THE NATIONAL EXAMINATIONS COUNCIL OF TANZANIA

CANDIDATES' ITEM RESPONSE ANALYSIS REPORT FOR THE ADVANCED CERTIFICATE OF SECONDARY EDUCATION EXAMINATION (ACSEE) 2019

131 PHYSICS

THE NATIONAL EXAMINATION COUNCIL OF TANZANIA

CANDIDATES' ITEM RESPONSE ANALYSIS REPORT FOR THE ADVANCED CERTIFICATE OF SECONDARY EDUCATION EXAMINATION (ACSEE) 2019

131 PHYSICS

Published by:
The National Examinations Council of Tanzania
P.O.Box 2624
Dar es Salaam, Tanzania.

Table of Contents

FOREWORD

The candidates' item response analysis report for the Advanced Certificate of Secondary Education Examination (ACSEE) 2019 on the Physics subject provides a summative evaluation of the two years of secondary education in Tanzania. The candidates' responses to the examination questions reveal what the education system was able or unable to offer to the candidates in their two years of secondary education.

The analysis presented in this report intends to contribute towards understanding possible reasons behind the candidates' performance on the Physics subject. It highlights the factors that made the candidates to score either high or low. The challenges faced by the candidates to perform averagely are also clearly stipulated. Such factors include misconception of ideas, failure to understand the demands of the questions, lack of mathematical skills hence failure to analyse the data in a good manner, and inadequate knowledge of the concepts related to the subject matter.

This feedback will enable educational stakeholders, teachers, parents, school managers and students to identify proper measures to improve candidates' performance in future examinations administered by the Council.

Finally, the Council would like to thank the examiners, co-ordinators, reviewers, IT specialists and data analysts who prepared and analysed the data used in this report.

Dr. Charles E. Msonde
EXECUTIVE SECRETARY

1.0 INTRODUCTION

This report is based on the analysis of candidates' responses to the Advanced Certificate of Secondary Education Examination (ACSEE) 2019 questions for 131 Physics papers 1 and 2. The papers were organized in order to test the candidates' competencies and skills in different areas as stipulated in the 2010 Physics syllabus and adhered to in the 2011 examination format.

Physics paper 1 was comprised of fourteen (14) questions which were categorized into three sections, namely A, B and C. Section A was comprised of six (6) questions and section B and C had four questions each. The candidates were required to answer a total of ten (10) questions by choosing four (4) questions from section A and three (3) questions from each sections in B and C.

Physics paper 2 had three sections namely A, B and C. Each section comprised of three (3) questions making a total of nine (9) questions. Candidates were required to answer five (5) questions by choosing at least one (1) question from each section. Generally, all questions in both papers aimed at testing the candidates' ability to comprehend, interpret and analyse the data based on the demand of the questions.

A total of 18,906 candidates sat for the examination, of which 16,768 (89.13%) passed the examination and 2,138 (10.87%) failed. In 2018, the number of candidates who sat for Physics examination was 19,547 of which 86.48 percent passed the examination and 13.52 percent failed. This implies that the candidates' performance in this year has increased by 2.65 percent. The following table shows the grade performance in Physics in 2019 as compared to 2018.

GRADE / YEAR	**A**	**B**	**C**	**D**	**E**	**S**	**F**
2019	50	683	2,771	5,496	5,920	1,848	2,044
2018	70	821	2,658	5,159	5,872	2,225	2,628

The table shows that, although the general performance in 2019 is better than in 2018, the candidates who scored grade A were more in 2018 than in 2019.

This report, therefore, intends to provide a detailed analysis based on the candidates' performance in each item. A brief note on what the candidates were required to do and the reasons for their performance are provided. Different extracts representing samples of the candidates' responses have been inserted to show clearly what the candidates did. Graphs and charts are also used to summarize the candidates' performance in a particular question.

Nevertheless, the percentage of performance in each question is categorized into three levels of performance based on the scores. The good, average and weak performance categories are in the ranges of 60 – 100, 35 – 59 and 0 – 34 respectively. For easy presentation in the charts, green, yellow and red colours are used to present these categories respectively. The report also indicates the candidates' performance in each topic and in grades as compared to the year 2018 (see appendices A, B and C). Finally, it provides a conclusion and gives 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 had short answer questions constructed from six topics as described in the analysis part. Each question carried 10 marks. The candidates' performance was considered as weak, average and good if the score ranges from 0 to 3, 3.5 to 5.5 and 6 to 10 marks respectively. The pass score for each question was taken from 3.5 and above. Therefore, the analysis of the candidates' performance on each question is as follows:

2.1.1 Question 1: Measurement

This question had parts (a) and (b). Part (a) required the candidates to (i) identify two basic rules of dimensional analysis and (ii) use the method of dimensions to derive the formula which relates the frequency of vibration, n, tension, T, length, l and mass per unit length m given that, the frequency of vibration of a stretched string is a function of its tension, the length and mass per unit length. Part (b) required them to (i) state four causes of systematic errors in an experiment and (ii) estimate the numerical value of drag force $D = \frac{1}{2} C\rho AV^2$ and its associated error if the measurements of the quantities C, A, ρ and V were recorded as (10 ± 0.00) unit less, (5 ± 0.2) cm^2 (15 ± 0.15) g/cm^3 and (3 ± 0.5) cm/sec^2 respectively.

A total of 18,498 candidates (97.8%) attempted this question. Analysis of the performance of the candidates revealed that 48.6 percent of them scored good marks, ranging from 6 to 10; 37.5 percent scored from 3.5 to 5.5; while 13.9 percent scored from 0 to 3 marks. These data are presented in Figure 1.

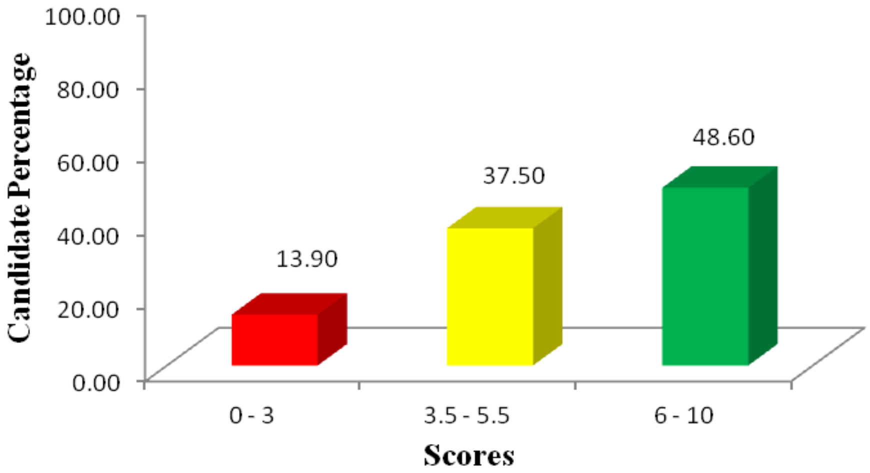


Figure 1: *The candidates' performance on question 1*

The candidates with good performance (6 - 10 marks) provided the correct responses to most parts of the question. They mentioned correctly the rules of dimensional analysis and applied it well to obtain the formula $n = \frac{k}{l}\sqrt{\frac{F}{m}}$ which relates the frequency of vibration n, tension T, length l and mass per unit length m of the stretched string. Furthermore, they were aware of the sources of systematic errors as they wrote the required responses which included *incorrect design or calibration of the instrument, lack of accuracy of the formula being used, incorrect interpretation of the scale of the instrument and limitations of the method used for measurement*. Apart from that, they had adequate understanding of the symbols used to represent errors as they were able to identify the measured value and its associated error in each measurement hence determined the value of drag force

$D = (3.375 \pm 1.230) \times 10^{-2}$ N correctly. Extract 1.1 shows one of the correct responses noted in this question from one of the candidates.

1(a)(i) The basic rules of dimensional analysis are;-

(i) We can only add or substract the physical quantities of same kind (ie of same unit) only. for example, we cannot add velocity and mass.

(ii) The physical relation is dimensionally correct if and only if the dimensions of all terms in both sides of physical relation are the same.

(ii) soln.

Given

$n \propto F^a L^b m^c$,

Then,

$n = kF^a L^b m^c$

and

~~[KFa L^b m^c] z~~

$[n] = [F]^a [L]^b [m]^c$

$[T^{-1}] = [MLT^{-2}]^a [L]^b [ML^{-1}]^c$

hence,

$[M^0 L^0 T^{-1}] = [M]^{a+c} [L]^{a+b-c} [T]^{-2a}$

by comparison;

$-2a = -1$

$a = \frac{1}{2}$;

also,

$a + c = 0$

$\frac{1}{2} + c = 0$

$c = -\frac{1}{2}$

Moreover,

$a + b - c = 0$

~~½ + ½ − c = 0.~~

$\frac{1}{2} + b + \frac{1}{2} = 0$

$b = -1$

1.(a)(ii) upon substituting;

$$n = k F^{1/2} L^{-1} m^{-1/2}$$

hence,

$$n = \frac{k}{L}\sqrt{\frac{F}{m}}$$

where k is dimensionless constant

(b) (i) The causes of systematic errors are:-

(i) The incorrect calibration of the instrument,

(ii) The lack of accurancy of formula used,

(iii) The used of poor ~~measure~~ method of measurement,

(iv) The incorrect design of the measuring instrument.

(ii) soln.

Given

$$D = \tfrac{1}{2} C \rho A V^2$$

hence,

$$D = \frac{1}{2} \times 10 \times 15 \times 5 \times 3^2$$

$$= 3375\,N$$

∴ The drag force's true value = 3375 gcm/s²

Moreover,

introducing "In" both sides:

$$\ln D = \ln(\tfrac{1}{2}) + \ln C + \ln \rho + \ln A + 2\ln V$$

upon differentiating;

$$\frac{\Delta D}{D} = 0 + \frac{\Delta C}{C} + \frac{\Delta \rho}{\rho} + \frac{\Delta A}{A} + \frac{2\Delta V}{V}$$

1.(b)(ii) hence,

$$\frac{\Delta D}{D} = \frac{\Delta C}{C} + \frac{\Delta \rho}{\rho} + \frac{\Delta A}{A} + \frac{2\Delta V}{V}$$

$$= \left(\frac{0}{10}\right) + \left(\frac{0.15}{15}\right) + \left(\frac{0.2}{5}\right) + \left(\frac{2 \times 0.5}{3}\right)$$

$$= 0 + 0.01 + 0.04 + 0.33$$

$$= 0.38$$

hence,

$$\Delta D = 3375 \times 0.38$$

$$= 1293.75$$

∴ The associated error is 1293.75 gcm/s^2

hence,

the value of drag force is

$$D = (3375 \pm 1293.75)\ gcm/s^2$$

Extract 1.1 is a correct response given by a candidate.

Extract 1.1 indicates how the candidate had adequate knowledge of dimensions and errors hence managed to describe the method of dimensional analysis and derive the relationship between physical quantities.

In contrast, the candidates who had weak performance lacked knowledge of basic rules, dimensional analysis, and errors in measurement. Most of them failed to retrieve the sources of systematic errors. As a result, they mentioned sources of other types of errors like random and gross errors. Extract 1.2 is a sample of the responses given by the candidates with poor performance on this question.

1. a) i/ Basic rules of dimensional analysis

- The three basic quantities are used which are mass, length and time only.
- Does not work on for constants and whole numbers.

ii/ Given:

n = frequency

F = tension

l = length

m = mass per unit length

$n \propto F l m$

but, $F = [MLT^{-2}]$

$n = 1/T = [T^{-1}]$

$m = \frac{[M]}{[L]}$

$m = [ML^{-1}]$

$n = kFlm$

$n = K \times [MLT^{-2}]^a [M]^b [MLT^{-1}]^c$

but $n = M^0 [T^{-1}] = [M^0 L^0 T^{-1}]$

$a = 2$; $b = 0$ and $c = 1/2$

$n = F^2 m^0 L^{1/2}$

$n = \sqrt{Fm/l}$

1. b) i/ Causes of Systematic errors in an experiment;
   - Air resistance
   - Nature of the material
   - Taking wrong observations of the readings

ii/ $D = \frac{1}{2} C \rho A V^2$

$C = (10 \pm 0.00)$

$A = (5 \pm 0.2)\,cm^2$

$\rho = (15 \pm 0.15)\,g/cm^3$

$V = (3 \pm 0.5)\,cm/sec^2$

$D = \frac{1}{2} C \rho A V^2$

$C = \Delta C/C$; $\rho = \Delta \rho/\rho$; $A = \Delta A/A$; $V^2 = 2 \times \Delta V/V$.

$D = \frac{1}{2}\left(\frac{\Delta C}{C} + \frac{\Delta \rho}{\rho} + \frac{\Delta A}{A} + \frac{2\Delta V}{V}\right)$

$D = \frac{1}{2}\left(\frac{0.00}{10} + \frac{0.2}{5} + \frac{0.15}{15} + \left(2 \times \frac{0.5}{3}\right)\right)$

$= \frac{1}{2}(0 + 0.04 + 0.01 + 0.33)$

$= \frac{1}{2} \times 5.33$

$D = 2.67 \times 100$

$D = 267$

∴ The numerical value of D is 267.

Extract 1.2, is a sample of poor responses given by the candidate.

In extract 1.2 the candidate demonstrated poor performance due to lack of knowledge of dimension, errors as well as differentiation.

2.1.2 Question 2: Newton's Laws of Motion

This question contained two parts: (a) and (b). In part (a), the candidates were required to calculate (i) the minimum rate of fuel consumption that enables the rocket to rise from the ground when a rocket of mass 20 kg has 180 kg of fuel and 1.6 km/sec exhaust velocity of the fuel and (ii) the ultimate vertical speed gained by the rocket when the rate of fuel consumption is 2 kg/sec. In part (b), they were required to (i) determine the least number of pieces required to stop the bullet if a rifle bullet loses $\frac{1}{20}$ of its velocity when passing through them and (ii) calculate the average force the water exert on the man of 100 kg who jumps into a swimming pool from a height of 5 m if it takes 0.4 seconds for the water in the pool to reduce its velocity to zero.

Data analysis reveals that 25.7 percent of the candidates attempted this question. Among them, 72.1 percent scored marks ranging from 0 to 3; 19.4 percent scored from 3.5 to 5.5 marks; and 8.5 percent scored from 6 to 10 marks. These scores imply that the candidates' performance in this question was weak because only 27.9 percent of the candidates scored from 3.5 to 10 marks as summarized in Figure 2.

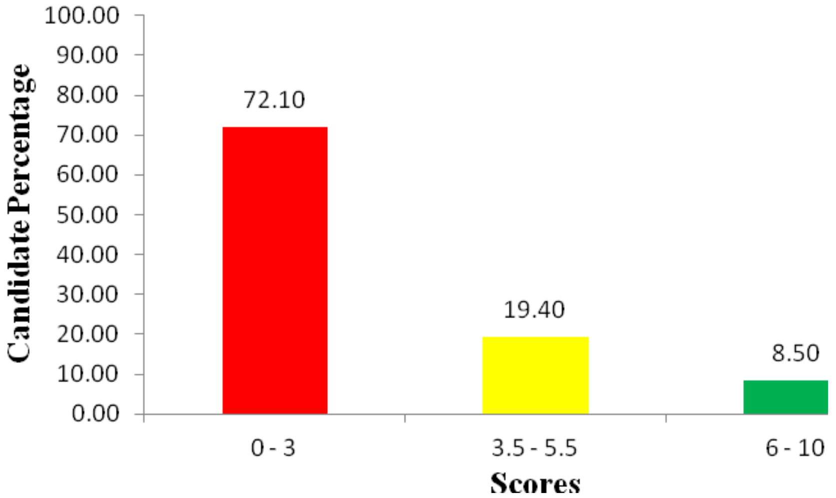


Figure 2: *The candidates' performance on question 2*

Figure 2 shows that, few candidates (25.7%) attempted this question, of which 26.4 percent scored zero. One of the factors noted to affect performance was the lack of adequate knowledge about rocket propulsion.

Most of the candidates failed to realize that the rate of rocket fuel consumption is minimum when the upward acceleration of the rocket is zero. Since the up thrust overcomes the weight of the rocket, then the rocket will move with uniform velocity. This concept could give them an expression $v\frac{dm}{dt} = mg$ from which the rate of fuel consumption $\frac{dm}{dt}$ would have been calculated. Similarly, in part (a) (ii), most of them failed to recall the formula to determine the ultimate vertical velocity of the rocket which is given by $V = v\log_e \frac{m_o}{m} - gt$. Another factor was the failure to understand that, in order to obtain the correct answer in part (b) they were required to be aware of the applications of Newton's laws of motion. Extract 2.1 shows responses of one of the candidates who demonstrated poor performance on this question.

2(a) Data given:

Mass (M) = 20kg.

Mass of fuel (M) = 180kg.

Total mass (M_o) = (20 + 180)kg = 200kg.

Velocity (V) = 1.6km/sec = 1600m/s

i/ Req: Minimum Rate of fuel (dm/dt) = ?.

From:

$V = u + at$, $u = 0$.

$V = at$, $a = g$.

$t = V/g = 1600/9.8$

$= 163.265$ sec.

$dm/dt = \frac{180\text{kg}}{163.265\text{ sec}}$

$= 1.1025$ kg/sec.

∴ The minimum rate of fuel consumption is 1.1025kg/sec.

ii/ Required: Speed (V) = ?

Rate of fuel consumption (dm/dt) = 21kg/sec.

from: $F = V\, dm/dt$.

$= 1600 \times 1.1025$

$= 1,764$N.

Also:

$\frac{F}{dm/dt} = V$.

$V = \frac{1764\text{N}}{21\text{kg/sec}}$

$= 882$ m/sec.

∴ The speed gained by the rocket is 882m/sec.

2(b) Data given:

ii/ Mass (m) = 100kg.

height (h) = 5m.

time (t) = 0.4sec.

Required: Force (F) =?

For 2nd law of motion.

~~$S = ut + \frac{1}{2}at^2$~~

$H = \frac{1}{2}gt^2$.

$V = u + at$

$V = gt$

$= 9.8 \times 0.4$

$= 3.92 m/s$.

But

$F = \frac{mV}{t}$

$= \frac{100 \times 3.92}{0.4}$

$= 980N$.

∴ The average force exerted on the water is 980N.

Extract 2.1 is a sample of poor response given by the candidate.

In extract 2.1 the candidate used inappropriate procedures and formulae in the presented calculations as he/she failed to determine reaction forces and describe the application of Newton's laws of motion in daily life.

In spite of the weak performance by the majority of the candidates who attempted this question, few candidates managed to provide the correct responses to some parts of the question. For instance, in part (b) (i) which was skipped by most candidates, some of them deduced that, when the bullet penetrates through the first piece of thickness *S*, its velocity v_o which decreases by $\frac{1}{20}$ becomes $v = v_o - \frac{1}{20}v_o = \frac{19}{20}v_o$. Then from Newton's third equation of motion $\left(\frac{19}{20}v_0\right)^2 = v_o^2 + 2aS$ giving the value of thickness $S = -\frac{39}{800a}v_0{}^2$. Again, if n is the number of pieces required to stop the bullet after it has passed the first piece, $o^2 = \left(\frac{19}{20}v_o\right)^2 + 2a(nS)$ giving the value of $n = -\frac{361}{800aS}v_0^2$. Replacing S in the latter equation gives $n = 9.25$. Thus, the total number of the pieces including the first piece is $n+1 = 9.25+1 = 10.25$. Since pieces exist as whole numbers, $n \approx 11$ pieces. Extract 2.2 presents the response by one of the candidates who responded correctly in this question.

2. (a).

(i) let mass of rocket be m.
exhaust be vr.

so:

$F - mg = ma$.

for rising up:

$F > mg$.

where $F = v_r\, dm/dt$ where dm/dt is the rate of consumption of fuel.

so:

$v_r\, dm/dt = mg$.

$dm/dt = \frac{mg}{v_r}$.

$v_r = 1600\ ms^{-1}$, $g = 9.8\ ms^{-2}$.

$m = 180 + 20 = 200\ kg$.

so:

$dm/dt = \frac{200\ kg \times 9.8\ ms^{-2}}{1600\ ms^{-1}}$.

$dm/dt = 1.225\ kgs^{-1}$.

(ii) From: $v = u + v_r \ln M_o/M - gt$.

Then: $u = 0$. by considering value of gravity

v = ultimate speed.

$v_r = 1600\ ms^{-1}$.

$M_o = 200\ kg$.

$M = 20\ kg$

$g = 9.8$.

$t = \frac{\text{mass of fuel}}{\text{rate of consumption}}$

2. (a) (ii)

$t = \frac{180 kg}{2 kg s^{-1}}$

$t = 90 s$

so:

$V = 1600 \ln \frac{200}{20} - 9.8(90)$

$V = 2802.14 ms^{-1}$

∴ Ultimate speed is $2802.14 ms^{-1}$

(b) (i) let Then number be X.

Then:

$v^2 = u^2 - 2as$

$v = \frac{19}{20}u, u^2$

so: $\left(\frac{19}{20}\right)^2 = u^2 - 2as$

$2as = \left(\frac{19}{20}\right)^2 u^2 - u^2$

$2as = \frac{39}{400} u^2$ ---(i)

Then let n number return The $19/20 u$ to zero.

$V^2 = u_0^2 - 2asn$

$u = \frac{19}{20}u, V = 0$

2. (b) (i) $0^2 = \left(\frac{19}{20}u\right)^2 - 2asn$.

$2asn = \left(\frac{19u}{20}\right)^2$.

$2as\,n = \frac{361u^2}{400}$.

but $2as = \frac{39u^2}{400}$ from eqn (i).

$\frac{39u^2}{400} \cdot n = \frac{361u^2}{400}$

$n \approx 9$

but

total number $x = n+1$.

$x = 9+1 = 10$.

∴ 10 pieces are required.

(ii) let velocity acquired by man from 5m fall be v.

so: $v = \sqrt{2gh}$

$g = 9.8\,ms^{-2}$. $h = 5\,m$.

so:

$v = \sqrt{2 \times 9.8 \times 5}$

$v = 9.9\,ms^{-1}$.

let The ~~deceleration~~ deceration be a.

so: $V_1^2 = V^2 - 2as$.

$V_1 = 0$.

$V = 9.9$

2. (b)(ii) from.

$v = u + at$.

so:

$v_1 = v + at$.

$a = \frac{v_1 - v}{t}$.

$a = \frac{(0 - 9.9)}{0.4}\ ms^{-2}$.

$a = -24.75\ ms^{-2}$ ((−) shows that the body is decelerating.

net force

$F = ma$.

$F = 100 \times 24.75 = 2475N$.

so Force acting on body is 2475 N.

Extract 2.2 shows a sample of a good answer provided by a candidate.

In extract 2.2 the candidate understood the demand of the question as he/she competently applied Newton's laws of motion to solve the problems.

2.1.3 Question 3: Projectile Motion

This question was divided into two parts: (a) and (b). In part (a), the candidates were required to (i) justify the statement that the projectile motion is a two dimensional motion and (ii) calculate the horizontal distance covered after the half time of flight when a rocket was launched with a velocity of 50 m/s from the surface of the moon (acceleration due to gravity 1.67 m/s^2) at an angle of 40^o to the horizontal. In part (b), they were required to (i) show that the angle of projection θ^o for a projectile launched from the origin is given by $\theta^0 = \tan^{-1}\left(\frac{4h_m}{R}\right)$ where R stand for horizontal range and h_m is the maximum vertical height and (ii) determine the angle of projection for which the horizontal range of a projectile is $4\sqrt{3}$ times its maximum height.

About eighty nine (88.8) percent of the candidates opted for this question. Among them, 12.1 percent scored from 0 to 3; 21.2 percent scored from 3.5 to 5.5 marks; and 66.7 percent scored from 6 to 10 marks. Therefore, the general performance on this question was good because 87.9 percent of the candidates scored from 3.5 to 10 marks. This implies that most of them had good understanding of the concept of *projectile motion* hence they adhered correctly to the demand of each part of the question. Extract 3.1 presents one of the good responses to this question.

3.(a)

(i) the Fact that projectile motion is the two dimensional motion can be justified by considering the equation of trajectory of the body undergoing projectile motion, that is;

$$y = x\tan\theta - \frac{g}{2u^2\cos^2\theta}x^2$$

which indicates that at every instant of time a body undergoes both vertical and horizontal displacement.

3.(a)(ii) soln

From,

$$x = u\cos\theta t \quad \text{---(i)}$$

and,

$$T = \frac{2u\sin\theta}{g_m}, \text{ hence,}$$

$$t = \frac{T}{2} = \frac{u\sin\theta}{g_m} \quad \text{---(ii)}$$

hence,

$$x = u\cos\theta \times \frac{u\sin\theta}{g_m}$$

$$= \frac{u^2\sin\theta\cos\theta}{g_m}$$

$$\therefore x = \frac{(50)^2 \times \sin(40^\circ) \times \cos(40^\circ)}{1.67}$$

$$= 737.132\text{m}$$

$\therefore$ horizontal distance covered is 737.132m

(b) (i) soln.

From,

$$h_m = \frac{(u\sin\theta)^2}{2g} \quad \text{—— (i)}$$

and,

$$R = \frac{2u^2\sin\theta\cos\theta}{g} \quad \text{—— (ii)}$$

Take eqn (i) ÷ eqn (ii);

$$\frac{h_m}{R} = \frac{u^2\sin^2\theta}{2g} \times \frac{g}{2u^2\sin\theta\cos\theta}$$

$$\frac{h_m}{R} = \frac{\tan\theta}{4}$$

3(b)(i) hence,

$$\tan\theta = \frac{4h_m}{R}$$

and,

$$\theta^\circ = \tan^{-1}\left(\frac{4h_m}{R}\right)$$ hence shown.

(ii) soln.

From derived Formula above;

$$\tan\theta = \frac{4h_m}{R}$$

Given,

$$R = 4\sqrt{3}\,h_m$$

hence,

$$\tan\theta = \frac{4h_m}{4\sqrt{3}\,h_m}$$

$$\tan\theta = \frac{1}{\sqrt{3}}$$

$$\theta = \tan^{-1}\left(\frac{1}{\sqrt{3}}\right)$$

$$= 30^\circ$$

∴ The Angle of projection is 30°

Extract 3.1: A sample of good response given by a candidate.

In extract 3.1 the candidate correctly and systematically presented the answers for each part. This indicates that he/she had a good understanding of the concepts and formulae of projectile motion.

On the other hand, candidates who scored low marks in this question presented incorrect responses to most parts of the question. For example, in part (a) (i), most of them failed to give the reason behind the given statement whereas in (a) (ii), they failed to retrieve proper formulae for horizontal range and maximum height. Moreover, some candidates used the acceleration of the earth due to gravity instead of that of the moon in calculating the horizontal distance covered by the rocket launched in the moon. This indicates that they did not read carefully the instructions and the constants given on the front page of the examination paper, where the acceleration of free fall on the moon was given. In part (b), most of them failed to derive the formula $\theta^0 = \tan^{-1}\left(\frac{4h_m}{R}\right)$ as applied in projectile motion indicating that they lacked content knowledge about the formula of range and maximum height of a projectile. Extract 3.2 is a sample of poor responses to this question.

3 a) i) projectile is a two dimensional motion.
– Because when a projectile is thrown from a certain angle it is acted upon the force of gravity. So two dimentional motion of the body and of the force of gravity will occur that why is called two dimensional motion.

ii) Data.
$U_1 = 50 m/s$
$\theta = 40°$
$R = ?$
after half time of flight

$$R = \frac{u^2 \sin 2\theta}{g}$$

$$T = 2\pi \sqrt{H/g}$$

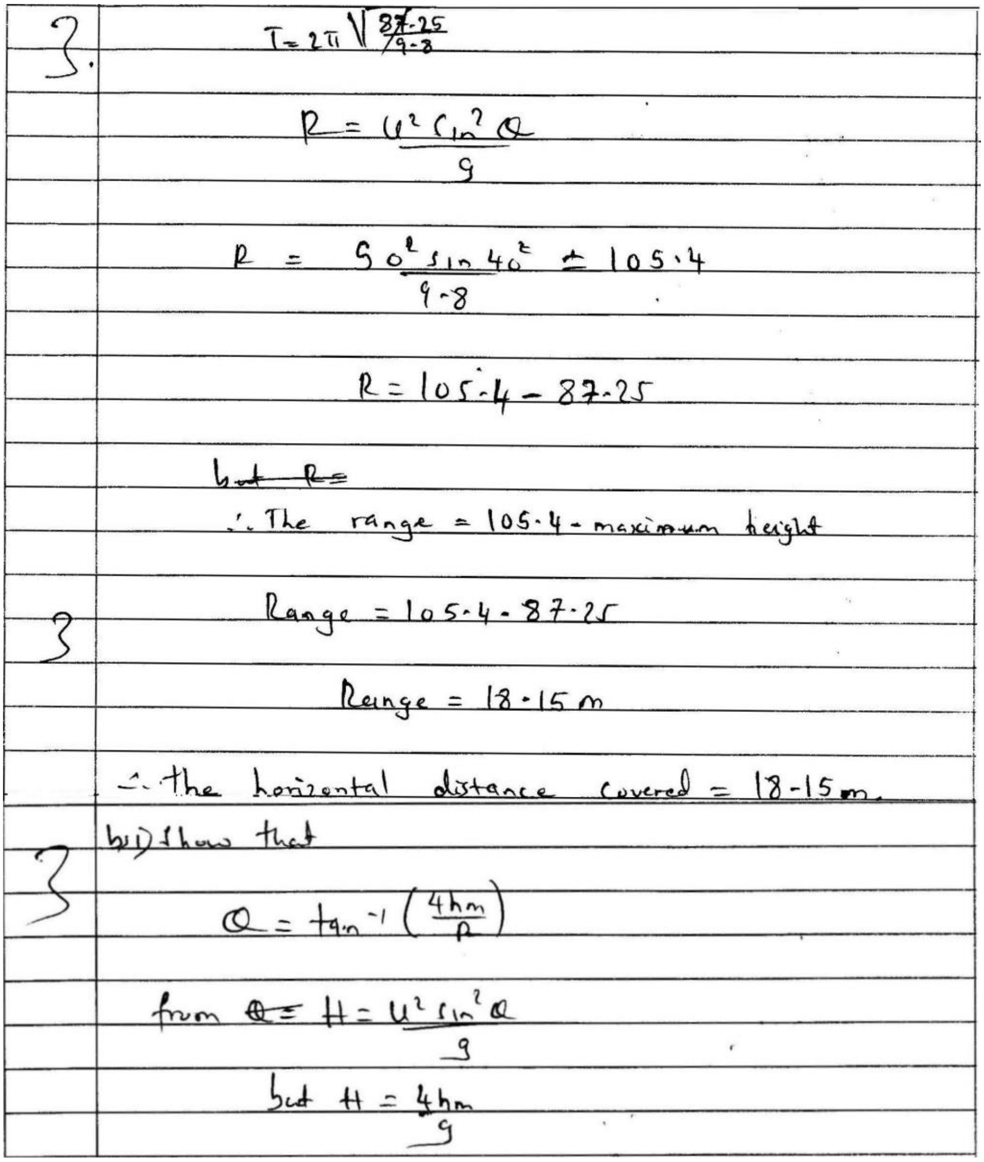
from $\frac{u^2 \sin^2\theta}{g} = H$

$$H = \frac{u^2 \sin^2\theta}{g}$$

$$H = \frac{50^2 \sin^2 40}{g} = 87.25 m$$

$H = 87.25m$ – maximum Height

$$T = 2\pi \sqrt{H/g}$$



3. $T = 2\pi\sqrt{\frac{87.25}{9.8}}$

$R = \frac{u^2 \sin^2 \theta}{g}$

$R = \frac{50^2 \sin 40^2}{9.8} = 105.4$

$R = 105.4 - 87.25$

~~but R=~~

∴ The range = 105.4 - maximum height

Range = 105.4 - 87.25

Range = 18.15 m

∴ the horizontal distance covered = 18.15 m.

b(i) Show that

$\theta = \tan^{-1}\left(\frac{4h_m}{R}\right)$

from ~~θ=~~ $H = \frac{u^2 \sin^2 \theta}{g}$

but $H = \frac{4h_m}{g}$

Extract 3.2 indicates inappropriate responses provided by a candidate.

In extract 3.2 the candidate used incorrect formulae and procedures in calculating the horizontal distance and maximum height hence received wrong responses.

2.1.4 Question 4: Simple Harmonic Motion

This question was comprised of parts (a) and (b). Part (a) required the candidates to: (i) provide two typical examples of simple harmonic motion (S.H.M) and (ii) explain why velocity and acceleration of a body executing

S.H.M are out of phase. Part (b) required them to (i) calculate the time taken by a particle to move a distance of 12.5 cm on either side from the mean position given that the period of a particle executing simple harmonic motion (S.H.M) is 3 seconds and its amplitude is 25 cm and (ii) find the minimum weight of a person as recorded by a machine of the platform given that the person weighing 50 kg stood on a platform which oscillates with a frequency of 2 Hz and amplitude of 0.05 m.

The number of candidates who opted for this question was 14927, equivalent to 79.0 percent. Their performance was as follows: 45 percent scored from 0 to 3 (including 5.9% who scored 0 marks); 32.1 percent scored from 3.5 to 5.5 marks; while 22.9 percent scored from 6 to 10 marks. The candidates' performance on this question is presented in Figure 3.

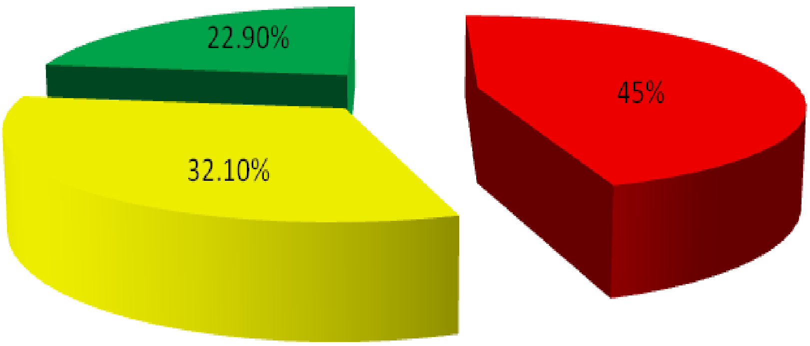


Figure 3: *The candidates' performance on question 4*

The candidates who performed well in this question managed to state correctly the two typical examples of simple harmonic motion, which include *oscillations of a loaded spring, oscillations of a liquid in a U- tube and oscillations of a floating cylinder and motion of a body dropped in a tunnel along earth's diameter*. Also they managed to give the fact that velocity and acceleration of a body executing S.H.M are out of phase because in S.H.M acceleration is always directed towards the centre. Hence, it is maximum at the extremes where the velocity is zero and minimum at the equilibrium where the velocity is maximum. Moreover, most of them attempted well in part (b) (i) but missed some required steps in solving part (b) (ii) as they failed to identify that for a body of mass *M*, placed on a platform which executes vertical S.H.M at angular speed w, its weight W is given by $W = Mg \pm Aw^2$ where g stands for acceleration due to gravity. Hence, they could not deduce the formula for minimum weight given that $W_m = Mg - Aw^2$. Extract 4.1 presents the sample of a response from one of the candidates who managed to provide required answers to each part of this question.

4a) i) Two typical example of simple harmonic (S.H.M)
• motion of simple pendulum.
• Oscillation of fluid in a U-tube apparatus

ii) Those ~~so are~~ velocity and acceleration are out of phase since at different point in SHM motion posses different values. That is
at maximum displacement
acceleration is maximum
velocity = 0
• at Equilibrium (mean position
acceleration is zero
velocity is maximum
Due to those they are out of phase,

b) i) Given T = 3 second
$w = 2\pi/T = \frac{2 \times 3.14}{3}$
w = 2.09 rad/sec.
amplitude a = 25 cm
displacement y = 12.5cm
from
equation of displacement of simple harmonic
y = a sin wt.
$y = a \sin(2\pi/T \, t)$
$12.5cm = 25cm \sin(\frac{2\pi}{3} \times t)$
$\sin(2\pi/3 \times t) = \frac{12.5cm}{25cm}$

b) ii) $\sin\left(\frac{2\pi t}{3}\right) = 0.5$

$\frac{2\pi t}{3} = \sin^{-1}(0.5)$

$\frac{2\pi t}{3} = \frac{\pi}{6}$

$\frac{2t}{3} = \frac{1}{6}$

$\frac{12t}{12} = \frac{3}{12}$

$t = 0.25$ sec

To move on either side $= 2t = 2\times0.25 = 0.5$ sec

$\therefore$

Time to move on either side $= 2t = 2\times0.25 = 0.5$ sec

$T = 0.5$ sec.

ii) mass $m = 50$ kg

frequency $= 2$ Hz

amplitude $A = 0.05$ m,

- Required minimum weight recorded by machine

but weight of man

$W = mg$

$= 50\text{ kg} \times 9.8\text{ m/s}^2$

$W = 490$ N

Due to oscillation, net force

$F_{net} = Ma$

but a = acceleration

$a = -\omega^2 A$

$a = \omega^2 A$

4 b) (ii) $a = (2\pi f)^2 A$

$= 4\pi^2 f^2 A$

$= (4 \times (3.14)^2 \times 2^2 \times 0.05)\ m/s^2$

$a = 7.89\ m/s^2$

Then net force

$f_{net} = ma$

$= (7.89 \times 50)\ N$

$= 394.5\ N$

$\therefore$

Minimum weight $= W - f_{net}$

$= 490N - 394.5N$

$= 95.5N$

$\therefore$ Minimum weight recorded by machine $= 95.5N$

Extract 4.1 is a sample of the correct response given by a candidate.

In extract 4.1 the candidate managed to describe Simple Harmonic Motion and applied the required formulae and procedures to deduce the period, acceleration, weight and net force.

Most of those who scored low marks (0 - 3) could not describe properly the typical examples of S.H.M and give the reason behind the acceleration and velocity of a body executing S.H.M being out of phase. They were also not aware of the appropriate formula for calculating the required quantities. For example in part (b) (i), they did not use the formula $y = A\sin\frac{2\pi t}{T}$ to calculate the time taken by the particle to move a given distance in either side from the mean position. Instead, they used other formulae related to the circular motion. Extract 4.2 shows a poor response from a candidate who supplied incorrect answers to the question.

04 a.) i) → Pendellum bob
→ water in a test tube.

ii) This is because the acceleration of a body excuiding simple harmonic motion is affected by gravitation hence velocity interupt out.

b)(i) soln

$T = 3\,s$

$A = 25\,cm = 0.25\,M$

$d = 12.5\,cm = 0.125\,M.$

$t = ?$

From

$T = 1/t$, so $t = 1/T = 0.33\,s.$

but also from

$\frac{\omega}{1} = \frac{2\pi}{T}$

$T = \frac{2\pi}{\omega}$

so $2\pi/\omega = 1/t$

but $\omega = v/r$

~~$v = \Delta d/\Delta t$~~ $= 0.125$

$2\pi r/v = 1/t$

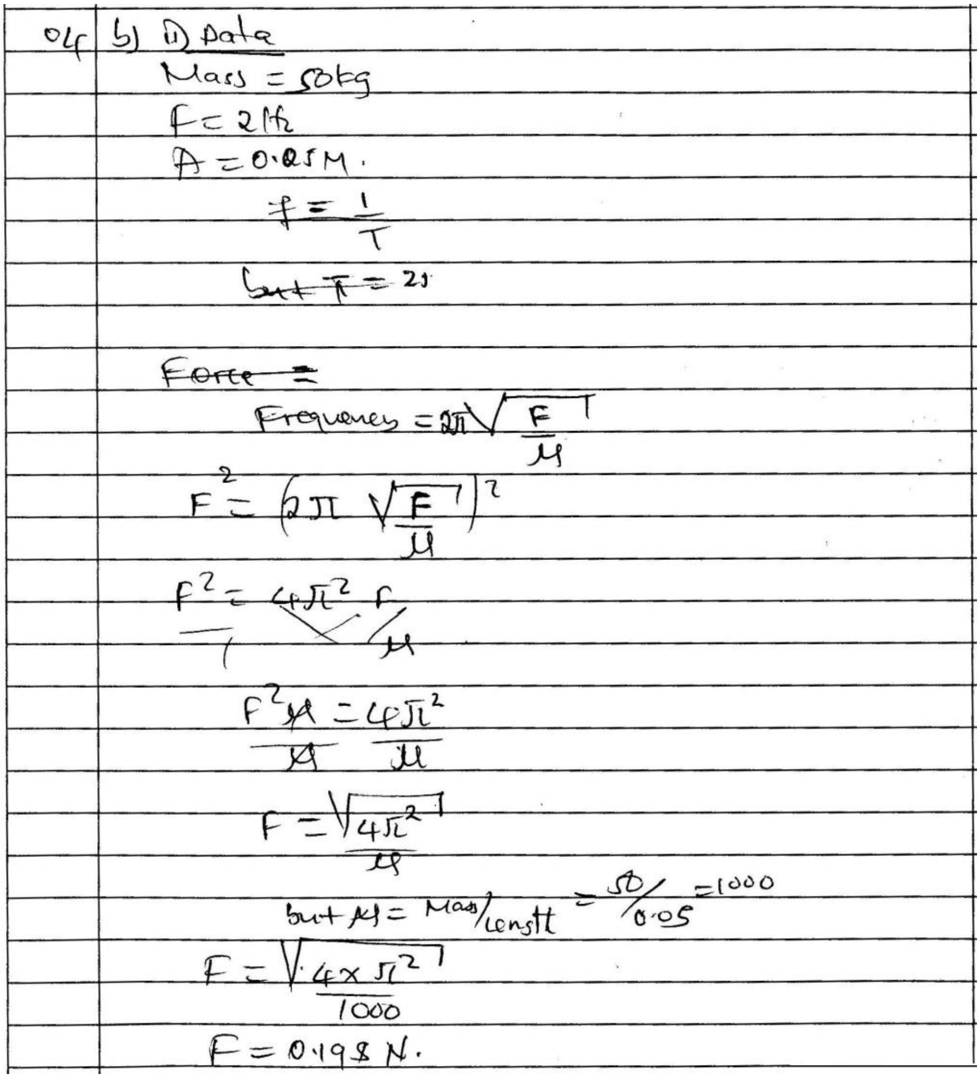
$2\pi r f = v.$

$2\pi r f = v$

$v = 0.05.$

but $v = \Delta d/\Delta t$

$\Delta t = \Delta d/v = 0.125/0.05 = 2.54\,s$


04 b) ii) Data

Mass = 50kg

F = 2Hz

A = 0.25M.

$f = \frac{1}{T}$

~~but T = 2s~~

~~Force =~~

Frequency $= 2\pi\sqrt{\frac{F}{\mu}}$

$F^2 = \left(2\pi\sqrt{\frac{F}{\mu}}\right)^2$

$\frac{F^2}{1} = 4\pi^2 \frac{F}{\mu}$

$\frac{F^2 \mu}{\mu} = \frac{4\pi^2}{\mu}$

$F = \sqrt{\frac{4\pi^2}{\mu}}$

but μ = Mass/Length $= \frac{50}{0.05} = 1000$

$F = \sqrt{\frac{4 \times \pi^2}{1000}}$

$F = 0.198$ N.

Extract 4.2: A sample of poor responses provided by a candidate.

In extract 4.2 the candidate partially described the typical examples of S.H.M, provided an incorrect reason to part (a) (ii), and applied incorrect formula in doing calculations.

2.1.5 Question 5: Circular Motion

This question consisted of two parts, titled (a) and (b). Part (a), required the candidates to (i) explain the aspect in which circular motion differs from linear motion and (ii) give reason why there must be a force acting on a particle moving with uniform speed in a circular path. In part (b) (i), they were required to calculate the average velocity of a particle moving in a semi-circular path AB of radius 6 m with a constant speed of 12 m/s. Part

(b) (ii) required the candidates to determine the magnitude of acceleration of a stone tied to the end of a string of 80 cm long then whirled in a horizontal circle with a constant speed, making 25 revolutions in 14 seconds.

A total of 9533 (50.4%) candidates attempted this question. Among them, 35.1 percent of them scored from 0 to 3; 48.4 percent scored from 3.5 to 5.5; and 16.5 percent scored from 6 to 10. These scores indicate that the performance on this question was good since 64.9 percent of the candidates scored from 3.5 to 10. Figure 4 illustrates the given information.

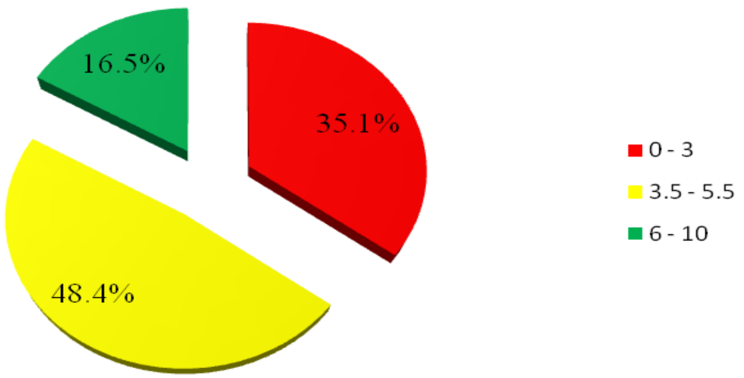
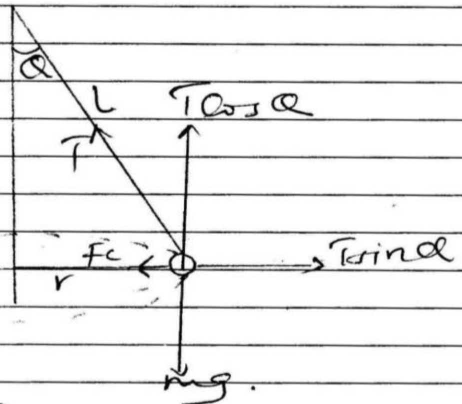


Figure 4: *The candidates' performance on question 5*

The analysis of the candidates' responses in this question revealed that most of them had a good understanding of the concept of *circular motion*. In part (a) (i), they stated correctly that circular motion differs from linear motion in the sense that in circular motion the direction changes continuously with time, unlike in linear motion. In part (a) (ii), they recognized that circular motion is facilitated by centripetal force due to the existence of centripetal acceleration which is always directed towards the centre of motion. Also, most of them attempted item (b) (ii) well but failed to do so in item (b) (i) due to various reasons, including inability to deduce that average velocity in some context is given by $v = \frac{Displacement}{Total\ time}$. Therefore, some of them calculated the average velocity as a mean of the velocities in Arc AB through the AB diameter. This was not correct since the direction of the velocity along Arc AB varies. However, some candidates detected the logic behind. Therefore, they managed to solve this item correctly as presented in Extract 5.1.

5(a)	(ii)	There must be a force acting because if there will be no force acting the body will leave the circular path and move in a straight line.
	(i)	Circular motion differ from linear motion in the espect of velocity. Velocity in circular motion is always changing interms of mainly direction while in linear motion velocity changes in terms of magnitude.
5(b)	(i)	Data given Speed (V) = 12 m/s. Radius (r) = 6 m. From the figure $\text{Speed}(V) = \frac{\text{distance } AB}{t}$. but $\text{distance } AB = \frac{1}{2}(\text{Circumference})$ $AB = \frac{1}{2} \cdot 2\pi r$. $\text{distance} = \pi r$. $t = \frac{\pi r}{V} = 1.57 \text{ sec}$.
5(b)	(i)	Average velocity, $V = \frac{2 \times \text{radius}}{t}$. $V = \frac{2 \times 6}{1.57}$ $V = 7.64 \text{ m/s}$. ∴ Average velocity = 7.64 m/s.

(ii)



From the diagram.

$T\cos Q = mg$ —(i)

$T\sin Q = \frac{mv^2}{r}$ —(ii)

By dividing the two equations;

$\frac{T\sin Q}{T\cos Q} = \frac{mv^2}{rmg}$

$\tan Q = v^2/rg$ —(iii)

5(b) (ii) From equation (iii)

$\tan Q = v^2/rg$

$v = \sqrt{rg\tan Q}$

$v = 8.94\,m/s$.

Then

$a = v^2/r$

$a = 100.4\,m/s^2$.

∴ Acceleration is $100.4\,m/s^2$.

Extract 5.1: A sample of good response provided by a candidate.

Extract 5.1 indicates how the candidate responded correctly to each item by describing the application of circular motion and applying the correct formulae and procedures in determining the time, average velocity and acceleration with respect to circular motion.

However, most of the 35.1 percent of the candidates who scored low marks (0 - 3) lacked knowledge about the concept of *circular motion* as they failed to distinguish it from linear motion and to give reasons behind the given task in part (a) (ii). Most of them also failed to draw the free force diagram to resolve the vertical and horizontal components of force acting on a body whirled in a horizontal circle. Extract 5.2 shows an example response by a candidate who gave incorrect answers to each of the question items.

5 (a) i) Circular motion refers to the motion that tends to move with respect to the direction of the Circular path.

BUT

linear motion refers to the motion that tends to move with the respect to the linear path.

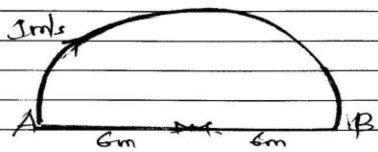
i) Circular motion has both linear and radial velocity

WHILE

linear motion has only linear Velocity

ii) There must be a force acting at a particle moving with Uniform Speed so as to balance the restoring force to not make the object to fly tangentially hence this is due to the presence of both tangential and radial acceleration.

5 (b) i) Redrawing the diagram



from the formula.

At Constant Speed = Acceleration is Zero

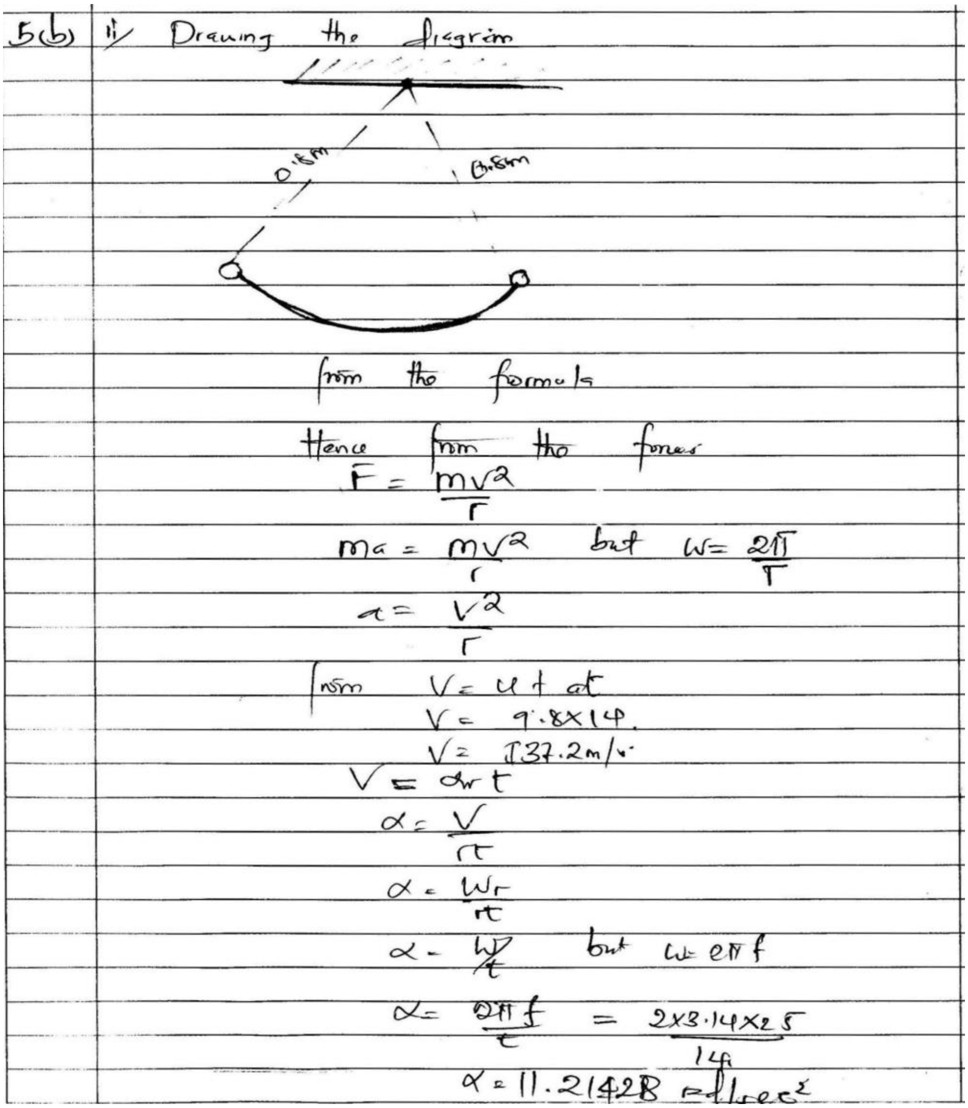
$F = mg - \frac{mv^2}{r}$ but $F = 0$.

$mg = \frac{mv^2}{r}$

$g = \frac{v^2}{r}$

$g \times r = V^2$

$\sqrt{g \times r} = V$


5(b) ii) Drawing the diagram

from the formula

Hence from the forces

$F = \frac{mv^2}{r}$

$ma = \frac{mv^2}{r}$ but $w = \frac{2\pi}{T}$

$a = \frac{v^2}{r}$

from $V = u + at$

$V = 9.8 \times 14$

$V = 137.2 m/s$

$V = \alpha r t$

$\alpha = \frac{V}{rt}$

$\alpha = \frac{Wr}{rt}$

$\alpha = \frac{W}{t}$ but $w = 2\pi f$

$\alpha = \frac{2\pi f}{t} = \frac{2 \times 3.14 \times 25}{14}$

$\alpha = 11.21428$ rad/sec²

Extract 5.2: A sample of poor response provided by a candidate.

Extract 5.2 indicates how the candidate failed to deduce the concepts of circular motion as he/she applied incorrect formulae leading to incorrect responses to all parts of the question items.

2.1.6 Question 6: Gravitation

The question aimed at assessing the candidates' knowledge about the concept of *Gravitation*. Thus, part (a) required them to (i) explain why the weight of a body becomes zero at the centre of the earth and (ii) determine how far above the earth surface does the value of acceleration due to gravity become 36% of its value on the surface. In part (b), the candidates were required to (i) compute the period of revolution of a satellite revolving in circular orbit at a height of 3400 km above the earth's surface and (ii) prove that the angular momentum for a satellite of mass M_s revolving round the earth of mass M_e in an orbit of radius r is equal to $\left(GM_eM_s^2r\right)^{\frac{1}{2}}$.

A total of 10,995 candidates corresponding to 58.2 percent attempted this question. Their scores were as follows: 42.9 percent scored below 3.5 marks, including 14.7 percent who scored 0 marks; 22.6 percent scored from 3.5 to 5.5; while 34.5 percent scored from 6 to 10 marks. These data reveal that the candidates' performance on this question was average because 57.1 percent of them scored from 3.5 to 10.

The candidates who scored average marks (3.5 - 5.5) performed well in part (a) (ii) and (b) (i) as they computed correctly the height above the earths' surface and the period of revolution of a satellite. However, they provided wrong responses to other parts of the question. This could have been contributed by their failure to understand that the weight and the acceleration due to gravity become zero due to the fact that the distance from the earths' surface to the centre of the earth becomes equal to the radius of the earth i.e from $g' = g\ (1 - d/g)$, if $d = g$, then $g' = 0$ and hence $W = m \times g' = 0$. In addition, most of them failed to retrieve and compare the required expressions for centripetal and gravitational forces to prove an expression of angular momentum of a satellite as given in part (b) (ii). Extract 6.1 is a sample of a good answer by one candidate.

6 (a) (ii)

$0.36 = \left(\frac{R}{R+h}\right)^2$

$\frac{0.6}{1} = \frac{R}{R+h}$

$0.6R + 0.6h = R$

$0.6h = R - 0.6R$

$0.6h = 0.4R$

$h = \frac{0.4}{0.6}R$ $\quad \frac{0.4}{0.6}R$

$h = 4266.67$ km

Height above = 4266.67 km

6. (b) Given

$h = 3400\ km$

from centripetal force = gravitation force

$m w^2 (R+h) = \frac{GMm}{(R+h)^2}$

$w^2 (R+h) = \frac{GM}{(R+h)^2}$

$\frac{4\pi^2}{T^2} = \frac{GM}{(R+h)^3}$

$T^2 = 4\pi^2 \frac{(R+h)^3}{GM}$

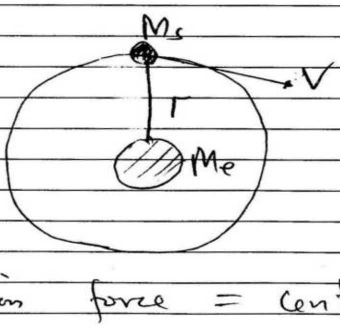
$T = 2\pi \sqrt{\frac{(R+h)^3}{gR^2}}$

6. (b) (i)

$T = 2\pi \sqrt{\frac{((6400+3400) \times 10^3)^3}{9.8 \times (6400 \times 10^3)^2}}$

Time period = 9621.13 seconds

(ii) For angular momentum of satellite ~~From~~ consider the figure below



From above

Gravitation force = Centripetal force

$\frac{G M_s M_e}{r^2} = \frac{M_s V^2}{r}$

orbital velocity $(V) = \sqrt{\frac{G M_e}{r}}$

but

angular momentum of satellite = $M_s V r$

6 (b)(ii)

Angular momentum (L) = $M_s \sqrt{\frac{GM_e}{r}} \cdot r$

$$L = \left[\frac{G M_e M_s^2 \cdot r^2}{r}\right]^{1/2}$$

Angular momentum (L) = $[G M_e M_s^2 r]^{1/2}$ proved

Extract 6.1: A sample of a good response given by one of the candidates.

In extract 6.1 the candidate was able to deduce Newton's law of universal gravitation as he/she applied the correct formulae in determining the height, periodic time and deriving an expression of angular momentum.

However, 42.9 percent of the candidates who scored low marks (0 - 3) faced several challenges including failure to provide specific reason on part (a) (i). They also lacked competence in retrieving and conveying the basic concepts of variation of the earth's acceleration due to gravity with depth as well as the formulae guiding planetary motion. Extract 6.2 is a sample of poor responses to this question.

6 A)

i) This is because as the body moves to the center of the earth also is pulled up by the other part of the earth as result lead to decrease in weight

But as body reached the earth's centre the upward pull of the earth on body balances with the pull of the body toward the center. Hence this causes cancellation of gravity forces as both act on same body.

Hence causing the body weight to become zero

ii) from

% decrease in weight = $2h/R \times 100\%$

$\therefore 36/100 = 2h/6400km$

$\therefore h = \frac{36 \times 6400km}{2 \times 100}$

h = 1152km

∴ About 1152km above the earth

6 B) i)

From
periodic time

$$T = 2\pi/R \sqrt{(R+h)^3/gR}$$

where $R = 6400\text{km} = 6400000\text{m}$

$$T = 2 \times 3.14 / 64 \times 10^5\text{m} \sqrt{\frac{((64+34) \times 10^5\text{m})^3}{9.8\text{m/s}^2 \times 64 \times 10^5\text{m}}}$$

$$T = 3.801\text{s}$$

$\therefore$ 3.801s will be the periodic time.

6 B) ii)

Required to prove

$$L = \sqrt{G M_e M_s^2 r}$$

$\because$ from

$$L = I\omega$$

$$(I\omega)^2 = G M_e M_s r^2$$

$$L = \sqrt{GM}$$

Extract 6.2 is a sample of poor response provided by a candidate.

Extract 6.2 indicates how the candidate provided an incorrect reason in part (a) (i) and used incorrect formulae in performing calculations.

2.1.7 Question 7: Thermometers and Thermal Conduction

This question was divided into parts (a) and (b). In part (a), the candidates were required to (i) explain why water is preferred as a cooling agent in many automobile engines and (ii) calculate the boiling point of water on a scale of thermometer with wrong calibration which reads the melting point of ice as - 10 ^{0}C and 40 ^{0}C in a place where the temperature is 30 ^{0}C. Part (b) required them to (i) analyse three practical applications of thermal expansion of solids in daily life situations and (ii) calculate the heat loss per minute by conduction given that a closed metal vessel containing water at 75 ^{0}C has a surface area of 0.5 m^2, uniform thickness of 4.0 m and its outside temperature of 15 ^{0}C.

Analysis of the candidates' performance revealed that more than half of them (69.2%) scored low marks, ranging from 0 to 3; 21.3 percent scored from 3.5 to 5.5 marks; while 9.5 percent scored from 6 to 10 as shown in Figure 5.

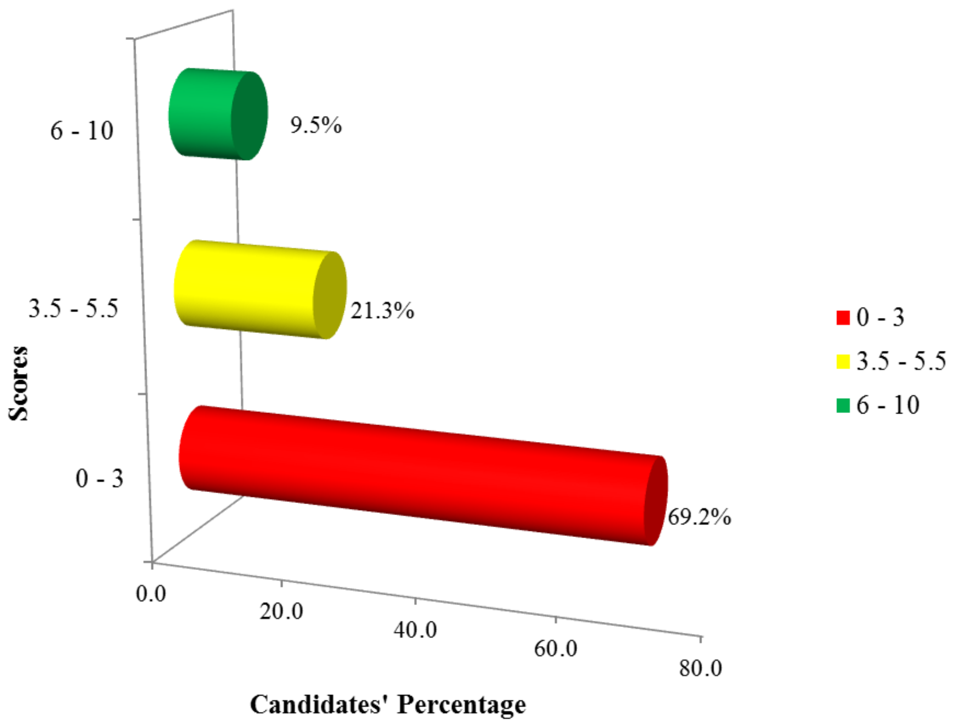


Figure 5: *The candidates' performance on question 7*

The data illustrated in Figure 5 shows that the candidates' performance in this question was poor because more than half failed to answer the question by scoring from 0 to 3 marks. Responses from most candidates who scored low marks had many errors, including failure to identify appropriate formula for calculating heat loss and temperature. They also provided invalid reasons as to why water is preferred as a cooling agent in automobile engines. Moreover, they failed to analyse the practical applications of thermal expansion of solids in daily life situations. Extract 7.1 shows a sample of a poor answer by one of the candidates.

7. A) i) Water is preprred as a cooling agent in many automobile engine because it has a great force of attraction which enables the engines to cool.
- Also it is a good conductor of heat and electricity, due to this it enables the engines to be not destructed.

(ii) Solution:
Wrong calibration it reads the melting point of ice as -10°C
If it reads 40°C in place where the temperature reads 30°C

40-30 = 10°C

10°C + -10°C = 0°C

∴ The boiling point of water on this scale is 0°C

(B) i) Melting of Iron.
ii) Increase in body temperature.
iii) Expansion of bridge when heated.

Extract 7.1: A sample of poor response given by a candidate.

Extract 7.1 indicates how the candidate failed to describe thermodynamic scale of temperature by retrieving the required formulae but also, to precisely analyse three practical applications of thermal expansion of solids in daily life activities.

Among the candidates who performed well, 0.4 percent scored all the marks allotted to this question because they had a good understanding of thermometers and thermal conduction. These candidates argued correctly that water is preferred as a cooling agent in many automobile engines because it has a high specific heat capacity which can absorb a larger amount of heat for a correspondingly small temperature rise. Also they were conversant with the Celsius scale, applications of thermal expansion, and the rate of thermal conduction in solids. An example answer is shown in Extract 7.2; the candidate attempted well each part of the question.

7

(a)

i/ Because it has a high heat capacity, thus it can absorb much heat and cause a little change in its internal energy to vapourize it.

ii/ Soln.

Scale 1 Scale 2.

from, $\left[\frac{T_\theta - T_0}{T_{100} - T_0}\right] = \left[\frac{T_\theta - T_0}{T_{100} - T_0}\right]$

thus,

$\rightarrow \left[\frac{40 - {}^-10}{T_{100} - {}^-10}\right] = \left[\frac{30 - 0}{100 - 0}\right]$

$\rightarrow \left(\frac{40 + 10}{T_{100} + 10}\right) = \frac{30}{100}$

$\rightarrow \frac{50}{T_{100} + 10} = \frac{30}{100}$

$\rightarrow \frac{50\,(100)}{30} = \frac{30\,(T_{100} + 10)}{30}$

$\rightarrow 166.667 = T_{100} + 10$

$\rightarrow T_{100} = 166.667 - 10$

$T_{100} = 156.667\ ^\circ C.$

$\therefore$ Boiling point of water on this scale is 156.667 °C.

7. (b) Applications of thermal expansion of solids.

(a) Electrical cables are loosely fitted on poles as a precaution that they will expand when it is hot or they will contract when it is cold.

(b) Pipes carrying hot water are fitted with joints at specific intervals. These joints allow for smooth expansion and contraction of the pipe.

(c) While ironing clothes, the ironing box has a thermostat that works by principle of bimetallic strip hence controlling the temperature of the ironing box.

ii) Soln.

From,

$$Q/t = \frac{KA\,(d\theta)}{dx}.$$

$$\rightarrow Q/t = \frac{400 \times 0.5 \times (75 - 15)}{(4 \times 10^{-3})}$$

$$Q/t = 3 \times 10^{6}\ J/s$$

$$= 3 \times 10^{6} \times 60s.$$

$$Q/t = 1.8 \times 10^{8} \text{ Joules per minute.}$$

$\therefore$ Heat loss per minute is 1.8×10^{8} Joules per minute.

Extract 7.2 is a sample of good answer by one of the candidates.

In extract 7.2 the candidate stated correctly why water is preferred as a cooling agent and applied the correct formulae and procedure to calculate the boiling point of water and heat loss per minute.

2.1.8 Question 8: Heat (Thermal Conduction and Thermal Radiation)

This question had parts (a) and (b). In part (a), the candidates were required to (i) sketch a graph which illustrates how the energy radiated by a black body is distributed among various wavelengths and (ii) give three interpretations which would be drawn from the graph in (a) (i). In part (b), they were required to (i) give a reason why stainless steel cooking pans are made with extra copper at the bottom and (ii) calculate the temperature with which the filament lamp of a 10 W lamp would operate if it is supposed to be a perfect black body of area 1 cm^2.

The question was opted for by 87.1 percent of the candidates. Among them, 28.5 percent scored from 0 to 3; 36.4 percent scored from 3.5 to 5.5 marks; and 35.1 percent scored from 6 to 10. These data reveal that 71.5 percent of the candidates who attempted this question scored from 3.5 to 10, which reflect good performance. Figure 6 illustrates this scenario.

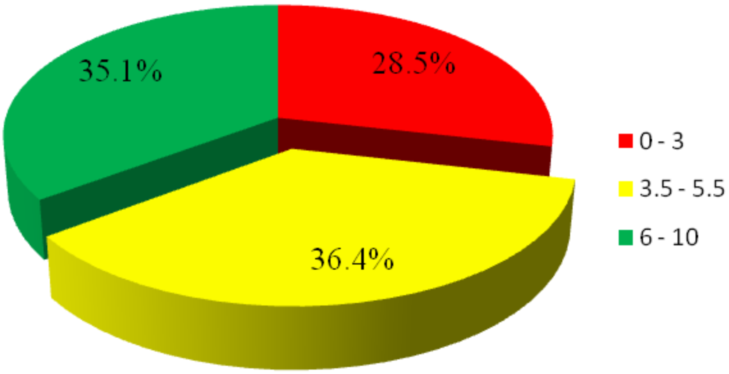
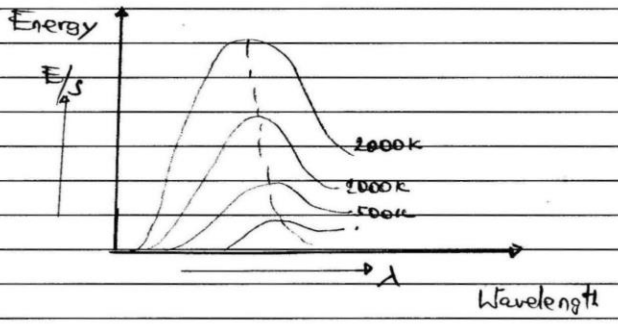


Figure 6: *The candidates' performance on question 8*

Most of the candidates who demonstrated good performance (6 -10 marks) responded correctly to almost all parts of the question, particularly part (b) which required the knowledge of thermal conductivity and blackbody radiation (Stefan’s law). However, part (a) (ii) seemed challenging to some of them as they failed to interpret correctly the graph they were asked to draw in part (a) (i). These candidates failed to recognize that, for a given temperature, the radiant intensity emitted by a black body is maximum for a particular wavelength. In addition, as the temperature of the body increases, the peak of the curve shifts towards a shorter wavelength. Also, the area under the curve gives the total energy radiated by the black body per second per unit area which is directly proportional to the fourth power of absolute temperature. Extract 8.1 presents an example of good responses taken from the script of one of the candidates.

8. (a) (i) SKETCH



(ii) INFORMATION

- Energy radiated by black body is directly proportional to the absolute temperature
- As the temperature increase, maximum peak are obtained at lower wavelength thus wavelength is inversely proportional to the absolute temperature
- The area covered by the graph represents total energy radiated by the black body at that temperature.

8. (b) (i) REASON;

This is because has copper has greater thermal conductivity than stainless steel therefore the pans are made with extra copper at the botton to quickly conduct heat from the source of heat to the contents in the cooking pans.

(ii) From stefan's law

$P = \sigma A T^4$

$10 = 5.67 \times 10^{-8} \times 1 \times 10^{-4} \times T^4$

$10 = 5.67 \times 10^{-12} T^4$

$T^4 = 1.764 \times 10^{12}$

Upon solving

$T = 1152.4K$

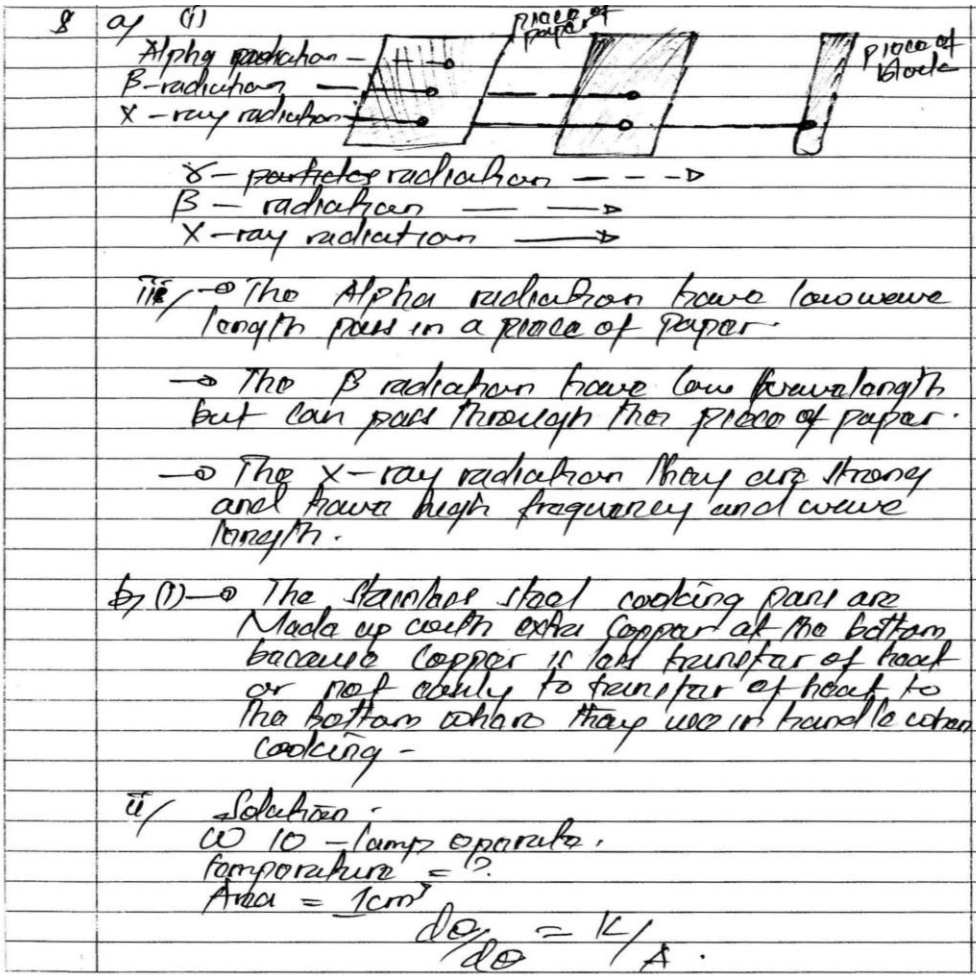
Hence

Temperature of the filament = $1152.4K$

Extract 8.1: A sample of the correct responses provided by a candidate.

Extract 8.1 indicates how the candidate managed to describe spectra of thermal radiation and applied the laws of blackbody in daily life to determine the temperature of the filament.

In the group of the candidates who scored low (0 -3) marks, 8.0 percent lacked knowledge of thermal radiation and presented wrong responses to each tested item; therefore, they scored 0 marks whereas 20.5 percent managed to answer correctly some parts of the question. Also, it was noted that part (a) of this question challenged most of the candidates in this group as they failed to draw and interpret the required graph of radiant energy of a black body against the wavelength. Some of them were totally confused because, instead of sketching the graph showing how the energy radiated by black body varies with wavelength, they attempted to illustrate the penetrating power of electromagnetic waves against various obstacles. Extract 8.2 is a sample of the poor responses presented by one of the candidates.



8 a/ (i)

Alpha radiation –
β-radiation –
X-ray radiation –

piece of paper
piece of block

γ – particles radiation – – – ▷
β – radiation —— ——▷
X-ray radiation ——▷

ii/ → The Alpha radiation have low wave length pass in a piece of paper.

→ The β radiation have low wavelength but can pass through the piece of paper.

→ The X-ray radiation they are strong and have high frequency and wave length.

b/ (i) → The stainless steel cooking pans are made up with extra copper at the bottom because copper is less transfer of heat or not ability to transfer of heat to the bottom where they use in handle when cooking.

ii/ Solution:
W 10 – lamp operate,
temperature = ?
Area = 1cm²

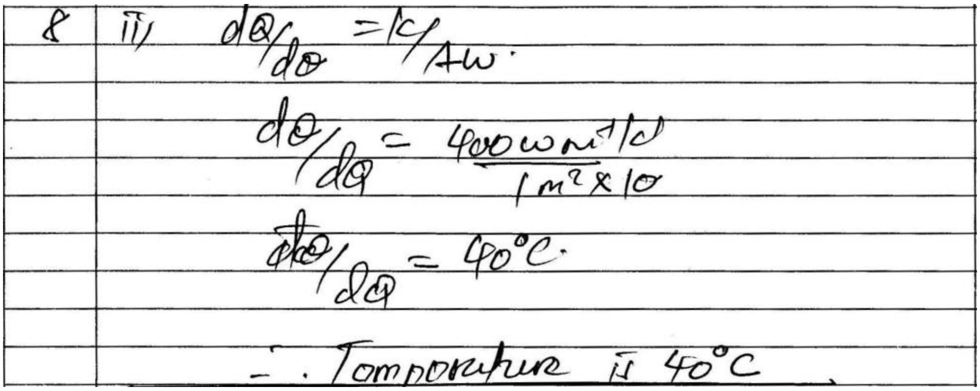
$\frac{dQ}{d\theta} = K/A$.

8 iii) dQ/dθ = K/Aw.

dθ/dQ = 400wm⁻¹K⁻¹ / 1m² x 10

dθ/dQ = 40°C.

∴ Temperature is 40°C



Extract 8.2: A sample of an incorrect response provided by a candidate.

In extract 8.2 the candidate drew a diagram illustrating the penetrating power of radioactive particles instead of sketching a graph of radiant energy against wavelength. He/she also applied an incorrect formula in calculating the temperature of the filament ended with wrong result.

2.1.9 Question 9: Current Electricity

In part (a) of this question, the candidates were required to (i) elaborate three significance of dielectric material in a capacitor and (ii) explain the reason behind the loss of electric energy when two capacitors are joined either in series or parallel. In part (b) (i), they were instructed that a researcher had 2 g of gold and wished to form it into a wire of resistance of 80 Ω at 0^{0}C. Then, they were required to calculate the length of the wire which would be formed while in (b) (ii) they were required to calculate potential difference between two points if 5 Joules of work are required to move 10 Coulombs from one point to another.

The question was attempted by 7,428 candidates corresponding to 39.3 percent. Among them, 62.5 percent scored from 0 to 3; 19.7 percent scored from 3.5 to 5.5; while 17.8 percent scored from 6 to 10 marks. These scores suggest that the general performance on this question was poor. The following bar chart is illustrative.

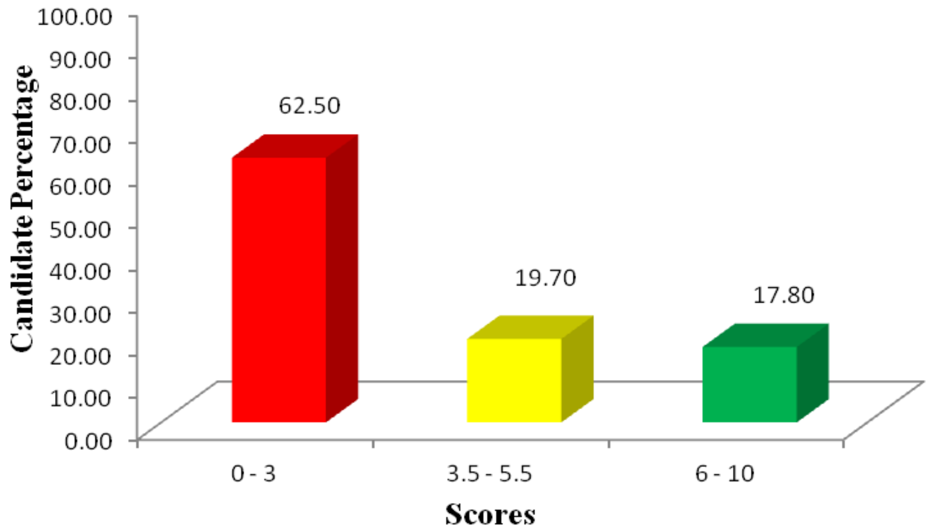
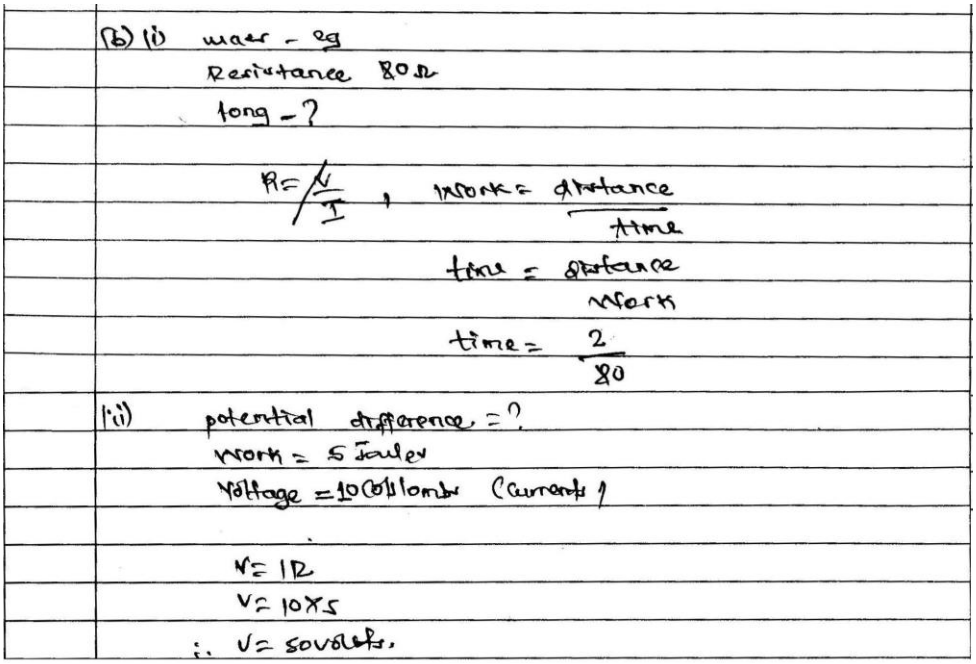


Figure 7: *The candidates' performance on question 9*

More than half of the candidates who had unsatisfactory performance (62.5%) provided incorrect responses to most of the items. The noted challenges in their responses include lack of knowledge about the function of dielectric material in a capacitor and how the flow of charges affect the electrical energy when two capacitors are joined either in series or parallel. These candidates were unaware that dielectric material keeps the plates apart to avoid charges flowing from one plate to another. In addition, it limits the potential difference that can be applied between such plates. Another observed challenge was the failure to retrieve the formula for resistivity in order to compose an expression for calculating the length of the wire. Extract 9.1 exhibits poor responses by one of the candidates.

9.	(a) (i) - used to restore currents.
	- Used to detect currents
	- Used to measure currents.
	(ii) loss of electrical energy when two capacitors are
	joined either in series or parallel are when electrical
	energy being in parallel because it does not form a direct
	currents so can brings the loss of electrical energy
	when two capacitor are joined in parallel.



(b) (i) wair – eg
Resistance 80Ω
long – ?

R = V/I , work = distance/time
time = distance/work
time = 2/80

(ii) potential difference = ?
work = 5 Joules
Voltage = 10 Coulomb (Current)

V = IR
V = 10 × 5
∴ V = 50 volts.

Extract 9.1 is a sample of candidates' incorrect responses to the question.

In extract 9.1 the candidate failed to elaborate correctly three significance of dielectric material in a capacitor but also to give a reason behind the loss of electric energy in capacitors.

On the other hand, 37.5 percent of the candidates who scored high (6 - 10) marks include 0.3 percent who wrote the correct responses to each item and scored all marks allotted to this question. These candidates showed a greater understanding of the function of dielectric material in a capacitor and managed to state correctly that energy is lost when capacitors are joined due to heating effect resulting from the flow of charges between the capacitor. In addition, they managed to retrieve and apply the formulae $l = \frac{RA}{\rho}$ and $V = \frac{W}{Q}$ to calculate the length l of the wire and potential difference V between the two points respectively. Extract 9.2 presents a sample of responses by one of the candidates with high performance on this question.

9. (a) (i) Three significances of dielectric material in a capacitor

→ It prevents loss of charge on a capacitor

→ It prevents loss of electrical energy stored in a capacitor

→ It increases the capacitance of a capacitor and hence the potential difference between plates.

ii, There is always a loss of electrical energy when two capacitors are joined either in series or parallel because the two capacitors tend to come to charge equilibrium, the charge stored becomes small, this affects the capacitance and inturn reduces energy.

$$E = \frac{1}{2} C V^2$$

$$E \propto C$$

(b) (i) Data.

Mass of gold = 2g.

$R_{wire} = 80\,\Omega$ $\theta_1 = 0°C$

$l = ?$

soln:-

$$R = \frac{\rho_g l}{A}$$

ρ_g = resistivity

ρ = density

But ∓ mass = ρV

$= \rho A l$.

Area = mass/ρL.

$R_{gold} = \frac{ρ_g L \times ρL}{m} = \frac{ρ_g l^2 ρ}{m}$.

$l^2 = \frac{R_g m}{ρ_g ρ}$.

$l^2 = \frac{8052 \times 2\times10^{-3}kg}{19300\, kg m^{-3} \times 2.27\times10^{-8} Ωm}$

$l^2 = \frac{0.16}{4.3811\times 10^{-4}}$

$\sqrt{l^2} = \sqrt{365.205}$

$l = 19.11m.$

∴ The length of the wire will be

$l = 19.11m.$

ii) Data:

V_d = ?

Workdone = 5 Joules.

Q = 10 coulomb

soln

recall:-

$\frac{workdone}{Q}$ = Potential difference

$Pd = \frac{5J}{10C}$

$Pd = 0.5\ J/c$ or Volts

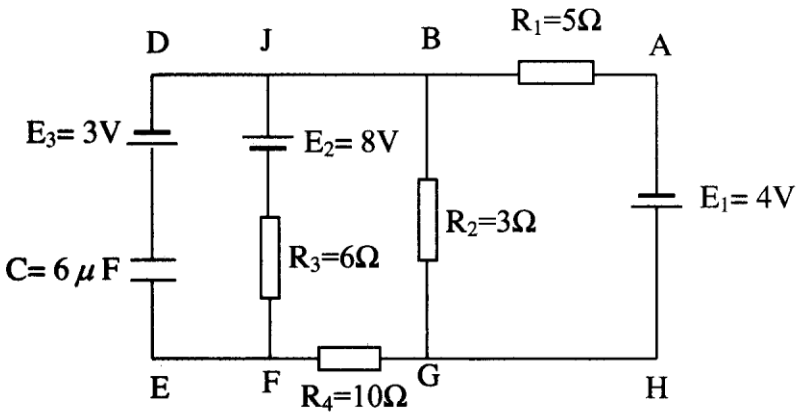
∴ The potential difference (Pd) = 0.5 Volts.

Extract 9.2: A sample of a good response provided by a candidate.

In extract 9.2 the candidate was very precise in applying the correct formulae and procedures in part (b) (i) and (ii).

2.1.10 Question 10: Current Electricity

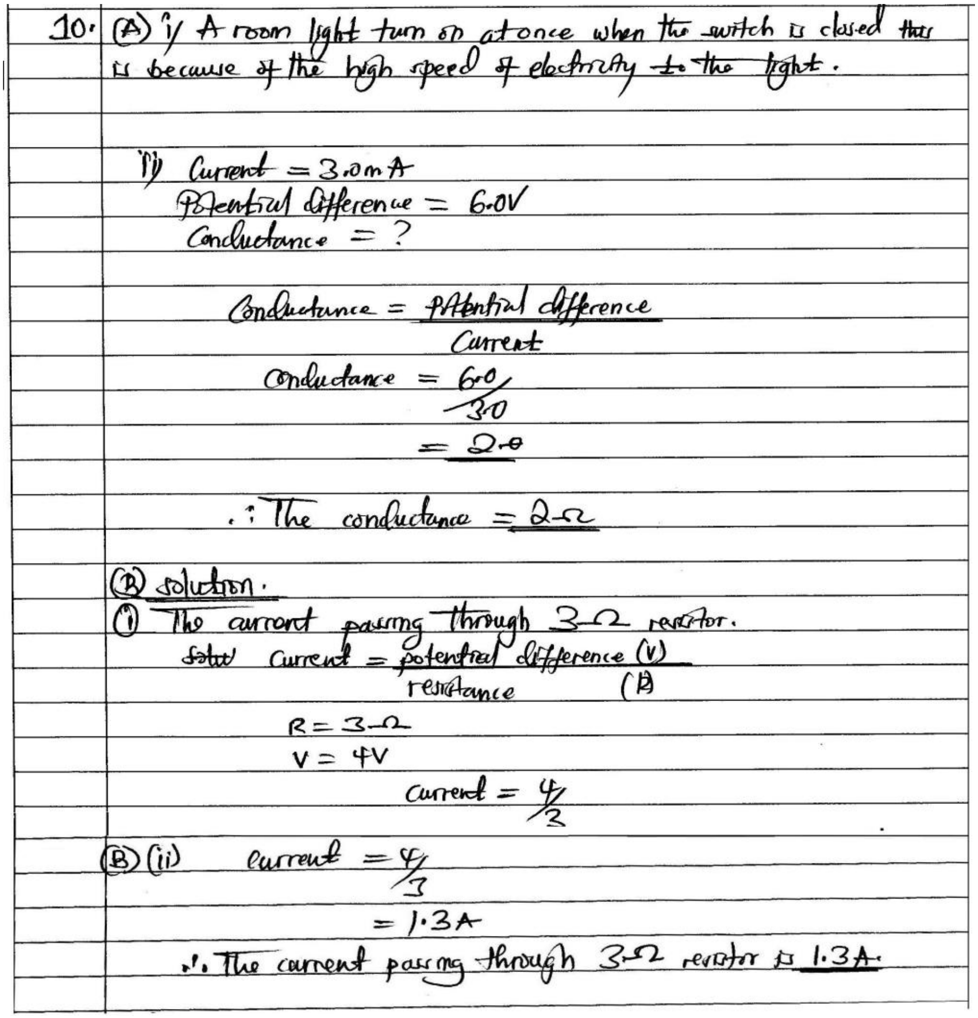
This question was comprised of two parts titled (a) and (b). Part (a) required the candidates to (i) explain why a room light turns on at once when the switch is closed and (ii) determine the value of conductance given that a current of 3.0 mA flows in a Television resistor R when a potential difference of 6.0 V is connected across its terminals. In part (b), the candidates were given a circuit diagram which contained a capacitor, resistors and three cells of negligible internal resistance as follows:



Then they were required to compute (i) the current passing through 3 Ω resistor and (ii) the charge on the capacitor.

The number of candidates who opted for this question was 15,595, equivalent to 82.5 percent. Their performance was as follows: 72.9 percent scored from 0 to 3; 21.3 percent scored from 3.5 to 5.5; while only 5.8 percent scored from 6 to 10, including 27 candidates who scored all 10 marks allotted to this question.

The general performance on this question was poor since many candidates (72.9%) scored from 0 - 3 marks which is below the pass mark. Further analysis of the candidates' responses to this question reveals, that in part (a) (i), most of them did not know that electromagnetic impulse is transmitted with nearly the speed of light. Hence as soon as the switch is closed, the electric field is established in the whole circuit. Consequently, free electrons in the wire begin drifting everywhere at once. In addition, although the value of current *I* and potential difference *V* were given in part (a) (ii), these candidates failed to determine the value of conductance, which is given as $G = \frac{1}{R} = \frac{I}{V}$. Furthermore, they failed to interpret and identify the direction of current in the circuit diagram and apply Kirchhoff's laws to solve the items in part (b), showing that they lacked knowledge of current electricity. Extract 10.1 is a sample of poor responses to this question.



10. (A) i/ A room light turn on at once when the switch is closed that is because of the high speed of electricity to the light.

ii) Current = 3.0mA
Potential difference = 6.0V
Conductance = ?

Conductance = $\frac{\text{Potential difference}}{\text{Current}}$

Conductance = $\frac{6.0}{3.0}$

= 2.0

∴ The conductance = 2Ω

(B) solution.
(i) The current passing through 3Ω resistor.
soln Current = $\frac{\text{potential difference (V)}}{\text{resistance (R)}}$

R = 3Ω
V = 4V
current = $\frac{4}{3}$

(B) (ii) current = $\frac{4}{3}$
= 1.3A
∴ The current passing through 3Ω resistor is 1.3A.

Extract 10.2: A sample of poor response given by a candidate.

In extract 10.2 the candidate partially stated the reason for item (a) (i) but failed to compute the value of conductance and to apply Kirchhoff's laws in part (b).

However, among the 27.1 percent of the candidates who scored from 3.5 to 10 marks, 5.8 percent (corresponding to 27 candidates) scored all 10 marks. These candidates showed a good understanding of the question as they presented their responses systematically and correctly. For example, most of them provided the reason why a room light turns on at once when the switch is closed. Also, they calculated accurately the value of conductance based on the definition; *conductance is the reciprocal of resistance*. In part (b), they managed to study the circuit and apply Kirchhoff's laws to determine the current passing through the 3 Ω resistor and the charge on the capacitor. Extract 10.2 presents a sample of good responses to this question from one of the candidates.

10 a) (i) Room light turn on at once when the switch is closed

Because

" Immediately when the switch is on, the electric field is developed making each electrons at every point in the circuit starts vibrating with it's drift velocity and since electric field has a speed of light, it's when room light turn on at once".

ii) Data given:

Current flowing, $I = 3{\cdot}0mA = 3\times10^{-3}A$

Potential difference, $V = 6{\cdot}0$

Resistance, $R = ?$

Conductance, $c = ?$

From Ohm's law

$V \propto I$

$V = IR$.

$R = \frac{V}{I}$

$R = \frac{6{\cdot}0V}{3\times10^{-3}A}$

$R = 2000\Omega$.

$R = 2k\Omega$

But

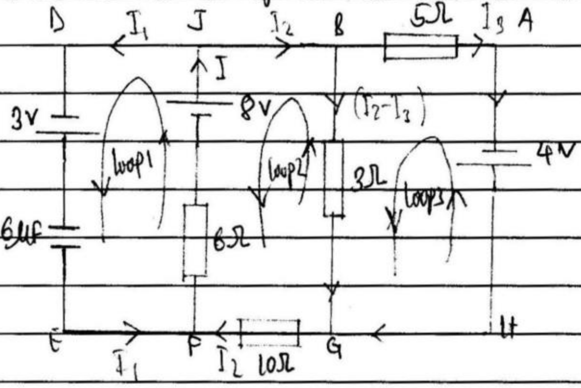
Conductance, $C = \frac{1}{R}$.

10 a (ii) $c = \frac{1}{2000\Omega} = \frac{1}{2\times10^{+3}\Omega}$

$c = 5\times10^{-4}\Omega^{-1}$

Hence Conductance = $5\times10^{-4}\Omega^{-1}$

b (i) Consider diagram



Apply Kirchoff's Current (KCL) law.
at junction J
$I = I_1 + I_2$
at junction B
$I_2 = I_3 + (I_2 - I_3)$

Again
Applying Kirchoff's voltage law
Around
loop1: $8 + 3 + V_c - 6I = 0$.
but
$V_c =$
$11 + V_c - 6I = 0$
$6I - V_c = 11$ ~ (1).

10 (b) Around:

loop 2: $-8 + 6I + 10I_2 + 3(I_2 - I_3) = 0$

$-8 + 6I + 10I_2 + 3I_2 - 3I_3 = 0$

$13I_2 - 3I_3 + 6I = 8$ — (ii)

Around loop 3: $-4 + 5I_3 - 3(I_2 - I_3) = 0$

$-4 + 5I_3 - 3I_2 + 3I_3 = 0$

$8I_3 - 3I_2 = 4$ — (iii)

taking eqtn (ii)

$13I_2 - 3I_3 + 6I = 8$

but $I = I_2 + I_1$.

$13I_2 - 3I_3 + 6(I_2 + I_1) = 8$

$13I_2 - 3I_3 + 6I_2 + 6I_1 = 8$

$19I_2 + 6I_1 - 3I_3 = 8$

but since in capacitor, C no current flows then $I_1 = 0$.

Then;

$19I_2 + 6(0) - 3I_3 = 8$

$19I_2 - 3I_3 = 8$ — (v)

On

$$\begin{cases} 8I_3 - 3I_2 = 4 \\ 19I_2 - 3I_3 = 8 \end{cases}$$

On solving.

$I_2 = 0.5315A$, $I_3 = 0.6993A$

Hence; the current through 3Ω

ie.

$= I_2 - I_3$

$= 0.5315 - 0.6993$

10(b) $= 0.1678A$

Hence the Current through 3Ω is $0.1678A$.

ii) Charge on Capacitor

From eqtn (i)

$6I - V_C = 11$

$V_C = 6I - 11$

but $I = I_1 + I_2$

$V_C = 6(I_1 + I_2) - 11$ but $I_1 = 0$

$V_C = 6(0 + I_2) - 11$

$V_C = 6I_2 - 11$

$V_C = 6(0.5315) - 11$

$V_C = 7.811V$

Again from $Q = CV$

$Q = 6\mu F \times 7.811$

$Q = 6 \times 10^{-6} \times 7.811$

$Q = 4.6866 \times 10^{-5}$ coulomb.

Hence:

Charge on the capacitor is

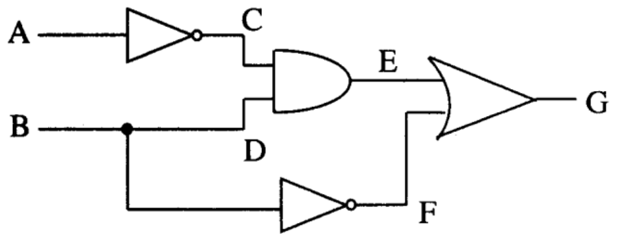
$Q = 4.6866 \times 10^{-5}$ coulomb.

Extract 10.2: A sample of a correct response given by a candidate.

Extract 10.2 indicates how the candidate was competent in applying Ohm's law to determine the conductance but also to analyse electrical network to find the current and charge on the capacitor.

2.1.11 Question 11: Electronics

Part (a) of this question required the candidates to (i) explain why transistors can not be used as rectifiers and (ii) calculate the base current in the NPN transistor circuit of collector current 5 mA if 95 % of the emitted electrons reach the collector region. In part (b), the candidates were required to (i) explain what causes damage to the transistor and (ii) construct the truth table for the following circuit diagram.



A total of 16,838 candidates (89.1%) attempted this question whereby 33.3 percent scored from 0 to 3; 34.1 percent scored from 3.5 to 5.5 marks; and 32.6 percent scored from 6 to 10 marks. These data reveal that the general performance on this question was good since 66.7 percent of the candidates scored more than one-third of the allotted marks to this question. Figure 8 illustrates this information.

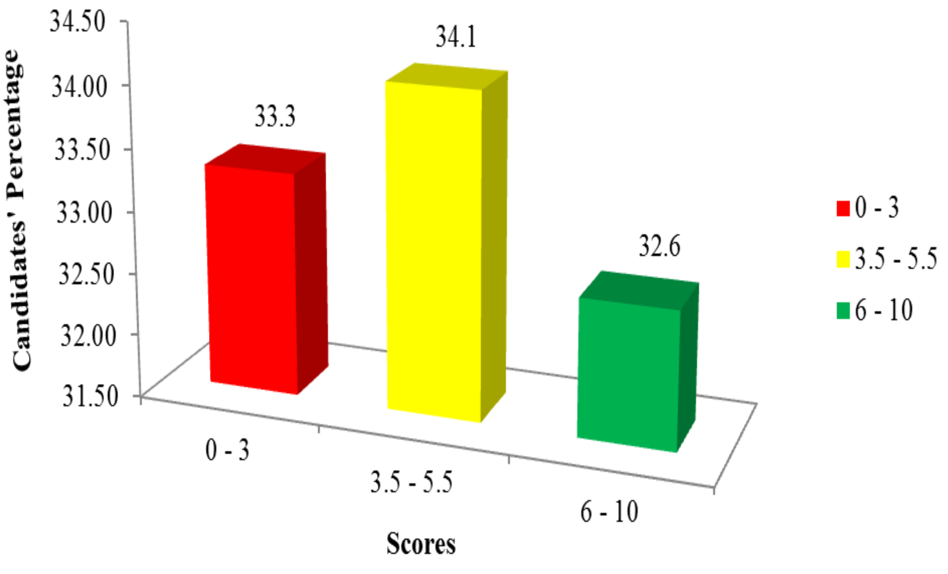


Figure 8: *The candidates' performance on question 11*

The analysis of the candidates' responses showed that those who scored average (from 3.5 - 5.5) marks managed to answer part (a) of this question correctly. These candidates understood that one of the basic properties for a transistor (semi-conductor device) to operate as a rectifier is that either base-emitter or base-collector has to be used as a diode i.e doping level should be the same. But the three layers of transistors have different doping levels. Therefore, it cannot be used as a rectifier. In addition, they had adequate knowledge of the concept of *current gain* as well as the relationship of the currents through the base, collector and emitter. Therefore, they calculated correctly the required base current in part (a) (ii). However, some of the candidates who scored from 6 to 10 marks responded correctly in both parts but others were not aware that operating the transistor beyond its maximum rating and excessive heat, which may result from excess current, are the causes of damage to the transistor. Extract 11.1 presents one of a correct response to this question.

11 (a) i. Transistors can not be used as rectifier because it consist of two different parts with different Level of doping, Hence current variation, therefore can not be used as rectifier.

(ii) solution

In NPN,

Given $I_C = 5mA$

$I_E = I_B + I_C$ but $\frac{95}{100}$ of $I_E = I_C$

$I_C = 0.95 I_E$ —— (i)

and $I_B = 0.5 I_E$ —— (ii)

dividing two equation

$$\frac{I_C}{I_B} = \frac{0.95}{0.05} = 19$$

$$I_B = \frac{I_C}{19} = \frac{5\times10^{-3}A}{19}$$

$I_B = 2.631 \times 10^{-4} A$. (Base current).

11 (b) i. Excess current in the transistor cause heating which leads to damage of transistor, sometimes called thermal runaway, overheating due to overloading of transistor.

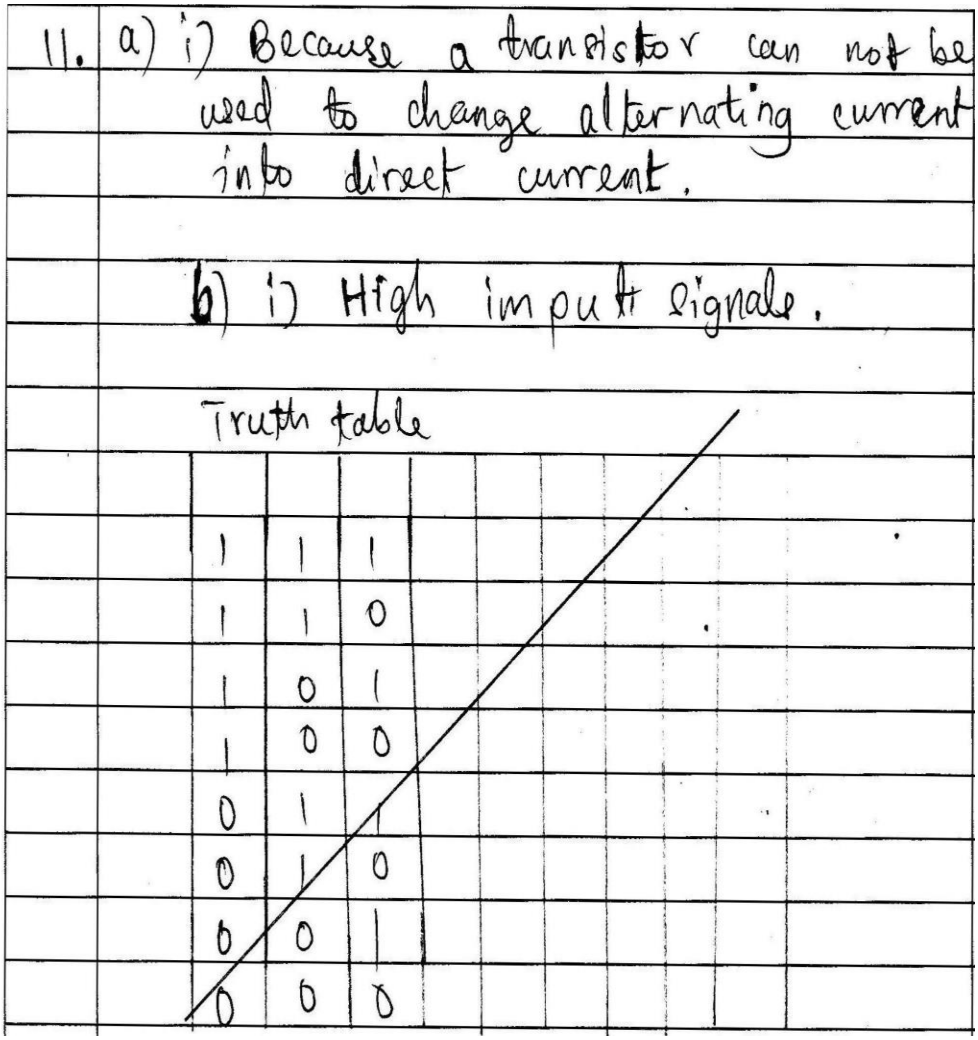
ii. Truth table for the circuit

Input						output
A	B	C	D	E	F	G
0	0	1	0	0	1	1
0	1	1	1	1	0	1
1	0	0	0	0	1	1
1	1	0	1	0	0	0

Extract 11.1: A sample of good answers by a candidate.

In extract 11.1 the candidate presented precise responses to all parts of the question and scored high marks.

In contrast, the candidates who performed poorly showed little understanding of the concept of *transistor*. They failed to interpret the characteristics of a transistor and its mode of operation. Therefore, they failed to fulfil the demands of the question items. For example, instead of calculating the base current as demanded in part (a) (ii), some of them applied irrelevant formula which gives the collector current. Further analysis on the candidates' responses revealed that some of them completely failed to construct the truth table based on the given circuit diagram implying that they lacked knowledge of the tested concept in this topic. Another observed challenge was the tendency of some candidates to cancel some responses and begin afresh showing that they were not sure about their answers. Extract 11.2 was taken to illustrate this scenario.

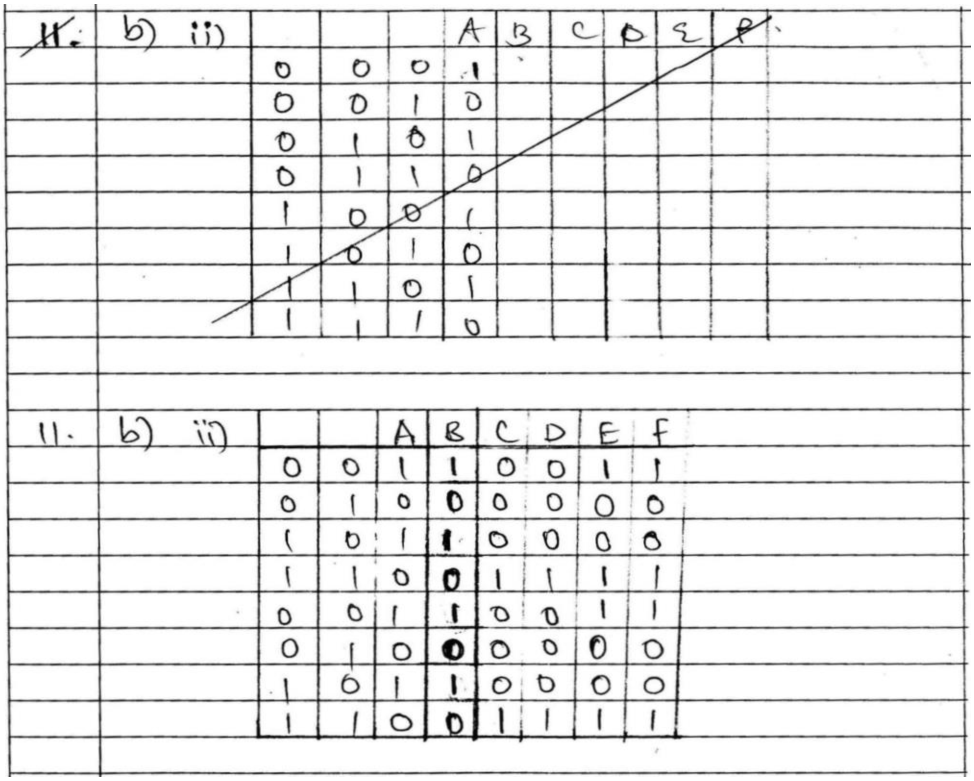


11. a) i) Because a transistor can not be used to change alternating current into direct current.

b) i) High input signals.

Truth table

1	1	1
1	1	0
1	0	1
1	0	0
0	1	1
0	1	0
0	0	1
0	0	0



11. b) ii)

			A	B	C	D	E	F
0	0	0	1					
0	0	1	0					
0	1	0	1					
0	1	1	0					
1	0	0	1					
1	0	1	0					
1	1	0	1					
1	1	1	0					

11. b) ii)

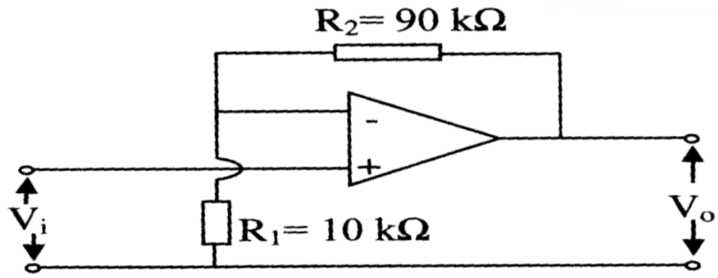
		A	B	C	D	E	F
0	0	1	1	0	0	1	1
0	1	0	0	0	0	0	0
1	0	1	1	0	0	0	0
1	1	0	0	1	1	1	1
0	0	1	1	0	0	1	1
0	1	0	0	0	0	0	0
1	0	1	1	0	0	0	0
1	1	0	0	1	1	1	1

Extract 11.2: An example of poor responses presented by a candidate.

In extract 11.2 the candidate lacked knowledge of logic gates especially in preparing the truth table of logic combinations.

2.1.12 Question 12: Electronics

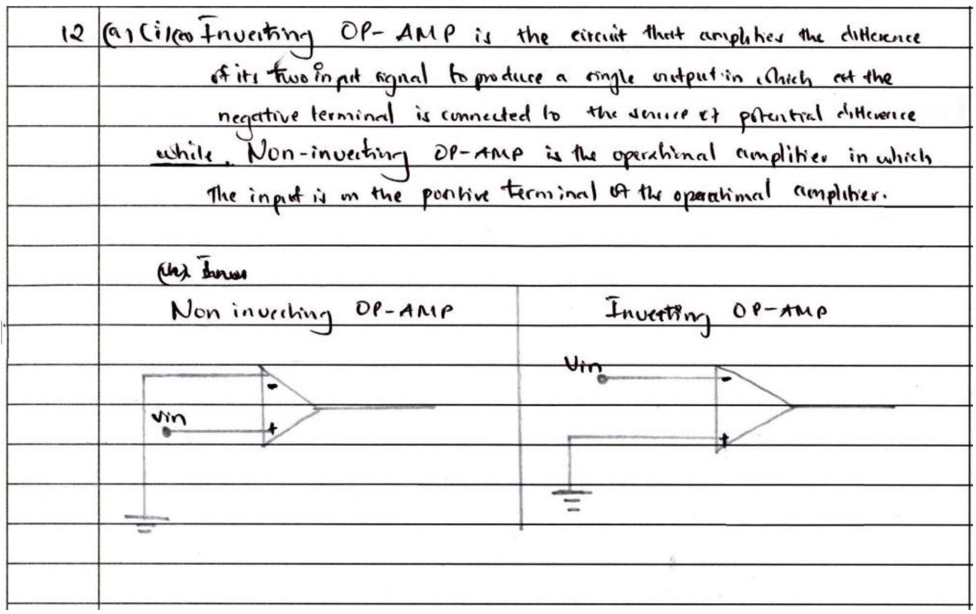
The question aimed at determining the candidates' knowledge of operational amplifiers. Therefore, part (a) required them to (i) distinguish between inverting OP–AMP and non-inverting OP–AMP and (ii) give one application of each type of OP–PAMP described in item (i). In part (b), the circuit diagram of a non –inverting amplifier with input and output voltages was given as follows:



Then, the candidates were required to (i) determine the closed loop voltage gain G_{ain}, given that $G_{ain} = 1 + \frac{R_2}{R_1}$, and (ii) use the circuit diagram to show how the expression given in part (b) (i) can be derived.

Data analysis reveals that 79.5 percent of the candidates attempted this question and had the following scores: 30.8 percent scored from 0 to 3 marks; 28.6 percent scored from 3.5 to 5.5; and 40.6 percent scored from 6 to 10 marks. These scores suggest that the candidates' performance on this question was good because more than two-third of them scored the pass mark and above.

The performance of those who scored average (3.5 - 5.5) marks was contributed by the candidates' ability to comprehend correctly the demand of the question on part (a). These candidates managed to distinguish inverting OP-AMP from non-inverting OP-AMP and state the application of operational amplifiers. However, they failed to study and interpret the circuit diagram to show the required steps in deriving the expression $G_{ain} = 1 + \frac{R_2}{R_1}$. Nevertheless, those who scored higher marks (6 - 10) were conversant with the topic as they managed to organize and analyse the concept by providing the correct responses to almost all parts of the question. Extract 12.1 is a sample answer taken from the script of one of the candidates who performed well in this question.


12 (a) (i) Inverting OP-AMP is the circuit that amplifies the difference of its two input signal to produce a single output in which at the negative terminal is connected to the source of potential difference while Non-inverting OP-AMP is the operational amplifier in which the input is on the positive terminal of the operational amplifier.

(ii) Non inverting OP-AMP   Inverting OP-AMP

12 (a)(ii)(a) Non inverting OP-AMP is used in analog to digital conversion while

Inverting OP-AMP is used in Digital to analog conversion

12 (b)(i) Given that;

$R_2 = 90\,k\Omega$

$R_1 = 10\,k\Omega$

(i) Required to find voltage gain

$$Gain = 1 + \frac{R_2}{R_1}$$

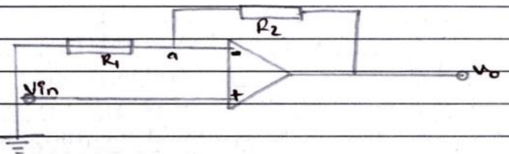
$$= 1 + \frac{90\,k\Omega}{10\,k\Omega}$$

$$= 1 + \frac{90}{10} = 1 + 9 = 10$$

$$= 10$$

∴ Voltage gain is 10 Ans.

12 (b)(ii)



Voltage drop across R_1

$$V_a = \left(\frac{R_1}{R_1 + R_2}\right) V_o$$

By virtual short

$$V_a = V_{in}$$

$$V_{in} = \left(\frac{R_1}{R_1 + R_2}\right) V_o$$

$$\text{Voltage gain } (A_v) = \frac{V_{out}}{V_{in}}$$

$$\frac{V_o}{V_{in}} = \frac{R_1 + R_2}{R_1}$$

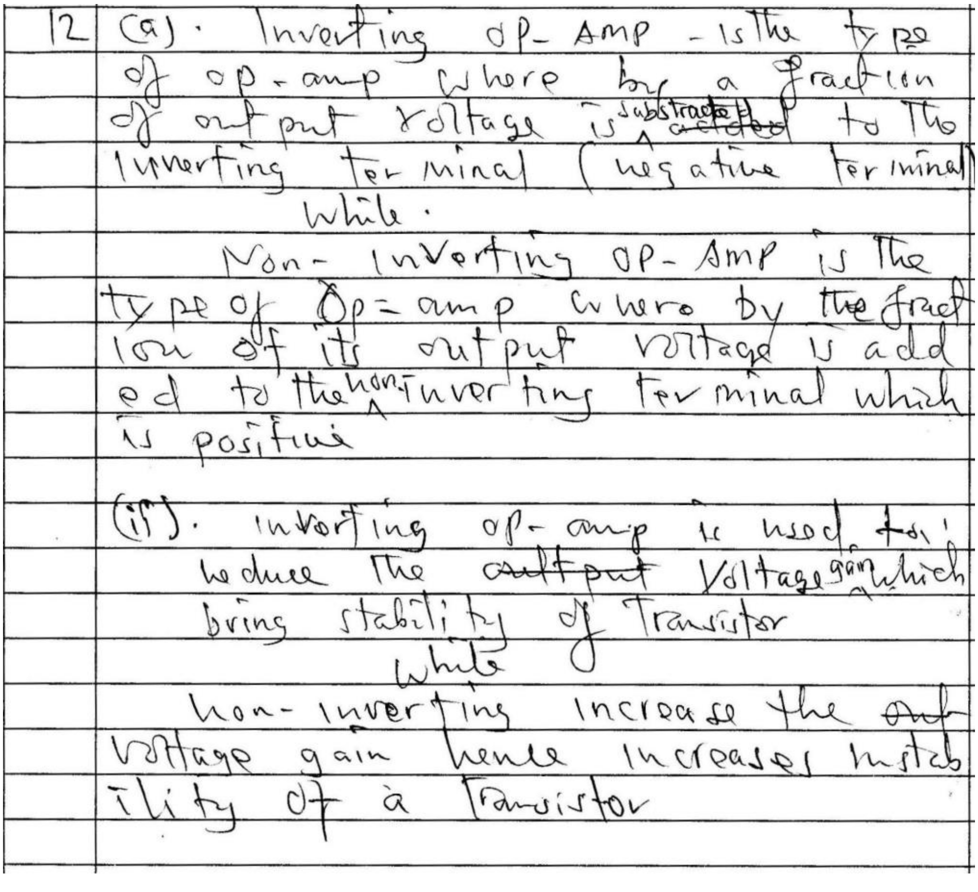
$$A_v = 1 + \frac{R_2}{R_1} \quad \text{where } A_v = Gain$$

$$\therefore Gain = 1 + \frac{R_2}{R_1} \quad \text{Hence shown}$$

Extract 12.1: A sample of a correct response provided by a candidate.

Extract 12.1 indicates how the candidate used a short and clear method to derive the required formula in part (b) (ii). He/she also managed to describe the properties and mode of action of operational amplifiers.

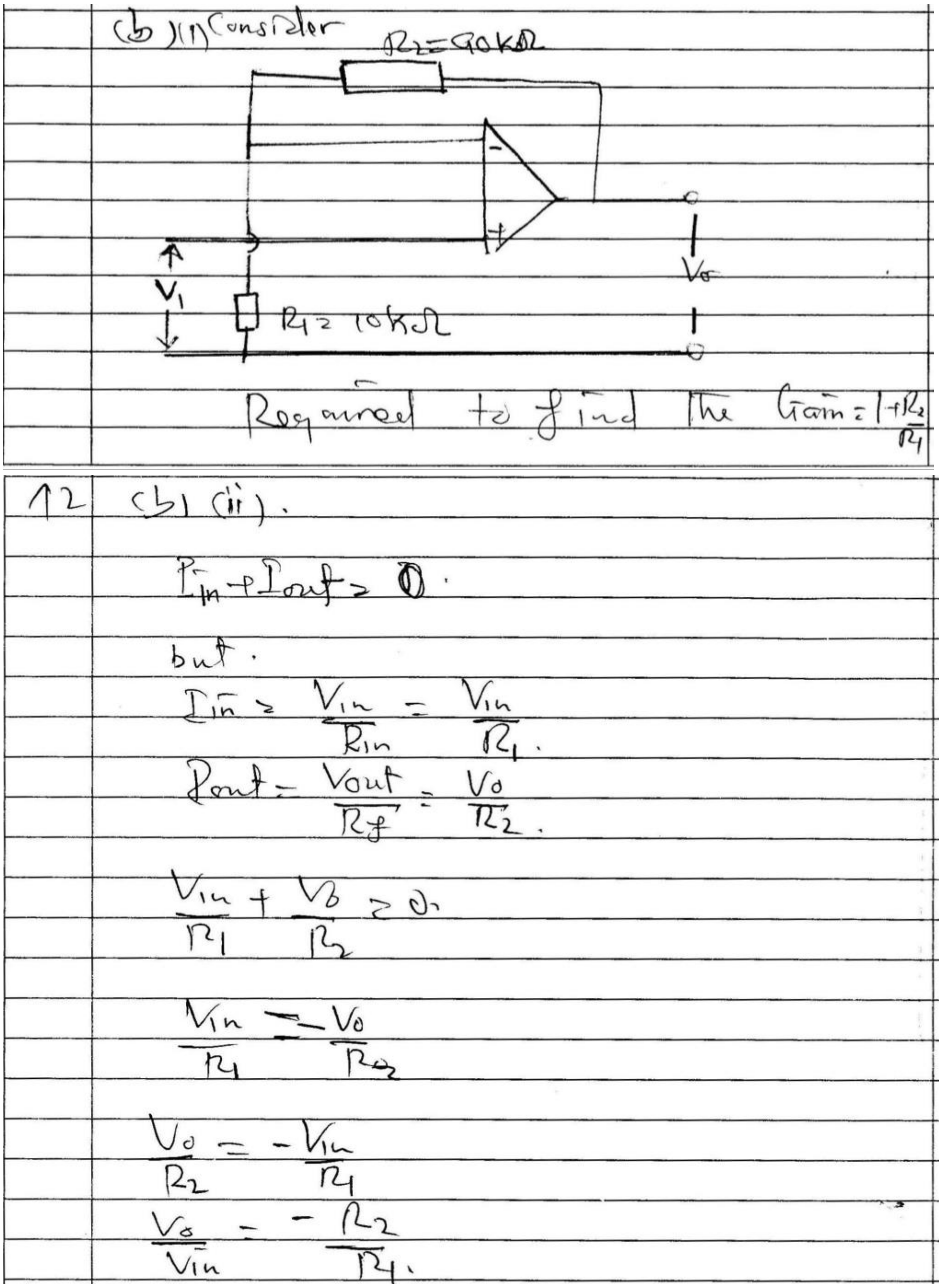
However, 30.8 percent of the candidates who scored low (0 - 3) marks lacked knowledge of analogue electronics especially operational amplifier as well as mathematical skills. Some of them failed to interpret the given circuit diagram in part (b) and to make a direct substitution of the given values of R_1 and R_2 into the formulae $G_{ain} = 1 + \frac{R_2}{R_1}$. Besides, they supplied incorrect responses to all items of part (a) of this question. For example, one candidate wrote, *Inverting OP - AMP is the negative terminal of the operational amplifier while non-inverting OP - AMP is the positive terminal of the operational amplifier*. This candidate failed to recognize that an inverting OP - AMP is the one in which input voltage is connected at the inverting terminal and the feedback is applied to the same terminal unlike for non-inverting OP - AMP in which input voltage is connected at the non-inverting terminal and the feedback is applied to the inverting terminal. Extract 12.2 shows one of the responses given by the candidate who could not answer this question.


12 (a). Inverting op-AMP is the type of op-amp where by a fraction of output voltage is substracted to the inverting terminal (negative terminal) while.

Non-inverting OP-AMP is the type of Op-amp where by the fraction of its output voltage is added to the non-inverting terminal which is positive

(ii). inverting op-amp is used to reduce the ~~output~~ voltage gain which bring stability of Transistor while

non-inverting increase the ~~out~~ voltage gain hence increases instability of a Transistor


(b)(i) Consider

$R_2 = 90k\Omega$

V_1

$R_1 = 10k\Omega$

V_o

Required to find the Gain $= 1 + \frac{R_2}{R_1}$

12 (b) (ii).

$I_{in} + I_{out} = 0$.

but.

$I_{in} = \frac{V_{in}}{R_{in}} = \frac{V_{in}}{R_1}$.

$I_{out} = \frac{V_{out}}{R_f} = \frac{V_o}{R_2}$.

$\frac{V_{in}}{R_1} + \frac{V_o}{R_2} = 0$,

$\frac{V_{in}}{R_1} = -\frac{V_o}{R_2}$

$\frac{V_o}{R_2} = -\frac{V_{in}}{R_1}$

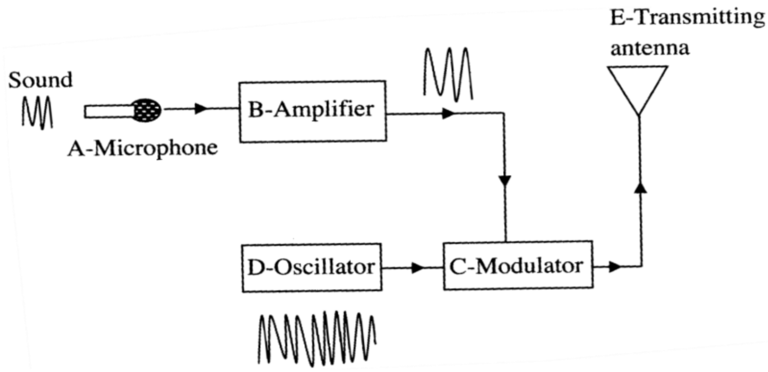
$\frac{V_o}{V_{in}} = -\frac{R_2}{R_1}$.

Extract 12.2: A sample of incorrect responses to all parts of the question.

Extract 12.2 indicate how the candidate failed to distinguish between inverting OP–AMP and non-inverting OP–AMP. In part (b) (ii), instead of showing how the given expression for voltage gain G_{ain} is obtained, he/she derived a formula for the voltage gain of inverting OP-AMP.

2.1.13 Question 13: Telecommunication

This question had parts (a) and (b). In part (a), the candidates were required to (i) identify three basic elements of a communication system and (ii) explain why sky waves are not used for transmission of TV signals. In part (b), a labelled diagram showing the essential components of a transmitter for radio broadcasting was given as follows:



The candidates were required to describe the role of each of the components labelled A, B, C, D and E in a communication system.

About three quarter of the candidates (73.5%) opted for this question. Among them, 28.3 percent scored from 0 to 3; 29 percent scored from 3.5 to 5.5; and 42.7 percent scored from 6 to 10. Therefore, 71.7 percent of the candidates who attempted this question scored above the pass marks (3.5 marks), implying that the performance on this question was good. This performance reveals that most of the candidates were competent in the assessed area as they managed to link the acquired knowledge about the functions of various electronic components for radio broadcasting.

The candidates who demonstrated good performance on this question (i.e from 6 - 10) were conversant not only with the concept of telecommunication but also with language skills as they provided correct and brief responses to most parts of the question. They mentioned three basic elements of communication system which are *transmitter, communication channel and Receiver* and had clear understanding that sky waves (*ionospheric propagation*) are not used for transmission of TV signals because frequencies of TV waves range from 80 to 200 MHz and the ionosphere cannot reflect back to the earth frequencies greater than 40 MHz. Moreover, they managed to study the given figure in part (b) and explain the role of the microphone, amplifier, modulator, oscillator and transmitting antenna. On the other hand, most of those who scored average (3.5 - 5.5) marks attempted only part (a). They failed to explain how each of the labelled components of the transmitter facilitates the communication channel. Therefore, they lost some marks. Extract 13.1 presents a sample of good responses to this question.

13 (a) (i) These are:

- Transmitter
- Communication channel
- Receiver

(ii) sky waves are not used for transmission of TV signals because the frequencies required for the transmission TV signals exceed 40 MHz as as a result if they were to be transmitted by sky waves they would not reflected back onto the earth's surface by the ionosphere. Instead they would propagate through the ionosphere and escape into space.

(b)

Component	Role played
A	This converts sound into electrical signals.
B	This raises the strength of the information signal before modulation is done.
C	This modulates the high frequency carrier wave with modulating signal necessary for its transmission into space
D	This creates/produces the high frequency carrier wave to be modulated by the information signal.
E	This converts the modulated waves into electromagnetic waves and send them towards or more distant receivers through space.

Extract 13.1: A sample of good response given by a candidate.

Extract 13.1 indicate how the candidate managed to provide clear and precise responses to all parts of the question.

In the category of those who scored low (0 - 3) marks, 10 percent of them scored 0. The major challenges these candidates faced include failure to understand the basic elements of the communication system and the ranges of frequencies on which TV signals as well as the sky wave propagation belongs. Additionally, most of them could not perfectly describe the roles of the essential components of the transmitter for radio broadcasting while others skipped this part. The candidates were required to explain the roles as follows: *(A) The Microphone converts sound signals into electrical signals, (B) The amplifier raises the strength of weak signals, (C) Modulator-superimposes the signal on the carrier wave in order to carry signal to larger distances, (D) Oscillator- produces a high frequency signal (a carrier wave)* and *(E) Transmitting antenna- captures the output of the modulator thereby converting the electrical signal into radio waves and transmit them into free space.* Extract 13.2 is an example of incorrect responses to this question.

13 a. i. - Microphone
- Modulator.
- Stabilizer

ii. Because Sky wave are not ~~stan~~ in equilibrium as in that they may rise in Temperature or fall in temperature and the TV signal can not ~~tr~~ transmission in that kind of situation

13 b. A: it collects the sound ~~wa~~ waves and transmitte to Amplifier

B: Amplifier is Amplifies the Sound waves to Mechanical Waves:

C: Modulator is it Modulate the Mechanical Waves to the Oscillator in terms of Radio waves

D Oscillator it oscillate the Radio wave ~~and~~ as in terms of frequency And transmitte to An Modulator to Antenna.

E: Transmitting Antenna it give out the Radio Wave as and transmitte them to different frequency.

Extract 13.2 is a sample of incorrect responses provided by a candidate.

Extract 13.2 shows how the candidate lacked knowledge of the assessed concepts. He/she failed even to state the role of a microphone, which is a common device used in everyday communication.

2.1.14 Question 14: Environmental Physics

This question aimed at assessing the candidates' knowledge about Environmental Physics. Thus, part (a) required them to (i) explain the meaning of epicentre and wind belt as used in Geophysics and (ii) give two positive effects of wind on plant growth. In part (b), the candidates were required to (i) identify three types of seismic waves and (ii) outline two characteristics of each type of wave described in part (b) (i).

A total of 10,915 candidates, corresponding to 57.7 percent, attempted this question. Their scores were as follows: 35.6 percent scored from 0 to 3; 32.6 percent scored from 3.5 to 5.5; while 31.8 percent scored from 6 to 10. These data reveal that the candidates' performance on this question is good because 64.4 percent passed the question by scoring from 3.5 to 10. The following pie chart is illustrative.

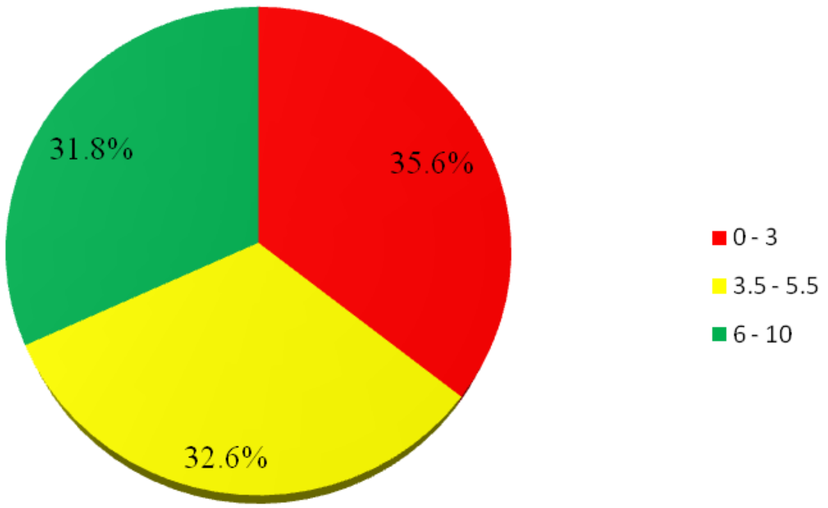


Figure 9: *The candidates' performance on question 14*

The candidates who scored average (3.5 - 5.5) marks were noted to perform well in part (a), but they provided wrong responses to other parts of the question. This was contributed by their failure to identify types of seismic waves and their characteristics. Further analysis on the candidates' performance showed that most of those who scored high (6 - 10) marks attempted well in both parts (a) and (b). They defined well the terms epicentre and wind belt. They also mentioned correctly the three types of seismic waves, which are P-waves, S- waves and Surface waves together with the characteristics of each. Extract 14.1 is a sample of good responses from the script of one candidate to illustrate this scenario.

14@ i) - Epicentre :- Is a point on the earth's surface that is vertically overhead the hypocentre (focus)

- Windbelts :- Are seasonal strong winds that are produced due to uneven heating of the earth's surface.

14a. ii) → The presence of wind provides a cooling effect to the plant, through erosion of water droplets on the stomata.

→ It also a mechanism by which seeds, and spores are transmitted, hence aid fertilization.

14b) i) → Primary ~~wave~~ body waves.
→ Secondary body waves.
→ Surface waves.

14 b) ii) Characteristics of Primary body waves
- They are the fastest seismic waves. (7–14 km/s)
- They pass through solid and liquid.
- They are detected first by ~~epi~~ seismic station

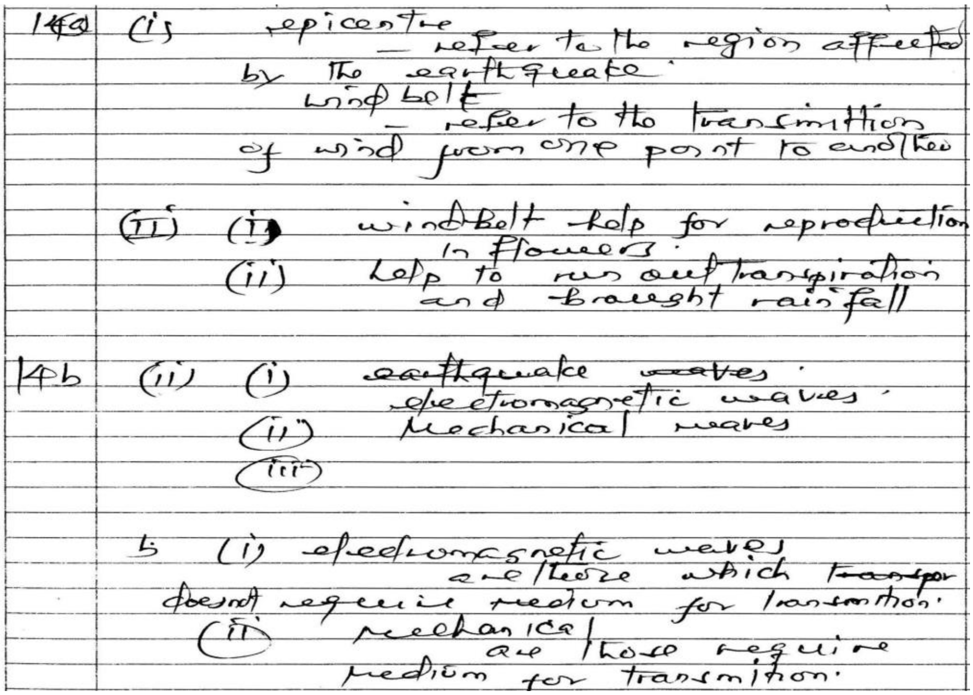
- Characteristics of Secondary body waves
- They are slow compared to primary wave (3.5–7 km/s)
- They travel through solid.

Characteristics of Surface waves
- They travel only on the surface of the Earth
- They may be travel in a transverse motion or longitudinal motion.

Extract 14.1: A sample of good responses given by a candidate.

Extract 14.1 indicates how the candidate had broad knowledge of environmental physics as he/she responded correctly to each item of the question.

Nevertheless, 35.6 percent of the candidates who scored low (0 - 3) marks attempted to define the terms epicentre and wind belt, but they failed to organise the concept in a good manner. For example, one candidate wrote: *Epicentre is a point within the earth at which wind start* and *wind belt is a region at the centre of the earth containing movement of air*. They were supposed to give the meaning of epicentre *as a ground surface directly vertically above the focus of earth quake* and wind belt *as a seasonal strong wind moving in one direction in a certain region of the earth.* Besides, some of them mentioned correctly the two effects of wind on plant growth. However, instead of identifying P-waves, S-waves and surface waves as the three types of seismic waves in relation to earthquake formation, they described electromagnetic and mechanical waves, which are types of waves based on the topic of vibrations and waves. Moreover, among the candidates who scored low marks, 7.7 percent scored zero marks as they failed to provide appropriate responses to each item. These candidates lacked knowledge about the tested areas. Their responses contained many conceptual and grammatical errors. Extract 14.2 shows a sample of poor responses to this question.


14a (i) epicentre – refer to the region affected by the earthquake.
wind belt – refer to the transimition of wind from one point to another
(ii) (i) windbelt help for reproduction in flowers.
(ii) help to run out transpiration and brought rainfall
14b (ii) (i) earthquake waves.
electromagnetic waves.
(ii) Mechanical waves
(iii)
b (i) electromagnetic waves are those which doesnot require medium for transmition.
(ii) mechanical are those require medium for transmition.

Extract 14.2: A sample of an incorrect response given by the candidate.

In extract 14.2 the candidate provided incorrect responses to each item. For instance, in part (b), he/she described the types of waves considering the topic of vibrations and waves instead of seismic waves.

2.2 131/2 PHYSICS 2

This paper comprised short answer questions constructed from six topics namely *Fluid dynamics*, *Vibrations and waves*, *Properties of matter*, *Electrostatics*, *Atomic Physics* and *Electromagnetism.* Each question carried 20 marks. The candidate's performance was considered as weak, average and good if the scores range from 0 to 6.5, 7 to 11.5 and 12 to 20 respectively. The pass score for each question was taken from 7 marks and above. The subsequent section analyses performance on each question.

2.2.1 Question 1: Fluid Dynamics

This question had parts (a), (b), (c) and (d). In part (a), the candidates were required to (i) give the meaning of the terms *velocity gradient*, *tangential stress* and *coefficient of viscosity* as used in fluid dynamics (ii) write Stokes' equation and define clearly the meaning of all the symbols used and (iii) state two assumptions used to develop the equation in 1 (a) (ii). In part (b), they were required to calculate the terminal velocity of the rain drops falling in air by assuming that the flow is laminar, the rain drops were spheres of diameter 1mm and the coefficient of viscosity $\eta = 1.8x10^{-5}$ Ns/m^2. Part (c) required the candidates to calculate the force acting on the plate when water flows past a horizontal plate of area 1.2 m^2 when the velocity gradient and coefficient of viscosity adjacent to the plate are 10 s^{-1} and 1.3x10^{-5} Nsm^{-2} respectively. In part (d), the candidates were required to find the volume of water that will flow out of the pipe in 1 minute when water flows through a horizontal pipe of cross-sectional area 10 cm^2 has one section of cross- sectional area 5 cm^2 and pressure difference between the two sections is 300 Pa.

The question was attempted by 95.4 percent of the candidates. Among them, 11.7 percent scored from 0 to 6.5 marks; 26.1 percent scored from 7 to 11.5 marks; and 62.2 percent scored from 12 to 20 marks. These scores imply that the candidates' performance on this question was good as 88.3 percent scored from 7 to 10. Figure 10 illustrates the performance of the candidates on this question.

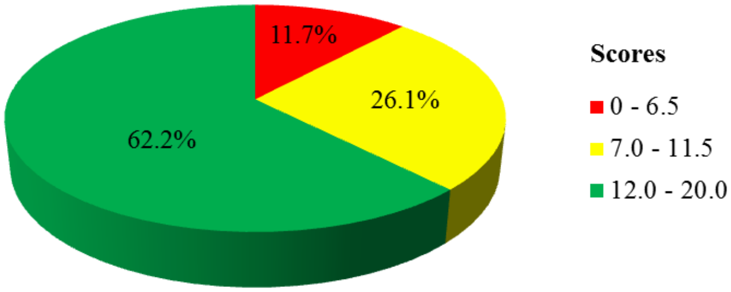


Figure 10 : *Candidates' performance on question 1*

The candidates who performed well in this question had an adequate knowledge of fluid dynamics. They managed to define velocity gradient, tangential stress, and coefficient of viscosity. Similarly, these candidates correctly wrote Stokes' equation and stated precisely the assumptions used to develop it. Most of them utilized the appropriate procedures and formula in finding the terminal velocity of the rain drops, force acting on the plate and the volume of water that flows out the pipe. Extract 15.1 shows one of the responses by a candidate who answered the question correctly.

1 (a) i/ Velocity gradient refers to the difference in velocity between two points per unit distance between two layers of flowing fluid.

Tangential stress
Refers to the force acting tangentially to the fluid layers per unit area of the adjacent layers.

Coefficient of viscosity
Refers to the force acting tangentially per unit velocity gradient in the unit area between the adjacent layers

(ii) Stokes law

$F = 6\pi\eta r V_T$.

where
F - Drag force
η - Coefficient of viscosity
r - radius of a spherical body.
V_T - Terminal velocity

(iii) - The body must be small and perfectly spherical

- The ~~body~~ fluid, to which the ball is freely falling, must be in large extent. example ocean.

1 (b) Soln.

Given

Diameter (D) = 1mm, Radius (r) = 0.5mm.

Coefficient of viscosity $\eta = 1.8 \times 10^{-5}$

Density of water (ρ) = 1000 kg/m³

Density of air (δ) = 1.29 kg/m³

Acceleration due gravity (g) = 9.8m/s.

Required : Terminal velocity (V_T) = ?

from, the relation.

$$V_T = \frac{2r^2(\rho - \delta)g}{9\eta}.$$

$$V_T = \frac{2(0.5 \times 10^{-3})^2(1000 - 1.29) \times 9.8}{9 \times 1.8 \times 10^{-5}}$$

$$V_T = \frac{4.894 \times 10^{-3}}{0.0162}$$

$$V_T = 0.302 \text{ m/s} \times 10^2$$

∴ Terminal velocity (V_T) = 0.302 m/s × 10^2
= 30.2 m/s.

c/ Solution

Given

Area (A) = 1.2m²

Velocity gradient ($\frac{dv}{dx}$) = $10 s^{-1}$

Coefficient of viscosity (η) = 1.3×10^{-5} N s M^{-2}

Required : force acting (F) = ?

from, the Newton law of fluid.

1 c/ From, Newton law of fluid.

$$F = A\eta \frac{dv}{dx}.$$

$$F = 1.2 \times 1.3 \times 10^{-5} \times 10.$$

$$F = 1.56 \times 10^{-4} N$$

Force acting $F = 1.56 \times 10^{-4}$ N.

d/ solution

Given:

Area $A_1 = 10cm^2$

Area $A_2 = 5cm^2$

Pressure difference $\Delta P = 300 Pa$

Time $(t) = 1min = 60sec.$

Required : Volume of water $V = ?$

from, the continuity principle

Rate of flow $Q = A_1 V_1 = k.$

To find the velocity V_1 through A_1, Velocity V_2 through A_2

from.

$$A_1 V_1 = A_2 V_2.$$

$$10cm^2 \times V_1 = 5cm^2 \, V_2.$$

$$V_2 = \frac{10cm^2 \times V_1}{5cm^2}$$

$$V_2 = 2V_1 \quad \text{------} \quad (i)$$

1 d/ To find velocity V_1 and V_2

from, the Bernoulli's principle

$$P_1 + \frac{1}{2}\rho v^2 + \rho hg = k$$

for horizontal flow $\rho hg = k$

$$P_1 + \frac{1}{2}\rho v^2 = K.$$

$$P_1 + \frac{1}{2}\rho v_1^2 = P_2 + \frac{1}{2}\rho v_2^2$$

$$P_1 - P_2 = \frac{1}{2}\rho v_2^2 - \frac{1}{2}\rho v_1^2$$

$$\Delta P = \frac{1}{2}\rho (v_2^2 - v_1^2).$$

$$\Delta P = \frac{1}{2}\rho (v_2^2 - v_1^2).$$

from equation - (i) above

$$V_2 = 2V_1$$

$$\Delta P = \tfrac{1}{2}\rho\left((2V_1)^2 - V_1^2\right).$$
$$\Delta P = \tfrac{1}{2}\times 1000\left(4V_1^2 - V_1^2\right)$$
$$300 = 500\left(4V_1^2 - V_1^2\right).$$
$$\frac{300}{500} = 3V_1^2$$
$$\frac{0.6}{3} = \frac{3V_1^2}{3}$$
$$0.2 = V_1^2$$
$$V_1 = \sqrt{0.2}$$
$$V_1 = 0.45\ m/s.$$

To find Velocity V_2 from.

$$V_2 = 2V_1 = 2\times 0.45 = 0.9\ m/s.$$

1 d/ From

$$\text{Rate} = \frac{V}{t} = A_1V_1$$
$$\frac{V}{t} = 10\times10^{-4}\times 0.45$$
$$\frac{V}{t} = 4.5\times10^{-4}.$$
$$V = 4.5\times10^{-4}\,t \text{, but } t = 60\text{sec}$$
$$V = 4.5\times10^{-4}\times 60$$
$$V = 0.027\ m^3.$$

$\therefore$ Volume of water, which will flow out in 1 minute $= 0.027\ m^3$.

Extract 15.1: A sample of good response provided by the candidate.

In Extract 15.1, the candidate answered correctly all parts of the question.

The candidates who performed poorly in this question did not know the basic concept in fluid dynamics. They failed to define the given terms such as velocity gradient, tangential stress and coefficient of viscosity. For instance, some of them defined velocity gradient as *the average speed of the liquid flowing in the pipe*. They failed to differentiate Stokes' equation given as $F = 6\pi r\eta v_T$ from Bernoulli's equation given by the relation $P+\rho g h + \frac{1}{2}\rho v^2 = k$. Besides, most of them applied the wrong formula and procedures, ending up getting incorrect values of terminal velocity, the force acting on the plate and the volume of water given out through the pipe. For example, one candidate calculated the force acting on a plate by using the formula $F = \frac{\eta}{A} x \frac{dv}{dy}$ instead of $F = \eta x \frac{dv}{dy} xA$. This candidate did not understand how variable A (cross-sectional area) relates with variable F (force acting on the plate) leading to the incorrect formulae. In general, these candidates had inadequate knowledge and skills in solving questions involving coefficient of viscosity as applied in fluid dynamics. Extract 15.2 is a sample of the incorrect responses given.

1(a) i) • Velocity gradient:-

→ As used in fluid dynamics is the average speed of fluid througwhich it flows in the pipe.

• Tangential Stress:

→ As used in fluid dynamics is the force in which the fluid flows per area.

• Coefficient of viscosity

→ As used in fluid dynamics is the average speed of the fluid in which it flows per unit area of the pipe.

ii) Stoke's equation;

$P + \rho gh + \frac{1}{2}\rho v^2 = \text{Constant}$.

where:-

P = Pressure.

ρgh = Potential energy.

$\frac{1}{2}\rho v^2$ = kinetic energy

(ii) Assuptions used to develop the equation
- The fluid is non-volatile
- There is no change in energy of the fluid.

(b) Data given:-

Diameter of rain drop = 1mm

Coefficient of viscosity $= 1.8 \times 10^{-5}\ Ns/m^2$.

Terminal velocity $= x$.

Area $= \frac{\pi d^2}{4}$, $d = 1mm\ (1 \times 10^{-3} m)$.

Area $= \frac{\pi (1 \times 10^{-3})^2}{4}$

$= \frac{3.14 (1 \times 10^{-3})^2}{4}$

Area $= 7.85 \times 10^{-7} m^2$.

Now;

Terminal velocity $= \frac{1.8 \times 10^{-5}}{7.85 \times 10^{-7}}$

$= 22.92$.

$\therefore$ The terminal velocity $= 22.92 m/s$.

(c) Data given:-

Area $= 1.2 m^2$.

velocity gradient $= 10 s^{-1}$

Coefficient of viscosity $=$ ~~1.3 Ns m^-2~~ $1.3 \times 10^{-5} Nsm^{-2}$.

force $= x$.

Force acting on Plate $= \frac{\text{Coefficient of viscosity} \times \text{velocity gradient}}{\text{Area}}$.

$= \frac{1.3 Nsm^{-2} \times 10 s^{-1}}{1.2 m^2}$

$= 1.08 \times 10^{-4} N$

$\therefore$ The force acting on plate $= 1.08 \times 10^{-4} N$

(d) Data given:-

Area$_1$ = 10 cm^2 $(1\times10^{-3} m^2)$

Area$_2$ = 5 cm^2 $(5\times10^{-4} m^2)$

Pressure = 300 Pa

$$A_1 P_1 = A_2 P_2$$

$$\frac{1\times10^{-3} m^2 \times 300}{5\times10^{-4}} = \frac{5\times10^{-4} m^2 \times P_2}{5\times10^{-4}}$$

$$P_2 = 600 Pa$$

∴ Pressure$_2$ = 600 Pa.

$$t^{1/2} = A_1 \times A_2 \times$$

$$60^{1/2} = 1\times10^{-3} m \times 5\times10^{-4} m$$

$$30t = 5\times10^{-7} m^2 \times m$$

$$\frac{30t}{30} = \frac{5\times10^{-7} m^3}{30}$$

$$1.67\times10^{-8} m^3,$$

∴ $1.67\times10^{-8} m^3$ [illegible] of water will flow out of the pipe in 1 minute.

Extract 15.2: A sample of incorrect responses provided by the candidate.

In Extract 15.2, the candidate failed to give the correct definition of velocity gradient, tangential stress and coefficient of viscosity. He/she stated Bernoulli's theorem instead of Stokes' law and applied the wrong formula to calculate terminal velocity, force acting on a plate and the volume of water flowing out.

2.2.2 Question 2: Vibrations and Waves

This question consisted of parts (a), (b) and (c). In part (a), the candidates were required to (i) provide evidence which proves that sound is a wave and (ii) explain why thunder of lightning is heard some moments after seeing the flash. Part (b) required the candidates to (i) define Doppler effects and (ii) calculate the frequency of the note heard by the cyclist before and after the train has passed away, when the engine driver of the railway train moving at 20 m/s, sounds a warning siren of frequency 480 Hz to cyclist moving at 10 m/s approaching each other. In part (c), the candidates had been instructed that two sheets of a Polaroid were lined up so that their polarization directions were initially parallel, if one sheet was rotated. Then they were required to (i) explain how the transmitted light intensity varies with the angle between the polarization direction of the polaroid and (ii) calculate the angle which the polaroid must be rotated to reduce the light intensity by 50%.

A total of 11,773 (62.3%) candidates attempted this question. The analysis depicts that 29.8 percent scored from 0 to 6.5, including 3.6 percent of the candidates who scored zero mark; 42.7 percent scored from 7 to 11.5 marks; and 27.5 percent scored from 12 to 20 marks. The general performance on this question was 70.2 percent, indicating good performance. Figure 11 illustrates the performance of the candidates on this question.

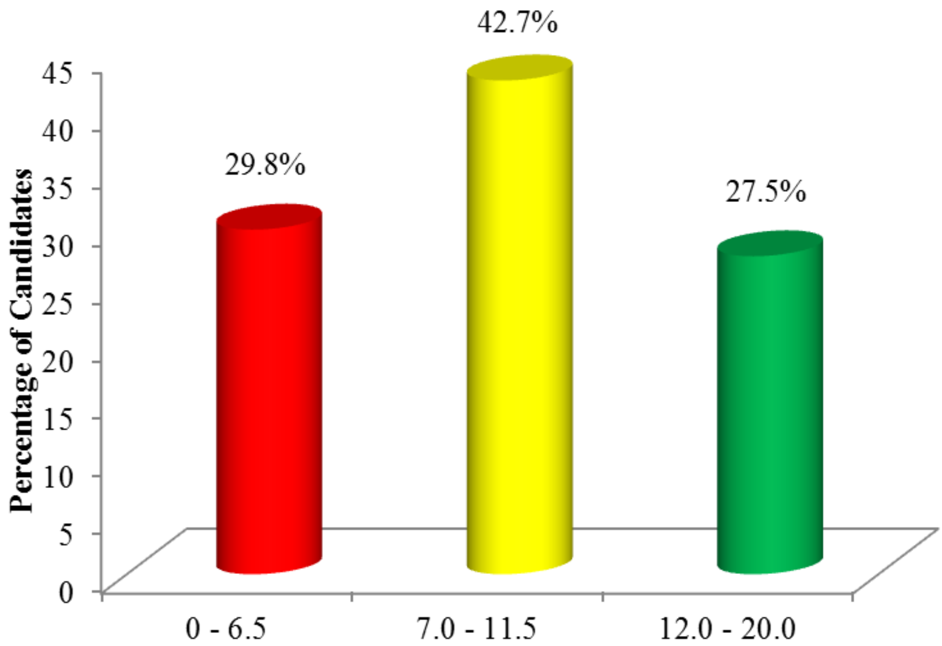


Figure 11: *Performance of candidates on question 2*

The candidates who performed well in this question managed to give the correct evidence that sound is a wave and explained correctly why a flash of light reaches us earlier than the sound of thunder. They also managed to define the term *Doppler effects* and applied the correct formula in calculating the frequency of the note heard by the cyclist before and after the train had passed. Furthermore, they managed to give the correct relation of how the transmitted light intensity varies with the angle between the polarization directions of the Polaroid as $I = I_o \cos^2\theta$. Moreover, they calculated correctly the angle which the Polaroid must be rotated to reduce the light intensity by 50%. These candidates seemed to have a good understanding of vibrations and waves particularly in Doppler effects, sound waves, light waves and polarization of waves. They showed great competence in using Malus law to portray the relationship between the transmitted light intensity and the angle between the polarization directions of the Polaroid. Extract 16.1 is a sample response by a candidate who answered the question correctly.

2 (a) (i) One evidence which proves that sound is a wave is: Existence of echoes.
⇒ Echo refers to a reflected sound.
On of the properties of waves is that: waves can be reflected. For this reason sound is a wave.

2 (a) (ii) This is because light travels faster than sound.
Speed of light = 3×10^8 m/s
Speed of sound in air = 340 m/s
For this reason lightning is heard some moments after seeing the flash

2 (b) (i) Doppler effect refers to the apparent change in frequency of a wave or wavelength of a wave when there is relative motion between the source of sound or light and the observer.

2 (b) (ii) ~~Speed~~ Given
Speed of cyclist, U_o = 10 m/s
Speed of train, U_s = 20 m/s
Actual frequency of siren, f = 480 Hz
Let,
f' = frequency heard by the cyclist before the train has passed away
f'' = frequency heard by the cyclist after the train has passed away.

2 (b) (ii)

Now,

$$f' = \left[\frac{V + U_o}{V - U_s}\right] f.$$

Where V = velocity of sound in air.

V = 340m/s.

$$f' = \left[\frac{340 + 10}{340 - 20}\right] \times 480 = 525\,Hz.$$

Again,

$$f'' = \left[\frac{V - U_o}{V + U_s}\right] f$$

$$f'' = \left[\frac{340 - 10}{340 + 20}\right] \times 480 = 440\,Hz.$$

∴ Frequency heard before the train passes,
$f' = 525\,Hz.$

Frequency heard after the train passes
$f'' = 440\,Hz.$

2 b (c) (i) Using Malus Equation,

$$I = I_o \cos^2\theta.$$

Where, I_o = Intensity of light transmitted by the first polaroid

2 (c) (i) I = Intensity of light transmitted by the 2nd polaroid.
θ = Angle between the transmission axes of the 1st and 2nd polaroid.

2 (c) (ii) let,
I_o = Intensity of light transmitted by 1st polaroid
I = Intensity of light transmitted by 2nd polaroid
θ = Angle between transmission axes of the 1st and 2nd polaroid

from, $I = I_o \cos^2\theta$ — Malus Equation.

$\Rightarrow \frac{I}{I_o} = \cos^2\theta$

$\frac{I}{I_o} \times 100\% = \cos^2\theta \times 100\%$

$\frac{I}{I_o} \times 100\% = 50\%$.

$50\% = \cos^2\theta \times 100\%$.

$\cos^2\theta = \frac{50}{100} = 0.5$.

$\cos^2\theta = 0.5$

$\cos\theta = \sqrt{0.5} = 0.7071$

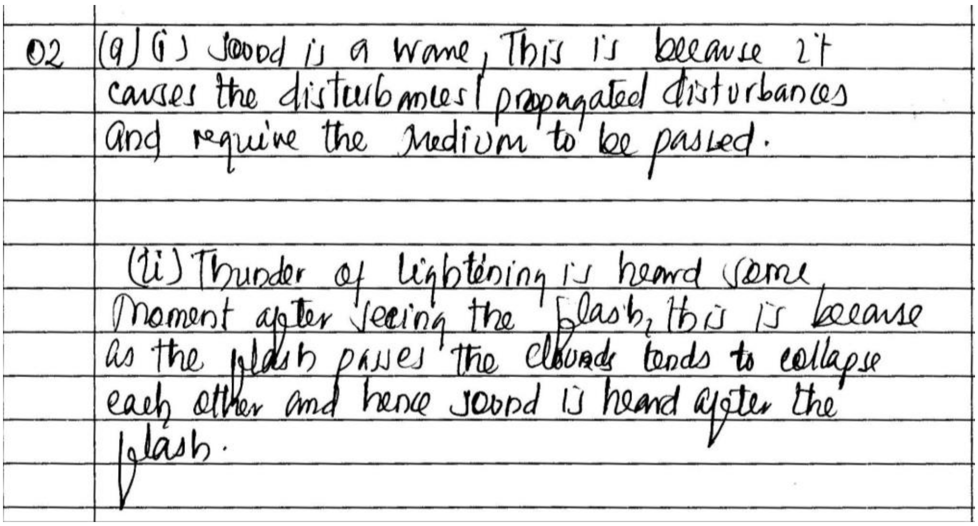
$\theta = \cos^{-1}(0.7071) = 45°$.

∴ The polaroid must be rotated 45° to reduce intensity of light by 50%.

Extract 16.1 is a sample of good response provided by the candidate.

In Extract 16.1, the candidate provided the correct responses to the question. He/she precisely explained the phenomenon and applied the correct formula in calculating frequency.

Contrarily, the candidates who scored low marks in this question provided incorrect evidence to prove that sound is a wave and failed to explain why a flash of light reaches us earlier than the sound of thunder. For example, one candidate explained why a flash reaches us earlier as *because the flash passes the clouds tends to collapse each other and hence sound is heard after the flash* which is completely wrong. This candidate was supposed to remember that light waves which travel through the vacuum have a greater speed (3×10^8 m/s) than sound waves (330 m/s) which travel through a given material medium. Accordingly, the flash of light reaches us earlier than the sound of thunder. Some of them, in part (b) (ii), confused the formula of finding apparent frequency of approaching with the separation of source and observer. They used $f'' = \left(\frac{v+v_o}{v-v_s}\right)\times f$ as the formula of separation/moving away instead of $f'' = \left(\frac{v-v_o}{v+v_s}\right)\times f$ and vice versa. They also faced problems in attempting part (c) which based on the concept of polarization. In this part, they wrongly explained how the intensity of light varies with the angle between the polarizations directions of the Polaroid. They also used the wrong formula to calculate the angle between the Polaroids for the light intensity to be reduced by 50%. This shows that most of them lacked content knowledge and mathematical skills in solving problems encompassing vibrations and waves especially in polarization. Extract 16.2 is an example of the incorrect responses given by one of the candidates.


Q2 (a) (i) Sound is a wave, This is because it causes the disturbances/propagated disturbances and require the medium to be passed.

(ii) Thunder of lightening is heard some moment after seeing the flash, this is because as the flash passes the clouds tends to collapse each other and hence sound is heard after the flash.

(b) (i) Doppler effect – This is the apparent change in frames as the source and the observer comes close or far away from each other.

(ii) Soln.

Data Given:

Speed of cyclist (V_o) = $10ms^{-1}$.

Speed of train (V_s) = $20ms^{-1}$.

frequency (f) = 480 Hz.

Required: frequency before and after the train has passed.

02 (b) (ii) CASE I.

Before the train has passed.

$$f' = \left(\frac{V - V_o}{V - V_s}\right) \times f$$

$$f' = \left(\frac{340ms^{-1} - 10ms^{-1}}{340ms^{-1} + 20ms^{-1}}\right) \times 480Hz.$$

$$f' = 440Hz.$$

Therefore, the frequency noted by the cyclist before the train has passed is 440Hz.

CASE II.

After the train has passed.

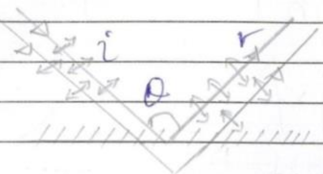
$$f'' = \left(\frac{V_o + V_o}{V - V_s}\right) \times f.$$

$$f'' = \left(\frac{340ms^{-1} + 10ms^{-1}}{340ms^{-1} - 20ms^{-1}}\right) \times 480 Hz.$$

$$f'' = 525 Hz.$$

Therefore, the frequency noted by the cyclist after the train has passed is 525 Hz.

02 (e)(i) Consider.



The transmitted light intensity vary with the angle between the polarization direction of the polaroids as the results the polaroids will form different angles and hence cause the variations of the intensity of light.

(ii) The polaroid must be rotated to the initial angle of the first polarised.

from

$\tan\theta = \mu$.

$\theta = \tan^{-1}\mu$.

$\theta = \tan^{-1} 1.5$.

$\theta = 56.31°$.

$\theta' = 90 - \theta$.

$\theta' = 90 - 56.31$

$\theta' = 33.69°$

∴ The angle is $33.69°$.

Extract 16.2: A sample of incorrect response given by a candidate.

In extract 16.2, the candidate wrote the incorrect explanation of the thunder of lightning heard some moment after seeing the flash. He/she used the wrong formula in calculating the apparent frequency and angle that the Polaroid must be rotated for the intensity of light to be 50%.

2.2.3 Question 3: Vibrations and Waves

This question had three parts (a), (b), and (c). Part (a) required the candidates to (i) give the meaning of wave function, longitudinal wave, and transverse wave and (ii) show that the maximum velocity of a progressive wave travelling in the $+x$-direction with equation $y = a\sin(wt - kx)$ is given as $v_{max} = \frac{2\pi a}{T}$. In part (b), they were required to (i) give the meaning of diffraction grating (ii) determine the angle at which the bright diffraction images will be observed when a diffraction grating has 500 lines per millimetre used with monochromatic light of wavelength 6×10^{-7}m at the normal incidence and (iii) explain why other orders of image in 3 (b) (ii) cannot be observed. In part (c), the candidates were required to (i) state Huygens's principle of wave construction and (ii) determine the wave length of monochromatic light when illuminated on a lens placed with convex surface of radius of curvature 50 cm in contact with the plane surface which resulting into Newton's rings whose radius of the 15th ring was 2.13 mm.

A total of 9133 (48.3%) candidates attempted this question. The analysis of data shows that 33.0 percent scored from 0 to 6.5 marks; 34.7 percent scored from 7 to 11.5 marks; and 32.3 percent scored from 12 to 20 marks. Figure 12 presents the performance of the candidates on this question.

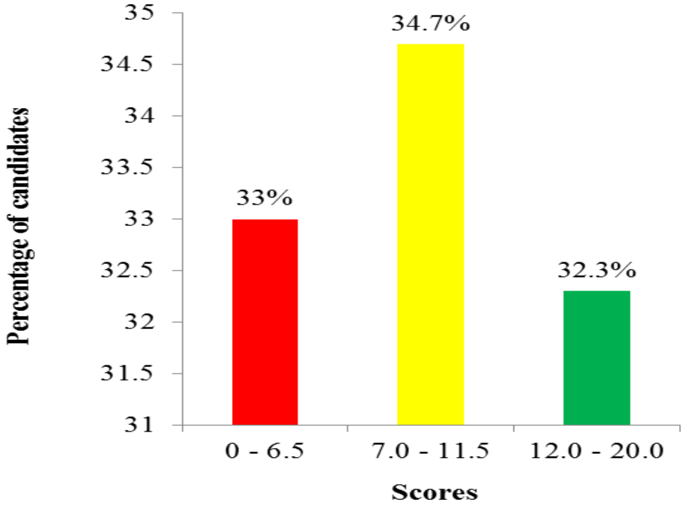


Figure 12: *The candidates' performance on question 3*

The candidates who performed well in this question had a good understanding of vibrations and waves. They managed to define correctly the terms wave function, longitudinal waves and transverse waves. They also managed to show clearly that $v_{max} = \frac{2\pi a}{T}$ from displacement equation $y = a\sin(wt - kx)$. They also managed to give the correct definition of diffraction grating and to retrieve the correct formula in finding the angle at which the bright diffraction images are observed. Moreover, they stated Huygens's principle and found the wave length correctly. Extract 17.1 shows a sample of responses by one of the candidates who provided correct answers to all parts of the question.

3. (a) (i) Wave function is a function which describes wave motions. It consists of time and displacement as well as angular phase.

$f(x,t) = a\sin(\omega t + \phi)$.

Longitudinal wave is the type of mechanical waves in which the particles move parallel to the direction of propagation of the wave.

Transverse wave: Is the type of mechanical waves whereby the particles vibrates perpendicular to the direction of propagation of a wave.

3 (a)(ii).

Given: $y = a\sin(\omega t - kx)$.

$V = \frac{dy}{dt} = \frac{d}{dt}(a\sin(\omega t - kx))$

$V = a\omega\cos(\omega t - kx)$.

for Maximum, $\cos\phi = 1$.

$V_{max} = a\omega$.

$V_{max} = a(2\pi f)$.

$= a\left(\frac{2\pi}{T}\right)$.

$\therefore V_{max} = 2\pi a/T$

3. (b) (i). Diffraction grating is the number of many equispaced parallel lines ruled on a glass or metal.

(ii). $g = 500$ lines/mm

$\lambda = 6 \times 10^{-7}$ m.

Required, α.

3. (b)(ii) from!

$$m\lambda = d\sin\theta .$$

$$\sin\theta = \frac{m\lambda}{d};$$

$$\theta = \sin^{-1}\left(\frac{m\lambda}{d}\right).$$

$$d = \frac{1}{g}$$

$$d = \left(\frac{500}{1\times10^{-3}}\right)^{-1} = 2\times10^{-6}m .$$

$$\theta = \sin^{-1}\left(\frac{m\lambda}{2\times10^{-6}}\right)$$

$$= \sin^{-1}\left(\frac{m \times 6\times10^{-7}m}{2\times10^{-6}m}\right)$$

$$\theta = \sin^{-1}(0.3m) .$$

for $m = 1$; $\theta = \sin^{-1}(0.3)$

$= 17.45^{0}.$

for $m = 2$; $\theta = \sin^{-1}(2\times0.3)$

$\theta = \sin^{-1}(0.6)$

$= 36.86^{0}$

for $m = 3$; $\theta = \sin^{-1}(3\times0.3)$.

$\theta = \sin^{-1}(0.9)$

$= 64.15^{0}.$

for $m = 4$; $\theta = \sin^{-1}(4\times0.3)$

$= \sin^{-1}(1.2)$

$= \infty$,

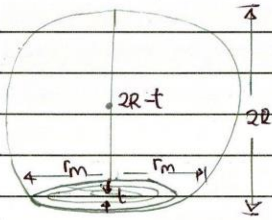
3(b) (iii). The other orders, from $m = 4, 5, 6 \ldots$ are not observed because they are diminished, that is the amplitude, decreases to the extent that it can not be observed.

3 (c)(i) Huygen's principle of wave construction state that " Every point on the primary wavefront act as a secondary source of wavelets in the direction of travel of a weve is perpendicular to wavefront and wavefront are equidistant from the source"

(ii) R = 50cm.

$r_m = 2.13mm$.

Required, λ.



$(2R-t)t = r_m \times$

$r_m^2 = 2Rt - t^2$.

$r_m^2 \simeq 2Rt$.

$r_m^2 = R(2t)$, but $2t = m\lambda$.

$r_m^2 = m\lambda R$.

$r_m = \sqrt{m\lambda R}$.

$\frac{r_m^2}{mR} = \lambda$.

$\lambda = \frac{r_m^2}{mR}$ = ~~2.13 × 10~~

$r_m = 2.13mm = 2.13 \times 10^{-3}m$

$r_m^2 = 4.5369 \times 10^{-6}m^2$.

$R = 0.5m$.

$m = 15^{th}$

$\lambda = \frac{r_m^2}{mR} = \frac{(2.13 \times 10^{-3})^2}{15 \times 0.5}$

$= \frac{4.5369 \times 10^{-6}m^2}{15 \times 0.5}$

$= 6.0492 \times 10^{-7}m$.

∴ The wavelength is $6.0492 \times 10^{-7}m$.

Extract 17.1: A sample of correct response given by the candidate.

In Extract 17.1, the candidate managed to provide correct responses to each part of the question. He/she performed correct numerical calculations to determine the angle at which the bright diffraction images will be observed and the wavelength of the monochromatic light used to produce Newton's rings.

The candidates who scored low marks in this question failed to give explanations mostly in parts (a) (i), (b) (iii) and (c) (i). They failed to give the correct definition of wave functions, longitudinal waves and transverse waves. For example, one candidate defined wave functions as *the number of fringes times the distance,* instead of *an equation which involves displacement x and time t describing the motion of the wave.* In part (b) (iii), they failed to say why other order of image cannot be observed. The candidates were supposed to know that the diffraction images cannot be observed if sinθ exceeds 1. For this case, the diffraction images will be observed at angles θ = 17.46°, 36.87° and 64.12° when the diffraction orders are m = 1, 2 and 3 respectively. Moreover, they applied inappropriate formulae in some parts of the question. For example, one candidate used the simple wave formula to find the wavelength of the monochromatic light in Newton's rings experiment as $f\lambda = v$ instead of $r_m^2 = mR\lambda$ for dark rings and $r_m^2 = (m + \frac{1}{2})R\lambda$ as used in Newton's ring. This indicates that the candidates lacked knowledge about vibrations and waves. They also did not know about the formation of interference patterns in Newton's ring experiment in particular. Extract 17.2 is a sample of responses from one of the candidate who gave incorrect answers to all parts of the question.

3. (a) (i) Wave function is the number of fringes times the distance.

Longitudinal wave is the wave in which frequency, wavelength and velocity of particles are in uniform, do not greatly vary. In this case wave travels vertically.
Transverse wave is the wave in which wavelength, frequency and velocity of particles are varying greatly. In this case wave travels horizontally.

3. (a) (ii) $y = a \sin(wt - kx)$ given;
Required: To show that $V_{max} = \frac{2\pi a}{T}$.

at maximum velocity $\sin(wt - kx) = 1$.
$y = a \sin(wt - kx)$.
$y = a$.
from
$f = V/\lambda$.

3. ~~(a)~~ (b) (ii) Given diffraction grating = 500 lines per millimetre.
Wavelength = 6×10^{-7} m.

Needed: Angle at which the bright diffraction images will be observed.
From:

$$\theta = 2\lambda G.$$
$$\theta = 2 \times 6 \times 10^{-7} \times 5 \times 10^{5}.$$
$$\theta = 1.2 \times 10^{-6} \text{ radians}.$$

(iii) Other order of images can not be observed due to dark fringes.

(c) (i) Huygen's principle of wave construction states that:
Wave is formed when light or sound particles moving with the same frequency, velocity and wavelength interact and travel together in the same direction vertically, horizontally or perpendicular from the same source.

(ii) Radius of curvature = 50.0 cm = (0.5 m)
Radius of the 15th ring = 2.13 mm = (2.13×10^{-3} m)

Wavelength:
From $f = V/\lambda$.

$$\lambda = \frac{V}{f}.$$

$$\lambda = \frac{\text{radius of carvature}}{\text{radius of the 15th ring}}.$$

3. ~~(b)~~ (c) (ii) : $\lambda = \frac{0.5 \text{ m}}{2.13 \times 10^{-3} \text{ m}}$

$$\lambda = 234.74.$$

∴ The wavelength is 234.74 m.

Extract 17.2: A sample of incorrect response provided by one of the candidates.

In Extract 17.2, the candidate failed to provide the correct meaning of the terms wave function, longitudinal waves and transverse waves. In part (c) (ii), he/she applied the incorrect formula to determine wavelength in Newton’s ring leading to the wrong answers.

2.2.4 Question 4: Properties of Matter

This question comprised parts (a), (b), and (c). In part (a), the candidates were required to (i) define Young's modulus of a material and (ii) explain why work is said to be done in stretching the wire. In part (b) the candidates were given information that a steel wire AB of the length 60 cm and cross sectional area 1.5 x 10^{-6} m^2 was attached at B with a copper wire BC of length 39 cm and cross sectional area 3.0 x 10^{-6} m^2, and that the combination of the two pieces of wire was suspended vertically from a fixed point at A and supports a weight of 250N. The candidates were required to find the extension (in millimetre) of the (i) steel wire and (ii) copper wire. Part (c) required the candidates to apply the kinetic theory of gases to determine (i) the average translational kinetic energy of air at a temperature of 290 K and (ii) the root mean square speed (r.m.s) of air at the same temperature as in 4(c) (i).

A total of 15,557 candidates, equivalent to 82.3 percent, attempted this question. The analysis of data reveals that 19.1 percent scored from 0 to 6.5; 52.9 percent scored from 7 to 11.5 marks; and 28.0 percent scored from 12 to 20 marks. Only 15 candidates (0.1%) scored all 20 marks in this question. The analysis of this question shows that the performance was good as 80.9 percent of the candidates scored from 7 to 20 marks. Figure 13 illustrates the performance of the candidates on this question.

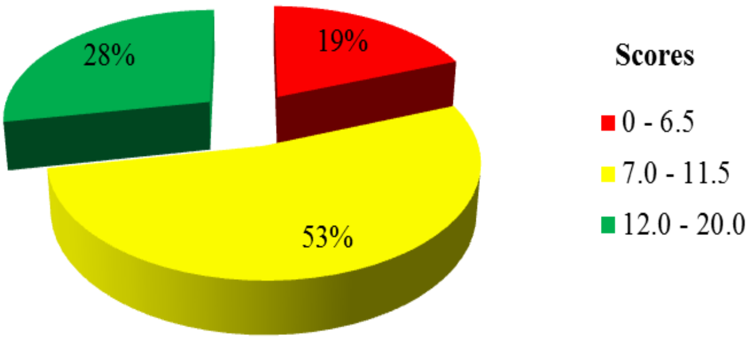


Figure 13: *The candidates' performance on question 4*

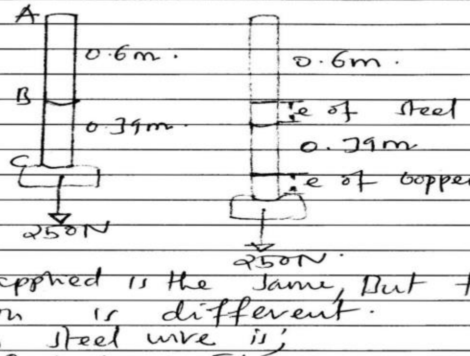
On one hand, the candidates who scored high marks in this question had a good knowledge of solving problems about the properties of matter by attempting most of this question correctly. Most of them managed to define the term Young's modulus of the material and explain correctly why work is said to be done in stretching a piece of wire. They also managed to recall the correct formula of Young's modulus in calculating the extension of steel and copper wire. They showed the ability to apply the kinetic theory of gases to determine the root mean square speed (r.m.s) of air in part (c) (ii). Extract 18.1 shows the answer by one candidate who performed well in this question.

4(a)
(i) Young's Modulus of a material.
⇒ This is the ratio between the normal stress applied on a body to the strain produced by a body.

(ii) Work is said to be done in stretching a wire, because initially molecules of wire have molecular potential energy which binding themselves, so on stretching you overcome that potential energy and cause them to have new greater energy of potential than before because you move molecules of wire far apart another hence, the energy to overcome potential or intermolecular force of attraction between molecules of wires is taken as workdone in stretching a wire

4(b) Data given.
Length of steel wire = 60cm ⇒ 0.6m.
Cross sectional area of wire steel = $1.5\times10^{-6}m^2$
length of copper wire = 39cm ⇒ 0.39m.
Cross sectional area of copper = $9.0\times10^{-6}m^2$.
Force, weight applied = 250N.

Soln
(i) Extension in steel wire.



Force applied is the same, But the extension is different.
(i) Extension in steel wire is;

$e_{steel} = \frac{FL}{AY}$

$= \frac{250N\times0.6m}{1.5\times10^{-6}m^2\times2.0\times10^{11}Nm^{-2}}$

$= 5\times10^{-4}m.$

But $1m \Rightarrow 1000mm.$
$5\times10^{-4}m \Rightarrow ?$
$\Rightarrow 0.5mm.$

∴ Extension of the steel wire = 0.5mm

4(b)(ii) Extension of copper wire.

$$e_{copper} = \frac{FL}{AY}$$

$$= \frac{258N \times 0.39m}{3.0 \times 10^{-6}m^2 \times 1.3 \times 10^{11} Nm^{-2}}$$

~~$= 2.5 \times 10^{-4}m$~~

$$= 0.25 mm$$

Extension of copper wire = 0.25mm

4(c)(i) Average translational kinetic energy of air at a temperature of 290K.

From.

$$PV = \frac{1}{3} Nmc^2.$$

But $PV = nRT$.

$$nRT = \frac{1}{3} Nmc^2.$$

Divide by 2 throughout

$$\frac{nRT}{2} = \frac{1}{3} \frac{Nmc^2}{2}.$$

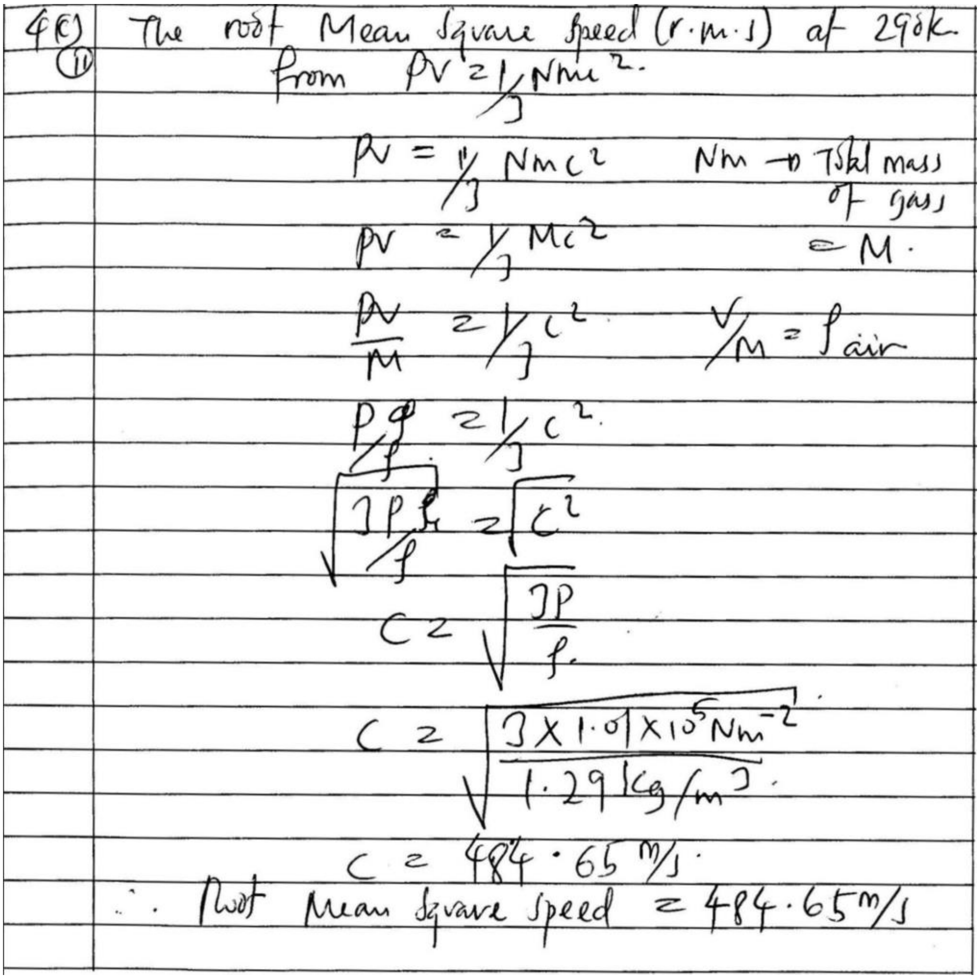
$$\frac{3nRT}{2} = \frac{Nmc^2}{2} = K.E.$$

$$K.E = \frac{3RT}{2}.$$ But R → Boltzmann's constant.

~~But~~ $K.E = \frac{3 \times 1.38 \times 10^{-23} JK^{-1} \times 290K}{2}$

$$K.E = 6.003 \times 10^{-21} J.$$

∴ Average translational kinetic energy of air at temperature of 290K is $6.003 \times 10^{-21} J$.



4(c)(ii) The root Mean Square speed (r.m.s) at 298K.
from $PV = \frac{1}{3}Nmc^2$.

$PV = \frac{1}{3}Nmc^2$ Nm → Total mass of gass = M.

$PV = \frac{1}{3}Mc^2$

$\frac{PV}{M} = \frac{1}{3}c^2$ $V/M = \rho_{air}$

$\frac{P}{\rho} = \frac{1}{3}c^2$

$\sqrt{\frac{3P}{\rho}} = \sqrt{c^2}$

$C = \sqrt{\frac{3P}{\rho}}$

$C = \sqrt{\frac{3 \times 1.01 \times 10^5 Nm^{-2}}{1.29 kg/m^3}}$

$C = 484.65 m/s$

∴ Root Mean Square speed = 484.65 m/s

Extract 18.1: A sample of good response given by the candidate.

In Extract 18.1, the candidate defined the term Young's modulus correctly and explained why work is said to be done in stretching a piece of wire. Consequently, the candidate applied the correct formula to do the calculations.

On the other hand, the candidates who scored low marks in this question lacked knowledge about the properties of matter. They failed to define Young's modulus of material and to explain why work is said to be done in a stretching wire. In order to define Young's modulus of a material, the candidates were supposed to know that it involves a ratio of tensile stress to tensile strain. Therefore, when a wire is stretched, the intermolecular forces oppose the increase in length of the wire. Work has thus to be done against these forces which appear as the elastic potential energy stored in the wire.

Since most of them failed to express Young's modulus equation, they were susceptible to using the wrong formula in finding the extension of steel and copper wire which led them to obtain incorrect answers. For example, in part (b) one candidate used the formula $e = \frac{F}{L} \div \frac{A}{L} = \frac{F}{A}$ to find extension which is the formula for pressure instead of $e = \frac{FL}{AE}$. Some of them failed to apply kinetic theory of gases in finding translational kinetic energy and the root mean square speed (r.m.s) of air molecules. One candidate confused the formula of translational kinetic energy of air molecules $(k.e = \frac{3}{2}kT)$ with that of moving bodies $(k.e = \frac{1}{2}mv^2)$ in (c) (i). Extract 18.2 is an example of incorrect answer by one of the candidates.

4a) i) ~~Young's Modulus of a material is the force per area per force~~

4(a) i) Youngs modulus - is the property of a material which shows how a material can be not elastic or the elasticity of a material.

4a) ii) Work is said to be done in streching a wire this is because in streching a wire the streching has to cover some distance and also when stretching there is a stretching force so force × distance brings workdone.

4b) Soln

Steel wire (AB)

L = 60cm

$A = 1.5 \times 10^{-6} m^2$

Copper wire (BC)

L = 39cm

$A = 3.0 \times 10^{-6} m^2$

L = 99cm $A = 4.5 \times 10^{-06}$

i) ~~Force~~ / Length

4b) i) Steel wire

$$F/L \div A/L$$

$$250/60 \div \frac{1.5\times10^{-6}}{60}$$

$$25/6 \times 60/1.5\times10^{-6}$$

$= 6\times10^{-9}$mm

∴ The extension of steel wire is 6×10^{-9}mm.

ii) Copper wire.

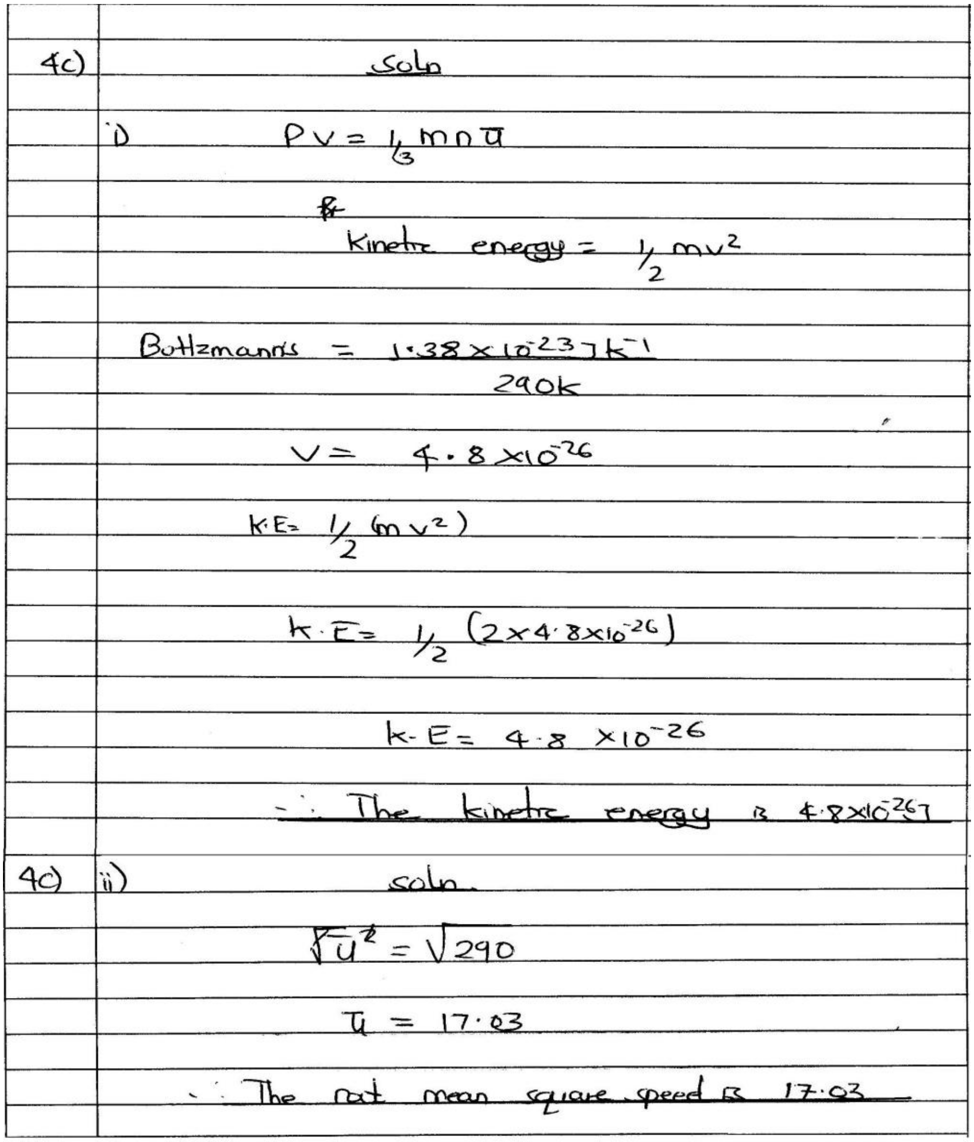
$$F/L \div L/A$$

$$250/39 \div 39/3.0\times10^{-6}$$

~~6.4~~ 1.17×10^{-4}

$= 1.17\times10^{-4}$mm

∴ The extension of steel wire is 1.17×10^{-4}mm



4c) soln

i) $PV = \frac{1}{3} mn\bar{u}$

&

Kinetic energy = $\frac{1}{2} mv^2$

Boltzmann's = $1.38 \times 10^{-23} JK^{-1}$

290k

$V = 4.8 \times 10^{-26}$

$K.E = \frac{1}{2} (mv^2)$

$K.E = \frac{1}{2} (2 \times 4.8 \times 10^{-26})$

$K.E = 4.8 \times 10^{-26}$

∴ The kinetic energy is $4.8 \times 10^{-26} J$

4c) ii) soln.

$\sqrt{\bar{u}^2} = \sqrt{290}$

$\bar{u} = 17.03$

∴ The root mean square speed is 17.03

Extract 18.2: A sample of incorrect response provided by the candidate.

Extract 18.2 is a response of a candidate who failed to define the terms correctly and used an inappropriate formula to perform calculations, leading to incorrect answers.

2.2.5 Question 5: Electrostatics

This question was divided into parts (a), (b) and (c). In part (a), the candidates were required to (i) define the terms electric potential and electric field-strength E at a point in the electrostatic field and (ii) show how the electric potential and electric field strength are related. In part (b), the candidates were required to calculate (i) the potential at the surface of the sphere and (ii) capacitance of the sphere, provided that outside the sphere, a charged sphere behaves like its charges were concentrated at the centre and that the electric field strength inside the sphere is zero where one sphere of radius 5.0 cm carries a positive charge of 6.7 nC. In part (c), the candidates were given Figure 1 which shows two horizontal parallel conducting plates in vacuum.

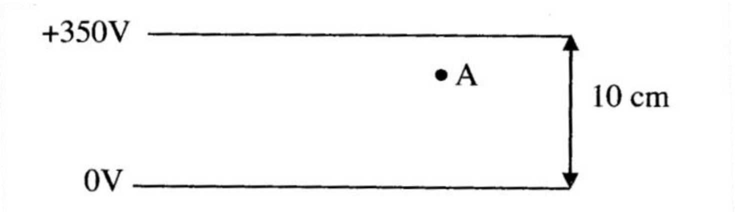


Figure 1

Then, they were asked, If a small particle of mass 4 x 10^{-12} kg carries a positive charge of 3.0 x 10^{-14} C is released at point A close to the upper plate, calculate: (i) the total force acting on the particle and (ii) the kinetic energy of the particle when it reaches the lower plate.

The question was attempted by 23.7 percent of candidates. Among them, 29.0 percent scored from 0 to 6.5 marks; 35.5 percent scored from 7 to 11.5 marks; and 35.2 scored from 12 to 20 marks. From this analysis, the general performance of the candidates on this question was good as 71.0 percent of candidates scored from 7 to 20 marks. Figure 14 indicates the performance of the candidates on this question.

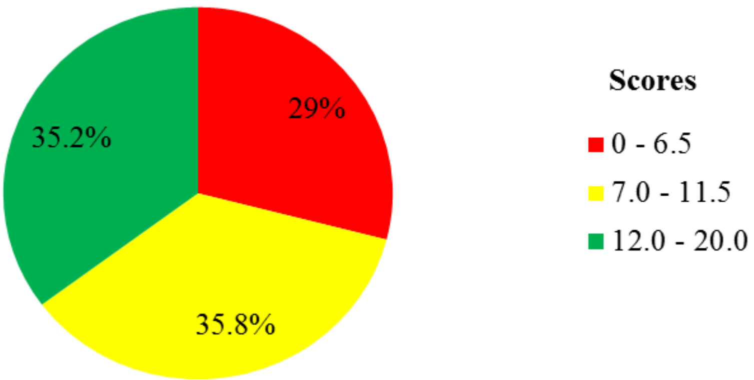


Figure 14: *The candidates' performance on question 5*

The candidates who performed well in this question were knowledgeable about the concept of electrostatics especially on the electric field strength and electric potential. They managed to define correctly the terms electric potential and electric field strength. They also succeeded to show mathematically how the two quantities are related as $E = \frac{dV}{dr}$ or $E = -\frac{dV}{dr}$. Besides, they applied the correct formula in calculating the potential at the surface of the sphere and its capacitance. In part (c), they managed to calculate the total force acting on the particle by using the formula $F_T = F_E + F_g$ and its kinetic energy of the particle when it reaches the lower plate. Extract 19.1 is a response of one of the candidates who performed well.

5 (a) (i) Electric potential.

Electric potential at a point is defined as the work done in moving a unit positive charge from infinity to that point in an electric field.

Electric field strength E

is the electrostatic force experienced per unit positive charge placed at a point in an electric field.

(ii) Relation

$$E = -\frac{dv}{dx}.$$

where

E is the field strength

v is the electric potential

x is distance

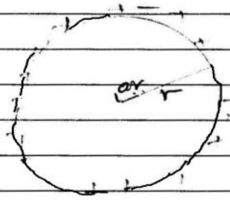
ie the electric field strength is the negative gradient of the potential.

5 (b) Given:

sphere radius $r = 5 \times 10^{-2}$ m.
charge $q = + 6.7 \times 10^{-9}$ C.

(i) potential,

recall that,



$dV = -\int E\,dr$

$$V = -\int_{\infty}^{r} \frac{q}{4\pi\varepsilon_0} \frac{dr}{r^2}$$

$$-V = \frac{q}{4\pi\varepsilon_0} \left[\frac{-1}{r} \right]_{\infty}^{r}$$

$$-V = \frac{-q}{4\pi\varepsilon_0 r}$$

$$V = \frac{q}{4\pi\varepsilon_0 r}$$

$$V = \left(\frac{1}{4\pi\varepsilon_0}\right) q \times \frac{1}{r}$$

$$V = 9 \times 10^{9} \times 6.7 \times 10^{-9} \times \frac{1}{5 \times 10^{-2}}$$

$$V = +1206 \text{ V}$$

∴ potential at surface of sphere is 1206

5 (b) (ii) capacitance

By definition,

$$C = \frac{q}{V}$$

$$V = \frac{q}{4\pi\varepsilon_0 r}$$

$$C = \frac{q \times 4\pi\varepsilon_0 r}{q}$$

$c = 4\pi\varepsilon_0 r$

$c = \frac{r}{1/4\pi\varepsilon_0}$

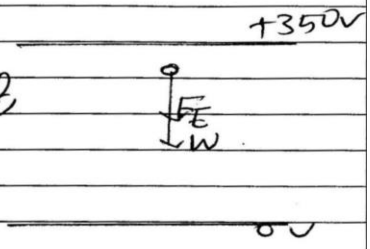
$c = \frac{5 \times 10^{-2}}{9 \times 10^{9}}$

$c = 5.9556 \times 10^{-12}\ F$

∴ the capacitance of the sphere is $5.556 \times 10^{-12}\ F$

5 (c)
(i)
Given
Mass $m = 4 \times 10^{-12}\ kg$
charge $q = +3 \times 10^{-14}\ C$
$d = 0.1\ m$

(i)



total force taking weight into account,

$F = F_E + W$

$F = qE + mg$

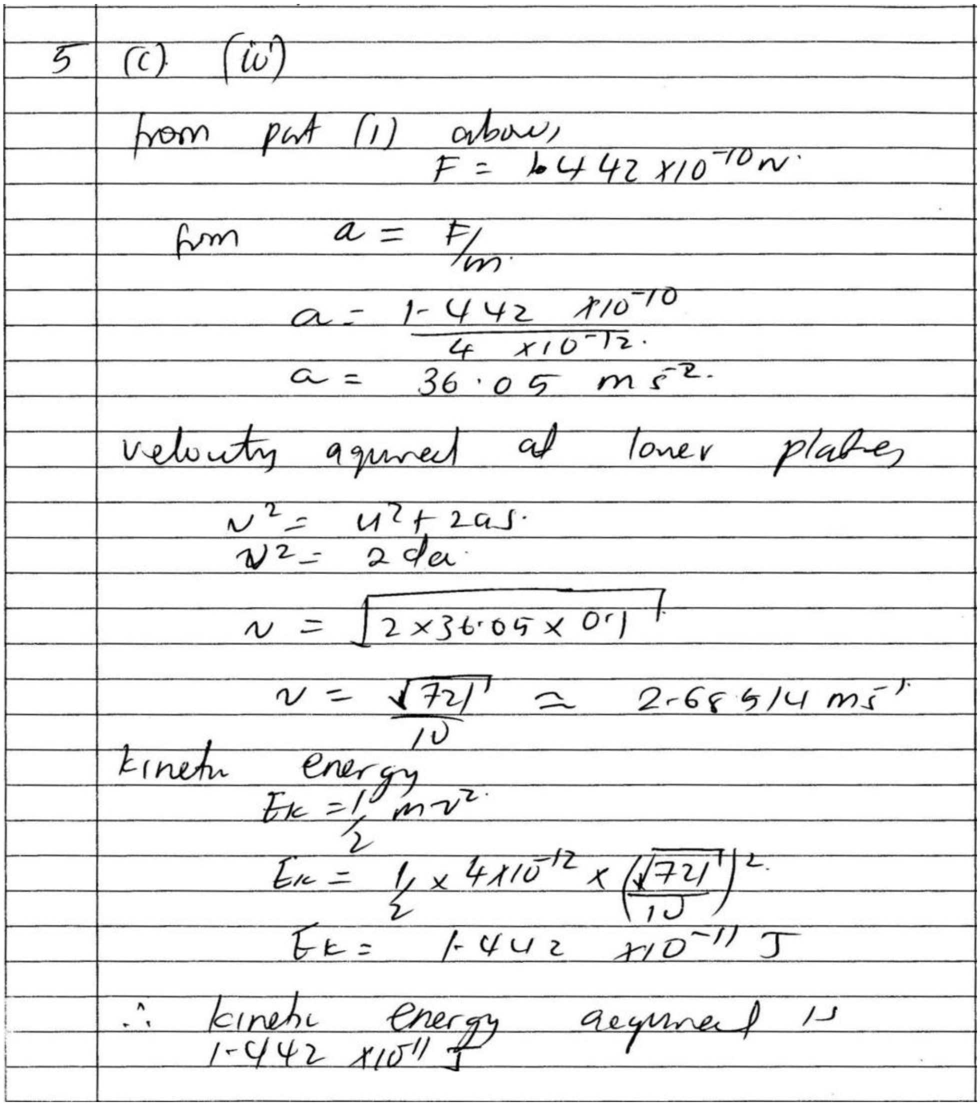
$E = \frac{v}{d}$

$F = \frac{qv}{d} + mg$

$F = \frac{3 \times 10^{-14} \times 350}{0.1} + 4 \times 10^{-12} \times 9.8$

$F = 1.442 \times 10^{-10}\ N$

∴ total force on the particle is $1.442 \times 10^{-10}\ N$



5 (c) (iv)

from part (i) above,

$F = 1.442 \times 10^{-10}$ N.

from $a = F/m$

$a = \frac{1.442 \times 10^{-10}}{4 \times 10^{-12}}$

$a = 36.05\ ms^{-2}$.

velocity acquired at lower plates

$v^2 = u^2 + 2as$.

$v^2 = 2da$.

$v = \sqrt{2 \times 36.05 \times 0.1}$

$v = \frac{\sqrt{721}}{10} \simeq 2.68514\ ms^{-1}$

kinetic energy

$E_k = \frac{1}{2} m v^2$.

$E_k = \frac{1}{2} \times 4 \times 10^{-12} \times \left(\frac{\sqrt{721}}{10}\right)^2$.

$E_k = 1.442 \times 10^{-11}$ J

$\therefore$ kinetic energy acquired is 1.442×10^{-11} J

Extract 19.1: A sample of the correct response given by one of the candidates.

In Extract 19.1, the candidate gave the correct responses according to the requirements of the question. He/she managed to recall and apply the formula for finding electric potential at the surface of the sphere, capacitance of the sphere, the total force acting on a particle and its kinetic energy.

Contrarily, the candidates who scored low marks (0 - 6.5) lacked knowledge about electrostatics. Some of them gave the wrong definitions of electric potential (V) and electric field strength (E). Hence they failed to address all parts of the question and scored zero. For example one of the candidates wrongly defined electric potential as *the ratio between charge and electric field strength* instead of the work done in bringing a unit positive charge from infinity to a point. Others failed to give the correct relation between V and E, as shown in the responses of one of the candidate that $r^2 = kV$ in place of $\mathrm{E} = \frac{\mathrm{dV}}{\mathrm{dr}}$ or $\mathrm{E} = -\frac{\mathrm{dV}}{\mathrm{dr}}$. They also failed to apply the correct formula in calculating the electric potential and capacitance of the sphere. In part (c), most of the candidates failed to identify the forces acting on a particle and used the wrong formula to calculate the kinetic energy. A good example is from one candidate who wrote the formula for force acting on a particle falling in air as $F = mg - U$ instead of writing the formula for a particle falling in electric fields as $F_T = F_E + F_g$ The candidates were required to use the formula for the energy stored in capacitor as $U = \frac{1}{2}cv^2$ in calculating the kinetic energy of alpha particles instead of just writing the formula ($K.E = \frac{1}{2}m_p v_p^2$). This indicates that they lacked knowledge about the general concept of electrostatics. Extract 19.2 is a sample of the wrong responses to this question.

5 Electric potential is the ration between charge and - electric field while Electric field-strength - is the force requires to attract charge at distant level.

(ii)

Relation:

$E_1 = F/q$ - - - (i)

$E_2 = q/V$ - - - (ii).

$E_1 = E_2 = E$ Than $F/q = q/V$.

$q^2 = FV$.

$F = Kq_1q_2/r^2$. assume, $q_1 = q_2 = q$.

$q^2 = kq^2V/r^2$

$r2 = kV$.

5(b) from:

Given Data:

radius of sphere, $r = 5cm \ (5\times10^{-2}m)$

Charge, $Q = 6.7nC \ (6.7\times10^{-9}C)$.

from:

$C = 4\pi\varepsilon_0 r$.

$C = 4\pi \times 8.8\times10^{-12} \times (5\times10^{-2})$

$= 5.53\times10^{-12}$.

$= 5.53pF$.

Then: $Q = CV$.

$\frac{Q}{C}$

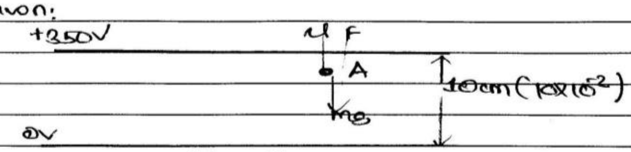
$V = \frac{6.7\times10^{-9}}{5.53\times10^{-12}}$

$V = 1.212V$.

∴ (i) Potential at the surface of sphere were 1.212V.

(ii) Capacitance of the sphere 5.53pF or $5.53\times10^{-12}F$

5c. Given:



$mg = U + F$.

$F = V/d$, $U = 4/3 \pi r^3 \rho g$

$m = (4/3 \pi r^3 \rho_0) g$.

(i) Force, $F = mg - U$

Given:

Mass of particle, $m = 4\times10^{-12}kg$.

Acceleration due to gravity, $g = 9.8 m/s^2$.

Charge, $Q = 3.0\times10^{-14}$

$F = [4\times10^{-12} \times 9.8] - 1.6\times10^{-11}C\,kg^{-1}$

$= -1.6\times10^{-11} N$

(ii) $K.E = \frac{1}{2}MV^2$ or $\frac{1}{2}CV^2$.

$K.E = \frac{1}{2} \times 3.0\times10^{-14} \times (350)$

$= 5.25\times10^{-12}J$.

Extract 19.2: A sample of incorrect response provided by the candidate.

In extract 19.2, the candidate gave an incorrect definition of electric potential and electric field strength. They also applied the incorrect formula to calculate the kinetic energy of the particle.

2.2.6 Question 6: Electrostatics

This question consisted of parts (a), (b) and (c). Part (a) required the candidates to (i) give the meaning of dielectric constant and (ii) state Coulomb's law of force between two electrically charged bodies. In part (b), the candidates were required to (i) agree or disagree and give a reason if there can be a potential difference between two adjacent conductors carrying the same positive charge and (ii) find final charge of each plate if a parallel plate capacitor with air as a dielectric, plates of area 4.0×10^{-2} m^2 and 20 mm apart charged to 100 V battery, when connected in parallel with a similar unchanged capacitor with plates of half the area and twice the distance apart under neglecting edge effect. Part (c) required the candidates to: (i) derive an expression for the total capacitance of two capacitors C_1 and C_2 connected in a series and (ii) calculate the charge and potential difference across each capacitor when two capacitors of 15 μF and 20 μF are connected in a series with a 600 V supply.

A total of 7,674 (40.6%) candidates attempted this question. Among them, 26.4 percent scored from 0 to 6.5 marks, including 2.3 percent of candidates who scored zero; 38.1 percent scored from 7 to 11.5 marks; and 35.5 percent scored from 12 to 20 marks. A total of 340 (1.8%) candidates managed to score full marks, 20 out of 20 marks. These scores suggest that the performance was good since 73.6 percent of the candidates scored from 7 to 20 marks. Figure 15 represents the performance of the candidates on this question.

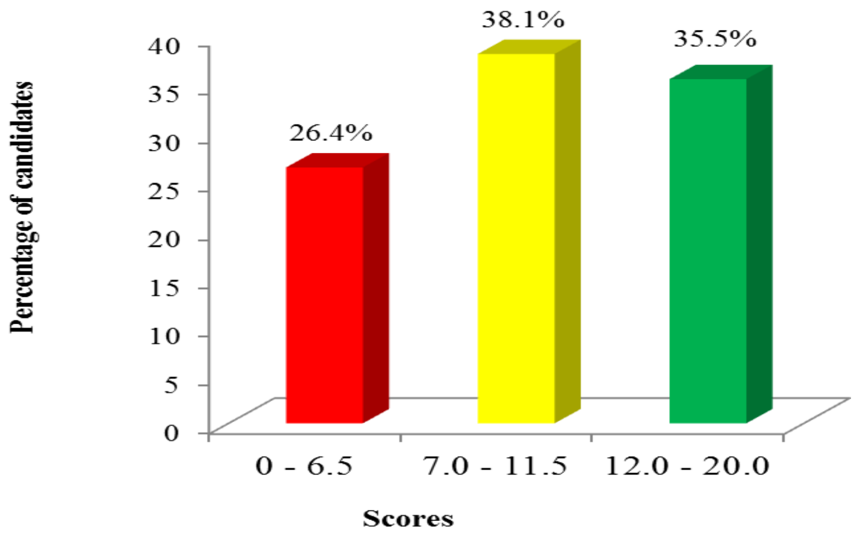
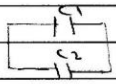


Figure 15: *The candidates' performance on question 6*

The observations made from the responses in the script of those who performed well in this question show that most candidates managed to define dielectric constant and to state correctly Coulomb's law of force between two charges. In part (c), they managed to derive an expression for the total capacitance of two capacitors C_1 and C_2 connected in a series and applied the correct formula to calculate the charge and potential difference across each capacitor. This indicates that these candidates had content knowledge and were good at numerical calculations. Extract 20.1 presents a sample of the correct responses by one of the candidates who answered the question.

6 (a) i: Dielectric constant is the ratio of the absolute ~~permitt~~ permitivity of the particular medium to absolute permitivity of air.

ii. Coulomb's law state that "The electrostatic force of attraction or repulsion between two charge varies directly proportional to the product of the charges and inversely proportional to square of distance of separation"



(b) ii. Soln.

from $c_1 = \frac{A\varepsilon_0}{d_1}$ ~~for second capacitor~~

$C_1 = \frac{4\times10^{-2}m \times 8.85\times10^{-12}}{(2\times10^{-3}m)}$ $\quad C_2 = \frac{A_2\varepsilon_0}{d_2}$

$C_2 = \frac{\left(\frac{4\times10^{-2}}{2}\times 8.85\times10^{-12}\right)}{4\times10^{-3}}$

$c_1 = 1.77\times10^{-10}F$

$c_2 = 4.425\times10^{-11}F$

from

$q_1 + q_2 = (c_1 + c_2)V$

$q_2 = 0$

$(1.77\times10^{-10}\times 100V) + 0 = (1.77\times10^{-10} + 4.425\times10^{-11})V$

$1.77\times10^{-8}C = 2.2125\times10^{-10}V$

$V = 80V$

Then $Q_2 = C_2V$

$Q_1 = C_1V$

$q_2 = (4.425\times10^{-11}\times 80)C$

$q_2 = 3.54\times10^{-9}C$

Also

$Q_1 = (80\times1.77\times10^{-10}F)$

$Q_1 = 1.416\times10^{-8}C$

$\therefore$ charge on first capacitor $= 1.416\times10^{-8}C$ and the other has $= 3.54\times10^{-9}C$

6(c) i.

~~from Q = CV~~

$V = Q/C$

$V_T = V_1 + V_2$

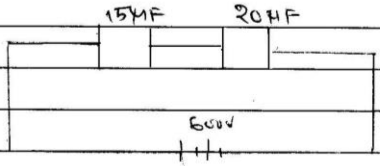
$\frac{Q}{C_T} = Q/C_1 + Q/C_2$

$Q(1/C_T) = Q(1/C_1 + 1/C_2)$

$1/C_T = 1/C_1 + 1/C_2$

$C_T = \frac{C_1C_2}{C_1+C_2}$

ii.



from

$C_T = \frac{C_1C_2}{C_1+C_2}$

$= \frac{15\times10^{-6}\times 20\times10^{-6}}{15\times10^{-6} + 20\times10^{-6}}$

$C_T = 8.571\times10^{-6}C$

Then

$Q = CV$

$Q = 8.571\times10^{-6}\times600$

$Q = 5.142\times10^{-3}C$

∴ Charge on each capacitor $= 5.142\times10^{-3}C$

From

$Q = C_1V_1$

$V_1 = Q/C_1 = \frac{5.142\times10^{-3}C}{(15\times10^{-6}F)}$

$V_1 = 342.857V$

∴ Potential difference at 15μF = 342.857V

Also

$600V = V(15μF) + V(20μF)$

$V(20μF) = 600 - V(15μF)$

$V(20μF) = 600 - (342.857V)$

$V(20μF) = 257.143V$

∴ Potential difference at 20μF = 257.143V

(b) YES,

Because the two conductors may differ in dimensions (radius) hence difference in potential difference

Extract 20.1: A sample of the correct response given by a candidate.

Extract 20.1 shows the answer by a candidate who correctly defined the term dielectric constant, stated Coulomb's law of force correctly and followed proper procedures in deriving the expression for the total capacitance and finally did the calculations appropriately.

The candidates who performed poorly in this question did not have adequate knowledge of the basic concept in electrostatics. They confused some terms such as dielectric constant with dielectric material. Accordingly, some of them defined dielectric constant as *non-conducting material placed in capacitors* instead of the ratio of the permittivity of material medium to that of free space. They also failed to state Coulomb's law properly. In addition, some of them derived the expression of the total capacitance of two capacitors connected in parallel ($C_T = C_1 + C_2$) instead of a series connection ($C_T = \frac{C_1 C_2}{C_2 + C_1}$). Hence, they obtained the wrong total charge and potential difference. Extract 20.2 shows a sample of poor responses by one of the candidates who provided incorrect answers to all parts of the question.

6(a)(i) Refers to the non-conducting material placed in a capacitor purposely for increasing capacitor's charge carrying capacity.

(ii) " The force between two electrically charged bodies is ~~directed~~ directly proportional to their magnitudes and inversely proportional to the square of their distance of separation ".

(b)(i) No, there can not be a potential difference between two adjacent conductors carrying the same positive charge. The reason is :-

For a potential difference to occur between two adjacent conductors, polarization of charges should take place. Hence for two same positive charges, polarization will not occur. Due to this there will also be no potential difference between two adjacent conductors carrying the same positive charge.

(ii) Solution

Area $(A_1) = 4.0 \times 10^{-2} m^2$. $\quad Q_1 = ?$

distance $(d_1) = 2 \times 10^{-3} m$. $\quad \varepsilon_0 = 8.8 \times 10^{-12} Fm^{-1}$

potential $(V) = 100V$.

$A_2 = \frac{1}{2} A_1 = \frac{1}{2} \times 4.0 \times 10^{-2} = 0.02\ m^2$.

$d_2 = 2 d_1 = 2 \times 2 \times 10^{-3} = 4 \times 10^{-3} m$

$Q_2 = ?$

from,

$Q = CV$.

$Q = \frac{\varepsilon_0 A}{d} V$.

$Q_1 = \frac{\varepsilon_0 A_1}{d_1} V$. $\quad , \quad Q_2 = \frac{\varepsilon_0 A_2}{d_2} V$

6 (b) (ii) $Q_1 = \frac{\varepsilon_0 A_1 V}{d_1} = \frac{8.8 \times 10^{-12} \times 4.0 \times 10^{-2} \times 100V}{2 \times 10^{-3} m}$

CONT

$Q_1 = 1.76 \times 10^{-8} C$

$Q_2 = \frac{\varepsilon_0 A_2 V}{d_2} = \frac{8.8 \times 10^{-12} \times 0.02 \times 100V}{4 \times 10^{-3}}$

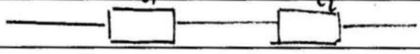
$Q_2 = 4.4 \times 10^{-9} C$

Hence,

final charge on plate 1 is $1.76 \times 10^{-8} C$

final charge on plate 2 is $4.4 \times 10^{-9} C$

(c) (i) To derive an expression for total capacitance of two capacitors C_1 and C_2 connected in series



from, $Q = Q_1 + Q_2$

$Q = CV$

$V = Q/C$

$V = \frac{Q_1 + Q_2}{C_1 + C_2}$

but, $Q_1 = C_1 V_1$

$Q_2 = C_2 V_2$

$V = \frac{C_1 V_1 + C_2 V_2}{C_1 + C_2}$ ---(i)

from, $Q = Q_1 + Q_2$

$C_T V = C_1 V_1 + C_2 V_2$

$C_T \left(\frac{C_1 V_1 + C_2 V_2}{C_1 + C_2} \right) = C_1 V_1 + C_2 V_2$

$C_T (C_1 V_1 + C_2 V_2) = (C_1 V_1 + C_2 V_2)(C_1 + C_2)$

$C_T = C_1 + C_2$

Hence, for total capacitance, $C_T = C_1 + C_2$ in series

6 (c) (ii) Cont.

Solution

$C_p = C_1 + C_2$.

$C_p = 15\mu F + 20\mu F$.

$C_p = (15 \times 10^{-6} F) + (20 \times 10^{-6} F)$

$C_p = 3.5 \times 10^{-5} F$.

from,

$Q = C_p V$.

~~$Q = 35$~~ $C_p = 3.5 \times 10^{-5} F$.

$V = 600V$.

$Q = 3.5 \times 10^{-5} F \times 600V$

$Q = 0.021\ C$.

On capacitor 1 C_1

$Q = C_1 V$.

~~$Q/V = C_1 = 600V$~~

$C_1 = $ ~~$Q/V = 0.021C$~~

$V = Q/C_1 = \frac{0.021}{15 \times 10^{-6}}$

$V = 1400V$.

on capacitor 2, C_1.

$V = Q/C_2$

$V = \frac{0.021}{20 \times 10^{-6}}$

$V = 1050V$.

Hence. Charge is $0.021C$.

On capacitor 1, potential difference, $1400V$.

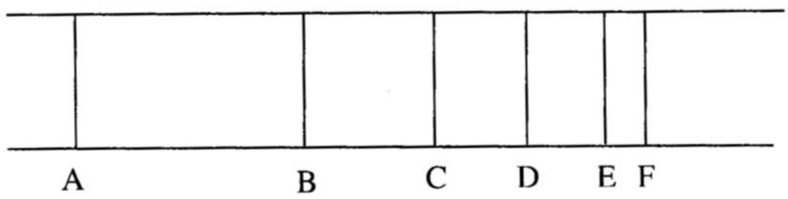
On capacitor 2, potential difference, $1050V$.

Extract 20.2: A sample of incorrect response given by a candidate.

In Extract 20.2, the candidate failed to define dielectric constant, incorrectly stated Coulomb's law of force and derived the wrong formula for series connection.

2.2.7 Question 7: Atomic Physics

The question was divided into parts (a), (b) and (c). In part (a), the candidates were required to (i) determine the wavelength of the series limit of Paschen series based on the Balmer series of hydrogen spectra and (ii) explain why electrons do not fall into the nucleus due to the electrostatic force of attraction. In part (b), they were required to (i) explain why the hydrogen atom is stable in the ground state and (ii) use mathematical equation to express the statement of Bohr's theory which state that the angular momentum of an electron is an integral multiple of $\frac{h}{2\pi}$ in which angular momentum is represented by the letter L and orbit by the letter n and (iii) determine the angular momentum of the electron in the orbit of energy level -3.4eV given that $E_n = \frac{-13.6}{n^2}\text{eV}$,where E is the energy of an electron and n is the principal quantum number of the hydrogen atom. Part (c) required the candidates to read carefully the following figure which represents a series of lines obtained when the excited electron of an atom of a certain element falls back.



Then the candidates were required to (i) account for the observed convergence of the lines from A to F and (ii) identify spectral series to which the spectrum belongs if the energy value of line A is -1.51 eV considering the energy value of each line in the spectrum can be calculated using the equation $E_n = \frac{-13.6}{n^2}\text{eV}$.

A total of 14,233 (75.3%) candidates attempted this question. The analysis shows that 23.9 percent scored from 0 to 6.5 marks; 51.2 percent scored from 7 to 11.5 marks; and 24.9 scored from 12 to 20 marks. These data portray that the candidates' performance was good as 76.1 percent scored from 7 to 20 marks. However, only 6 candidates scored full marks. Figure 16 depicts the candidates' performance on this question.

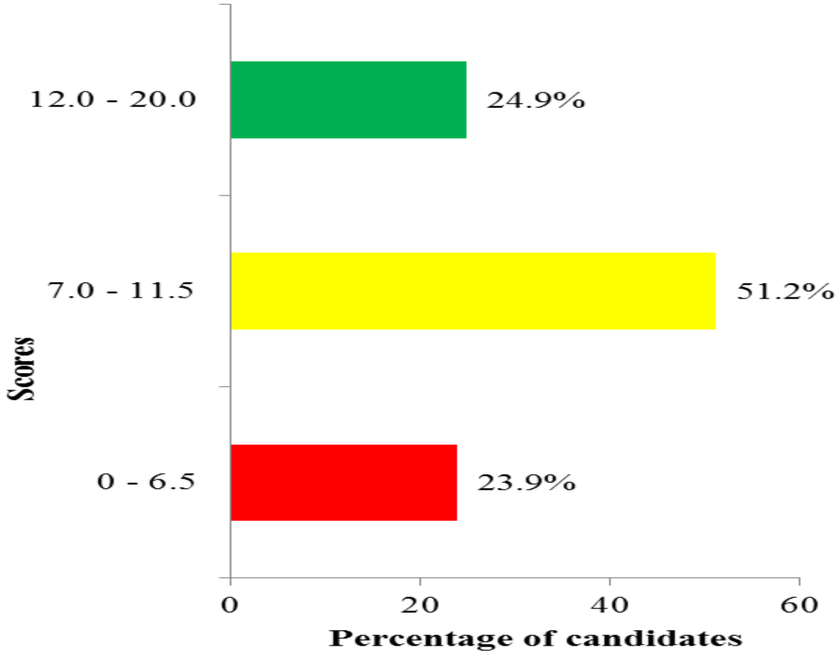
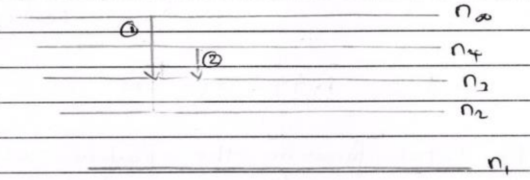


Figure 16: *The candidates' performance on question 7*

The candidates who performed well the question managed to apply Balmer series of hydrogen spectra to determine the wavelength of the series limit of Paschen series. Most of them managed to explain why electrons do not fall into the nucleus due to the electrostatic force of attraction. In part (b) (i), the candidates described the reasons for the stability of the hydrogen atom in the ground state. For example, one candidate wrote, *hydrogen atom is stable in the ground state because at this stage there is no state of lower energy to which a downward transition can occur*. In part (b) (ii), they managed to apply Bohr's theorem to express the mathematical equation of angular momentum, that is $L = \frac{h}{2\pi} n$. Hence, they used the correct formula to calculate the angular momentum. Extract 21.1 shows one of the responses by a candidate who answered the question correctly.

7.(a)(i) Soln

Consider the paschen series:



- For first Radiation, $\lambda_1 = ?$

from $$\frac{1}{\lambda} = R_H\left[\frac{1}{n_3^2} - \frac{1}{n_\infty^2}\right].$$

$$\lambda_1 = \frac{n_3^2}{R_H}.$$

But $R_H = 1.0974 \times 10^7 m^{-1}$.

$$\lambda_1 = \frac{3^2}{1.0974 \times 10^7 m^{-1}}$$

$$\lambda_1 \doteq 8.2 \times 10^{-7} m.$$

- For second Radiation.

$$\frac{1}{\lambda} = R_H\left[\frac{1}{n_3^2} - \frac{1}{n_4^2}\right]$$

$$\frac{1}{\lambda_2} = 1.0974 \times 10^{+7} m^{-1}\left[\frac{1}{3^2} - \frac{1}{4^2}\right].$$

$$\lambda_2 = 1.87 \times 10^{-6} m.$$

∴ The paschen series limit wavelength are $\simeq$ from $8.2 \times 10^{-7} m$ to $\simeq 1.87 \times 10^{-6} m$.

7.(a)(ii) • The electrons do not fall to the Nucleus because;

- The Energy possesed by electron In a given orbit is constant and does not lose energy In form of Radiation and hence the Electrostatic force force Provides only Centripetal force for electron to orbit its path which has zero workdone on electron and hence electron can not fall to Nucleus.

b) i) Hydrogen atom is stable at ground state because it has minimum potential energy at the ground state.

ii) From Bohr's postulate

$$L = \frac{nh}{2\pi}$$

Where L = Angular momentum.

h = Planck's constant.

n = Orbit number.

iii) Soln.

Energy of a given orbit, $E_n = -3.4eV$.

Angular momentum, L = ?

from $E_n = \frac{-13.6\ eV}{n^2}$.

$$-3.4eV = \frac{-13.6eV}{n^2}$$

$$n = \sqrt{\frac{13.6eV}{3.4eV}}$$

n = 2.

7. b) iii)	from Bohr:
	$L = \frac{nh}{2\pi}$
	$L = \frac{2 \times 6.6 \times 10^{-34} Js}{2\pi}$
	$L \simeq 2.1 \times 10^{-34} kgm^2 s^{-1}$.
	∴ The Angular momentum of Electron ≃ $2.1 \times 10^{-34} kgm^2 s^{-1}$.
c) i)	The lines A to F were formed due series of de-excitation through different energy level from higher to lower and on each de-excitation the Radiation of a given wavelength is produced and hence lead to number of ~~Radiations from A to F~~ lines A to F in a given line spectrum of an element.
ii)	Soln.
	Energy value for line A, $E_n = -1.51 eV$.
	So from $E_n = -\frac{13.6 eV}{n^2}$
	$n = \sqrt{\frac{-13.6 eV}{-1.51 eV}}$
	$n \approx 3$
7. c) ii)	Hence, the spectrum belongs to Paschen series because the electron de-excites from the higher energy level to third energy level.

Extract 21.1: A sample of the correct response provided by the candidate.

In Extract 21.1, the candidate correctly addressed the question by following correct procedures, applying correct formulas and executing the calculations accurately.

The candidates who scored low marks in this question had insufficient knowledge of atomic physics notably about the structure of the atom and nuclear physics. Some of them confused the quantum number of the orbit of Paschen series and that of other series. For example, one candidate substituted the quantum number $n_1=2$ and $n_2=3$ in finding the lower limit of wavelength of Paschen series instead of $n_1=3$ and $n_2=4$. As a result, he/she obtained an incorrect value. They also failed to provide the correct explanation in part (b) (i) and (ii); most of them gave insufficient reasons for the stability of the hydrogen atom in the ground state. Additionally, they used the wrong formula to calculate angular momentum. For instance, one of the candidates used the formula for linear momentum $P=\frac{h}{\lambda}$ derived from the dual nature of matter as a result of de-Broglie wavelength equation instead of angular momentum $L=\frac{h}{2\pi}n$ derived from Bohr's model of the atom. Extract 21.2 is a sample of poor responses by one of the candidates.

7 (a) (i) Balmen series

$n_1=2 \quad n_2=3$

Pachen series

$n_1=3, \; n_2=4.$

$\frac{1}{\lambda} = Rh \left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$

$\frac{1}{\lambda} = RH = \left[\frac{1}{(2)^2} - \frac{1}{(4)^2}\right].$

$\frac{1}{\lambda} = 1.0974\times10^{7} \times 0.1875$

$\lambda = 4.85\times10^{-7}\,m$

Wavelength $(\lambda) = 4.85\times10^{-7}\,m.$

7 (a)

(ii) Electrons donot fall into the nucleus due to the fact that electron when excited they posses higher energy which overcomes electrostatic force between nucleus and electrons

(b)

(1) Hydrogen is stable due to the fact that at ground state Hydrogen atom has no higher excitation energy.

(ii) ~~$h/2\pi$~~ =

7 (b) (iii)

$\Delta E = E_n - E$

$= -13.6ev - (-3.4ev)$

$\Delta E = -10.2ev$

Momentum (p)

$p = h/\lambda$

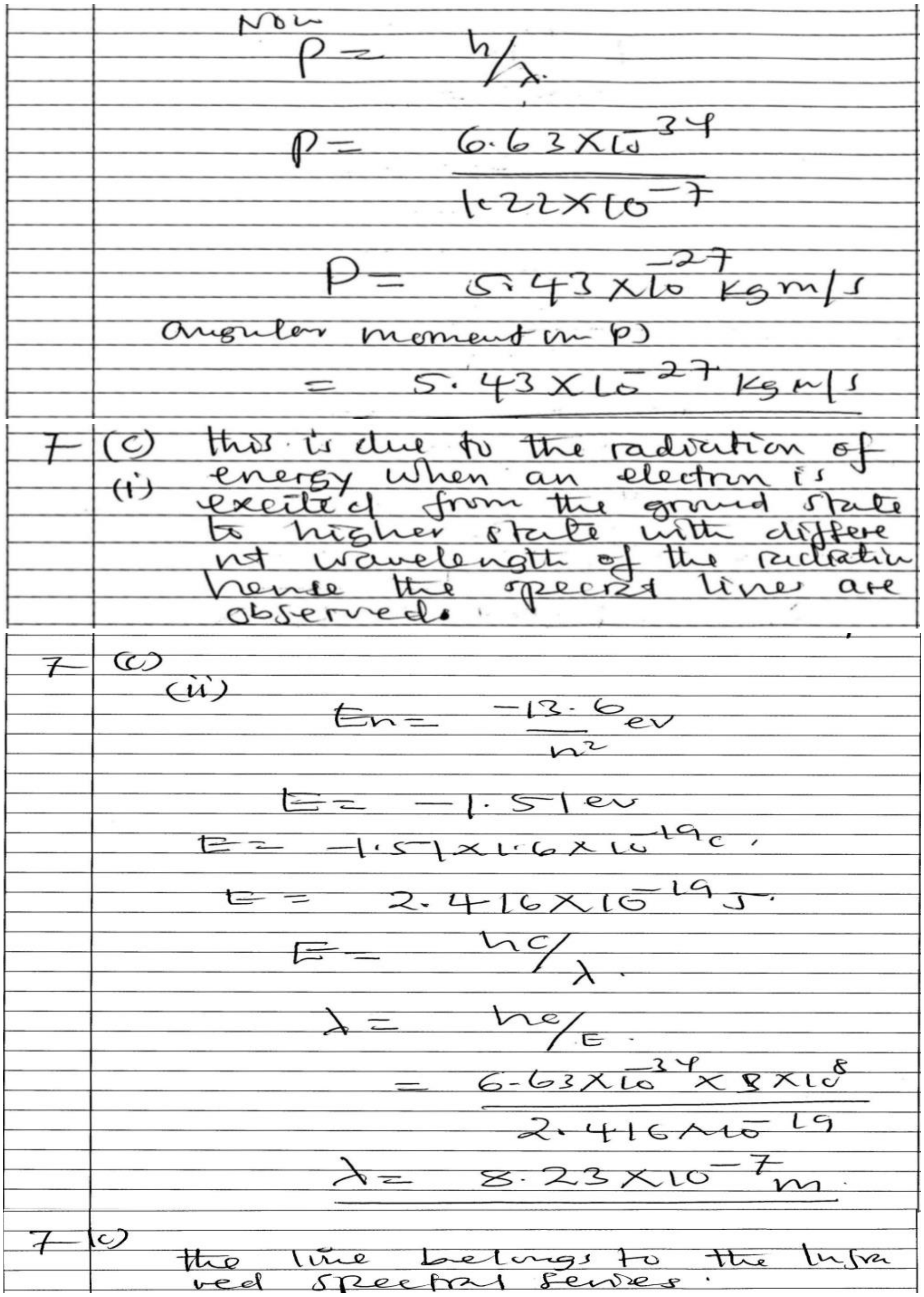
$\Delta E = hc/\lambda$

$\lambda = hc/\Delta E$

$\lambda = \dfrac{6.63 \times 10^{-34} \times 3 \times 10^{8}}{10.2 \times 10.2 \times 1.6 \times 10^{-19}}$

$\lambda = \dfrac{1.989 \times 10^{-25}}{1.632 \times 10^{-18}}$

$\lambda = 1.22 \times 10^{-7} m$



Now
$p = h/\lambda$.
$p = \frac{6.63\times10^{-34}}{1.22\times10^{-7}}$
$P = 5.43\times10^{-27}$ kgm/s
angular moment (m p)
$= 5.43\times10^{-27}$ kgm/s

7 (c) (i) this is due to the radiation of energy when an electron is excited from the ground state to higher state with differe nt wavelength of the radiation hence the specral lines are observed.

7 (c) (ii)
$E_n = \frac{-13.6}{n^2}$ ev
$E = -1.51$ ev
$E = -1.51\times1.6\times10^{-19}$ c,
$E = 2.416\times10^{-19}$ J.
$E = hc/\lambda$.
$\lambda = hc/E$.
$= \frac{6.63\times10^{-34}\times8\times10^{8}}{2.416\times10^{-19}}$
$\lambda = 8.23\times10^{-7}$ m.

7 (c) the line belongs to the Infra red spectral series.

Extract 21.2: A sample of incorrect response given by a candidate.

In Extract 21.2, the candidate applied an irrelevant formula and procedures to perform calculations to all parts of the question, leading to incorrect answers.

2.2.8 Question 8: Atomic Physics

The question contained parts (a), (b) and (c). In part (a), the candidates were required to give the meaning of the following terms as used in nuclear Physics: (i) mass defect and (ii) binding energy. In part (b) the candidates were given the equation of disintegration of $^{238}_{92}U$ which gives alpha particles represented as $^{238}_{92}U \rightarrow ^{234}_{90}Th + ^{4}_{2}He$. They were required to calculate (i) the total energy released in the disintegration reaction and (ii) the kinetic energy of alpha particles when the nucleus was at rest before disintegration. Part (c) required the candidates to (i) elaborate two aspects on which fission reactions differ from fusion reactions and (ii) explain why high temperature is required to cause nuclear fusion.

A total of 11,228 (59.4%) candidates attempted this question. Among them, 57.7 percent scored from 0 to 6.5 marks; 34.5 percent scored from 7 to 11.5 marks; and 7.8 percent scored from 12 to 20 marks. The analysis shows that the performance on this question is average since 42.3 percent scored from 7 to 20 marks. Figure 17 illustrates the candidates' performance on this question.

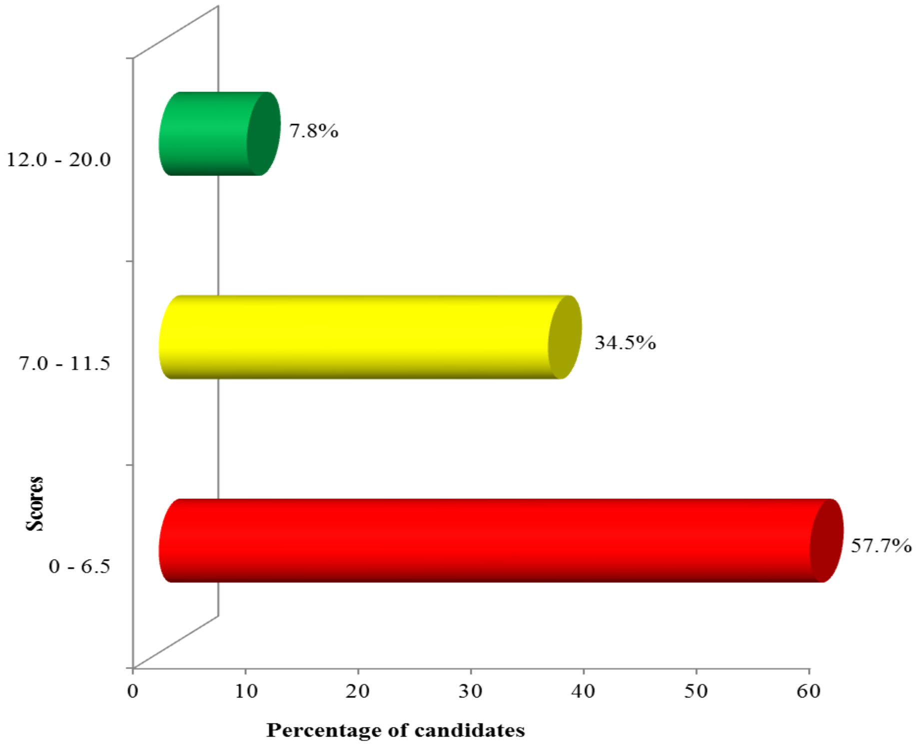
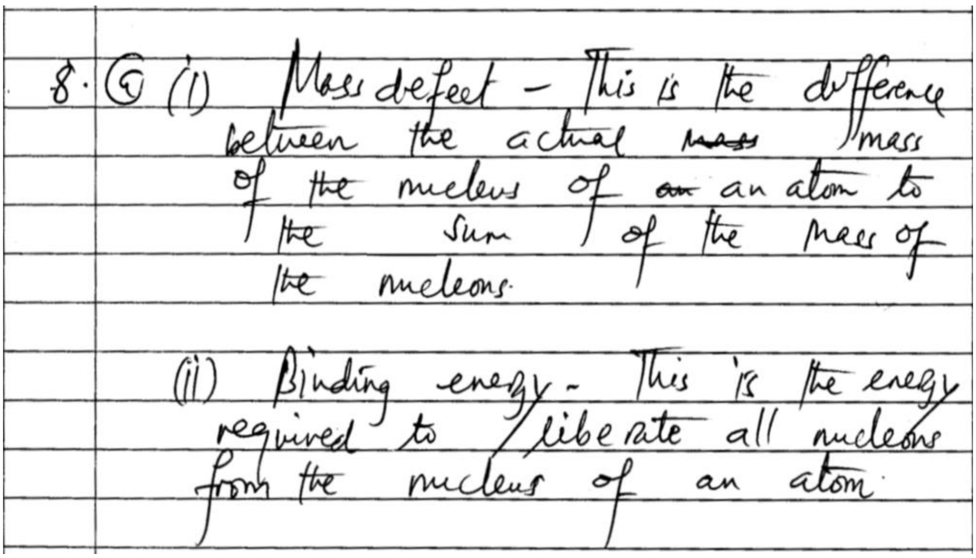


Figure 17: *The candidates' performance on question 8*

The candidates, who scored good marks in this question had an adequate knowledge of atomic physics specifically about nuclear reactions. These candidates managed to define the terms *mass defect* and *binding energy*. However, some of them failed to use the nuclear reaction for the disintegration of $^{238}_{92}U$ represented by the reaction $^{238}_{92}U \rightarrow ^{234}_{90}Th + ^{4}_{2}He$. They failed to use the reaction $^{238}_{92}U \rightarrow ^{234}_{90}Th + ^{4}_{2}He$ to calculate the total energy released in the disintegration reaction and the kinetic energy of alpha particles when the nucleus was at rest before disintegration. Most of them managed to elaborate the aspects in which fission reactions differ from fusion reactions. They also explained correctly the need of high temperature to cause nuclear fusion. For example, one candidate correctly wrote the difference between fission reactions and fusion reactions as:

> *The aspects in which fission reactions differ from fusion reactions are: In fission, heavy nucleus splits into nuclei with less weight while in fusion, nuclei of light atoms fuse together to form heavy nucleus".* Also, *"fission occurs at room temperature when low energy is absorbed by the nucleus but fusion occurs at extremely high temperatures*.

Extract 22.1 is a sample of correct responses to this question by one of the candidates who answered correctly almost all parts of the question.


8. (a) (i) Mass defect – This is the difference between the actual mass of the nucleus of an atom to the sum of the mass of the nucleons.

(ii) Binding energy - This is the energy required to liberate all nucleons from the nucleus of an atom.

8(b) $^{238}_{92}U \longrightarrow ^{234}_{90}Th + ^{4}_{2}He$.

(i) Energy released.

soln

Mass defect = Mass of $\left(^{234}_{92}Th + ^{4}_{2}He \right)$ − Mass of $^{238}_{92}U$ in amu.

NB: But the masses of the nuclei are not provided in form of amu.

8(b) But the difference obtained above will be the change in mass (Δm)

Then

Energy released = $\Delta m c^2$ (Einstein equation)

This will be converted into mev by the relation

1 amu = 931 mev.

x = ?

The value of x will be obtained in mev

8(b) (i) So the value of x will be the energy released during the disintegration in in MeV.

8(b) (ii) KE of α − particle.

Consider.

$^{238}_{92}U$ (M)

Before disintegration

After disintegration

V_2 (M_2) $^{234}_{90}Th$ (m_1) V_1 α $\left(^{4}_{2}He\right)$

Conserving momentum

$MV = m_2 V_2 - M_1 V_1$

But $V = 0$ (uranium being at rest)

$0 = M_2 V_2 - M_1 V_1$

8(b) (ii)

$M_1 V_1 = M_2 V_2$

$V_2 = \frac{M_1 V_1}{M_2}$. - - - (1)

KE of α and Th = Total energy released.

$\frac{1}{2} M_1 V_1^2 + \frac{1}{2} M_2 V_2^2 = X$.

$\frac{1}{2} M_1 V_1^2 + \frac{1}{2} M_2 \left(\frac{M_1 V_1}{M_2}\right)^2 = X$

$\frac{1}{2} M_1 V_1^2 + \frac{1}{2} M_2 \frac{M_1^2 V_1^2}{M_2^2} = X$

$\frac{1}{2} M_1 V_1^2 + \frac{1}{2} \frac{M_1^2 V_1^2}{M_2} = X$.

Multiply by M_2 both sides

$\frac{1}{2} M_1 V_1^2 M_2 + \frac{1}{2} M_1^2 V_1^2 = X M_2$

$\frac{1}{2} M_1 V_1^2 (M_1 + M_2) = X M_2$.

$\frac{X M_2}{M_1 + M_2} = \frac{1}{2} M_1 V_1^2$

But $\frac{1}{2} M_1 V_1^2 =$ KE of α particle.

$KE_\alpha = \frac{X M_2}{(M_1 + M_2)}$

where $X \rightarrow$ the value of released energy

So $KE_\alpha = \frac{234X}{234+4} = \left(\frac{234X}{238}\right)$ mev

8(c)(i)

Fusion reaction	Fission reaction
(i) Involves the combination of two or more lighter nuclei to form a single heavy nucleus	(i) Involves the disintegration of a single heavy nuclei into two or more lighter nuclei.
(ii) The fusion reaction produces huge amount of energy and also requires large temperatures so as to combine the nuclei to form a larger nucleus. hence not easily sustained in the nuclear reactor	(ii) Fission reaction gives small amount of energy compared to fusion reaction, also it does not require large amounts of energy, therefore the fission reactions can be sustained in a nuclear reactor.

8(c) (ii) Nuclear fusion is the combination of two or more lighter nuclei to form a single heavy nucleus, so in order to combine these lighter nuclei large amount of energy in form of heat is required to cause fusion, as to overcome nuclear repulsion that can arise in combining the lighter nuclei, so, because of this it requires high temprature.

Extract 22.1: A sample of a good response provided by a candidate.

In Extract 22.1, the candidate managed to define the terms, give a clear explanation, and differentiate fusion from fission reaction correctly.

The candidates who attained low marks in this question did not understand the basic concepts of atomic physics. These candidates failed to define mass defect and binding energy. In order to define these terms as used in nuclear Physics, the candidates were supposed to know that the mass of a nucleus is smaller than the sum of the masses of the constituent nucleons.

Therefore, the mass defect is the difference between the sum of the masses of nucleons (protons and neutrons) in the nucleus and the actual mass of the nucleus. They were also supposed to understand that the binding energy of the nucleus is provided by the mass defect and, therefore define binding energy as the total energy required to liberate all the nucleons from the nucleus. In part (b), they failed to study the disintegration of $^{238}_{92}\text{U}$ which gave the alpha particles represented by the equation $^{238}_{92}\text{U} \rightarrow {}^{234}_{90}\text{Th} + {}^{4}_{2}\text{He}$. The candidates were required to determine the mass defect in a.m.u and then convert it into energy.

Similarly, they failed to calculate the kinetic energy of alpha particles when the nucleus was at rest before disintegration. For example, one candidate used the formula for kinetic energy of a moving body in linear motion as "$\text{K.e} = \frac{1}{2}\text{ m v}^2$" to calculate the kinetic energy of alpha particles when the nucleus was at rest before disintegration instead of using the relation, K.E = $\left(\frac{\text{Mass of thorium}}{\text{Mass of thorium+mass of helium}}\right) \times$ total energy released, Q in nuclear reactions. Consequently, some candidates failed to elaborate the aspects in which fission reactions differ from fusion reactions. In this item, the candidates were supposed to know that fission occurs from splitting a heavy nucleus into lighter nuclei accompanied with the release of less energy per gram. On the other hand, fusion reactions occur from a combination of lighter nuclei to form a heavier nucleus which is accompanied with the release of more energy per gram. Extract 22.2 is a sample of incorrect responses to the question.

8(a) (i)	Mass defect → is the change in mass of an element (always decreasing) as the result of change in energy :- The mass of a substance change in energy hence the mass of the whole substance decrease from the original one.
(ii)	Binding energy :- Is the energy produced as the result of mass defect :- When a mass of object change to produce energy.

8(c) (i) (i) Fission reaction result to two or more particles :- particle disintegrate while
~~Fussion~~ fusion reaction result to formation of a body :- particles ~~joint~~ join to form large body.

(ii) Fission produce energy :- High energy is produced during ~~fusi~~ fission while
Fusion require energy :- High energy is consumed during fusion reaction.

8 c (ii) High temperature is required to cause nuclear fusion because :-
1: The material fusing together must be in gaseous form then
2: The material must be in ionic form :- High energy is first required to transfer the material from its physical state to ionic state :- to Energy to ionize the material.
3: Then ~~t~~ much energy is required to combine the ~~electron~~ atom together since there is high repulsive force exerted by internal particles (protons) : due to this repulsive force of protons as well as between electron themselves high energy is required to make them together.

Briefly : ionization energy is endothermic as well as second electron affinity is endothermic hence higher energy is required during nuclear fusion.

Extract 22.2: A sample of incorrect response provided by one of the candidates.

In Extract 22.2, the candidate failed to define the terms and explained incorrectly some concepts. Consequently, he/she failed to differentiate fission reaction from fusion reaction.

2.2.9 Question 9: Electromagnetism

This question was comprised of parts (a), (b) and (c). In part (a), the candidates were required to (i) identify four factors that affect the force experienced by a current-carrying conductor in a magnetic field, (ii) write the mathematical expression which defines magnetic flux density and use it to deduce its S.I units and (iii) apply the expression obtained in 9 (a) (ii) to develop the formula for the force on a conductor carrying current I if the conductor and the magnetic fields are not at right angles. In part (b), they were required to (i) distinguish the terms magnetically soft and magnetically hard materials, (ii) state the condition which makes the magnetic force on a moving charge in a magnetic field to be maximum and (iii) determine the magnitude of force experienced by a stationary charge in a uniform magnetic field. Part (c) required the candidates to (i) identify the position of the rotating coil in the magnetic field where the induced e.m.f is zero and give the reason and (ii) use a mathematical expression to justify the statement that there will be no change in the kinetic energy of a charged particle which enters a uniform magnetic field when its initial velocity is directed parallel to the field.

A total of 2,366 (12.5%) candidates attempted this question. Among them, 36.8 percent scored from 0 to 6.5 marks; 36.3 scored from 7 to 11.5 marks; and 26.9 scored from 12 to 20 marks. From the analysis, the candidates' performance was good since 63.2 percent scored 7 marks and above. Figure 18 portrays the performance of the candidates on this question.

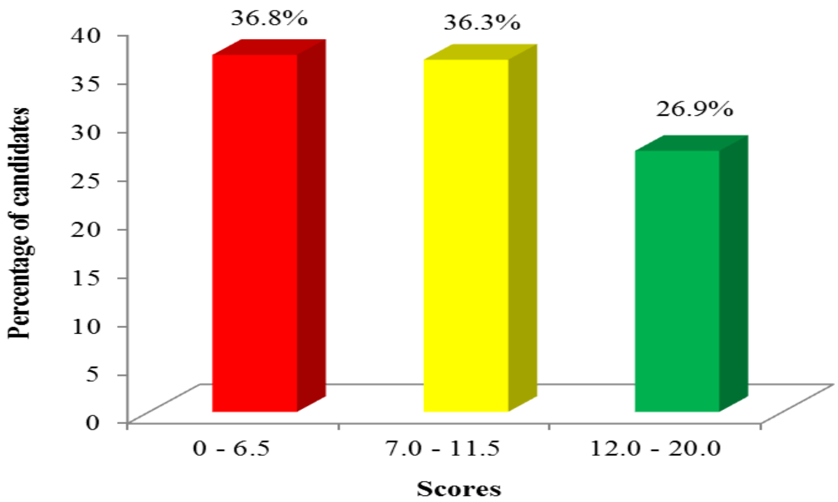


Figure 18: *The candidates' performance on question 9*

The candidates who performed well in this question managed to identify the factors on which the force experienced by a current-carrying conductor depends. They were also managed to write the mathematical expression which defined magnetic flux density ($B = \frac{F}{IL}$) and used it to deduce correctly its S.I units which is ($Nm^{-1}A^{-1}$ or $Tesla$). They also applied the mathematical expression for the magnetic flux density $B = \frac{F}{IL}$ correctly to develop the formula for the force on a conductor carrying current I, if the conductor and the magnetic fields are not at right angles. They also managed to distinguish magnetically soft and magnetically hard materials. These candidates stated precisely the condition which makes the magnetic force on a moving charge to be maximum. They also determined the magnitude of the force experienced by stationary charge in the uniform magnetic field.

Additionally, with reasons, they managed to identify the position at which the induced e.m.f becomes zero when the coil rotates in the magnetic field. Finally, they applied the correct mathematical expression to justify that no change in kinetic energy of a particle when it enters parallel to a uniform magnetic field. This indicates that most candidates who attempted the question had a good knowledge of electromagnetism especially about the magnetic forces on current carrying conductors in a magnetic field. Extract 23.1 is a sample of the correct responses to this question by one of the candidates.

09. a/ i/ – Magnetic flux density of (B) of a magnetic field when the current-carrying conductor present
– The length of a current-carrying conductor (L).
– Current (I) of a current-carrying conductor in a magnetic field.
– The Angle (θ) between the magnetic field and the current carrying conductor.

ii/ $F = BIL\sin\theta$

09. a/ iii/ From; $B = \frac{F}{VQ}$

$F = BVQ$ but $Q = It$

$V = L/t$

$F = B\frac{L}{t} \cdot It$

$F = BIL$ as not right angle include $\sin\theta$

$\therefore F = BIL\sin\theta$ (hence developed).

b/ i/ Magnetically soft materials are those materials which with narrow shape in hystresis curve as having small magnetic flux density and higher intensity of magnetization, also having weak magnetization toward magnetic material. Example are paramagnetic and diamagnetic.

WHILE

Magnetically hard materials are those materials which has wide shape in represented in hystresis curve, and has stronger magnetization effect towards a magnet. Example is ferromagnetic like iron which is stronger ferromagnetic and hence called magnetically hard material.

09. b/ ii/ – should be at right angle ie the moving charge should move perpendicular to the magnetic field and make angle 90°.
– should travel with higher speed and should have greater charge and moving in a stronger or higher magnetic flux density ie magnetic field should be stronger which is uniform

iii/ From; $F = BVQ\sin\theta$

As the stationary charge, mean that the means that charge does not move and experience velocity of 0m/s, thus;

$$F = B \times 0 m/s \times Q \times \sin\theta = 0N$$

∴ Magnitude of force is 0N.

c/ i/ At the right angle where $\theta = 90°$ the rotating coil in the magnetic field induce emf is zero; this because as we consider the formula of induced emf $E = N d\Phi/dt$ but $\Phi = AB\cos\theta$

Thus, $E = \frac{NB\cos\theta \, dA}{dt}$ or

$E = NA\cos\theta \, dB/dt$

09. (c) (i) As the angle is 90° the value of $\cos\theta = 0$

$$E = AN\cos 90° \, dB/dt$$

$$E = AN(0)\,dB/dt = 0.$$

∴ Thus at right angle of a rotating coil the induced emf is zero.

(ii) From; $F = BVQ\sin\theta$

$$r \times \frac{mv^2}{r} = BVQ \times r\sin\theta$$

$$\frac{1}{2}mv^2 = \frac{1}{2}BVQr\sin\theta$$

$$K.E = \frac{1}{2}BVQr\sin\theta$$

Thus, if the initial velocity is directed parallel to the field mean that the angle is 0°, hence from our formula

$$K.E = \frac{1}{2}BVQr\sin 0° \qquad \sin 0° = 0$$

$$K.E = \frac{1}{2}BVQr \times (0) = 0$$

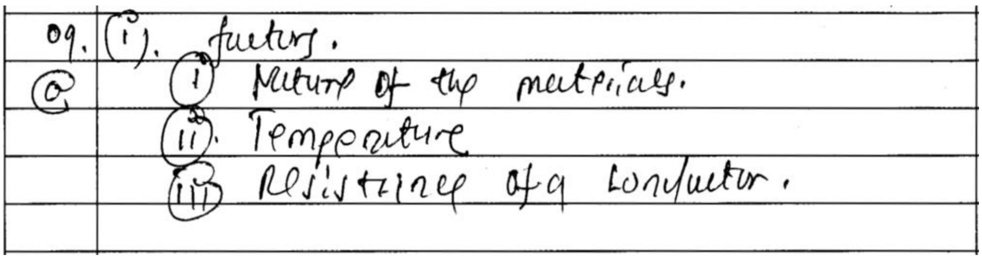
∴ Kinetic energy of a charged particle can not changed as a velocity is parallel to the field.

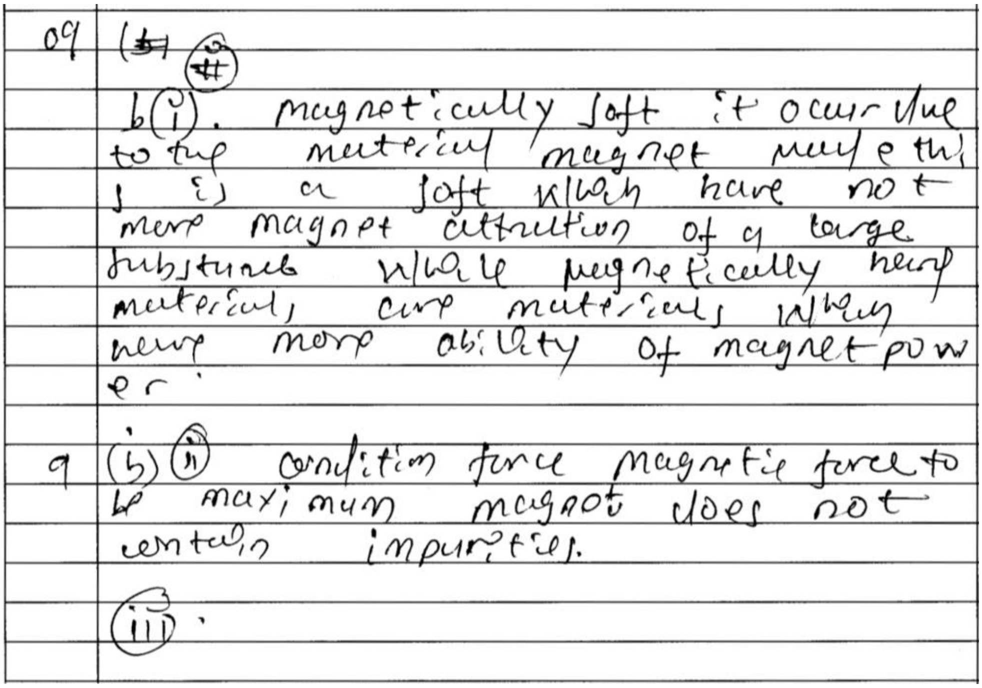
Extract 23.1: A sample of the correct response provided by a candidate.

Extract 23.1, is a sample of the correct answer by the candidate who managed to provide precise descriptions, systematic procedures and calculations in all parts of the question.

As for the candidates who scored low marks in this question, they lacked sufficient knowledge about electromagnetism. They failed to identify the factors that affect the force experienced on current-carrying conductor. For example, one candidate mentioned the factors as *"nature of materials, temperature and resistance of a conductor"* which some of them are the factors affecting the resistance of the conductor instead of *magnitude of current I, length of conductor L, magnetic flux density B* and *angle between the direction of the field and the conductor*. They also failed to distinguish magnetically soft from magnetically hard materials. These candidates failed to recall that magnetically hard materials retain their magnetism for a long time once magnetized and are characterized by having low retentivity and greater coercivity while magnetically soft materials do not retain their magnetism, though they are easily magnetized. Such materials have high retentivity and low coercivity.

Moreover, some candidates failed to give the correct condition that maximize the magnetic force on a moving charge in magnetic field. In this item, the candidates were supposed to realize that, for the magnetic force on a moving charge to be maximum, a charge should move perpendicular to the direction of the magnetic field. That is, from $F = qvB\sin\theta$, when $\theta = 90^o$, $\sin\theta = 1$ and the value of F becomes maximum. Some candidates related the centripetal force with the magnetic force due to the electric field. Thus, they failed to continue as the conceptual approach was absolutely inappropriate. Other candidates failed to state the position at which the induced e.m.f becomes zero when the coil is rotating in the magnetic field. These candidates failed to recognize that the e.m.f becomes zero when the axis of the coil is perpendicular to the magnetic field lines. That is, if $E = E_o\cos\theta$, $\theta = 90^o$ and $\cos 90^o = 0$; therefore the induced e.m.f is zero. Extract 23.2 shows one of the responses by the candidate who provided incorrect answers to all parts of the question.


09. (i). factors.
(a) (i) Nature of the materials.
(ii). Temperature
(iii) Resistance of a conductor.



09 (a) (ii)
b(i). magnetically soft it occur due to the material magnet make this is a soft which have not more magnet attraction of a large substance while magnetically heary material, are materials which heary more ability of magnet power.

9 (b) (ii) condition force magnetic force to be maximum magnet does not contain impurities.

(iii).

Extract 23.2: A sample of incorrect response provided by a candidate.

In Extract 23.2, the candidate failed to provide correct responses to all parts of the question.

3.0 ANALYSIS OF CANDIDATES' PERFORMANCE PER TOPIC

3.1 Candidates' Performance per Topic

The analysis of the candidates' performance on each topic reveals that, in Physics paper 1, they performed well in three topics which are *Measurement* (86.1%), *Electronics* (69.2%) and *Environmental Physics* (64.4%). They also performed averagely in two topics which are *Mechanics* (58.6%) and *Heat* (51.2%). The average performance on these topics was influenced by the lack of adequate knowledge. Few candidates failed to attempt some parts of various questions especially those which demanded critical thinking, aiming at assessing higher order of learning outcomes. Some candidates seemed to have a poor background in mathematics as they failed to analyse and interpret the given data values for correct procedures and accurate calculations. However, they had weak performance in the topic of *Current electricity* (32.3%). Such performance might have been contributed by the failure to apply the correct formula for a particular quantity. For example, some candidates applied Ohm's law to determine the value of conductance instead of using the reciprocal of the resistance of a given device. Another factor was the failure to identify the direction of electric current, flow of current at different points in the circuit, and the use of Kirchhoff's laws when traversing round the loops. These factors caused most candidates fail to formulate the required equations and to use appropriate mathematical approaches to obtain the correct answers.

In Physics paper 2, the analysis shows that among the six (06) topics that were tested, the candidates demonstrated good performance on five (05) topics, which are *Fluid dynamics* (88.3%), *Properties of matter* (80.9%), *Electrostatics* (72.3%), *Vibrations and waves* (68.6%) and *Electromagnetism* (63.2%). They demonstrated average performance on only one (01) topic which is *Atomic Physics* (59.2%). The average performance in this topic was stemmed from the lack of knowledge about the distinctive features of mass defect at the expense of binding energy, inability to differentiate fission nuclear reactions from fusion nuclear reactions, and incompetence in analysing, the data given and using proper formula to solve problems involving computation. The summary of the candidates' performance on each topic tested in ACSEE 2019 for both paper 1 and paper 2 is shown in Appendix A.

3.2 Comparison of Candidates' Performance on each Topic and in terms of Grades between 2018 and 2019

When comparing the performance of the candidates in the topics tested in ACSEE 2018 and 2019, a rise and fall in performance in some topics is evident. The reflection of the candidates' performance portrays a considerable increase in performance from 86.6 percent in 2018 to 88.3 percent in 2019 on the topic of *Fluid dynamics*. Another substantial increase in performance was observed on the topic of *Measurement* in which the candidates' performance in 2018 was 81.5 percent in comparison to 86.1 percent in 2019.

Furthermore, a massive increase in performance was observed on the topics of *Properties of matter* (53.5%), *Electrostatics* (37.0%) and *Electronics* (53.2%) in 2018 as compared to 80.9 percent, 72.3 percent and 69.2 percent on the same topics in 2019 respectively. This remarkable increase in performance on these topics indicates that teachers and students improved their methods of teaching and learning as the students performed averagely on all three topics in 2018. The topic of *Vibrations and waves* had a slight increase in performance from 64.3 percent in 2018 to 68.6 percent in 2019.

Moreover, performance on the topic of *Environmental Physics* highly improved from 24.2 percent (weak) in 2018 to 64.4 percent (good) in 2019. This signifies that teachers and students succeeded in raising the performance on this topic as it had been done poorly in recent years. Another measurable increase in performance was observed on the topic of Electromagnetism, which increased from 43.5 percent in 2018 to 63.2 percent in 2019. In contrast, the performance on following topics remained the same in 2018 and 2019, though there were small differences. These topics include Atomic Physics (57.8%), Mechanics (42.0%) and Heat (55.0%) in 2018 while the performance on the same topics were 59.2 percent, 58.6 percent and 51.2 percent in 2019 respectively.

Despite this good performance on the cited topics, the topic of Current electricity still needs to be debated on to improve candidates' performance. The performance of the candidates on this topic remained the same but only differed in magnitude from 20.9 percent in 2018 to 32.3 percent in 2019. Although there is a notable change in the candidates performance, deliberate measures should be taken to improve the performance on this topic in future examinations.

When the grade performance of candidates is compared between the years 2018 and 2019, 0.36 percent scored A_s in 2018 while 0.26 percent scored the same grade in 2019. Similarly, 4.2 percent obtained B_s in 2018 while the same grade was scored by 3.6 percent of the candidates in 2019. From this analysis, the number of candidates who scored A_s and B_s in 2018 was greater than those scored the same grades in 2019.

Further analysis reveals that more candidates attained grades C, D and E in 2019 in comparison to those sat the examination in 2018. Nevertheless, more candidates (11.38%) obtained the subsidiary grade S in 2018 than those who scored the same grade in 2019. Like-wise, poor performance (13.44%) was observed more among the candidates who sat the examination in 2018 than among the candidates (10.81%) who sat the examination in 2019.

In general, more than 50 percent of the candidates who did the examination in 2018 and 2019 scored D and E grades. However, the performance of candidates in 2019 was better than in 2018. A summary of the comparison of the candidates' grade performance on each topic tested in ACSEE 2019 for both Physics paper 1 and 2 compared to the year 2018 is shown in Appendices B and C.

4.0 CONCLUSION AND RECOMMENDATIONS

4.1 Conclusion

The analysis of the candidates' performance per question in the Physics examination in 2019 revealed that most of the candidates attempted well the questions, although some of them faced difficulties in responding to the questions. The major challenges which were identified through this analysis include the following:

(a) Inadequate knowledge about some concepts

This caused some candidates to score low or no marks in some items or question as they provided incorrect responses to the question. This may have been caused by poor coverage of some topics by the teachers, ineffective revision of the candidates as well as inadequate exercises/tests /examinations and corrections which could enhance the candidates' understanding and easy retrieval of the required concepts in each topic.

(b) Lack of mathematical skills

This made some candidates to perform some calculations incorrectly either due to errors in writing formulae, executing the calculation or failure to recall the formulae.

(c) Failure to understand the demand of the question

This was caused by language barrier. Some candidates failed to understand the demands of the question especially in relation to the items which required explanation.

(d) Failure to answer all parts of the questions

Some candidates did not address all the questions given. This might be caused by their failure to cope with the required speed when doing the examination or lack of knowledge.

Although the candidates faced some challenges in attempting the questions in ACSEE 2019 in both Physics paper 1 and 2, their performance in 2019 has greatly improved, compared to 2018. Appendices A and B reveal that eight (8) topics out of twelve (12) were performed well, three (03) topics were performed averagely and only one (01) topic was performed poorly. This indicates that the majority of the candidates had sufficient content knowledge. They were also good at answering questions involving calculations. In general, the candidates' performance has increased by 2.65 percent.

4.2 Recommendations

In order to improve the performance of the candidates in future, the following are the recommendations:

(a) Teachers and students should put much effort on the topics which are frequently performed poorly. The emphasis should be put on the topic of Current electricity. Teachers have to apply appropriate approaches in guiding students through deducing and applying Kirchhoff's laws of electrical networks.

(b) Teachers should encourage students to do effective revision by giving them adequate tests and examinations in order to improve their speed in attempting examinations. They should also be given group assignments, home works, project works, field excursions/trips which in turn promote the spirit of learning through participation.

(c) Teachers should teach using experimentations and demonstrations to assist students in acquiring and grasping the concept, knowledge and skills in the topics of Mechanics and Heat, which were performed averagely.

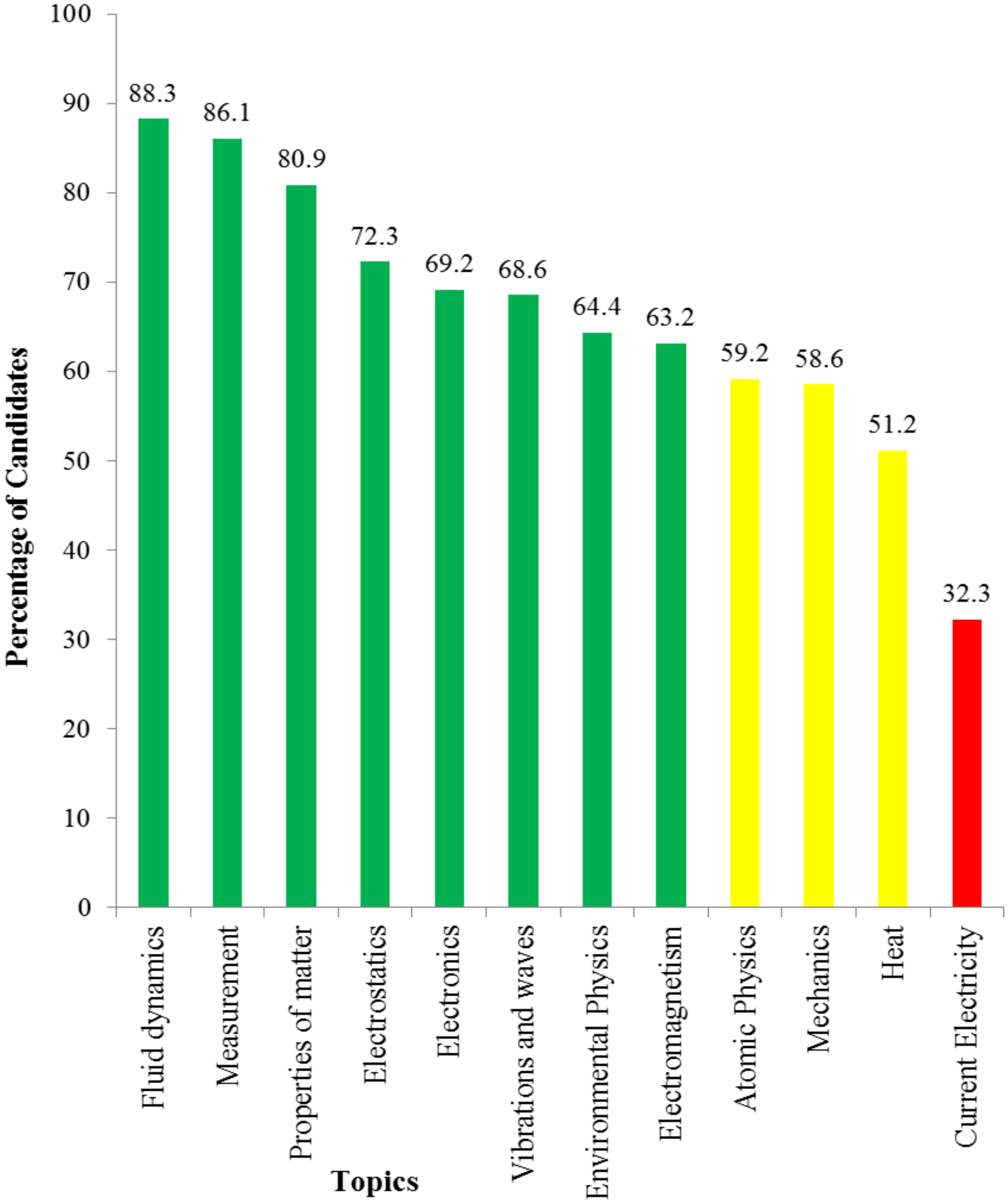
(d) Teachers should guide students and make a close follow up to help each student during classroom teaching and learning.

(e) Students have to prepare well in each topic by reading various Physics books and journals to improve their understanding of the concepts, theories, principles and laws.

(f) Students should practise effectively on how to identify the demand of the questions especially those which require explanations in order to improve language competencies.

Appendix A

CANDIDATES' PERFORMANCE IN EACH TOPIC ON THE YEAR 2019



Appendix B

COMPARISON OF THE CANDIDATES' PERFORMANCE ON EACH TOPIC BETWEEN 2018 AND 2019

S/n.	Topic	2018 EXAMINATION PAPER			2019 EXAMINATION PAPER		
		Number of questions	Percentage of Candidates Who Scored an Average of 35 Percentage or Above	Remarks	Number of questions	Percentage of Candidates Who Scored an Average of 35 Percentage or Above	Remarks
1	Fluid Dynamics	1	86.6	Good	1	88.3	Good
2	Measurement	1	81.5	Good	1	86.1	Good
3	Properties of Matter	2	53.5	Average	1	80.9	Good
4	Electrostatics	1	37	Average	2	72.3	Good
5	Electronics	3	53.2	Average	3	69.2	Good
6	Vibrations and Waves	2	64.3	Good	2	68.6	Good
7	Environmental Physics	1	24.2	Weak	1	64.4	Good
8	Electromagnetism	1	43.5	Average	1	63.2	Good
9	Atomic Physics	2	57.8	Average	2	59.2	Average
10	Mechanics	5	42	Average	5	58.6	Average
11	Heat	2	55	Average	2	51.2	Average
12	Current Electricity	2	20.9	Weak	2	32.3	Weak

Appendix C

COMPARISON OF THE CANDIDATES' PERFORMANCE IN GRADES BETWEEN 2018 AND 2019