = (15)\Delta t + \frac{1}{2}(-9.8)\Delta t^2 \checkmark$$

$$y_c = 15\Delta t - 4.9\Delta t^2 + 30 \dots (1)$$

(6)

**Take  $y_B$  as height of ball above ground at meeting point**

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

$$y_B - 0 = (40)(\Delta t - 0.5) + \frac{1}{2}(-9.8)(\Delta t - 0.5)^2 \checkmark$$

$$y_B = 44.9\Delta t - 4.9\Delta t^2 - 21.225 \dots (2)$$

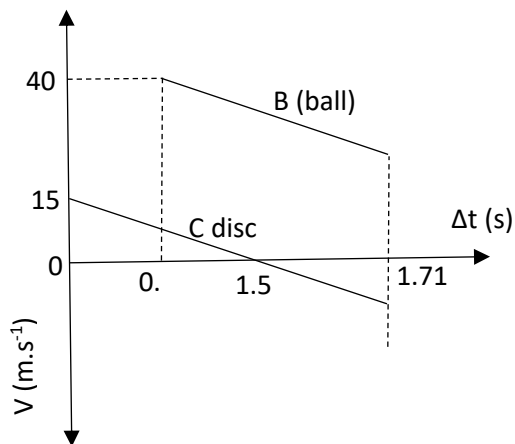
At meeting point

$$y_C = y_B$$

$$15\Delta t - 4.9\Delta t^2 + 30 = 44.9\Delta t - 4.9\Delta t^2 - 21.225 \checkmark$$

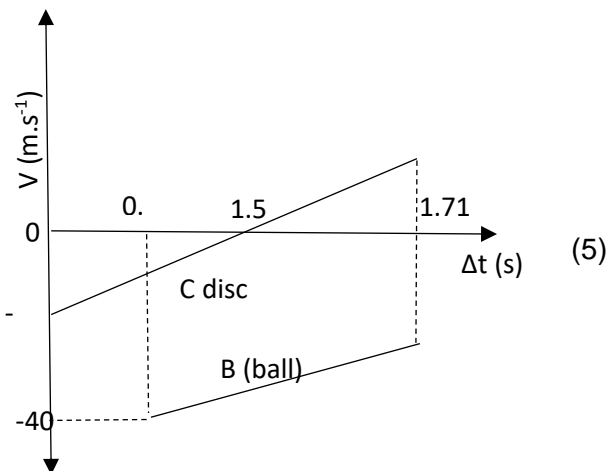
$$\Delta t = 1.17 \text{ s } \checkmark$$

### 3.4 UPWARDS AS POSITIVE



- Initial velocities 40 and 15 and straight lines ✓
- B starting at 0,5 s ✓
- Parallel lines with negative gradient ✓
- Time at which disc reaches maximum height (answer from 3.2.1) 1,53 s ✓
- Time at which B hits C (answer from 4.3) 1,71 s ✓

### DOWNWARDS AS POSITIVE



- Initial velocities - 40 and - 15 and straight lines ✓
- B starting at 0,5 s ✓
- Parallel lines with negative gradient ✓
- Time at which disc reaches maximum height (answer from 3.2.1) 1,53 s ✓
- Time at which B hits C (answer from 4.3) 1,71 s ✓

## 3 Momentum and impulse

### Question 1

1.1 The total linear momentum of an isolated system is conserved. **✓✓** (2)

1.2  $\sum p_i = \sum p_f$  **✓**  
 $\frac{(15)(V) + 0V}{V = 8,36 \text{ m.s}^{-1}}$  **✓** (4)

1.3  $V_f = V_i + a\Delta t$  **✓**  
 $0 = 4,4 + (a)(3)$   
 $a = -1,47 \text{ m.s}^{-2}$  **✓** (4)  
 $F_f = F_{\text{net}} = ma$   
 $F_f = (15 + 13,5)(-1,47)$  **✓**

$$F_f = 41,9 \text{ N} \quad \checkmark \quad (4)$$

## Question 2

2.1 A system on which the resultant/net external force is zero.  $\checkmark\checkmark$  (2)

2.2 According to Newton 3rd Law, the rocket exerts a force on the toy cart to the left/opposite to direction of motion.  $\checkmark\checkmark$  (2)

$$\begin{aligned} 2.3 \quad \Sigma p_i &= \Sigma p_f \quad \checkmark \\ (m_1 + m_2) v_i &= m_1 v_{(1)f} + m_2 v_{(2)f} \\ (20 + m_2) 2,5 \checkmark &= 20(0,6) \checkmark + (30m_2) \checkmark \\ m_2 &= 1,38 \text{ kg} \quad \checkmark \end{aligned} \quad (5)$$

## Question 3

3.1 The product of the resultant/net force acting on an object and the time the net force acts on the object.  $\checkmark\checkmark$  (2)

$$\begin{aligned} 3.2 \quad \Sigma p_i &= \Sigma p_f \quad \checkmark \\ m_1 v_{(1)i} + m_2 v_{(2)i} &= m_1 v_{(1)f} + m_2 v_{(2)f} \\ \underline{m(10) + 1,7m(-15)} \checkmark &= \underline{m(-5) + 1,7m v_f} \checkmark \\ v_f &= -6,18 \text{ m} \cdot \text{s}^{-1} \\ &= 6,18 \text{ m} \cdot \text{s}^{-1} \text{ west} \quad \checkmark \end{aligned} \quad (5)$$

3.3

3.3.1 Inelastic  $\checkmark$  (1)

3.3.2

$$\begin{aligned} \Delta K &= K_f - K_i \\ \Sigma K_i &= \Sigma K_f + \text{energy lost/energie verloor} \\ \left. \begin{aligned} \frac{1}{2} m_P v_{Pi}^2 + \frac{1}{2} m_Q v_{Qi}^2 &= \frac{1}{2} m_P v_{Pf}^2 + \frac{1}{2} m_Q v_{Qf}^2 + 175000 \text{ J} \end{aligned} \right\} \text{Any/Enige} \checkmark \\ \frac{1}{2} m (10^2) + \frac{1}{2} (1,7m) (15^2) \checkmark &= \frac{1}{2} m (5^2) + \frac{1}{2} (1,7m) (6,18)^2 \checkmark + 175000 \checkmark \\ m &= 881,54 \text{ kg} \quad \checkmark \end{aligned} \quad (5)$$

$$\begin{aligned} 3.3.3 \quad F_{net} &= \frac{MV_{final} - MV_{initial}}{\Delta t} \checkmark \\ &= \frac{881,54(-5 - 10) \checkmark}{1,75 - 1,25 \checkmark} \\ &= -26\,446,20 \\ F_{net} &= 26\,446,20 \text{ N} \checkmark \end{aligned} \quad (4)$$

[17]

# 4 Work, Energy, Power

## QUESTION 1.

- 1.1. The total mechanical energy in an isolated system remains constant / the same.
- 1.2.

### NOTE/LET WEL

- Mass may be omitted during substitution. / Massa mag uitgelaat word tydens vervanging.
- If equations of motion are used. Max 1/3 for correct answer. / Indien bewegingsvergelikings gebruik word. Maks 1/3 vir korrekte antwoord.

### OPTION 1/OPSIE 1

$$\begin{aligned} E_{P/mech\ top/mech\ bo} &= E_{Q/mech\ ground / meg\ grond} \\ (E_p + E_k)_{P/top/bo} &= (E_p + E_k)_{Q/bottom/onder} \\ (mgh + \frac{1}{2}mv^2)_{P/top/bo} &= (mgh + \frac{1}{2}mv^2)_{Q/bottom/onder} \\ (2)(9.8)(5) + 0 &= 0 + \frac{1}{2}(2)v_f^2 \checkmark \\ v_f &= 9.90\ m\cdot s^{-1} \checkmark (9.899) \end{aligned} \quad \left. \vphantom{\begin{aligned} E_{P/mech\ top/mech\ bo} &= E_{Q/mech\ ground / meg\ grond} \\ (E_p + E_k)_{P/top/bo} &= (E_p + E_k)_{Q/bottom/onder} \\ (mgh + \frac{1}{2}mv^2)_{P/top/bo} &= (mgh + \frac{1}{2}mv^2)_{Q/bottom/onder} \end{aligned}} \right\} \checkmark \text{Any one/Enige een}$$

### OPTION 2/OPSIE 2

$$\begin{aligned} \Delta E_p + \Delta E_k &= 0 \\ (mgh_f - mgh_i) + \frac{1}{2}m(v_f^2 - v_i^2) &= 0 \\ 0 - (2)(9.8)(5) + \frac{1}{2}(2)(v_f^2 - 0) &\checkmark = 0 \\ v_f &= 9.90\ m\cdot s^{-1} \checkmark (9.899) \end{aligned} \quad \left. \vphantom{\begin{aligned} \Delta E_p + \Delta E_k &= 0 \\ (mgh_f - mgh_i) + \frac{1}{2}m(v_f^2 - v_i^2) &= 0 \end{aligned}} \right\} \checkmark \text{Any one/Enige een}$$

- 1.3.

### OPTION 1/OPSIE 1

$$\begin{aligned} W_{net} &= \Delta E_k \\ W_f &= \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2 \\ W_N + W_f + W_w &= \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2 \\ f\Delta x \cos\theta &= \frac{1}{2}m(v_f^2 - v_i^2) \\ f(10)\cos 180^\circ &\checkmark = \frac{1}{2}(2)(4^2 - 9.90^2) \checkmark \\ f &= 8.2\ N \checkmark \end{aligned} \quad \left. \vphantom{\begin{aligned} W_{net} &= \Delta E_k \\ W_f &= \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2 \\ W_N + W_f + W_w &= \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2 \end{aligned}} \right\} \checkmark \text{Any one/Enige een}$$

### OPTION 2/OPSIE 2

$$\begin{aligned} W_{nc} &= \Delta E_k + \Delta E_p \\ W_f &= \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2 \\ W_N + W_f &= \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2 \\ f\Delta x \cos\theta &= \frac{1}{2}m(v_f^2 - v_i^2) + mg(h_f - h_i) \\ f(10)\cos 180^\circ &\checkmark = \frac{1}{2}(2)(4^2 - 9.90^2) + 0 \checkmark \\ f &= 8.2\ N \checkmark \end{aligned} \quad \left. \vphantom{\begin{aligned} W_{nc} &= \Delta E_k + \Delta E_p \\ W_f &= \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2 \\ W_N + W_f &= \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2 \end{aligned}} \right\} \checkmark \text{Any one/Enige een}$$

- 1.4.

**LEFT NEGATIVE/LINKS NEGATIEF**

$$\begin{aligned}
 F_{\text{net}}\Delta t &= \Delta p \\
 F_{\text{net}}\Delta t &= mv_f - mv_i \\
 F_{\text{net}}\Delta t &= m(v_f - v_i) \\
 -14 &= 2(v_f - 4) \\
 v_f &= -3 \text{ m}\cdot\text{s}^{-1}
 \end{aligned}$$

✓ Any one/Enige een

**ACCEPT/AANVAAR**  
Impulse/Impuls =  $m\Delta v$

$$\begin{aligned}
 \Delta E_K &= \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2 \\
 &= \frac{1}{2}(2)[(-3)^2 - 4^2] \\
 &= -7 \text{ J}
 \end{aligned}$$

Do not penalise if +3 is substituted.  
Moenie penaliseer indien +3 vervang is.

**ACCEPT/AANVAAR**

$$\begin{aligned}
 \Delta E_K &= \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2 \\
 &= \frac{1}{2}(2)[(0)^2 - (-3)^2] \\
 &= -9 \text{ J}
 \end{aligned}$$

Do not penalise if +3 is substituted.  
Moenie penaliseer indien +3 vervang is.

**RIGHT NEGATIVE/REGS NEGATIEF**

$$\begin{aligned}
 F_{\text{net}}\Delta t &= \Delta p \\
 F_{\text{net}}\Delta t &= mv_f - mv_i \\
 F_{\text{net}}\Delta t &= m(v_f - v_i) \\
 14 &= 2(v_f - (-4)) \\
 v_f &= 3 \text{ m}\cdot\text{s}^{-1}
 \end{aligned}$$

✓ Any one/Enige een

**ACCEPT/AANVAAR**  
Impulse/Impuls =  $m\Delta v$

$$\begin{aligned}
 \Delta E_K &= \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2 \\
 &= \frac{1}{2}(2)[(3)^2 - (-4)^2] \\
 &= -7 \text{ J}
 \end{aligned}$$

Do not penalise if +4 is substituted.  
Moenie penaliseer indien +4 vervang is.

**ACCEPT/AANVAAR**

$$\begin{aligned}
 \Delta E_K &= \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2 \\
 &= \frac{1}{2}(2)[(0)^2 - (-3)^2] \\
 &= -9 \text{ J}
 \end{aligned}$$

Do not penalise if +3 is substituted.  
Moenie penaliseer indien +3 vervang is.

[1]

**QUESTION 2**

2.1. The rate at which work is done/energy is expended.  
2.2.

(3)

**OPTION 1/OPSIE 1**

$$\begin{aligned}
 P &= \frac{W}{\Delta t} \\
 &= \frac{\Delta mgh}{\Delta t} \\
 &= \frac{(1\,250)(9,8)(5,8)}{60} \\
 &= 1\,184,17 \text{ W} \quad (1\,184,167)
 \end{aligned}$$

✓ Any one/Enige een

**OPTION 2/OPSIE 2**

$$\begin{aligned}
 P &= \frac{W}{\Delta t} \\
 &= \frac{F\Delta x \cos \theta}{\Delta t} \quad \text{or/of} \quad \frac{F\Delta y \cos \theta}{\Delta t} \\
 &= \frac{mg \Delta x \cos 0^\circ}{\Delta t} \\
 &= \frac{(1\,250)(9,8)(5,8) \cos 0^\circ}{60} \\
 &= 1\,184,17 \text{ W} \quad (1\,184,167)
 \end{aligned}$$

✓ Any one/Enige een

2.3.1. A conservative force is a force for which the work done (in moving an object between two points) is independent of the path taken.

2.3.2. Non-conservative

2.3.3. (Gravitational) potential to kinetic (energy)

2.3.4.

### **Marking criteria/ Nasienkriteria**

- Any one of the following formulae/ *Enigeen van die volgende formules*:  
 $W_{\text{net}} = \Delta E_k$  /  $W_{\text{nc}} = \Delta E_k + \Delta E_p$  ✓
- Substitution to calculate the  $\Delta E_k$  or initial velocity. ✓  
*Vervanging om  $\Delta E_k$  of begin snelheid te bereken.*
- Correct substitution of  $\Delta E_k$  in: / *Korrekte vervangings van  $\Delta E_k$  in:*  
 $W_{\text{net}} = \Delta E_k$  /  $W_{\text{nc}} = \Delta E_k + \Delta E_p$  ✓
- Correct substitution into / *Korrekte vervangings in  $F\Delta x \cos\theta$ .* ✓
- Final answer / *Finale antwoord*: 284 089 N ✓ (283 510,63 N to/tot 284 200 N)

### **OPTION 1/OPSIE 1**

From R to the wall / *Vanaf R na die muur*:

$$\begin{aligned}\Delta U &= mg(h_f - h_i) \\ &= 1\,250(9,8)(0 - 5,8) \checkmark \\ &= -71\,050 \text{ J}\end{aligned}$$

$$\Delta K = -\Delta U = 71\,050 \text{ J}$$

Into the wall: / *In die muur in*

$$\begin{aligned}W_{\text{net}} &= \Delta K \\ W_{\text{wall/muur}} &= K_f - K_i \\ F_{\text{wall/muur}} \Delta x \cos\theta &= K_f - K_i \\ F_{\text{wall/muur}} (0,25) \cos 180^\circ &= 0 - 71\,050 \checkmark \\ F_{\text{wall/muur}} &= 284\,089 \text{ N} \checkmark\end{aligned}$$

✓ Any one/Enige een

### **OPTION 2/OPSIE 2**

From R to the wall / *Vanaf R na die muur*

$$\begin{aligned}W_{\text{nc}} &= \Delta K + \Delta U \\ W_{\text{nc}} &= (mgh_f - mgh_i) + \frac{1}{2}m(v_f^2 - v_i^2) \\ 0 &= 0 - (1\,250)(9,8)(5,8) + \frac{1}{2}(1\,250)(v_f^2 - 0) \checkmark \\ v_i &= 10,66 \text{ m}\cdot\text{s}^{-1} \text{ (10,662)}\end{aligned}$$

✓ Any one/Enige een

Into the wall / *In die muur in:*

$$\begin{aligned}W_{\text{net}} &= \Delta K \\ W_{\text{wall/muur}} &= K_f - K_i \\ F_{\text{wall/muur}} \Delta x \cos\theta &= K_f - K_i \\ F_{\text{wall/muur}} (0,25) \cos 180^\circ &= 0 - \frac{1}{2}(1\,250)(10,66)^2 \checkmark \\ F_{\text{wall/muur}} &= 284\,089 \text{ N} \checkmark \quad (284\,195,61 \text{ N})\end{aligned}$$

[14]

### QUESTION 3

3.1. The work done on an object by a net force  $\checkmark$  is equal to the change in the object's kinetic energy.

3.2.

$$\text{Gradient/slope} = \frac{\Delta E_k}{\Delta x}$$

$$\left. \begin{array}{l} \text{But } W_{\text{net}} = \Delta E_k \\ F_{\text{net}} \Delta x \cos \theta = \Delta E_k \\ F_{\text{net}} \Delta x \cos 0^\circ = \Delta E_k \end{array} \right\} \checkmark$$

$$F_{\text{net}} = \frac{\Delta E_k}{\Delta x} = \text{gradient/slope} \checkmark$$

3.3.

Third region C:

$$\begin{aligned} F_{\text{net}} &= \frac{\Delta E_k}{\Delta x} \checkmark \\ &= \frac{180 - 88}{15 - 10} \checkmark \\ &= 18,4 \text{ N} \checkmark \end{aligned}$$

3.4.

$$F_{\text{net}} = F_A + F_f \checkmark$$

$$18,4 = 30 - F_f \checkmark$$

$$F_f = 11,6 \text{ N} \checkmark$$

3.5. Second region B

5.6. Second region B has the smallest gradient  $\checkmark$  The net force (gradient) will be smallest  $\checkmark$   
 $\therefore$  force of friction is the largest



# 5 Doppler effect

## QUESTION 1

1.1 Doppler effect: as 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 Towards. ✓ (1)

1.3 
$$f_L = \frac{V \pm V_L}{V \pm V_S} f_S \quad f_L = \frac{V \pm V_L}{V \pm V_S} f_S \quad (6)$$

$$3148 \sqrt{=} \frac{340}{340 - V_S} \sqrt{F_S}$$

$$2073 \sqrt{=} \frac{340}{340 + V_S} \sqrt{f_S}$$

$$\frac{3148(340 - V_S)}{340} f_S = \frac{2073(340 + V_S)}{340} f_S$$

$$V_S = 70 \text{ m.s}^{-1} \quad \checkmark$$

1.4 
$$\Delta t = \frac{\Delta x}{V} \quad \checkmark \quad (2)$$

$$= \frac{350}{70}$$

$$= 5 \text{ s} \quad \checkmark$$

[11]

## QUESTION 2

2.1 Doppler effect: as 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)

2.2  $V = f\lambda \quad \checkmark \quad (3)$

$$340 = (880) \lambda$$

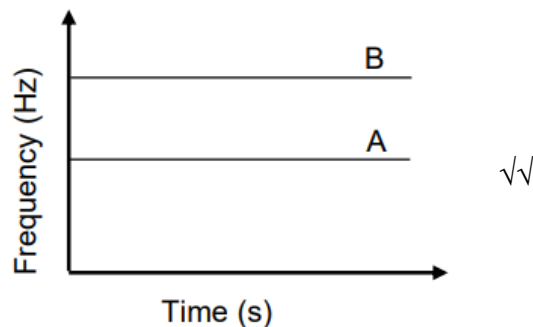
$$\lambda = 0,39 \text{ m (0,386)} \quad \checkmark$$

2.3  $f_L = \frac{V \pm V_L}{V \pm V_S} f_S \quad \checkmark \quad (4)$

$$f_L = \frac{340+10}{340} \sqrt{(880)} \quad \checkmark$$

$$f_L = 905,88 \text{ Hz} \quad \checkmark$$

2.4 (2)



[11]

### QUESTION 3

3.1.1  $V = f\lambda$  ✓ (2)

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

3.1.2  $f_L = \frac{v \pm v_L}{v \pm v_S} f_S$  ✓  
 $= 0,65 \text{ m}$  ✓

$$f_L = \frac{340}{340-15} \sqrt{(520)} \quad \checkmark \quad (6)$$

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

$$V = f\lambda \quad \checkmark$$

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

$$= 0.63 \text{ m} \quad \checkmark$$

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)

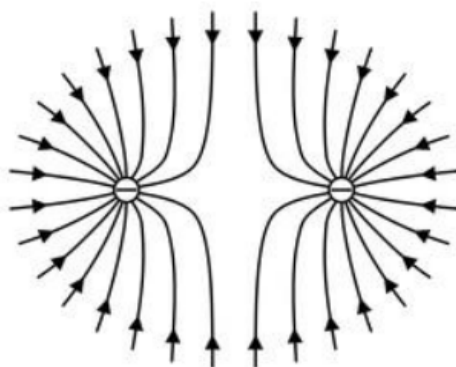
[12]

## 6 Electrostatics

### QUESTION 1

1.1 The electric field at a point is the electrostatic force experienced per unit positive charge placed at that point. ✓✓ (2)

1.2



**Marking criteria/Nasienriglyne**

✓ Shape/form/ all lines need to be curved / *Vorm / alle lyne moet 'n kurwe hê.*

✓ Direction of arrows towards sphere/*Rigting van pyle na die sfere*

✓ All other field rules applied. / *Alle ander veldreëls toegepas.*

**Do not penalise if different amounts of lines around the charges.**

Ignore if different number of lines are drawn around each charge. / *Ignoreer indien die verskillende aantal lyne getrek is rondom elke lading.*

(3)

1.3

$$F_{C \text{ on/op } B} = \frac{1,57 \times 10^{-7}}{r^2}$$

$$F_{\text{net on/op } B} = F_{A \text{ on/op } B} + F_{C \text{ on/op } B}$$

$$0,004078 \checkmark = 0,003272 + \frac{1,57 \times 10^{-7}}{r^2}$$

$$r = 0,01399 \text{ m (accept/aanvaar } 0,014 \text{ m)} \checkmark$$

accept 0,01 m rounding off

(5)

1.4.1

$$\begin{aligned} Q_{\text{new/nuwe}} &= \frac{Q_A + Q_B}{2} \\ &= \frac{+5,6 + (-2,34)}{2} \checkmark \\ &= 1,63 \text{ nC} \\ &= 1,63 \times 10^{-9} \text{ C} \checkmark \end{aligned} \quad \left. \vphantom{\begin{aligned} Q_{\text{new/nuwe}} &= \frac{Q_A + Q_B}{2} \\ &= \frac{+5,6 + (-2,34)}{2} \checkmark \\ &= 1,63 \text{ nC} \\ &= 1,63 \times 10^{-9} \text{ C} \checkmark \end{aligned}} \right\} \text{ accept either or}$$

(2)

1.4.2

B is positively charged ✓ and C negative. Attractive pattern. ✓ The electric field pattern has changed. It is now originating from B and ending at C. ✓ This is because B is now positively charged whilst C remains negatively charged.

(3)

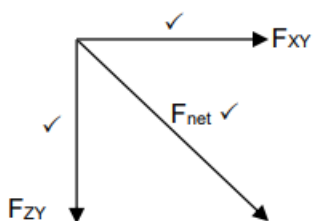
[15]

## QUESTION 2

- 2.1 The magnitude of the electrostatic force exerted by one point charge on another point charge is directly proportional to the product of the (magnitudes of the) charges ✓ and inversely proportional to the square of the distance between them. ✓ (2)

2.2  $F = \frac{KQ_1Q_2}{r^2}$  ✓  
 $F = \frac{(9 \times 10^9)(6 \times 10^{-6})(8 \times 10^{-6})}{(0.2)^2}$  ✓  
 $F = 10.8 \text{ N}$  ✓ (4)

2.3



Marking criteria	
$F_{Z \text{ op } Y}$ if correct direction	✓
$F_{X \text{ op } Y}$ if correct direction	✓
Resultant vector	✓

(3)

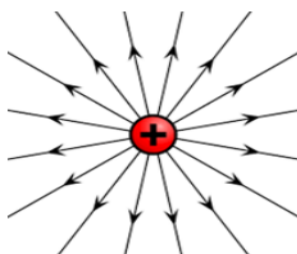
2.4  $F_{net}^2 = F_{XY}^2 + F_{ZY}^2$  ✓  
 $15.20^2 = 10.8^2 + F_{ZY}^2$   
 $F_{ZY} = 10.969 \text{ N}$

$F_{ZY} = \frac{KQ_YQ_Z}{r^2}$   
 $10.969 \text{ ✓} = \frac{(9 \times 10^9)(8 \times 10^{-6})Q_Z}{(0.3)^2}$  ✓  
 $F = 1.34 \times 10^{-5} \text{ N}$  ✓ (4)

[13]

## QUESTION 3

3.1



Shape (radial)/Vorm (radiaal) ✓

Correct direction/Korrekte rigting ✓

(2)

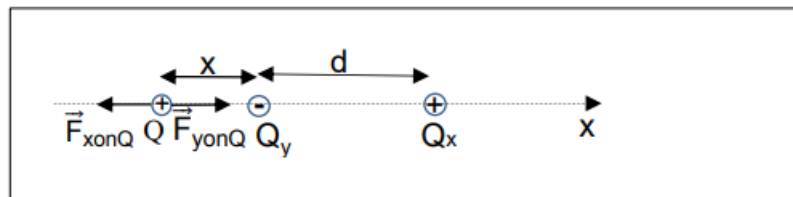
- 3.2 An electric field is a region of space in which an electric charge experiences a force. ✓ The direction of the electric field at a point is the direction that a positive test charge would move if placed at that point. ✓ (2)

$$\begin{aligned}
 3.2 \quad Q &= nq_e \checkmark \\
 Q &= (3,125 \times 10^{10}) (1,6 \times 10^{-19}) \checkmark \\
 Q &= +5 \times 10^{-9} \text{ C } \checkmark
 \end{aligned}
 \tag{3}$$

$$\begin{aligned}
 3.4 \quad E &= \frac{KQ}{r^2} \checkmark \\
 E &= \frac{(9 \times 10^9)(5 \times 10^{-9})}{(0,8)^2} \checkmark \\
 E &= 70,31 \text{ N} \cdot \text{C}^{-1} \checkmark
 \end{aligned}
 \tag{3}$$

3.5 GREATER THAN/GROTER AS/  
 The electric field at a point due to a point charge is inversely proportional to the square of the distance between the point and the charge/ $(E \propto \frac{1}{r^2}) \checkmark$

3.6



$$-F_{X \text{ on } Q} + F_{Y \text{ on } Q} = 0 \checkmark$$

$$\frac{KQ_x Q}{(d+x)^2} = \frac{KQ_y Q}{(x)^2}$$

$$\sqrt{\frac{(5 \times 10^{-9})}{(0,4+x)^2}} \checkmark = \sqrt{\frac{4 \times 10^{-9}}{x^2}} \checkmark$$

$$x = 3,39 \text{ m } \checkmark$$

(4)

[16]

## 7 Electrodynamics

### QUESTION 1

1.1 Q/split ring commutator/commutator✓ (1)

1.2 Replace Q/split ring commutator with slip rings. ✓ (1)

1.3

1.3.1

(3)

$$I_{\text{rms/wgk}} = \frac{I_{\text{max/maks}}}{\sqrt{2}} \checkmark$$

$$= \frac{0,35}{\sqrt{2}} \checkmark$$

$$\therefore I_{\text{rms/wgk}} = 0,25 \text{ A} \checkmark$$

1.3.2

(3)

<b>OPTION 1/OPSIE 1</b> $P_{\text{ave/gemid}} = \frac{V_{\text{rms/wgk}}^2}{R} \checkmark$ $60 = \frac{240^2}{R} \checkmark$ $\therefore R = 960 \Omega \checkmark$	<b>Notes/Aantekeninge</b> Do not penalise if subscripts are omitted. <i>Moenie penaliseer indien onderskrifte weggelaat is nie</i>
<b>OPTION 2/OPSIE 2</b> $P_{\text{ave/gemid}} = I_{\text{rms/wgk}}^2 R \checkmark$ $60 = (0,25)^2 R \checkmark$ $\therefore R = 960 \Omega \checkmark$	
<b>OPTION 3/OPSIE 3</b> $R = \frac{V_{\text{rms/wgk}}}{I_{\text{rms/wgk}}} \checkmark$ $= \frac{240}{0,25} \checkmark$ $= 960 \Omega \checkmark$	<b>Notes/Aantekeninge</b> <b>Accept/Aanvaar:</b> $R = \frac{V}{I}$ as formula/formule

[8]

**QUESTION 2**

2.1 A: coil / armature ✓

(3)

B: brushes ✓

C: commutator / split-ring (commutator) ✓

2.2 **ANY ONE** ✓

(1)

Maintains contact with the commutator.

Takes current into the coil.

2.3 DC motor ✓

(1)

2.4 Due to the motor effect ✓

(1)

$$2.5 \quad V_{\text{rms}} = \frac{V_{\text{max}}}{\sqrt{2}} \checkmark$$

$$= \frac{1}{\sqrt{2}} \checkmark$$

$$= 0.707 \text{ V} \checkmark$$

2.6 0.04 s ✓ (v doubles ∴ emf doubles ∴ f doubles ∴ period halves)

(3)

(2)

2.7

**POSITIVE MARKING FROM QUESTION 1.5**

**OPTION 1**

$$\begin{aligned} P_{\text{ave}} &= V_{\text{rms}} I_{\text{rms}} \checkmark \\ &= \left( \frac{V_{\text{max}}}{\sqrt{2}} \right) \left( \frac{I_{\text{max}}}{\sqrt{2}} \right) \checkmark \quad \text{'1 mark for formula} \\ &= \left( \frac{1}{\sqrt{2}} \right) \left( \frac{2}{\sqrt{2}} \right) \checkmark \\ &= 1 \text{ W } \checkmark \end{aligned}$$

**OPTION 2**

$$\begin{aligned} P_{\text{ave}} &= V_{\text{rms}} I_{\text{rms}} \checkmark \\ &= \left( \frac{1}{\sqrt{2}} \right) \left( \frac{I_{\text{max}}}{\sqrt{2}} \right) \checkmark \\ &= \left( \frac{1}{\sqrt{2}} \right) \left( \frac{2}{\sqrt{2}} \right) \checkmark \\ &= 1 \text{ W } \checkmark \end{aligned}$$

(4)

**[16]**

**QUESTION 3**

3.1

3.1.1 R: armature/coil(s) ✓

(3)

T: Carbon brushes ✓

X: Slip rings ✓

3.1.2 Faraday's Law ✓

(1)

3.2

3.2.1 115 V ✓

(1)

3.2.2

(4)

OPTION 1	OPTION 2
$V_{\text{rms}} = I_{\text{rms}} R$ $I_{\text{rms}} = \frac{15}{45} \checkmark$ $= 0,333 \text{ A}$ $I_{\text{rms}} = \frac{I_{\text{max}}}{\sqrt{2}}$ $I_{\text{max}} = (0,333) \sqrt{2} \checkmark = 0,47 \text{ A } \checkmark$	$V_{\text{rms}} = \frac{V_{\text{max}}}{\sqrt{2}}$ $V_{\text{max}} = (15) \sqrt{2} \checkmark$ $= 21,213 \text{ V}$ $V_{\text{max}} = I_{\text{max}} R$ $I_{\text{max}} = \frac{21,213}{45} \checkmark = 0,47 \text{ A } \checkmark$

**[9]**

## 8 Photoelectric Effect

### QUESTION 1

- 1.1 Threshold Frequency ✓ (1)  
 1.2 The minimum energy that an electron in a metal needs to be emitted from the metal surface. ✓ ✓ (2)  
 1.3

$$\begin{aligned} W_0 &= h \times f_0 \checkmark \\ &= 6,63 \times 10^{-34} \times 5 \times 10^{14} \checkmark \\ &= 3,315 \times 10^{-19} \text{ J } \checkmark \end{aligned}$$

(3)

- 1.4 POSITIVE MARKING FROM

#### OPTION 1

$$\begin{aligned} \text{Gradient} &= 6,63 \times 10^{-34} \checkmark = \frac{\Delta E}{\Delta f} = \frac{11 \times 10^{-19} - 0}{f_1 - 5 \times 10^{14}} \checkmark \checkmark \\ \therefore f_1 &= 2,16 \times 10^{15} \text{ Hz } \checkmark \end{aligned}$$

#### OPTION 2

$$\begin{aligned} E &= W_0 + E_{k(max)} \checkmark \\ 6,63 \times 10^{-34} \times f_1 \checkmark &= 3,315 \times 10^{-19} + 11 \times 10^{-19} \checkmark \\ \therefore f_1 &= 2,16 \times 10^{15} \text{ Hz } \checkmark \end{aligned}$$

(4)

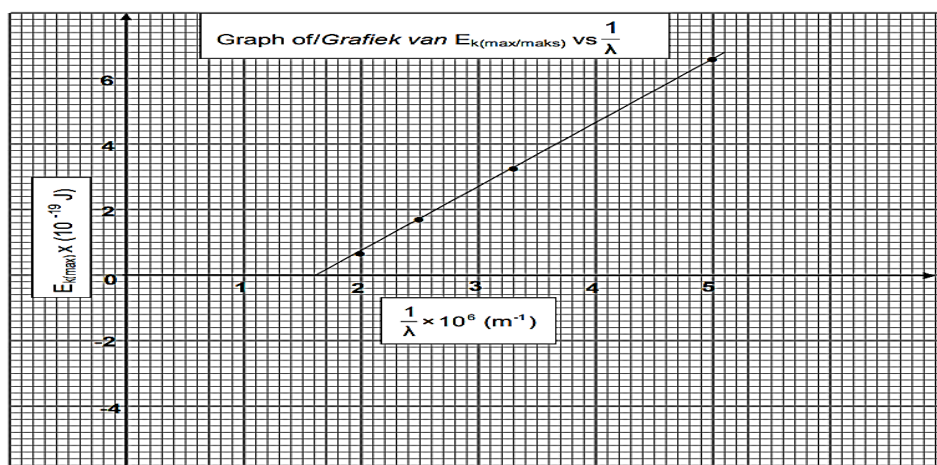
- 1.5 INCREASE ✓ (1)  
 [11]

### QUESTION 2

- 2.1 Is a process whereby electrons are ejected from a metal surface when light of suitable frequency is incident on that surface. ✓ ✓ (2)



2.2



(2)

2.3.1

**OPTION 1/OPSIE 1**

$$\frac{1}{\lambda} = 1,6 \times 10^6 \text{ m}^{-1} \checkmark$$

$$f_o = c \frac{1}{\lambda} \checkmark$$

$$= (3 \times 10^8)(1,6 \times 10^6) \checkmark$$

$$= 4,8 \times 10^{14} \text{ Hz} \checkmark \quad (\text{Accept/Aanvaar } 4,8 \times 10^{14} \text{ Hz to/tot } 5,1 \times 10^{14})$$

**OPTION 2/OPSIE 2**By extrapolation: y-intercept =  $-W_o$  / Deur ekstrapolasie : y-afsnit =  $-W_o$ 

$$W_o = hf_o \checkmark$$

$$3,2 \times 10^{-19} \checkmark = (6,63 \times 10^{-34})f_o \checkmark$$

$$f_o = 4,8 \times 10^{14} \text{ Hz} \checkmark \quad (\text{Accept/Aanvaar } 4,8 \times 10^{14} \text{ Hz to/tot } 4,83 \times 10^{14})$$

**OPTION 3/OPSIE 3** (Points from the graph/ Punte vanaf grafiek)

$$E = W_o + E_{k(\text{max})}$$

$$\frac{hc}{\lambda_o} = hf_o + E_{k(\text{max})} \checkmark$$

$$(6,63 \times 10^{-34})(3 \times 10^8)(1,6 \times 10^6) \checkmark = (6,63 \times 10^{-34})f_o + 0 \checkmark$$

$$f_o = 4,8 \times 10^{14} \text{ Hz} \checkmark$$

**OR/OF**

$$(6,63 \times 10^{-34})(3 \times 10^8)(5 \times 10^6) = (6,63 \times 10^{-34})f_o + 6,6 \times 10^{-19}$$

$$f_o = 4,92 \times 10^{14} \text{ Hz}$$

**OR/OF**

$$(6,63 \times 10^{-34})(3 \times 10^8)(3,3 \times 10^6) = (6,63 \times 10^{-34})f_o + 3,3 \times 10^{-19}$$

$$f_o = 4,8 \times 10^{14} \text{ Hz}$$

**OR/OF**

$$(6,63 \times 10^{-34})(3 \times 10^8)(2,5 \times 10^6) = (6,63 \times 10^{-34})f_o + 1,7 \times 10^{-19}$$

$$f_o = 4,94 \times 10^{14} \text{ Hz}$$

**OR/OF**

$$(6,63 \times 10^{-34})(3 \times 10^8)(2,2 \times 10^6) = (6,63 \times 10^{-34})f_o + 0,7 \times 10^{-19}$$

$$f_o = 5,54 \times 10^{14} \text{ Hz}$$

(4)

2.5

$$hc = \text{Gradient/ Helling} \checkmark$$

$$= \frac{\Delta y}{\Delta x}$$

$$= \frac{6,6 \times 10^{-19}}{(5 - 1,6) \times 10^6} \checkmark$$

$$= 1,941 \times 10^{-25} \text{ (J}\cdot\text{m)}$$

$$h = \frac{\text{gradient / helling}}{c}$$

$$h = \frac{1,941 \times 10^{-25}}{3 \times 10^8} \checkmark$$

$$= 6,47 \times 10^{-34} \text{ J}\cdot\text{s} \checkmark$$

(4)

(Points from the graph

(Punte vanaf grafiek)

$$\frac{hc}{\lambda} = W_0 + K_{\max} = 3,2 \times 10^{-19} \checkmark + 6,6 \times 10^{-19} \checkmark$$

$$h = \frac{9,8 \times 10^{-19}}{(3 \times 10^8)(5 \times 10^6)} \checkmark = 6,53 \times 10^{-34} \text{ J}\cdot\text{s}$$

**OR/OF**

$$\frac{hc}{\lambda} = W_0 + K_{\max} = 3,2 \times 10^{-19} \checkmark + 3,3 \times 10^{-19} \checkmark$$

$$h = \frac{6,5 \times 10^{-19}}{(3 \times 10^8)(3,3 \times 10^6)} \checkmark = 6,57 \times 10^{-34} \text{ J}\cdot\text{s}$$

**OR/OF**

$$\frac{hc}{\lambda} = W_0 + K_{\max} = 3,2 \times 10^{-19} \checkmark + 1,7 \times 10^{-19} \checkmark$$

$$h = \frac{4,7 \times 10^{-19}}{(3 \times 10^8)(2,5 \times 10^6)} \checkmark = 6,27 \times 10^{-34} \text{ J}\cdot\text{s}$$

**OR/OF**

$$\frac{hc}{\lambda} = W_0 + K_{\max} = 3,2 \times 10^{-19} \checkmark + 0,7 \times 10^{-19} \checkmark$$

$$h = \frac{3,9 \times 10^{-19}}{(3 \times 10^8)(2 \times 10^6)} \checkmark = 6,5 \times 10^{-34} \text{ J}\cdot\text{s}$$

[13  
]

### QUESTION 3

- 3.1 The minimum frequency of light needed to emit electrons from a certain metal surface  $\checkmark \checkmark$

(2)

$$\begin{aligned}
 3.2.1 \quad W_0 &= hf_0 \checkmark \\
 &= 6,63 \times 10^{-34} \times 5,1 \times 10^{14} \checkmark \\
 &= 3,38 \times 10^{-19} \text{ J } \checkmark
 \end{aligned}
 \tag{3}$$

$$\begin{aligned}
 3.2.2 \quad E &= h \frac{c}{\lambda} \checkmark \\
 &= \frac{6,63 \times 10^{-34} \times 3 \times 10^8}{400 \times 10^{-9}} \checkmark \\
 &= 4,97 \times 10^{-19} \text{ J } \checkmark
 \end{aligned}
 \tag{4}$$

$$\begin{aligned}
 3.2.3 \quad E &= h \frac{c}{\lambda} = W_0 + Ek_{\text{max/maks}} \checkmark \\
 4,97 \times 10^{-19} \checkmark &= 3,38 \times 10^{-19} + \\
 &Ek_{\text{max/maks}} \checkmark \\
 Ek_{\text{max/maks}} &= 1,59 \times 10^{-19} \text{ J } \checkmark
 \end{aligned}
 \tag{4}$$

- 3.3 An atom (electron) in higher (excited) energy state/level returns to a lower energy state/level.  $\checkmark$   
 Energy is released as light (photons/frequencies of light are released).  $\checkmark$

(2)

[15]

# 1 Nomenclature

## QUESTION 1

Consider the organic compounds **A** to **F** below.

1.1

1.1.1 E ✓ (1)

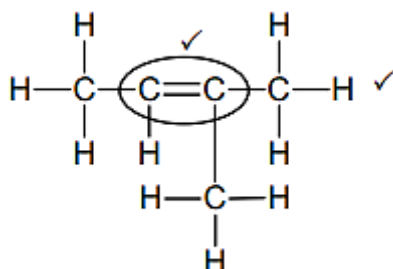
1.1.2 C ✓ (1)

1.1.3 D ✓ (1)

1.2

1.2.1 Pent-2 ✓-yne ✓ (2)

1.2.2 (2)



1.2.3 2-methylbut-1-ene  
OR  
3-methylbut-1-ene (3)

### Marking criteria

- Correct stem i.e. but-1-ene. ✓
- Only one type of substituent, methyl, correctly identified. ✓
- Entire name correct. ✓

1.3

1.3.1 Esters ✓ (1)

1.3.2 Sulphuric acid/H<sub>2</sub>SO<sub>4</sub> ✓ (1)

1.3.3 Methyl/ propanoate ✓ (2)

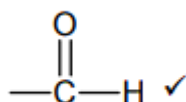
**[14]**

## QUESTION 2

2.1 A bond / an atom / a group of atoms ✓ that determine(s) the (physical and chemical) properties of a group of organic compounds. ✓ (2)

2.2

2.2.1 (1)

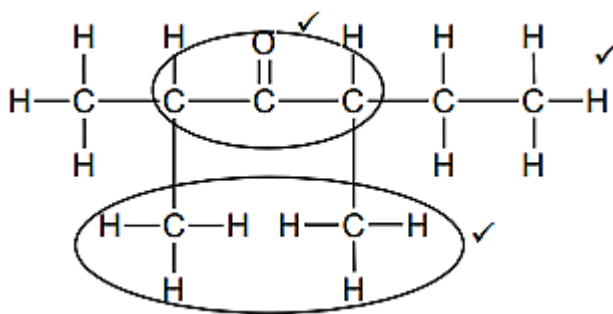


2.2.2 Carboxyl (group) ✓ (1)

2.3

2.3.1 Ketones ✓ (1)

2.3.2



(3)

2.4

2.4.1 5-bromo-4-ethyl-2,2-dimethylhexane

(3)

**Marking criteria**

- Correct stem i.e. hexane. ✓
- All substituent (bromo, ethyl and dimethyl) correctly identified. ✓
- IUPAC name completely correct including numbering, sequence, hyphens and commas. ✓

2.4.2

✓

4-methylpent-2-yne ✓

(2)

**[13]****QUESTION 3**

3.1

3.1.1 F ✓

(1)

3.1.2 B & F ✓

(1)

3.1.3 C ✓

(1)

3.2

3.2.1 Haloalkane / alkyl halide ✓

(1)

3.2.2 3,5-dibromooctane

(3)

**Marking criteria**

- Correct stem i.e. Octane. ✓
- dibromo. ✓
- Substituents (dibromo) correctly numbered, hyphens, commas correctly used. ✓

3.3

3.3.1 Pentan-3-one ✓✓

(2)

3.3.2 3-methylbutan-2-one✓

(2)

**OR**

3-methylbutanone✓

**OR**

methylbutanone✓

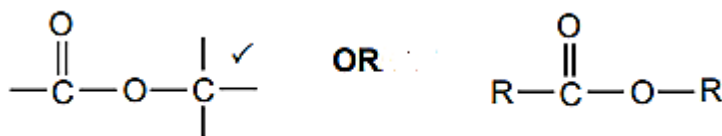
**OR**

3-methyl-2-butanone✓

3.4

3.4.1 Hexyl methanoate ✓ (2)

3.4.2 (1)

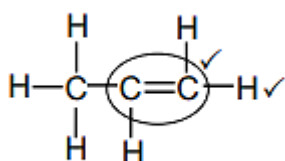


3.5

3.5.1 Cracking/Elimination ✓ (1)

3.5.2  $\text{C}_7\text{H}_{16}$  ✓✓ (2)

3.5.3 (2)



## 2 Physical Properties

### QUESTION 1

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

1.2 Functional group/Type of intermolecular forces/Homologous series✓ (1)

1.3 B✓ (1)

1.4 • Compound A/butan-1-ol has hydrogen bonding (dipole-dipole and London forces) between molecules. (4)

• Compound B/butan-2-one has dipole-dipole forces (and London forces) between molecules.

• Intermolecular forces in compound A/butan-1-ol are stronger than intermolecular forces in compound B/butan-2-one.

**OR**

• Intermolecular forces in compound B/butan-2-one are weaker than intermolecular forces in compound A/butan-1-ol.

• More energy is needed to overcome intermolecular forces in compound A/butan-ol than in compound B/butan-2-one.

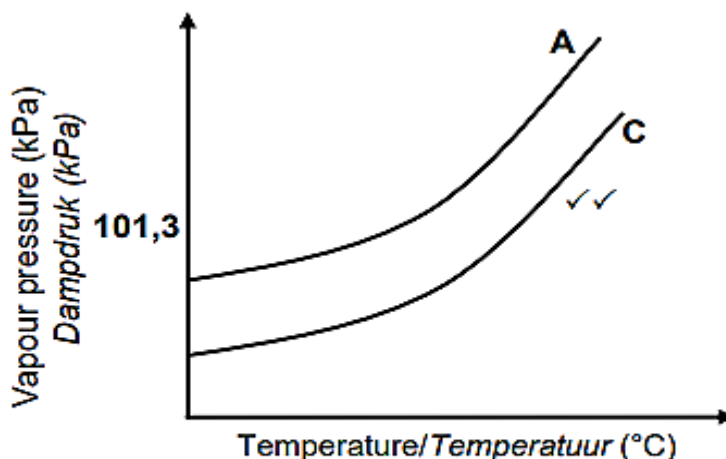
1.5

1.5.1 Boiling point (of compound A/butan-1-ol) ✓ (1)

1.5.2 Gas✓ (1)

1.5.3

(2)



[12]

### QUESTION 3

3.1 As the number of C atoms increases: (2)

- The surface area/chain length/molecular mass of the alcohols increases ✓
- The strength of London forces/induced dipole forces/dispersion forces increase. ✓

3.2 (3)

- Alcohols have both (London forces) and hydrogen bonds ✓
- Ketones have both (London forces) and dipole-dipole forces ✓
- Hydrogen bonds in the alcohols are stronger than the dipole-dipole forces in ketones ✓

3.3 To have one independent variable ✓ OR To have a fair test (1)

3.4 Ketone ✓ Lower boiling point ✓ (2)

3.5

3.5.1 Increases ✓ (1)

3.5.2 Q ✓ (2)

It is the temperature where the graph intercepts the dotted line. ✓

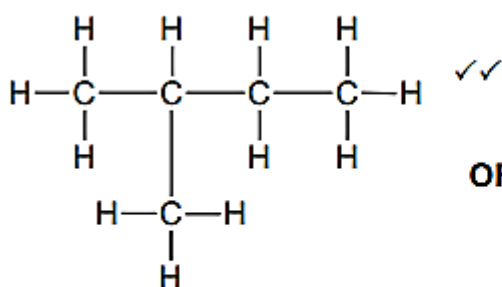
3.5.3 S ✓ (4)

- At a given temperature, S has the lowest vapour pressure/highest boiling point. ✓
- Strongest intermolecular forces/London forces/dispersion forces/induced dipole forces. ✓
- Highest energy needed to overcome/break the intermolecular forces. ✓

3.6

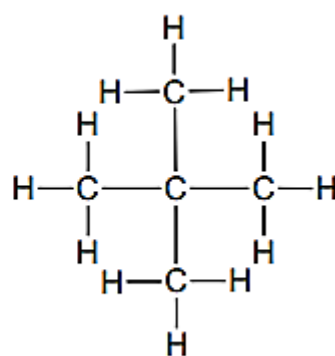
3.6.1

(3)



2-methylbutane ✓

OR



2,2-dimethylpropane ✓

3.6.2 Higher than ✓

(1)  
[19]

## 3 Organic Reactions

### QUESTION 1

1.1 Secondary ✓ (2)

The C atom bonded to the –OH group is bonded to TWO other C atoms. ✓

1.2

1.2.1 Dehydration ✓ (1)

1.2.2 Hydration ✓ (1)

1.2.3 Dehydrohalogenation/dehydrobromination ✓ (1)

1.3

1.3.1 Substitution/Hydrolysis ✓ (1)

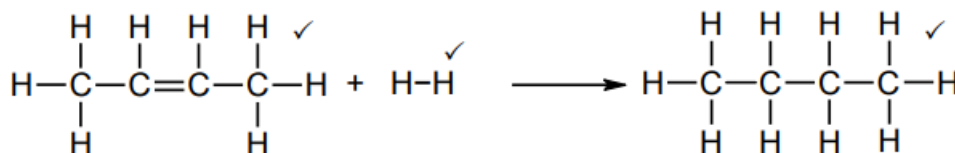
1.3.2 • Dilute base/sodium hydroxide/NaOH ✓ (2)

• Moderate temperature/(mild) heat ✓

1.3.3 2-✓bromobutane ✓ (2)

1.4 NaOH/KOH ✓ (1)

1.5 (3)



1.6 Butane ✓

(1)  
[15]

### QUESTION 2

1.1 Tertiary ✓

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

(2)



1.2

1.2.1 Concentrated strong base ✓

**OR**

Concentrated NaOH/KOH/LiOH/sodium hydroxide/ potassium hydroxide/ lithium hydroxide

**OR**

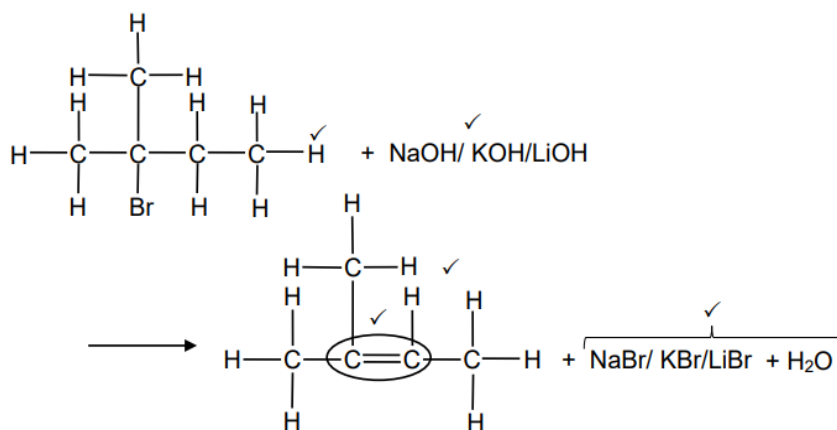
Strong base/NaOH/KOH/LiOH/sodium hydroxide/ potassium hydroxide/lithium hydroxide in ethanol.

(1)

1.2.2 Elimination/dehydrohalogenation/dehydrobromination ✓

(1)

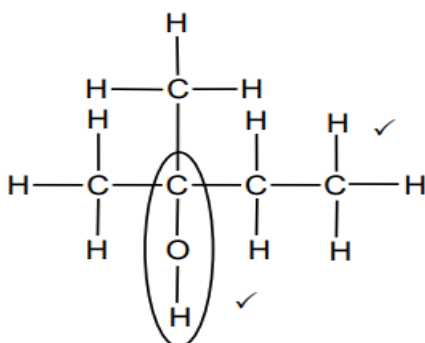
1.2.3



(5)

1.3

1.3.1



(2)

1.3.2 Water/H<sub>2</sub>O ✓

(1)

1.3.3 Hydration ✓

(1)

1.4

1.4.1 Substitution/Hydrolysis ✓

(1)

1.4.2 Dilute strong base ✓

**OR:**

Dilute NaOH/KOH/LiOH/sodium hydroxide/potassium hydroxide/lithium hydroxide

**OR:**

NaOH(aq)/KOH(aq)/LiOH(aq) OR: (Add) water/H<sub>2</sub>O

(1)

**[15]**

### QUESTION 3

3.1.1 Heat/sunlight/ultraviolet light/radiation/light ✓

(1)

3.1.2 HBr/hydrogen bromide ✓

(1)

- 3.1.3 Hydrolysis✓ (1)
- 3.1.4 H<sub>2</sub>O/water✓ (1)
- OR
- NaOH/KOH/LiOH/sodium hydroxide/potassium hydroxide/lithium hydroxide
- 3.1.5 2-bromo✓propane ✓ (2)
- 3.2 + NaOH (in ethanol/etanol) ✓ (8)
- CH<sub>3</sub>CH<sub>2</sub>Cl + (conc/gekons) NaOH ✓  $\xrightarrow{\Delta}$  CH<sub>2</sub>CH<sub>2</sub> ✓ + NaCl ✓ + H<sub>2</sub>O ✓
- CH<sub>2</sub>CH<sub>2</sub> + H<sub>2</sub> ✓  $\xrightarrow{\text{Pt}}$  CH<sub>3</sub>CH<sub>3</sub> ✓

[14]

## 4 Rates of Reactions

### QUESTION 1

- 1.1 Rate of the reaction/ volume of gas (formed) per unit time ✓ (1)
- 1.2 Average rate =  $\frac{\Delta V}{\Delta t}$  ✓
- =  $\frac{60 - 0}{30 - 0}$  ✓
- = 2,0 cm<sup>3</sup>·s<sup>-1</sup> ✓ (3)
- 1.3 Less than ✓
- Smaller gradient at 50 s/ change in volume per unit time is less/ rate of change in volume is less. ✓ (2)
- 1.4 Increase ✓ (1)
- 1.5 Increase in surface area causes more number of collisions✓. The number of effective collisions per second will increase✓, resulting in an increase in the rate of reaction. ✓ (3)
- 1.6 **OPTION 1**
- $n(\text{Mg}) = \frac{m}{M}$
- =  $\frac{20}{24}$  ✓
- = 0,833 mol/ mol
- $n(\text{H}_2\text{SO}_4) = c \times V$
- = 1 x 0,1 ✓
- = 0,1 mol
- Mole ratio → Mg : H<sub>2</sub>SO<sub>4</sub> → 1 : 1 (equation)
- 0,1 : 0,1 ✓
- $n(\text{Mg}) \text{ left} = 0,833 - 0,1 = 0,733$  ✓

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

$$0,733 = \frac{m}{24}$$

$$m(\text{Mg}) = 17,59 \text{ g} \checkmark$$

## QUESTION 2

2.1 The change in concentration/number of moles/mass✓ of reactants or products per unit time. ✓ (2)

2.2 100 (s) ✓ (1)

2.3 Higher than ✓ (1)

Initially the concentration of the acid is high. /Initially there are more particles per unit volume. ✓ (2)

More effective collisions per unit time. ✓

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

$$0.1 = \frac{n}{0.15} \checkmark$$

$$n = 0.15 \text{ mol} \checkmark$$

$$n(\text{CO}_2) = n(\text{H}_2\text{SO}_4) = 0.15 \text{ mol}$$

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

$$0.15 = \frac{V}{22,4} \checkmark$$

$$V = 0.34 \text{ dm}^3 \checkmark$$

(5)

2.5 Lower temperature✓

Na<sub>2</sub>CO<sub>3</sub> chunks✓

(2)

[13]

## QUESTION 3

3.1.1 Temperature ✓✓ (2)

3.1.2 At higher temperature a bigger fraction of the molecules/more molecules✓ move faster/have more kinetic energy✓, leading to more effective collisions. ✓

(4)

3.2.1 He added a catalyst. ✓✓

(2)

3.2.2 P: ΔH, heat of reaction/ change in enthalpy/ΔH,✓

Q: activation energy ✓

(2)

[9]

## 5 Chemical Equilibrium

### QUESTION 1

1.1. Low. ✓  $K_c$  is smaller than 1 ✓ (2)

1.2

Initial quantity (mol)	2	2	0
Change (mol)	$x$ ✓	$x$	$2x$ ✓
Quantity at equilibrium (mol)	$2-x$	$2-x$	$2x$ ✓
Equilibrium concentration (mol.dm <sup>-3</sup> )	$\frac{2-x}{5}$	$\frac{2-x}{5}$	$\frac{2x}{5}$ ✓

$$K_c = \frac{[NO]^2}{[N_2][O_2]} \checkmark$$

$$1,2 \times 10^{-4} = \frac{\left(\frac{2x}{5}\right)^2}{\left(\frac{2-x}{5}\right)\left(\frac{2-x}{5}\right)} \checkmark$$

$$x = 0.0109 \text{ mol}$$

$$[NO] = \frac{2(0.0109)}{5}$$

$$= 4,36 \times 10^{-3} \text{ mol.dm}^{-3} \checkmark$$

(8)

1.3.1 Remains the same ✓

(1)

1.3.2 Remains the same ✓

(1)

1.4 Endothermic ✓

$K_c$  increases, therefore forward reaction was favoured. ✓

Temperature increase will favour endothermic reaction. ✓

Therefore, forward reaction is endothermic

(3)

[15]

### QUESTION 2

2.1. Reaction in which products can be converted back to reactants ✓ ✓ (2)

2.2 FORWARD REACTION ✓ (1)

2.3 No. ✓ The rate of forward reaction is equal to the rate of reverse reaction ✓ (2)

- 2.4.1 Increases✓ (1)  
 2.4.2 Remains the same✓ (1)  
 2.4.3 Increases✓ (1)  
 2.4 The amount of HI remains constant. ✓ The volume decreases. The concentration increases according to  $c = \frac{n}{V}$ ✓ (2)  
 2.5.1 High yield. ✓  $K_c > 1$ ✓✓ (3)  
 2.5.2 EXOTHERMIC. ✓  
 The value  $K_c$  decreases with an increase in temperature. ✓  
 As temperature increases, the concentration of products decreases ✓  
 Reverse reaction is favoured by an increase in temperature✓ (4)

2.6

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

$$50,3 \checkmark = \frac{[HI]^2}{(0,46)(0,39)} \checkmark$$

$$[HI] = 3 \text{ mol.dm}^{-3} \checkmark$$

(4)  
[22]

### QUESTION 3

- 3.1. A reaction where products can be changed back to reactants. ✓✓ (2)

3.2

	SO <sub>3</sub>	SO <sub>2</sub>	O <sub>2</sub>	
Initial quantity (mol) <i>Aanvangshoeveelheid (mol)</i>	12	0	0	
Change (mol) <i>Verandering (mol)</i>	10	10	5 ✓	Ratio ✓ <i>Verhouding</i>
Quantity at equilibrium (mol)/ <i>Hoeveelheid by ewewig (mol)</i>	2	10	5	
Equilibrium concentration (mol·dm <sup>-3</sup> ) <i>Ewewigkonsentrasie (mol·dm<sup>-3</sup>)</i>	1	5	2,5	Dividing by 2 ✓ <i>Gedeel deur 2</i>

$$K_c = \frac{[SO_2]^2[O_2]}{[SO_3]} \checkmark$$

$$= \frac{(5)^2(2,5)}{(1)^2} \checkmark$$

$$= 62,5 \checkmark$$

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)

- 3.3.1 O<sub>2</sub>(g) + 2SO<sub>2</sub>(g) → 2SO<sub>3</sub>(g) ✓ (1)  
 3.3.2 Decrease in concentration (of SO<sub>3</sub>). ✓ (1)  
 3.3.3 Temperature increases. ✓  
  - At t = 4 minutes, the rate of both the forward and reverse reaction increases. ✓
  - The rate of the forward endothermic reaction increases more. / The forward endothermic reaction is favoured. ✓
  - Increase in temperature favours an endothermic reaction. ✓ (1)
 3.3.4 Greater than ✓ (1)

3.3.5

- At  $t = 4$  minutes, the temperature was increased, and the forward reaction was favoured. /Increase in temperature favours the forward endothermic reaction. ✓
- Concentration of products increases and concentration of reactants decreases. ✓

(2)  
[18]

## 6 Acids and Bases

### QUESTION 1

- 1.1 Titration/Volumetric analysis ✓ (1)
- 1.2 To measure the (exact) volume of acid needed to reach endpoint/to neutralise the base. ✓ (1)
- 1.3 Acids produce hydrogen ions ( $H^+$ )/hydronium ions ( $H_3O^+$ ) in solution/when dissolved in water. ✓✓ (2)
- 1.4  $H_2SO_4$  ionises completely ✓ (1)
- 1.5 Blue to yellow ✓ (1)

1.6

#### Marking guidelines/Nasienriglyne:

- Formula/Formule:  $c = \frac{n}{V} / n = cV / \frac{c_a \times V_a}{c_b \times V_b} = \frac{n_a}{n_b}$  ✓
- Substitution of/Vervanging van:  $(0,1)(25)/(0,1)(0,025)$  ✓
- Use mol ratio/Gebruik molverhouding:  $n_a : n_b = 1 : 2$  ✓
- Final answer/Finale antwoord:  $12,5 \text{ cm}^3 / 0,0125 \text{ dm}^3$  ✓

(4)

#### OPTION 1/OPSIE 1

$$\frac{c_a V_a}{c_b V_b} = \frac{n_a}{n_b} \quad \checkmark$$

$$\frac{(0,1) V_a}{(0,1)(25)} = \frac{1}{2} \quad \checkmark$$

$$\therefore V_a = 12,5 \text{ cm}^3 \quad \checkmark$$

#### OPTION 2/OPSIE 2

$$c_b = \frac{n}{V} \quad \checkmark$$

$$0,1 = \frac{n}{0,025} \quad \checkmark$$

$$n_b = 2,5 \times 10^{-3} \text{ mol}$$

$$n_a = \frac{1}{2} n_b = \frac{1}{2} (2,5 \times 10^{-3}) \quad \checkmark$$

$$= 1,25 \times 10^{-3} \text{ mol}$$

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

$$0,1 = \frac{1,25 \times 10^{-3}}{V}$$

$$\therefore V_a = 0,0125 \text{ dm}^3 / 12,5 \text{ cm}^3 \quad \checkmark$$

1.7

<b>Marking guidelines/Nasiënriglyne:</b> <ul style="list-style-type: none"> <li>Formula/Formule: <math>c = \frac{n}{V}</math> ✓</li> <li>Substitution of/Vervanging van: <math>(0,1)(0,005)/0,0175</math> in <math>n = cV</math> ✓</li> <li>Substitute/Vervang <math>V = 0,0425 \text{ dm}^3</math> ✓</li> <li>Use/Gebruik <math>[\text{H}_3\text{O}^+] : [\text{H}_2\text{SO}_4] = 2 : 1</math> ✓</li> <li>Formula/Formule: <math>\text{pH} = -\log[\text{H}_3\text{O}^+]</math> ✓</li> <li>Substitute/Vervang <math>[\text{H}^+]</math> ✓</li> <li>Final answer/Finale antwoord: 1,63 ✓</li> </ul>		(7)
<b>OPTION 1/OPSIE 1</b> $n_{\text{a(excess/oormaat)}} = cV$ ✓ $= (0,1)(0,005)$ ✓ $= 5 \times 10^{-4} \text{ mol}$ $c_{\text{a}} = \frac{n}{V}$ $= \frac{5 \times 10^{-4}}{4,25 \times 10^{-2}}$ ✓ $= 1,18 \times 10^{-2} \text{ mol} \cdot \text{dm}^{-3}$ $c(\text{H}^+) = 2c_{\text{a}}$ $= 2(1,18 \times 10^{-2})$ ✓ $= 2,36 \times 10^{-2} \text{ mol} \cdot \text{dm}^{-3}$ $\text{pH} = -\log[\text{H}_3\text{O}^+]$ ✓ $= -\log(2,36 \times 10^{-2})$ ✓ $= 1,63$ ✓	<b>OPTION 2/OPSIE 2</b> $n_{\text{a(final/finaal)}} = cV$ ✓ $= (0,1)(0,0175)$ ✓ $= 1,75 \times 10^{-3} \text{ mol}$ $n_{\text{a(exs/oor)}} = n_{\text{a(final/finaal)}} - n_{\text{a(react/reageer)}}$ $= 1,75 \times 10^{-3} - 1,25 \times 10^{-3}$ $= 5 \times 10^{-4} \text{ mol}$ $c_{\text{a}} = \frac{n}{V}$ $= \frac{5 \times 10^{-4}}{4,25 \times 10^{-2}}$ ✓ $= 1,18 \times 10^{-2} \text{ mol} \cdot \text{dm}^{-3}$ $c(\text{H}^+) = 2c_{\text{a}}$ $= 2(1,18 \times 10^{-2})$ ✓ $= 2,36 \times 10^{-2} \text{ mol} \cdot \text{dm}^{-3}$ $\text{pH} = -\log[\text{H}_3\text{O}^+]$ ✓ $= -\log(2,36 \times 10^{-2})$ ✓ $= 1,63$ ✓	

[17]

**QUESTION 2**

2.1 Standard solution ✓

2.2

(1)

2.2.1

(4)

**Marking criteria/Nasienkriteria:**

- Any one of the formulae/*Enige een van die formules*:  $c = \frac{m}{MV}$  /  $n = \frac{m}{M}$  /  $c = \frac{n}{V}$  ✓
- Substitution of  $40 \text{ g} \cdot \text{mol}^{-1}$  into correct formula. ✓  
*Vervanging van  $40 \text{ g} \cdot \text{mol}^{-1}$  in korrekte formule.*
- Substitution of  $0,25 \text{ dm}^3$  into correct formula. ✓  
*Vervanging van  $0,25 \text{ dm}^3$  in korrekte formule.*
- Final answer/*Finale antwoord*:  $0,2 \text{ mol} \cdot \text{dm}^{-3}$  ✓

**OPTION 1/OPSIE 1**

$$c = \frac{m}{MV} \checkmark$$

$$= \frac{2}{\sqrt{40 \times 0,25}} \checkmark$$

$$= 0,20 \text{ mol} \cdot \text{dm}^{-3} \checkmark$$

**OPTION 2/OPSIE 2**

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

$$= \frac{2}{40} \checkmark$$

$$= 0,05 \text{ mol} \checkmark$$

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

$$= \frac{0,05}{0,25} \checkmark$$

$$= 0,20 \text{ mol} \cdot \text{dm}^{-3} \checkmark$$

Any one formula/  
*enige formule* ✓

2.2.2

(4)

**OPTION 1/OPSIE 1**

$$[\text{H}_3\text{O}^+][\text{OH}^-] = 1 \times 10^{-14}$$

$$[\text{H}_3\text{O}^+](0,2) = 1 \times 10^{-14} \checkmark$$

$$[\text{H}_3\text{O}^+] = 5 \times 10^{-14} \text{ mol} \cdot \text{dm}^{-3}$$

$$\downarrow$$

$$\text{pH} = -\log[\text{H}_3\text{O}^+] \checkmark$$

$$= -\log(5 \times 10^{-14}) \checkmark$$

$$= 13,30 \checkmark$$

**OPTION 2/OPSIE 2**

$$\text{pOH} = -\log[\text{OH}^-] \checkmark$$

$$= -\log(0,2) \checkmark$$

$$= 0,6989 \quad (0,7)$$

$$\downarrow$$

$$\text{pH} + \text{pOH} = 14$$

$$\text{pH} = 14 - 0,6989 \checkmark$$

$$= 13,30 \checkmark$$



2.3

OPTION 1/OPSIE 1	OPTION 2/OPSIE 2
$n(\text{NaOH})_{\text{used/gebruik}} = c_b V_b$ $= 0,2 \times 0,025 \checkmark$ $= 5 \times 10^{-3} \text{ mol}$	$n(\text{NaOH})_{\text{used/gebruik}} = \frac{25}{250} \times \frac{2}{40} \checkmark$ $= 5 \times 10^{-3} \text{ mol}$
$n(\text{HCl})_{\text{excess/oormaat}} = n(\text{NaOH}) = 5 \times 10^{-3} \text{ mol} \checkmark$	
$n(\text{CaCO}_3) = \frac{m}{M}$ $= \frac{1,5}{100} \checkmark$ $= 0,015 \text{ mol} \quad (0,02 \text{ mol})$	
$n(\text{HCl})_{\text{reacted/reageer}} = 2n(\text{CaCO}_3) = 0,03 \text{ mol} \checkmark \quad (0,04 \text{ mol})$	
$n(\text{HCl})_{\text{ini/aanv.}} = 5 \times 10^{-3} + 0,03 \checkmark \checkmark$ $= 0,035 \text{ mol} \quad (0,045 \text{ mol})$	
$c(\text{HCl})_{\text{ini/aanv}} = \frac{n}{V}$ $= \frac{0,035}{0,05} \checkmark$ $= 0,70 \text{ mol} \cdot \text{dm}^{-3} \checkmark \quad (0,90 \text{ mol} \cdot \text{dm}^{-3})$	

(8)

[17]

**QUESTION 3**

3.1.1 It is a proton donator ✓✓ (2)

3.1.2 An acid that donates ONLY one proton per molecule. ✓ ✓ (2)3.1.3 Strong acid ✓  
It completely ionises in water ✓ (2)

3.2

3.2.1 (3)

$$[\text{H}_3\text{O}^+][\text{OH}^-] = K_w = 1 \times 10^{-14} \checkmark$$

$$[\text{H}_3\text{O}^+](1 \times 10^{-11}) \checkmark = 1 \times 10^{-14}$$

$$[\text{H}_3\text{O}^+] = 1 \times 10^{-3} \text{ mol} \cdot \text{dm}^{-3} \checkmark$$

3.2.2 (3)

$$\text{pH} = -\log [\text{H}_3\text{O}^+] \checkmark$$

$$\text{pH} = -\log (10^{-3}) \checkmark$$

$$\text{pH} = 3 \checkmark$$

3.3

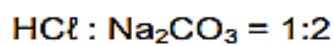
3.3.1  $\text{CO}_3^{2-}(\text{aq}) + \text{H}_2\text{O}(\text{aq}) \checkmark = \text{HCO}_3^-(\text{aq}) + \text{OH}^-(\text{aq}) \checkmark$  bal ✓ (3)3.3.2  $\text{HCO}_3^- \checkmark$  (1)

3.4

$$n = \frac{m}{M} \checkmark \quad (6)$$

$$= \frac{4,24}{106} \checkmark$$

$$= 0,04 \text{ mol}$$



Thus  $n(\text{HCl}) = 2(0,04) = 0,08 \text{ mol} \checkmark$

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

$$= \frac{0,08}{0,25} \checkmark$$

$$= 0,32 \text{ mol} \cdot \text{dm}^{-3} \checkmark$$

OR

$$\frac{C_a V_a}{C_b V_b} = \frac{n_a}{n_b} \checkmark$$

$$\checkmark \frac{c_a (0,25)}{(0,04)} = \frac{2}{1} \checkmark$$

$$C_a (0,25) \checkmark = 0,08 \text{ mol} \cdot \text{dm}^{-3} \checkmark$$

$$C_a = 0,32 \text{ mol} \cdot \text{dm}^{-3} \checkmark$$

[17]