THE UNITED REPUBLIC OF TANZANIA
MINISTRY OF EDUCATION, SCIENCE AND TECHNOLOGY
NATIONAL EXAMINATIONS COUNCIL OF TANZANIA

CANDIDATES' ITEM RESPONSE ANALYSIS REPORT FOR THE ADVANCED CERTIFICATE OF SECONDARY EDUCATION EXAMINATION (ACSEE) 2020

131 PHYSICS

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FOREWORD

The National Examinations Council of Tanzania has prepared this Candidates' Item Response Analysis (CIRA) report for the Advanced Certificate of Secondary Education Examinations (ACSEE) 2020 to provide feedback to stakeholders such as students, teachers, parents, policy makers and the public on the performance of the candidates who sat for the Physics examination.

The Advanced Certificate of Secondary Education Examination marks the end of two years of Advanced Secondary Education. This summative evaluation among other things, shows the effectiveness of the educational system in general and the education delivery system in particular. Basically, the candidates' responses to the examination questions is a strong indicator of what the education system was able or unable to offer to students in their two years of Advanced Secondary Education.

The analysis presented in this report is intended to contribute towards understanding of reasons for the performance in Physics subject. The report highlights some of the factors that contributed to candidates scoring high marks. It also includes some of the factors which made the candidates fail to score high marks to some of the questions. The factors for failure include lack of knowledge about various concepts, poor background of mathematical skills and improper use of formulae and procedures to perform calculations.

The analysis provided in the report will enable educational stakeholders to identify proper measures to be taken to improve candidates' performance in the future examinations administered by the Council.

Lastly, the Council would like to express sincere appreciation to examination officers, examiners and all other members of staff who participated in the preparation of this report.

Dr Charles E.Msonde

EXECUTIVE SECRETARY

1.0 INTRODUCTION

This report analyses the performance of the candidates who sat for the Advanced Certificate of Secondary Education Examinations (ACSEE) 2020 in Physics papers 1 and 2. The papers were set to test the candidates' competencies and skills in different areas according to the 2010 syllabus to suit the 2019 examination format.

The 131 Physics 1 examination paper contained ten (10) questions grouped into sections A and B. Section A had seven (7) short-answer questions each carrying 10 marks. Section B consisted of three (3) structured essay type questions each carrying 15 marks. The candidates were required to attempt all questions in Section A and any two (2) questions from section B.

In contrast, Physics paper 2 had six (6) structured essay-type questions. The candidates were required to answer any five (5) questions. Each question carried 20 marks. Generally, all questions in both papers aimed at testing the candidates' skills and ability to comprehend, interpret and analyse data based on the demands of the questions.

A total of 17,045 school candidates sat for the examination. Among them, 15,631 (92.25%) passed the examination and 1,414 (7.75%) failed. In 2019, the number of candidates who sat for the Physics examination was 18,906. Among them, 16,768 (89.13%) passed the examination and 2,138 (10.87%) failed. This implies that the candidates' performance in this year has increased by 3.12 percent. The analysis of the candidates' performance in 2020 in grades as compared to the years 2019 and 2018 is summarized in Table 1.

Table 1: Candidates' Performance in terms of Grades

YEAR	Grades							
	A	**B**	**C**	**D**	**E**	**S**	**F**	**Total**
2020	85	812	3,059	5,432	4,826	1,417	1,313	**16,944**
2019	50	683	2,771	5,496	5,920	1,848	2,044	**18,812**
2018	70	821	2,658	5,159	5,872	2,225	2,628	**19,433**

In Table 1, many candidates attained Grades D (5,432), E (4,826) and C (3,059). However, 812 and 85 candidates attained Grades B and A respectively. This indicates improvements as compared to the past two years.

The following section analyses the candidates' responses in relation to the demands of the questions. Brief notes on what the candidates were required to do and the reasons for their performance are provided. The samples of candidates' responses are also inserted to illustrate the cases presented. Also, graphs and charts are used to summarize the candidates' performance on the respective question.

However, the percentage of performance on each question is grouped into three levels based on the scores. The good, average and weak performance categories are in the ranges of 60 – 100, 35 – 59 and 0 – 34 respectively. Green, yellow and red colours are used to represent these categories respectively. Lastly, the report provides a conclusion and recommendations that may help to improve candidates' performance in future examinations.

2.0 ANALYSIS OF THE CANDIDATES' PERFORMANCE ON EACH QUESTION

2.1 131/1 Physics 1

This paper assessed 5 topics, namely Measurement, Mechanics (*Newton's Laws of Motion, Uniform Circular Motion, Gravitation* and *Projectile Motion*), Heat (*Thermal Radiation, Thermodynamics* and *Thermal Conduction*), Environmental Physics, Current Electricity and Electronics (*Logic Gates* and *Operational Amplifiers*). The first 4 topics were assessed in Section A which comprised 7 questions. Each question carried 10 marks. The last 2 topics were assessed in Section B, which consisted of 3 questions. Each question carried 15 marks. The analysis of each question is as follows:

2.1.1 Question 1: Measurement and Newton's Laws of Motion

This question had two parts: (a) and (b). Part (a) was constructed from the topic of Measurement. This part required the candidates to (i) apply the method of dimensions to derive an expression for the acceleration of a particle moving in a uniform circular motion and (ii) check the correctness of the equation, $\gamma = \frac{hrJg}{2\cos\theta}$, where; θ, J, r, g, γ and h are the angle of contact, density of liquid, radius of the tube, acceleration due to gravity, surface tension and the height of the liquid respectively. Part (b) was constructed from the topic of Newton's laws of motion. The part required

the candidates to calculate the tension in the cable which delivers the power of 23 kW when pulling a fully loaded elevator at a constant speed of 0.75 m/s.

A total of 17043 candidates, corresponding to 100 per cent attempted this question. Their scores were as follows: 31 per cent scored below 3.5 marks, including 9.4 per cent who scored 0 marks; 19.8 per cent scored from 3.5 to 5.5; while 49.2 per cent scored from 6 to 10 marks. These data reveal that the candidates' performance on this question was good because 69 per cent of them scored from 3.5 to 10 marks. Figure 1 illustrates the given information.

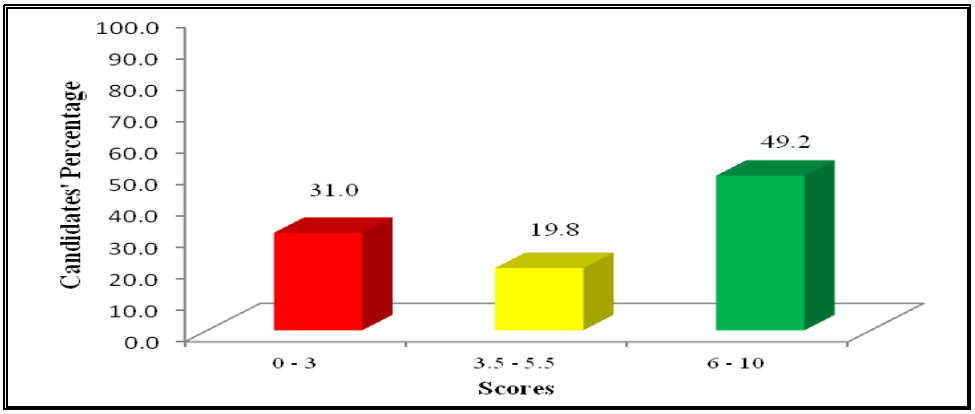
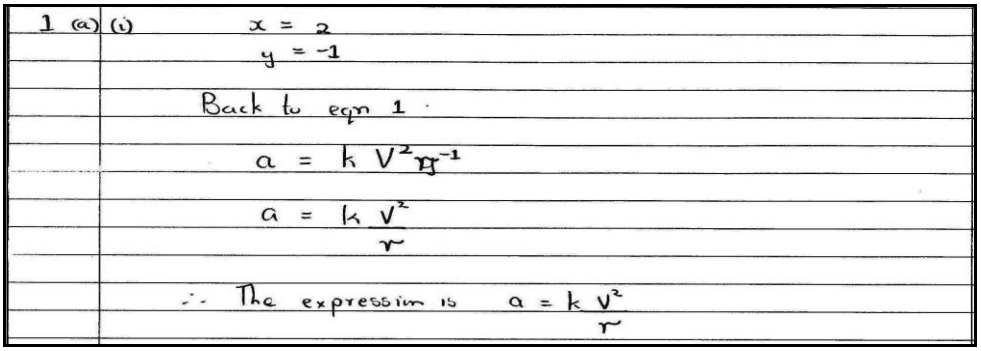


Figure 1: *The candidates' performance on Question 1in Paper 1*

The analysis of the candidates' responses in this question revealed that most of them had a good understanding of the concepts of Measurement and Newton's laws of motion. In part (a), they used correctly the knowledge of dimensional analysis to derive an expression for the acceleration of a particle moving in a circle and to check the correctness of the given equation. Also they correctly applied the concepts of Newton's laws of motion to calculate the tension as presented in Extract 1.1.



(a) (ii). $\gamma = \frac{hr J g}{2 \cos\theta}$

$[\theta] = 1$ (Dimensionless.

$[J] = \frac{[M]}{[L]^3} = \frac{\text{mass}}{\text{Volume}}$

$[J] = ML^{-3}$.

$[r] = L$

$[g] = LT^{-2}$

$[\gamma] = \frac{ML^{+1}T^{-2}}{L} = \frac{\text{Force}}{\text{Length.}}$

$[\gamma] = MT^{-2}$.

1 (a) (ii) Height $[h] = L$.

By using the principle of homogenity.

Eqn:

$$\gamma = \frac{hr J_g}{2\cos\theta}$$

Substitute the dimensions.

$$MT^{-2} = \frac{[L][L][ML^{-3}][LT^{-2}]}{1}$$

$$MT^{-2} = [L^3][ML^{-3}][T^{-2}]$$

$$MT^{-2} = MT^{-2}$$

∴ Since the dimensions in the R.H.S is equal to the dimensions in the left (L.H.S) hence the equation is dimensionally correct.

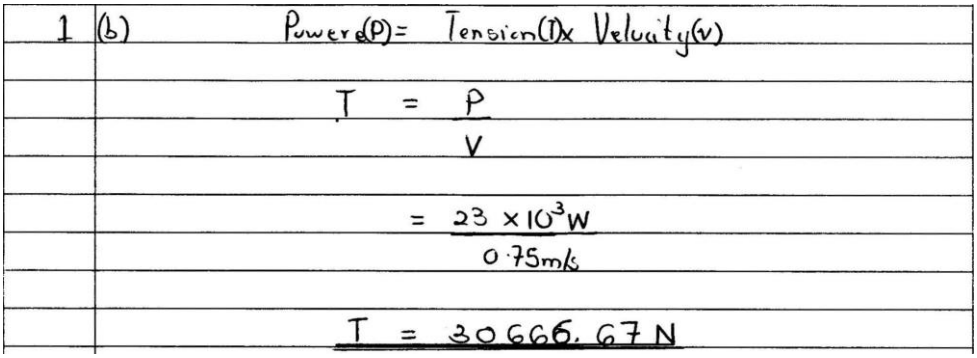
(b) Power; $P = \frac{\text{Workdone (W)}}{\text{Time (T)}}$.

$P = \frac{F \times d}{t}$ F = Force, d = distance

$P = F \times \frac{d}{t}$

$P = F \times V$

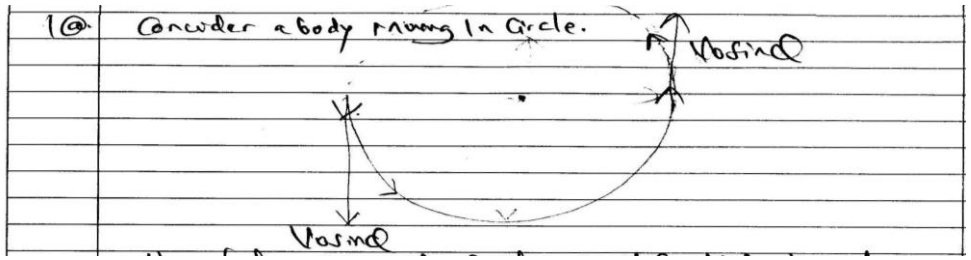
But the force = Tension.



Extract 1.1: *A sample of the good responses in Paper 1.*

Extract 1.1 indicates that the candidate responded correctly to each item by deriving an expression for the acceleration of a particle moving in a circle, checking the correctness of the given equation and applying the correct formulae and procedures to calculate the tension in the cable.

However, most of the candidates who scored low marks (31%) lacked knowledge about the concepts of Measurement and Newton's laws of motion. For instance, in part (a) (i), some of the candidates used these two concepts interchangeably to derive the formula for the acceleration of a particle moving in a uniform circular motion. In part (a) (ii), they failed to check whether the equation was correct or not because they didn't understood the dimensions of γ and $\cos\theta$. Some of these candidates used the dimensions of force $\left(MLT^{-2}\right)$ instead of the dimensions of surface tension $\left(MT^{-2}\right)$. As an example, the other incorrect dimensions of surface tension given by the candidates were $\left(ML^{-2}T^{-2}\right)$ and $\left(ML^{-1}T^{-2}\right)$. In contrast, the candidates were supposed to understand that the dimensions of $\cos\theta$ is 1 since angle θ is a dimensionless variable. In part (b), most of the candidates used wrong the formula of Power = Work = Force x distance. instead of Power = Tension x velocity in calculating the tension in the cable. Extract 1.2 shows a sample response by a candidate who gave incorrect answers to each of the question items.



there body move in circular circuit (path) where by its total velocity at instant is $V_0 \sin\theta$ (due to resolution.

then

Since acceleration a,

$$a = V/t.$$

but here $V_{total} = V_0 \sin\theta - (-V_0 \sin\theta)$

$$\therefore V_T = 2V_0 \sin\theta.$$

also time =

from $V = L/t = \frac{2r\theta}{t}$.

$$\therefore t = \frac{2r\theta}{V}.$$

$$\therefore a = \frac{2V_0 \sin\theta}{2r\theta/V}$$

but since θ is very small, $\therefore \sin\theta \approx \theta$

$$\therefore a = \frac{2V_0\theta}{2r\theta/V} = \frac{2V_0^2\theta}{2r\theta}$$

$$\therefore a = V_0^2/r$$

$$\therefore a = V^2/r.$$

(ii.)

$$\gamma = \frac{hrJg}{2\cos\theta}$$

θ – angle, J = density of liquid

r – reading on tube g – acc. d. g.

γ – surface tens, h = height of liq.

$$\therefore \gamma = \frac{hrJg}{2\cos\theta}.$$

by reverse

Comparison dimensionally.

$$\gamma = hrJg \cdot (2\cos\theta)^{-1}.$$

Then dimensions.

$$ML^0T^{-2} = K(M^0LT^0)^a \cdot (M^0LT^0)^b \cdot (ML^{-3}T^0)^c \cdot (M^0LT^{-2})^d.$$

For (ML^0T^{-2}): by Comparison:

$M^1 = M^0 + M^0 + M^c \therefore c = 1.$

$L^0 = L^a + L^b + L^{-3c} + L^d \therefore a + b + -3c + d = 0.$

$T^{-2} = T^{-2d} \therefore -2d = -2 \ (d = 1$

but since equal, $a = b$ (dimensionally.

$\therefore a + a + -3c + d = 0.$

$2a + -3(1) + 1 = 0.$

$-2a - 3 + 1 = 0.$

$\frac{-2a}{-2} = \frac{2}{-2} \quad a = -1.$

also $a + b = -1.$

$a = -1 - b.$

$\therefore -1 - b.$

$\therefore (hr) = -1, J = 1, g = 1.$

then formular should be

$$\frac{Jg}{hr \cdot k} = \frac{Jg}{hr2\cos\theta}.$$

∴ The formular is not correct, the correct formular should be

$$\gamma = \frac{Jg}{hr2\cos\theta}$$

Extract 1.2: *A sample of the poor responses in Paper 1*

Extract 1.2 indicates that the candidate failed to deduce the concepts of Measurement and Newton's laws of motion as he/she used the concepts of circular motion instead of dimensional analysis to solve part (a) (i). In part (a) (ii), instead of checking whether the equation is correct he/she derived the formula leading to the incorrect response.

2.1.2 Question 2: Uniform Circular Motion and Newton's Laws of Motion

This question was divided into two parts: (a) and (b). Part (a) required the candidates to explain (i) why the outer rail of a curved railway track is raised over the inner and (ii) how a helicopter gets its lifting force based on Newton's laws of motion. Part (b) required them to determine the internal energy produced by a bullet of the mass of 10 g travelling horizontally at a speed of $1.0\times10^{2}\,ms^{-1}$ which embed itself in a block of wood of mass 9.9×10^{2} g suspended freely by two strings.

The analysis of data reveals that 100 per cent of the candidates who attempted this question, had the following scores: 44.7 per cent scored from 0 to 3 marks; 36.9 per cent scored from 3.5 to 5.5 and 18.4 per cent scored from 6 to 10 marks. These scores suggest that the candidates' performance on this question was average because more than one-third of them scored the pass mark or above. These data are summarized in Figure 2.

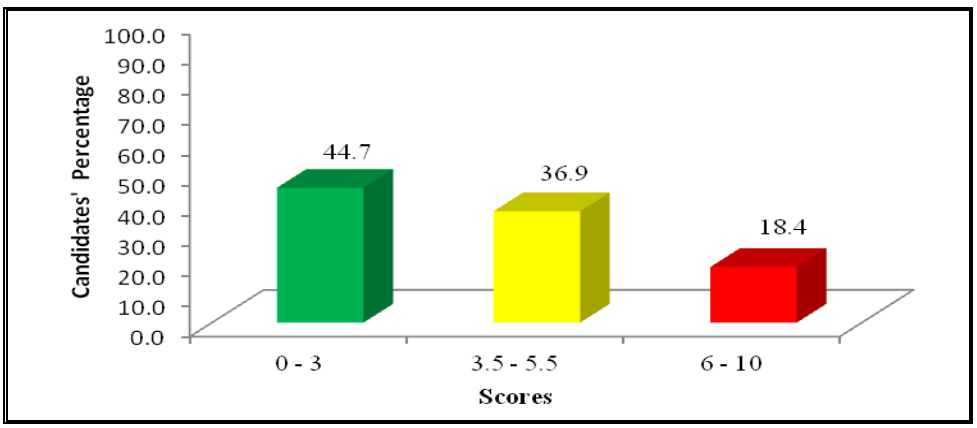


Figure 2: *Distribution of candidates' scores on Question 2 in Paper 1*

The average performance of the candidates was contributed to their ability to comprehend the demand of the question in part (a). These candidates explained why banking is crucial at a curved railway track. However, they

failed to explain sufficiently the concept of lifting force of the helicopter based on Newton's laws of motion. Nevertheless, those who scored higher marks (6 - 10) were knowledgeable about the topic as they organized and analysed the concept by providing the correct responses to almost all parts of the question. Extract 2.1 is a sample answer from the script of one candidate who performed well on this question.

2. a)i) This is to increase the maximum safety velocity for negotiating a corner around a curved railway. Raising outer rail than inner one creates an additional component of the weight of the track to the centripetal force whereas safety speed become greater than previous.

ii) From Newton's third law of motion, When blades of a helicopter rotates create an action force downward whereas an equivalent reaction force is created in upward direction and causing it to lift up.

Also from second's Newton's law of motion, an upward force on a helicopter is due to the thrust given by rate of change of air circulating the helicopter blades

$F_{upward} = \frac{V_r dm}{dt} \Rightarrow A\rho V_r^2$, A - area of blades
ρ - Density of air
V - velocity of air.

2 b) Given

mass, $m = 10g$

speed, $v = 1.0 \times 10^2 m/s$

$m_{block}, m_b = 9.9 \times 10^2 g$

solution

From, principle of conservation of linear momentum

Momentum before impact = momentum after impact

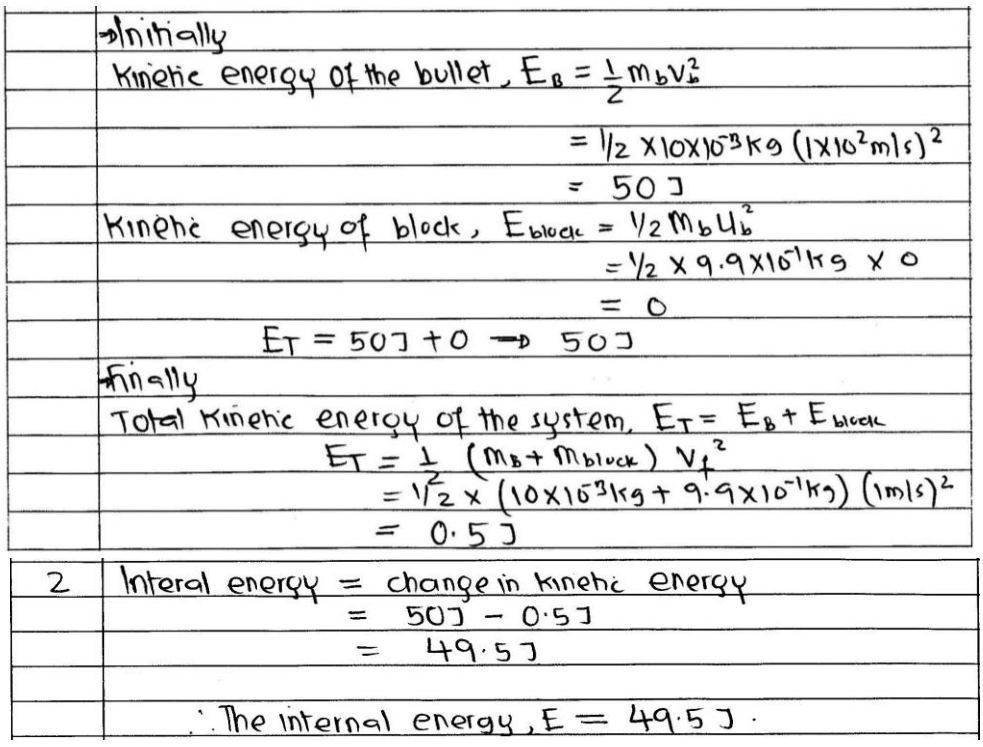
Let v_f be their final common velocity

$$mv + 0 = (m + m_b)v_f$$

$$v_f = \frac{mv + 0}{m + m_b}$$

$$v_f = \frac{10g \times 1 \times 10^2 m/s}{10g + 9.9 \times 10^2 g}$$

$$v_f = 1 m/s$$



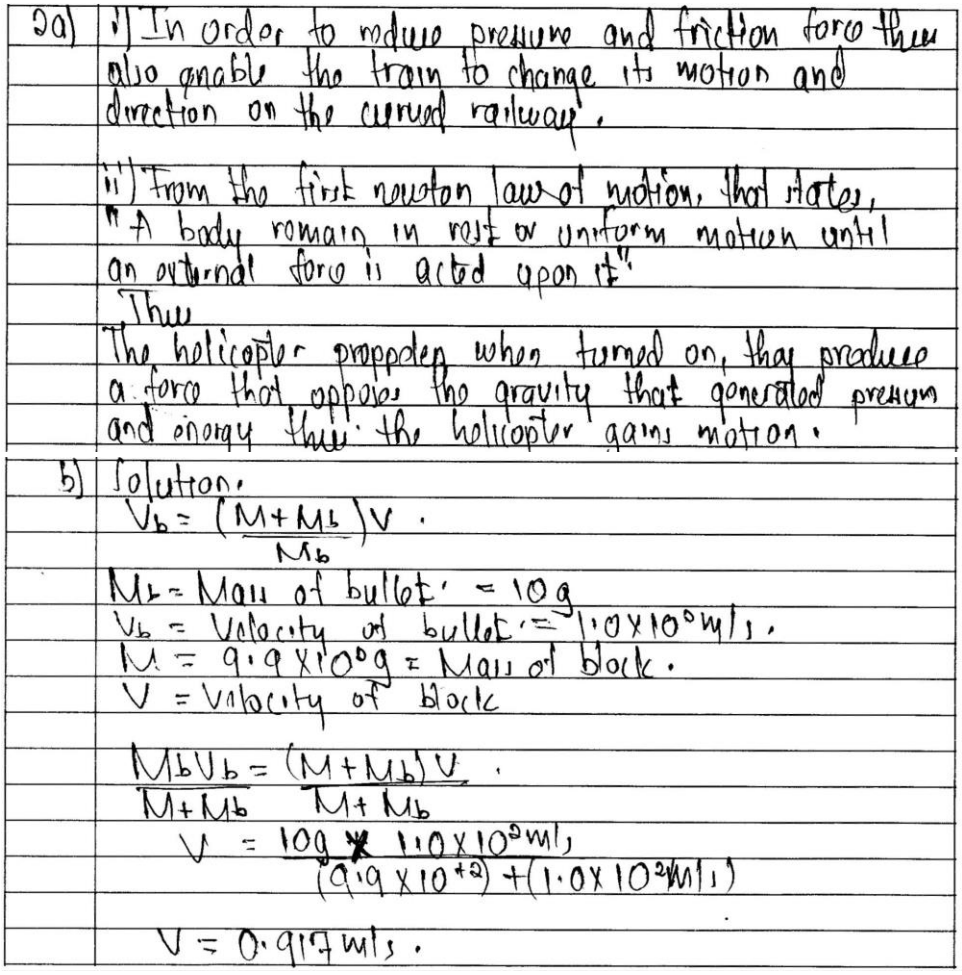
Extract 2.1: *A sample of the good responses to Question 2 in Paper 1*

In Extract 2.1, the candidate applied the concepts of circular motion and Newton's laws of motion to give the correct answers in part (a). In part (b), he/she correctly used the principle of conservation of linear momentum to determine the required internal energy.

In contrast, 44.7 per cent of the candidates scored low (0 - 3) marks. These candidates lacked knowledge of uniform circular motion and Newton's laws of motion especially to explain the importance of track banking around curves. For example, one candidate wrote *'outer rail of curved railway track is raised over the inner in order to allow expansion during hot'*. This candidate used the concept of thermal expansion of solids instead of providing the advantages of raising the outer rail of the curved railway track.

Similarly, in part (b), the candidates used the wrong concept to calculate internal energy. The candidates were first required to find the initial kinetic energy of the bullet, the common velocity of the system after impact and the final kinetic energy of the system using the principle of conservation of momentum. The difference between the initial kinetic

energy and the final kinetic energy is the internal energy. Extract 2.2 shows one of the incorrect responses to the question.


2a) i) In order to reduce pressure and friction force they also enable the train to change its motion and direction on the curved railway.

ii) From the first newton law of motion, that states, "A body remain in rest or uniform motion until an external force is acted upon it"
Thus
The helicopter propeller when turned on, they produce a force that oppose the gravity that generated pressure and energy thus the helicopter gains motion.

b) Solution.
$V_b = \frac{(M+M_b)}{M_b} V$.
M_b = Mass of bullet = 10 g
V_b = Velocity of bullet = 1.0×10^2 m/s.
M = 9.9×10^3 g = Mass of block.
V = Velocity of block

$\frac{M_b V_b}{M+M_b} = \frac{(M+M_b)V}{M+M_b}$.
$V = \frac{10g \times 1.0 \times 10^2 m/s}{(9.9 \times 10^{+2}) + (1.0 \times 10^2 m/s)}$
$V = 0.917$ m/s.

Extract 2.2: *A sample of the incorrect responses to Question 2 in Paper 1*

In Extract 2.2, the candidate provided wrong responses as to why the outer rail of the curved railway track is raised over the inner and how a helicopter gets its lifting force. In part (b), he/she applied the formula to find the final velocity instead of determining the internal energy produced by the bullet.

2.1.3 Question 3: Gravitation

Part (a) of this question required the candidates to find the gravitational potential at a point on the earth's surface if the values of universal gravitational constant, mass and radius of the earth are

6.7×10^{-11} Nm^2kg^{-2}, 6.0×10^{-24} kg and 6.4×10^{6} m respectively. In part (b), it was given that a communication satellite occupies an orbit such that its period of revolution about the earth is 24 hours. The candidates were required to (i) give the significance of this period and (ii) establish an expression for the radius R_0 of the orbit stating clearly the meaning of all the symbols used.

The question was attempted by 17,042 candidates corresponding to 100 per cent. Among them, 45.6 per cent scored from 0 to 3 of which 12.8 per cent scored 0 marks; 30.7 per cent scored from 3.5 to 5.5 while 23.7 per cent scored from 6 to 10 marks. These scores suggest that the general performance on this question was average since 54.4 per cent scored from 3.5 to 10 marks. The following bar chart illustrates the data.

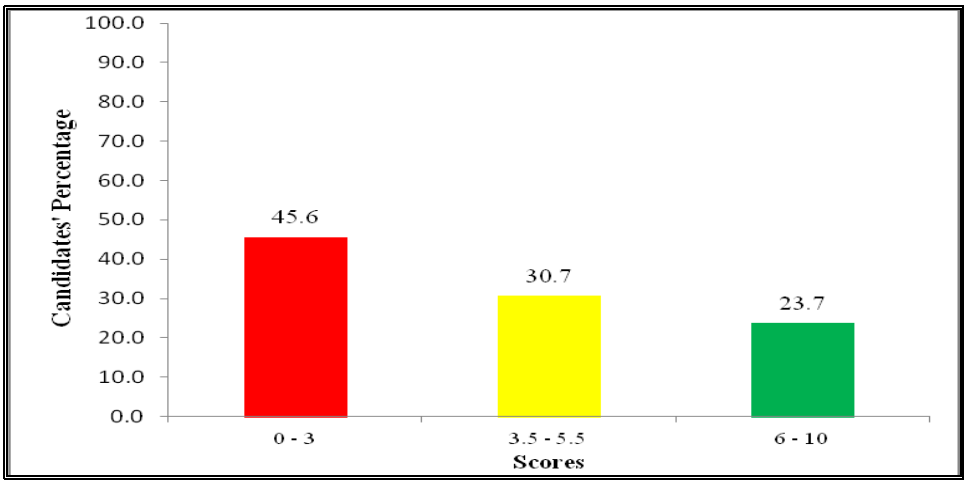


Figure 3: *The candidates' performance to Question 3 in Paper 1*

The analysis of the candidates' responses shows that those who scored average marks (30.7%) performed well in part (a) as they computed correctly the gravitational potential at a point on the earth's surface. However, they provided unsatisfactory procedures for establishing an expression for the radius, R_o of the orbit in part (b). This was contributed by their failure to distinguish between an expression of gravitational force of attraction and the gravitational potential. The candidates were supposed to compare these two formulae to deduce an expression of R_0.

Concerning, the candidates who scored good marks (23.7%) they retrieved and applied the correct formulae and procedures to determine the gravitational potential at a point and establish the required expression for the radius of the orbit. Extract 3.1 is a sample of the good responses.

3 a) Soln.

Data

$G = 6.7 \times 10^{-11} \, Nm^2 kg^{-2}$

$M_e = 6 \times 10^{24} kg$

$R_e = 6.4 \times 10^6 m$

from

$$V = -\frac{GM_e}{R_e}$$

$$= -\left(\frac{6.7 \times 10^{-11} \times 6 \times 10^{24}}{6.4 \times 10^6 m}\right)$$

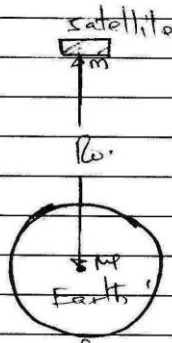
$$= -6.28 \times 10^{7} J/kg$$

b) Given

Period of Revolution = 24 hours

i) The period of revolution (24 hours) of the satellite suggest that the satellite is situated on the parking orbit as it revolve in the same period as that of earth

3 b) ii) Consider the satellite Moving around the earth



The Gravitation force provide neccesary centripetal force

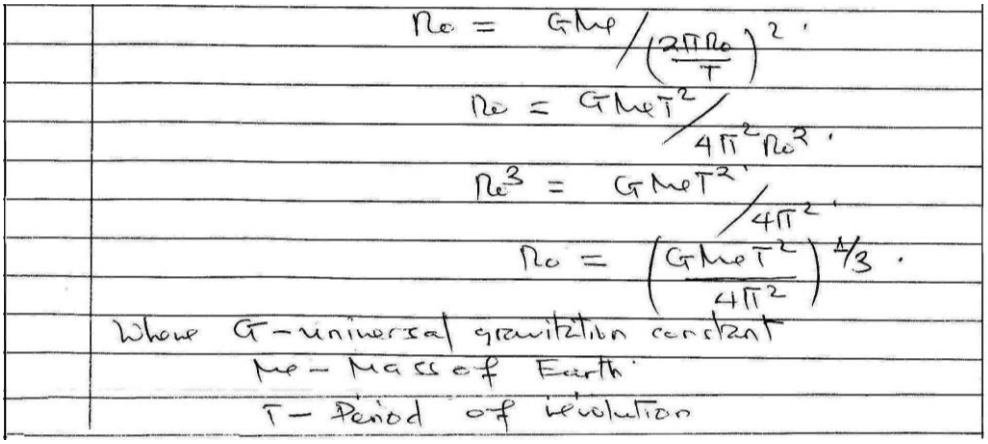
$$\frac{mv^2}{R_e} = \frac{GMem}{R_e^2}$$

$$mv^2 = \frac{GMem}{R_e}$$

$$R_e = \frac{GMem}{mv^2}$$

$$R_e = \frac{GM_e}{v^2}$$

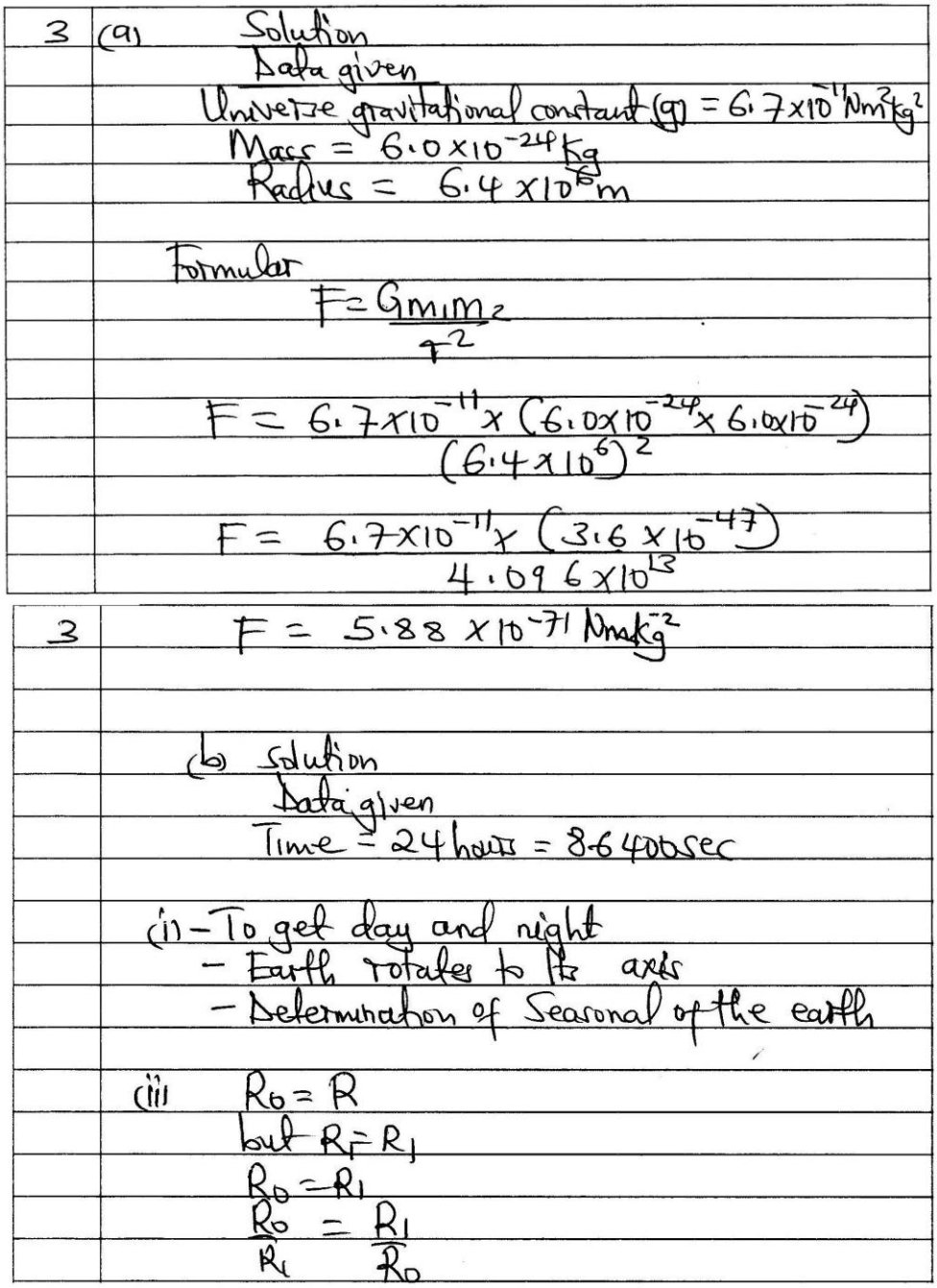
But $V = \frac{2\pi R_e}{T}$



Extract 3.1: *A sample of the good responses in Paper 1*

In Extract 3.1, the candidate applied the concept of gravitational potential and packing orbit with regard to gravitation to provide the correct answers to the question.

Concerning those who scored low (0 - 3) marks, 12.8 per cent lacked knowledge of gravitation as they presented wrong responses to each tested item. Therefore, they scored 0 marks. In contrast, 32.8 per cent correctly answered few parts of the question. Also, part (b) (i) of this question challenged most of the candidates as they failed to state the physical meaning of the period taken by the satellite to revolve around the earth. For example, one candidate wrote *'the physical significance of this period, it results to day and night'*. This shows that he/she lacked the knowledge of parking orbit. The candidates were supposed to understand that for easy communication, a satellite has to appear fixed in the sky such that its period of revolution has to be the same as that of the earth's rotation which is 24 hours. Thus the significance of the period was to show that the satellite is at a fixed position relative to the earth's rotational motion. In part (b) (ii), most of the candidates failed to sketch an illustrative diagram for easy interpretation of the given information in establishing an expression for the radius, R_o of the orbit. Extract 3.2 is a sample of the poor responses.



Extract 3.2: *A sample of the incorrect responses to Question 3 in Paper 1*

In extract 3.2, the candidate calculated the gravitational force of attraction instead of the gravitational potential. Also, he/she failed to state the physical meaning of the period, interpret and establish an expression for the radius.

2.1.4 Question 4: Projectile Motion

This question had two parts: (a) and (b). In part (a), it was given that an object falling freely from a given height, H hits an inclined plane at a height, h from the ground. If the direction of velocity of the object as a results of the impact becomes horizontal, what would be the value of $\frac{h}{H}$ at the time it reaches the ground? Part (b) required the candidates to calculate (i) the horizontal velocity of the ball and (ii) the total time of flight of the ball kicked with an initial velocity of 8.0 m/s such that, it just passes over the barrier which is 2.2 m high neglecting air resistance.

A total of 17,040 candidates equivalent to 100 per cent attempted this question. Their scores were as follows: 51 per cent scored below 3.5 marks, including 25.2 per cent who scored 0 marks; 31.4 per cent scored from 3.5 to 5.5 and 17.6 per cent scored from 6 to 10 marks. These data reveal that the candidates' performance on this question was average as 49 per cent of them scored from 3.5 to 10. Figure 4 is illustrative.

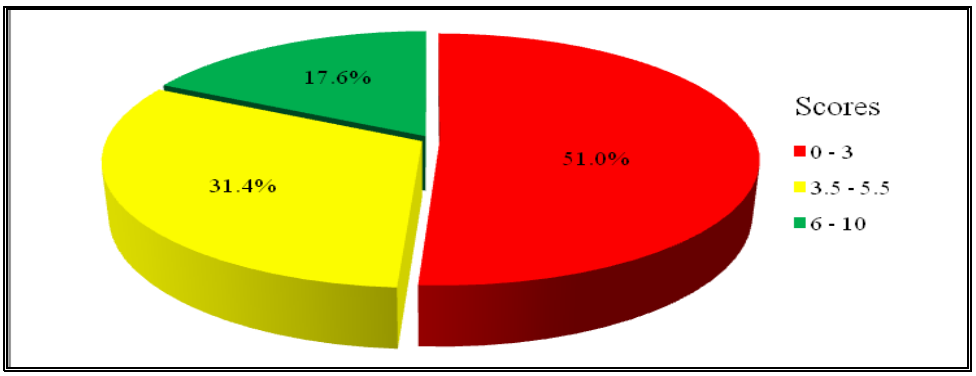
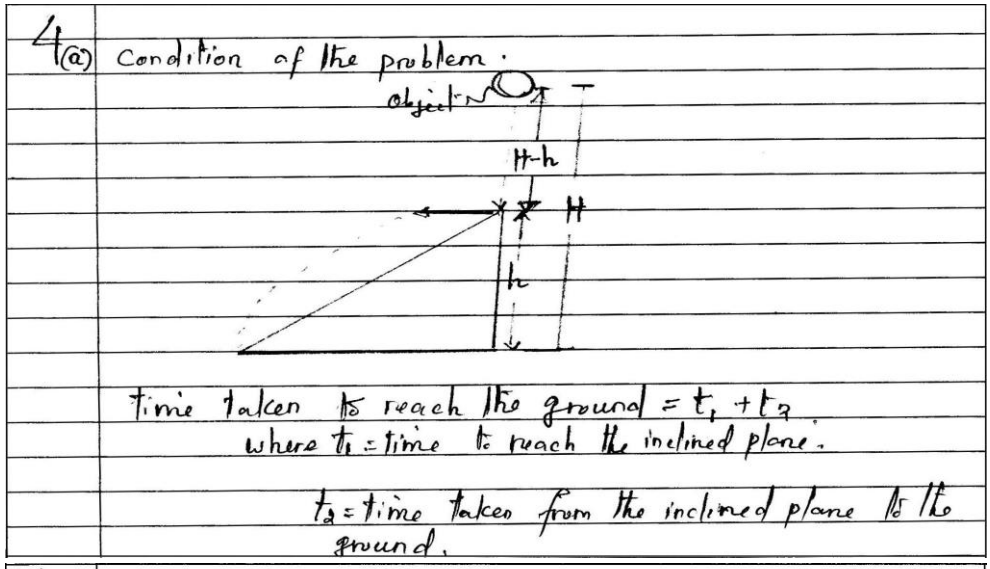


Figure 4: *The candidates' performance on Question 4 in Paper 1*

The analysis of the candidates' responses shows that, some of the candidates who scored average marks (31.4%) managed to establish the condition of the given task in part (a) and to apply mathematics skills to evaluate the value of $\frac{h}{H}$ at a time an object reaches the ground. However, a few of them failed to apply the correct formulae to determine the horizontal velocity of the ball and the total time of its flight. The candidates failed to interpret that the height (2.2 m) given in the question represents the maximum height attained

by the ball. They were supposed to apply the formula $h_{\max} = \frac{v^2 \sin^2 \alpha}{2g}$ to first determine the angle of projection, α then the horizontal velocity by using the formula $v_x = v\cos\alpha$. The candidates who scored good marks (17.6%) explored their competence by presenting the condition of the given tasks and applied the correct formulae and demonstrated neat and precise procedures to obtain the required values. Extract 4.1 provides an example of the correct responses.



$$\therefore 0 = \frac{-1}{2}(H-h)^{-1/2} + \frac{1}{2}h^{-1/2}.$$

$$\frac{1}{2}(H-h)^{-1/2} = \frac{1}{2}h^{-1/2}.$$

$$(H-h)^{-1/2} = h^{-1/2}.$$

$$H-h = h$$

$$H = h+h.$$

$$H = 2h.$$

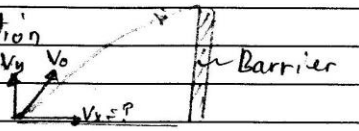
$$\frac{h}{H} = \frac{1}{2}.$$

$\therefore$ The value of $h/H = 1/2$ at the time it reaches the ground.

4(b) Given:

$V_0 = 8\ m/s.$

$h = 2.2m$



But $V_x = V_0\cos\theta.$

But $\theta = ?$

from Maximum height $(H) = \frac{V_0^2\sin^2\theta}{2g}.$

$$\therefore \sin^2\theta = \frac{2gH}{V_0^2}.$$

$$\sin\theta = \sqrt{\frac{2gH}{V_0^2}}$$

$$\theta = \sin^{-1}\left(\sqrt{\frac{2gH}{V_0^2}}\right), \text{ But } H = 2.2.$$

$$\therefore \theta = \sin^{-1}\left(\sqrt{\frac{2\times 9.8\times 2.2}{8^2}}\right)$$

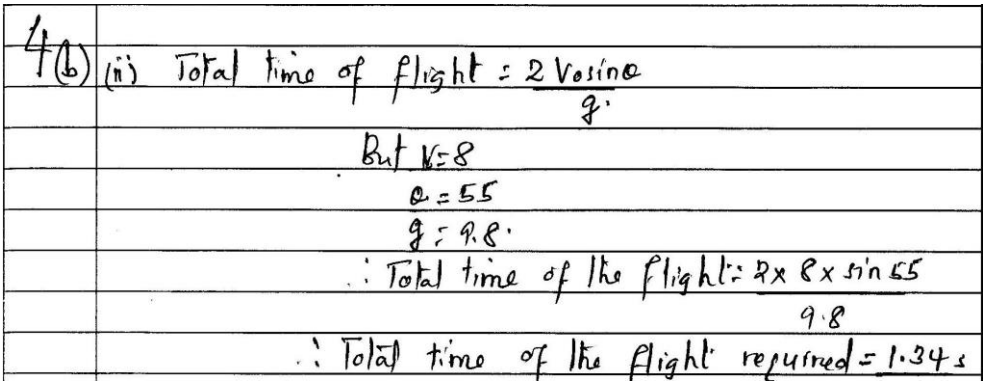
$$\theta = 55.16^\circ \approx 55^\circ$$

$\therefore$ Recall V_x (Horizontal velocity) $= V_0\cos\theta.$

$$= 8\times\cos 55$$

$$= 4.569\ m/s.$$

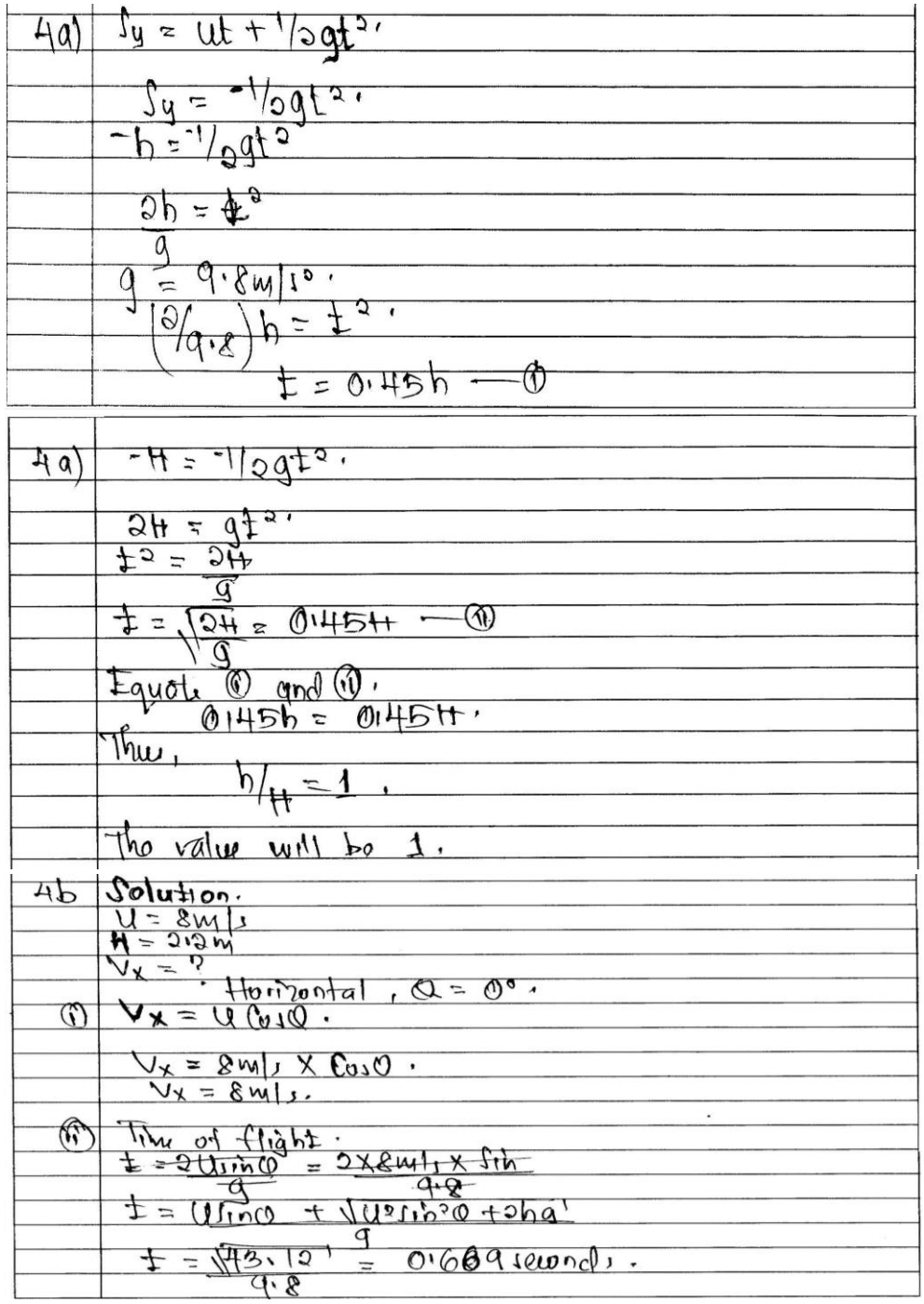
$\therefore$ Horizontal velocity $= 4.569\ m/s.$



Extract 4.1: *A sample of the good responses in Paper 1*

Extract 4.1 indicates that the candidate applied the correct formulae and procedures to determine the required values in all items.

Though the performance of some candidates on this question was average, more than a half (51%) of the candidates scored low marks (0 - 3) including 25.2 per cent who scored 0 marks. These candidates lacked competence in retrieving and conveying the basic concepts of projectile motion to determine the required values. A further analysis indicates that, those who scored 0 marks in part (a) and (b) applied Newton's equations of motion with regard to linear motion instead of projectile motion to find the values of $\frac{h}{H}$, the horizontal velocity of the ball and the total time of its flight. These candidates were supposed to find the total time of flight by taking the sum of the time taken by the object to hit the plane $t_1=\sqrt{\frac{2(H-h)}{g}}$ and the time taken by the object to travel from the plane to the ground $t_2=\sqrt{\frac{2h}{g}}$. Bearing in mind that the total time taken by the object to reach the ground would be maximum for height h if $\frac{dt}{dh}=0$, the value of $\frac{h}{H}$ could easily be found. Moreover, it was noted that in part (b) they applied the vertical displacement equation $y=(v_0\sin\theta)t-\frac{1}{2}gt^2$ instead of $h_{max}=\frac{v^2\sin^2\alpha}{2g}$ to find the angle of projection, the horizontal velocity and the total time of its flight. Extract 4.2 is a sample of the poor responses to the question.



Extract 4.2: *A sample of poor responses to Question 4 in Paper 1*

In Extract 4.2, the candidate failed to evaluate the values of $\frac{h}{H}$, horizontal velocity of the ball and the total time of its flight.

2.1.5 Question 5: Thermal Radiation and Thermodynamics

In part (a), the candidates were required to give evidence for the validity of the first law of thermodynamics. Part (b) required them to (i) explain what would happen on a black body when it is constantly heated based on Wien's displacement law and (ii) estimate the rise in temperature of the gas if 60 Joules is supplied to 2 moles of the helium gas placed inside an insulated container of a fixed volume.

The question was attempted by 17,044 candidates corresponding to 100 percent. Among them, 75 per cent scored from 0 to 3 marks; 17.1 per cent scored from 3.5 to 5.5 while only 7.9 per cent scored from 6 to 10 marks. These scores suggest that the general performance on this question was weak. The following bar chart is illustrative.

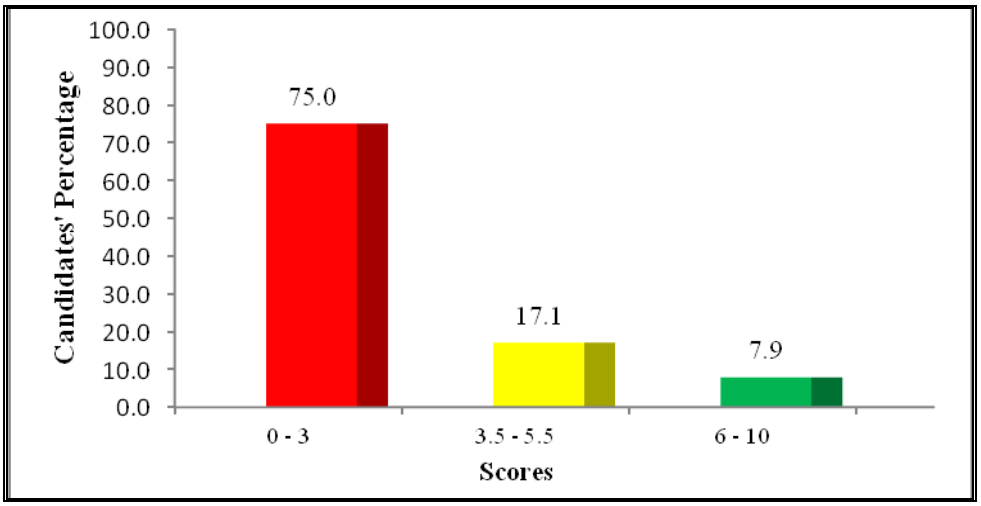
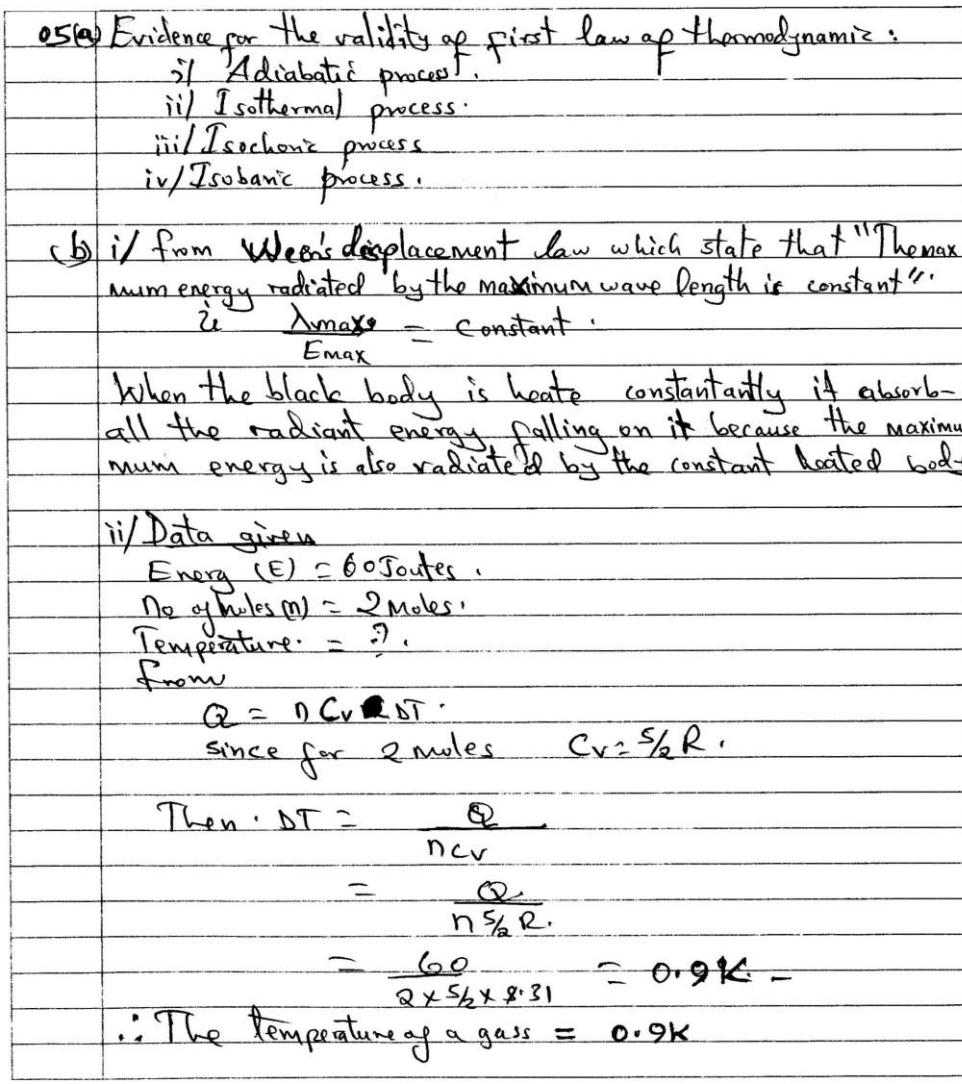


Figure 5: *The candidates' performance on Question 5 in Paper 1*

The analysis of data reveals that three quarter (75%) of the candidates attained unsatisfactory performance (0 - 3 marks). These candidates provided incorrect responses to most items. The noted challenges in their responses include their lack of knowledge about establishing the first law of thermodynamics in connection with its applications in real life. In part (a), a few candidates incorrectly listed the types of thermodynamic processes like isothermal, isochoric and adiabatic while others provided wrong responses. Another challenge was in part (b) (i); where the candidates failed to retrieve the applications of Wien's displacement law of

black body radiation $\left(\lambda_m \propto \frac{1}{T}\right)$ in daily life. They lacked the knowledge that when a black body is constantly heated, its temperature increases with the emission of radiations of smaller wavelength and so higher energy is given out such that there is a colour change from red to white. For example, when iron is heated, it first becomes light-red, dark-red, then yellow and ultimately white. In part (b) (ii) most of them failed to apply the First law of thermodynamics to estimate the rise in the temperature of the helium gas. Extract 5.1 shows a sample of the incorrect answers.


05(a) Evidence for the validity of first law of thermodynamic:
i/ Adiabatic process.
ii/ Isothermal process.
iii/ Isochoric process
iv/ Isobaric process.

(b) i/ from Wein's displacement law which state that "The maximum energy radiated by the maximum wave length is constant".
ie $\frac{\lambda max}{E max} = constant$.
When the black body is heate constantantly it absorb- all the radiant energy falling on it because the maximu mum energy is also radiated by the constant heated body

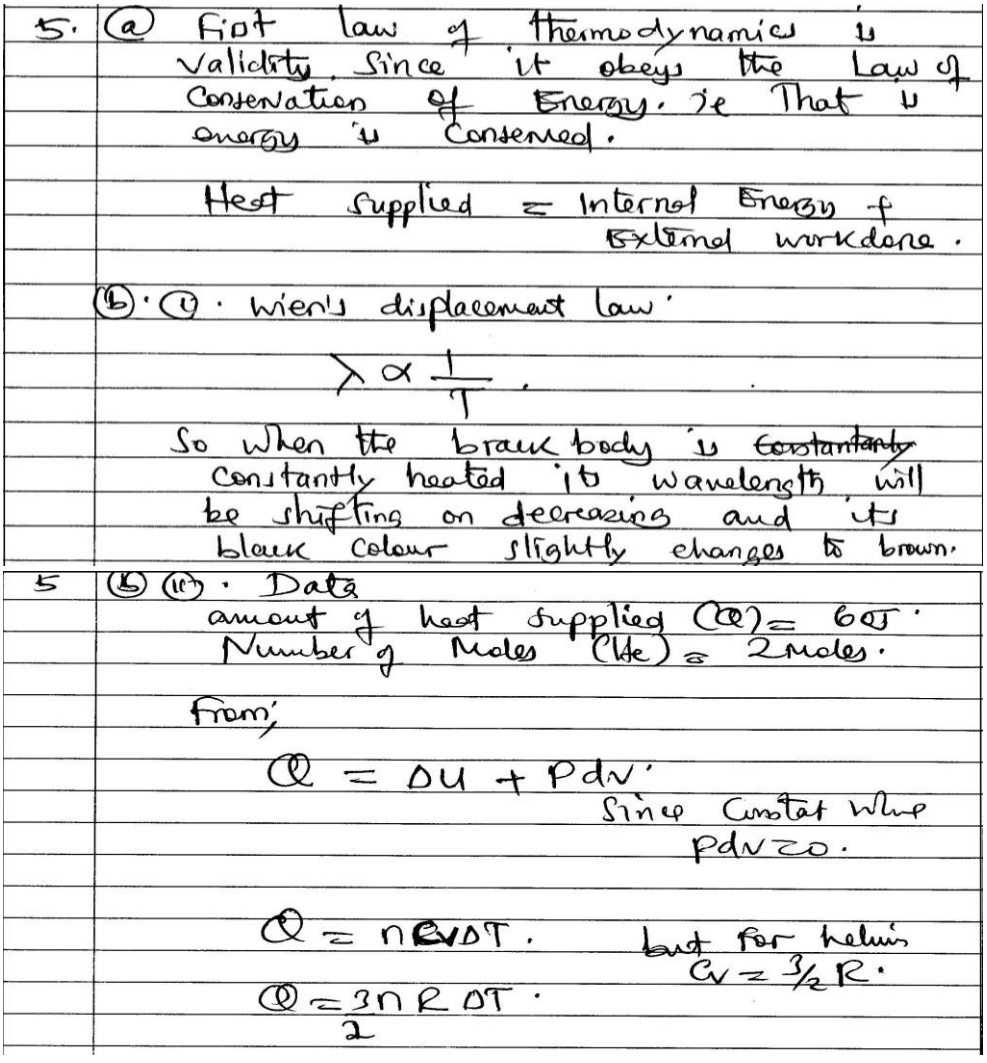
ii/ Data given
Energy (E) = 60Joutes.
No of moles (n) = 2 Moles.
Temperature. = ?.
From
$Q = n C_v \Delta T$.
since for 2 moles $C_v = 5/2 R$.

Then. $\Delta T = \frac{Q}{nC_v}$
$= \frac{Q}{n\,5/2\,R}$.
$= \frac{60}{2 \times 5/2 \times 8.31} = 0.9K$.
∴ The temperature of a gass = 0.9K

Extract 5.1: *A sample of the incorrect responses to Question 5 in Paper 1*

In Extract 5.1 the candidate provided types of thermodynamic processes as evidence for the validity of the first law of thermodynamics. He/she also stated the Wien's displacement law instead of explaining the effect occurred on a black body when constantly heated.

Despite the weak performance on the question, a further analysis indicates that the candidates who scored good marks (7.9%) demonstrated a good understanding of thermal radiation and thermodynamics. For example, in part (a), most of them showed how the first law of thermodynamics obeys the law of conservation of energy. Similarly, they applied Wien's displacement law in part (b) (i) to explain the effect occurred on a black body when constantly heated. Extract 5.2 illustrates a good response.



5. (a) First law of thermodynamics is validity. Since it obeys the Law of Conservation of Energy. ie That is energy is Conserved.

Heat supplied = Internal Energy + External workdone.

(b) (i) Wien's displacement law.

$\lambda \propto \frac{1}{T}$.

So when the black body is ~~Constantly~~ constantly heated its wavelength will be shifting on decreasing and its black colour slightly changes to brown.

5 (b) (ii) Data

amount of heat supplied (Q) = 60J.

Number of Moles (He) = 2moles.

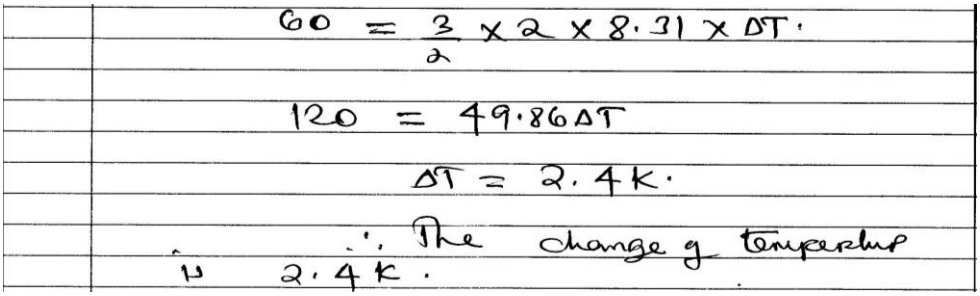
From;

$Q = \Delta U + P\Delta V$.

Since Constat Vlue $P\Delta V = 0$.

$Q = n C_V \Delta T$. but for helium $C_V = 3/2 R$.

$Q = \frac{3}{2} n R \Delta T$.



Extract 5.2: *A sample of the good responses to Question 5 in Paper 1*

In extract 5.2, the candidate correctly applied the formulae and procedures in parts (a) and (b) (i & ii).

2.1.6 Question 6: Thermal Conduction

Part (a) required the candidates to explain (i) why it is preferred to purchase a cooking utensil of low specific heat capacity and (ii) how a fish survives in a pond during an extreme winter season even if the pond is deep frozen on the surface. In part (b), it was given that the ice on a pond is 10 mm thick. If the temperature above and below its surfaces are 263 K and 273K respectively, calculate the rate of heat transfer through the ice.

A total of 17,044 (100%) candidates responded to the question and the distribution of their performance is illustrated in Figure 6.

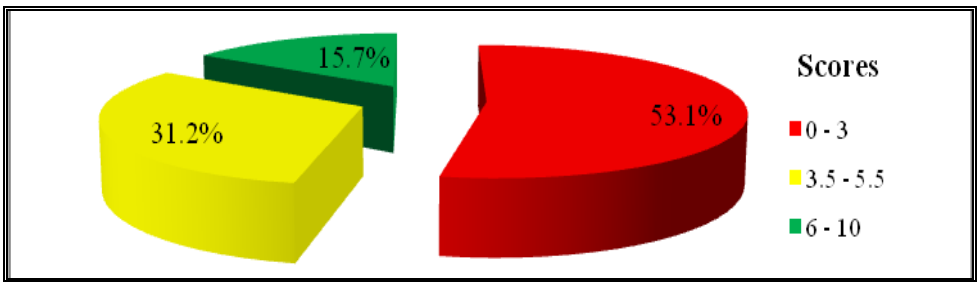
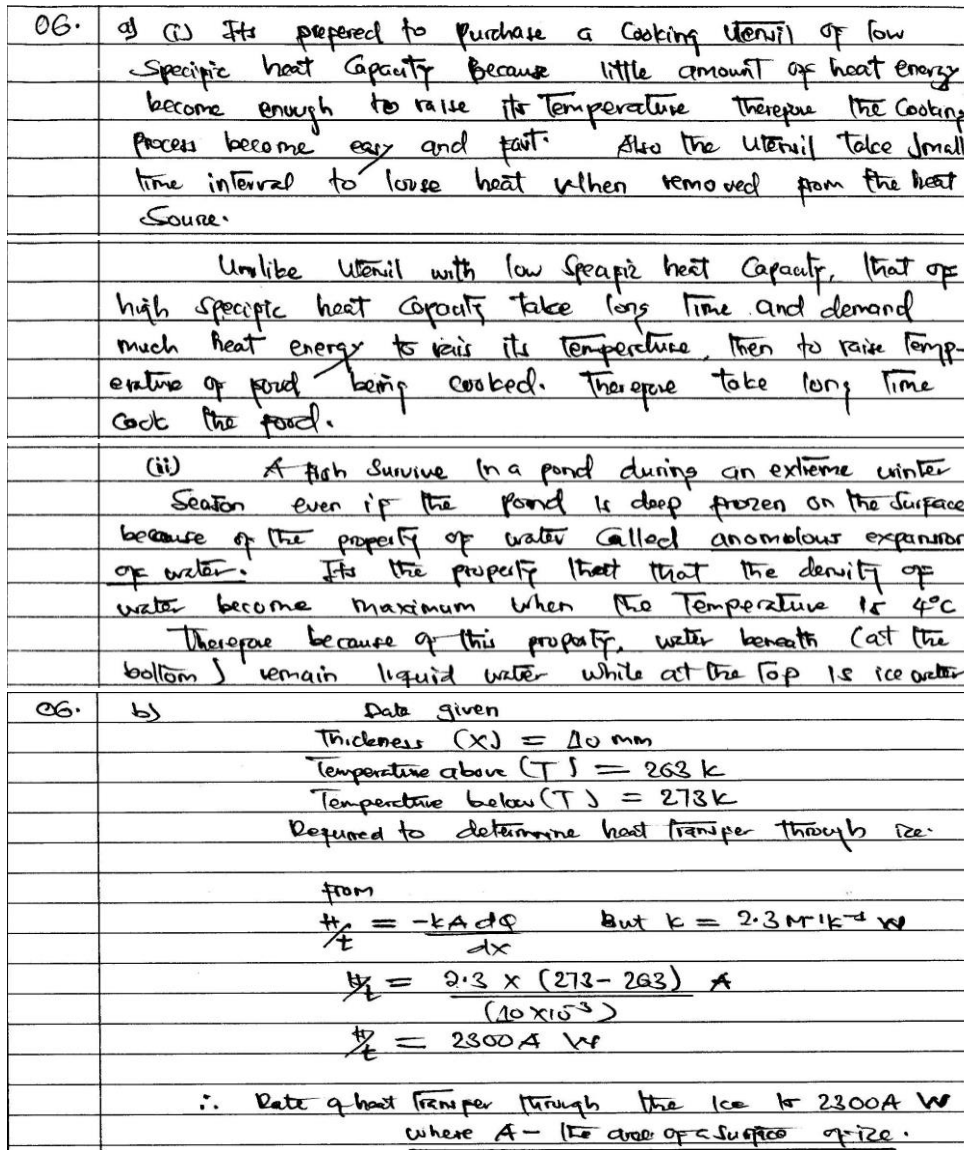


Figure 6: *Distribution of **the** candidates' scores on Question 6*

Figure 6 shows that the performance on this question was average since 46.9 per cent scored from 3.5 to 10 marks while 53.1 per cent scored below 3.5 marks.

The analysis of good performance (15.7%) show that most of such candidates managed to apply the Kinetic theory of matter to describe the application of thermal conduction in domestic activities. These candidates

gave correct reasons why it is preferred to purchase a cooking utensil of low specific heat capacity and how a fish survives in a pond during an extreme winter season. However, few of them failed to apply coefficient of thermal conductivity under a steady state condition to determine the rate of heat flow through ice. Extract 6.1 presents a correct response.


06. a) (i) Its prefered to purchase a Cooking Utenvil of low Specipic heat Capacity Because little amount of heat energy become enough to raise its Temperature therepore the Cooking Process become easy and fast. Also the Utenvil Take small time interval to loose heat when removed from the heat Source.

Unlike Utenvil with low Speapic heat Capacity, that of high specipic heat Capacity take long time and demand much heat energy to rais its temperature, then to raise Temperature of food being cooked. Therepore take long time cook the food.

(ii) A fish Survive in a pond during an extreme winter Seaton even if the pond is deep frozen on the surface because of the property of water Called anomalous expansion of water. Its the property that that the denvity of water become maximum when the Temperature is 4°C. Therepore because of this property, water beneath (at the bottom) remain liquid water while at the top is ice water

06. b) Data given

Thickness (x) = 10 mm

Temperature above (T) = 263 K

Temperature below (T) = 273K

Required to determine heat transfer through ice.

from

$\frac{H}{t} = \frac{-kA\,d\theta}{dx}$ but $k = 2.3\ M^1K^{-1}\ W$

$\frac{H}{t} = \frac{2.3 \times (273-263)\ A}{(10 \times 10^{-3})}$

$\frac{H}{t} = 2300A\ W$

∴ Rate of heat transfer through the ice is 2300A W where A – the area of surface of ice.

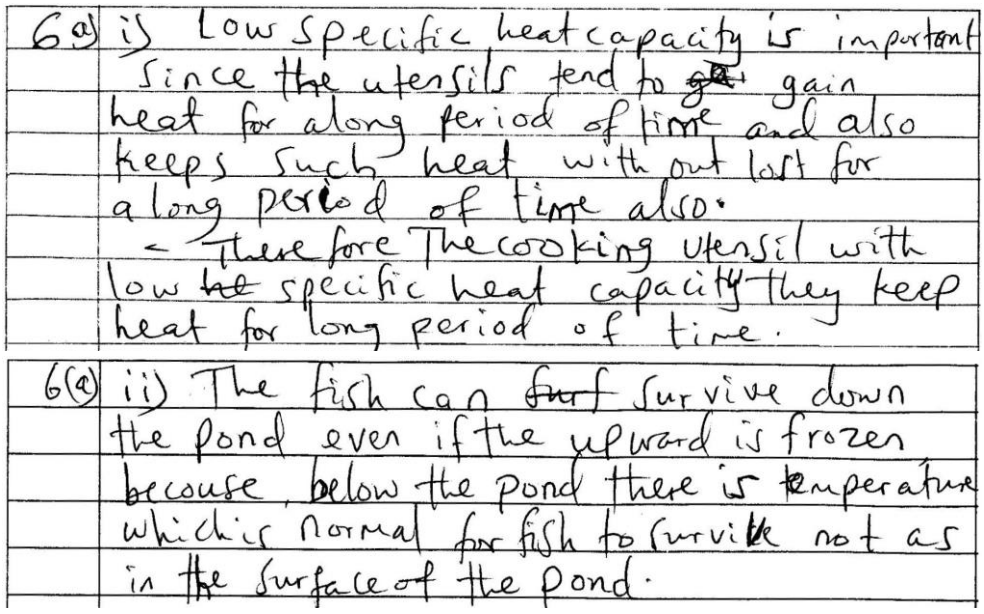
Extract 6.1: *A sample of the correct responses in Paper 1*

Extract 6.1 shows that the candidate correctly explained why cooking utensils of low specific capacity are more preferred and how a fish can

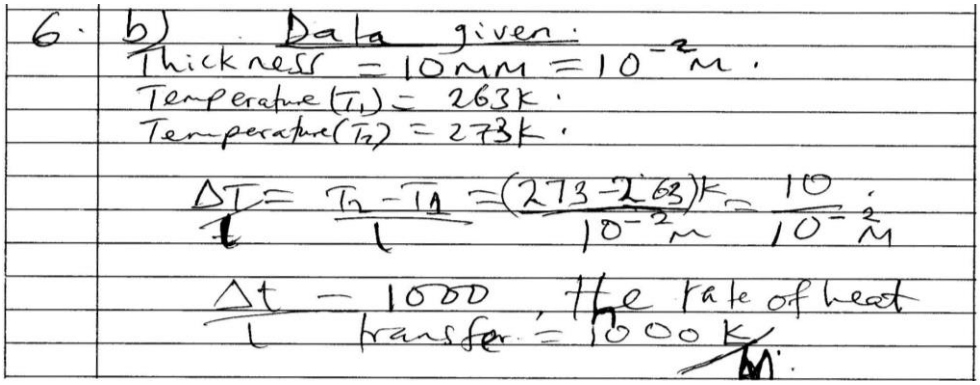
survive in frozen water. He/she also managed to apply the correct formula to find the rate of heat flow.

However, more than a half (53.1%) of the candidates scored below 3.5 marks. The analysis on the scripts of those who scored 0 marks (11.7%) show that they failed to provide correct answers due to inadequate knowledge of heat transfer particularly of thermal conduction. For example one candidate explained that *'a cooking utensil of low specific heat capacity can increase heat energy to higher amount and therefore increase the wastage of heat to the surrounding'*. Such a candidate lacked the knowledge that a cooking utensil of low specific heat capacity is preferred to ensures that little heat is used to raise its temperature; therefore, more heat would be transferred to the vessel.

Another observed challenge was to apply the concept of anomalous expansion of water. They faced difficulty in explaining how the fish survives in a deep frozen pond. For instance, one candidate wrote *'the fish survive in deep frozen pond because it does not allow internal heat to leave in water by convection by using its scales and also a fish absorb a lot of oxygen and store at gills'*. In fact, during an extreme winter season, the temperature at the surface of water is about 0 ^{0}C due to low density while at the bottom it remain 4 ^{0}C because of high density. Therefore fish sinks to the bottom for it to survive. Extract 6.2 illustrates an example of the poor responses.


6(a) i) Low specific heat capacity is important since the utensils tend to gain heat for along period of time and also keeps such heat with out lost for along period of time also.
← Therefore The cooking utensil with low specific heat capacity they keep heat for long period of time.

6(a) ii) The fish can survive down the pond even if the upward is frozen because, below the pond there is temperature which is normal for fish to survive not as in the surface of the pond.



Extract 6.2: *A sample of the incorrect responses in Paper 1*

In Extract 6.2, the candidate provided incorrect responses in part (a). In part (b), he/she applied the wrong formula to determine the rate of heat flow.

2.1.7 Question 7: Environmental Physics

This question had two parts: (a) and (b). Part (a) required the candidates to elaborate (i) two solutions for thermal pollution and (ii) three disadvantages of tidal energy. In part (b), they were required to identify three constituents of outer zone of the earth.

The question was attempted by 17044 (100%) candidates. The performance on the question was average since 53.9 per cent scored above 3 marks. The percentage of the candidates who scored from 0 to 3 marks was 46.1. These data are summarised in Figure 7.

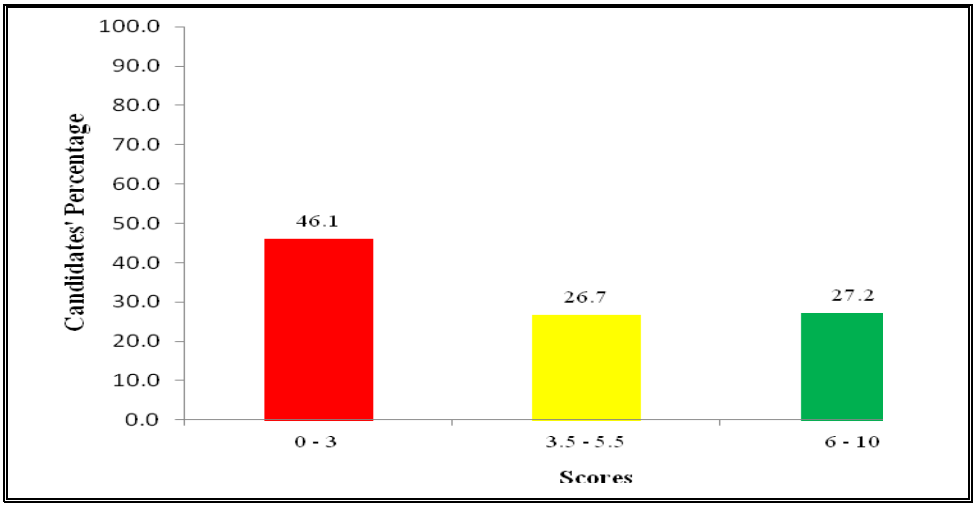
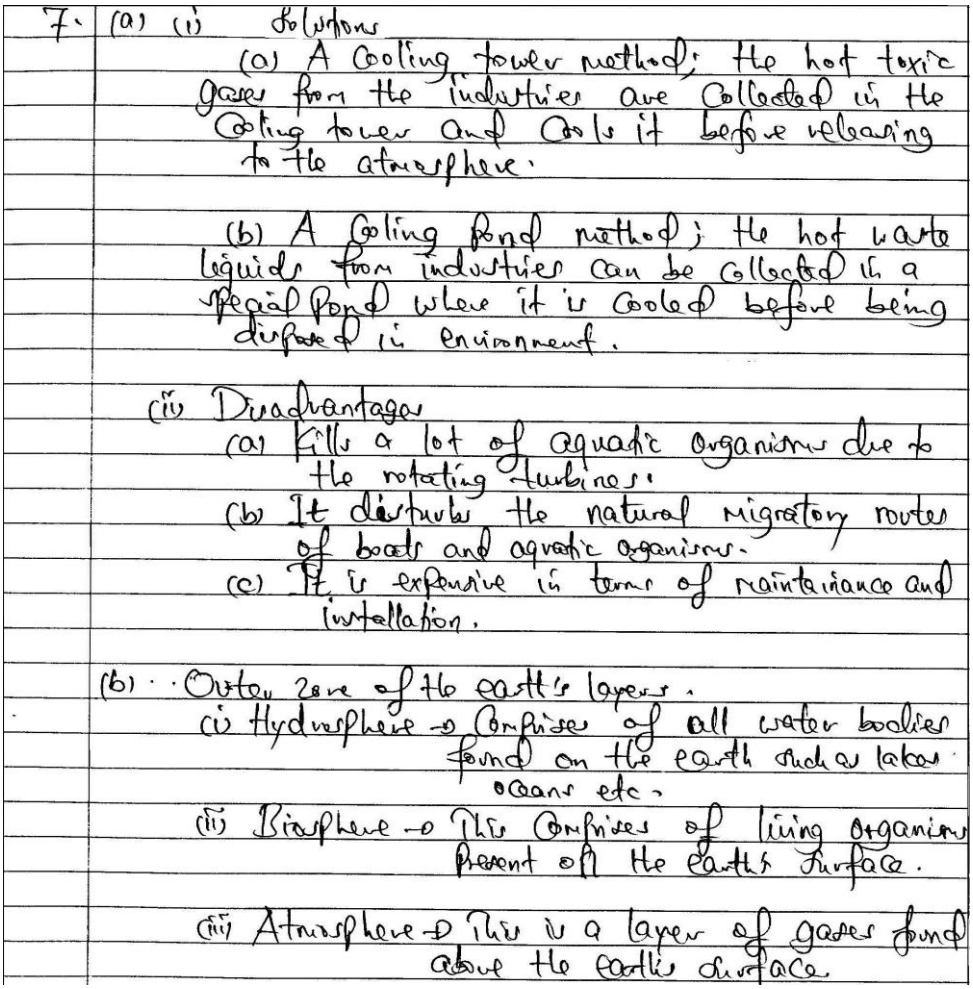


Figure 7: *Distribution of candidates' scores on Question 7 in Paper 1*

Data analysis reveals that, the overall performance on this question was average as 53.9 % of the candidates scored 3.5 marks or above. The candidates who scored high marks (27.2%) had a good understanding of environmental pollution and the effects caused by wave energy (tidal energy) to humankind. Most of these candidates competently elaborated the methods of controlling pollutants in the environment and the disasters caused by tidal energy. However, some of those who scored 3.5 to 5.5 marks (26.7%) failed to classify three components of outer zone of the earth and its contents. Extract 7.1 is a sample of the correct responses.


7. (a) (i) Solutions
(a) A cooling tower method; the hot toxic gases from the industries are collected in the cooling tower and cools it before releasing to the atmosphere.

(b) A cooling pond method; the hot waste liquids from industries can be collected in a special pond where it is cooled before being disposed in environment.

(ii) Disadvantages
(a) Kills a lot of aquatic organisms due to the rotating turbines.
(b) It disturbs the natural migratory routes of boats and aquatic organisms.
(c) It is expensive in terms of maintenance and installation.

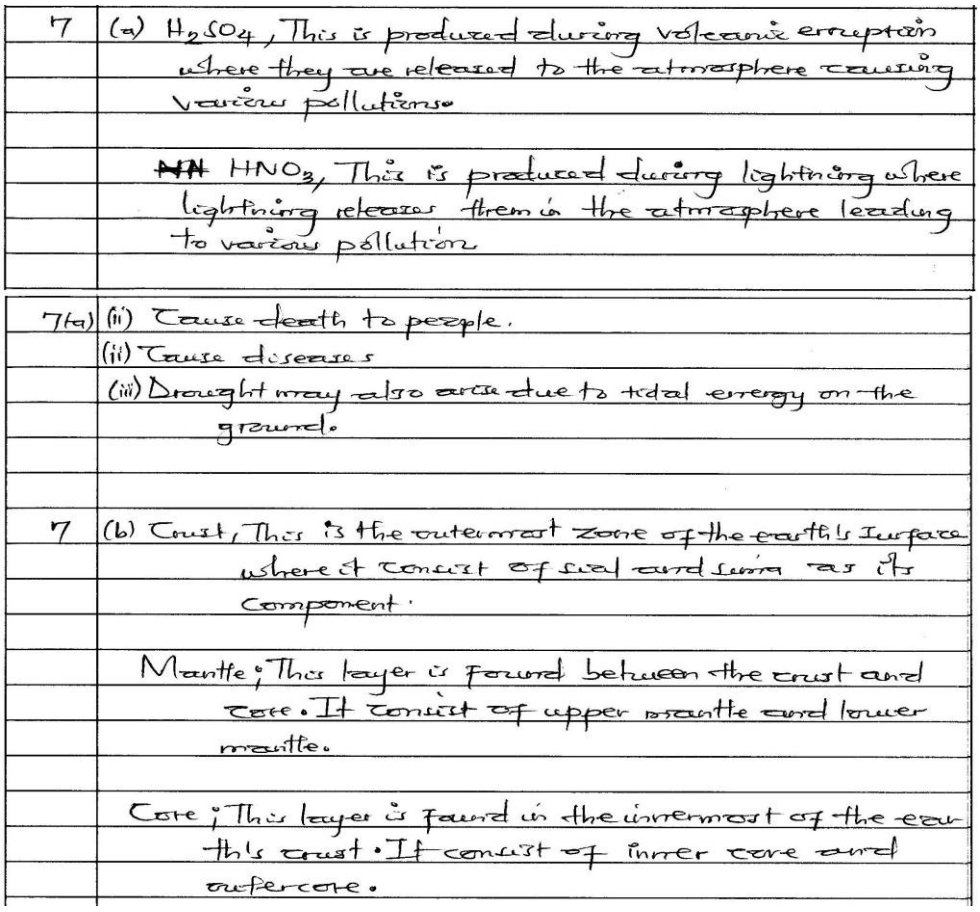
(b) Outer zone of the earth's layers.
(i) Hydrosphere → Comprises of all water bodies found on the earth such as lakes oceans etc.
(ii) Biosphere → This comprises of living organisms present on the earth's surface.
(iii) Atmosphere → This is a layer of gases found above the earth's surface.

Extract 7.1: *A sample of the correct responses in Paper 1*

In Extract 7.1, the candidate provided the correct solutions for thermal pollution, demerits of tidal energy to the environment, and three constituents of outer zone of the earth.

Despite the average performance on the question, some of the candidates (46.1%) scored from 0 to 3 as they gave incorrect responses to most parts of the question. In part (a), for example, instead of providing ways of controlling thermal pollution, one candidate incorrectly wrote gases like H_2SO_4 and HNO_3, which pollute the environment. This candidate lacked knowledge of the types of environmental pollutants and their methods of disposal.

A further loss of marks in this question was attributed to inadequate competences in the concepts of energy from the environment where many candidates (10.4%) scored 0 marks. These candidates failed to assess the hazards of energy from sea wave to the environment. For instance, one candidate mentioned three disadvantages of tidal energy: *it cause diseases*, *migration of people* and *heavy rain*. Extract 7.2 shows an incorrect response to the question.


7 (a) H_2SO_4, This is produced during volcanic erruption where they are released to the atmosphere causing various pollutions.

~~NN~~ HNO_3, This is produced during lightning where lightning releases them in the atmosphere leading to various pollution

7(a) (ii) Cause death to people.
(ii) Cause diseases
(iii) Drought may also arise due to tidal energy on the ground.

7 (b) Crust, This is the outermost zone of the earth's surface where it consist of sial and sima as its component.

Mantle; This layer is found between the crust and core. It consist of upper mantle and lower mantle.

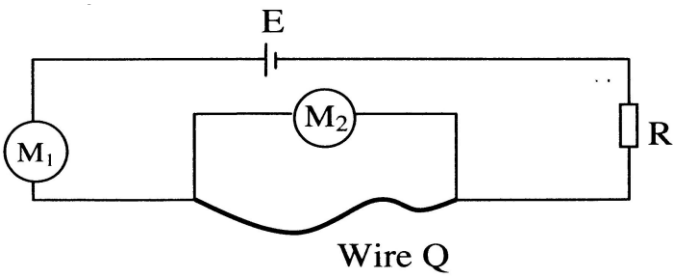
Core; This layer is found in the innermost of the earth's crust. It consist of inner core and outercore.

Extract 7.2: *A sample of the incorrect responses in Paper 1*

In Extract 7.2, instead of giving measures of controlling thermal pollution the candidate wrote ammonium (HNO_3) and hydrogen sulphate (H_2SO_4) gases, which are not environmentally friendly. In part (b), the candidate wrote *crust, mantle* and *core* which are inner parts of the earth instead of hydrosphere, atmosphere and biosphere as required by the question.

2.1.8 Question 8: Current Electricity

This question had three parts: (a), (b), and (c). In part (a), the candidates were required to (i) state how a step-up transformer differs from a step-down transformer and (ii) explain why the transmission of electricity is always done at the highest possible voltage. Part (b) (i) required the candidates to find the value of the resistance required to give a charging current of 2 A on an accumulator of e.m.f 50 V and internal resistance 2 Ω when it is charged on a 100 V d.c source. In part (b) (ii), the candidates were given a figure which shows a circuit for measuring the resistance of wire Q which is kept at a constant temperature. Then, they were required to identify the devices labelled M_1 and M_2 and state their functions.



Figure

Part (c) required the candidates to (i) explain why alloys are used for making standard resistance coils and (ii) determine the temperature coefficient of resistance and its resistance at $0\,^0C$ of a coil of wire of resistance 10.8 Ω at 20 ^{0}C and 14.1 Ω at 100 ^{0}C.

A total of 7,978 (46.8%) candidates answered this question. Among them, 50.8 per cent scored from 0 to 5 marks; 33.5 per cent scored from 5.5 to 8.5; and 15.7 per cent scored from 9 to 15 marks. These data reveal that the general performance on this question was average. Figure 8 summarizes these results.

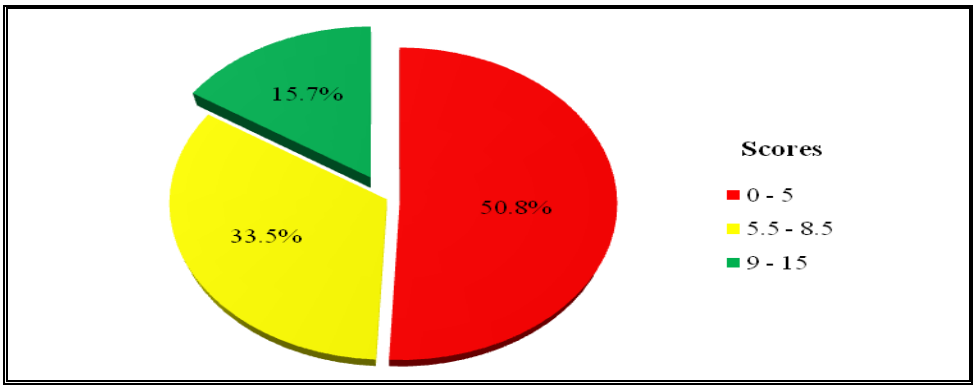


Figure 8: *The candidates' performance on Question 8 in Paper 1*

According to the analysed responses from the scripts, the candidates who scored good marks (15.7%) correctly analysed the mechanisms for electric conduction in metals. They stated correctly how a step-up transformer differs from a step-down transformer and the reason behind the transmission of electricity always being done at the highest possible voltage. Moreover, they studied the given circuit diagram and correctly identified the names of devices labelled M_1 and M_2 with their functions.

A further analysis show that the candidates who scored average marks (5.5 - 8.5) managed to provide the correct responses for part (a) and (b), but they failed to investigate the temperature coefficient of resistance and hence the resistance. Extract 8.1 is one of the correct responses to the question.

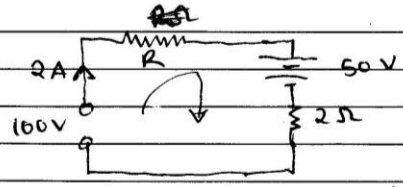
8	a)	
	Step-up transformer	Step down transformer
i)	Have higher number of turn of secondary than that of primary	Have higher primary number turn compare to that of secondary
ii)	secondary voltage is greater than that of primary voltage	primary voltage is greater than that of secondary voltage

ii) From

$P = I^2 R$.

The power is transmitted at higher voltage so as to decreases the value of current which will reduces the power losses in the cable which depend on I^2

b) i)



apply Kirchoff voltage law

$100 - IR - 50 - 2I = 0$

$IR = 100 - 50 - 2I$

$R = \frac{100 - 50 - 2I}{I} = \frac{100 - 50 - 4}{2}$

$R = 23\Omega$

8 b) ii)

M_1 – Ammeter
used to measure current.

M_2 – voltmeter
used to measure voltage.

c) i) – This because alloys has very small temperature coefficient of resistance.

– It has ver high resistivity.

ii)

from

$R = R_0 (1 + \alpha\theta)$.

$R_1 = R_0 (1 + \alpha\theta_1)$

$R_2 = R_0 (1 + \alpha\theta_2)$

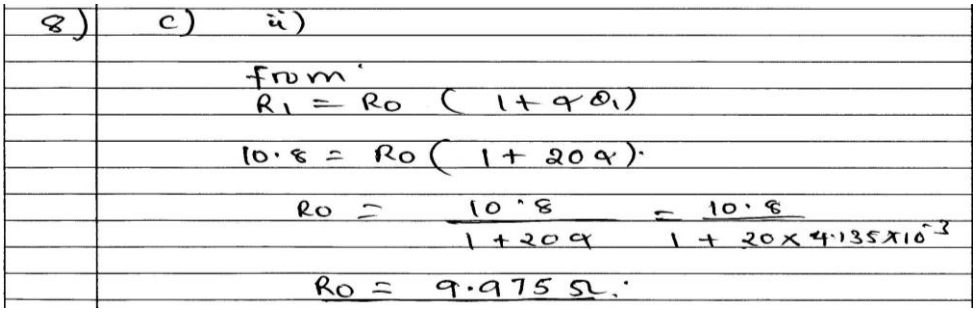
$\frac{R_1}{R_2} = \frac{1 + \alpha\theta_1}{1 + \alpha\theta_2}$

$\frac{10.8}{14.1} = \frac{1 + 20\alpha}{1 + 100\alpha}$.

$10.8 + 1080\alpha = 14.1 + 282\alpha$

$798\alpha = 3.3$

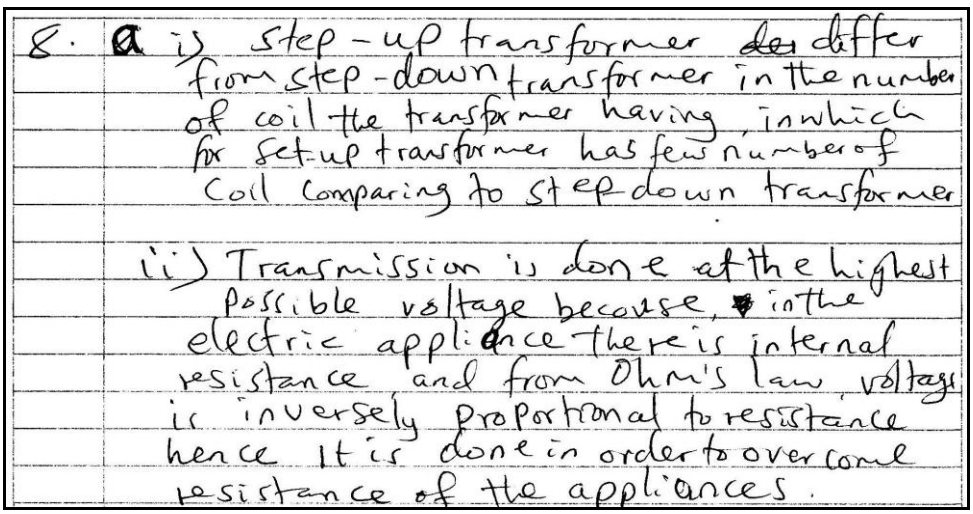
$\alpha = 4.135 \times 10^{-3}\ \Omega/^\circ C$



Extract 8.1: *A sample of the correct responses in Paper 1*

In Extract 8.1, the candidate correctly provided distinctive characteristics between the two types of transformers, systematically analysed electrical networks and deduced Kirchhoff's voltage law to determine the required resistances and temperature coefficient of resistance. He/she also identified the devices and stated their functions.

Among the 50.8 percent of the candidates who scored (0 - 5) marks, 5.2 percent scored 0 marks. These candidates lacked knowledge of electric conduction in metals. Others faced challenges in attempting parts (b) and (c). In part (b), they failed to understand the concept of charging and the skills in how the ammeter (M_1) and the voltmeter (M_2) are connected in the circuit. Accordingly they confused the names of these two devices. In part (c), most of them failed to understand that alloys are suitable for making standard resistance coils because they have high resistivity and low value of temperature coefficient of resistance. Moreover, instead of applying Kirchhoff's laws to determine the values of resistance they used Ohm's law. Extract 8.2 represents a sample of the incorrect responses to the question.



8 b) i) Data given,
accumulator e.m.f = 50 V.
d.c source e.m.f = 100V.
Resistance = ?
current required = 2A.

but from, $V = IR$.

$R = \frac{V}{I} = \frac{50}{2} = 25\Omega$.

ii) To identify the device.

M_1 = voltmeter which is used to measure e.m.f produced by the current source.

M_2 = Glavanometer, which is Purposely to Show polarization of the Current.

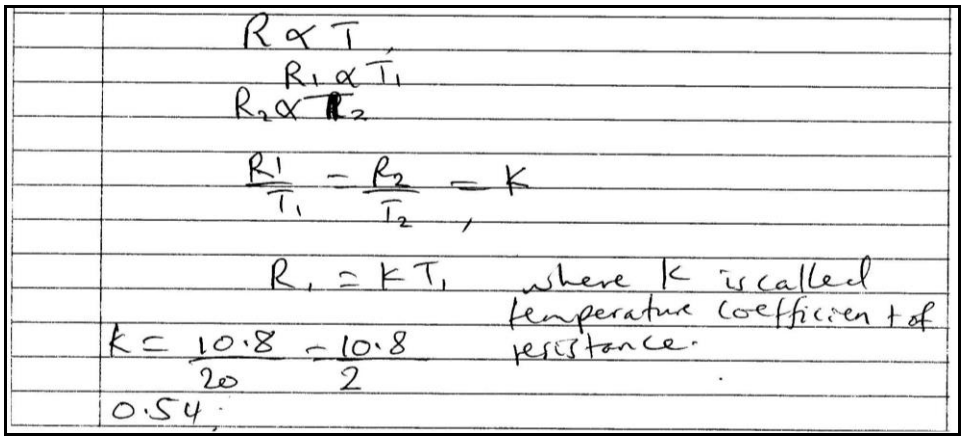
8 c (i) Alloys are used purposely do not have specific and fixed resistance but all the metals in an alloys expresses their resistance hence such modifies and offers the standardized resistance.

8c ii) Data given.

Resistance(R_1) = 10.8 Ω
temperature(T_1) = 20 °C.
Resistance(R_2) = 14.1 Ω
Temperature(T_2) = 100 °C.
Temperature at 0°C the resistance will be = ?

But is known that,

Resistance(R) ∝ Temperature(T)

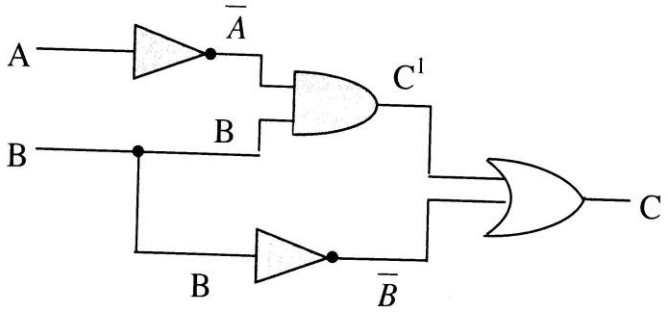


Extract 8.2: *A sample of the incorrect responses in Paper 1*

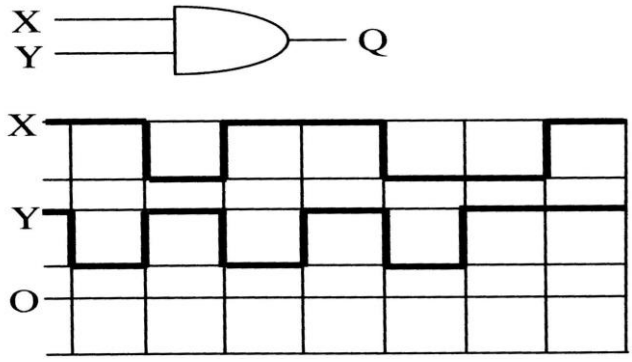
In Extract 8.2, the candidate partially stated the difference between the step-up transformer and the step-down transformer for item (a) (i) and applied incorrect formulae in parts (b) and (c). Therefore, he/she obtained the wrong responses.

2.1.9 Question 9: Logic Gates

Part (a) required the candidates to state the function of (i) digital circuit and (ii) integrated circuit. In part (b), the candidates were required to (i) identify three basic logical gates that make up all digital circuits and (ii) construct the truth table from the logic gates shown in the following figure.



In part (c), the candidates were given a figure which shows a circuit symbol of a logic gate and two input waveforms, X and Y, as follows:



The candidates were then required to (i) give the name of the circuit symbol and (ii) sketch the output waveform Q.

The question was answered by 15,889 candidates, which correspond to 93.2 per cent. The analysis reveals that 38.9 per cent of the candidates scored from 9 to 15 marks; 47.7 per cent scored from 5.5 to 8.5; and 13.4 per cent scored from 0 to 5 out of 15 marks. These data are summarised in Figure 9.

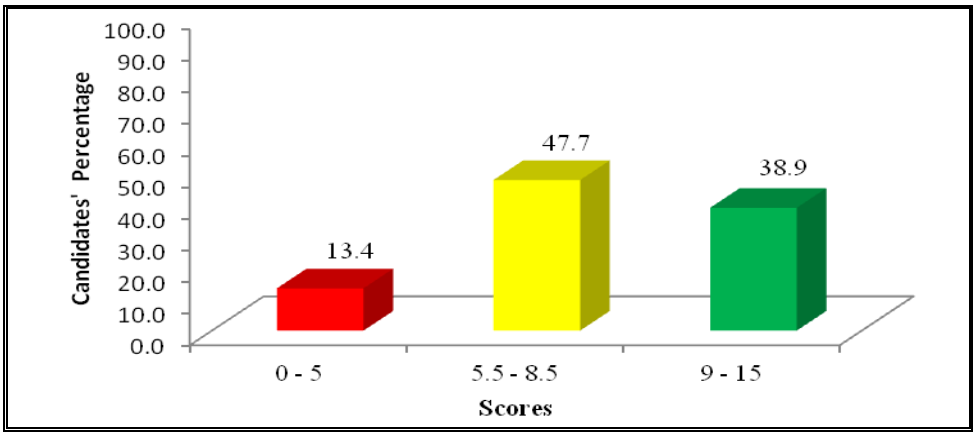


Figure 9: *Distribution of the candidates' scores on Question 9, in Paper 1*

Figure 9 indicates that the general performance of the candidates on this question was good since 86.6 per cent of the candidates scored 5.5 to 15 marks.

The candidates who scored good marks (38.9%) stated the roles of digital and integrated circuits in electronic systems. They also identified the basic types of logic gates and applied Boolean Algebra to analyse the given logic circuit and create logical truth table. In addition, about 1.2 per cent corresponding to 195 candidates, scored (14.5 - 15) marks. These

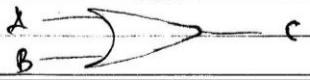
candidates showed their competence in part (c) where they correctly described two input waveforms X and Y to identify the output waveform Q. Extract 9.1 illustrates a sample of the correct responses.

9 (a) (i) Digital circuits are used to perform discrete operations, since they operate in form of 0 and 1. Simply, digital circuits performs binary operations.

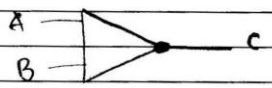
(ii) Integrated circuit are used in performing many operations at once since they contain alot of components in them. They can behave as switch, amplifier.

9 (b) (i) AND-gate.

OR-gate.



9 (b) (i) NOT-gate.

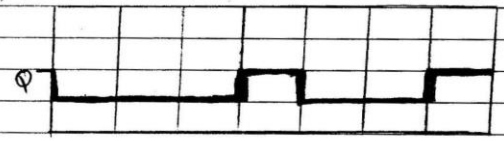


9 (b) (ii)

A	B	$\bar{A}$	$\bar{B}$	C	C
0	0	1	1	0	1
0	1	1	0	1	1
1	0	0	1	0	1
1	1	0	0	0	0

9 (c) (i) The circuit symbol represents an ~~fan~~ AND-gate

(ii)

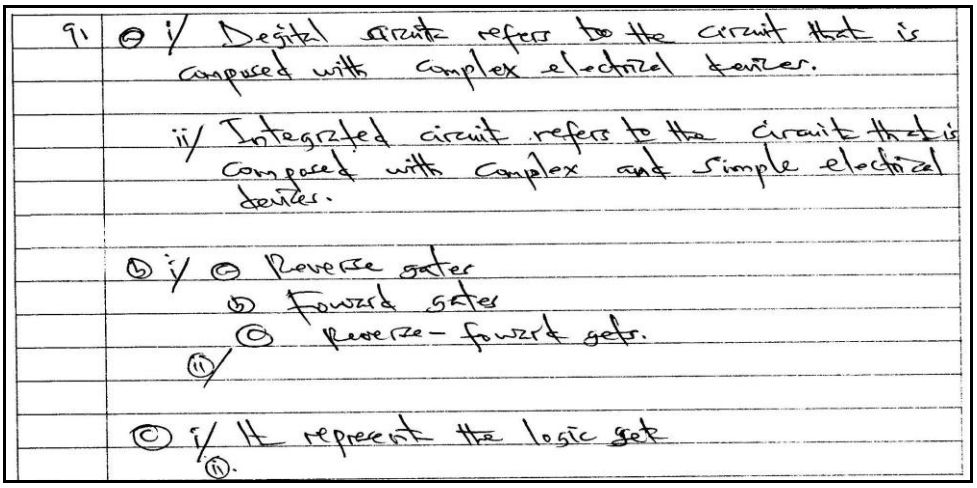


Q is affected by logical connection AND where it is only 1 when both input and output are one (on).

Extract 9.1: *A sample of the correct responses in Paper 1*

Nevertheless, 13.4 per cent of the candidates scored low (0 - 5) marks. Most of these candidates had a misconception between digital circuit and integrated circuit in part (a). Therefore, they failed to state its functions. Some of them also faced challenges in part (b) where they failed to construct the truth table from the given logic gates due to poor knowledge of applying Boolean operations. Furthermore, instead of identifying OR, AND and NOT as the basic logic gates, some wrote NAND and NOR gates which are combinations of the basic gates.

Part (c) was the most difficult to many candidates in this group. They failed to analyse the logic circuit due to two input waveforms, X and Y to sketch the output waveform, Q. Extract 9.2 presents a sample of the incorrect responses.



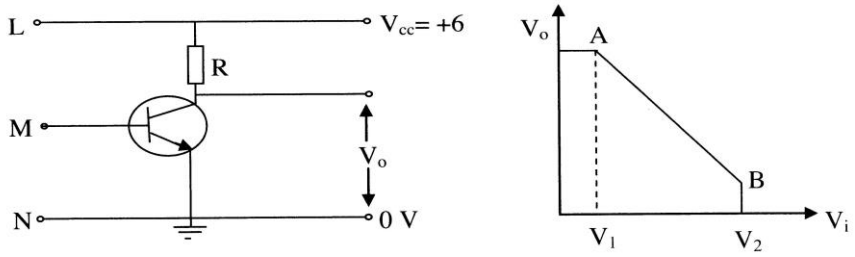
Extract 9.2: *A sample of the incorrect responses in Paper 1*

In Extract 9.2 the candidate failed to clarify the roles of digital and integrated circuits. In addition, he/she provided incorrect responses to other parts of the question.

2.1.10 Question 10: Operational Amplifiers

Part (a) of this question required the candidates to (i) identify four important properties of semiconductor and (ii) find the donor concentration given that the mobility of electrons is 0.39 m^2/volt sec and the resistivity of n-type germanium at room temperature is 0.01 Ω m. Part (b) required the candidates to (i) give the output voltage of the circuit diagram in the

following figure when L is connected to M and (ii) explain how the circuit can be used as a switching circuit.



In part (c), the candidates were required to briefly explain the transfer characteristic of operational amplifier.

Data analysis reveals that 10,219 candidates, equivalent to 60 per cent attempted this question. Among them, 77.6 per cent scored from 0 to 5 marks; 19.6 per cent scored from 5.5 to 8.5 marks; and 2.8 per cent scored from 9 to 15 marks. These scores imply that the candidates' performance on this question was weak. Figure 10 summarizes the statistical analysis of this question.

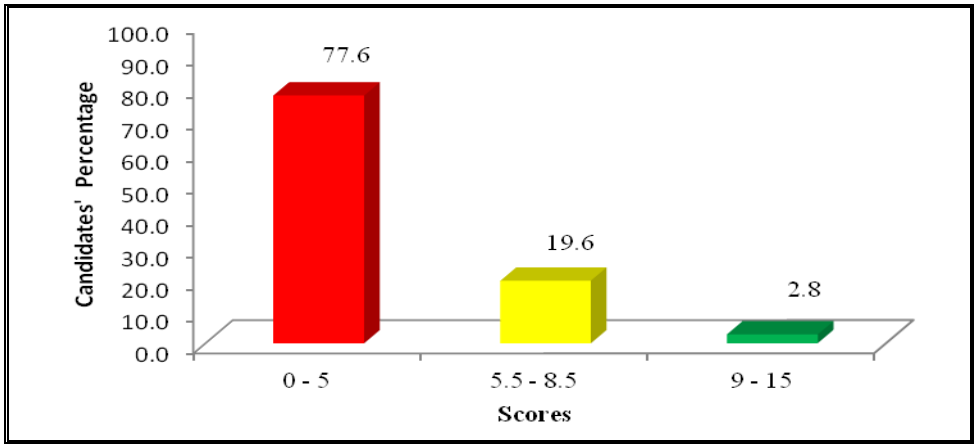


Figure 10: *Distribution of the candidates' scores on Question 10 in Paper 1*

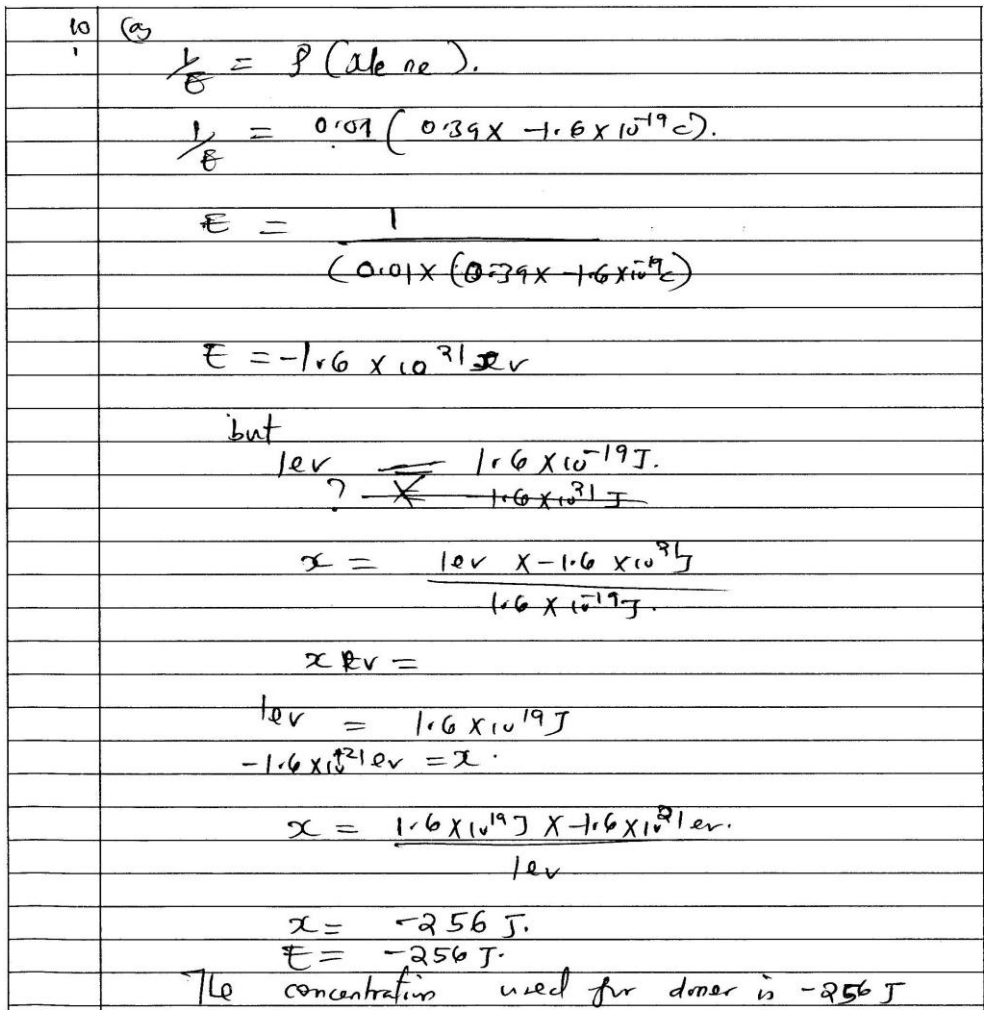
Figure 10 shows that a large number of candidates (77.6%) scored from 0 to 5 marks. One of the factors noted to affect performance was their lack of adequate knowledge about semiconductors and transistors. Most of these candidates faced difficulty in identifying the relationship between resistivity and conductivity. Hence they failed to determine the donor concentration. For illustration, one of the candidates wrote,

"semiconductors are transparent in nature, allows partially light to pass through". Besides, in part (b), most of them did not understand how the transistor can be used as a switch. Moreover, in part (c), they failed to describe the transfer characteristic of the operational amplifier. Extract 10.1 is a sample of the incorrect responses.

10 (a) four important of semiconductor.
(i) Semiconductor used for measure impurity of particle.
(ii) Semiconductor used for measure current in the circuit
(iii) Semiconductor. Determine the nature of the material eg.
Silicon, get germanium
(iv) Semiconductor either good conduct heat and of
Electricity one wing Conductor.

(b) Data given

Resistivity (ρ) = 0.01 Ωm
donen donor concentration = ?
mobility of electron is 0.39 m²/volts
μ_e = 0.39 m²/volts.
$n_e = -1.6 \times 10^{-19} C$
$\rho = \frac{\Delta R}{L}$
for n-type their have large
excesive electron comparated to hole
$n_e >>> n_h$.
$n_h \approx 0$.
$\rho = E(\mu_e n_e + n_h \mu_h)$
$n_h =$
$\frac{1}{\rho} = E(\mu_e n_e)$
$E =$
$\frac{1}{E} = \rho(\mu_e n_e)$



Extract 10.1: *A sample of the incorrect responses in Paper 1*

In Extract 10.1 the candidate provided incorrect properties of semiconductors and used wrong formula to determine the donor concentration and output voltage.

Further, the performance of the candidates who scored average (19.6%) marks was attributed to their ability to comprehend the demand of the question in part (a). These candidates managed to state four important properties of semiconductors and calculate donor concentration based on the relationship between resistivity and conductivity. However, they failed to interpret the transistor circuit to examine the output voltage and explain how it could act as a switch.

Nevertheless, the candidates who scored good marks (2.8%) were conversant with the topic as they correctly organized and analysed the given concepts. Extract 10.2 is a sample of the correct responses to the question.

10(a) (i) - Is made up of covalent bonds.

- It has negative temperature coefficient of resistance

- Its conductivity is largely altered on the addition of the impurities

- Its conductivity lies between that of the conductors and those of insulators.

10(a) (ii)

Resistivity (ρ) = 0.01 Ωm.

conductivity of the semiconductor will be

$$\sigma = \frac{1}{\text{Resistivity}} = \frac{1}{0.01}$$

$$\sigma = 100\ \Omega^{-1}m^{-1}$$

10(a) (ii) The conductivity $\sigma = n_e \cdot \mu_e \cdot e$.

$e = 1.6 \times 10^{-19}$ c

$$n_e = \frac{\sigma}{\mu_e \cdot e}$$

$\mu_e = 0.39 m^2/V$ sec

$e = 1.6 \times 10^{-19}$

$$n_e = \frac{100}{0.39 \times 1.6 \times 10^{-19}}$$

$$n_e = 1.603 \times 10^{21}/m^3$$

donor concentration is $1.603 \times 10^{21}/m^3$

10(b) (i) When L is connected to M, the output voltage will be 0V

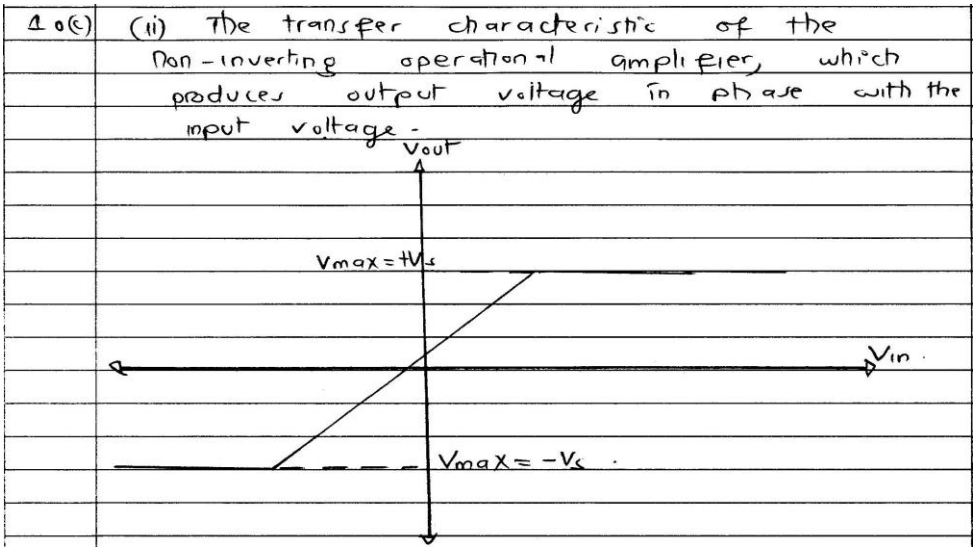
Reason: When L is connected to M, the supply voltage will provide the base bias voltage enough to produce the base current, that will cause the transistor to reach the saturation point where collector current is maximum. Thus voltage drop across R will be maximum approximately equal to V_{cc} and $V_o = 0V$.

(ii) The circuit can be used as the switching circuit, when operated in the two regions the cut-off region and saturation region, whereby at the cut-off region, M is connected to N causing base bias voltage to be zero, and thus

10(b) no flow of the base current. $I_c = \beta \cdot I_B$, the collector current will also be zero, and hence the transistor will remain in the off state.

At the saturation region, the terminal M is connected to L, causing the supply voltage to provide the base bias voltage, which is enough to cause the flow of base current and hence collector current will be maximum. Here a transistor is turned on and acts as a closed switch.

10(c) (i) The transfer characteristic of an operational amplifier is a plot of the output voltage to the input voltage of the operational amplifier



Extract 10.2: *A sample of the good responses in Paper 1*

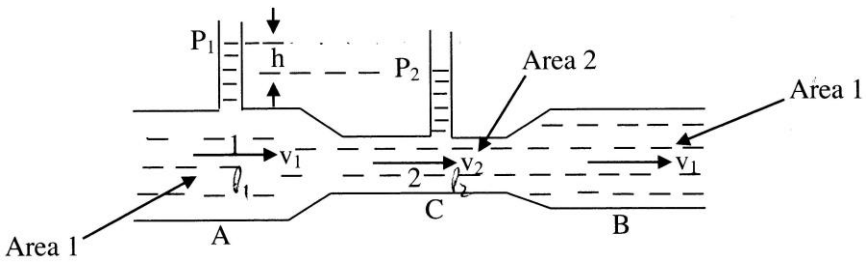
Extract 10.2 shows that the candidate was competent in the concepts of semiconductors, transistors and OP amp since he/she was neat and precise in providing the correct responses to almost all parts of the question.

2.2 131/2 Physics 2

The paper contained six (6) questions set from six topics. The topics are Fluid Dynamics, Vibrations and Waves, Properties of Matter, Electrostatics, Electromagnetism and Atomic Physics. Each question carried 20 marks. The pass mark for each question was 7 marks and above.

2.2.1 Question 1: Fluid Dynamics

This question comprised four parts: (a), (b), (c) and (d). Part (a) required the candidates to state two factors that determine the magnitude of viscous force. In part (b), the candidates were required to identify two limitations and three importance of applying Stoke's law in fluid motion. In part (c), it was given that a venture meter consists of two identical wide tubes A and B connected by a narrow tube C. The liquid enters through the wide tube A, and after passing through the narrow tube C leaves through the other wide tube B. The entire arrangement was as shown in the following figure.



The candidates were required to use Bernoulli's theorem at points 1 and 2 to show that the expression for the rate of flow of the liquid is given by $Q = A_1A_2\sqrt{\frac{2gh}{A_1^2-A_2^2}}$, where all symbols carry their usual meaning.

Part (d) required the candidates to calculate the initial speed with which the water (i) flows from the orifice and (ii) strikes the ground if the plug of area $10^{-4}m^2$ is removed by the orifice on the side bottom of the cylindrical tank of radius 1 m resting on a platform 5 m high and initially filled with water to a height of 5 m.

A total of 16,994 candidates corresponding to 99.7 per cent attempted this question. Their scores were as follows: 10.9 per cent scored from 0 to 6.5 marks; 21.1 per cent scored from 7 to 11.5 marks; and 68 per cent scored from 12 to 20 marks. Figure 11 portrays the performance of the candidates on this question.

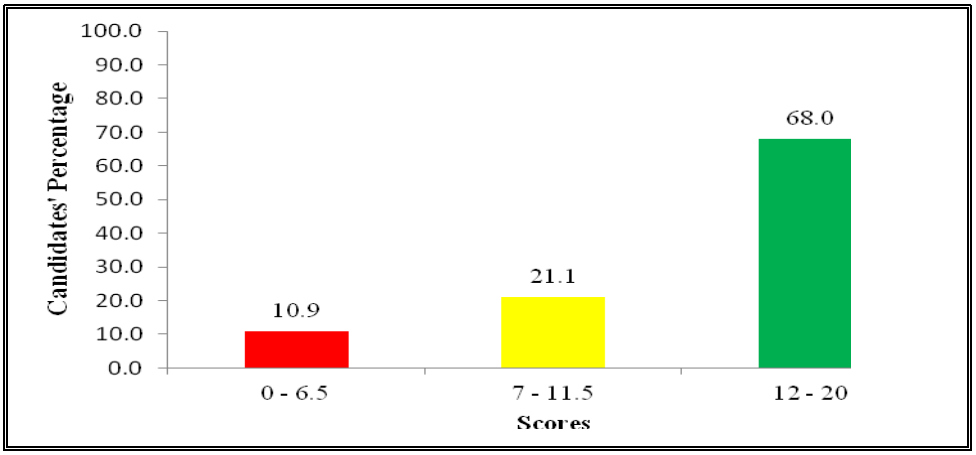


Figure 11: *Distribution of candidates' scores on Question 1 in Paper 2*

Figure 11 shows that the general performance of the candidates on this question was good since 89.1 percent of the candidates scored 7 to 20 marks.

The candidates who scored good marks (68.0%) correctly stated two factors on which the magnitude of viscous force depends. Also they identified two limitations and three importance of applying Stokes' law in fluids motion. In addition, most of them studied the venture meter diagram and used Bernoulli's theorem to analyse an expression for the rate of fluid flow. The correct responses given by the candidates signify that they understood the content and they were knowledgeable about the Fluid Dynamics. Extract 11.1 shows a sample of correct responses.

1 a) From

Viscous force $(F) = 6\pi r \eta V$

Hence;

Factors determining magnitude of viscous force are

(i) Radius of a body.

(ii) Terminal velocity with which it is falling

(iii) Nature of fluid.

(b) Limitation's of stokes's law are:-

(i) A body must be falling in a fluid of infinite extend.

(ii) A spherical body falling must be smooth and rigid

(iii) A body must fall with relatively high speed.

Importance of applying stokes' law are:-

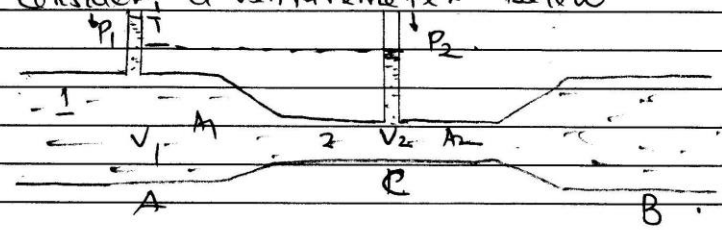
(i) It is useful in Millikan experiment when studying about charge.

(ii) It explains why large rain drops hurts more than small rain drops on hitting

(iii) It is useful in determining the radius of various spherical bodies.

c) solution

Consider a venturemeter below.



1 Where

P_1 and P_2 are pressures at wide tube and narrow tube respectively.

A_1 and A_2 are areas at wide tube and narrow tube respectively.

V_1 and V_2 are velocities at wide tube and narrow tube respectively.

h is height difference between two tube, then

From Bernoulli's equation:

$$P_1 + \rho h_1 g + \tfrac{1}{2}\rho V_1^2 = P_2 + \rho h_2 g + \tfrac{1}{2}\rho V_2^2$$

but For horizontal tube

$$h_1 = h_2 = h,$$

$$P_1 + \tfrac{1}{2}\rho V_1^2 = P_2 + \tfrac{1}{2}\rho V_2^2 \quad \text{---(i)}$$

Also

From equation of continuity

$$Q = A_1 V_1 = A_2 V_2.$$

$$V_2 = \frac{A_1 V_1}{A_2} \quad \text{---(ii)}.$$

From equation (i)

$$P_1 - P_2 = \tfrac{1}{2}\rho (V_2^2 - V_1^2)$$

$$\Delta P = \frac{1}{2}\rho (V_2^2 - V_1^2) \quad \text{---(iii)}$$

Inserting equation (ii) into (iii)

$$\Delta P = \frac{1}{2}\rho \left(\left(\frac{A_1 V_1}{A_2}\right)^2 - V_1^2\right),$$

$$\Delta P = \frac{1}{2}\rho V_1^2 \left(\frac{A_1^2}{A_2^2} - 1\right),$$

also

$$\Delta P = \rho h g.$$

then.

1

$$\rho h g = \frac{1}{2} V_1^2 \left(\frac{A_1^2 - A_2^2}{A_2^2}\right),$$

$$V_1^2 = \frac{2gh \cdot A_2^2}{A_1^2 - A_2^2},$$

$$V_1 = A_2 \sqrt{\frac{2gh}{A_1^2 - A_2^2}} \quad \text{---(iv)}$$

Also from equation of continuity

$$Q = A_1 V_1 \quad \text{---(v)}$$

Then inserting equation (iv) into (v) we get

$$Q = A_1 A_2 \sqrt{\frac{2gh}{A_1^2 - A_2^2}}$$

Where Q is Rate of flow of liquid

A_1 is area at wide tube

A_2 is area at narrow tube.

h is height difference

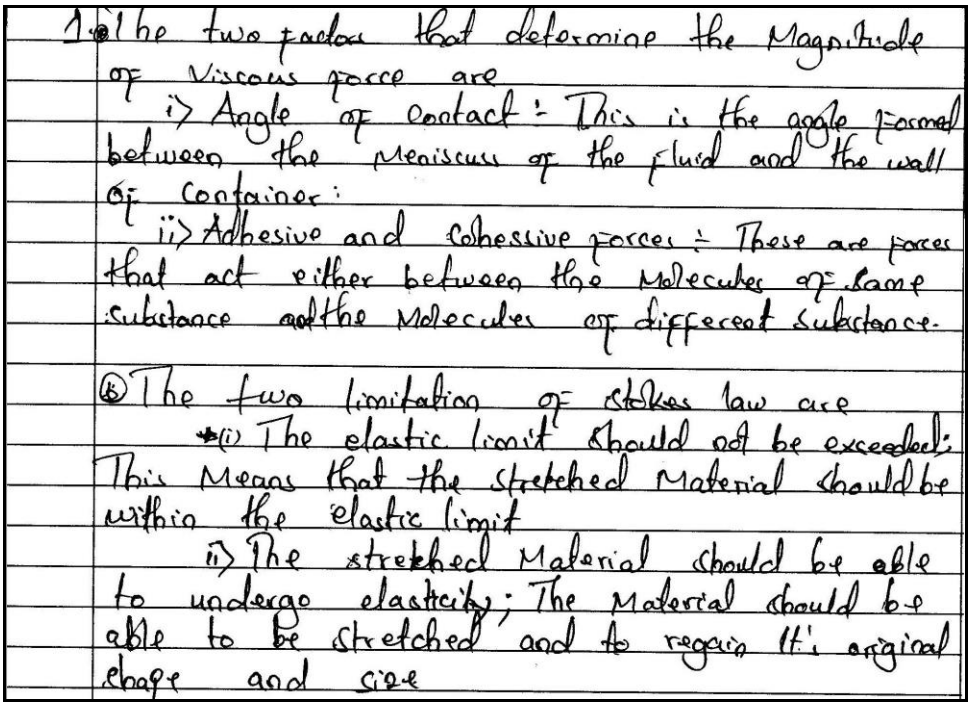
g is acceleration due to gravity

hence shown.

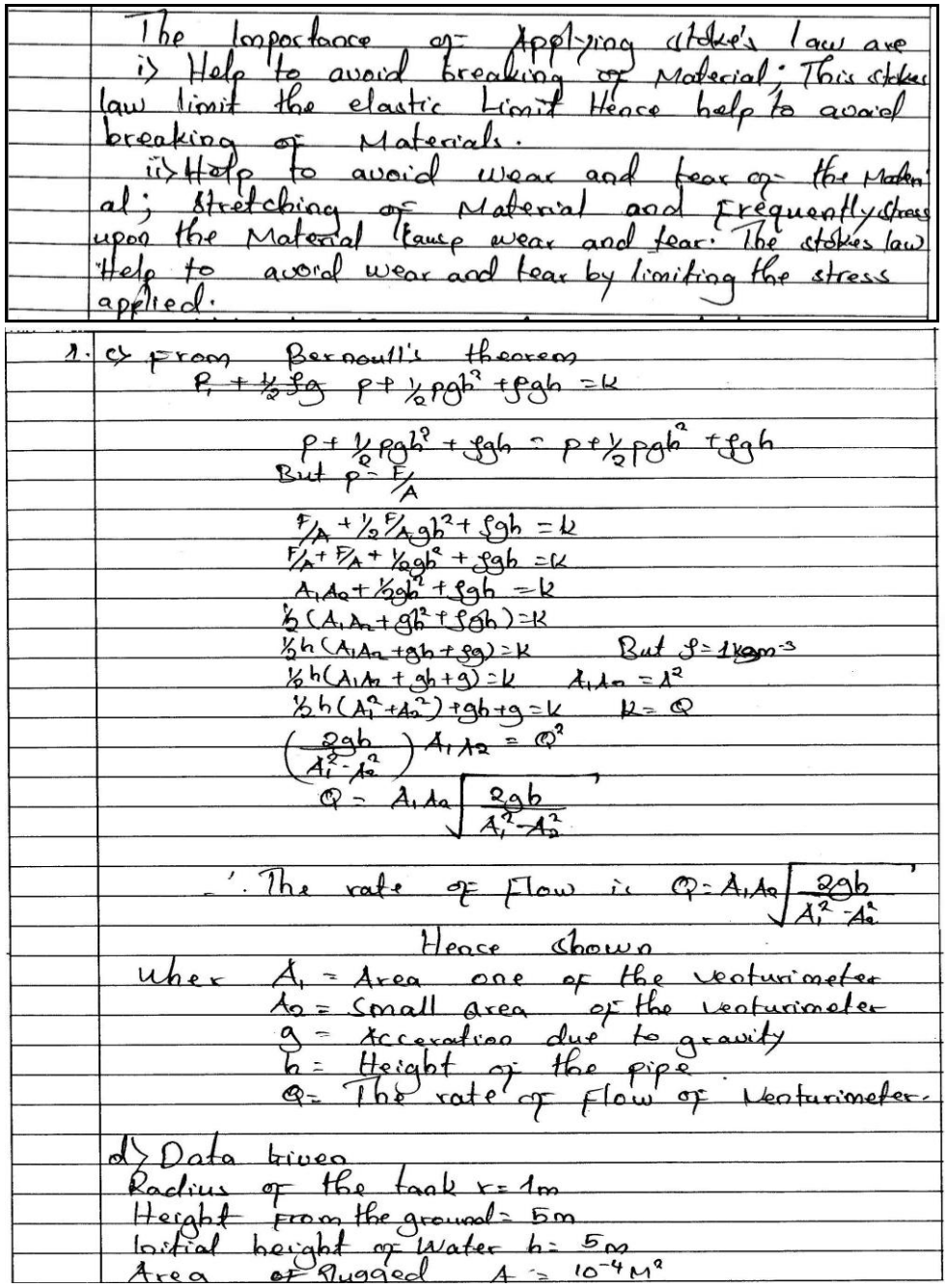
Extract 11.1: *A sample of the correct responses to Question 1 in Paper 2*

The responses in Extract 11.1 show the candidates' ability in applying Bernoulli's and continuity equations to express the formula $Q = A_1A_2\sqrt{\frac{2gh}{A_1^2-A_2^2}}$. Also in part (d) he/she applied Torricelli's theorem to obtain the correct answers.

A further analysis of the candidates' responses reveals that most of the candidates with weak (10.9%) performance had insufficient knowledge of the subtopic *Bernoulli's principle, Streamline flow and continuity*. Some of them had misconceptions such that they applied the concepts of *Properties of Matter* to answer part (a) of the question. As a result, they failed to derive an expression for the rate of fluid flow in part (c) and determine the initial speed with which water flows from the orifice and the speed it strikes the ground in part (d). The observed difficulty stems from their failure to understand that the venture meter was horizontal such that the liquid flow was horizontal ($h_1 = h_2$). In addition, they failed to identify appropriate formulae in solving problems. Some of the candidates applied Stoke's law instead of Torricelli's theorem and continuity equation ended with incorrect responses. All these responses indicate the candidates' inadequate knowledge of the tested concepts. Extract 11.2 indicates a sample of the incorrect responses.


1. (a) The two factors that determine the Magnitude of Viscous force are
i) Angle of contact: This is the angle formed between the meniscus of the fluid and the wall of container.
ii) Adhesive and cohesive forces: These are forces that act either between the Molecules of same substance and the Molecules of different substance.

(b) The two limitation of stokes law are
(i) The elastic limit should not be exceeded; This Means that the stretched Material should be within the elastic limit
ii) The stretched Material should be able to undergo elasticity; The Material should be able to be stretched and to regain it's orginal shape and size



Extract 11.2: *A sample of the incorrect responses to Question 1 in Paper 2*

In Extract 11.2, the candidate used Stoke's law to provide incorrect responses to part (a) and (b). In part (c) and (d), he/she failed to apply Bernoulli's theorem.

2.2.2 Question 2: Vibrations and Waves

Part (a) required the candidates to give the importance of (i) dextro – rotatory substance (ii) laevo-rotatory substance (iii) optically active substance (iv) double refraction in relation to the production of plane polarized light. Part (b) required the candidates to differentiate (i) polaroid from polarimeter (ii) plane of vibration from plane of polarization (iii) ordinary light from plane polarized light. In part (c), they were required to describe the construction of Nicol Prism. Part (d) required them to briefly explain the observations made with regard to the formation of fringes in Newton's ring experiment when (i) the glass plate is silvered, (ii) the sodium lamp is replaced by a white light, (iii) a few drops of a transparent liquid are introduced between the lens and the plate. In part (e), they were asked to give two factors that govern the radius of the ring in Newton's ring experiment.

The question was attempted by 7,270 candidates, which corresponds to 42.7 per cent. The analysis of data reveals that 91.1 per cent of the candidates scored from 0 to 6.5; 8.1 per cent scored from 7 to 11.5 and only 0.8 per cent scored from 12 to 20 marks. The data are presented in Figure 12.

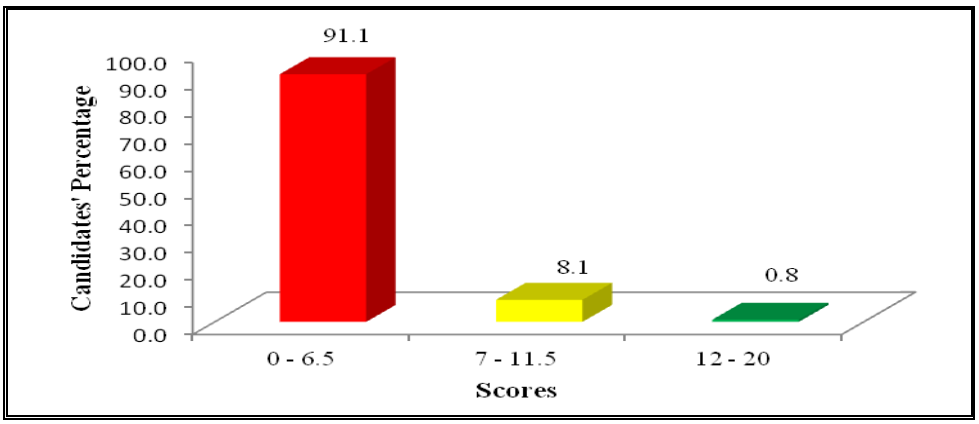
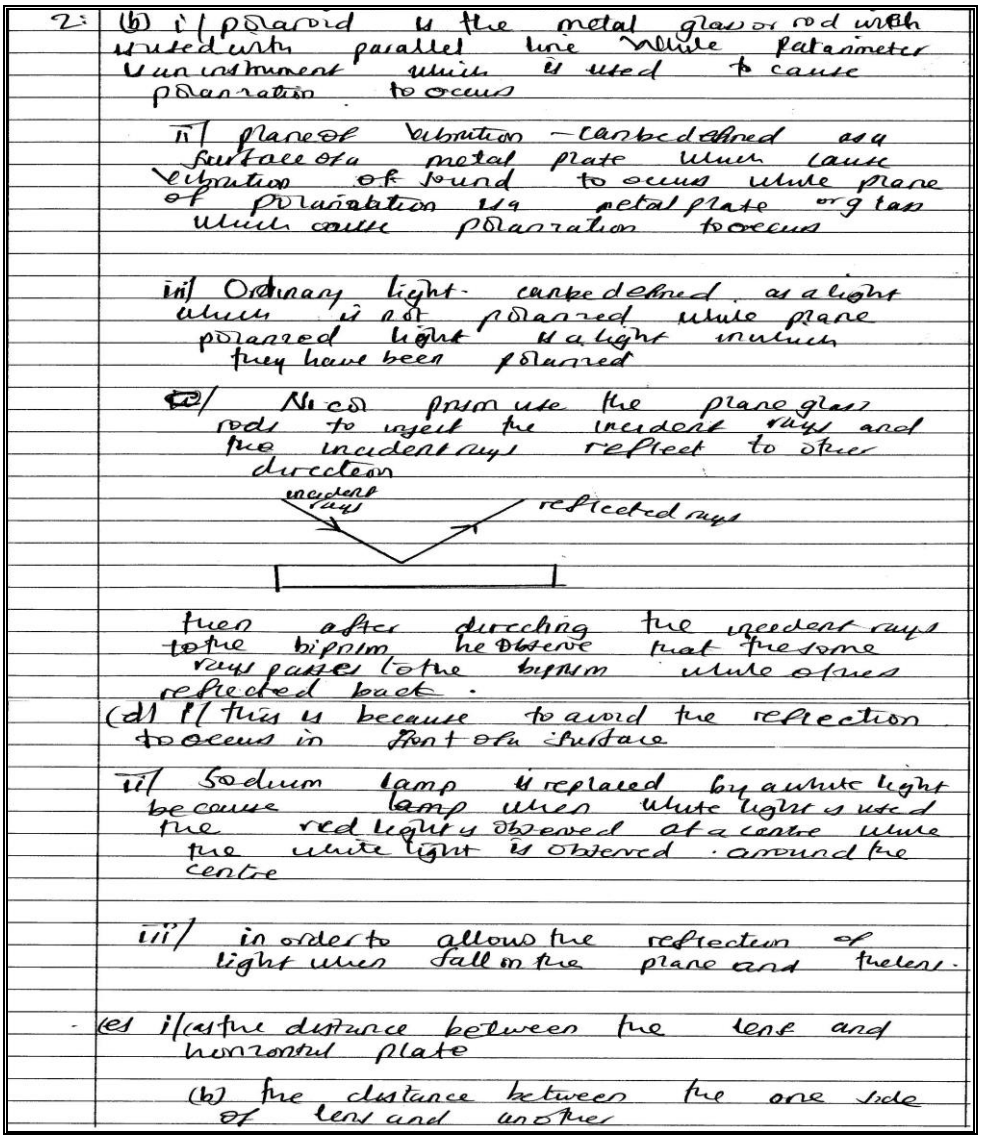


Figure 12: *Distribution of the candidates' scores on Question 2 in Paper 2*

Figure 12 shows that 91.1 percent of the candidates scored from 0 to 6.5 marks, which shows that the general performance of the candidates on this question was weak. The data indicates that most of the candidates skipped this question. However, 91.1 per cent of the candidates who scored 0 to 6.5 marks provided incorrect responses with a lot of grammatical errors. For

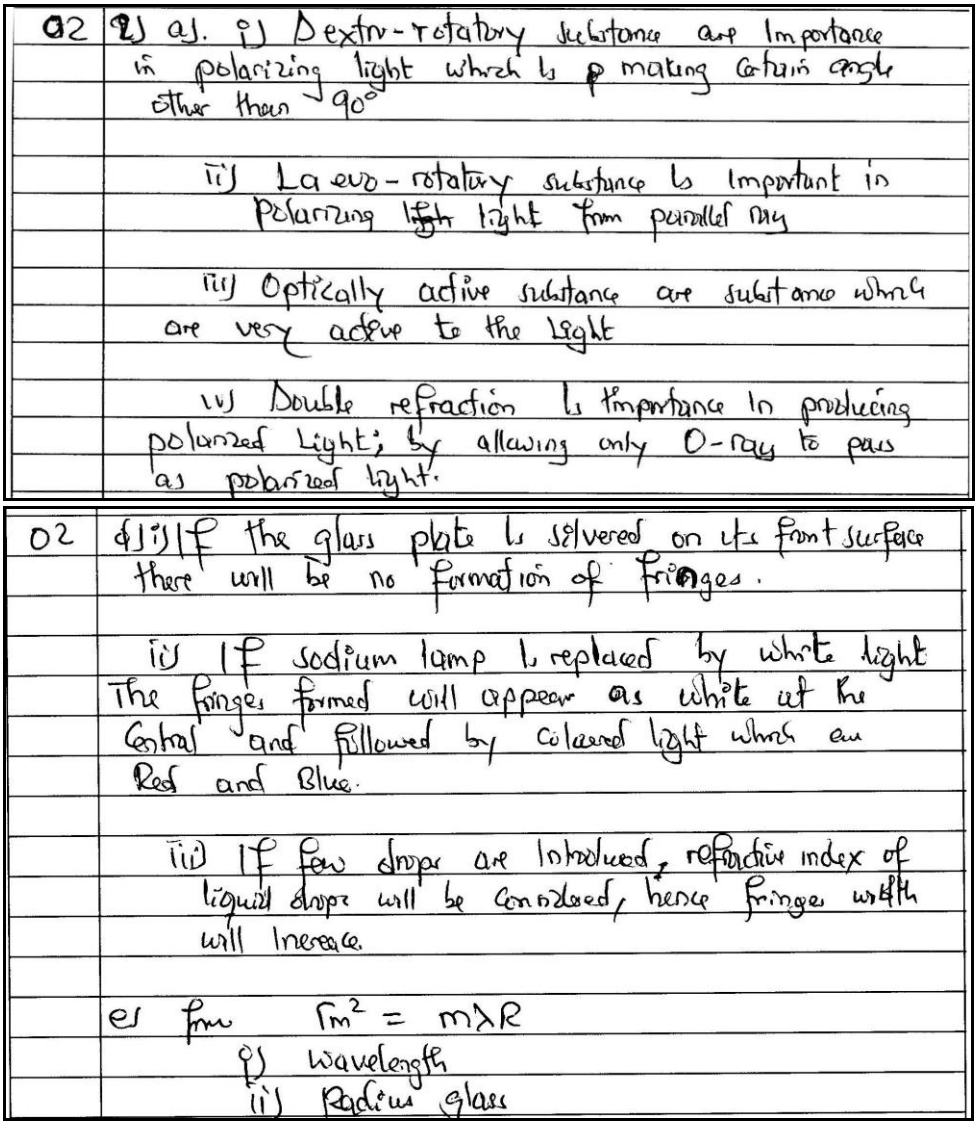
instance, in part (b), one candidate wrote ordinary light *as a light which is not polarized* while plane polarized light *is a light which they have been polarized.* This suggests that they had inadequate knowledge of the topic of *Vibrations and Waves* especially about the polarization derived from physical optics. Extract 12.1 illustrates an incorrect response.



Extract 12.1: *A sample of the incorrect responses on Question 2 in Paper 2*

Extract 12.1 shows incorrect responses from a candidate who failed to describe the construction of Nicol Prism. Thus, he/she provided incorrect responses to other parts of the question.

In contrast, the candidates with good performance (0.8%) on this question demonstrated an adequate knowledge of the topic of *Vibrations and Waves*. This is evident in their responses on the concept of polarisation in parts (a), (b) and (c). Besides, they gave factors which govern the radius of the ring in Newton's ring experiment and explained the observations made with regard to the formation of fringes. Extract 12.2 is a sample of the candidates' good responses.


Q2 a) i) Dextro-rotatory substance are important in polarizing light which is by making certain angle other than 90°

ii) Laevo-rotatory substance is important in polarizing ~~light~~ light from parallel ray

iii) Optically active substance are substance which are very active to the light

iv) Double refraction is importance in producing polarized light; by allowing only O-ray to pass as polarized light.

Q2 d) i) If the glass plate is silvered on its front surface there will be no formation of fringes.

ii) If sodium lamp is replaced by white light The fringes formed will appear as white at the Central and followed by coloured light which are Red and Blue.

iii) If few drops are introduced, refractive index of liquid drops will be considered, hence fringes width will increase.

e) from $r_m^2 = m\lambda R$

i) wavelength

ii) Radius glass

Extract 12.2: *A sample of the candidate's good responses to Question 2 in Paper 2*

In Extract 12.2, the candidate managed to use the concept of physical optics to provide the correct responses to parts (a), (d) and (e).

2.2.3 Question 3: Properties of Matter

Part (a) of this question required the candidates to explain why (i) the rise of liquid is affected if the top of the capillary tube is closed and (ii) rain drops are spherical in shape. In part (b), they were required to (i) explain why brick walls are plastered with cement and (ii) calculate the true pressure difference in a barometer containing two uniform capillary tubes of radii 6.5×10^{-4} m and 1.24×10^{-3} m if the height of water in a narrow tube is 0.2 m more than that in a wide tube. Part (c) required the candidates to (i) give the meaning of surface tension and its S.I Units and (ii) calculate the ratio of the total surface energy of the 64 drops to that of a single drop when 64 rain drops combined into a single drop.

The question was attempted by 16,927 candidates, equivalent to 99.3 per cent. The distribution of their scores is shown in Figure 13.

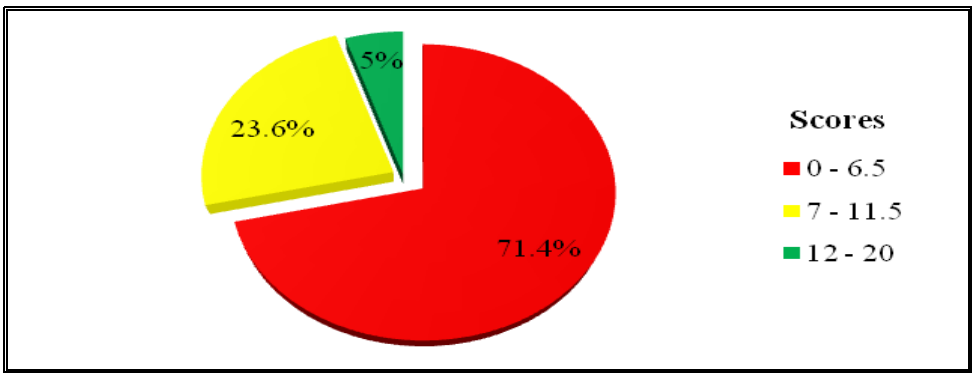
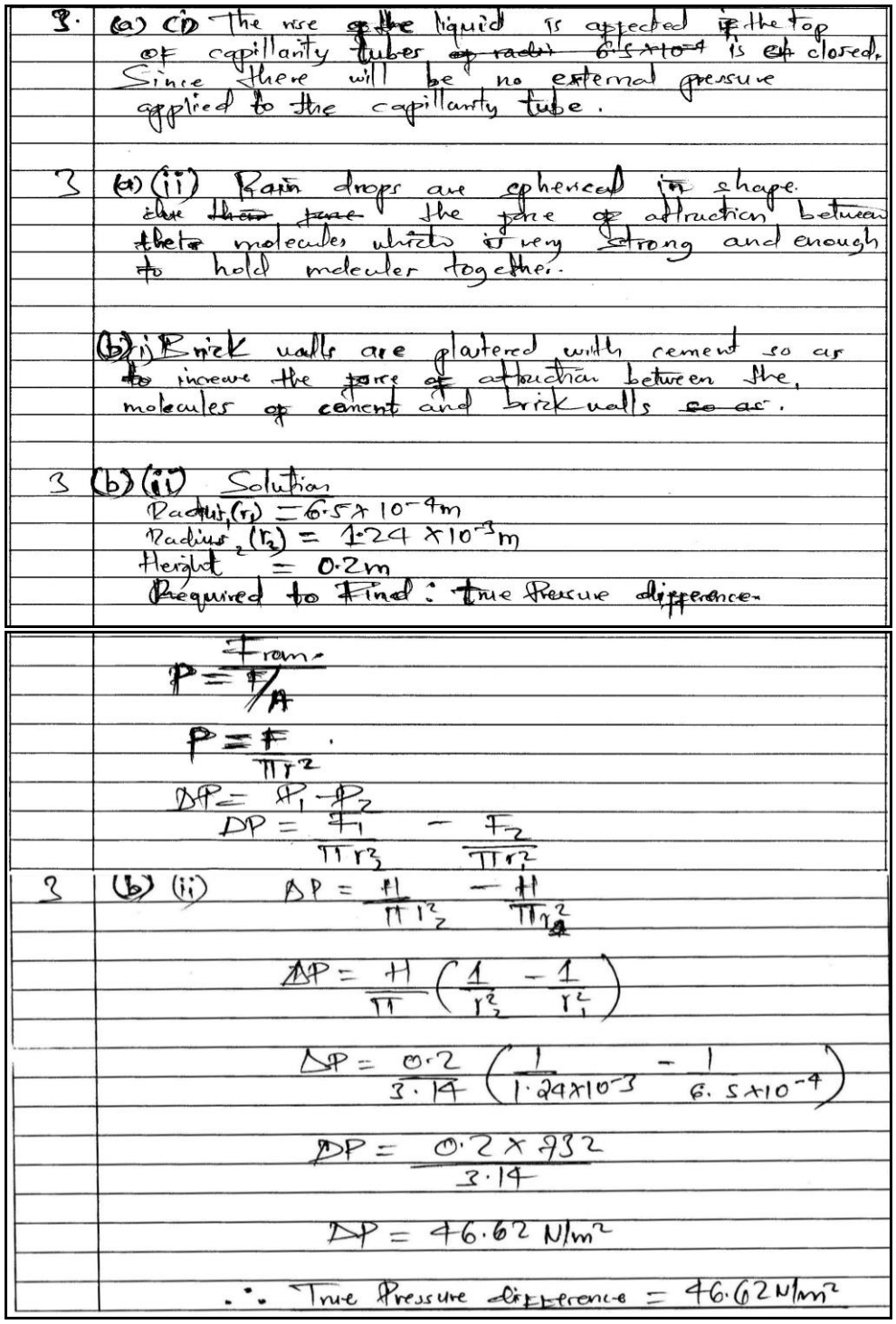


Figure 13: *Distribution of candidates' scores on Question 3 in Paper 2*

Figure 13 shows that 71.4 per cent of the candidates scored from 0 to 6.5 marks, 23.6 per cent scored from 7 to 11.5 marks while 5 per cent scored marks ranging from 12 to 20 marks.

The statistical analysis indicates that the overall performance on this question was weak because more than a half (71.4%) of the candidates scored below average (< 7 mark). However, among them, 4.5 per cent, equivalent to 761 candidates, scored 0 marks. These candidates lacked basic knowledge of surface tension. Their responses indicated that they failed to describe and analyse surface tension in terms of molecular theory and surface energy respectively. Another observed challenge was the failure to identify the applications of capillarity which could help them in responding

correctly to most parts of the question. Extract 13.1 shows a sample of the incorrect responses.

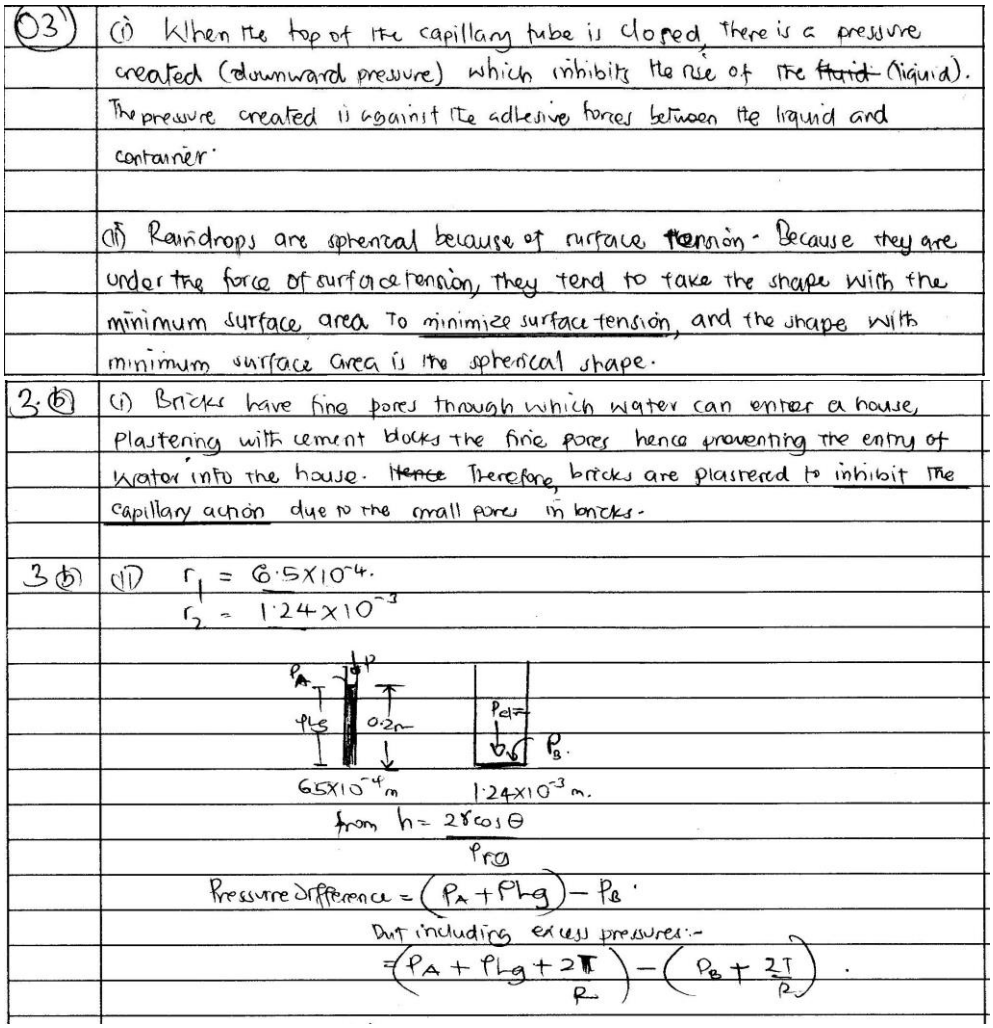


Extract 13.1: *A sample of the incorrect responses to Question 3 in Paper 2*

In Extract 13.1, the candidate applied the incorrect formula to find a true pressure difference. He/she also provided responses to other parts which not meet the demands of the question.

Although the candidates showed weak performance on this question, 5.0 per cent scored good marks (12 - 20). They had an adequate knowledge of the topic of *Properties of Matter*. These candidates assessed the phenomena that result from liquid surface tension. In addition, they derived expressions which helped them to determine the true pressure difference and the ratio of total surface energy.

A further analysis on the responses reveals that most of the candidates who scored average marks (7 - 11.5) skipped part (b) (ii) and (c) (ii) due to poor mathematical skills. Extract 13.2 is a sample of the good responses.



(03) (i) When the top of the capillary tube is closed, there is a pressure created (downward pressure) which inhibits the rise of the ~~fluid~~ (liquid). The pressure created is against the adhesive forces between the liquid and container.

(ii) Raindrops are spherical because of surface ~~tension~~. Because they are under the force of surface tension, they tend to take the shape with the minimum surface area. To minimize surface tension, and the shape with minimum surface area is the spherical shape.

2.(b) (i) Bricks have fine pores through which water can enter a house, Plastering with cement blocks the fine pores hence preventing the entry of water into the house. ~~Hence~~ Therefore, bricks are plastered to inhibit the capillary action due to the small pores in bricks.

3(b) (ii) $r_1 = 6.5 \times 10^{-4}$.

$r_2 = 1.24 \times 10^{-3}$

from $h = \frac{2T\cos\theta}{\rho r g}$

Pressure difference $= (P_A + P_{Lg}) - P_B$.

But including excess pressures:-

$= \left(P_A + P_{Lg} + \frac{2T}{R}\right) - \left(P_B + \frac{2T}{R}\right)$.

Where T = water surface tension

R – Tube radius

But $P_A = P_B$ = Atmospheric pressure.

$$\Delta P = \cancel{P_A} + \rho g + \frac{2\gamma}{R_1} - \cancel{P_A} - \frac{2T}{R_2}.$$

$$= \rho g + \frac{2T}{R_1} - \frac{2T}{R_2}$$

$$\Delta P = \rho g + 2T\left(\frac{1}{R_1} - \frac{1}{R_2}\right).$$

$$= \left(1000 \times 0.2 \times 9.8\right) + 2 \times 0.072\left(\frac{1}{6.5\times10^{-4}} - \frac{1}{1.29\times10^{-3}}\right)$$

Actual pressure difference is 2065.408 Pa.

(c) (i) Surface tension is the unit force per unit length acting tangentially on a line (imaginary) drawn on the surface (meniscus) of the liquid.

$$\gamma = \frac{f}{L} = \frac{N}{m} = Nm^{-1}.$$

The S-I unit is Newton per metre (Nm^{-1}).

(c) (ii) $n_1 = 64$.

$n_2 = 1$.

$E = Wd = \gamma \partial A$.

$= \gamma \partial A_1$.

But $64\left(\frac{4}{3}\pi r^3\right) = \left(\frac{4}{3}\pi R^3\right)$

($\frac{4}{3}\pi r^3$: unit radius; $\frac{4}{3}\pi R^3$: coalescent radius)

$64r^3 = R^3$.

$R = 4r$

$\therefore R = 4r$

$W_{small} = 0.072\left(4\pi r^2\right) \times 64$.

$W_{big} = 0.072\left(4\pi R^2\right)$.

$$\frac{W_{small}}{W_{big}} = \frac{0.072 \times 64 \times 4\pi r^2}{0.072 \times 4\pi R^2} = \frac{64r^2}{R^2}$$

But $R = 4r$.

$$\frac{W_{small}}{W_{big}} = \frac{64r^2}{(4r)^2}.$$

Extract 13.2: *A sample of the good responses to Question 3 in Paper 2*

In Extract 13.2, the candidate correctly explained the observations and analysed the tested concepts. Moreover, he/she applied appropriate formulae and appropriately manipulated the data to obtain the correct answer.

2.2.4 Question 4: Electrostatics

Part (a) of the question required the candidates to (i) give the meaning of capacitance and relative permittivity and (ii) calculate the capacitance of a pair of parallel plates 0.1 m by 0.1 m with an air gap of 5 mm. In part (b), the candidates were required to (i) state the meaning of Van de Graaff generator and (ii) calculate the minimum radius of the spherical shell in a Van de Graaff generator of shell electrode at 25×10^5 V if the dielectric strength of the gas surrounding the electrode is 5×10^7 V/m. Part (c) required the candidates to (i) state Coulomb's law of forces and (ii) find the force acting on an electron and its acceleration if it has travelled 20 mm from rest when placed in a uniform electric field of field strength 1.2×10^5 Vm^{-1}.

The question was attempted by 16,409 candidates, equivalent to 96.3 per cent. Among them, 21.6 per cent scored from 0 to 6.5 marks, 20.5 per cent scored from 7 to 11.5 marks and 57.9 per cent scored from 12 to 20 marks. Figure 14 summarizes the results.

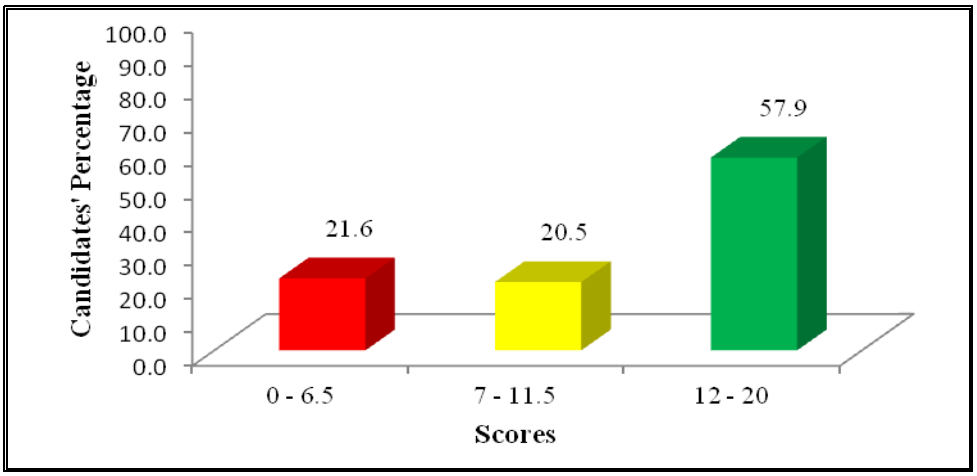


Figure 14: *Distribution of the candidates' scores on Question 4 in Paper 2*

Figure 14 shows that the general performance on this question was good since 78.4 per cent of them passed the question.

The analysis indicated that the candidates who scored from 7 to 20 marks managed to explain the terms *capacitance* and *relative permitivity*. They also applied the correct formula to find the capacitance of a pair of parallel plate capacitor in part (a). In part (b) and (c), most of them managed to

describe a Van de Graaff generator and Coulomb's law of forces. The good performance of these candidates was attributed to their understanding of the demands of the question and enough competence in the concepts of Electric potential and Capacitance. Extract 14.1 is a sample of the good responses.

4. a) i) capacitance is the ability of a capacitor to store electric charges.

$$Q = CV$$

$$C = \frac{Q}{V}, \quad C - \text{capacitance}$$

Relative permittivity, ε_r is the ratio of capacitance of a given material to the capacitance of air.

$$\varepsilon_r = \frac{C_m}{C_o}$$

ii) Given:

Area, $A = 0.1\,m \times 0.1\,m \Rightarrow 0.01\,m^2$

Distance, $d = 5mm \Rightarrow 5 \times 10^{-3}\,m$

$\varepsilon_o = 8.854 \times 10^{-12}\,Fm^{-1}$

From, $C = \frac{A\varepsilon_o}{d}$

$$= \frac{0.01m^2 \times 8.854 \times 10^{-12}\,Fm^{-1}}{5 \times 10^{-3}\,m}$$

$$C = 1.7708 \times 10^{-11}\,F$$

$\therefore$ capacitance, $C = 1.7708 \times 10^{-11}\,F$.

4. b) i) Van de Graaff generator is an electrostatic device that is used to produce voltage of higher orders to about 10^7 volts.

ii) Given:

$V = 25 \times 10^5\,V$

$E = 5 \times 10^7\,V/m$

$r = 1$

From,

$$E = \frac{1}{4\pi\varepsilon_o} \cdot \frac{q}{r^2}$$

But, $V = \frac{1}{4\pi\varepsilon_o} \cdot \frac{q}{r}$,

$$E = \frac{q}{4\pi\varepsilon_0 r} \cdot \frac{1}{r}$$

$$E = \frac{V}{r}$$

$$r = \frac{V}{E}$$

$$r = \frac{25 \times 10^5 V}{5 \times 10^7 V/m}$$

$$r = 0.05 m$$

$\therefore$ Radius, $r = 0.05m$.

4 c) i) Coulomb's law states that "Electrostatic force of attraction or repulsion between two point charges is directly proportional to the product of magnitudes of their charges, and inversely proportional to the square of their distance apart".

That is, $F \propto Q_1 Q_2$

$$F \propto \frac{1}{r^2}$$

$$F \propto \frac{Q_1 Q_2}{r^2}$$

$$F = K\frac{Q_1 Q_2}{r^2}$$

$$F = \frac{1}{4\pi\varepsilon_0\varepsilon_r} \cdot \frac{Q_1 Q_2}{r^2}$$

ii) Given:

$E = 1.2 \times 10^5 V/m$.

$F = ?$

$a = ?$

$m_e = 9.1 \times 10^{-31} kg$.

$e = 1.6 \times 10^{-19} C$

From, $eE = ma$

$$a = \frac{eE}{m}$$

$$= \frac{1.6 \times 10^{-19} C \times 1.2 \times 10^5 V/m}{9.1 \times 10^{-31} kg}$$

$$= 2.10989011 \times 10^{16} m/s^2$$

4. But, force, $F = eE$

$= 1.6 \times 10^{-19} C \times 1.2 \times 10^{5} V/m$.

$= 1.92 \times 10^{-14} N$.

$\therefore$ Force, $F = 1.92 \times 10^{-14} N$

Acceleration, $a = 2.10989011 \times 10^{16} m/s^2$.

Extract 14.1: *A sample of the good responses to Question 4 in Paper 2*

Despite the good performance on this question, 21.6 per cent of the candidates showed insufficiency knowledge of the topic *Electrostatics.* They failed to give the meaning of capacitance, relative permitivity and Van de Graaff generator besides stating Coulomb's law of forces. For example, one candidate defined *Van de Graaff generator is a type of generator that is used to describe the charge present in the atom*. Others failed to retrieve proper formulae to do calculations. As a result, they failed to deduce the effective capacitance of the parallel capacitor connection and determine the minimum radius of the spherical shell in parts (a) (ii) and (b) (ii) respectively. Also, some of the candidates used unrelated concepts to explain the terms or to state the laws. Nevertheless, in part (c), some of them failed to analyse the motion of an electron in a uniform electric field to find the force acting on it and its acceleration. Extract 14.2 shows a sample of the incorrect responses.

4 (a) (ii) Formular

parallel capacitor $= C_1 + C_2$

$= 0.1 + 01$

$= 0.2$

$C_{cell} = C_1 + C_2$

$5 \times 10^{-3} C = 0.1 + 0.1$

$\frac{5 \times 10^{-3} C}{5 \times 10^{-3}} = \frac{0.2}{5 \times 10^{-3}}$

$C = 40$

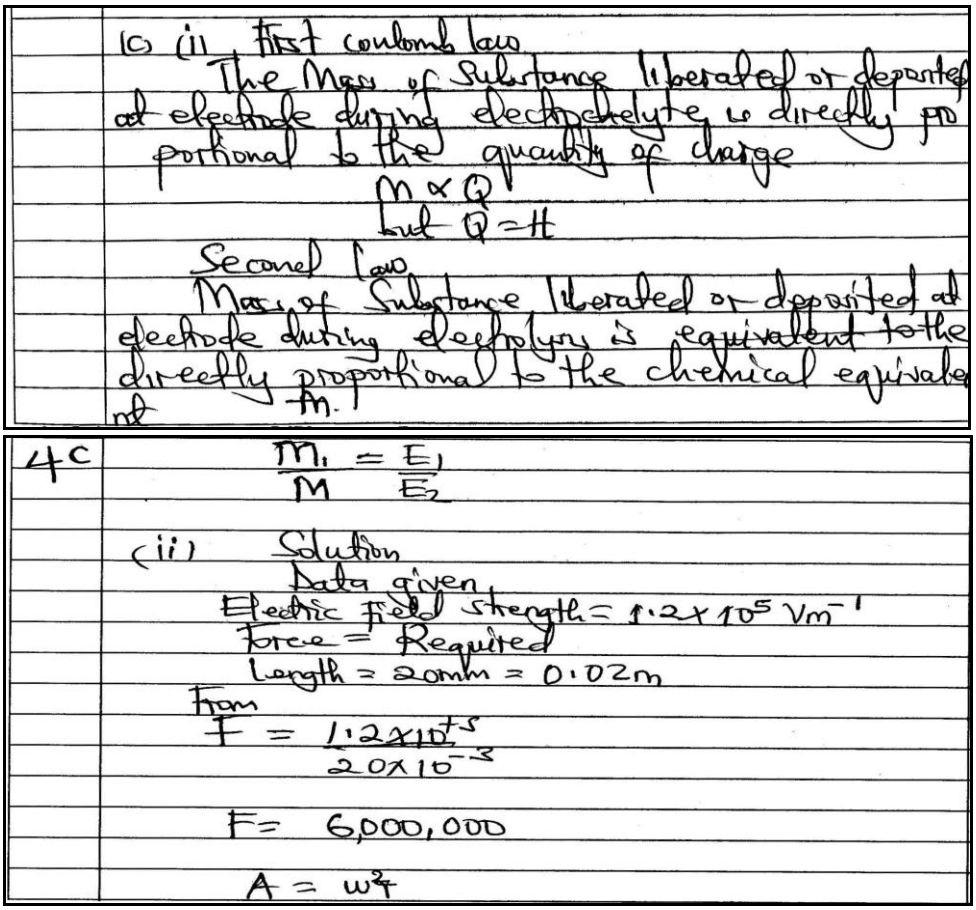
(b) Solution

Data given

Potential difference $= 0.5 \times 10^{5} V$

Dielectric strength $= 5 \times 10^{7} V/m$

Minimum radius = Required



Extract 14.2: *A sample of the incorrect responses to Question 4 in Paper 2*

2.2.5 Question 5: Electromagnetism

This question consisted of four parts: (a), (b), and (c). Part (a) required the candidates to (i) distinguish between diamagnetic, paramagnetic and ferromagnetic materials based on the relative permeability μ_r (ii) give the meaning of intensity of magnetization I for a paramagnetic material and use Curie's law to show how it relates with the absolute temperature (T). Part (b) required the candidates to (i) explain why the material used for making the core of a transformer should have a narrow hysteresis loop and (ii) find the relative permeability, susceptibility, and the permeability of a specimen of iron which is uniformly magnetized by the magnetizing field of 300 Am^{-1} and producing the magnetic flux density of 0.4 Wbm^{-2}. In part (c), it was given that two parallel co-axial circular coils of equal radius R and number of turns *N*, carrying equal currents *I* in the same direction and separated by

a distance *R*. The candidates were required to show that $B = 0.72\frac{\mu_o NI}{R}$, where *B* is the field on the axis around the mid-point between the coils which is uniformly distributed over a distance that is small as compared to R and μ_o is the permeability of free space.

The data indicate that 10,944 candidates, equivalent to 64.2 per cent, attempted the question. Among them, 72.5 per cent scored from 0 to 6.5 marks; 16 per cent scored from 7 to 11.5 marks; and 11.5 per cent scored from 12 to 20 marks. The data are summarized in Figure 15.

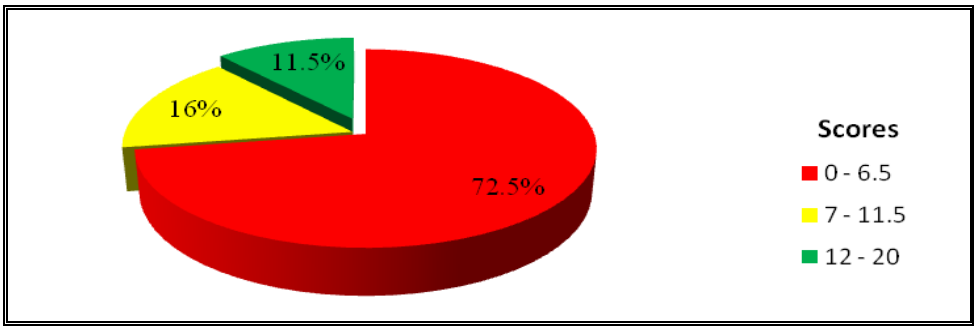


Figure 15: *Distribution of candidates' scores on Question 5 in Paper 2*

The statistical data in Figure 15 show that the majority of the candidates (72.5%) scored below 7.0 marks. This implies that the general performance on this question is weak.

The analysis indicated that the candidates who scored low marks (72.5%) failed to distinguish diamagnetic, paramagnetic and ferromagnetic materials based on relative permeability. The reason was lack of knowledge and failure to adhere to the demands of the question. Some candidates defined the terms based on magnetic properties instead of relative permeability. Others failed to use Curie's law to show how the intensity of magnetisation is related to absolute temperature.

A further analysis reveals that, among the 72.5 per cent of the candidates who scored 0 to 6.5 marks, 34 per cent, equivalent to 3,716 candidates scored 0 marks. These candidates completely lacked the knowledge of magnetic properties of materials. Therefore, they provided incorrect responses to all parts of the question. For example, in part (b), they failed to interpret the hysteresis loop and applied incorrect formulae to find the

relative permeability and susceptibility of the specimen. Extract 15.1 is illustrative.

5@ ii) Intensity of magnetization: This is the ratio between the magnetic flux density and the magnetizing force of a material.

Thus:-

Intensity $I = B/H$.

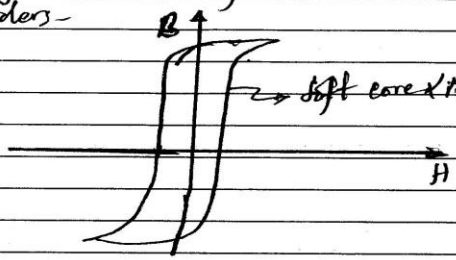
Again:- From Curie law:-

$$V = \sqrt{\frac{nRT}{Mr}}$$

5@ i) Diamagnetic material: This are the material which have zero relative permeability and hence they are not attracted by

5.(b) c) The material used for making the core of the transformer should have the narrow hysteresis because the material which have the narrow hysteresis have the large magnetizing force with respect to the magnetizing force and hence it help for the step up or step down the voltage in a transformer.

Consider:-



5.(b) ii) Solution.

Data given.

Magnetic flux density, $B = 0.4\ Wb\,m^{-2}$.

Magnetizing field, $H/L = 300\ Am^{-1}$

Req:- Relative permeability $\mu_r = ?$

Susceptibility, $X = ?$

Permeability of the specimen, $\mu = ?$

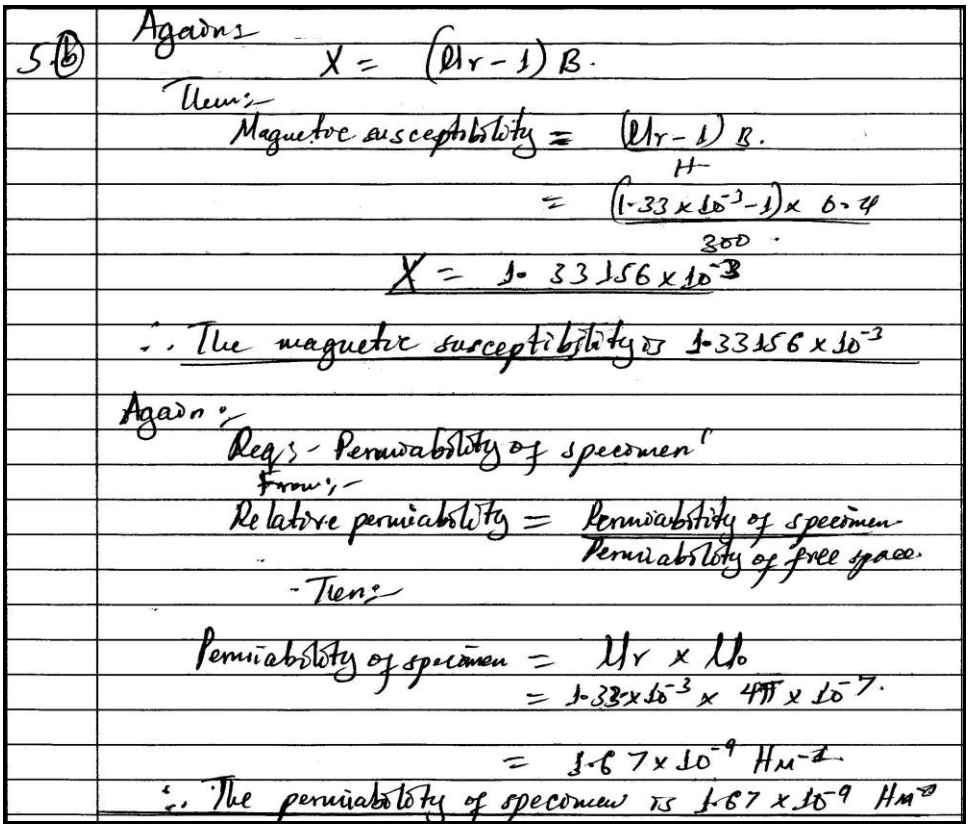
From:-

Relative permeability $\mu_r = B/H$

$$\mu_r = \frac{0.4\ Wb\,m^{-2}}{300\ Am^{-1}}$$

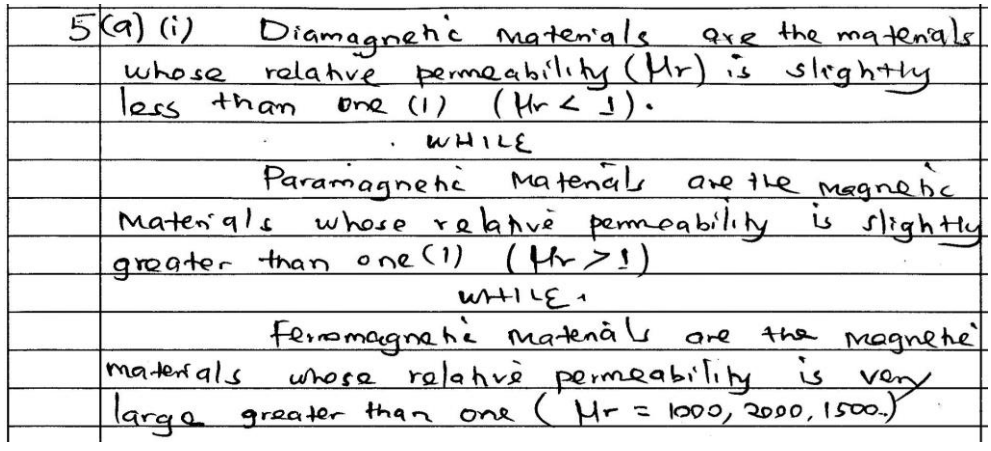
$$\mu_r = 1.33 \times 10^{-3}\ Wb\,m^{-1}A^{-1}$$

∴ The relative permeability is $1.33 \times 10^{-3}\ Wb\,m^{-1}$



Extract 15.1: *A sample of the poor responses to Question 5 in Paper 2*

In contrast, the few (11.5%) candidates who scored good marks showed a good understanding of the basic terms used in *Electromagnetism*. These candidates were familiar with the magnetic properties of materials since they correctly described the terms and applied the correct formula and procedures to provide responses per the demands of the question. Extract 15.2 is a sample of the correct responses.



(ii) Intensity of Magnetisation refers to the ratio of magnetic moment to the volume of a magnetic material.

$$I = \frac{\text{Magnetic moment } (m)}{\text{volume } (V)}.$$

Also

From Curie's law.

"Intensity of magnetisation (I) of a magnetic material is directly proportional to the flux density (B) and inversely proportional to absolute temperature (T)

$$I \propto \frac{B}{T}.$$

$$I = \frac{CB}{T}.$$

C is curie constant.

When CB = constant.

$$I \propto \frac{1}{T}.$$

Hence; Intensity of magnetisation (I) is inversely proportional to absolute temperature (T)

5 (b) (i) Hysteresis loop of a material implies the energy loss per cycle.

Therefore, narrow hysteresis loop is required in the material for making core of the transformer so as to ensure small (Minimum) energy loss during transformer action

(ii) solution

Data given

Magnetising force $(H) = 300 Am^{-1}$

Magnetic flux density $(B) = 0.4 Wbm^{-2}$.

Required

- Relative permeability (μ_r).

from

$$B = \mu H.$$

but $\mu = \mu_0 \mu_r$

$$B = \mu_0 \mu_r H.$$

$$\mu_r = \frac{B}{\mu_0 H}.$$

$$= \frac{0.4}{300 \times 4\pi \times 10^{-7}}$$

$$= 1061.$$

Hence; Relative permeability is 1061.

- Susceptibility $(\chi_m) = ?$

from

$$\chi_m = -1 + \mu_r.$$

$$= 1061 - 1$$

$$= 1060.$$

Hence;

The susceptibility is 1060.

5 • Permeability of speamen (μ) = ?

from

$$B = \mu H$$

$$\mu = \frac{B}{H}$$

$$= \frac{0.4}{300.}$$

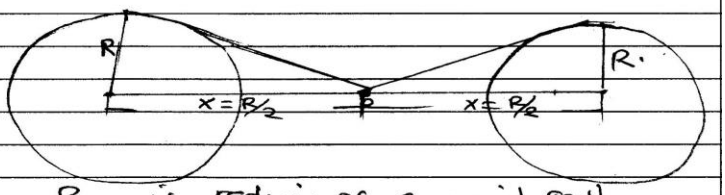
$$= 1.33 \times 10^{-3} Hm^{-1}$$

Hence,

Permeability of speamen of iron is $1.33 \times 10^{-3} Hm^{-1}$

(c) solution

Consider two co-axial circular coils below



Where R is radius of co-axial coils.

x is distance from centre to point

Then from.

Flux density (B) of circular coil is given by:

$$B = \frac{\mu N I R^2}{2(R^2 + X^2)^{3/2}}.$$

but $X = R/2$.

$$B_1 = \frac{\mu N I R^2}{2(R^2 + R^2/4)^{3/2}}.$$

$$B_1 = \frac{\mu N I R^2}{2R^3(1 + 1/4)^{3/2}}$$

$$B_1 = \frac{\mu N I}{2R(5/4)^{3/2}}$$

Extract 15.2: *A sample of the correct responses to Question 5 in Paper 2*

2.2.6 Question 6: Atomic Physics

This question had five parts: (a), (b), (c), (d), and (e). Part (a) required the candidates to differentiate (i) Ionization energy from excitation energy and (ii) Ionization potential from excitation potential. Part (b) required the candidates to (i) state Bohr's frequency condition, (ii) explain why a very thin gold foil is used in Rutherford's α – particle scattering experiment and (iii) compute the orbital radius and the velocity of electron in a hydrogen atom when energy of -2.2×10^{-18} J is required to separate hydrogen atom into a proton and an electron. In part (c), they were required to explain the meaning of (i) Binding energy curve (ii) Nuclear Mass (iii) Nuclear reaction and (iv) Artificial radioactivity as applied in atomic and nuclear

Physics. Part (d) required the candidates to find the (i) number of K-40 atoms in the sample and (ii) half-life of K-40 when the activity of 1.6 mg of radioactive potassium chloride (chloride of isotope K-40) was found to be 180 s^{-1} taking molar mass of K-40 Cl to be 0.075 $kgmol^{-1}$. In part (e), they were required to find how long can an electric lamp of 200 W be kept glowing by fusion of 3.0 kg of deuterium given that the fusion reaction taking place is ${}_{1}^{2}H+{}_{1}^{2}H \rightarrow {}_{2}^{3}He+{}_{0}^{1}n+3.27$ MeV.

A total of 16,647 (97.7%) candidates responded to the question and their performance is illustrated in Figure 16.

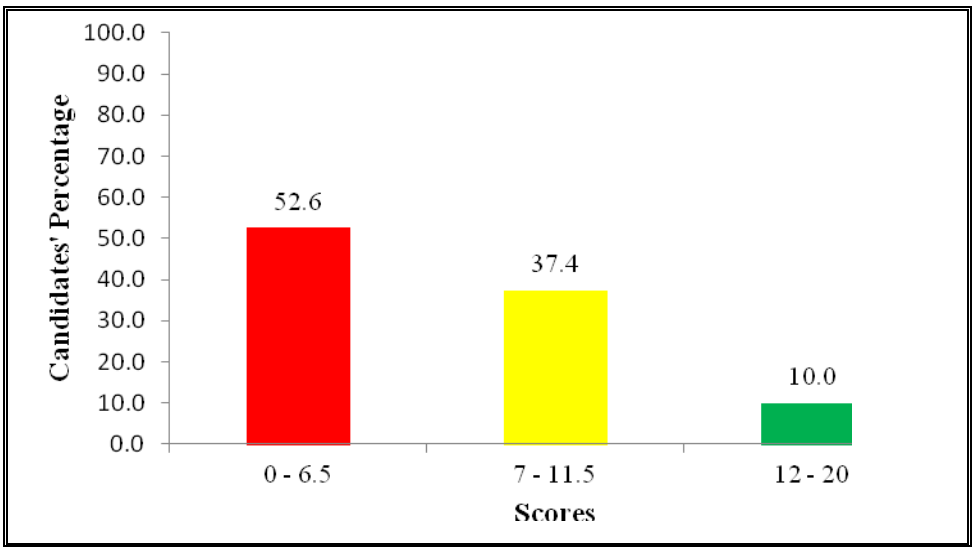


Figure 16: *Distribution of candidates' scores on Question 6 in Paper 2*

Figure 16 shows, that 47.4 per cent of the candidates scored from 7 to 20 marks while 52.6 per cent scored below 7 marks. Thus, the performance on this question was average.

Most of the candidates who performed well (10.0%) had a good understanding of the concepts tested. In part (a), they correctly differentiated Ionization energy and Ionization potential from excitation energy and excitation potential respectively. In part (b), they clearly stated Bohr's frequency condition and the reason why a very thin gold foil is used in Rutherford's α – particle scattering experiment. However, some of them failed to compute the orbital radius and the velocity of electron in a hydrogen atom. The candidates also demonstrated their competence in part (c), (d) and (e); they gave the meaning of the tested terms and applied the

correct formulae to obtain the correct answers. Extract 16.1 shows parts of the good responses.

6 a) i) Ionization energy is the energy required to remove an electron (especially most loosely bound) outside its nuclear influence whereas excitation energy is the energy required to cause a promotion to an electron from its lower ground state to any of its respective higher state.

ii) Ionization potential is the potential required to remove an electron from its nuclear influence while excitation potential is the potential required to cause a promotion of an electron from its lower ground state to any of its respective higher state.

b) i) Bohr's frequency condition states that "only frequency corresponding to the difference in frequencies between two energy states will cause a promotion"

$E_2 - E_1 = hf$.

$hf_2 - hf_1 = hf$

$h(f_2 - f_1) = hf$

$f_2 - f_1 = f$

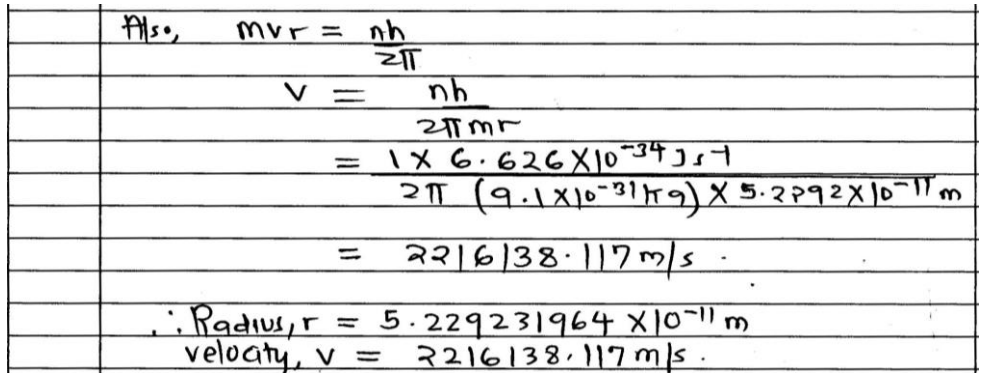
6 ii) A thin gold foil is used because the target α-particle has to face perpendicularly only a single atom in the foil, so that they can penetrate easily through the other side.

iii) Given: ~~Ionization~~ energy, $E = -2.2 \times 10^{-18}$ J, $Z = 1$

from, $E_T = \frac{-Ze^2}{8\pi\varepsilon_0 r}$

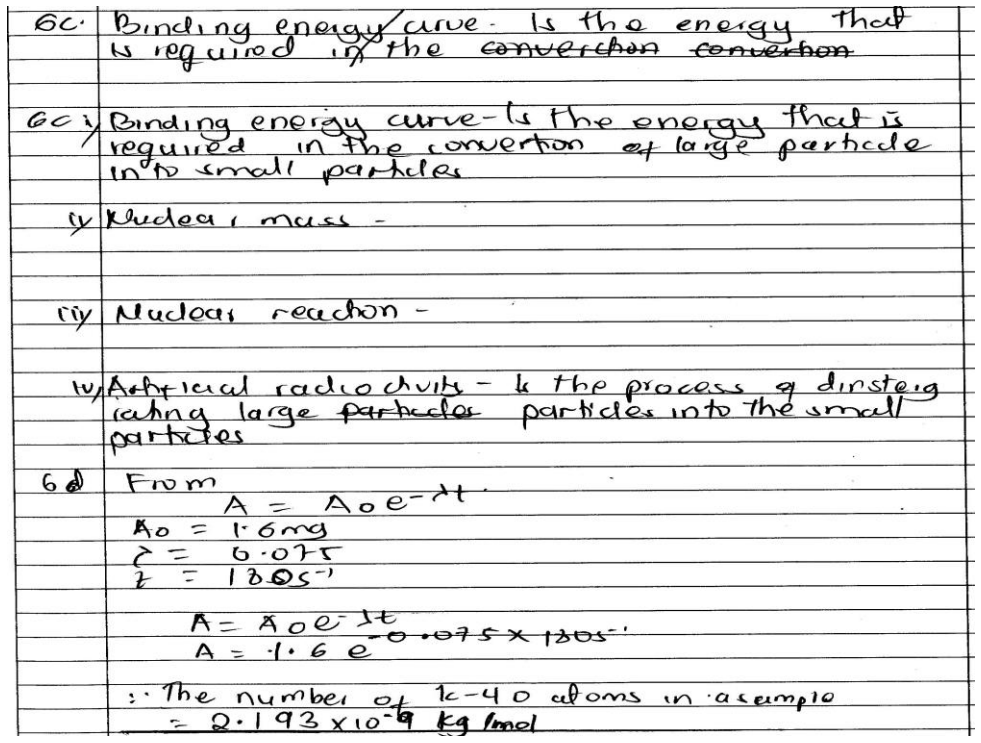
$-2.2 \times 10^{-18}\text{ J} = \frac{-(1) \times (1.6 \times 10^{-19}\text{c})^2}{8\pi \times 8.854 \times 10^{-12}\text{Fm}^{-1} \times r}$

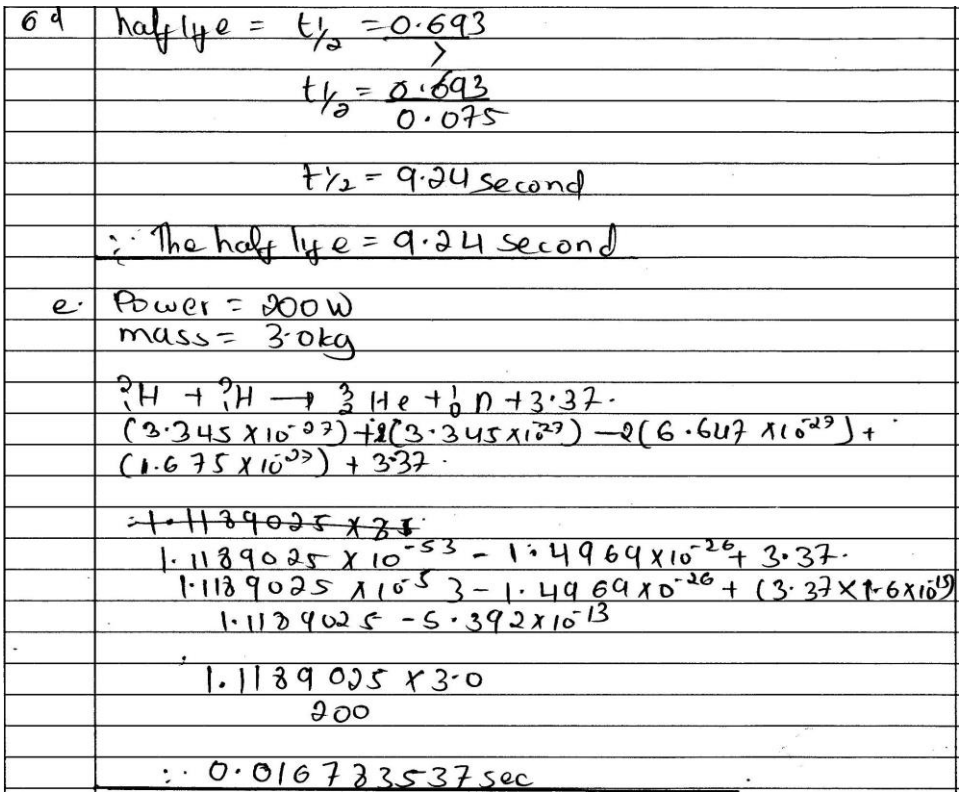
$r = 5.229231964 \times 10^{-11}$ m.



Extract 16.1: *A sample of the good responses to Question 6 in Paper 2*

In the contrast, the candidates who demonstrated weak performance (52.6%) lacked knowledge of the Structure of the atom and Nuclear Physics. Most of them failed to retrieve and summarize the main components of Bohr's model of atom. Consequently, they failed to state Bohr's frequency condition or to determine the orbital radius and velocity of electron in a hydrogen atom. A further analysis showed that most of the candidates failed to describe the structure of the nucleus as well as identify the criteria for stable and unstable nuclei. Therefore, they provided incorrect responses about the tested concepts in parts (c), (d), and (e). Extract 16.2 is a sample of the incorrect responses.





Extract 16.2: *A sample of the poor responses to Question 6 in Paper 2*

3.0 ANALYSIS OF CANDIDATES' PERFORMANCE PER TOPIC

The analysis indicates that the candidates had good performance in 3 out of 12 topics that were tested in Physics Paper 1 and 2. These topics are *Fluid dynamics* (89.1%), *Electrostatics* (78.4%) and *Measurement* (69%). They had average performance in six (6) topics of *Electronics (54.5%)*, *Environmental Physics* (53.9%), *Mechanics* (52.9%), *Current electricity* (49.2%), *Atomic Physics* (47.4%) and *Heat* (36%). The average performance was contributed by their failure to attempt some parts of the questions, especially those which required critical thinking to assess higher order learning outcomes. Similarly, those with poor mathematical skills failed to analyse and interpret the given data to perform appropriate calculations.

The weak performance was observed in the topics of *Properties of matter* (28.6%), *Electromagnetism* (27.5%) and *Vibrations and waves* (8.9%). Such performance was influenced by the candidates' inadequate knowledge of the examined concepts, provision of incorrect responses in performing

calculations due to incorrect use of formulae and poor mathematical skills. The analysis of the candidates' performance per topic is summarized in Appendices A and B.

4.0 CONCLUSION AND RECOMMENDATIONS

4.1 Conclusion

The analysis of the candidates' performance per question in Physics Papers 1 and 2 for the ACSEE 2020 revealed that most of the candidates answered the questions well. However, some of the candidates faced difficulties in responding to the questions on the topics of Properties of Matter, Electromagnetism; and Vibrations and Waves. Poor performance was due to the following:

(a) Lack of knowledge about various concepts. Some of the candidates provided incorrect responses to the questions. Most of the candidates failed to comprehend the questions due to poor masterly of the subject matter.

(b) Poor background of mathematical skills. Most of the candidates failed to analyse and interpret the given data values for correct procedures and appropriate calculations.

(c) Failure of the candidates to apply appropriate formulae.This challenge was observed among some of the candidates who used incorrect formulae to perform calculations. Others applied the formulae interchangeably, especially in related concepts.

4.2 Recommendations

To improve performance of candidates in Physics, particularly in the topics which were poorly performed, the following measures are recommended:

(a) Teachers should emphasize the use of the polaroid, glass block, light source and Nicol prism for students to demonstrate the production of plane polarized light.

(b) Teachers should guide students when conducting experiments to determine the wavelength of monochromatic light using Newton's rings methods.

(c) Teachers should assist students in groups to demonstrate the movement of a charged particle in a uniform magnetic field and

interpret the hysteresis loop for magnetic flux density B and magnetic field intensity H.

(d) Teachers should encourage students to do effective revision and provide adequate tests and examinations to improve their confidence and ability in answering questions.

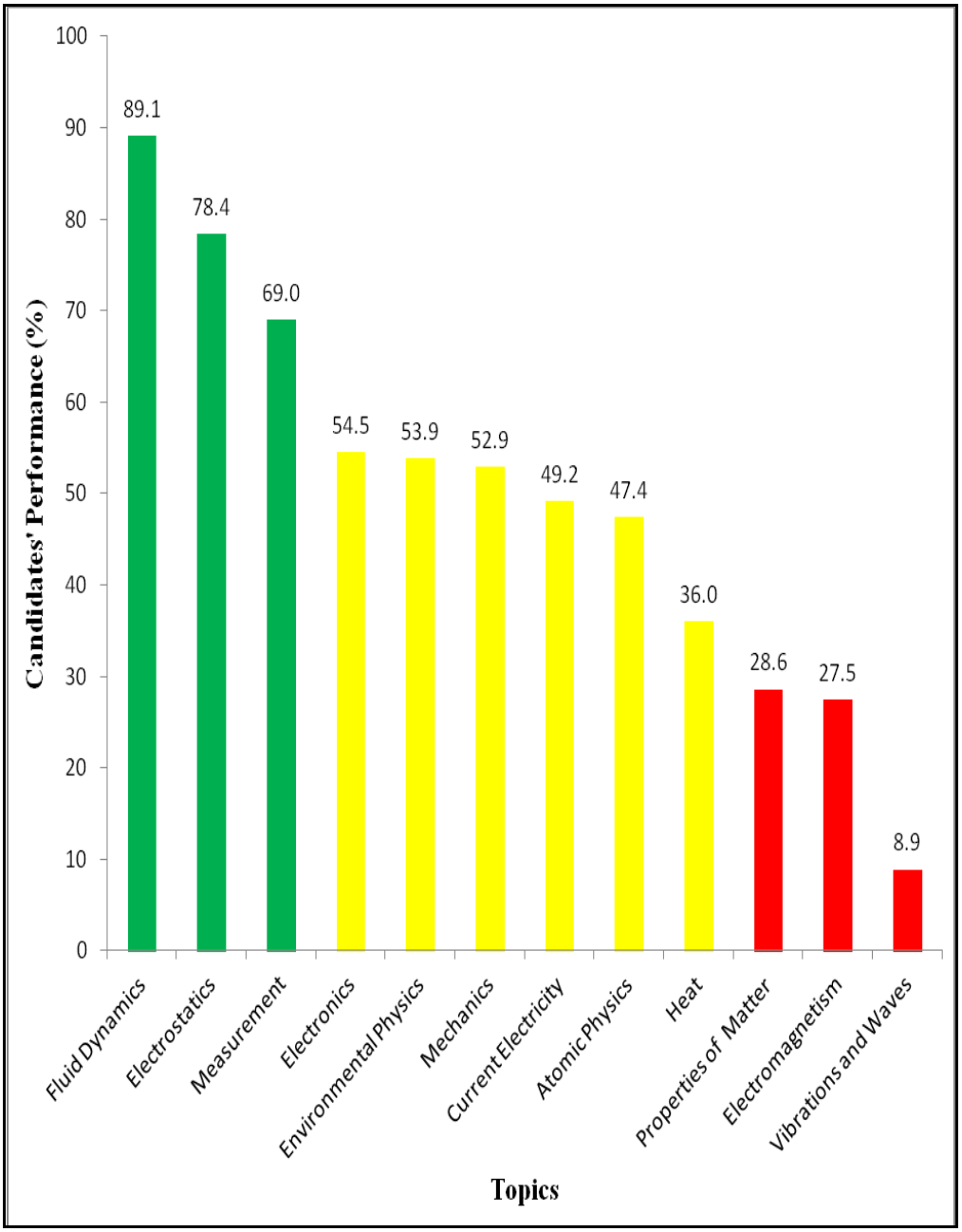
(e) Students should work in groups to describe and demonstrate various phenomenon of surface tension in terms of molecular theory.

(f) Students should put more effort in reading various Physics books to improve their knowledge about concepts, theories, laws and formulae.

Appendices

Appendix A

THE CANDIDATES' PERFORMANCE IN EACH TOPIC ON THE YEAR 2020



Appendix B

THE CANDIDATES' PERFORMANCE IN EACH TOPIC ON THE YEAR 2020

S/n.	Topic	2020 EXAMINATION PAPER		
		Number of questions	Percentage of Candidates Who Scored an Average of 35 Percentage or Above	Remarks
1	Fluid Dynamics	1	89.1	Good
2	Electrostatics	1	78.4	Good
3	Measurement	1	69.0	Good
4	Electronics	2	54.5	Average
5	Environmental Physics	1	53.9	Average
6	Mechanics	3	52.9	Average
7	Current Electricity	1	49.2	Average
8	Atomic Physics	1	47.4	Average
9	Heat	2	36.0	Average
10	Properties of Matter	1	28.6	Weak
11	Electromagnetism	1	27.5	Weak
12	Vibrations and Waves	1	8.9	Weak