NATIONAL SENIOR CERTIFICATE

**GRADE 12**

PHYSICAL SCIENCES: PHYSICS (P1)

SEPTEMBER 2022

MARKING GUIDELINES

**MARKS: 150**

**This marking guidelines consist of 15 pages.**

**QUESTION 1**

1.1    B ✓✓                                                                                      (2)

1.2    A ✓✓                                                                                      (2)

1.3    C ✓✓                                                                                      (2)

1.4    A ✓✓                                                                                      (2)
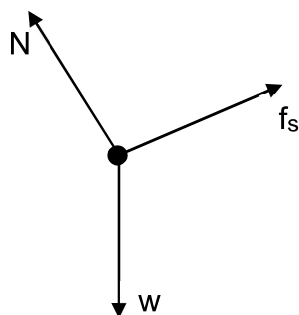
1.5    B ✓✓                                                                                      (2)

1.6    D ✓✓                                                                                      (2)

1.7    D ✓✓                                                                                      (2)

1.8    A ✓✓                                                                                      (2)

1.9    C ✓✓                                                                                      (2)

1.10   A ✓✓                                                                                      (2)

**[20]**

**QUESTION 2**

2.1.1   The force that opposes the tendency of motion of a stationary object relative to a surface. ✓✓                                                                                       (2)

2.1.2



| | **Accept the following symbols:** |
|---|---|
| N✓ | $F_N$/Normal force/$F_{surface\ on\ crate}$ |
| $f_s$✓ | $f$/$F_f$/frictional force/static frictional force |
| w✓ | $F_g$/mg/weight/gravitational force/$F_{Earth\ on\ crate}$ |

Take uphill as POSITIVE

**Notes:**
- Mark is awarded for label and arrow.
- Do not penalize for length of arrows
- Deduct 1 mark for any additional force.
- If force(s) do not make contact with dot/body: 2/3
- If arrows missing: 2/3                                                                                       (3)

2.1.3

$F_{net} = ma$

$\therefore f_s^{max} + (-mg\sin\theta) = ma^{max}$    Any one ✓

$\mu_s F_N - mg\sin\theta = ma^{max}$

$\mu_s\ mg\cos\theta - mg\sin\theta = ma^{max}$

$\therefore f_s^{max} - m(9,8)(\sin 10°) = ma^{max}$ .....①

But $f_s^{max} = \mu_s N$

$\therefore f_s^{max} = \mu_s(mg\cos\theta)$....②

Subst. ② into ① :

$\therefore \mu_s(mg\cos\theta) - m(9,8)(\sin 10°) = m(a^{max})$

$\therefore (0,35)\,m(9,8)(\cos 10°)✓ -m(9,8)(\sin 10°) = m(a^{max})$

$(\div m) : \therefore (0,35)(9,8)(\cos 10°)✓ - (9,8)(\sin 10°)✓ = a^{max}$

$\therefore$ the maximum acceleration is 1,676 m·s$^{-2}$ ✓

                                                                                       (5)

2.2.1

| Marking criteria |
| --- |
| -1 mark for each key word/phrase omitted in the correct context. |

Each body in the universe attracts every other body with a (gravitational) <u>force</u> that is <u>directly proportional to the product of their masses</u> and <u>inversely proportional to the square of the distance between their centers.</u> ✓✓
**OR:**
Every particle in the universe attracts every other particle with a (gravitational) <u>force</u> that is <u>directly proportional to the product of their masses</u> and <u>inversely proportional to the square of the distance between them.</u> ✓✓                    (2)

2.2.2

$$g_E = \frac{GM_E}{R_E^2} = 9,8 \text{ m}\cdot\text{s}^{-2}$$

$$g_M = \frac{GM_M}{R_M^2} \checkmark$$

$$= \frac{G\left(\frac{M_E}{153}\right)}{\left(\frac{R_E}{5}\right)^2} \checkmark$$

$$= \frac{25}{153} \frac{GM_E}{R_E^2}$$

$$= \frac{25}{153} (9,8)$$

$$= 1,60 \quad \text{m}\cdot\text{s}^{-2} \quad \checkmark$$

(downwards)                    (3)

2.2.3  Equal to ✓                    (1)

**[16]**

**QUESTION 3**

3.1  Motion during which the only force acting on an object is the gravitational force.✓✓  (2)

3.2
   **OPTION 1:**
   **UPWARDS POSITIVE:**

| **For stone X:** | **For stone Y:** |
|---|---|
| $\Delta y = v_i \Delta t + \frac{1}{2}a(\Delta t)^2$ ✓ | $\Delta y = v_i \Delta t + \frac{1}{2}a(\Delta t)^2$ |
| $0 = (3v)(10) + \frac{1}{2}(-9,8)(10)^2$✓ | $0 = \left(\frac{49}{3}\right)\Delta t + \frac{1}{2}(-9,8)(\Delta t)^2$ ✓ |
| $0 = 30v - 490$ | $0 = \Delta t\left(\frac{49}{3} - 4,9\Delta t\right)$ |
| $490 = 30v$ | $\Delta t = 0$ s or $\Delta t = 3,333$ s |
| $v = \left(\frac{49}{3}\right)$ m⬜s⁻¹ → $v = \left(\frac{49}{3}\right)\,\text{m}\,\text{s}^{-1}$ | $\Delta t = 3,33$ s (3,333 s) ✓ |

(4)

   **DOWNWARDS POSITIVE:**

| **For stone X:** | **For stone Y:** |
|---|---|
| $\Delta y = v_i \Delta t + \frac{1}{2}a(\Delta t)^2$ ✓ | $\Delta y = v_i \Delta t + \frac{1}{2}a(\Delta t)^2$ |
| $0 = (3v)(10) + \frac{1}{2}(9,8)(10)^2$✓ | $0 = \left(-\frac{49}{3}\right)\Delta t + \frac{1}{2}(9,8)(\Delta t)^2$ ✓ |
| $0 = 30⬜v + 490$ | $0 = \Delta t\left(-\frac{49}{3} + 4,9⬜\Delta t\right)$ |
| $-490 = 30⬜v$ | $\Delta t = 0$ s or $\Delta t = 3,333$ s |
| $v = \left(-\frac{49}{3}\right)\,\text{m}⬜\text{s}^{-1}$ | $\Delta t = 3,33$ s (3,333 s) ✓ |

| **OPTION 2:** <br> **UPWARDS POSITIVE:** <br><br> **For stone X:** <br> Consider upward motion: <br> $v_f = v_i + a\Delta t$✓ <br> $\underline{0 = v_i + (-9,8)(5)}$✓ <br> $v_i = 49$ m⬜s⁻¹ | **For stone Y:** <br> $v_{B_i} = \frac{49}{3}$ m⬜s⁻¹ or 16.333 m⬜s⁻¹ <br> Consider upward motion: <br> $v_f = v_i + a\Delta t$ <br> $\underline{0 = 16,333 + (9,8)\Delta t}$✓ <br> $\Delta t = 1,666(1,67\text{ s})$ <br> $\Delta t(\text{total}) = 2 \times 1,666 = 3,33$ s |

**DOWNWARDS POSITIVE:**

| **For stone X:** | **For stone Y:** |
|---|---|
| Consider upward motion: | $v_{B_i}$ = -$\frac{49}{3}$ m□s⁻¹ or -16.333 m□s⁻¹ |
| $v_f = v_i + a\Delta t$✓ | Consider upward motion: |
| $\underline{0 = v_i + (9,8)(5)}$✓ | $v_f = v_i + a\Delta t$ |
| $v_i$ = -49 m□s⁻¹ | $\underline{0 = -16,333 + (9,8)\Delta t}$✓ |
|  | $\Delta t$ = 1,666(1,67 s) |
|  | $\Delta t$(total) = 2 x 1,666 = 3,33 s |

3.3  **POSITIVE MARKING FROM QUESTION 3.2:**

**OPTION 1:**
**UPWARDS POSITIVE:**

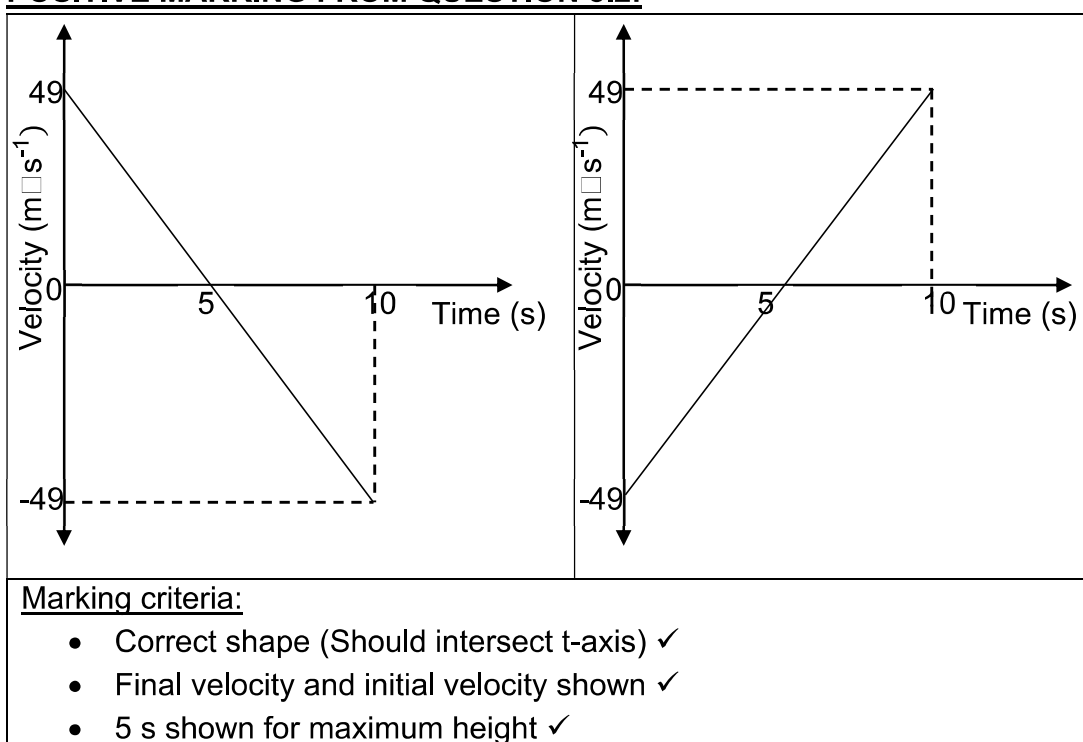| **For stone Y** | **For stone X** |
|---|---|
| $\Delta y = v_i \Delta t + \frac{1}{2}a(\Delta t)^2$ ✓ | $\Delta y = v_i \Delta t + \frac{1}{2}a(\Delta t)^2$ |
| H = $\left(\frac{49}{3}\right)\left(\frac{5}{3}\right) + \frac{1}{2}(-9,8)\left(\frac{5}{3}\right)^2$ ✓ | = $\underline{(49)(5)}$ ✓ + $\frac{1}{2}(-9,8)(5)^2$✓ |
| H = $\left(\frac{245}{18}\right)$m | = $\frac{245}{2}$ = 9$\left(\frac{245}{18}\right)$✓   = 9H |

**DOWNWARDS POSITIVE:**

| **For stone Y** | **For stone X** |
|---|---|
| $\Delta y = v_i \Delta t + \frac{1}{2}a(\Delta t)^2$ ✓ | $\Delta y = v_i \Delta t + \frac{1}{2}a(\Delta t)^2$ |
| H = $\left(-\frac{49}{3}\right)\left(\frac{5}{3}\right) + \frac{1}{2}(9,8)\left(\frac{5}{3}\right)^2$ ✓ | = $\underline{(-49)(5)}$ ✓ + $\frac{1}{2}(9,8)(5)^2$✓ |
| H = $\left(-\frac{245}{18}\right)$m | = -$\frac{245}{2}$ = 9$\left(-\frac{245}{18}\right)$✓   = 9H |

| **OPTION 2:**<br>**UPWARDS POSITIVE:**<br><br>**For stone Y**<br>$\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$✓<br>    = (49)(5) ✓ + $\frac{1}{2}$ (-9,8)(5)²✓<br>    = 122,5 m | **For stone X**<br>$\Delta y = v_i\Delta t + \frac{1}{2}$ a□t²<br>    = (16.333)(1,666) + $\frac{1}{2}$ (9,8)(1,666)²✓<br>    =  13,61 m = H<br>13,61 X 9 = 122,49 m = 9H(122,5 m)✓ |
|---|---|

| DOWNWARDS POSITIVE:<br><br>**For stone Y**<br><br>$\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ✓<br><br>$= (-49)(5)$ ✓ $+ \frac{1}{2}(9,8)(5)^2$ ✓<br><br>$= -122,5$ m | **For stone X**<br><br>$\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$<br><br>$= (-16.333)(1,666) + \frac{1}{2}(9,8)(1,666)^2$ ✓<br><br>$= -13,61$ m $= H$<br><br>$-13,61 \times 9 = -122,49$ m $= 9H(122,5$ m$)$ ✓ |
|---|---|

(5)

3.4 **POSITIVE MARKING FROM QUESTION 3.2:**



Marking criteria:
  - Correct shape (Should intersect t-axis) ✓
  - Final velocity and initial velocity shown ✓
  - 5 s shown for maximum height ✓

(3)

**[14]**

## QUESTION 4

4.1 The product of an object's mass and its velocity. ✓✓ **(2 or 0)**   (2)

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

4.3

| OPTION 1 | OPTION 2 |
|---|---|
| $\sum p_i = \sum p_f$      ⎤ Any one✓ <br> $m_A v_{A_i} + m_B v_{B_i} = m_A v_{A_f} + m_B v_{B_f}$ ⎦ <br> $\underline{m_A(4) + m_B(-1)}$ ✓ $= \underline{m_A(1) + m_B(3)}$✓ <br> $4m_A - m_A = 3m_B + m_B$ <br> $\underline{3m_A = 4m_B}$ ✓ <br> $\dfrac{m_A}{m_B} = \dfrac{4}{3}$ <br> $m_A : m_B = 4:3$ | $\Delta p_A = -\Delta p_B$      ⎤ Any one✓ <br> $m_A\left(v_{A_f} - v_{A_i}\right) = m_B\left(v_{B_f} - v_{B_i}\right)$ ⎦ <br> $\underline{m_A(1-4)}$ ✓ $= \underline{-m_A(3-(-1))}$ ✓ <br> $m_A(-3) = -m_B(4)$ <br> $\underline{m_A(-3) = m_B(4)}$ ✓ <br> $\dfrac{m_A}{m_B} = \dfrac{-4}{-3} = \dfrac{4}{3}$ <br> $m_A : m_B = 4:3$ |

| **Marking criteria:** |
|---|
| •   Formula <br><br> •   Right hand substitution into formula <br><br> •   Left hand substitution into formula <br><br> •   This step: $m_A(-3) = m_B(4)$ |

(4)

4.4
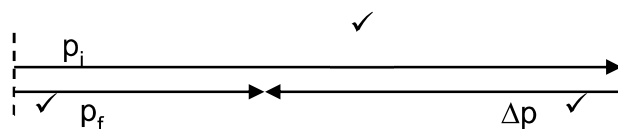


(3)

| Criteria | mark |
|---|---|
| •   Large initial momentum in the same direction as final momentum | ✓ |
| •   Small final momentum in the same direction as initial momentum | ✓ |
| •   Change in momentum in the opposite direction | ✓ |

**[11]**

**QUESTION 5**

5.1   The net work done on an object is equal to the change in the object's kinetic energy. ✓✓

**OR:**

The work done on an object by the net force is equal to the change in the object's kinetic energy. ✓✓                    (2)

**OPTION 1:**

5.2

$W_{net} = \Delta E_K$ OR $W_f + W_w + W_N = \Delta E_K$ } Any one✓

$f\Delta x\Box\cos\theta + mg\Delta x(\cos\theta) + 0 = \frac{1}{2}m(v_f^2 - v_i^2)$

$\underline{(45)(\Delta x)(\cos 180°) + (10)(9,8)(\Delta x)(\cos 125°)}$ ✓ $+ 0 = \frac{1}{2}(10)(0^2 - 8,84^2)$✓

$-45\Box\Delta x - 56,2105\Box\Delta x = -390,728$

$\Delta x = 3,86$ m

$x = 3,86$ m✓                    (4)

NB: The work done by the gravitational force $W_w$ can also be calculated as follows:

$W_w = mg\sin\theta\Delta x\cos\Box$
    $= (10)(9,8)(\sin35°)x\cos180°$
    $= (-56,2105x)J$

OR: $W_w = -\Delta Ep$
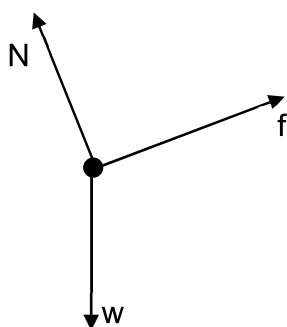    $= mg(h_i - h_f)$
    $= (10)(9,8)(0 - x\sin35°)$
    $= (-56,2105x)J$

**OPTION 2:**

$W_{nc} = \Delta E_p + \Delta E_k$

$= mg(h_f - h_i) + \frac{1}{2}m(v_f^2 - v_i^2)$

$W_f = mg(h_f - h_i) + \frac{1}{2}m(v_f^2 - v_i^2)$ } Any one✓

$f\underline{\Delta x}\cos\theta = mg(h_f - h_i) + \frac{1}{2}m(v_f^2 - v_i^2)$

$\underline{(45)x\cos 180° = (10)(9,8)(x\sin35° - 0)}$✓ $+\frac{1}{2}(10)(0^2 - 8,84^2)$✓

$-45x = 56,2105x - 390,728$

$x = 3,86$ m✓

5.3



| Accepted labels | |
|---|---|
| N✓ | $F_N$ /Normal force/$F_{normal}$ |
| f✓ | f/$F_f$/ frictional force/ $f_s$ |
| w✓ | $F_g$/mg/weight/gravitational force |

| Notes: |
|---|
| • Mark is awarded for label and arrow. |
| • Do not penalize for length of arrows |
| • Deduct 1 mark for any additional force. |
| • If force(s) do not make contact with dot/body: 2/3 |
| • If arrows missing: 2/3 |

(3)

5.4

| OPTION 1: | OPTION 2: |
|---|---|
| $f_s = w_{\parallel} = mg\sin\theta$ ✓ <br> $\quad = (10)(9,8)(\sin 35°)$ ✓ <br> $f_s = 56,21$ N ✓ | $\mu_s = \tan\theta = \tan 35° = 0,7002$ <br> $f_s = \mu_s N = \mu_s mg\cos\theta$ (ANY ONE)✓ <br> $\quad = (0,7002)(10)(9.8)(\cos 35°)$ ✓ <br> $= 56,21$ N✓ |

(3)

**[12]**

## QUESTION 6

6.1 The apparent 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)

6.2

| |
|---|
| $v = f_s\lambda$ ✓ <br> $340 = (300)\lambda$✓ <br> $\lambda = 1,13$ m ✓ |

(3)

6.3    **ANY ONE:**
   • To monitor the heartbeat of a foetus (unborn baby).✓
   • To measure the rate of blood flow.✓                                        (1)

6.4.1

| OPTION 1: | OPTION 2: |
|---|---|
| $f_L = \left(\dfrac{v\pm v_L}{v\pm v_S}\right)f_s$✓ <br><br> $\quad = \left(\dfrac{340}{340\text{-}30}\right)(300)$ ✓ <br> $\quad = 329,032$ Hz <br><br> $v = f_L\lambda$ <br> $340 = (329,032)\lambda$ ✓ <br> $\lambda = 1,033$ m ✓ | $\lambda_B = \dfrac{v\text{-}v_S}{f_s}$✓ <br><br> $= \dfrac{340\text{-}30\ ✓}{300✓}$ <br> $= 1,03$ m✓ |

(4)

6.4.2

| OPTION 1: | OPTION 2: |
|---|---|
| $f_L = \left(\frac{v \pm v_L}{v \pm v_S}\right) f_s$ $= \left(\frac{340}{340+30}\right)^{\checkmark} (300)^{\checkmark}$ $= 275,676 \text{ H}_Z$ $v = f\lambda$ $(340) = (275,676)\lambda$ $\lambda = \frac{340}{275,676}$ $= 1,23 \text{ m} \checkmark$ | $\lambda_A = \left(\frac{V - V_S}{f_s}\right) \checkmark$ $= \left(\frac{340+30}{300}\right)^{\checkmark}$ $= 1,23 \text{ m} \checkmark$ |

(3)

6.5    Less than✓                                                                    (1)

**[14]**


## QUESTION 7

7.1.1   Distance (between the point charges)/medium/air✓                        (1)

7.1.2   The electrostatic force is directly proportional to the product of charges.✓    (1)

7.1.3

| $\text{gradient} = \frac{\Delta F}{\Delta Q^2}$ $= \frac{(4-3) \times 10^{12}}{\Delta Q^2}\checkmark$ $= \frac{1 \times 10^{12}}{1}\checkmark$ $= 1 \times 10^{12} \text{ N} \square \text{C}^{-2}\checkmark$ | **NOTE:** accept any value from the graph |
|---|---|

(3)

7.1.4

$F = \frac{KQ_1 Q_2}{r^2}\checkmark$

$\frac{F}{Q^2} = \frac{k}{r^2}$

$1 \times 10^{12} \checkmark = \frac{9 \times 10^9}{r^2}\checkmark$

$r^2 = 9 \times 10^{-3}$

$r = 0,09487 \text{ m } (0,095 \text{ m})\checkmark$

NOTE: If $F = \frac{KQ^2}{r^2}$ is used, then maximum: $\frac{3}{4}$

(4)

7.2.1   A region of space in which an electric charge experiences a force.  ✓✓        (2)

7.2.2

$E = \dfrac{kQ}{r^2}$ ✓

$E_{net,p} = 0$

$\dfrac{kQ_1}{r^2}$ ✓ $= \dfrac{kQ_2}{r^2}$

$\dfrac{\left(9 \times 10^9\right)\left(8 \times 10^{-6}\right)}{(0,4-d)^2} = \dfrac{\left(9 \times 10^9\right)\left(2 \times 10^{-6}\right)}{d^2}$ ✓

ACCEPT: If $10^{-6}$ is omitted since it appears on both sides.

$\dfrac{d^2}{(0,4-d)^2} = \dfrac{\left(2 \times 10^{-6}\right)}{\left(8 \times 10^{-6}\right)}$

$= 0,25$

$\dfrac{d}{0,4-d} = 0,5$

$d = 0,1333$ m

∴The distance is 0,1333 m ✓        (4)

7.2.3

| OPTION 1: | OPTION 2: |
|---|---|
| $Q_{new} = \dfrac{Q_1 + Q_2}{2}$ $= \dfrac{8 \times 10^{-6} + 2 \times 10^{-6}}{2}$ ✓ $= 5 \times 10^{-6}$ C | $Q_{new} = \dfrac{Q_1 + Q_2}{2}$ $= \dfrac{8 \times 10^{-6} + 2 \times 10^{-6}}{2}$ ✓ $= 5 \times 10^{-6}$ C |
| $n = \dfrac{Q}{e}$ ✓ $n = \dfrac{5 \times 10^{-6} - 8 \times 10^{-6}}{-1,6 \times 10^{-19}}$ ✓ $n = 1,875 \times 10^{13}$ electrons ✓ | $n = \dfrac{Q}{e}$ ✓ $n = \dfrac{5 \times 10^{-6} - 2 \times 10^{-6}}{-1,6 \times 10^{-19}}$ ✓ $n = 1,875 \times 10^{13}$ electrons ✓ |

(4)

[19]

**QUESTION 8**

8.1     Emf✓                                                                (1)

8.2.1

> $V_{lost} = Ir$
> $24 - 21{,}6✓ = I(2)$
> $I = 1{,}2$ A
>
> $I_{total} = 1{,}2$ A
> $V_{12\,\Omega} = IR = (1{,}2)(12)✓ = 14{,}4$ V
> $V_{10\,\Omega} = 21{,}6 - 14{,}4 = 7{,}2$ V
> $I_{10\,\Omega} = \dfrac{V}{R}\;✓ = \dfrac{7{,}2}{10}\;✓ = 0{,}72$ A✓
> $I_A = 0{,}72$ A

(5)

8.2.2

> $I_X = 1{,}2✓ - 0{,}72$
> $\quad = 0{,}48$ A
> $R_X = \dfrac{V}{I}\;✓ = \dfrac{7{,}2}{0{,}48}\;✓$
> $\quad = 1{,}50\ \Omega✓$

(4)

8.3

> **POSITIVE MARKING FROM QUESTION 8.2.1**
> $P = I^2R✓$
> $\quad = (1{,}2)^2✓\ (12)✓$
> $\quad = 17{,}28$ W✓

(4)

8.4     Decreases ✓
- Total resistance in the circuit increases. ✓
- Current in the circuit decreases $\left(I \propto \dfrac{1}{R}\right)$. ✓
- $P = I^2R$; when R is constant, P decreases ✓

(4)

**[18]**

                                                  

**QUESTION 9**

9.1.1     From electrical energy to mechanical energy. ✓           (1)

9.1.2     Clockwise. ✓           (2)

9.1.3     (carbon) brush✓✓           (1)

9.1.4     It reverses the direction of the current in the coil after each half-cycle. ✓           (1)

9.1.5     Increases. ✓
          The current increases✓           (2)

9.2.1     The rms potential difference is the AC potential difference which dissipates/produces the same amount of energy as an equivalent DC potential difference✓✓
          **ACCEPT:**
          The rms voltage is the DC potential difference which dissipates/produces the same amount of energy as the equivalent AC potential difference✓✓     (2)

9.2.2     $V_{rms} = \dfrac{V_{rms}}{\sqrt{2}}$✓

          $200 = \dfrac{V_{rms}}{\sqrt{2}}$✓

          $V_{rms} = (200)(\sqrt{2})$

          $V_{rms} = 282,8427$ V✓           (3)

                                                      **[12]**

**QUESTION 10**

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

10.1.2 The minimum energy that an electron in the metal needs to be emitted from the metal surface.✓✓ (2)

10.1.3 (a) Frequency (of the incident light). ✓ (1)
(b) Frequency (of the incident light).✓ (1)
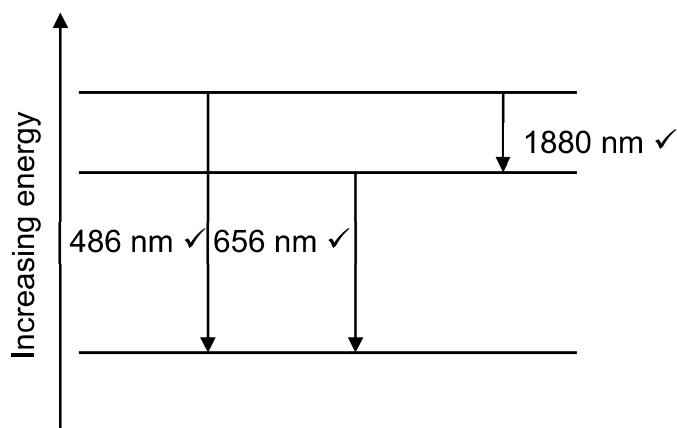
10.1.4

E = hf

$E = \frac{hc}{\lambda}$ ✓

$\therefore E = \frac{(6{,}63 \times 10^{-34})(3 \times 10^{8})}{(450 \times 10^{-9})}$ ✓ ✓

$E = 4{,}42 \times 10^{-19}$ J ✓

Since photon energy is less than the work function of the metal, so, no emission occurs. ✓ (5)

10.2.



486 nm ✓ 656 nm ✓ 1880 nm ✓

**[14]**
**TOTAL: 150**