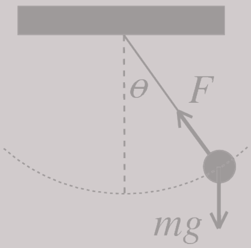
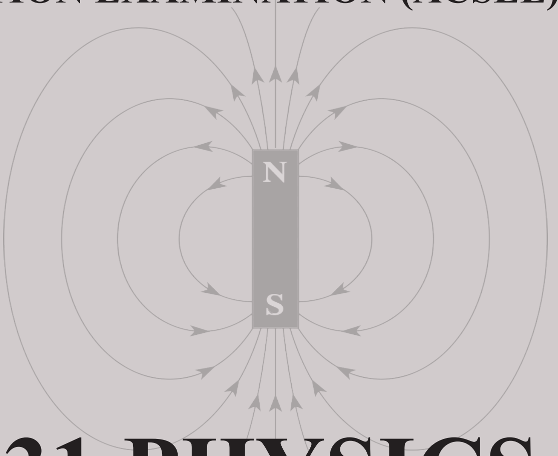
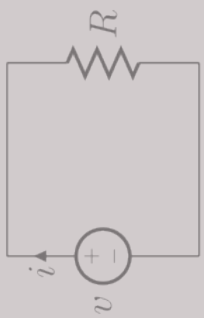
THE NATIONAL EXAMINATIONS COUNCIL OF TANZANIA

CANDIDATES' ITEM RESPONSE ANALYSIS REPORT FOR THE ADVANCED CERTIFICATE OF SECONDARY EDUCATION EXAMINATION (ACSEE) 2018







131 PHYSICS

THE NATIONAL EXAMINATIONS COUNCIL OF TANZANIA

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131 PHYSICS

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FOREWORD

The National Examinations Council of Tanzania is pleased to issue the Candidates' Items Response Analysis Report in Advanced Certificate of Secondary Education Examination (ACSEE) on Physics Subject, 2018. The report was prepared in order to give feedback to students, teachers, parents, policy makers and the public in general about the candidates' performance.

The Advanced Certificate of Secondary Education Examination marks the end of the two years of secondary education. It is a summative evaluation which among other things shows the effectiveness of the education system in general and the education delivery system in particular. In actual fact, the candidates' responses to the examination questions are a strong indicator of what the education system was successful or failed to offer to the students in their two years of secondary education.

The analysis presented in this report is intended to contribute towards the understanding of some of the reasons behind the performance of the candidates in Physics subject. The report highlights some of the factors which made the candidates fail to score high marks in the questions. Such factors include failure to comprehend the concepts in the question items, lack of mathematical skills, misconception of some principles and laws in physics and their applications in solving the questions. The feedback provided will help the educational administrators, school managers, teachers and students to identify proper measures to be taken in order to improve the candidates' performance in future examinations administered by the Council.

The National Examinations Council of Tanzania will highly appreciate comments and suggestions from teachers, students and the public in general that can be used in improving the future reports.

Finally, the Council would like to thank the Examiners and different stakeholders who participated in the preparation of this report.

Dr. Charles E. Msonde
EXECUTIVE SECRETARY

1.0 INTRODUCTION

This report analyses the performance of the candidates who sat for the Advanced Certificate of Secondary Education Examinations (ACSEE) in 131/1 Physics 1 and 131/2 Physics 2 papers conducted in May, 2018. All these papers examined the candidates' competences and skills as stipulated in the Physics syllabus of the year 2010 which adhered to the 2011 Examination format.

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

Physics paper 2 had three sections namely A, B and C. Each section consisted of three (3) questions making a total of nine (9) questions. Candidates were instructed to answer five (5) questions by choosing at least one (1) question from each section.

A total of 19,547 candidates sat for Physics papers in May, 2018. The results reveals that 86.48 percent of them passed this examination with the following scoring grades: A (70), B (821), C (2,658), D (5,159), E (5,872) and S (2,225). On the other hand, 2,628 candidates failed by scoring F grade. Generally, the candidates' performance in the year increased by 0.7 percent as compared to the year 2017 where 85.78 percent of the candidates passed the examination.

The next section of the report analyses the candidates' performance in each question. It describes what the candidates were required to do in each question, their performance levels and possible reasons for the observed performance. Sample answers to the questions have been extracted from the candidates' scripts and attached to illustrate the cases presented. The graphs or charts have been used to summarize the candidates' performance in particular questions. The performance in each question is rated as good, average or weak if the percentage of candidates' marks are in the range of 60–100, 35–59 and 0–34, respectively. These categories of performance are also indicated by using special colours, whereas the green, yellow and red colours denote good, average and weak performance, respectively as seen in the graphs or charts and in the Appendix. It is expected that the report will be useful as it provides recommendations that may help to enhance the teaching and learning of Physics subject and therefore promote the candidates' performance in the future.

2.0 ANALYSIS OF THE CANDIDATES' PERFORMANCE IN EACH QUESTION

2.1 131/1 PHYSICS 1

This paper comprised of short answer questions constructed from six topics as indicated in the analysis part. Each question carried a weight of 10 marks and the performance of the candidates were regarded as weak, average and good in score ranges of 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. The following section shows the analysis of performance in each question.

2.1.1 Question 1: Measurement

This question was divided into two parts: (a) and (b). Part (a) required the candidates to: (i) explain how random and systematic errors can be minimized during an experiment and (ii) determine the precision of the Young's modulus, γ of the wire given that $\gamma = \frac{4Fl}{\pi d^2 e}$, tension F = 500 N, length of loaded wire l = 3 m, diameter of wire d = 1 mm, its extension e = 5 mm and errors associated with these quantities as 0.5 N, 2 mm, 0.01 mm and 0.1 mm, respectively. In part (b), they were required to: (i) state the law of dimensional analysis, and (ii) apply dimensional analysis to check whether the given expression $v = \sqrt{\frac{T}{m}}$ where v, T and m are transverse wave along the wire, tension and mass, respectively, is correct or not.

A total of 18,914 candidates equivalent to 96.8 percent attempted this question. The analysis shows that 13.4 percent scored marks ranging from 0 to 3, 22.5 percent scored 3.5 to 5.5 marks and 64.1 percent scored 6.0 to 10 marks. These scores imply that the candidates' performance in this question was good since 86.6 percent passed the question with marks ranging from 3.5 to 10. The pie chart (Figure 1) illustrates the performance of the candidates in this question.

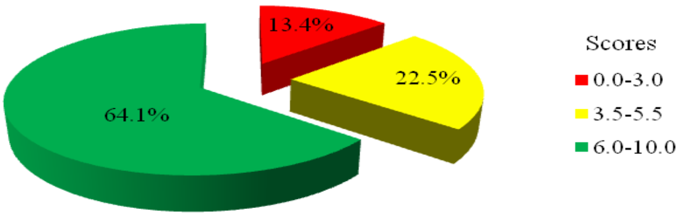


Figure 1: *Candidate's performance in question 1*

Those candidates (86.6%) who scored pass marks had a good mastery of the content as they were able to perform error analysis in estimating the precision of Young's modulus of the wire. A good number of them had adequate skills on the applications of dimensional equations in analysing physical quantities to check the validity of the given expression. Extract 1.1.1 shows a sample of responses from one of the candidates who performed well in this question.

Extract 1.1.1

1a (i) Random errors can be minimized through.

- doing many experiments and finding the average of results collected so as to get accurate answer.
- Being carefully during the time of doing experiments.

Systematic error can be minimized by.

- carefully design and calibration of the apparatus that are to be used in experiment.
- checking for zero error and eliminating it if possible before starting during the experiment

1a (ii) From: $Y = \frac{4FL}{\pi d^2 e}$.

Apply ln both sides

$\ln Y = \ln 4 + \ln F + \ln L - (\ln \pi + 2\ln d + \ln e)$.

As error is maximized.

$\ln Y = \ln 4 + \ln F + \ln L + \ln \pi + 2\ln d + \ln e$

$\pm\frac{\Delta Y}{Y} = \pm\frac{\Delta F}{F} + \pm\frac{\Delta L}{L} + 2\pm\frac{\Delta d}{d} + \pm\frac{\Delta e}{e}$

$\pm\frac{\Delta Y}{Y} = \frac{0.5}{500} + \frac{2}{3000} + 2\left(\frac{0.01}{1}\right) + \left(\frac{0.1}{5}\right)$

then

1a(ii) $\pm \frac{\Delta Y}{Y} = (1 \times 10^{-3}) + (6.67 \times 10^{-4}) + 0.02 + 0.02$

$\pm \frac{\Delta Y}{Y} = 0.041667$

∴ Relative error in young's modulus is

$\pm \frac{\Delta Y}{Y} = 0.041667.$

then percentage error is

$= \pm \frac{\Delta Y}{Y} \times 100\%$

$= 0.041667 \times 100\%$

$= 4.1667\%$

Precision = 100% − percentage error

$= 100\% - 4.1667\%$

$= 95.83\%$

∴ The precision to which the young's modulus can be determined is

$= 93.83\%$.

1 b (i). law of dimensional analysis states "The physical relation is dimensionally correct if the dimensions of fundamental quantities of Length, mass and time are the same to each term on both sides of the dimensional equation."

(ii) $V = \sqrt{\frac{T}{m}}$ —— ①

$[V] = [M^0 L T^{-1}]$.

$[T] = [M L T^{-2}]$.

$[m] = [M L^0 T^0]$.

substitute the above in (i)

$[M^0 L T^{-1}] = \sqrt{\frac{[M L T^{-2}]}{[M]}}$

$$= \left([m^0 L T^{-2}]\right)^{1/2}.$$

$$= [m^0 L^{1/2} T^{-1}].$$

$$\therefore [m^0 L T^{-1}] \neq [m^0 L^{1/2} T^{-1}]$$

from above, the dimension on the left hand side not equal to that of right hand side and so, the equation (expression) given is not correct.

Extract 1.1.1, a sample of a candidate who explained how random and systematic errors can be minimized. He/she used the given formula to estimate the Young's modulus γ of the wire, state the law of dimensional analysis and check the validity of the given expression correctly.

Most of the candidates (13.4%) who scored low marks lacked mathematical skills in applying dimensional equations to analyse the given expressions. A number of them had little understanding on the concept of measurements as they failed to estimate the precision of Young's modulus γ of the wire and to check the correctness of a given physical relation. In part (b) (ii), most of them provided the dimension of velocity as LT^{-2} instead of LT^{-1} and therefore failed to make the correct conclusion. Extract 1.1.2 is a sample of a candidate's poor answer.

Extract 1.1.2

1 (a)

(i) - By Pro

(ii) $Y = \frac{4FL}{\pi d^2 e}$

$F = 400N$

$L = 3m$

$d = 1mm$

$e = 5mm$

$$Y = \frac{4(400)(3\times10^{-6})}{\pi(1\times10^{3})(1\times5\times10^{-3})}$$

$$Y = \frac{4(400)(3\times10^{-6})}{\pi(1\times10^{3})(5\times10^{-3})} \quad \frac{N}{m^2}$$

$$Y = 3.05 \times 10^{14}$$

Precision are

$3.05 \times 10^{14} \pm 0.5N/mm$

$3.05 \times 10^{14} \pm 0.01mm$

$3.05 \times 10^{14} \pm 0.1mm$

(b) (i)

1 (ii)

$V = \sqrt{\frac{T}{m}}$

V = ~~Velocity~~ Speed

T = Tension

m = mass

Dimensions:

$m = M$

from $\rho = \frac{M}{V}$

$m = V\rho$

$m = [L^3][ML^{-3}]$

$m = [M]$

Velocity

from

$\text{Velocity} = \frac{\text{Speed}}{\text{time}}$

$V = \frac{[LT^{-1}]}{T^{-1}}$

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

Tension = F/A = $\frac{}{L^3}$

$[LT^{-2}] = \sqrt{\cdot}$

$[LT^{-2}] =$

Extract 1.1.2, a sample of a candidate who wrote the formulae, but failed to use the concept of measurements to estimate the precision of Young's modulus of a wire. In part (b), he/she analysed the dimensions of velocity as LT^{-2} instead of LT^{-1} and therefore failed to provide a logical conclusion.

2.1.2 Question 2: Newton's Laws of Motion

In part (a) of this question, the candidates were required to: (i) give a condition under which a passenger in a lift feels weightless and (ii) calculate the tension in the supporting cable of an elevator of mass 500 kg which was originally moving downward at 4 m/s and brought to rest with constant acceleration at a distance of 20 m. In part (b), they were required to: (i) find the mass of a helicopter whose rotating blades swept out an area of radius 2 m and imparting a downward velocity of 8 m/s and (ii) compute the mass of water striking the wall per second when a jet of water with velocity of 5 m/s and a cross-sectional area of $3x10^{-2}$ m^2 strikes the wall at right angle losing its velocity to zero.

The data analysis shows that, 53.8 percent of the candidates attempted this question. Of those, 54.8 percent scored marks ranging from 0 to 3.0 while 21.4 percent scored 3.5 to 5.5 marks. Only 23.8 percent scored marks ranging from 6.0 to 10. These data are presented in Figure 2.

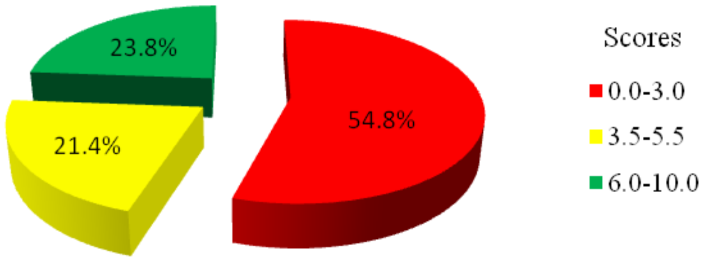


Figure 2: *The candidates' performance in question 2*

The data presented in Figure 2 shows that 45.2 percent of the candidates scored pass marks ranging from 3.5 to 10 indicating an average performance.

The candidates who scored good marks (6 - 10) were capable of applying the concepts of Newton's laws of motion in the daily life situations. Most of them responded correctly on how the apparent weight of a passenger in a lift differs from his/her actual weight. Most of them used appropriate formulae to manipulate the data and determine the tension in the supporting cable of an elevator. Moreover, most of the candidates in this group managed to formulate an equation of a net force at equilibrium to find the mass of a helicopter and the mass of water striking the wall per second.

Extract 1.2.1 is a sample of good responses given by one of the candidates who scored high marks in this question.

Extract 1.2.1

02. (a) (i) A passenger in a lift feels weightless when the lift is freely falling (i.e $a = g$)

i.e $R = m(g-g) = 0$.

(ii) Soln

Given

$m = 500kg$

$u = 4m/s$

$v = 0$

$s = 20m$

$T = ?$

From

$ma = mg - T$.

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

$0 = u^2 + 2as$

$a = \frac{-u^2}{2s}$

$a = -\frac{4^2}{2 \times 20} ms^{-2}$

$= -0.4ms^{-2}$

then

$T = mg - ma$

$= m(g-a)$

$= 500(10 - 0.4)$

$= 4800N$

∴ The tension is 4800N

02. (b) (i) Soln

Given

$r = 2m$ $\quad$ $\rho = 1.3\,kgm^{-3}$

$V = 8ms^{-1}$ $\quad$ $g = 10ms^{-2}$

$m = ?$

then

$mg = \rho A V^2$

$m = \frac{\rho A V^2}{g}$

$= \frac{\rho \pi r^2 V^2}{g}$

$= \frac{1.3 \times 3.14 \times 2^2 \times 8^2}{10}\ kg$

$= 104.4992\ kg$

∴ The mass of helicopter is 104.4992 kg

02. (b) (ii) Given

$V = 5ms^{-1}$ $\quad$ $\rho = 1000\,kgm^{-3}$

$A = 3 \times 10^{-2}\,m^2$

$dm/dt = ?$

From 2nd Newton's law of motion

$dm/dt = \frac{d}{dt}(\rho V)$

$= \frac{d}{dt}(\rho A L)$

$= \rho A \frac{dL}{dt}$ $\quad$ but $dL/dt = V$

$= \rho A V$

$\therefore dm/dt = 1000 \times 3 \times 10^{-2} \times 5$

$= 150\ kgs^{-1}$

∴ The rate of mass of water striking wall is $150\,kgs^{-1}$

Extract 1.2.1, a sample of an answer where a candidate provided a correct condition for a passenger in a lift feeling weightless and used the correct formulae to compute the required quantities.

In contrast, the candidates who performed poorly showed little understanding of the concepts of Newton's laws of motion. They failed to recognise that when the lift is moving downward the net force provides the downward acceleration to the person in such a way that he/she feels lighter as he/she walks about on the floor of the lift. For example, instead of resolving the net force acting on a man in a lift, some of them used the concepts of centripetal force by using irrelevant formulae e.g $F = \frac{MV^2}{R}$ to find the tension. Furthermore, most of them failed to identify the force at equilibrium acting on a helicopter to find its mass. Extract 1.2.2 was taken to illustrate the case.

Extract 1.2.2

2 (a) (i) the passenger in lift feels weightless. when the ~~car~~

— when the lift is banding at the corner where the centripetal force is perpendicular to the velocity of the ~~car~~ lift.

(ii) — ~~Mass of cable~~ = 500kg.

— v

(iii) given data

mass of cable(m) = 500kg

velocity = 4 m/s

distance = 20 m/s

tension supply = ?

— from

$f = MV^2/r$

$f = \frac{Mv^2}{r}$

f = tension

v = velocity

r = distance

$f = \frac{500 \times (4)^2}{20}$

$f = \frac{500 \times 16}{20} = 400N$

$\therefore$ The value of tension is equal to 400N

2 (b)(i) Given data

radius = 2M

velocity = 8M/s

Mass = ??

Area

Fn

Area = πr^2

Area = $\pi \times (2)^2$

$= 4\pi m^2$

$A r = 4\pi r^2$

$\therefore$ The area is $4\pi m^2$.

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

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

$F = Ma$

$a_c = \frac{V^2}{r} = \frac{(8)^2}{2}$

$a = \frac{64}{2} = 32 M/s$

$\therefore$ The acceleration is $32 m/s^2$

$F = \rho VA$

$ma = \rho VA$

$Mg = \rho VA$

$10 \text{ Mass} = 1.0 \times 8 \times 12.56$

Mass = 100.48 kg.

$\therefore$ The value of mass of the body is 100.48kg.

2	(b)
	(ii) Data given.
	velocity = 5m/s
	Area = $3 \times 10^{-2} m^2$
	Density water = 1000 kg/m3
	$dm/dt = ?$
	from
	$F = \rho V A \cos\theta$
	$\theta = 0°$
	$F = Mg$.
	$\frac{g\, dm/dt}{g} = \frac{\rho V A}{g}$
	$dm/dt = \frac{\rho V A}{g}$
	$dm/dt = \frac{1000 \times \cancel{10}\ (1000 \times 3 \times 10^{-2} \times 5) kg}{10}$
	$dm/dt = \left(\frac{1000 \times 3 \times 10^{-2} \times 5}{10}\right)$
	$dm/dt = 15$ kg/second
	The rate of water flow per wheel
	$dm/dt = 15$ kg/second

Extract 1.2.2, a sample of an answer of a candidate who used an incorrect formula of $F = \frac{MV^2}{R}$ instead of $T = m(g - a)$ to calculate the tension in the supporting cable of an elevator. In part (b), the correct formula was $mg = \rho v^2 A$, but the candidate wrote $mg = \rho v A$ ending with incorrect answers.

2.1.3 Question 3: Projectile Motion

The question aimed at determining the candidates' knowledge on the concepts of projectile motion. Therefore, part (a) required them to: (i) state the difference between projectile motion and uniform circular motion and (ii) calculate the height above the target at which the rifle must be aimed so that the bullet with muzzle velocity of 1000 m/s would hit a small target at 200 m. In part (b) they were required to: (i) calculate the horizontal distance at which the object would strike the ground when thrown horizontally with a velocity of 15 m/s from the top of a 40 m high building and (ii) find the speed of travel when a man jumps a maximum horizontal distance of 1 m spending a minimum time on the ground.

A total of 16,359 (83.7%) candidates attempted this question, out of which 40.3 percent scored below 3.5 marks, including 9.0 percent who scored 0 mark. The candidates who scored marks ranging from 3.5 to 5.5 were 38.3 percent while those who scored 6.0 to 10 marks were 21.4 percent. This indicates that the candidates' performance in this question was at the upper margin of average (59.7%).

Some of the candidates who scored high marks (6 - 10) were very systematic in organizing their responses. They showed their competences in analysing the concepts as demanded by the question. Moreover, most of them had a good understanding of the subject matter as they applied appropriate formulae and procedures in attempting the parts which involved calculations. Extract 1.3.1 is a sample of good responses from one of the candidates.

Extract 1.3.1

03'	
(a)	~~In~~ In projectile motion acceleration due to gravity
(i)	(= g) is perpendicular to the velocity
	(horizontal component) at the maximum height
	Or point while in circular motion
	Centripetal acceleration (= ac) is perpendicular
	to its velocity at any instant of time and directed

03(a)(ii) towards the centre of the circle.

→ In projectile motion horizontal component of velocity is constant throughout the motion while in circular motion the velocity is changing by changing direction at every instant of time.

→ In the projectile motion the acceleration due to gravity (= g) is constant throughout the entire motion while in the circular motion, acceleration of the body is not constant.

03. (b) (ii)

Soln

$u = 1000\,m/s$.

$x = 200\,m$ $\quad g = 10\,m/s^2$.

$y = ?$

From

$y = \frac{1}{2} g t^2$

But $t = x/u$.

$y = \frac{1}{2} g \cdot \left(\frac{x}{u}\right)^2$

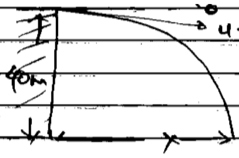
$= \frac{g x^2}{2u^2}$

$y = \frac{g x^2}{2u^2} = \frac{10 \times (200)^2}{2\,(1000)^2}$

$y = 0.2\,m. \equiv 20\,cm.$

→ ∴ The rifle must be aimed at 0.2 m (= 20 cm) high above the target in order to hit the target.

(b)
(i)



$y = 40m$

$\theta = 0$

$-y = u_y t - \frac{1}{2} g t^2$ $g = 10 m/s^2$

$-y = u \sin\theta\, t - \frac{1}{2} g t^2$

$-y = u \sin 0°\, t - \frac{1}{2} g t^2$

$-y = -\frac{1}{2} g t^2$

$y = \frac{1}{2} g t^2$

$t = \sqrt{\frac{2y}{g}}$

$t = \sqrt{\frac{2 \times 40}{10}}$

$t = 2.828$ seconds.

Range $(x) = u_x t$

$= u \cos\theta\, t$ $u = 15 m/s$

$= u \cos 0°\, t = u \cdot t$

$x = 15 m/s \times 2.828 s$

$x = 42.42 m$

∴ The object will strike the ground at 42.42 m from the building.

02.
(b)
(ii)

$R_{max} = 1 m$

From

$R_{max} = \frac{U_o^2}{g}$ $g = 10 m/s^2$

$U_o^2 = g \cdot R_{max}$ $\theta = 45°$ for maximum horizontal range.

$U_o^2 = 10 \times 1$

$U_o = \sqrt{10 \times 1}$

$U_o = 3.16 m/s$

The speed of travel

$V_x = U_o \cos\theta$

$= 3.16 \times \cos 45°$

$V_x = 2.236 m/s$

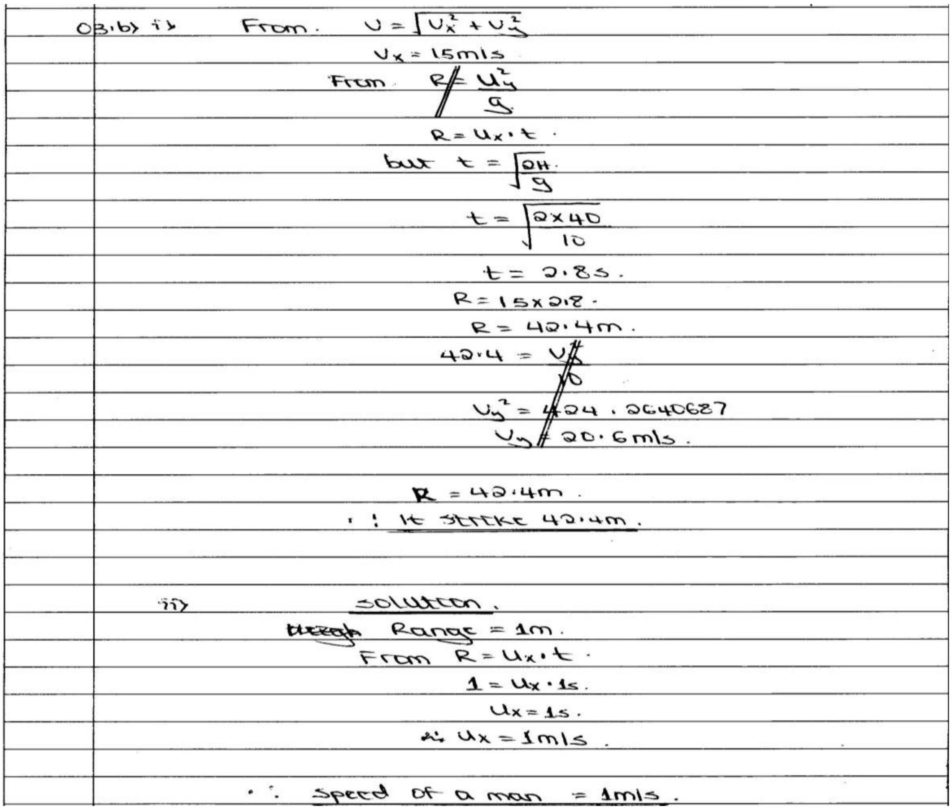
∴ speed of travel of the man is 2.236 m/s.

Extract 1.3.1, a sample of an answer of a candidate who was systematic in performing calculations including all important steps, formulae, illustrations and correct substitution of data.

However, most of the 40.3 percent of the candidates who scored low marks (0 - 3) failed to distinguish projectile motion from uniform circular motion. A good number of them were not able to compute correctly the height at which the rifle must be aimed at, the horizontal distance and the speed of travel while others gave responses which did not have a logical flow of ideas. In addition, some used the correct diagrams in attempting the question but failed to identify the proper formulae and procedures in computing the data. For example, one candidate wrote: *Projectile motion is the motion which depends on external forces while uniform circular motion is the one whose acceleration due to gravity remain constant all the time.* Such a response indicates that this candidates' knowledge on the topic of Projectile Motion was weak. The candidates should understand that projectile motion is controlled by acceleration due to gravity, 'g' while in uniform circular motion centripetal force or tension dominate. Extract 1.3.2 shows a sample of a poor answer.

Extract 1.3.2

03. a) i) - In projectile motion the acceleration change in
both magnitude and direction but in circular moti-
on acceleration changes in magnitude.
- In projectile motion acceleration (g) make an-
gle with velocity (It perpendicular to v) white
in circular do not form angle with velocity.



03.(b) i) From. $U = \sqrt{U_x^2 + U_y^2}$

$U_x = 15 m/s$

From $\cancel{R = \frac{U_y^2}{g}}$

$R = U_x \cdot t$

but $t = \sqrt{\frac{2H}{g}}$

$t = \sqrt{\frac{2 \times 40}{10}}$

$t = 2.8s$.

$R = 15 \times 2.8$

$R = 42.4m$.

$\cancel{42.4 = \frac{U_y^2}{10}}$

$\cancel{U_y^2 = 424.2640687}$

$\cancel{U_y = 20.6 m/s}$.

$R = 42.4m$.

$\therefore$ It strike 42.4m.

ii) solution.

~~through~~ Range = 1m.

From $R = U_x \cdot t$.

$1 = U_x \cdot 1s$.

$U_x = 1s$.

$\therefore U_x = 1 m/s$.

$\therefore$ speed of a man = 1m/s.

Extract 1.3.2, indicates a sample of response of a candidate who used diagrams in attempting the question, but applied the incorrect formulae in performing calculations and therefore he/she obtained incorrect answers.

2.1.4 Question 4: Simple Harmonic Motion

This question had three parts namely (a), (b) and (c). In part (a), the candidates were required to give the meaning of (i) periodic motion and (ii) oscillatory motion. Part (b) required the candidates to: (i) list four important properties of a particle executing simple harmonic motion and (ii) sketch a labelled graph representing the total energy of a particle executing simple harmonic motion (S.H.M). In part (c), they were required to find the time interval of a body executing simple harmonic motion from time t = 0 at which its displacement be half its amplitude given that the periodic time is 4 seconds.

Data analysis reveal that, 81.9 percent of the candidates attempted this question and had the following scores: 49.7 percent scored marks ranging from 0 to 3, 34.5 percent scored 3.5 to 5.5 marks and 15.8 percent scored 6 to 10 marks. These scores imply that the candidates' performance in this question was average because 50.3 percent of the candidates scored marks ranging from 3.5 to 10 as summarized in Figure 4.

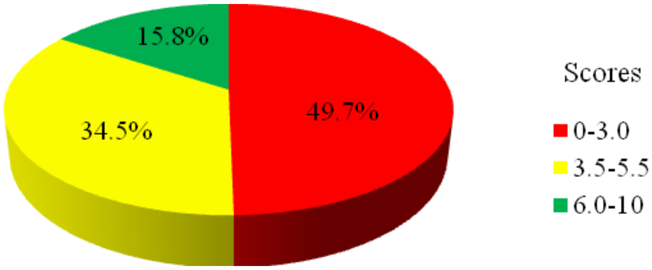


Figure 4: *The candidates' performance in question 4.*

The performance of those who scored average marks (3.5 - 5.5) in this question could have been contributed by the candidates' ability to comprehend correctly the concepts on some parts of the question items. Most of them gave four important properties of a simple harmonic motion, but failed to sketch a well labelled graph that represents the total energy of a particle executing simple harmonic motion. Nevertheless, those who scored higher marks (6 - 10) had good mathematical skills in applying formulae and procedures to calculate the time interval of a body as demanded in part (c) of the question. Extract 1.4.1 is a sample answer taken from the script of one of the candidates who performed well in this question.

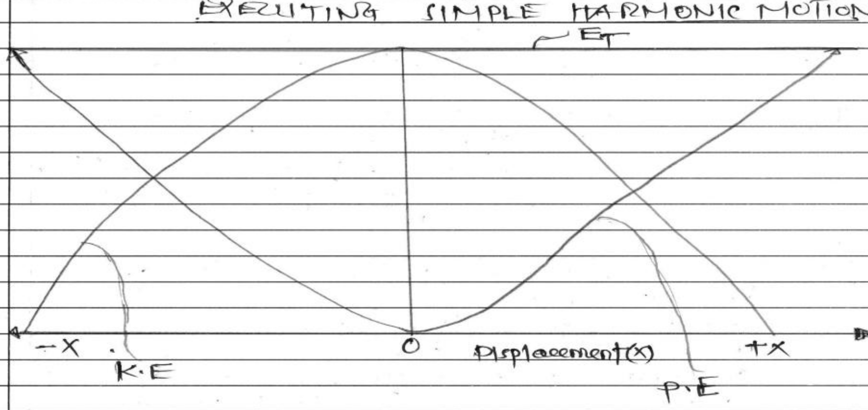
Extract 1.4.1

4 (a) (i) Periodic motion: Is the motion which repeat itself after a regular interval of time
Example: - revolution of earth around the sun.
- Rotation of clock.

(ii) Oscillatory motion: Is the to and fro motion of the body about the equilibrium position (mean position)
Example - Motion of loaded helical spring.

(b) (i) Important properties of particles executing simple harmonic motion
(01) It is to and fro motion of the body about its equilibrium position.
(02) The graph of acceleration, velocity and displacement vary sinusoidally with time but they are not in phase.
(03) The magnitude of frequency and period of oscillation are independent on the amplitude.
(04) Acceleration is ~~directly~~ directly proportional to its displacement and directed towards the centre
$A \propto -X$.
A = acceleration
X = displacement

4(b) (ii) THE SKETCH OF GRAPH REPRESENTING TOTAL ENERGY OF A PARTICLE EXECUTING SIMPLE HARMONIC MOTION



Where
K.E = Kinetic energy
P.E = Potential energy
E_T = Total energy

4(c) Data.

Period $(T) = 4s$

Time interval $(t) = ?$

Initial time $(t_i) = 0$.

displacement $(x) = a/2$

Amplitude $= a$.

From

$$x = a\sin\omega t.$$

$$\frac{a}{2} = a\sin\omega t.$$

$$0.5 = \sin\left(\frac{2\pi}{T}\right)t$$

$$\sin^{-1}(0.5) = \left(\frac{2\pi}{T}\right)t.$$

$$\sin^{-1}(0.5) = \left(\frac{2\pi}{4}\right)t.$$

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

$$30^0 = \left(\frac{\pi}{2}\right)t.$$

$$\left(\frac{30^0 \times 2}{180^0}\right) = t.$$

$$t = \left(\frac{6}{18}\right)s = \left(\frac{1}{3}\right) \text{seconds}$$

$\therefore$ Time interval $= 0.33\ s$ or $1/3$ seconds.

Extract 1.4.1, a sample of an answer of a candidate who was very systematic and accurate in presenting his/her work in all parts of the question. This indicates that he/she had understood well the concepts, properties and principles governing simple harmonic motion.

On the other hand, the candidates who performed poorly (49.7%) failed to comprehend correctly the demands of most of the question items. Most of them had poor mathematical skills required to attempt the part which needed calculations. Besides that, they confused between potential energy (P.E) and kinetic energy (K.E) in sketching a graph by labelling these energies interchangeably. This reveal that they lacked knowledge on the principles concerning simple harmonic motion. For example, one candidate wrote: *The four important properties of a particle executing simple harmonic motion are; must be small, low density, low molecular weight and must be less denser than water*. In this case, he/she provided the physical properties of a body which basically affect the behaviour of a particle to execute simple harmonic motion. Extract 1.4.2 shows a sample of poor responses.

Extract 1.4.2

4. (a) (i) periodic motion
(ii) Oscillatory motion

(i) = Periodic motion - is the motion which involve the distance and time at the same time

(ii) Oscillatory motion
is the kind of motion which involve the vibration of moving bodies

(b) (i) must be small.
(ii) low density
(iii) low molecular weight
(iv). Must be less denser than water

(C) Solution
time = 4sec.
how at t_o = ?
$t = \sqrt{\frac{h(2)}{g}}$

$g = 9.8$
$h = ?$
but
$t_1 = 4sec$
$t_o = \frac{t_1}{g}$
$t_o = \frac{4}{9.8}$ $t_o = 0.4 sec$

Extract 1.4.2, a sample of an answer of a candidate who wrote incorrect responses to all parts of the question. For instance in part (b) (i), instead of writing the basic properties possessed by a particle executing simple harmonic motion, he/she provided the physical properties which in actual fact do not support the motion.

2.1.5 Question 5: Gravitation

In part (a) of this question, the candidates were required to: (i) determine the orbital speed and (ii) find the gravitational potential energy for a satellite of mass 600 kg kept in circular orbit at a height of 2 x 10^6 km above the earth's surface. In part (b), they were required to: (i) state what would happen if gravity suddenly disappears, (ii) calculate the height of the mountain above the sea level where the gravitational field strength at the base of mountain is 9.81 N/kg and that at the top of mountain is 9.7 N/kg.

The question was attempted by 10,943 candidates corresponding to 56 percent, out of whom 80 percent scored marks ranging from 0 to 3, 15.1 percent scored 3.5 to 5.5 marks while only 4.9 percent scored 6 to 10 marks. These scores suggest that the general performance in this question was weak. The following pie chart divulges the information given above.

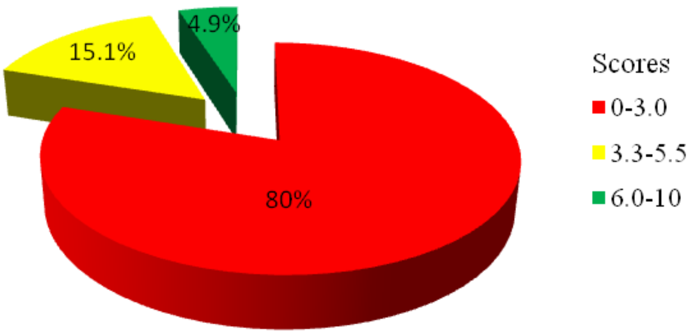


Figure 5: *The candidates' performance in question 5*

A larger number of candidates who performed poorly failed to apply the concept of gravitation in almost all parts of the question. Most of them were not able to predict precisely what would happen if gravity suddenly disappears. These candidates were unaware that, gravitational force holds all bodies in the universe and if it disappears nothing would exist on the earth due to centrifugal force. Besides that, their responses had various errors and misconceptions on gravitational and mechanical potential energy, hence they failed to apply the correct formulae in the question items. Extract 1.5.1 is a sample of responses from one of the candidates who provided incorrect answers to all parts of the question.

Extract 1.5.1

5. a) Solution.

Mass = 600kg

weight = 2×10^6 km

ii) Gravitational potential energy = Mgh.

Where g = $10 m/s^2$ = 600kg x $10 m/s^2$ x ~~km~~ 2×10^6 km

= 1.2×10^{10} joule

Gravitational potential energy = ~~1.2×10^{10} J~~

G.p.E = 1.2×10^{10} J.

b) i) bodies will not be able to control their Motion.

ii)

5. a) i) Solution

~~ob~~ Orbital Speed = Mass x weight

= ~~6~~ 600kg x 2×10^6 km.

= 1.2×10^9 kgkm.

∴ Orbital Speed = ~~1.2×10^9 kgkm.~~

= 1.2×10^9 kg km.

b) ii) Solution.

Gravitational field strength = 9.81N/kg.

Gravitational field ~~at~~ the top = 9.7N/kg.

height of the Mountain above the sea level

$= \frac{9.81}{9.7}$

= 1.011m

∴ Height of the Mountain above the sea level = 1.011m

Extract 1.5.1, a sample of an answer of a candidate who used the formula P.E = mgh instead of $P.E = \frac{g r_e^2 m}{r_e + h}$ to calculate the gravitational potential energy. In part (a) (i) he/she calculated the orbital speed using the formula, "orbital velocity = mass x height" which is dimensionally not correct.

On the other hand, few candidates (4.9%) who scored higher marks (6 - 10) had a good understanding on the topic of Gravitation as they applied appropriate formulae and procedures in determining the orbital speed and gravitation potential energy of the satellite. Moreover, they were able to calculate the height of mountain above the sea level. However, 15.1 percent of the candidates who scored moderate (3.5 - 5.5) marks attempted some parts of the question items and scored average marks. Extract 1.5.2 shows the responses from one of the candidates who answered this question correctly.

Extract 1.5.2

5 a) i/ Solution

where G = gravitation constant
M = Mass of the earth.
R = radius of the earth
h = required height.

from Orbital speed = $\sqrt{\frac{GMe}{R+h}}$

R, radius of the earth = $6 \cdot 4 \times 10^6$ km
h, height above the earth's surface = 2×10^6 km
$GMe = gR^2 = 10 \times (6 \cdot 4 \times 10^9)^2$

5 a) i/

Orbital speed = $\sqrt{\frac{10 \times (6 \cdot 4 \times 10^9)^2}{(6.4 \times 10^6 + 2 \times 10^6) \times 10^3 m}}$

Orbital speed = $22 0 8 20 \cdot 979$ m/s

ii/ Gravitation potential energy, U.

$U = -\frac{GMeM}{(R+h)}$

$= \frac{-gR^2M}{R+h}$

$= \frac{-10 \times (6 \cdot 4 \times 10^9)^2 \times 600}{(6 \cdot 4 \times 10^9) + (2 \times 10^9)}$

$= -2.925714286 \times 10^{13}$ J.

5 b)i/ If gravity suddenly dissapeared things would start floating into space because nothing would be holding objects to the ground. The objects would keep on floating until infinity (theoratically).

5 b)ii/ solution

from $mg = \frac{GM_e m}{R^2}$ ... Newton's law of gravitation

$$g = \frac{GM_e}{R^2}$$

$$g' = \frac{GM_e}{(R+h)^2}$$

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

$$\frac{g}{g'} = \left(1 + \frac{h}{R}\right)^{-2}$$

$$\sqrt{\left(\frac{9.81}{9.7}\right)} = \frac{R}{R+h}$$

$$\frac{h}{r} = 1.005654119 - 1$$

$$h = \left(6.4\times10^6 (5.654118564\times10^{-3})\right) km$$

$h = 36186.35881$ km. above sea level.

Extract 1.5.2 shows how a candidate was systematic and accurate in presenting hi/her responses in all parts of the question hence scoring good marks.

2.1.6 Question 6: Rotation of Rigid Bodies

This question aimed at assessing the candidates' knowledge on the topic of Rotation of Rigid Bodies. Thus, part (a) required them to: (i) explain why a flywheel is designed such that most of its mass is concentrated at the rim and, (ii) estimate the couple that will bring the wheel to rest in 10 seconds given that its wheel radius of 40 cm and mass of 3 kg is rotating at angular velocity of 3600 revolutions per minute. In part (b), the candidates were required to: (i) explain why an ice skater rotates at low speed when she stretches her arms and a leg outward and (ii) calculate the moment of inertia of a sphere about an axis which is tangent to its surface given the mass and radius of the sphere as 10 kg and 0.2 m, respectively.

Only 27.8 percent of the candidates attempted this question and their scores were as follows: 65.2 percent scored below 3.5 marks, including 26.4 percent who scored 0 marks. 20.4 percent scored marks ranging from 3.5 to 5.5 while 14.4 percent scored 6 to 10 marks. These data reveal that the candidates' performance in this question was at a very lower margin of average because only 34.8 percent passed the question by scoring marks ranging from 3.5 to 10.

The candidates who scored average (3.5 - 5.5) marks were noted to perform well in part (a) (ii) and (b) (ii), but provided wrong responses to other parts of the question. This could have been contributed by the failure of the candidates to understand the basis of conservation of angular momentum and its applications into everyday experiences. A small group of candidates (14.4%) presented the responses which agreed with the demands of the question items. They provided reasonable arguments as well as applying the concepts of moment of inertia to estimate the couple. Extract 1.6.1 is a sample of good responses taken from the script of one of the candidates to illustrate this case.

Extract 1.6.1

6(a)	i) Mass of the ~~flm~~ flywheel are concentrated
	at the rim in order to increase
	moment of inertial so as to prevent
	~~the~~ change of rotational
	motion when it rotate.
	ii) Data
	time (t) = 10 sec
	Radius (r) = 40cm = 0.4m.
	mass (m) = 3kg
	frequence (f) = 3600 r.p.m.
	torque (T) = ?.

from

Toque $(T) =$ Moment of inertia$(I) \times$ angular acceleration(α)

$T = I\alpha.$

but

M.I for wheel

$I = \frac{1}{2} Mr^2$

$= \frac{1}{2} \times 3kg \times (0.4)^2.$

$I = \underline{0.24\, kgm^2}.$

angular acceleration (α)

$\alpha = \cancel{\omega^2 r}.\ \omega/t$

$\omega = \omega_0 + \alpha t$

but $\omega_0 = 0.$

$\omega = \alpha t$

$\alpha = (\omega/t)$

6.- $\alpha = \left(\frac{2\pi f}{t}\right).$

$f = 3600\, r.p.m = 60.r.p.s.$

$\alpha = \left(\frac{2\pi \times 60}{10}\right) = 37.699\ rad/s^2.$

So,

$T = I.\alpha.$

$T = 0.24\, kgm^2 \times 37.699\ rad/s^2.$

$T = 9.05\ Nm.$

$\therefore$ toque is 9.05 Nm.

6 b)(i) When Ice skaters stretches their legs and aims they increases moment of inertial hence opposition due to rotational motion increase hence their speed of spin decreases

(ii) Data.

Moment of inertia (M.I) = Required.

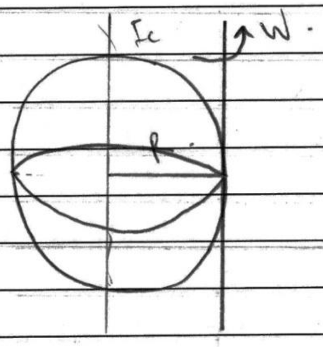
given.

mass of sphere $(M) = 10kg$

radius of sphere $(R) = 0.2m$

Soln,

6



from, Parallel axis theorem.

$I = I_c + mh^2$

but $h = R$.

$I_c = \frac{2}{5} MR^2$.

$I = \frac{2}{5} MR^2 + MR^2$.

$I = \frac{7}{5} MR^2$.

$$I_c = \frac{2}{5} MR^2.$$

$$I = \frac{2}{5} mR^2 + MR^2.$$

$$I = \frac{7}{5} MR^2.$$

So,

$$I = \frac{7}{5} \times 10 \times 0.2^2.$$

$$I = 0.56 \ kgm^2.$$

∴ moment of inertial is $0.56 \ kgm^2$.

Extract 1.6.1 shows how a candidate was conversant with the topic of Rotation of Rigid Bodies as he/she was able to provide the correct responses to all parts of the question.

Nevertheless, a larger number (65.2%) of candidates who scored low (0 - 3) marks were not able to provide concrete reasons on part (a) (i) and (b) (i). They lacked competences of conveying the concept based on the law of conservation of angular momentum in relation to daily life situations and other possible phenomena. Most of them just listed down the data as given in the question items, but failed to grasp the intended formulae in tackling the question. Extract 1.6.2 gives a sample of responses of a candidate who performed poorly in this question.

Extract 1.6.2

6. a) (i) Flywheel $= \frac{\omega r t}{2\pi}$

Because at rim ~~mass~~ the moment of inertial

$I = Mr^2$

(ii) Solution

data

Time = 10 seconds

radius = 40cm = 0.4m

Mass = 3kg

Revolutions = 3600 per minute

Couple = ??

From

Couple = Fr

but

F = mass x acceleration

but a = ω

ω = 2πf

a = 2π x 3600

$a = 1.36 \times 10^6$

$F = 3 \times 1.36 \times 10^6$

$F = 4.07 \times 10^6$ N

6 (a) (i) Couple = Fr

$Couple = 1.63 \times 10^8$ N

$Couple = 1.63 \times 10^8$ N

b) ii) solution

data

Mass = 10kg

Radius = 0.2M

Moment of inertial (I) = ?!

but

$I = Mr^2$

$I = 10kg \times (0.2m)^2$

$I = 0.4kg/m^2$

Moment of inertial $= 0.4kg/m^2$

Extract 1.6.2 indicates responses of a candidate who lacked knowledge on the concepts of moment of inertia, torques and the law of conservation of angular momentum which were the focus points for solving this question.

2.1.7 Question 7: Heat (Thermometers)

This question had three parts namely (a), (b) and (c). Part (a) required the candidates to: (i) identify the type of thermometer which is suitable for calibration of other thermometers and, (ii) explain why at least two fixed points are required to define a temperature scale. In part (b), they were required to: (i) list two qualities which makes a particular property suitable for use in practical thermometers, and (ii) describe how mercury in glass thermometer could be made sensitive. Part (c) required them to: (i) give the meaning of a triple point of water and, (ii) evaluate the temperature in Kelvin if the pressure recorded by a constant volume gas thermometer is 6.8×10^4 Nm^{-2} and pressure at a triple point 273.16 K is 4.6×10^4 Nm^{-2}.

Majority (95.8%) of the candidates attempted this question. Out of them, 33.8 percent scored marks ranging from 0 to 3, 36.4 percent scored 3.5 to 5.5 marks and 29.8 percent scored 6 to 10 marks. Generally, the performance in this question was good, having 66.2 percent of the candidates scoring the pass marks ranging from 3.5 to 10.

The candidates who scored high marks (6 - 10) were able to provide the acceptable responses. A larger number of them responded correctly in most parts of the question indicating that they had good mastery on the subtopic of thermometers. In addition, those who scored average marks ranging from 3.5 to 5.5, attempted a few question items. Most of them failed not only to describe thermodynamic scale of temperature, but also to evaluate the temperature in Kelvin based on the given requirements. Extract 1.7.1 is a sample of good responses from the candidates who performed well in this question.

Extract 1.7.1

7. (a) (i) It is gas thermometer. This is because such thermometer is very sensitive

(ii) Two fixed point are ~~rq~~ required to define temperature scale since any tempe ratu in construction of temperatre there should fundamental interval so in doing so the two fixed points are required so as to establish temperature scale. where the fundamental interval of such temperature scale is obtained

(b) (i). The thermometric property should be sensitive to temperature change.
• The thermometric property should vary lineary and continously with the temperature change.

(ii). By narrowing capillary tube of the thermometer.

• By increasing surface area of the bulb of mercury.

• By narrowing walls of bulb to ensure faster heat conduction across walls of bulb.

• At the vaccum part above the mercury should be evacuated to allow free expansion of ~~ti~~ mercury.

(c) (i) Is the temperature at which all states of matter that is water vapour, liquid water and ice co-exist in equilibrium. It normally occurs at 273.16 K.

7. (c) (ii) Data Given.

Pressure at temperature given $P_T = 6.8 \times 10^4 N/m^2$

Pressure at triple point $(P_{tr}) = 4.6 \times 10^4 N/m^2$

Temperature at triple point $(T_{tr}) = 273.16K$

Required

Temperature (T_θ) at given pressure

From

$$P_{tr} \propto T_{tr} \quad \text{— (i)}$$

$$P_T \propto T_\theta \quad \text{— (ii)}$$

$$\frac{P_{tr}}{P_t} = \frac{T_r}{T_\theta}.$$

$$T_\theta = \left(\frac{P_t}{P_{tr}}\right) T_{tr}$$

$$T = \frac{6.8 \times 10^4}{4.6 \times 10^4} \times 273.16K$$

$$= 403.80K.$$

$\therefore$ Recorded temperature = 403.80K.

Extract 1.7.1 indicates how a candidate was able to give correct explanations and procedures in performing calculations to score good marks.

However, the candidates who scored low marks (0 - 3) had inadequate knowledge on the thermometric properties of substance as they failed to classify types and uses of thermometers. Most of them provided responses with illogical flow of ideas deviating from the demands of the question items. Some of them also failed to apply the formula and use of correct procedures to calculate the temperature in Kelvin scale. Extract 1.7.2 represents responses of one of the candidates who had poor performance in this question.

Extract 1.7.2

7(a)	(i) mercury thermometer.
	(ii) Because temperature become high value in
	°C so it need two fixed point to define
	temperature scale.
7(c)	(i) Tripal point of water is the end boiling point
	of water at °c.
	(ii) Data given
	Temperature 273.16K
	Force $4.6 \times 10^{-4}\ Nm^{-2}$
	$273.16\ K \quad = \quad 4.6 \times 10^{-4}\ Nm^{-2}$
	$?\ K \quad = \quad 6.8 \times 10^{4}\ Nm^{-2}$
	$4.6 \times 10^{-4}\ K = 273.16\ K \times 6.8 \times 10^{4}$
	but $273.16 - 273 = 0.16\ °c$
	$4.6 \times 10^{-4}\ K = 0.16 \times 6.8$
	$0.00046\ K = 10880$
	$K = 10880 / 0.00046$
	$K = 23652173.91 + 273$
	$K = 23652446.91$
	$K = 23.65 \times 10^{6}$
	∴ Temperature in kelvin 23.66×10^{6}
7(b)	(i) qualities which make a particular proper
	ty suitable for Use in particular thermom
	eter are
	1 - Temperature
	2 - climate changing.

Extract 1.7.2 indicates one of the candidate who provided incorrect answers to all parts of the question. For instance in part (c), he/she failed to recall the formulae to solve the question.

2.1.8 Question 8: Heat (First Law of Thermodynamics and Thermal Radiation)

This question had two parts namely, (a) and (b). In part (a), the candidates were required to determine: (i) external work done, and (ii) the increase in internal energy when one gram of water becomes 1671 cm^3 of steam at a pressure of 1 atmosphere and latent heat of vaporization at this pressure is 2256 J/g. In part (b), they were required to: (i) explain why during emission of radiation from black body its temperature does not reach zero Kelvin, and (ii) find heat radiated by black ball of a radius of 1m in 4 seconds which is maintained at a temperature of 30 ^oC.

74.1 percent of the candidates opted for this question. Out of them, 56.2 percent scored marks ranging from 0 to 3 marks, 24.4 percent scored 3.5 to 5.5 marks and 19.4 scored 6 to 10 marks. Therefore, 43.8 percent of the candidates who attempted this question scored marks above the pass mark (3.5 marks), implying that, the performance in this question was average with the inclination towards the lower margin. This performance indicates that, most of the candidates were not competent on the assessed topics, particularly First Law of Thermodynamics and Thermal Radiation.

Those who scored 0 to 3 marks (56.2%) included 19.6 percent who provided wrong responses to each question item, therefore, scored 0 marks. Most of them lacked knowledge on the topic, hence attempted very few items and gave incorrect responses. The other 36.6 percent who scored some few marks were able to provide responses or steps which were partially correct in some question items. For example, some of them were able to recall the formulae for external and internal energy in part (a), but failed to apply it to derive the required formulae for calculating the required parameters. Some of them listed the given data in (b) (ii) and wrote Stephan's law, but failed to compute correctly the required parameter. Extract 1.8.1 shows an example of the work of a candidate who scored low marks in this question as a result of some errors mentioned above.

Extract 1.8.1

8@ i)	Solution
	$m = 1 \times 10^{-3}$ kg $\simeq 1$ g
	Vol $= 1.671$ $dm^3 \simeq 1671$ cm^3
	P = 1 atm
	L = 2256 J/g
i)	From 1^{st} law of thermodynamics
	$\Delta Q = \Delta U + Pdv$
	but,
	$W = Pdv$
	$W = 1$ atm $\times 1671$ cm^3
	$= 1671$ J
	Workdone = 1671 J
ii)	then,
	$\Delta Q = \Delta U + W$
	but $\Delta Q = ML$
	$ML = \Delta U + W$
	$\Delta U = ML - W$
	$= (1 \times 2256) - 1671$
	$= 585$ J
b i)	A black body tend to emitt all radiations completely that fall on it hence it it produce high temperature from it power is directly proportional to it T^4 in Kelvin.
ii)	Solution
	$t = 30°C$ $r = 1m$
	$P = ?$
	$t = 4sec$

08	From stefan's law
	$P = \varepsilon \sigma A T^4$
	but $P = \frac{heat\ [energy]}{time}$
	heat $= \varepsilon \sigma A T^4 \cdot$ time
	$A = \pi r^2$
	$= 3.14$ m^2

~~powerwatt~~ $= 1 \times (5.67 \times 10^{-8}) \times 3.14 \times 303^4$

Power $= 1.5007 \times 10^3$ J/sec

1 sec $\equiv 1.5007 \times 10^3$ J

4 sec $\equiv x$?

Heat $= 6.003 \times 10^3$ J/sec

$= 6.003 \times 10^3$ watt

Extract 1.8.1, a sample of an answer of a candidate who retrieved well the laws and the formulae for calculating the required parameters in each of the performed items, but failed to perform correctly the required calculations. He/she also gave incorrect explanation in part (b) (i).

Most of those who performed well in this question had adequate knowledge on the concepts of Thermodynamics and Thermal Radiations, hence were able to recall and apply the formulae for external work done and internal energy of a gas in solving the question in part (a). Most of them were also capable of recalling and applying Stephens law in part (b) (ii) to find the heat radiated by the ball. Extract 1.8.2 presents a sample from the work of one of the candidates who responded well in this question.

Extract 1.8.2

Ans. (a). Given: 1 gram of water $= 1\,cm^3$, V_w.

Volume of steam, $V_s = 1671\,cm^3$.

Pressure, $P = 1$ atm. $= 1.013 \times 10^5\,Nm^{-2}$

$L_v = 2256$ J/g

(i). external work done,

From; $dw = P\,dv$.

$$\int_0^w dw = \int_{V_w}^{V_s} P\,dv$$

$$w - 0 = P \int_{V_w}^{V_s} dv$$

$$w = P\,[v]\Big|_{V_w}^{V_s}$$

$$w = P(V_s - V_w)$$

$w = 1.013 \times 10^5\,Nm^{-2} \times (1671 - 1) \times 10^{-6}\,m^3$.

$w = 169.171$ J.

$\therefore$ External work done $= 169.17$ J

Qn 8. (ii). Increase in Internal energy, ΔU

From: $dH = dw + \Delta U$.

$\Delta U = dH - dw$.

$\Delta U = H - W$.

where;

H = heat supplied = $m \times L_v$

$= 1g \times 2256 J/g$

$= 2256 J$.

Then;

$\Delta U = 2256 J - 169.17 J$

$\Delta U = 2086.83 J$.

$\therefore$ Internal energy $= 2086.83 J$.

Qn 8. (b) (i) - During the emission of radiations from the black body, its temperature do not becomes zero kelvin because it also absorbs radiant energy from the surroundings while emitting at the same time.

- In accordance to Prevost's theory the blackbody emitt energy to surrounding and absorb energy from the surrounding at the same rate when reaches equilibrium. As a result its temperature never be ok (ii). Given: radius, $r = 1m$.

Temperature, $T = 30°c = (30+273)K$.

$= 303 K$

time, $t = 4$ seconds

Required: Heat radiated dH.

From; stefan's Law

$$P = \sigma \varepsilon A T^4.$$

$$dH/dt = \sigma \varepsilon A T^4$$

$$dH = \sigma \varepsilon A T^4 . dt.$$

- Since a ball is black body; $\varepsilon = 1$

while it's area $= 4\pi r^2$.

Then: $dH = (5.67 \times 10^{-8} \times 4\pi \times 1^2 \times 303^4 \times 4) J$

$dH = 24.01 \times 10^3 J$

$\therefore$ Heat radiated $= 24.01 \times 10^3 J$.

(ii). Given: radius, $r = 1m$.

Temperature, $T = 30°c = (30+273)K$.

$= 303 K$

time, $t = 4$ seconds

Required: Heat radiated dH.

From; stefan's Law

$$P = \sigma \varepsilon A T^4.$$

$$dH/dt = \sigma \varepsilon A T^4$$

$$dH = \sigma \varepsilon A T^4 . dt.$$

- Since a ball is black body; $\varepsilon = 1$

while it's area $= 4\pi r^2$.

Then: $dH = (5.67 \times 10^{-8} \times 4\pi \times 1^2 \times 303^4 \times 4) J$

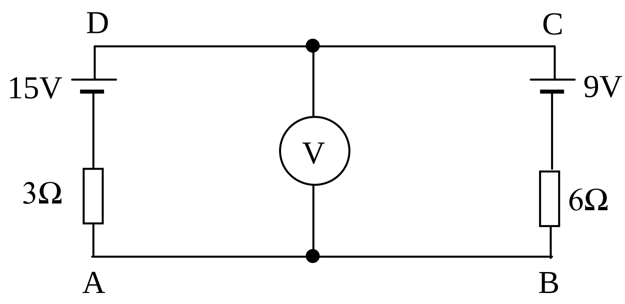
$dH = 24.01 \times 10^3 J$

$\therefore$ Heat radiated $= 24.01 \times 10^3 J$.

Extract 1.8.2, a sample of an answer of a candidate who responded correctly and systematically to most parts of the question. For example, in part (b) (i), he/she gave strong reasons for why the temperature of a black body does not reach zero Kelvin when emitting radiations.

2.1.9 Question 9: Current Electricity (Electric Conduction in Metals)

This question had parts (a), (b) and (c). Part (a), required the candidates to: (i) give the definition of the term node as applied to the electric circuit, and (ii) outline three important points which are usually referred as sign convection in solving Kirchhoff's second law problems. Part (b) required them to: (i) differentiate between Ohmic conductor and Non-ohmic conductor and give one example in each case, and (ii) study the following circuit then find the reading on the high resistance voltmeter V.



In part (c), the candidates were required to: (i) explain why e.m.f of a cell is sometimes called "a special terminal potential difference", and (ii) calculate the current flowing in the circuit when three similar cells each of e.m.f 1.5 V and internal resistance of 0.3 Ω are connected in parallel across a 2 Ω resistor. The question was attempted by 89.7 percent of the candidates of which, 70.7 percent failed as they scored 0 to 3 marks. 23.9 percent scored 3.5 to 5.5 marks and only 5.4 percent scored 6 to 10 marks. These data are presented in Figure 6.

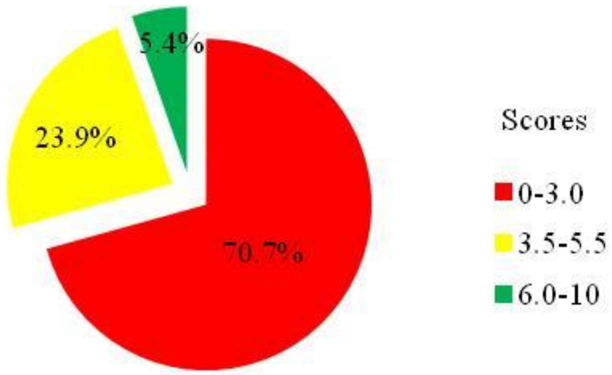


Figure 6: *Performance of candidates in question 9*

From the data given above, the performance of candidates in this question was weak since 29.1 percent only passed the question.

Most of the candidates who scored low marks in this question were not able to respond correctly to most of the question items. They provided correct responses to either one or two question items, especially (b) (i) and (c) (ii). For example, in item (b) (i), most of them gave correct examples of Ohmic and non-ohmic conductors, but gave a wrong distinction between the two types of conductors. Some of them also skipped to answer some question items indicating that they were incapable of attempting them. Among the challenges which might have contributed for the candidates to show weak responses in this question include: inability of most of them to respond precisely to some question items that required explanations due to language problems and lack of knowledge of Kirchhoff's laws and their applications in solving the question from the given circuit. Other candidates did not understand the term node. In this case, most of them defined node using the concept of wave instead of referring to the concept of electricity. The following extract shows the responses given by one of the candidates who had poor performance in this question.

Extract 1.9.1

9a i.

ii. i. Total current flowing in a conductor is equal to total potential difference leaving the current

ii. In series ~~ele~~ circuit connection current is the same throught

iii. In parallel connection the potential difference is the same throught

b i. ohmic conductor have the same current flowing each point of a wire. while Non ohmic conductor have different current flowing each point in a wire when current flow is one ampire

ii. $V = IR$

$= 9 \times 6$

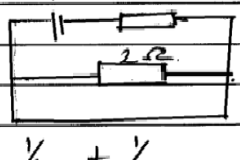
$= 54V$

c i ~~iii~~ because the current flowing out of it diffrent ~~from~~ with the source of current

ii.

1.5V 0.3Ω

2Ω



$1/R_T = 1/0.3 + 1/2$

Extract 1.9.1, a sample of an answer of a candidate who provided responses with various errors to most of question items performed. For example, in (a)(ii), he/she stated that *"total current flowing in a conductor is equal to total potential difference leaving the current"*. This statement is incorrect conceptually as well as to the demand of the question.

Most of the candidates who scored well (6 to 10 marks) in this question managed to give correct responses to many question items. It was noted that most of them missed 1 to 3 marks to score all the marks in this question. Most of them, were challenged with items (a) (i) or (c) (i) or both. The challenges in (a) (i) were due to the fact that, the term node is more common in the topic of Vibrations and Waves than in Current Electricity where it is explained under the discussion of Kirchhoff's laws as the junction of three or more branches of current. Item c (i) was also challenging because it required critical thinking from the candidates. Nevertheless, there were few a candidates who had superior competences in the topic of Current electricity, hence provided correct answers to each part of the question and scored all 10 marks allotted in this question. Extract 1.9.2 is an example of the work of one of the candidates who managed to perform well in this question.

Extract 1.9.2

9. a) i/ Node – Is a junction in the circuit where by current meets or leaves the circuit.

ii/ Important ~~laws~~ points in Kirchoffs second law

1. Choose as many as possible loops in the circuit.
2. Show the direction of the current through the resistors.
3. Write the voltage relation and Electromotive force and solve the equations to obtain the potential difference drops.

b) i/ Ohmic conductors is the type of conductor which obeys Ohm's law, that is linear variation of current and voltage at constant Resistance.

$I \propto V$

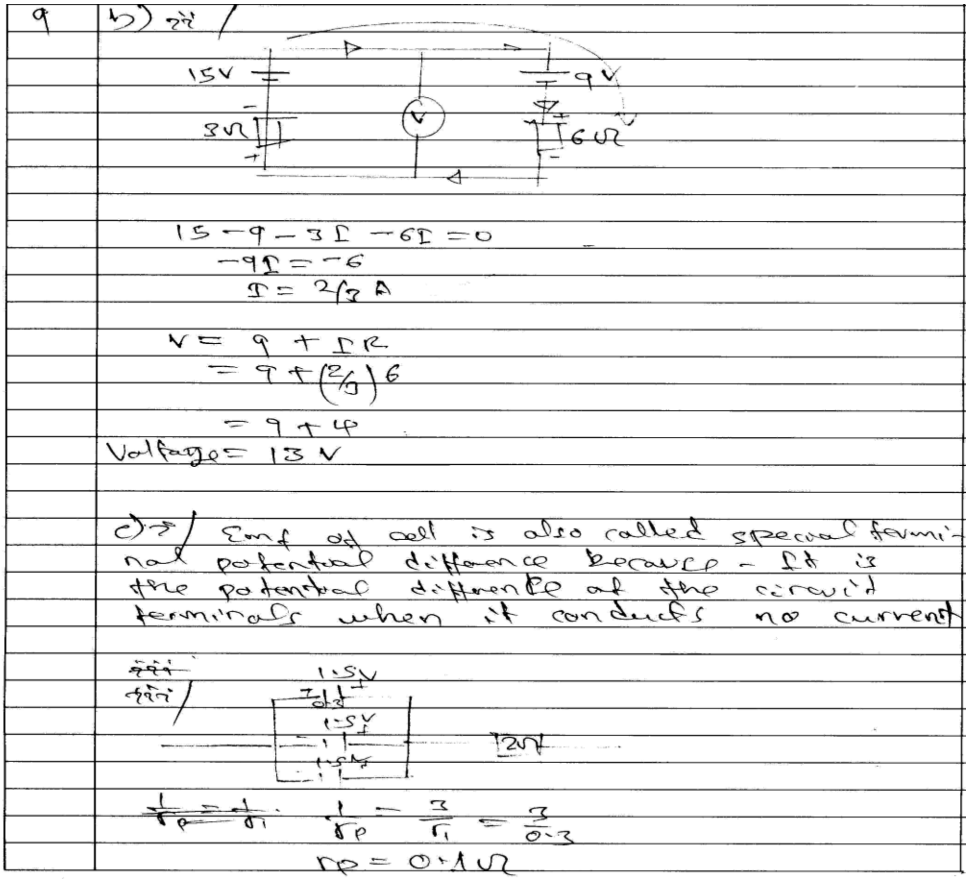
Example copper wire

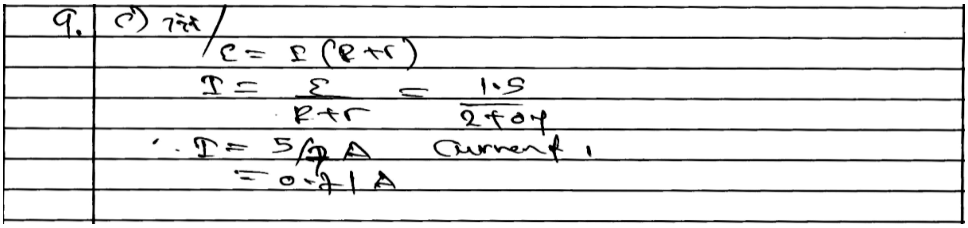
While

Non-Ohmic conductors is the type of conductor which does not obey ohm's law and ordinary condition

Example

Silicon.





Extract 1.9.2, a sample of correct responses provided to most parts of the question. For example, the candidate was able to apply Kirchhoff's law to solve correctly the question item in (b)(ii).

2.1.10 Question 10: Current Electricity (Alternating Current, A.C)

This question was divided into three parts: (a), (b) and (c). In part (a), the candidates were required to: (i) mention four types of energy losses suffered by a transformer, and (ii) explain why choke coil is preferred over resistance to control alternating current. In part (b), they were required to: (i) identify two difficulties which would arise when two straight wires are used to transmit electricity direct from the source to the city station, and (ii) explain what could be done to light a 30 V bulb from a 220 V A.C supply. In part (c), they were required to determine: (i) maximum current flowing in the circuit, and (ii) source frequency for which the current is maximum, given that, a series LCR circuit with inductance L = 0.12 H, capacitance C = 480 nF and resistance R = 23 Ω is connected to a 230 V variable frequency supply.

A total of 7,891 candidates (40.4%) attempted this question. Analysis of the performance of the candidates revealed that the majority (87.6%) of them scored low marks ranging from 0 to 3 while 11.3 percent scored 3.5 to 5.5 marks and the minority (1.1%) scored 6 to 10 marks. (Figure 7).

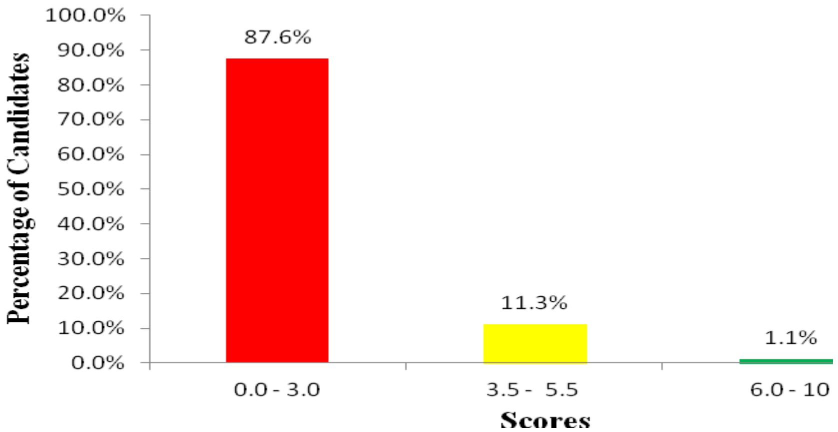


Figure 7: *Performance of candidates in question 10*

The data depicted above indicates that the performance of the candidates in this question was weak since only 12.4 percent passed the question by scoring marks greater or equal to the pass mark (3.5).

Responses from most of the candidates who scored marks from 0 to 3 were noted to possess various errors including writing wrong formulae, incorrect calculations and provision of invalid reasons to some explanations. The responses of those who scored 0 marks (46.3%), revealed lack of the basic knowledge on Alternating Current. Therefore, they failed to give correct answers to some question items like, (a) (i) and (c) which required them to recall basic concepts or formulae related to A.C. Such a big failure in this question indicates that the assessed areas of the topic were not understood by the majority of the candidates or probably not covered in class or through students' self initiatives. Extract 1.10.1, shows the responses given by one of the candidates who had poor performance in this question.

Extract 1.10.1

Qn 10 (i) types of energy loses by a transformer are;
(i) potential energy
(ii) kinetic energy.
(iii) ~~mech~~ internal energy.
(iv) thermal energy.

(ii) Because the altenating current changes all thetime.

(b)(i) (i) problem of reliability due to presence of many soldered points.
(ii) electric shock

(ii) Nothing wouldbe observed because the 30V is small compared to 240

Qn 10 (c) solution.
Required: Maximum current.
From imperdence
$Z = \sqrt{R^2 + (X_L - X_C)^2}$

But
$X_L = \omega L$
$X_L = 2\pi f \cdot L$

and $X_C = 1/\omega C$

$X_C = \frac{1}{2\pi f C}$.

$Z = \sqrt{R^2 + \frac{2\pi f L}{1} - \frac{1}{2\pi f C}}$ $\frac{}{2\pi f C}$.

$Z = \sqrt{R^2 + \frac{4\pi^2 f^2 LC - (\cancel{2\pi} 1}{2\pi f C}}$.

$Z = \sqrt{R^2 + \frac{4\pi^2 f^2 LC - 1}{2\pi f C}}$.

$Z = \sqrt{R^2 + \frac{4\pi^2 f^2 LC - 1}{2\pi f C}}$

therefore

$I = V/Z$

$I = \frac{250}{\sqrt{(23)^2 + \frac{4\pi^2 \times f^2 \times 0.12 \times 480 \times 10^{-9}}{2\pi f \times 480 \times 10^{-C}}}}$

9n 10c	Since frequence unit provided the numerical value of I will not be obtained and therefore the maximum current will be
	$I = \frac{250}{\sqrt{(23)^2 + 4\pi^2 \times f^2 \times 0.12 \times 450\times10^{-9}}} \over 2\pi f \times 450\times10^{-9}$ Ampere.
(ii)	Solution.
	Required: Source frequency.
	From
	$Z = \sqrt{R^2 + XL^2 - Xc^2}$
	$Z^2 = R^2 + (XL - Xc)^2$
	$Z^2 = R^2 + (XL - Xc)^2$
	Since $XL = wL$ and $Xc = 1/wc$
	$Z^2 = R^2 + \left(wL - \frac{1}{wC}\right)^2$
	$Z^2 = R^2 + \left(\frac{2\pi f L}{1} - \frac{1}{2\pi f c}\right)^2$. $\overline{2\pi f c}$
	$Z^2 = R^2 + \left(\frac{4\pi^2 f^2 L - 1}{2\pi f c}\right)^2$.
	$Z^2 = R^2 + \frac{8\pi^4 f^4 L^2 - I^2}{4\pi^2 f^2 c^2}$
	$Z^2 - R^2 = \frac{2\pi^2 f^2 L^2 - 1}{c^2}$
Qn 10	then $Z^2 - R^2 + 1 = \frac{2\pi^2 f^2 L^2}{c^2}$
	multiply by c^2 both sides.
	$(Z^2 - R^2 + 1) c^2 = 2\pi^2 f^2 L^2$
	Divide by $2\pi^2 L^2$ both sides.
	$f^2 = \frac{(Z^2 - R^2 + 1) c^2}{2\pi^2 L^2}$
	Square both sides
	$f = \sqrt{\frac{(Z^2 - R^2 + 1) c^2}{2\pi^2 L^2}}$
	∴ the frequence will be $\sqrt{\frac{(Z^2 - R^2 + 1) c^2}{2\pi^2 L^2}}$

Extract 1.10.1, a sample of an answer of a candidate who provided incorrect responses to most of the question items. For example in (a) (i), he/she listed various kinds of energy which are studied in mechanics and heat topics instead of types of energy losses suffered by a transformer.

A few candidates in the category of those who scored high marks (6 to 10 marks) were able to answer correctly each part of the question, hence scored all the marks. The rest in this group were not able to give correct responses to some question items especially (a) (ii) and (b) (i). These question items were meant to measure the ability of the candidates to reason critically, hence evaluating higher cognitive level. Extract 1.10.2 shows an example of good responses for this question.

Extract 1.10.2

10 (a) (i) Types of Energy Losses in transformer.

— Iron loss

— copper loss.

— Hysteres loss.

— Magnetic flux loss.

(ii) Choke coil has no power loss in transmition.

10 (b)(i) — Heating effect — which reduce some energy.

— Impendence increase as the distance increase which reduce ~~the~~ the energy transmitted

(b)(ii) Since the supply is of high voltage ~~&~~ the source should be stepped down by step down transformer

10 (c) (i) Solution

$L = 0.12H$

$R = 23\Omega$.

$V = 230V$.

$C = 480nF$.

For maximum current to be ~~obt~~ obtained should be at Resonance.

(Inductive reactance) $X_L = X_C$ (capacitive reactance)

From $V = IR$

$I = V/R$.

$= 230/23$

$= 10A$

but

$I_{rm} = I_0/\sqrt{2}$

$I = I_{rm}\sqrt{2}$

$= 10\sqrt{2}$

maximum current $= 14.14A$

10 (c) (ii) Now for frequency of resonance

$f = \dfrac{1}{2\pi\sqrt{LC}}$

$= \dfrac{1}{2\pi\sqrt{0.12 \times 418nF}}$

$= 669.48\ Hz$

$\therefore$ The frequency is $669.48\ Hz$

Extract 1.10.2, a sample of correct responses given to most of question items except in part (a) (ii) where the candidate wrote, "*choke coil has no power loss in transmission*" instead of *"choke coil has small amount of electrical power loss"*.

2.1.11 Question11: Electronics (Semiconductors)

This question consisted of three parts namely (a), (b) and (c). Part (a), required the candidates to: (i) list two chief properties of semiconductors, and (ii) explain why it easier to establish the current in a semiconductor than in an insulator. Part (b), required them to: (i) state a condition that could be employed to make an insulator conduct some electricity, and (ii) distinguish between conductor and semiconductor on the basis of their energy band structures. In part (c), the candidates were required to: (i) give the meaning of a depletion layer as used in p-n junction device, and (ii) describe the effect of applying a reversed bias to the junction diode.

The candidates who opted for this question were 19,094 which is equivalent to 97.7 percent of the candidates who sat for 131/1 Physics

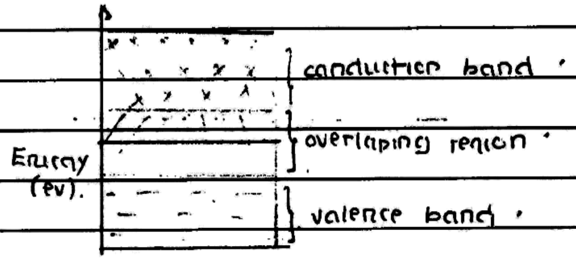
Paper 1. Among them, 43.1 percent scored marks ranging from 0 to 3, 39 percent scored 3.5 to 5.5 and 17.9 scored 6 to 10 marks. These data implies that the performance of the candidates in this question was average, since 56.9 percent of them scored marks greater or equal to the pass mark (3.5 marks).

Some candidates, among those who performed well, scored all the marks after providing correct answers to each question item. They were conversant with the concepts related to semiconductor and insulators, hence listed correctly the chief properties of semiconductors and explained perfectly well the reasons for why it is easier to establish the current in a semiconductor than in an insulator. Basing on the physical properties which reduce the resistance of a material, most of them were able to state the condition that could be employed to make an insulator conduct some electricity. Majority of them also gave clear distinctions between a conductor and a semiconductor in terms of energy band structures. In addition, a good number of them were capable of applying the knowledge of formation of junction diode to define the depletion layer as used in p-n junction device. Furthermore, most of them described clearly the effect of applying a reversed bias to the junction diode. Extract 1.11.1 shows the responses of one of the candidates who provided good answers in this question.

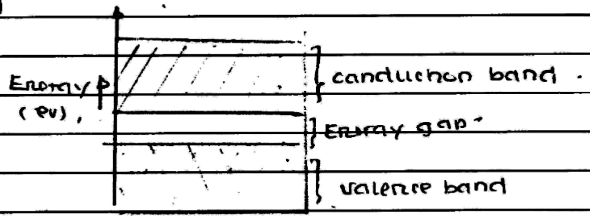
Extract 1.11.1

11	(a)(i) Its resistivity lies between of that of conductors and
	insulators.
	(ii) Semiconductors have negative temperature
	coefficient of resistance.
11 a	(ii) This is because forbidden band in an insulator is
	large compared to that of semiconductors, hence,
	valence electrons in semiconductors require less amount
	of energy to jump to conduction band compared with
	that of insulators. Hence, it is easily to establish
	current in a semi-conductor
b	(i) Under high temperature and high voltage to
	cause electrons to jump from valence band to
	conduction band.

11 (c) conductors:- These materials, their conduction band and valence band overlap to each other such that it is easily for electron to jump from valence band to conduction band. No forbidden band.

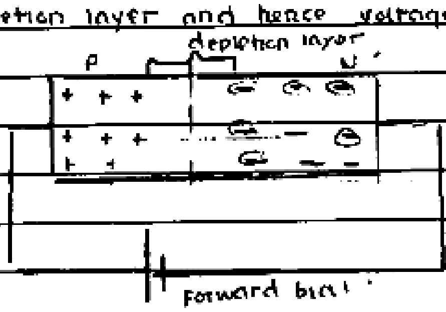


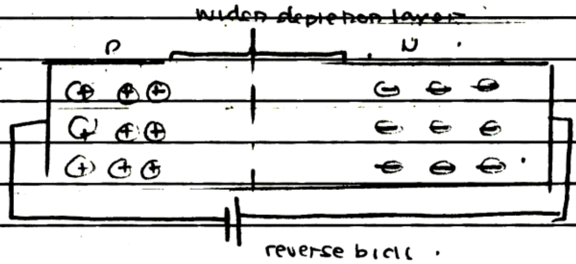
Semiconductors: these materials, contain, conduction, forbidden and valence band. There is no overlaping of conduction band and valence band. The forbidden band is small



c (i) Depletion layer:- Refers to the region on either side of pn junction which is depleted of charge carriers. This occurs due to recombination of holes and electrons.

11 (c)(ii) Applying of a reverse bias to the junction diode cause widen of depletion layer and hence voltage barrier increase





This is because, under reverse bias, holes are attracted toward negative terminal and electrons toward positive terminal and hence widen depletion layer

Extract 1.11.1, a sample of correct responses presented in each part of the question. Well labelled diagrams were drawn to support the given explanations.

On the other hand, most of the candidates who answered this question poorly (43.1%), provided correct responses on part b (ii) only which required them to distinguish between conductor and semiconductors, but failed in most of the other question items. This might be due to the fact that the distinction between conductor and insulator is familiar to students since they were covered in ordinary secondary education. The main reason which could have led to low performance for most of the lower achievers includes: lack of semiconductor knowledge, poor understanding and interpretation of the demands of the question, lack of synthesis and evaluation competences. These led to most of the candidates failing to provide correct answers to some question items especially in parts (a) (ii) and (c) (ii) which required critical thinking competences. Extract 1.11.2, shows an example of responses from one of the candidate who failed in this question.

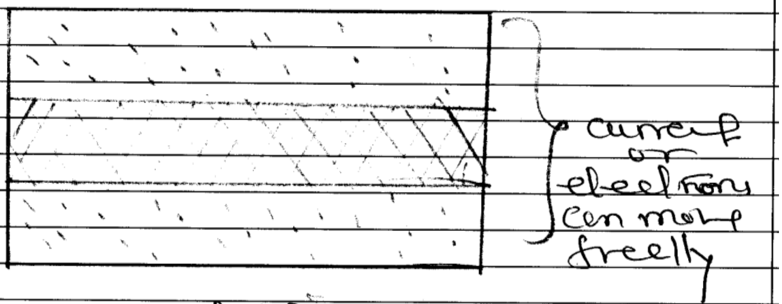
Extract 1.11.2

11.(a)(i) Chief Properties of semi Conductors
(a). should have forbidden gap
(b) should be electrons move freely.

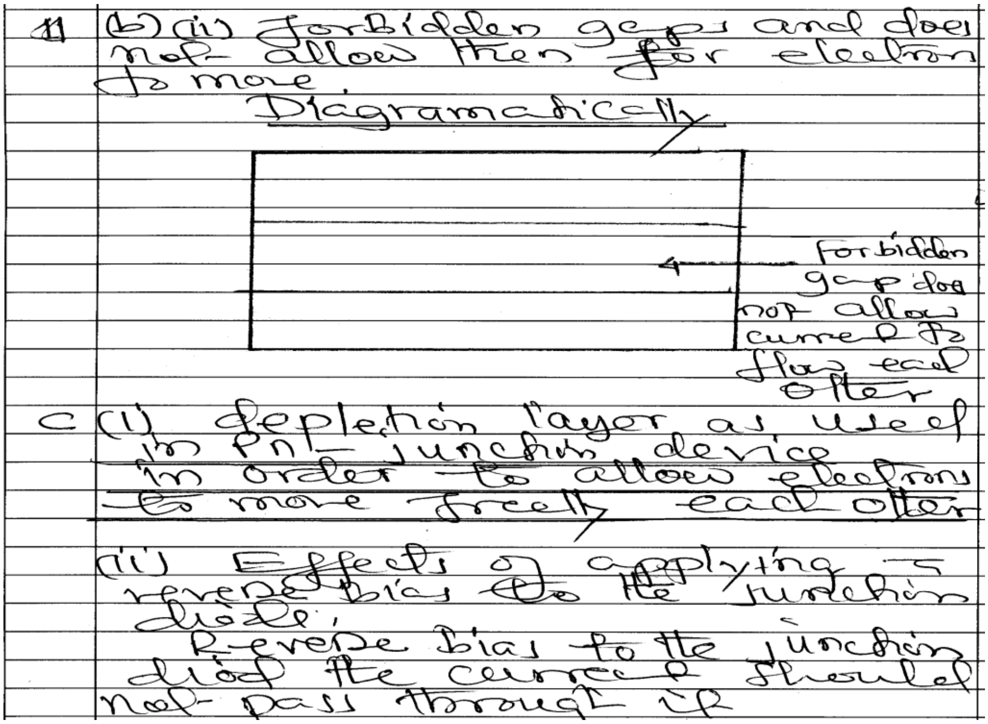
(ii) It easier to establish the current in a semiconductor than in an insulator. This because:
Semiconductor allow electrons or current to flow throughout while Insulator is the divice does not allow current or electrons to move throughout

11(B) (i) method which used to employed to make an insulator conduct some electricity is
(a) Should have a forbidden gaps for electrons to be free to move.
(b) Should wrapted by using ions in order to allow current to flow through it.

(ii) Conductors are the materials which can allow current or electrons to move free when are forbidden gaps are clossely each other.
Diagramatically



while
Semiconductors are the materials which does not allow current or electrons to move each other because contain



11 (b) (ii) Forbidden gaps and does not allow then for electron to move.

Diagramatically

Forbidden gap does not allow current to flow each other

c (i) depletion layer as used in PN junction device in order to allow electrons to move freely each other

(ii) Effects of applying reverse bias to the junction diode,

Reverse bias to the junction diod the current should not pass through it

Extract 1.11.2, shows a sample of a candidates' responses which do not fulfil the demands in most parts of the question items and hence scored low marks.

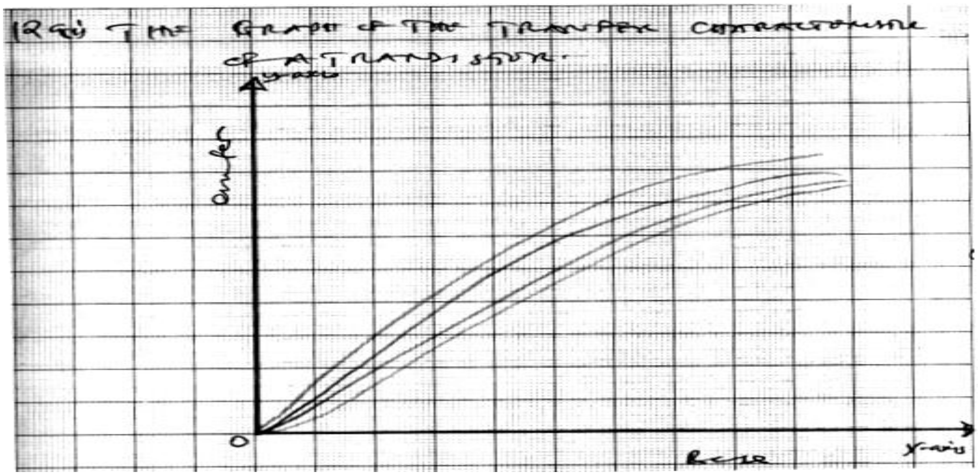
2.1.12 Question 12: Electronics (Transistors)

This question consisted of three parts (a), (b) and (c). In part (a) the candidates were required to: (i) sketch the graph of transfer characteristic of a transistor, and (ii) state the significance of the slope from the graph in (a) (i). In part (b) they were require to: (i) give basic conditions for a transistor to operate properly as an amplifier, and (ii) explain how a junction transistor can be connected to act as a current operated device. Part (c) required the candidates to: (i) explain why the magnitude of output frequency of a full wave rectifier is twice the input frequency, and (ii) draw a simple basic transistor switching circuit diagram.

The question was attempted by 55.5 percent of the candidates. Among them, 82.8 percent scored marks ranging from 0 to 3, 13.6 scored 3.5 to 5.5 marks and only 3.6 percent scored 6 to 10 marks. Therefore, the performance of the candidates in this question was weak since only 17.2 percent of them were able to score above the pass mark. This indicates that, majority of the candidates had insufficient knowledge on Electronics especially the subtopic of Transistors where the question items came from.

In the category of those who scored low marks (0 - 3), 44.3 percent of them scored 0 marks. Among the factors which led to this worst score includes lack of both knowledge and competence of the content from which the question was constructed. Most of them decided to write anything they learnt in the topic. Some of them had forgotten key terms hence, their explanations or definitions missed validity. It is also possible that, this topic was not well covered in the class or by the students through self study initiatives. Extract 1.12.1 is an example of responses from a candidate with poor scores in this question.

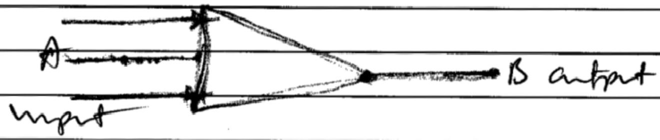
Extract 1.12.1



12 The graph of transfer characteristic of a transistor can be drawn on the graph paper

The significant of the slope from the graph is

12 (c) The diagram of the simple basic transistor switching circuit diagram



(ii) The magnitude of the output frequency of a full wave rectifier is twice the input frequency because of the efficient made by full wave rectification

b The basic condition for the transistor to operate properly as an amplifier are

(i) To amplifying the signal of the circuit

(ii) Used as the switch to switch circuit

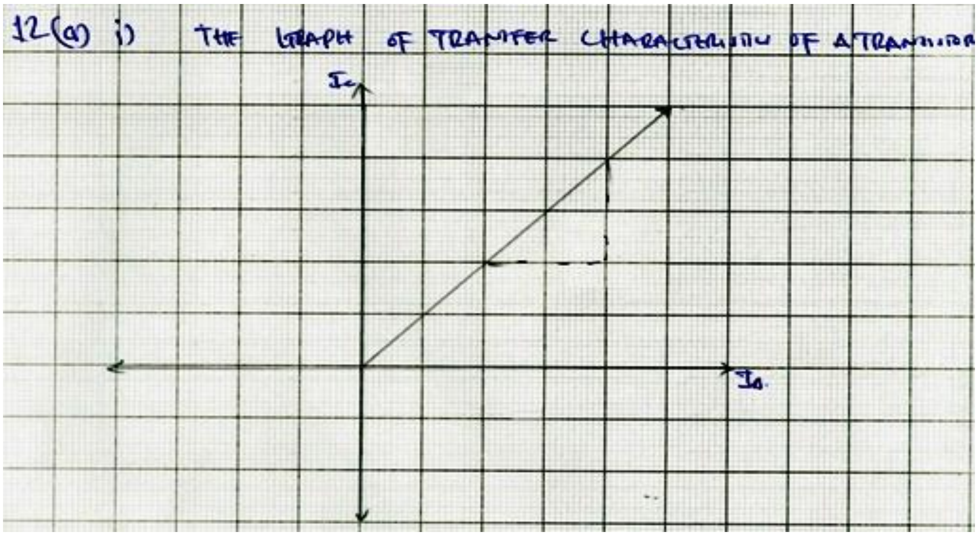
(iii) Used as the detector used in alarm system.

Extract 1.12.1, a sample of irrelevant answers provided in each attempted question item. For example, in part (a) (i), instead of a graph of transfer characteristics, a collector base output characteristics graph was sketched while in part (c) (ii), a logic gate symbol was drawn instead of switching circuit.

Furthermore, most of those who scored marks from 3.5 to 5.5, were noted to perform well in the question items in parts (a), (b) (i) and (c) (ii), but failed those in part (c). This might be due to the fact that the concepts assessed by the former question items are among the common ideas in the subtopic of Transistors. Actually, part (c) required the candidates to have higher cognitive ability and competences beyond just recalling the symbols.

The question item also demanded good organization and drawing skills. Therefore, only 0.1 percent of the candidates were capable of doing that as well as giving correct answers to other parts of the question. Extract 1.12.2 represents the responses of one of the candidates who scored all 10 marks in this question.

Extract 1.12.2



12 a) (i) Graph of tranfer characteristics

(ii) from the graph slope = !

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

$$= \frac{\Delta I_c}{\Delta I_B} = \alpha$$

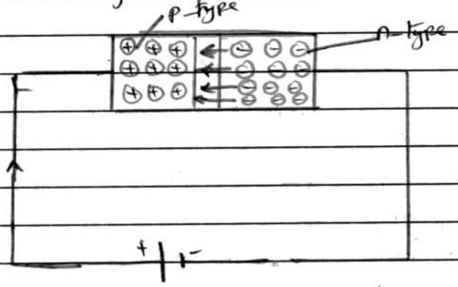
- This signify the amplification factor of a transistor

b) (i) A condition for a transistor to operate properly as an amplifier is that the base-emitter circuit should be forward biased and collector emitter circuit should be reverse

12 b) (i) biased.

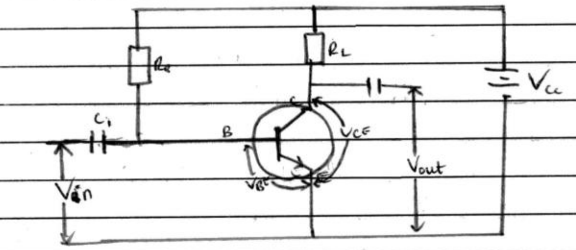
ii) The junction transistor should be connected in forward biased Mode so as to act as a current operated device. Because In forward biased mode the depletion layer at the junction decreases and hence depletion potential decrease, also, this allow the eletrons to move across the junction and hence conduction of current.

Consider the diagram below.



c) i) The magnitude of output frequency of a full wave rectifier is twice the input frequency, because in full wave rectification there are two pathways in which amplification takes place and hence frequency to be amplified twice. Example in Center-tap full wave rectification the two diodes are used and also frequency Must be doubled.

(ii) A simple basic transistor switching circuit diagram.



12 c) (ii) where

V_{cc} – is the voltage supply

V_{in} – is the input voltage

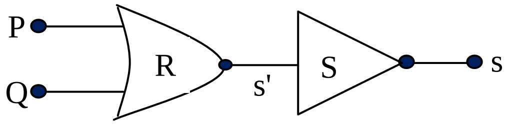
V_{out} – is the output voltage

R_L – is the Load resistance.

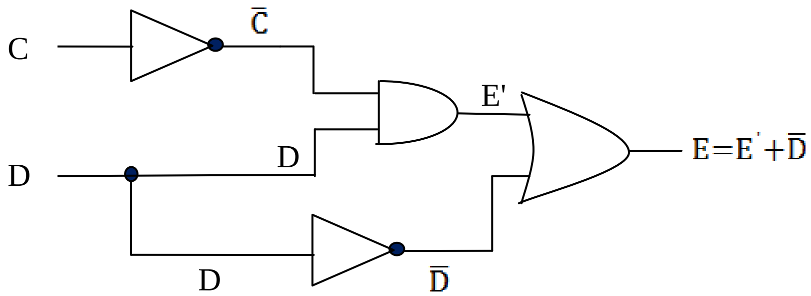
Extract 1.12.2, a sample of an answer from a candidate who responded correctly and systematically in each part of the question items. For instance in (b) (ii) correct explanations with supporting diagram were given to show how a junction transistor can be connected to act as a current operator device.

2.1.13 Question13: Electronics (Logic Gates)

This question had three parts namely (a), (b) and (c). In part (a) the candidates were required to: (i) give the meaning of the term "logic gate", and (ii) list three basic logic gates that make up all digital circuits. In part (b) they were required to: (i) identify the logic gates marked R and S in the following figure, and (ii) write down the output at 's' when $P = 1$ and $Q = 1$ as well as when $P = 0$ and $Q = 0$.



In part (c), they were required to obtain the truth table for the circuit shown in figure below.



97.8 percent of the candidates attempted this question and the performance was as follows: Those who scored marks ranging from 0 to 3, 3.5 to 5.5 and 6 to 10 were 14.6, 19.3 and 66.1 percent, respectively. These data implies that the performance in this question was good since 85.4 percent of the candidates scored marks above the pass mark. This indicates that most of the candidates acquired the intended knowledge and were competent in the topic of Electronics, particularly in the subtopic of Logic Gates.

The group of candidates who had good performance (66.1%) comprised of 4.1 percent of those who managed to answer correctly each item in this question. Those were having adequate knowledge of logic gates, since they were able to define correctly the term logic gate as applied in digital electronics and listed accurately the three basic logic gate that make up all digital circuits. They were also able to identify that, the logic gate marked R was a NOR gate and S, was a NOT gate. They were also capable of applying operational principles of binary numbers (0 and 1) to construct appropriately the truth table of the given logic circuit and find the output at "s" in part (c). Extract 1.13.1 shows good responses for this question from a candidate who managed to provide correct answers to most of the question items.

Extract 1.13.1

13 a) i/ A Logic gate - is the type electronic circuit which makes logical decisions with two or more input and give out only one output.
Example OR-gate

ii/ Basic logic gates
1. OR-gate
2. AND-gate
3. NOT-gate

b) i/ R - NOR-gate
S NOT-gate

ii/

Input			Output
P	Q	S'	S
1	1	0	1

When P = 1, Q = 1
The output at S is 1.

Input			Output
P	Q	S'	S
0	0	1	0

When P = 0, Q = 0
The output S = 0

13. c) Truth table

Input					Output
C	D	$\bar{C}$	$\bar{D}$	$\bar{E}$	E
0	0	1	1	0	1
0	1	1	0	1	1
1	0	0	1	0	1
1	1	0	0	0	0

Extract 1.13.1, a sample of an answer of a candidate who managed to provide precise definition of logic gate and was able to find correctly the output at "s". He/ she also constructed a correct truth table in part (c).

In the group of those who performed poorly, 4.9 percent provided wrong answers for each question item hence, scored 0 marks. The other 9.7 percent were able to answer correctly a few question items particularly those in part (a) and item (b)(i). These items required a recall of the concepts (knowledge level of cognitive domain). Generally, the concepts examined in these question items are very common ones in the topic of Electronics. Most of the candidates failed to answer parts (b) (ii) and (c) which required higher cognitive levels involving application, analysis and synthesis of ideas. Extract 1.13.2 shows the work of one of the candidates who attempted this question poorly.

Extract 1.13.2

13. a) i/ A logic gate is gate whereby current or volts are economised.

ii/ 3 basic logic gates are:
i/ NOR - gate
ii/ OR - gate
iii/ NAND - gate

b/ i/ R = OR gate
S = NAND gate

ii/

P	Q	S
1	1	1
1	0	1
0	1	1
0	0	0

When P = ~~0~~ 1
Q = 1

When P = 0
Q = 0

P	Q	S
0	0	0
1	0	1
0	1	1
1	1	1

13. c/

C	$\bar{C}$	D	$\bar{D}$	E'	E = E' + $\bar{D}$
1	1	1	1	0	1
1	1	0	0	0	0
0	0	1	1	0	1
0	0	0	0	1	1

Extract 1.13.2, a sample of responses which were incorrect with respect to the demands of the question items. For instance, in (a) (ii), the candidate mentioned various logic gates he/she knew instead of the basic logic gates.

2.1.14 Question 14: Environmental Physics

This question consisted of three parts namely (a), (b) and (c). In part (a), the candidates were required to: (i) give a meaning of solar constant, and (ii) list two factors on which the solar constant depends. In part (b) they were required to: (i) give two advantages of photovoltaic system, and (ii) explain briefly how photovoltaic cell works. In part (c), the candidates were required to: (i) estimate the maximum power available from 10 m^2 of solar panel, and (ii) calculate the volume of water per second which must pass through when the inlet and outlet temperatures of the panel are at 10 ^oC and 60 ^oC, respectively under the assumption that waves carry away energy at the same rate as the maximum power available.

The number of candidates who opted for this question was 9539, corresponding to 48.8 percent. Their performance was as follows: 75.8 percent scored marks ranging from 0 to 3, (including 44.2 % who scored 0 marks), 15.9 percent scored 3.5 to 5.5 marks while 8.3 percent scored 6 to 10 marks including nine (9) candidates who scored all the10 marks allotted in this question. The performance of the candidates in this question is presented in Figure 8.

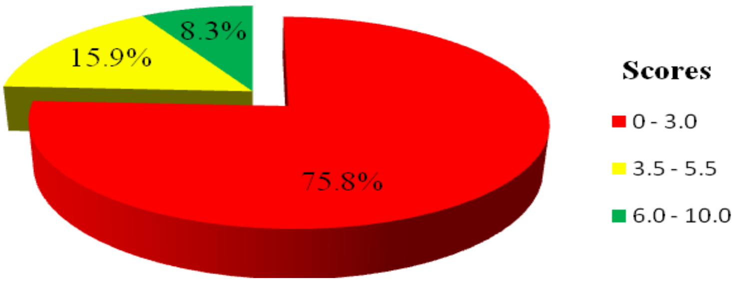


Figure 8: *Performance of candidates in question 14*

The general performance in this topic was weak since only 24.2 percent of the candidates scored marks within or above the pass mark. The performance on the same topic for last year (2017) was good as 83 percent of the candidates passed (Appendix A). This big drop of performance (from good to weak) indicates that some areas of the topic were not well understood by the students. Therefore, it is advised that during the teaching/learning of this topic, concentration should be given to each objective of the topic as contained in the syllabus to make students conversant in all areas.

Most of those who scored marks within the failure range (0 to 3 marks) were not able to define solar constant in (a) (i), hence, failed to respond correctly to part (c) since it required the concept of solar constant. Most of the candidates within this category lacked knowledge on the principle of photovoltaic cell, thus, failed to mention its advantages and mechanism. Extract 1.14.1 shows one of the work of a candidate with low performance in this question.

Extract 1.14.1

14 (a) (i) Solar Constant.

Is the amount of radiant energy (radiations) emitted by the sun toward the other body due to the absolute temperature.

(ii) The solar constant depends.

01. Absolute temperature.

02. Radius of the sun and that of the body

(b) Advantages of photovoltanic system.

01. It is used in the establishment of galvanic cells.

02. It is used

(c) (i) Given: Area, $A = 10\,m^2$.

required; Power.

From, $P = \sigma \varepsilon_o A T^4$.

but solar constant $= \sigma A T^4$.

$P = \cancel{\sigma} \varepsilon \delta A T^4$.

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

$= 5.67 \times 10^{-7} T^4$.

∴ Power available $= 5.67 \times 10^{-7} T^4$ interms of temperature available.

14. (c) (ii) Given; Temperature $T_1 = 10°C$.

Temperature $T_2 = 60°C$.

Required; volume of water.

From; $P = \sigma \varepsilon A T^4$.

$V/t = 5.67 \times 10$

From. Prevost's law.

Extract 1.14.1, a sample of an answer from a candidate who gave incorrect definition of solar constant and used incorrect formula to calculate maximum power from the solar panel. The other given responses were also incorrect hence he/she scored 0 marks in this question.

A total of 9 candidates who scored all the marks in this question had adequate knowledge hence, they were able to recall the concept of solar constant and the factors on which it depends. They also gave precise explanations on the advantages and mechanism of photovoltaic system. Moreover, they were capable to interpret the demands of the question and link them with the concepts of Heat as well as Fluid Dynamics. A good number of them estimated well the maximum power in a solar panel and the volume of water per second which must pass through the panel. Such precise responses demonstrated their interpretational, analytical and synthetic reasoning competences with regard to the subtopic of Energy from the environment, particularly Photovoltaic System. Extract 1.14.2 shows one of good responses for this question.

Extract 1.14.2

14 (a) (i) Solar constant is the amount of solar energy received per second per unit surface area placed perpendicularly with the sun rays on earth's surface

(ii) (i) The orientation of the place with respect to sun rays (latitude)

(ii) The time during the day as the sun energy reaching the earth changes as with change in time of the day

(b) (i) (i) Photovoltaic system do not produce any waste to the environment

(ii) Photovoltaic cells can be arranged in series and parallel to provide the required voltage and current

(b) (ii) Photovoltaic cell consists of semiconductors in which one is positive and another is negative. As light from the sun falls on it, electrons are knocked off from negative semi-conducter to the positive one. In the process electromotive force is generated

(c) (i) Data given:

Area (A) = $10m^2$

Solar Constant(C) = $1.4 kWm^{-2}$

From

Maximum power = A · C

14 $\Rightarrow P_{max} = (10 \times 1.4\times10^{3})(m^{2} \times W\,m^{-2})$

$P_{max} = 14000\,W$.

$\therefore$ Maximum power $= 14000\,W$

(c) (ii) Given $\theta_1 = 10^{\circ}C$

$\theta_2 = 60^{\circ}C$

from:

$P_{max} = (m/t)(C_w)\,\Delta\theta$

But

$P_{max} = 14000\,W$

$C_w = 4200\,J\,kg^{-1}K^{-1}$

$\Delta\theta = 60 - 10 = 50^{\circ}C$

$\Rightarrow (m/t) = \dfrac{P_{max}}{c\,\Delta\theta}$

$\Rightarrow (m/t) = \left(\dfrac{14000}{4200\times50}\right) kg\,s^{-1}$

$\Rightarrow m/t = 0.06667\,kg\,s^{-1}$

$\Rightarrow (m/t) = \left(\dfrac{\rho V}{t}\right)$, $\rho = 1000\,kg\,m^{-3}$

$\Rightarrow (V/t) = \dfrac{0.06667\,kg\,s^{-1}}{1000\,kg\,m^{-3}}$

$V/t = 6.67\times10^{-5}\,m^{3}s^{-1}$

$\therefore$ Volume processed $= 6.67\times10^{-5}\,m^{3}s^{-1}$

Extract 1.14.2, a sample of an answer from a candidate who presented neat and correct responses to each question item. For example in (c) (ii) he/she was able to calculate systematically the volume per second of water which must pass through the panel.

2.2 131/2 PHYSICS 2

This paper consisted of short answer questions constructed from six topics as indicated in the analysis Each question carried a weight of 20 marks and the performance of the candidates were regarded as weak, average and good in the score ranges of 0 to 6.5, 7 to 11.5 and 12 to 20 marks, respectively. In this paper, 7 to 20 marks was taken as the range of pass marks.

2.2.1 Question 1: Fluid Dynamics

This question had four parts namely (a), (b), (c) and (d). In part (a), the candidates were given Bernoulli's equations: $p + \rho gh + \frac{1}{2}\rho v^2 = constant$, then they were required to: (i) explain what does each term on the left hand side of the equation represent, and (ii) mention any three conditions which make the equation valid. In part (b) they were required to calculate the flow rate and the velocity at the outlet of the pipe in the second floor bathroom given that: water is supplied to a house at ground level through a pipe of an inner diameter of 1.5 cm at an absolute pressure of 6.5×10^5 Pa, with a velocity of 5 m/s and the pipe line leading to the second floor bathroom 8 m above has an inner diameter of 0.75 cm. Part (c) required them to define the terms: (i) non-viscous fluid, (ii) stead flow, (iii) line of flow and (iv) turbulent flow as applied to fluid flow. In part (d) the candidates were given a stem of question which reads: "A horizontal pipeline increases uniformly from 0.080 m diameter to 0.160 m diameter in the direction of flow of water. When 96 litres of water is flowing per second, a pressure gauge at 0.08 m diameter section reads 3.5×10^5 Pa". Then they were required to calculate the reading of the gauge at the 0.160 m diameter section while neglecting any loss.

The question was opted for by 93.1 percent of the candidates whereby 18.5 percent of these candidates scored marks ranging from 0 to 6.5 (including 1.4 percent who scored 0 marks out of 20 marks), 35.5 percent scored 7 to 11.5 marks and 46 percent scored 12 to 20 marks. The performance for this question was good since the majority of candidates (81.5%) passed the question by scoring marks greater or equal to 7. This implies that the candidates had acquired the intended knowledge, skills and competences on the assessed areas of the topic of Fluid Dynamics. The data stated above are summarised in Figure 9.

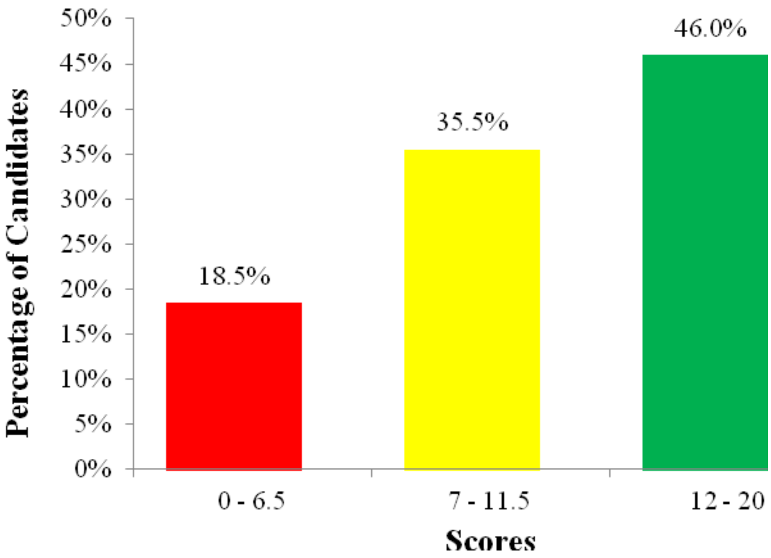


Figure 9: *Performance of candidates in question 1*

The candidates who scored 12 to 20 marks showed a good understanding of the question as they presented their responses systematically and correctly. Most of them were able to identify and apply the principle of continuity and Bernoulli's Principle which were necessary for carrying out the calculations in this question. Their responses were also free from errors, indicating that they mastered well the content of the topic of Fluid Dynamics and they were having adequate mathematical skills to carry out the calculations. Extract 2.1.1 shows a sample of responses of one of the candidates who did well in this question.

Extract 2.1.1

01. (a)

Given: $P + \rho g h + \frac{1}{2}\rho v^2 = K$.

(i) Required: Representation of each expression.

Then: P is Pressure energy per unit volume

$\rho g h$ is Potential energy per unit volume

$\frac{1}{2}\rho v^2$ is Kinetic energy per unit volume.

(ii). Conditions for validity of Bernoulli's theorem

(a) The fluid must be non- viscous
(b) The fluid must be Incompressible fluid
(c) The fluid flow must be steady fluid flow
(d) The fluid must be Irrotational fluid

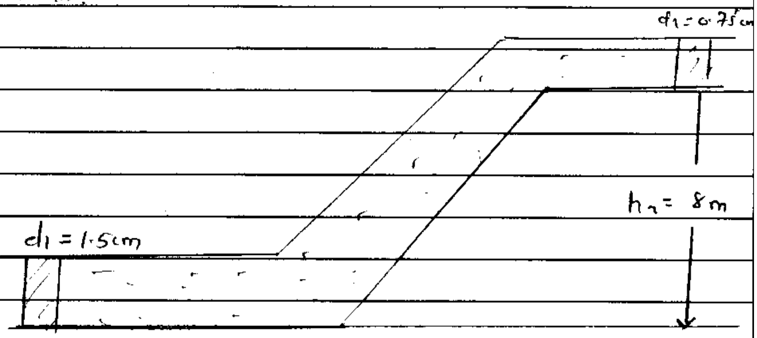
(b) solution.

Data given

Inner diameter $(d_1) = 1{\cdot}5\,cm$
Inner pressure $(P_1) = 6{\cdot}5 \times 10^5\,Pa.$
Inner velocity $(V_1) = 5\,m/s$
height of second floor $(h_2) = 8\,m$
diameter $(d_2) = 0{\cdot}75\,cm.$

Required: Velocity (V_2) and Pressure (P_2) on outlet floor of bathroom.

Q1 b) Consider



$P_1 = 6{\cdot}5 \times 10^5\,Pa$

From; Continuity principle

$$A_1 V_1 = A_2 V_2.$$

$$V_2 = \frac{A_1 V_1}{A_2}$$

$$V_2 = \frac{\frac{\pi \times (1.5\times10^{-2})^2}{4} \times 5m/s}{\frac{\pi(0.75\times10^{-2})^2}{4}}$$

$$V_2 = \underline{\underline{20m/s}}$$

∴ The velocity on outlet to second floor of bathroom is $\underline{\underline{20m/s}}$.

Also;

From: Bernoulli's theorem

Q1. b)

$$P + \tfrac{1}{2}\rho v^2 + \rho g h = k$$

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

$$h_1 = 0.$$

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

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

$$P_2 = 6.5\times10^5 + \tfrac{1}{2}\times1000\times(5^2 - 20^2) - 1000\times9.8\times8$$

$$P_2 = 3.84\times10^5\ Pa.$$

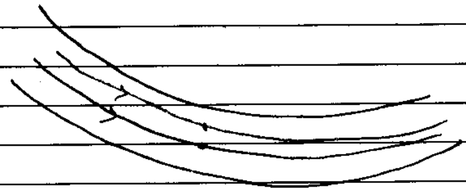
∴ The pressure on outlet bathroom is $\underline{\underline{3.84\times10^5\ Pa}}$

c) (i) Non - Viscous fluid

Is the fluid which do not have internal frictional forces between the adjacent layers.

(ii) Steady flow

Is the fluid flow in which pressure, density and velocity do not vary with time at any point.

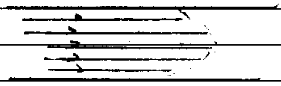


Q1. e) (iii) Line of flow

Is the path taken by particles of fluid when moving in the pipe.

The line of flow indicates direction of fluid flow

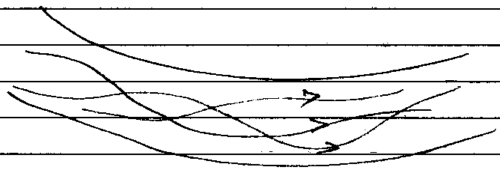
Consider:



(iv) Turbulent flow

Is the fluid flow in which water or fluid cross each other at any point and its density, velocity and pressure varies with time to each point

Consider:



d) solution:

Data given

small diameter $(d_1) = 0.080\,m$

large diameter $(d_1) = 0.160\,m$.

Rate of flow $(Q) = 90$ Litre/seconds

Pressure at small diameter $(P_1) = 3.5 \times 10^5\,Pa$.

Required: pressure at large diameter (P_2).

Q1 d) From: Bernoulli's theorem

$$P_1 + \rho g h_1 + \frac{1}{2}\rho v_1^2 = P_2 + \rho g h_2 + \frac{1}{2}\rho v_2^2$$

For horizontal pipe $h_1 = h_2 = 0$.

$$P_1 + \frac{1}{2}\rho v_1^2 = P_2 + \frac{1}{2}\rho V_2^2$$

But: $Q = AV$.

$$96 \times 10^{-3} = \frac{\pi}{4} \times (0.08)^2 \times V_1$$

$$V_1 = 19.1\ m/s$$

Also:

Continuity principle

$$A_1 V_1 = A_2 V_2.$$

$$V_2 = \frac{A_1 V_1}{A_2}.$$

$$V_2 = \frac{\pi/4\ (0.08)^2 \times 19.1}{\pi/4\ (0.16)^2}$$

$$V_2 = 4.77\ m/s.$$

Then,

$$3.5 \times 10^5 + \frac{1}{2} \times 1000 \times 19.1^2 = P_2 + \frac{1}{2} \times 1000 \times 4.77^2$$

$$P_2 = 5.21 \times 10^5\ Pa.$$

$\therefore$ The reading pressure is $5.2 \times 10^5\ Pa.$

Extract 2.1.1, a sample of an answer from a candidate who managed to provide correct responses to each part of the question. For example, he/she was able to explain and illustrate by clear diagrams as shown in parts (b) and (c).

Those who scored 0 to 6.5 marks provided incorrect answers to many parts of the question while some of them solved a few parts of the question and skipped the others. Generally, the responses of lower achievers in this question showed that most of them were having inadequate knowledge on the topic of Fluid Dynamics, hence, provided inappropriate answers to most parts of the question. Extract 2.1.2 shows a sample of the responses of one of the candidates who scored poorly in this question.

Extract 2.1.2

1 (a) SECTION A

(ii) $P + \rho gh + \frac{1}{2}\rho V^2 = \text{Constant}$

P – represents Pressure.

ρ – represents density of liquid

g – represents gravitation constant

h – represents height

v – represents velocity.

(ii) $E_T = \cancel{\rho}mgh + \frac{1}{2}mv^2$

$E_{T/V} = \frac{\cancel{\rho}mgh}{V} + \frac{1}{2}\frac{mv^2}{V}$

$E_{T/V} = \rho gh + \frac{1}{2}\rho V^2$

Conditions:

- Energy total per unit volume is equal to the sum of potential energy and kinetic energy $E_{T/V} = P + \rho gh + \frac{1}{2}\rho V^2$
- Pressure is equal throughout $P = P_1 = P_2$
- Involves both static and dynamic pressure.
  - static pressure $= \rho gh$
  - dynamic pressure $= \frac{1}{2}\rho V^2$

(b). soln

$d = 1.5\text{cm}$.

$P_1 = 6.5 \times 10^5 Pa$.

$V = 5\text{m/s}$

$x = 8\text{m}$.

$V = x$

$P = x$

1 (b)(i) soln

from,

$P_2 = \left(\frac{P_1 r_1^4 L_2}{r_1^4 L_2} - \frac{P_3 r_2^4 L_1}{r_2^4 L_1}\right)$

let $P_2 = 0$

$\frac{P_1 r_1^4 L_2}{r_1^4 L_2} = \frac{P_3 r_1^4 L_1}{r_2^4 L_1}$

$P_3 = \frac{(P_1 r_1^4 L_2)(r_2^4 L_1)}{(r_1^4 L_2)(r_1^4 L_1)}$

$P_1 \; 6.5 \times 10^5$

$V = 5\text{m/s}$

$V = \sqrt{2gh}$

$L_2 = 8\text{m}$,

$r_2 = 0.75$

$r_1 = \cancel{\quad} 1.5$

$h = \frac{V^2}{2g}$

$h = \frac{5^2}{2 \times 9.8}$

$h = 1.3$.

$h = 1.3$

$$P_3 = \frac{8 \times 6.5\times10^{5} \times (1.5\times10^{-2})^{4} \times (0.75)^{4} \times 1.31}{(1.5\times10^{-2})^{4} \times 8 \times (1.5\times10^{-2})^{4} \times 1.31}$$

$$P_3 = \frac{8 \times 6.5 \times 10^{5} \times 5\times10^{-8} \times 0.316 \times 1.3}{5\times10^{-8} \times .8 \times 5\times10^{-8} \times 0.316 \times 1.3}$$

$$P_3 = \frac{1.06808\times10^{-3}}{1.027\times10^{-15}}$$

$$P_3 = 1.04\times10^{12}\ Pa.$$

Pressure after the pipe is $\underline{1.04\times10^{12}\ Pa}$

(ii) velocity:

from,

$$Q = \frac{4\pi r^4}{8\pi L}$$

$$V/t = \frac{4\pi r^4}{8\pi L}$$

$$V/t = \left(\frac{4\pi \times (0.75)^4}{8\pi \times 8}\right)$$

$$V/t = \frac{0.3164}{16}$$

$V/t = 0.0197$ $\quad V/t = 19.7\times10^{-3}\ m^3/sec$

Extract 2.1.2, a sample of an answer from a candidate who gave incorrect answers to each question item. For instance, in (a) (ii) he/she named the symbol contained in each term of the given expression instead of writing the names of the quantities represented by each term.

2.2.2 Question 2: Vibrations and Waves (Wave Motion)

This question consisted of four parts namely (a), (b), (c) and (d) of which, part (a) required the candidates to give the meaning of: (i) progressive waves, (ii) refraction of waves, (iii) diffraction of waves and (iv) standing waves. Part (b) required them to determine the amplitude and phase angle formed when two opposite progressive waves represented by: $Y_1 = 5\text{Sin}\left(\text{wt} + \frac{\pi}{3}\right)$ and $Y_2 = 5\text{Sin}\left(\text{wt} - \frac{\pi}{3}\right)$ form a standing wave. In part (c), the candidates were required to determine the end correction of the tube and the velocity of sound in air given that the shortest lengths of the resonance tube closed at one end are 31.6 cm when resounded to a fork of frequency 256 Hz and 20.5 cm when resounded to a fork of frequency 384 Hz. In part (d), they were required to: (i) define the term interference of waves, and (ii) determine the wavelength of light and the distance between two adjacent bright fringes given that: a viewing screen is separated from a double - slit source by 1.2 m, the distance between the two slits is 0.030 mm and the second order bright fringe (m = 2) is 4.5 cm from the central line.

A total of 11,726 (60%) of the candidates attempted this question whereby 36.6 percent of them scored marks ranging from 0 to 6.5, 35.4 percent scored 7 to 11.5 marks and 28 percent scored 12 to 20 marks. These scores indicate that the performance in this question was good since 63.4 percent of the candidates scored more than one-third of the allotted marks in the question. Figure 10 illustrates the information given above.

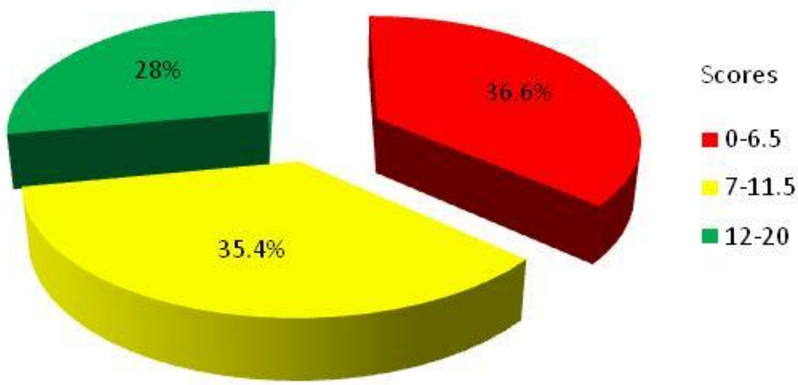


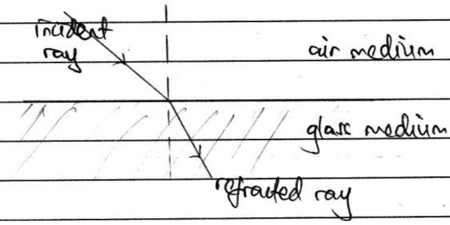
Figure 10: *Performance of candidates in question 2.*

Among the candidates who performed well in this question, 4,690 candidates (0.4%) scored all the 20 marks allotted in this question as they were able to define correctly the terms progressive waves, refraction of waves, diffraction of waves and standing waves. Moreover, they derived correctly the equation of resultant waves formed by a superposition of given waves, hence deduced the required amplitude and phase angle of the resultant wave. They also used a correct formula to relate the end correction, length of the resonance tube and wave length, hence, computed the required values of end correction and velocity of sound in air. Others missed to score all the marks due to skipping some important steps in doing the calculations as well as provision of incorrect conditions which makes Bernoulli's equation valid. Extract 2.2.1 shows the responses given by one of the candidates who did well in this question.

Extract 2.2.1

2. a) i) Progressive wave is the perodic disturbance of particles that causes transfer of energy from one point to another. It is also referred to as travelling wave

ii) Refraction of waves is the bending of waves as they pass from one medium to another due to diference in the natural properties of those material media.



2. a) iii) Diffraction of waves is the spreading of waves as they pass through an aperture.
- Diffraction of waves depends on the size of aperture. Small aperture means greater diffraction and viceversa.

iv) Standing waves these are resultant waves formed when two progressive waves with same amplitude, wavelength and frequency travelling opposite against each other are superimposed in a certain medium.

2. b) From Principle of Superposition of waves.

$$y = y_1 + y_2$$

$$y = 5\sin\left(\omega t + \frac{\pi}{3}\right) + 5\sin\left(\omega t - \frac{\pi}{3}\right)$$

$$y = 5\left[\sin\left(\omega t + \frac{\pi}{3}\right) + \sin\left(\omega t - \frac{\pi}{3}\right)\right]$$

From the factor formula;

$$\sin P + \sin Q = 2\sin\left(\frac{P+Q}{2}\right)\cos\left(\frac{P-Q}{2}\right)$$

$$y = 5\left[2\sin\left(\frac{\omega t + \frac{\pi}{3} + \omega t - \frac{\pi}{3}}{2}\right)\cos\left(\frac{\omega t + \frac{\pi}{3} - \omega t + \frac{\pi}{3}}{2}\right)\right]$$

$$y = 10\sin(\omega t)\cos\left(\frac{\pi}{3}\right)$$

$$y = \left(10\cos\frac{\pi}{3}\right)\sin(\omega t + 0)$$

Comparing with $y = A\sin(\omega t + \Phi)$

$$A = 10\cos\frac{\pi}{3}$$

2. b)

$$A = 10 \times \frac{1}{5}$$

$$A = 2 \text{ units}$$

Hence the resultant amplitude is 2 units
where $[A] = L$ thus units can be metre, centimetre ...

Also: $\Phi = 0$ -- from the comparison.

Hence the phase angle formed is 0 radians.

2. b)

$$A = 10 \times \frac{1}{5}$$

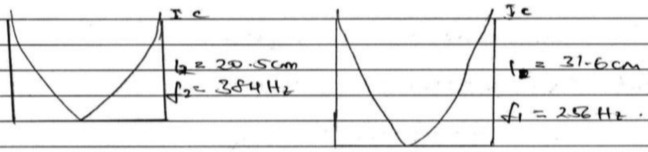
$$A = 2 \text{ units}$$

Hence the resultant amplitude is 2 units
where $[A] = L$ thus units can be metre, centimetre ...

Also: $\Phi = 0$ -- from the comparison.

Hence the phase angle formed is 0 radians.

2\. c)



From the illustration above;

$$\frac{\lambda}{4} = L + C.$$

$$\frac{\lambda}{4} = L_1 + C \quad \text{and} \quad \frac{\lambda}{4} = L_2 + C.$$

But $\quad V = f\lambda.$

$$V = f_1 \cdot 4(L_1 + C) \quad \text{and} \quad V = f_2\left[4(L_2+C)\right]$$

$$V = 4f_1(L_1+C) = 4f_2(L_2+C)$$

$$4f_1(L_1+C) = 4f_2(L_2+C).$$

Hence. $\quad \dfrac{f_1}{f_2} = \dfrac{L_2+C}{L_1+C}.$

2\. c)

$$f_1L_1 + f_1C = f_2L_2 + f_2C.$$

$$f_1L_1 - f_1L_2 = (f_2C - f_1C)$$

$$C(f_2 - f_1) = f_1L_1 - f_2L_2.$$

$$C = \frac{(f_1L_1 - f_2L_2)}{(f_2 - f_1)}$$

$$C = \frac{(256\,Hz \times 31.6\,cm - 384\,Hz \times 20.5\,cm)}{(384\,Hz - 256\,Hz)}$$

$$C = \frac{217.6\ Hz.cm.}{128\ Hz}.$$

$$C = 1.7\ cm$$

∴ The end correction is $1.7cm$.

But $\quad V = 4f_1(L_1+C) = 4f_2(L_2+C).$

$$V = 4f_1(L_1+C).$$

$$V = 4 \times 256Hz(31.6cm + 1.7cm).$$

$$V = 34099.2\ cm/s$$

But $\quad 1m = 100cm.$

$$? \leftarrow 34099.2cm$$

$$= \frac{34099.2cm \times 1m}{100cm}$$

$$\therefore \quad V = 340.992\ m/s.$$

Hence the velocity of sound in air is $340.992\ m/s$.

2\. d)i) Interference of waves is the phenomenon of overlapping of two or more waves ~~of the same~~ that are monochromatic and coherent when they are superimposed on the same medium at the same time.

2. d) ii) $D = 1.2m$

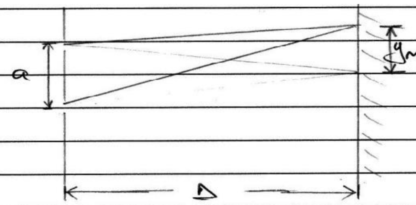
$a = 0.020mm$

$m = 2$

$y_m = 4.5cm$

$\lambda = ?$

$\beta = ?$



Since $P = \frac{ya}{D}$.

For constructive interference $P = m\lambda$.

$m\lambda = \frac{y_m a}{D}$.

$y_m = \frac{m\lambda D}{a}$.

$y_2 = \frac{2 \times \lambda \times 1.2m}{(0.020mm \times 10^{-3})m}$ [∵ 1m = 1000mm].

$\lambda = \frac{y_2 a}{mD}$. [∵ 1m = 100cm]

$\lambda = \frac{(4.5cm \times 10^{-2})m \times (0.020mm \times 10^{-3})m}{2 \times 1.2m}$.

$\lambda = 5.625 \times 10^{-7} m$

∴ The wavelength is 5.625×10^{-7} m.

2. d) ii) Using: $\beta = \frac{\lambda D}{a}$.

$\beta = \frac{5.625 \times 10^{-7} m \times 1.2m}{(0.020mm \times 10^{-3})m}$.

$\beta = 0.0225$ m.

$= 22.5mm$ [∵ 1m = 1000mm].

∴ The distance between two adjacent bright fringes is 22.5 mm.

Extract 2.2.1, a sample of an answer from a candidate who wrote correct explanations and showed clear illustrations and steps in performing calculations.

On the other hand, those who scored marks ranging from 0 to 6.5 marks in this question were lacking basic knowledge of the topic of Vibrations and Waves and some of them were having difficulties in understanding the demands of the question items. For instance, it was observed that some candidates failed to define the terms "refraction of waves" and "diffraction of waves" which are among the basic concepts in the topic of vibrations and waves. Extract 2.2.2 shows the responses of one of the candidates who performed poorly in this question.

Extract 2.2.2

2 (a) (i) Progressive wave - Are the wave consisting of node and antinode.

(ii) Refraction of wave -

(iii) Diffraction of waves -

(iv) Standing wave - refers to the wave which are stationary in given point.

(b) $Y_1 = 5\sin\left[wt + \frac{\pi}{3}\right]$

$Y_2 = 5\sin\left[wt - \frac{\pi}{3}\right]$

Soln

From

$Y = a\sin\left[wt + 2\pi x\right]$

Amplitude $a = 5m$.

$2\cancel{\pi}x = \frac{\cancel{\pi}}{3}$

$2x = \frac{1}{3}$

$x = \frac{1}{6}$

2. (c) Solution

Data given

Frequency $(F_1) = 256\,Hz$.

Frequency $(F_2) = 384$.

Length $L_1 = 31.6\,cm$

Lenghth $L_2 = 20.5\,cm$.

$F_1 + F_2 = FB_1$

$256 + 384 = 640\,Hz$

$31.6\,cm = 0.316\,m$

$20.5\,cm = 0.205\,m$.

$0.316 + 0.205 = 0.521\,m$

$= \frac{640\,H}{0.521}$

$= 1228.4$

Extract 2.2.2, indicates a sample of an answer from a candidate who attempted to define stationary waves by using the properties of progressive waves leaving other quantities undefined. Also he/she applied incorrect formulae in performing calculations ended with incorrect answers.

2.2.3 Question 3: Vibrations and Waves (Physical Optics)

This question comprised of four parts namely (a), (b), (c) and (d). In part (a), the candidates were required to define the term coherent source of light. Part (b) required them to: (i) mention three methods (apart from double slit experiment) that can be used to form interference pattern, and (ii) explain whether transverse or longitudinal waves could exist if the vibratory motion causing them were not simple harmonic. In part (c), the candidates were given a stem of the question which reads: "A beam of monochromatic light of wavelength 680 nm in air passes into glass". Then they were required to calculate: (i) the speed of light in glass, (ii) the frequency of light and (iii) the wavelength of light in glass. Part (d) required the candidates to find: (i) the angle to the normal of a second order maximum, (ii) largest number of orders that can be visible and, (iii) the angular separation between the third and fourth order images given that, light of wavelength 644 nm is incident on a grating with a spacing of $2.00x10^{-6}\ m$.

A few candidates (29.2%) opted for this question. 34.9 percent of them scored marks ranging from 0 to 6.5 (including 4 percent who scored 0 marks), 33.2 percent scored 7 to 11.5 marks and 31.9 scored 12 to 20 marks (Figure 11). Based on these data the performance of the candidates in this question was good since 65.1 percent scored more than one third of the marks awarded to the question. The performance in this question is higher than that of question 2 (constructed from the same topic) although the former question attracted majority of the candidates.

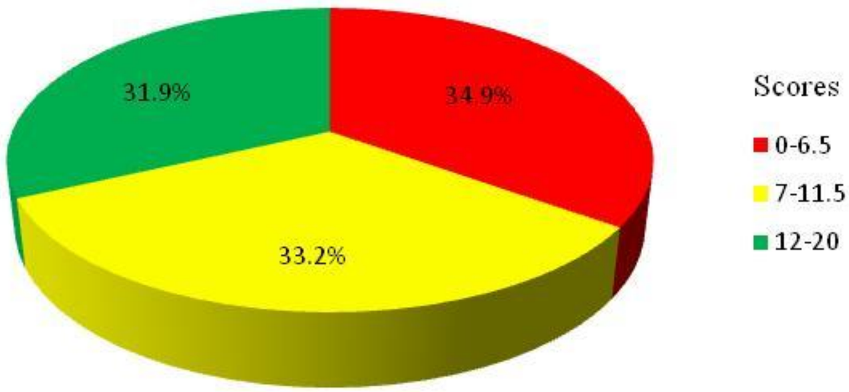


Figure 11: *Performance of candidates in question 3.*

Most of the candidates (31.9%) who did well in this question were able to give a correct definition of coherent sources and applied the required formulae for calculating the speed, frequency and wavelength of light in glass. Majority of them used appropriate formulae for finding the angle to the normal of second order maximum, the largest visible number of order and the angular separation between the 3^{rd} and 4^{th} order images. However, most of them failed to give logical reasons in 2 (b) (ii) which required them to explain whether transverse or longitudinal waves could exist if the vibratory motions causing them were not simple harmonic. Extract 2.3.1 shows an example of good responses for this question.

Extract 2.3.1

3. (a) Coherent sources of light are the sources producing light of the same frequency, wavelength and amplitude

(b) i/ • Newton's rings.
• Lloyd's mirrors.
• Fresnell's biprism.
• Wedge fringes.

(c) • Data given:
Wavelength of light, λ_1 = 680 nm ($= 680 \times 10^{-9}$ m).
Refractive index of glass, $\mu_g = 1.52$.

Solution:

i/ Let V_2 be speed of ~~sound~~ light in glass;
• From;

$$\mu_g = \frac{\lambda_1}{\lambda_2} = \frac{V_1}{V_2} \quad \text{—(i)}$$

$$\mu_g = \frac{V_1}{V_2}$$

$$V_2 = \frac{V_1}{\mu_g}$$

3. (c) Where: V_1 = speed of light in air $= 3 \times 10^8 ms^{-1}$.

$$\Rightarrow \mu_g = \frac{V_1}{V_2}$$

$$V_2 = \frac{3 \times 10^8 ms^{-1}}{1.52}$$

$$\therefore V_2 = 1.97 \times 10^8 ms^{-1}.$$

ii/ Let f_1 be frequency of Light;
• From:

$$V_1 = \lambda_1 f_1.$$

$$f_1 = \frac{V_1}{\lambda_1} = \frac{3 \times 10^8 ms^{-1}}{680 \times 10^{-9} m}$$

$$= 4.41 \times 10^{14} HZ$$

$$\therefore f_1 = 4.41 \times 10^{14} HZ$$

iii/ Let λ_2 be Wavelength of Light in glass.
• From; eqn (i);

$$\mu_g = \frac{\lambda_1}{\lambda_2} = \frac{V_1}{V_2}$$

$$\Downarrow$$

$$\mu_g = \frac{\lambda_1}{\lambda_2}.$$

$$\lambda_2 = \frac{\lambda_1}{\mu_g} = \frac{680 \times 10^{-9} m}{1.52}$$

$$\therefore \lambda_2 = 4.47368 \times 10^{-7} m (= 447.36 nm$$

3. (d) · Data given;

Wavelength, $\lambda = 644nm (= 644 \times 10^{-9}m)$

Grating spacing, $d = 2 \times 10^{-6}m$.

Solution:

i/ Let θ be angle to the normal for second Order maximum (ie; $n=2$).

· From;

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

$$\sin\theta = \frac{n\lambda}{d}$$

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

$$= \sin^{-1}\left(\frac{2 \times 644 \times 10^{-9}m}{2 \times 10^{-6}m}\right)$$

$$= 40^{\circ}.$$

$$\therefore \theta = 40^{\circ}.$$

ii/ Let n_{max} be largest number of Orders that can be visible;

from;

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

- n_{max} is Obtained when $\sin\theta = 1$

$$\Rightarrow n\lambda = d.$$

$$n_{max} = \frac{d}{\lambda} = \frac{2 \times 10^{-6}m}{644 \times 10^{-9}m}$$

$$n_{max} = 3.$$

$$\therefore n_{max} = 3.$$

3. (iii) Let θ be angular separation.

· From;

$$\theta = \theta_4 - \theta_3 \quad \text{——(i)}.$$

1st step; Find θ_3.

From;

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

$$\sin\theta_3 = \frac{3\lambda}{d}.$$

$$\theta_3 = \sin^{-1}\left(\frac{3\lambda}{d}\right).$$

$$= \sin^{-1}\left(\frac{3 \times 644 \times 10^{-9}m}{2 \times 10^{-6}m}\right)$$

$$\theta_3 = 75^{\circ}.$$

• For θ_4;

$$\theta_4 = \sin^{-1}\left(\frac{4 \times 644 \times 10^{-9}m}{2 \times 10^{-6}m}\right)$$

$$= \alpha \text{ (=Impossible)}$$

Fourth image can not be Obtained since the maximum number of orders is 3.

Thus;

$$\theta = \theta_3 - \theta_4$$

$$= 75^\circ - \alpha$$

$$\theta = 75^\circ.$$

$\therefore$ The angular separation is 75°

(b) ii/ If the vibration motion is not simple harmonic motion, Longitudinal waves would exist.

• Reason:

- This is due to the fact that vibrating particles

(ii) to oscillate to and fro and hence appear parallel to the direction of wave motion as in sound wave

Extract 2.3.1 shows the work of a candidate who was systematic in performing the question as he/she used the correct formulae and procedures except for part 3 (b) (ii) which was found to challenge most of the candidates.

Most of those who scored low marks in this question (34.9%) defined partially the term coherent source and mentioned incorrect methods that can be used to form interference pattern. Most of them were also not able to apply correctly the formula of refractive index of light passing from one medium to another to determine the values of velocity and wavelength of a monochromatic light in glass. This implies that during the teaching/learning process some candidates did not get enough exercises especially on the tested area of the topic. Extract 2.3.2 is the sample of responses given by one of the candidates who did all parts of this question and scored 0 marks.

Extract 2.3.2

3. a) Coherent sources of light
→ Are sources of light which produce bright fringe and Dark fringe in Monochromatic wave in a screen.

b) i/ — polaroids
— Diffractions
— Refraction

ii/ Transverse wave will exist due to the following reasons
i/ It is formed mechanical by energy transformation and needs materials to travell
ii/ Are the one whose they propagate and vibrate perpendicular to others.

c) Data:
$\lambda = 680$
i) $V = ?$
From.
$Ug = \frac{V}{\lambda}$
$1.52 = \frac{V}{680}$
$1.52 = \frac{\lambda}{V}$.
$1.52\,V = \lambda$.
$\frac{1.52V}{1.52} = \frac{680}{1.52}$
$V = 447.37\ m/s$.

but $V = \lambda f$.
$\frac{447.37}{680} = \frac{680f}{680}$ ∴ frequency $= 0.658\ Hz$

3. d)
Data
Wavelength $= 664\ nm$.
spacing $= 2.00 \times 10^{-6}\ m$.
Angle $= ?$
from.
$\theta = \frac{n\lambda}{a}$.
$\sin\theta = \frac{2 \times 664}{2.00 \times 10^{-6}}$
$\sin\theta = 6.64 \times 10^{-7}$
∴ $\theta = 1^{?}\ 3.7 \times 10^{6}$

Extract 2.3.2, shows a sample of an answer from a candidate who explained the effect of interference of light produced by coherent sources instead of defining the term coherent source. He/she also provided reasons which do not carry any idea on explaining "whether transverse or longitudinal waves could exist if the vibratory motion causing them were not simple harmonic

2.2.4 Question 4: Properties of Matter (Surface Tension)

This question had four parts namely (a), (b), (c) and (d). In part (a), the candidates were required to mention any two factors which affect the surface tension of a liquid giving two typical examples to each factor. Part (b) required them to explain the reason for the molecules of a liquid at the surface of the liquid to possess high potential energy than those within it. In part (c), they were required to: (i) derive an expression for excess pressure inside a soap bubble of radius R and surface tension γ when the pressure inside and outside the bubble are P_2 and P_1 respectively, and (ii) calculate the excess pressure inside the soap bubble of a diameter 5 mm if the atmospheric pressure is 10^5 Pa and the surface tension of soap solution is 2.8×10^{-2} Nm^{-1}. In part (d), the candidates were given that: "water rises up in a glass capillary tube to a height of 9.0 cm while mercury falls down by 3.4 cm in the same capillary tube". Then they were required to determine the ratio of surface tensions of mercury and water assuming the angles of contact for water - glass and mercury - glass are 0^o and 135^o, respectively.

More than two thirds (70.1%) of the candidates attempted this question. 31.9 percent of those who attempted this question scored marks ranging from 0 to 6.5, 34.6 percent scored 7 to 11.5 marks while 33.5 percent scored 12 to 20 marks (Figure 12). The performance in this question was generally good since 68.1 percent of the candidates passed the question by scoring 7 marks and above. This implies that majority of the candidates who opted for this question understood well the concepts related to the topic of Properties of Matter.

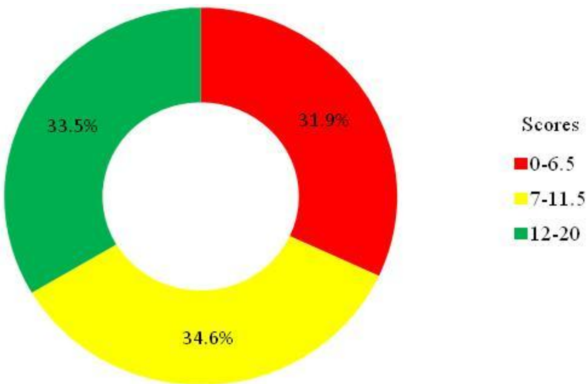


Figure 12: *Performance of candidates in question 4.*

Most of the candidates who had good scores (12 to 20 marks) in this question were capable of providing logical factors affecting surface tension and supported their explanations with vivid examples. Moreover, a good number of them wrote correct reasons on why molecules on the surface of a liquid have more potential energy than those inside the liquid. Most of them also derived correctly the expression for excess pressure inside a soap bubble and substituted clearly the data for calculating the pressure inside the soap bubble. Extract 2.4.1, shows an example of the responses from one of the candidates who had a good score in this question.

Extract 2.4.1

4a. factors affecting surface tension.

1. Temperature.

Increase in temperature lowers surface tension.

Example.

1. Hot soup are tastier than cold ones because hot soup spread over a wider area on the tongue due to low surface tension.

ii. Hot water is better in cleaning / washing clothes as it have higher penetrating power due to lower surface tension.

ii. Presence of Impurities

Impurities do lower surface tension of the liquid.

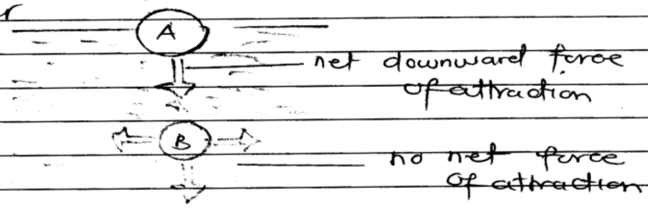
Examples.

1. Soapy water is better cleaning than pure water. Soapy water penetrate more the fabric due to lower surface tension.

ii. Oils and detergents are spilled on pond in order to kill masquito eggs. This is by lowering surface tension of water the eggs drown

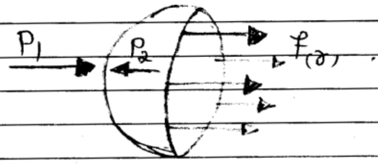
b. The liquid molecules in the interior of the liquid have no net intermolecular force of attraction on it as it's equally attracted from both sides. Now when we move the molecule upward work ~~done~~ has ~~bee~~ to be done, against the downward force experienced. This work is then converted and stored in form of potential energy when the molecule reach the surface. thus higher potential

4. energy
consider



4 C. Deriving expression of excess pressure Inside Soap bubble.

Consider



The soap bubble has two surfaces in contact with air thus force due to surface tension ~~th~~

$f_\gamma = \gamma \times 4\pi R$.

but the force ~~exter~~ exerted due to the pressure outside

$f_1 = P_1 \pi R^2$.

but also the force due to pressure Inside.

$f_2 = P_2 \pi R^2$

Now

$f_2 = f_1 + f_\gamma$

$P_2 \pi R^2 = P_1 \pi R^2 + 4\pi R\gamma$

thus $P_2 \pi R^2 - P_1 \pi R^2 = 4\pi R\gamma$

4. $(P_2 - P_1)\pi R^2 = 4\pi R\gamma$

thus

$$(P_2 - P_1) = \frac{4\pi R\gamma}{\pi R^2}.$$

$$(P_2 - P_1) = \frac{4\gamma}{R}.$$

Whereby $(P_2 - P_1)$ = Excess pressure Inside the bubble.

γ = Surface tension

R = Radius of the bubble.

ii) from:

$$P_2 - P_1 = \frac{4\gamma}{R}$$

$$P_2 = \frac{4\gamma}{R} + P_1$$

but P_1 (pressure outside) is the atmospheric pressure

$$P_2 = \frac{4\gamma}{R} + P_a$$

but also $R = \frac{\text{diameter}}{2}$

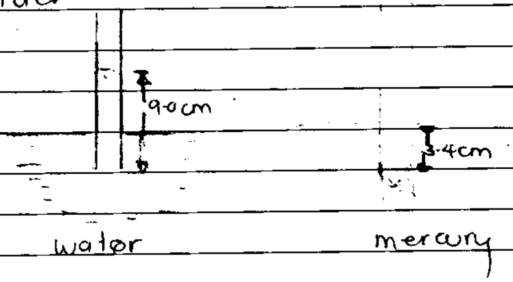
$$R = \frac{5\times10^{-3}}{2} = 2.5\times10^{-3}\,m$$

$$P_2 = \frac{4\times2.8\times10^{-2}}{2.5\times10^{-3}} + 1\times10^{5}$$

$$P_2 = 100{,}044.8\ Pa$$

The pressure inside bubble = 100,044.8 Pa

4d consider



Now from:

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

but for water

$$h_w = \frac{2\gamma_w\cos\theta}{\rho_w g r}$$

$$\gamma_w = \frac{h_w \rho_w g r}{2\cos\theta} \quad \text{-----} \quad (1)$$

but for mercury

$$h_m = \frac{2\gamma_m \cos\theta_2}{\rho_m g r}$$

$$\gamma_m = \frac{h_m \rho_m g r}{2\cos\theta_2} \quad \text{-----(ii)}$$

Now equation (ii) by (i) we have

$$\frac{\gamma_m}{\gamma_w} = \frac{h_m \rho_m}{\cos\theta_2} \times \frac{\cos\theta_1}{h_w \rho_w}$$

then

$$\frac{\gamma_m}{\gamma_w} = \frac{-3.4\times10^{-2}\times13.6\times10^3}{\cos 135^\circ} \times \frac{\cos 0^\circ}{9\times10^{-2}\times1\times10^3}$$

$$= 7.27 : 1$$

Extract 2.4.1, a sample of an answer from a candidate who mentioned correct factors affecting surface tension including logical reasons to support the answers. He/she attempted correctly all other question items.

Conversely, most of the 31.9 percent of the candidates who had poor performance in this question, gave incorrect responses in relation to the factors affecting surface tension and were unable to derive appropriately the expression for excess pressure inside the soap bubble. In addition, it has been noted that, most of these candidates used wrong formulae, hence, failed to obtain the correct answers in question items which required calculations. Extract 2.4.2 shows an example of the responses of one of the candidates who had poor performance in this question.

Extract 2.4.2

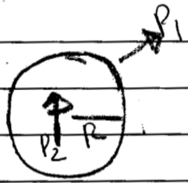
04. (a) Factors affecting surface tension of the liquid

1. surface area of that liquid
always large surface area experience low surface tension hence surface tension is proportional to the small area
example ~~pound~~ skater when you put soap with in the water in large surface the bubbles soon disappear due to low surface tension

2. Pressure exerted on the surface of the liquid
the pressure exerted on the surface of the liquid peel of the surface tension (as it's large pressure on small surface)
hence the pressure applied should be low
example the high pressure when applied to the surface block the surface tension barrier to support thing like floating needle and pound skater

(b) This is because the molecules on the surface can used to act for the surface tension also the molecules within are high accumulated as well as they hold those of outer hence the outer molecules have more potential energy.

(C) (i) Consider the surface of the ~~liquid below~~ soap bubble below of Radius R and surface tension Y when the pressure inside the bubble is P_2 and that of outside is P_1



let the pressure act on the outside of the buble we consider as atmospheric pressure (P_2)

the ~~outside~~ pressure P_1

C (i) The difference in pressure is given by

Atmospheric pressure — Inside pressure

$P_2 - P_1$

Since $P = \frac{F}{A}$

hence the surface tension $= \frac{F}{A}$

$P_2 - P_1 = \frac{F}{A}$

F = surface tension (Y)

$P_2 - P_1 = \frac{Y}{A}$

but A in given diameter D = 2R

$P_2 - P_1 = \frac{2R}{Y}$ ~~hence shown~~

$P_2 - P_1$ (excess pressure)

$P_2 - P_1 = \frac{2R}{Y}$ hence shown

4 (ii) (c) Data Given

Diameter = 5mm = 5×10^{-3} m

Phespherz = 10^5 Pa

Pressure inside - ?

$\gamma = 2.8 \times 10^{-2} Nm^{-1}$

Solution

From the formula

$P_2 - P_1 = \frac{2R}{\gamma} = D$

$P_2 - P_1 = \frac{D}{\gamma}$

$P_2 = \frac{D}{\gamma} + P_1$

$P_2 = \frac{5 \times 10^{-3} m}{2.8 \times 10^{-2} Nm^{-1}} + 10^5 Pa$

$P_2 = 0.1786 + 10^5$ Pa

$P_2 = 1.786 \times 10^{-5}$ Pa

Hence the pressure exered inside is 1.786×10^{-5} Pa

Q4 (d) Data Given

height rise = 9.0 cm (water)

Lenght fall = 3.4 cm (merury)

angle of contact (water-glass) = 0°

angle of contact (merury-glass) = 135°

ratio of surface tension of merury and water

Extract 2.4.2, indicates a sample of an answer from a candidate who provided long explanations to support incorrect factors affecting surface tension. He/she also applied incorrect arguments to derive the formula for excess pressure inside the soap bubble while in part (d) he/she analysed the data without using them.

2.2.5 Question 5: Properties of Matter (Elasticity and Kinetic Theory of Gases)

This question consisted of parts (a), (b), (c) and (d), of which part (a) required the candidates to give brief explanations on the following two observations: (i) bridges are declared unsafe after long use, and (ii) iron is more elastic than rubber. Part (b) required them to calculate the force which stretches a composite wire of a diameter 1 cm by 1.2 mm given that the wire is made up of copper and steel of lengths 2.2 m and 2 m, respectively and the Young's Modulus for copper and steel are 1.1×10^{11}Pa and 2.0×10^{11} Pa, respectively. Part (c) required the candidates to explain what do they understand by the terms: (i) a perfectly elastic material, (ii) the ultimate tensile strength, (iii) an elastic limit, and (iv) Poisson's ratio. In part (d), it was given that: "two rods of different materials but of equal cross - sections and lengths of 1.0 m each are joined to make a rod of length 2.0 m. The metal of one rod has coefficient of linear thermal expansion $10^{-5}/^{o}C$ and Young Modulus $3{\times}10^{10}\mathrm{N/m^2}$ and the other metal has the values of $2{\times}10^{-5}/^{\circ}\mathrm{C}$ and $10^{10}\mathrm{N/m^2}$, respectively". Then, the candidates were required to calculate the pressure which must be applied to the ends of the composite rod to prevent its expansion when a temperature is raised by $100^{\circ}\mathrm{C}$.

A total of 13,234 candidates corresponding to 67.7 percent attempted this question. Out of them, 61.1 percent scored marks ranging from 0 to 6.5, 27 percent scored 7 to 11.5 marks and 11.9 percent scored 12 to 20 marks (Figure 13). These results imply that the performance of the candidates in this question was average, but leaned towards the lower margin as only 38.9 percent passed the question.

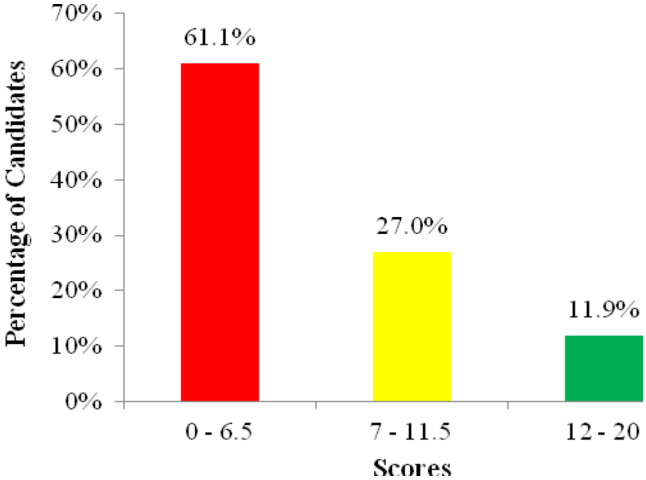


Figure 13: *Performance of candidates in question 5.*

The candidates who had a poor performance in this question provided answers with many errors. Most of them gave incorrect reasons on parts which required brief explanations. Their responses indicated that they lacked knowledge and various skills which were required to make them competent in solving the questions. For instance, most of them were able to extract data given on the stem of the question, but failed to recall or derive the appropriate formula for substituting those data. Extract 2.5.1 shows the answers given by one of the candidates who performed poorly in this question.

Extract 2.5.1

5 (a) (i) The Bridges are declared unsafe after long use because when extending for a longtime it become weaker where it can undergo elastic limit and cause it to break.

(ii) Iron is more elastic than rubber because rubber can ~~undergo deformation~~ break before reach elastic limit While Iron break after reach elastic limit.

5 (b) $d = 1cm$

$L_1 = 2.2m$

$L_2 = 2m$

$e = 1.2m$

$Y_{cu} = 1.1 \times 10^{11}$ Pa

$Y_s = 2 \times 10^{11}$ Pa

$F = Y \cdot \Delta\alpha \Delta\theta$

$F = \frac{1}{2} \frac{EAe}{L}$

(c) (i) A perfectly plastic material is the type of elastic Material which

(ii) The ultimate tensile strength is the strong material, which are elastic in nature.

(iii) Elastic limit is the point where elastic is not exceeded:

(iv) poison's ratio

5 (d) $L_1 = 1.0m$

$L_2 = 1.0m$

$\alpha_1 = 10^{-5} / °c$

$Y_1 = 3 \times 10^{30} Nm^{-2}$

$\alpha_2 = 2 \times 10^{-5} / °c$

$Y_2 = 10^{10} Nm^{-2}$

$\theta_2 = 100°c$

$F = Y \cdot \Delta\alpha \cdot \Delta\theta$

$\theta_1 = 0°c$

$\Delta Y = (3 \times 10^{10} - 10^{10}) N/m^2 = 2 \times 10^{10}$

$\Delta\alpha = (10^{-5} - 2 \times 10^{-5}) /°c = -1 \times 10^{-5}$

$\Delta\theta = (100 - 0)°c = 100°c$

$F = 20 \times 10^6 N$.

~~$P = F/A$~~

~~$A = \pi r^2 h$.~~

Pressure $= Y_{cu} + Y_s$

$= (3 \times 10^{30} + 10^{10}) Nm^{-2}$

$= 4 \times 10^{10} Nm^{-2}$

$\therefore$ The pressure applied is $4 \times 10^{10} Nm^{-2}$

Extract 2.5.1, indicates how the candidate provided incorrect responses to each question item. For instance, in part (b) he/she used the formula $F = \frac{1}{2}\frac{EAe}{L}$ instead of $F = \frac{EAe}{L}$ and therefore received incorrect answer.

Those who scored high marks (11.9%) in this question included a 0.4 percent who provided correct answers to each part of the question, hence, scored all the 20 marks awarded for this question. The rest were challenged by some parts, especially those which required explanations. This implies that those candidates understood the demands of each question item and were having adequate knowledge and competence on the topic of Properties of Matter. Extract 2.5.2 shows an example of the work of a candidate who managed to give correct answers to all parts of this question.

Extract 2.5.2

5(a) Bridges declared unsafe after long use because when bridge are subjected to stress for a long time they become weak hence as stress increase also their strain increase hence they will finally break.

(i) Iron is more elastic than rubber because when the same force applied in iron is applied in rubber, ~~for~~ rubber will produce large strain compared to iron hence its modulus of elasticity become small compared to iron, hence iron is more elastic than rubber.

5.b Data.

Diameter (d) = 1 cm.

length of cupper (l_1) = 2.2m.

length of steel (L_2) = 2m.

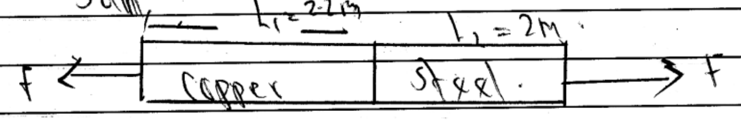
Total extension (e_T) = 1.2mm.

Young modulus of cupper (Y_1) = 11×10^{11} Pa.

Young modulus of steel (Y_2) = 2×10^{11} Pa.

Force (F) = is required.

Soln



Soln,

total extension e_T = eten

= extension of copper (e_1) + extension of steel (e_2)

$$e_T = e_1 + e_2$$

also

from Young modulus $(Y) = \frac{\text{stress } (F/A)}{\text{strain } (e/L)}$

$$Y = \frac{FL}{Ae}$$

$$\left\{ e = \frac{FL}{AY} \right\}$$

copper. steel

$$e_1 = \frac{FL_1}{AY_1}, \quad e_2 = \frac{FL_2}{AY_2}$$

$$e_T = \frac{FL_1}{AY_1} + \frac{FL_2}{AY_2}$$

$$e_T = \frac{F}{A}\left[\frac{L_1}{Y_1} + \frac{L_2}{Y_2}\right]$$

$$\left\{ F = \frac{e_T \cdot A}{\left[\frac{L_1}{Y_1} + \frac{L_2}{Y_2}\right]} \right\}$$

$$e_T = 1.2\ mm = 1.2 \times 10^{-3}\ m$$

$$A = \frac{\pi d^2}{4} = \frac{\pi (0.01)^2}{4} = 7.85 \times 10^{-5}\ m^2$$

So, force.

$$F = \frac{1.2 \times 10^{-3} \times 7.85 \times 10^{-5}}{\left(\frac{2.2}{1.1 \times 10^{11}} + \frac{2}{2 \times 10^{11}}\right)}\ N$$

$$F = 3141.59\ N$$

$\therefore$ Force is 3141.59 N

5.c i) Perfect plastic materials
- are the materials which do not regain its ~~the~~ original size and shape after removal of deforming force.

ii) Ultimate tensile strength
-> Refers to the maximum stress or force in which a body or material can withstand without breaking or before it break.

iii) Elastic limit of extension
- refers to maximum point in which material can regain to its original size and shape after removal of deforming force.

iv) Poisson's ratio
- Refers to the ratio of lateral strain to longitudinal strain.

$$\left\{ = -\frac{\Delta D/D}{\Delta L/L} \right\}$$

5.d Data.
Length of material $(L) = 1m$.
Total length $(L_T) = 2m$.
coefficient of linear expansivity $(\alpha_1) = 10^{-5}/°c$
Young Modulus of $(Y_1) = 3\times10^{10} N/m^2$
coefficient of linear expansivity $(\alpha_2) = 2\times10^{-5}/°c$
Young modulus ~~o~~ $(Y_2) = 10^{10} N/m^2$.
temperature change $(\Delta\theta) = 100°c$

Pressure (P) = Required.

Soln

total extension (e_T) = extension of body 1 (e_1) + extension of body 2 (e_2)

$$\{ e_T = e_1 + e_2 . \}$$

also, ~~ex~~

5 d) from linear expansivity

$$\alpha = \frac{e}{L\Delta\theta}.$$

$$e = \alpha L \Delta\theta.$$

$$e_1 = \alpha_1 L_1 \Delta\theta.$$

$$e_2 = \alpha_2 L \Delta\theta.$$

$$e_T = \alpha_1 L \Delta\theta + \alpha_2 L \Delta\theta \quad ---- \text{(i)}$$

also, Young modulus (Y) $= \dfrac{\text{Stress } (F/A)}{\text{strain } (e/L)}$

$$Y = \frac{FL}{Ae}$$

$$e = \frac{FL}{YA}$$

$$e_1 = \frac{FL}{AY_1}, \quad e_2 = \frac{FL}{AY_2}.$$

$$e_T = \frac{FL}{AY_1} + \frac{FL}{AY_2}.$$

$$e_T = \frac{FL}{A}\left(\frac{1}{Y_1} + \frac{1}{Y_2}\right).$$

but $F/A = P$ (pressure).

$$e_T = PL\left[\frac{1}{Y_1} + \frac{1}{Y_2}\right] \quad -- \text{(ii)}$$

5 then combine equation (i) and (ii).

$$\alpha_1 L \Delta\theta + \alpha_2 L \Delta\theta = PL\left\{\frac{1}{Y_1} + \frac{1}{Y_2}\right\}$$

$$\Delta\theta \cancel{L} (\alpha_1 + \alpha_2) = P\cancel{L}\left[\frac{1}{Y_1} + \frac{1}{Y_2}\right]$$

$$\Delta\theta(\alpha_1 + \alpha_2) = P\left[\frac{Y_2 + Y_1}{Y_1 Y_2}\right].$$

$$P_2 = \frac{\Delta\theta(\alpha_1 + \alpha_2) Y_1 Y_2}{(Y_1 + Y_2)}$$

$$P = \left[\frac{100 \times (10^{-5} + 2\times10^{-5})(3\times10^{10} \times 1\times10^{10})}{(3\times10^{10} + 10^{10})}\right] N/m^2$$

$$P = 22.5 \times 10^6 \; N/m^2.$$

$\therefore$ Pressure will be $22.5 \times 10^6 \; N/m^2$.

Extract 2.5.2, a sample of an answer from a candidate who was able to provide the reasons on why the bridges are declared unsafe after long use, as well as why iron is more elastic than rubber. Moreover, he/she gave appropriate responses to all other question items.

2.2.6 Question 6: Electrostatics

This question comprised of four parts namely (a), (b), (c) and (d). In part (a), the candidates were required to explain the effect of dielectric material on the capacitance of a capacitor when the capacitor is: (i) isolated, and (ii) connected to the battery. Part (b) required them to explain how electrolytic capacitors are made. In part (c), the candidates were given the question which read: "Two point charges each of mass m and charge Q were suspended at a common point by two threads of negligible mass and length L. If the two point charges were at equilibrium show that: (i) the distance of separation $x = \left(\frac{Q^2L}{2\pi\varepsilon_0 mg}\right)^{\frac{1}{3}}$, and (ii) the angle of inclination, $\beta = \sqrt[3]{\frac{Q^2}{16\pi\varepsilon_0 mgL^2}}$." In the final part (d), they were given a stem of the question which read: "Two charges $q_a = +3\mu C$ and $q_b = -3\mu C$ are located 0.2 m apart in vacuum". Then, they were required to find: (i) the electric field at the midpoint of the line joining the two charges, and (ii) the force experienced by the negative test charge of magnitude 1.5×10^{-9}C placed at that midpoint.

Only 18.5 percent of the candidates opted for this question. Out of them 63 percent scored marks ranging from 0 to 6.5 (including 16.8 percent who scored 0 marks), 29.3 percent scored 7 to 11.5 marks and 8.7 percent scored 12 to 20 marks (Figure 14).

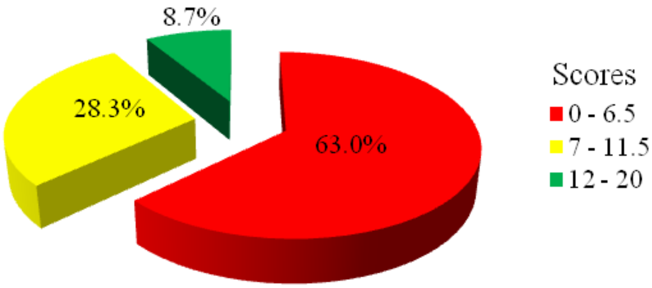
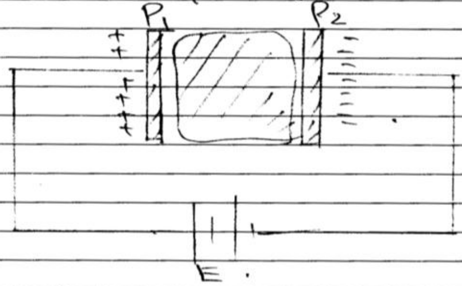


Figure 14: *Performance of candidates in question 6.*

Most of those who had poor performance (63%) in this question provided responses characterised by incorrect concepts, formulae and errors in computation. A good number of them attempted few parts of the question items leaving other parts. Generally it was noted that, their failure in this question was contributed by various reasons including: low ability to recall the important concepts of the topic, poor competence in derivations of formulae and lack of knowledge of solving questions involving two or more forces acting on a charge. Extract 2.6.1 represent an example of a responses from one of the candidates who had a poor performance in this question.

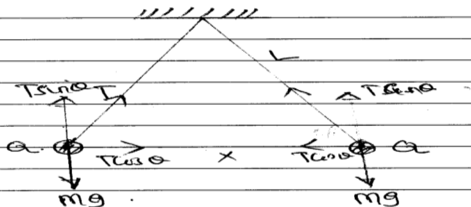
Extract 2.6.1

(b) Electrolytic Capacitors are made by two parallel conductors separated by insulators within it. The ends of the two conductors are then connected to the battery which gives rise to the potential difference across capacitors.



6. (c) i/ Required to show that distance of separation X is given by; $x = \left(\frac{Q^2 L}{2\pi\varepsilon_0 mg}\right)^{1/3}$.

• Consider:



- From the electrostatic force of attraction.

$$F = \frac{Q^2}{4\pi\varepsilon_0 x^2}.$$

$$T\cos\theta = \frac{Q^2}{4\pi\varepsilon_0 x^2}. \quad \text{—— (i)}$$

But; $\cos\theta = \frac{x/2}{L}$.

$$\cos\theta = \frac{x}{2L}. \quad \text{—— (ii)}$$

• Upon substituting:

$$T\cdot\frac{x}{2L} = \frac{Q^2}{4\pi\varepsilon_0 x^2}$$

$$T\cdot x = \frac{Q^2}{2\pi\varepsilon_0 x^2}$$

$$x^3 = \frac{Q^2}{2\pi\varepsilon_0 T} \quad \text{—— (iii)}$$

• At equilibrium; $T = mg$.

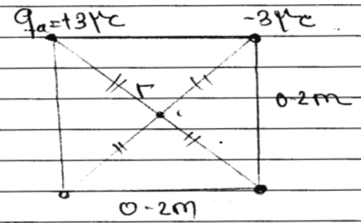
6. (c) i/ $X^3 = \frac{Q^2 L}{2\pi \varepsilon_0 m g}$.

$\therefore X = \left(\frac{Q^2 L}{2\pi \varepsilon_0 m g}\right)^{1/3}$.

Hence shown.

(d). Solution:

(i)



By pythagorus;

$c^2 = 0.2^2 + 0.2^2$.

$c^2 = 0.08$

$c = 0.28m$

But; $r = \frac{0.28}{2} = 0.14m$.

Now;

$E = \frac{Q}{4\pi\varepsilon_0 r} = \frac{3 \times 10^{-6} c}{4\pi \times 8.854 \times 10^{-12} F m^{-1} \times 0.14}$.

$\therefore E = 1.93 \times 10^5 N C^{-1}$.

(ii) Let F be force required;

6. (d). From;

$F = \frac{\cancel{q} Q_0}{4\pi \varepsilon_0 r^2}$.

~~Where~~; $F = EQ$

Where; $Q = 1.5 \times 10^{-9} c$.

$\Rightarrow F = 1.93 \times 10^5 N c^{-1} \times 1.5 \times 10^{-9} c$.

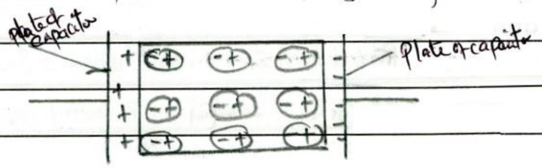
$\therefore F = 2.89 \times 10^{-4} N$.

Extract 2.6.1, indicates a sample of an answer from a candidate who made incorrect resolution of components of tension in part (c) as well as a wrong illustration of the position of point charge in part (d).

Among those who performed well, 0.1 percent were able to provide correct answers to each question item, hence managed to scored all the 20 marks. Others scored less than 20 marks due some errors which were mostly caused by lack of accuracy, and critical thinking abilities in giving answers especially of parts (a) and (b), which required explanation. Extract 2.6.2 shows responses from one of the candidates who responded well in this question.

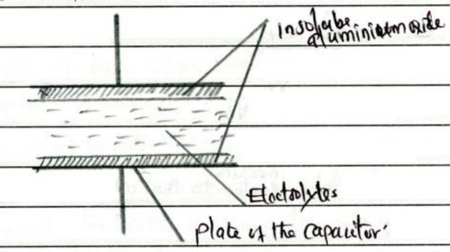
Extract 2.6.2

6 (a) (i) The dielectric Material when the ~~capacitance~~ capacitor is isolated tends to increase the capacitance of the capacitor by producing electric field inside the capacitor which results to the production of opposites charge to that of the plate hence increasing the capacitance of the capacitor.



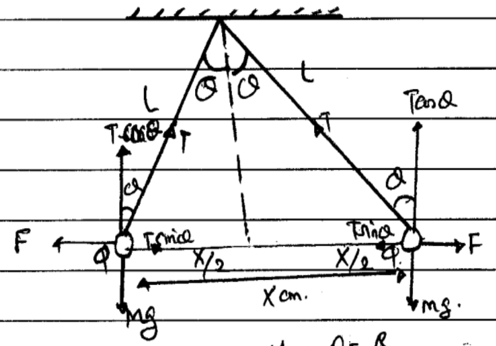
(ii) When the capacitor is connected to the battery the electric field inside the capacitor cancels out and results to the movement of electric charges from one plate to another, such that they move from one plate which is the positive plate and accumulate to another plate which is the negative plate until the ratio of charge of ~~the~~ between the two plates equal to the supply voltage of the battery. and hence the charge flow ceases. and behave like open switch.

6 (b) The electrolytic capacitor is made from electrolytes such ~~the~~ as aluminium which forms the insoluble oxides at the inner of the plates making it impossible for the electric current to flow through. The insoluble aluminium oxide is very resistant on oxidation hence is more unreactive as shown below



(c)(i) Consider two charges of magnitude. Q suspended by threads of length l such that the distance of their separation = x. as shown in the diagram below and the mass of each charge is equal to m.

6 (c) (i)



where $\theta = \beta$.

Then, from the diagram above, $T\sin\theta = F_e$

where $F_e = \frac{1(Q)(Q)}{4\pi\varepsilon_0 X^2} = \frac{Q^2}{4\pi\varepsilon_0 X^2}$

Hence, $T\sin\theta = \frac{Q^2}{4\pi\varepsilon_0 X^2}$ --- (i)

Also, $T\cos\theta = mg$ --- (ii)

dividing equation (i) by (ii)

$$\frac{T\sin\theta}{T\cos\theta} = \frac{Q^2}{4\pi\varepsilon_0 X^2 \cdot mg}$$

$$\tan\theta = \frac{Q^2}{4\pi\varepsilon_0 X^2 mg}$$

but from the diagram, $\tan\theta = \frac{X}{2L}$.

hence, $\frac{X}{2L} = \frac{Q^2}{4\pi\varepsilon_0 X^2 mg}$

$$2LQ^2 = 4\pi\varepsilon_0 X^3 mg$$

$$LQ^2 = 2\pi\varepsilon_0 X^3 mg$$

$$X^3 = \frac{LQ^2}{2\pi\varepsilon_0 mg}$$

Cube root both sides.

$$\sqrt[3]{X^3} = \sqrt[3]{\frac{LQ^2}{2\pi\varepsilon_0 mg}} = \left(\frac{LQ^2}{2\pi\varepsilon_0 mg}\right)^{1/3}$$

Hence, proved, $X = \left(\frac{Q^2 L}{2\pi\varepsilon_0 mg}\right)^{1/3}$.

6 (a)(ii) Angle of inclination from the diagram

Required to prove that $\beta = \sqrt[3]{\frac{q^2}{16\pi\varepsilon_0 mg L^2}}$

But from the diagram above, $\tan\beta = \frac{X}{2L}$.

where $X = \sqrt[3]{\frac{q^2 L}{2\pi\varepsilon_0 mg}}$

hence, $\tan\beta = \sqrt[3]{\frac{q^2 L}{2\pi\varepsilon_0 mg}} \Big/ 2L$.

$$\beta = \frac{1}{2L}\sqrt[3]{\frac{q^2 L}{2\pi\varepsilon_0 mg}}$$

$$= \sqrt[3]{\frac{q^2 L}{(8L^3) \times 2\pi\varepsilon_0 mg}}$$

$$= \sqrt[3]{\frac{q^2}{16\pi\varepsilon_0 mg L^2}}$$

Hence the angle of inclination $\beta = \sqrt[3]{\frac{q^2}{16\pi\varepsilon_0 mg L^2}}$

Hence Proved.

6 (d) (i) given $q_a = +3\mu C$, and $q_b = -3\mu C$

$d = 0.2m$

Electric field at mid point joining the two charge = ?

from $E = \frac{q}{4\pi\varepsilon_0 r^2}$

$$E = \frac{q_a}{4\pi\varepsilon_0 r^2} + \frac{q_B}{4\pi\varepsilon_0 r^2}$$

$$E = \frac{1}{4\pi\varepsilon_0 r^2}\left(q_a + q_B\right).$$

6 (d) (i) Electric field $= \frac{1}{4\pi\varepsilon_0 \times (0.2)^2}$ $(\because +3\mu C + 3\mu C)$

$$= \frac{6\mu C}{4\pi\varepsilon_0 \times (0.2)^2}$$

$$= 1.35 \times 10^6 N/C.$$

$\therefore$ Electric field at the Mid point joining between two charges $= 1.35 \times 10^6 N/C$

(iii) The force experienced.

Consider the two charges.

$q_a \xrightarrow{\quad x \quad} q \xrightarrow{\quad 0.2-x \quad} q_B$

$|\longleftarrow 0.2 \longrightarrow|$

Finding the distance x.

$$\frac{1}{4\pi\varepsilon_0 x^2} q_A = \frac{1 \, q_b}{4\pi\varepsilon_0 (0.2-x)^2}$$

$$\frac{q_a}{x^2} = \frac{q_b}{(0.2-x)^2}$$

$$0.3\mu C x^2 = 0.3\mu C (0.2-x)^2$$

$$x^2 = (0.2-x)^2$$

$$x^2 = x^2 - 0.4x + 0.04$$

$$x^2 - 0.4x + 0.04 - \cancel{x^2} = 0$$

$$0.4x = 0.04$$

$$x = \frac{0.04}{0.4}$$

$$x = 0.1 \text{ m}$$

hence the force experienced. when the charge q is placed

$$F_a = \frac{q_a q}{4\pi (0.1)^2}$$

$$F_b = \frac{q q_b}{(0.1)^2}$$

Resultant force $= F_a + F_b$

$$F_a = \frac{3\times10^{-6} \times 1.5\times10^{-9}}{4\pi\varepsilon_0 \times (0.1)^2} = 4.05\times10^{-3} \text{ N}$$

6 (a) And the force experienced, $F_b = \frac{3\times10^{-6} \times 1.5\times10^{-9}}{4\pi\times(8.85\times10^{-12})\times(0.1)^2}$

$$= 4.05\times10^{-3} \text{ N}$$

Hence the force experience, $F = F_a + F_b$.

$$F = 4.05\times10^{-3} \text{ N} + 4.05\times10^{-3} \text{ N}$$

$$= 8.1\times10^{-3} \text{ N}$$

$\therefore$ Hence the force experienced $= 8.1\times10^{-3}$ N.

Extract 2.6.2, shows a sample of an answer from a candidate who provided a good illustrative diagrams and resolved correctly the components of weight. Also he/she calculated correctly the forces acting on the point charges and verified systematically the given expressions.

2.2.7 Question 7: Electromagnetism

This question consisted of five parts namely (a), (b), (c), (d) and (e). Part (a) required the candidates to: (i) define the term Ballistic galvanometer, (ii) state two conditions to be fulfilled for the galvanometer to be used as a ballistic galvanometer, and (iii) use laws of electromagnetism to show that the charge delivered to the galvanometer does not depend on how long it takes to remove the search coil from the magnetic field. The stems of the question were given as 'a small flat coil of N turns and area A with its plane perpendicular to the magnetic field of flux density B, a search coil connected to the ballistic galvanometer and the total resistance R of the circuit'. In part (c), the candidates were given a stem of the question which read: "A circular coil of 300 turns has a radius of 10 cm and carries a current of 7.5 A". They were then required to calculate the magnetic field susceptibility at: (i) the centre of the coil, and (ii) a point which is at a distance of 5 cm from the centre of the coil. In part (d), they were required to define: (i) ampere, and (ii) hysteresis. In part (e), they were given a stem of the question which read: "Two parallel conductors A and B are situated 0.16 m apart. Conductor A, carries a current of 4 A and conductor B carries a current of 8 A". Then, the candidates were required to calculate the distance from point A to a point where the magnetic fields due to A and B cancel each other while ignoring the effect of earth's magnetic field.

A total of 2,996 candidates constituting 15.6 percent attempted this question whereby 56.5 percent of them scored marks ranging from 0 to 6.5 (including 9.4 percent of those who scored 0 marks). 32.3 percent scored 7 to 11.5 marks and 11.2 percent scored 12 to 20 marks. The candidates' performance is given in Figure 15. Generally, the performance of the candidates in this question was below average since only 43.5 percent passed the question. This indicates that most of the candidates did not understand well the assessed content in the topic of Electromagnetism. Similarly, the performance in the same topic for the year 2017 was weak (Appendix A) whereby only 21.5 percent of the candidates passed the question. However, despite of the noted improvement, further improvements are required on the teaching/learning materials and methodology for the purpose of raising the ability of the students to understand, retrieve and apply thoroughly the knowledge of electromagnetism in solving various problems.

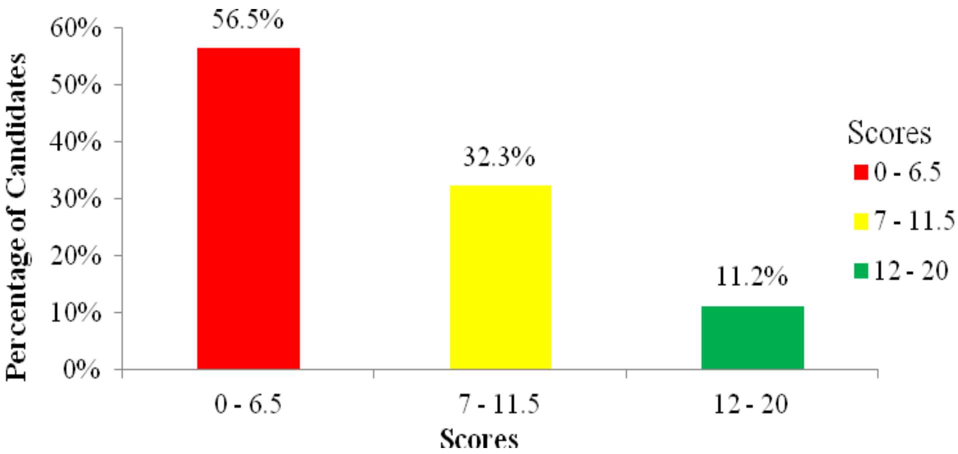


Figure 15: *Performance of candidates in question 7.*

Most of the candidates (56.5%) who scored low marks in this question provided responses which were poorly organized. Their definitions and explanations possessed some misconceptions and contradictions making the responses wrong. Others failed to answer some parts of the question especially those involving calculations. Most of those candidates had poor communication skills and lacked computational ability. Such skills and abilities are deemed important in answering this question, since most of its question items required explanations, derivations and calculations. Extract 2.7.1 show the responses given by one of the candidates who performed poorly in this question.

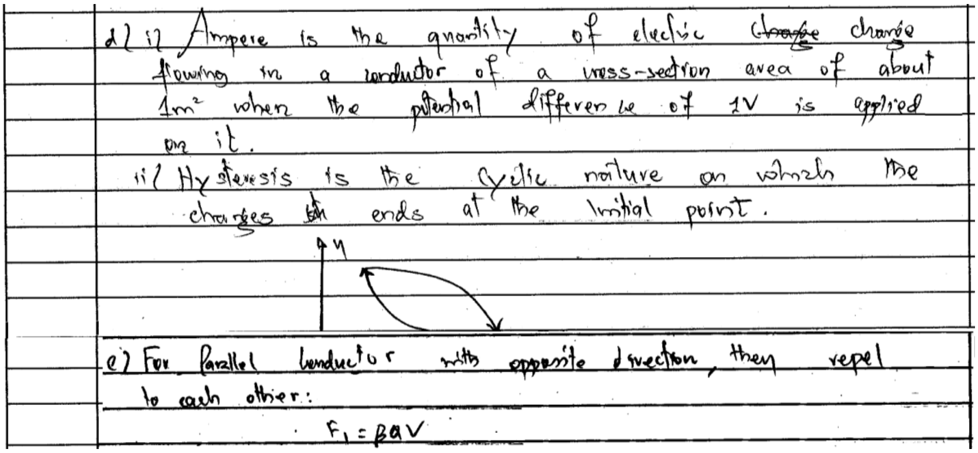
Extract 2.7.1

7. a) i) Ballistic Galvanometer is a device used to measure the direction of a current due to the influence of magnet torque which leads to the rotation of the coil

ii) - The Galvanometer should be connected with the external device

- The Galvanometer should be under the influence of magnetic fields

c) - Metal, Iron and Steel


d) i) Ampere is the quantity of electric ~~charge~~ charge flowing in a conductor of a cross-section area of about $1m^2$ when the potential difference of 1V is applied on it.

ii) Hysteresis is the cyclic nature on which the charges ~~th~~ ends at the initial point.

e) For parallel conductor with opposite direction, they repel to each other:

$F_1 = BaV$

Extract 2.7.1, a sample of an answer of a candidate who defined a ballistic galvanometer as a device used to measure the "direction of a current" while it "measures charge". He/she also mentioned magnetic materials as metal, iron and steel instead of ferromagnetic, paramagnetic and diamagnetic. Generally, all responses given in this extract were incorrect.

The group of those who performed well (11.2 %) in this question, consisted of 300 candidates (0.1%) who managed to score all the marks allotted in this question. Those candidates were able to define precisely the term ballistic galvanometer and explained well the conditions to be fulfilled for a galvanometer to be used as a ballistic galvanometer. They were also able to apply the law of electromagnetism to deduce an expression for induced charge in a coil, hence, managed to verify that "charge delivered to the galvanometer is independent of time taken to remove the search coil". In addition, most them showed good ability to recall the formulae for magnetic field strength at the centre and at a point along the axis of the coil and described correctly the three magnetic materials (Ferromagnetic, Paramagnetic and Diamagnetic materials). Extract 2.7.2 shows one of good responses for this question.

Extract 2.7.2

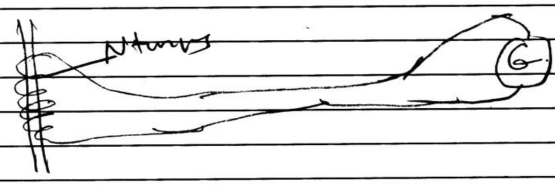
7(a)(i) Ballistic Galvanometer – Is a device which is used to detect the presence of charges by using the principle of electromagnetic Induction.

(ii) (a) It must have a coil or seaching coil which have several numbers of turns

(b) It must be capable to produce charges when their is a change in magnetic flux linking with seaching coil.

(c) It must have a resistance.

7(a)(iii) From.



from.

$E = IR$, $E = \frac{dN\Phi}{dt}$

but $I = \frac{dQ}{dt}$

$R\frac{d\Phi}{dt} = \frac{dN\Phi}{dt}$

$Rd\Phi = dN\Phi$

$RdQ = d(N\Phi)$

7a.

7a(iii)

$Rd\Phi = Nd\Phi$

$dQ = \frac{N(BA)}{R}$

$Q = \frac{NBA}{R}$

$\underset{\text{(Charges)}}{Q} = \frac{NBA}{R}$

Delivered Induced Charges $= \frac{NBA}{R}$

This e shaw that Delivered Charges is independent from the time taken to remove the seaching Coil.

7(b). Given

$N = 300$

$r = 0.1\,m$

$I = 7.5A$

(i) Magnetic field at the center of the coil.

$$B = \left(\frac{\mu_0 I}{2r}\right) = \left(\frac{4\pi \times 10^{-7} \times 7.5}{2 \times 0.1}\right) \times 300$$

$$B = 0.014T$$

∴ Magnetic field at the center $= 0.014T$

7b. at 0.05m

$$B = \frac{(\mu_0 N I) r^2}{2(x^2+r^2)^{3/2}} = \left(\frac{4\pi \times 10^{-7} \times 300 \times 7.5 \times 0.1}{2(0.1^2 + 0.05^2)^{3/2}}\right)$$

∴ $B = 0.01T$

7(c) (i)(a) Paramagnetic Materials – are materials which can be weak magnetized in the direction of magnetic field.

(b) Dimagnetic Materials – are materials which can be weak magnetized in opposite to the direction of external magnetic field.

(c) Ferromagnetic materials – are materials which can be strongly magnetized in the direction of external magnetic field.

7c(ii)

Dimagnetic material	Paramagnetic materials	Ferromagnetic materials
Have Negative value of magnetic susceptibility	Have small positive value of magnetic susceptibility	Have large positive value of magnetic susceptibility

7d (i) Ampere - Is a strength of the current flowing through the two parallel long wire of infinite length placed 1 m apart in a vacume to develope a force of $2\times10^{-7}N$.

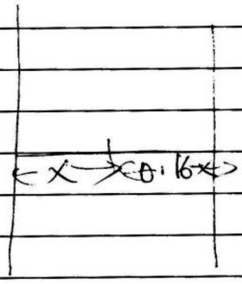
(ii) Hysteresis - lagging of magnetic flux density behind the magnetizing force.

7e Given

$d = 0.16m$.

$I_A = 4A$

$I_B = 8A$.



from.

$$B = \frac{\mu_o I}{2\pi d}$$

$$B_A = B_B$$

$$\frac{\mu_o I_A}{2\pi x} = \frac{\mu_o I_B}{2\pi(0.16-x)}$$

$$\frac{4}{x} = \frac{8}{(0.16-x)}$$

$$\frac{4}{8} = \frac{x}{0.16-x}$$

$$\frac{1}{2} = \frac{x}{0.16-x}$$

$$2x = 0.16 - x$$

$$3x = 0.16$$

$$x = 0.053m.$$

∴ The distance will be 0.053 m.

Extract 2.7.2, shows the responses of a candidate who provided the correct answers in most parts of the question items. For example, in part (b), (c) and (e) he/she applied correctly the formulae and concepts in all calculations and described well the types of magnetic materials.

2.2.8 Question 8: Atomic Physics (Quantum Physics and Nuclear Physics)

This question had four parts namely (a), (b), (c) and (d). Part (a) required the candidates to: (i) define the term photon, (ii) list three properties of a photon, and (iii) state any four laws of photoelectric emission. In part (b), they were required to: (i) briefly explain the factor which influenced de-Broglie to think that the material particles may also show wave nature and give explanation why wave nature of matter is not noticeable in daily life observations, and (ii) prove that de - Broglie wave length $\lambda = \frac{h}{\sqrt{2meV}}$ where m is the mass of the electron, e is the charge of the electron, h is the Planck's constant and V is the accelerating potential. They were also required to: (iii) calculate the work function of the material from which the emitter is made given that "Light of wavelength 488 nm is produced by an argon laser which is used in the photoelectric effect and when light from that spectral line is incident on the emitter, stopping potential of photoelectrons is 0.38V". In part (c), the candidates were required to define and provide one suitable reaction equation of: (i) Alpha decay, (ii) Beta decay, (iii) Gamma decay, (iv) Fission, and (v) Fusion. In part (d), the candidates were given a stem of the question which read: "A freshly prepared sample of a radioactive isotope Y contains 10^{12} atoms. The half-life of the isotope is 15 hours". Then they were required to calculate: (i) the initial activity, and (ii) the number of radioactive atoms of Y remaining after 2 hours.

The question was attempted by 12,515 candidates making 64.1 percent. Out of them, 39.4 percent scored marks ranging from 0 to 6.5, 37.5 percent scored 7 to 11.5 marks and 23.1 percent scored 12 to 20 marks out of the 20 marks allotted in this question. Generally, the performance in this question was good as 60.1 percent of the candidates passed the question. This implies that the topic was moderately understood by most of the candidates. Nevertheless, the performance was supposed to be higher than observed since the assessed concepts are also covered in Chemistry, therefore, most of the candidates could have studied them twice.

Most of the candidates who scored 12 to 20 marks had shown a good understanding of the concept on photon and its properties. Their ability to recall and state the laws of photoelectric emission as well as concepts of alpha decay, beta decay, gamma decay, fission and fusion was also high. A good number of them were having adequate interpretational and application competences which enabled them to analyse the data given in the question items of parts c (iii) and (d), and used appropriate formulae to calculate the required parameters. However, some of them lacked evaluation knowledge, hence, failed to give suitable responses in part (b) (i) which required critical thinking. Extract 2.8.1 shows the work of one of the candidates who managed to provide the required responses in this question.

Extract 2.8.1

8	a) i/. Photon;
	This refers to a quantum of energy carried by an electromagnetic radiation.
	ii/. - It travels with the speed of light.
	- It can be diffracted.
	- It can cause photoelectron emission on a particular surface of matter
8 a)	iii/. - For a particular frequency above the threshold frequency, the intensity of photoelectrons emitted is directly proportional to the intensity of photons falling on a particular metal surface.
	- No photoelectric emission occurs unless the incident radiation is above a minimum frequency called the threshold frequency.
	- For a particular intensity of incident
8a	iii/. radiation, the kinetic energy of the emitted photoelectrons is directly proportional to the frequency of the incident radiations.
	- Photoelectric emission is an instantaneous process of order of 10^{-9} s.
b	i/. ~~It was~~ The reason that led ~~to~~ de-Broglie to think that material particles may also show wave nature was that it was observed from Einstein's law of relativity that matter can be converted to energy and since nature loves symmetry, ~~he~~ it was postulated that material particles could also show wave properties.
	The wave nature of matter is not noticeable in our daily observations ~~since~~ due to the large mass of objects surrounding us for instance a moving ball; and since the wavelength of matter waves is inversely proportional to the mass of the body, the wavelength becomes too small to be detected by any apparatus including our naked eyes.

8b ii/. $mc = \frac{h}{\lambda}$

$\lambda = \frac{h}{mc}$ = Wavelength of matter waves / De Broglie wavelength.

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

$v = c = \sqrt{\frac{2eV}{m}}$ ... (i)

Substituting the above equation into the de Broglie wavelength;

$\lambda = \frac{h}{m\sqrt{\frac{2eV}{m}}} = \frac{h}{\sqrt{m^2 \cdot \frac{2eV}{m}}}$.

$\therefore \lambda = \frac{h}{\sqrt{2meV}}$.

iii/. $\lambda = 488 \times 10^{-9}$ m

$V_s = 0.38V$.

From Einstein's photoelectric equation:

$hf = W_0 + V_s \cdot e$.

$\therefore W_0 = hf - e \cdot V_s$. $\quad h = \frac{c}{\lambda}$.

$\therefore W_0 = \frac{hc}{\lambda} - eV_s$.

$W_0 = \frac{6.63 \times 10^{-34} Js \times 3 \times 10^{8} ms^{-1}}{488 \times 10^{-9} m} - 1.6 \times 10^{-19} C \times$

$W_0 = 3.467819672 \times 10^{-19} J$.

$W_0 = 2.167387295 eV$.

8 c) i/. Alpha decay.

This is the spontaneous emission of an alpha particle i.e Helium nucleus by ~~on~~ an ~~un~~ unstable heavy ~~nucleus~~ nuclide to form a nuclide two steps earlier in the periodic table.

$^{238}_{95}U \longrightarrow \underset{\alpha\text{-particle}}{^{4}_{2}He} + {}^{234}_{93}Ra$.

ii/. Beta decay.

This is the spontaneous emission of an electron from an ~~is~~ unstable nuclide ~~tea~~ forming a nuclide one step later in the periodic table.

$^{14}_{6}C \longrightarrow {}^{14}_{7}N + \underset{\beta\text{-particle}}{^{0}_{-1}e}$.

iii/. Gamma decay.

This is the spontaneous emission of a photon of radiation by an unstable nuclide & that was formed after either α or β - decayed nuclide falls to its ground unexcited state.

$^{238}_{95}U \longrightarrow {}^{4}_{2}He + {}^{234}_{93}Ra \xrightarrow[\text{decay}]{\text{Gamma}} {}^{234}_{93}Ra$

iv/. Fission.

This is the ~~formation~~ decay of a large nuclide ~~by~~ ~~th~~ to release two ~~at~~ stable nuclides accompan by emission of large amount of energy.

$^{235}_{95}U + {}^{1}_{0}n \longrightarrow$ Ba nuclide + Krypton + 3 neutrons + Q.

8 c | v/. Fusion

This is a nuclear reaction involving the formati of a larger stable nuclide by the fusion of two smaller unstable nuclides accompanied with the emission of large amount of energy.

$^{1}_{1}H + ^{1}_{1}H \longrightarrow ^{2}_{2}He + Q.$

d) i/. $\frac{dN}{dt} = -\lambda N. =$ Activity.

$A_o = \lambda N_o.$

$\lambda = \frac{\ln 2}{T^{1/2}}.$

$T^{1/2} = 15\text{hours} = 54,000s.$

~~$\therefore A_o = 10^{12} \times 54,000$~~

$\therefore A_o = \frac{10^{12} \times \ln 2}{54000 s}.$

$A_o = 12,836,058.9$ Bq

ii/. $N = N_o e^{-\lambda t}.$

$\lambda = \frac{\ln 2}{T^{1/2}}$

$N_o = 10^{12}$ atoms. $T^{1/2} = 15$hours.

$t = 2$hours.

$\therefore N = 10^{12} \times e^{-\left(\frac{\ln 2}{15} \times 2\right)}$

$N = 9.117224886 \times 10^{11}$ atoms.

Extract 2.8.1, a sample of an answer of a candidate who provided the correct answers to most parts of the question including part (c), which challenged most of the candidates who opted for this question.

Furthermore, it was noted that most works of the candidates who scored low marks in this question were characterized by provision of incorrect concepts, formulae and some of them failed to answer certain parts of the question. This indicated that most of them had learnt the topic from which the question items were constructed, but failed to retrieve the concepts properly. Hence, they wrote responses which contained partial information about the concepts required. Extract 2.8.2 shows the responses of one of the candidates who provided incorrect answers to most of the items in this question.

Extract 2.8.2

8. a/ i/ Photon is the charged particle which occur in the atom of element and emits the wavelength of light when excited to the higher energy level.

ii/ Properties of photons.
- It carry a charge.
- Can be emmitted to higher energy level.
- Can disintergrate to half of its life

iii/ Laws of photoelectric emmission
First law.
"The rate of the disintegration of radioactive materials is directly proportional to the number of particle in the origin
ie $dN/dt \propto N$.

Second law.
"The amount of intensity of the radioactive material emitted is directly proportion to the photoelectric current in the same element particle
ie Intensity $\propto$ I.

Third law
"The element disintergration. Can emits the wavelength of light until it reaches a maximum value called workfunction".

Fourth law.
"The rate of the decay of the element particle is directly proportional to the amount of the remained materials after disintergrated half of the original.

b/ i/ ~~De~~
i/ De-Broglie think that the materials particles may also show wave nature this is due to that when the materials particle pass through the radioactive radiation can emmitts the wavelength of light from the ground state to the higher energy level with the emmission of the colored light + so that this show that the materials particle can emmits the wavelength of light for example. Alpha particle which carry positive charge, Beta particle which carry negative charge and Gamma Rays which is neutral. Wave nature of matter not noticeable to our daily observation ~~this is due to~~

ii/ From data.

De-Broglie wavelength (λ).

~~Kinetic energy~~ (E). Kinetic energy (E).

Mass of electron (m)

Charge of electron (e)

Plank constant (h).

Accelerating potential difference

Soln

From the planks equation.

$$\Delta E = \frac{hc}{\lambda}.$$

$$\lambda E = hc \Rightarrow \lambda = \frac{hc}{E}.$$

where

(Energy change) ΔE . = KE . (Kinetic energy).

$K.E = \frac{1}{2}mv^2$ also $K.F = eV$.

hence. $\frac{1}{2}mv^2 = eV$

$$\lambda = \frac{hc}{\cancel{\frac{1}{2}mv^2}\ 4m^2v^2} \qquad v^2 = 2mv$$

where m is the mass of electron Me.

$$\lambda = \frac{hc}{\sqrt{2meV^2}}.$$

c = Constant speed of light.

So that

$$\lambda = \frac{h}{\sqrt{2meV}}.$$

Hence shown.

iii/ Data given

Wavelength (λ) = 488 nm.

Stoping potential (V) = 0.38V.

Workfunction (w_0) = ?

From

$w_0 = hf$

$$w_0 = \frac{h}{\lambda}. \quad \text{where} \quad w_0 = \frac{2\pi}{\lambda} +$$

$w_0 = \cancel{4.8}$

$$= 488 \times 0.38 + \frac{2\times\pi}{4.28}.$$

$= 0.0128.$

Hence the workfunction is 00128 m

i/ Alpha decay is the disintegration of the particle element with the emission of light wavelength to the positive terminal charge.

$^{16}_{6}C + ^{4}_{2}\alpha \longrightarrow ^{16}_{2}C + ^{1}_{0}n + Energy$

ii/ Beta decay. is the disintegration of the particle of element with the emission of wavelength of light to the negative terminal charge.

$^{16}_{6}C + ^{1}_{0}B \longrightarrow ^{16}_{6}C + Energy$

iii/ Gamma decay is the disintegration of the particle of the element with emission of wavelength of light to with no any charge carrier.

$^{61}_{9}C + ^{1}_{0}\gamma \longrightarrow ^{61}_{9}C + Energy.$

iv/ Fission is the process which involve the joining of the smallest particle of radioactive material to make large particles. nuclei

$^{2}_{1}He + ^{2}_{1}He \longrightarrow ^{4}_{2}He$

v Fusion is the process which involve the broken down of large nuclei materials into smaller po nuclei particle

$^{4}_{2}He \longrightarrow ^{2}_{1}He + ^{2}_{1}He.$

d/ Data given

Half life ($t\frac{1}{2}$) = 15hours.

Radioactive isotopes = 10^{12} atom

i/ Initial activity (λi) = ?

$$\lambda = \frac{dN/dt}{t\frac{1}{2}}.$$

$$= \frac{10^{12}}{15 \times 60 \times 3600}.$$

$$= 3.026 \times 10^{6}.$$

Hence the activity is 3.086×10^{6}. mm.

ii/ Number of radioactive

$$\frac{dN}{dt} = \frac{\lambda}{t1/2}.$$

$$\frac{dN}{dt} = \frac{10^{12}}{2 \times 60 \times 3600}$$

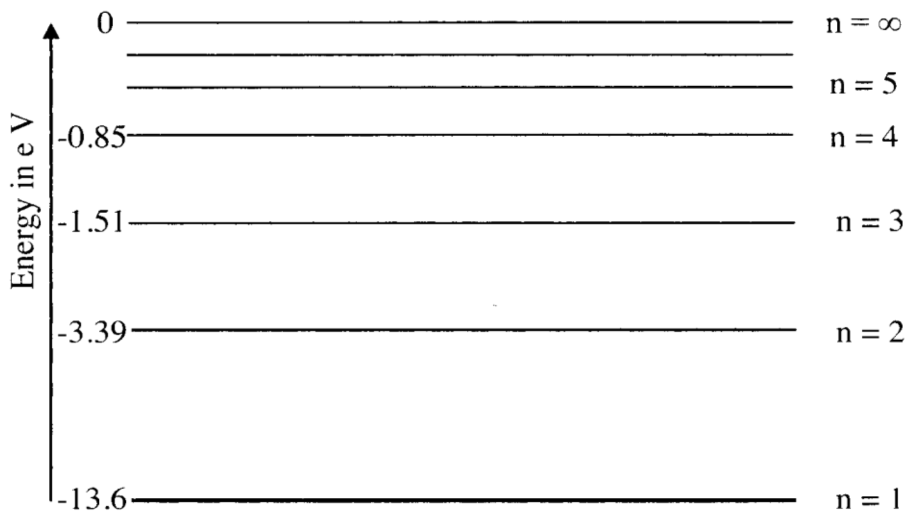
$$= 23.148.$$

Hence the number of radioactive atom Y is 36.148 atom

Extract 2.8.2, a sample of an answer of a candidate who provided incorrect answers to most of the given responses although the work is well arranged. For example he/she defined alpha decay as "*disintegration of the particle element with emission of light to the positive terminal*". This indicates that, he/she failed to recall properly the concept.

2.2.9 Question 9: Atomic Physics (Structure of the Atom and Nuclear Physics)

This question had parts (a), (b), (c) and (d). In part (a), the candidates were required to: (i) mention any four important features in the design of a nuclear reactor, (ii) differentiate binding energy from mass defect, and (iii) calculate the binding energy per nucleon in MeV and the packing fraction of the alpha particle given that: masses of proton, neutron and alpha particle are 1.0080 1.0087 and 4.0026 u, respectively. Part (b) required them to: (i) state any three limitations of Bohr's model of hydrogen atom, (ii) develop an expression for the radius r of the orbit of an electron of mass m and charge e revolving around the nucleus in terms of m, e, π, quantum number n, Planck constant h and permittivity of free space ε_o and use the derived expression to calculate the Bohr's radius. In part (c), they were required to: (i) distinguish between ionization energy and excitation energy, and (ii) explain why hydrogen spectrum contains a large number of spectral lines although its atom has only one electron. In part (d), the candidates were given the following diagram:



Then they were required to: (i) calculate the frequency and wavelength of the radiation emitted as a result of an electron transition from n = 4 to when an electron is at ground state, and (ii) determine the energy at the energy level where n = 5.

82.1 percent of the candidates attempted this question whereby 45.1 percent of them scored marks within the failure range of performance (0 to 6.5 marks), 35.1 percent scored within the average range (7 to 11.5 marks) and 19.8 percent scored marks within the good range of performance (12 to 20 marks). These data are depicted in Figure 16.

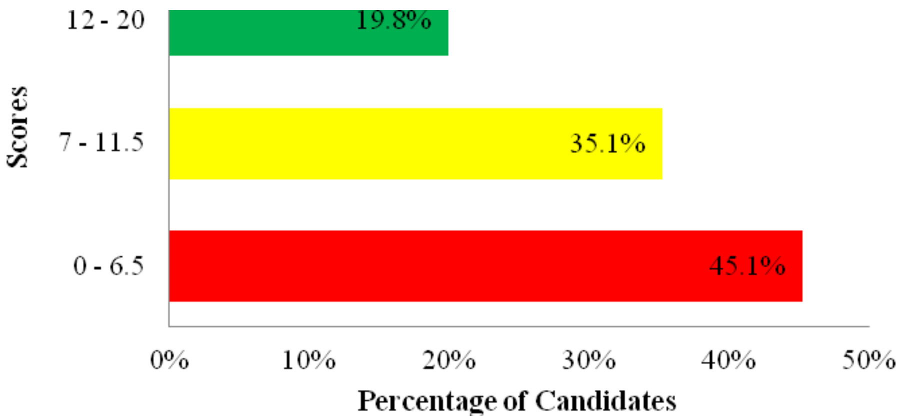


Figure 16: *Performance of candidates in question 9.*

The data given in Figure 16 indicate that a total of 54.9 percent of the candidates scored marks within the passing range, hence, an average performance. However, the number of those who failed is relatively large (45.1%), with 747 candidates (4.7%) scoring 0 marks. This indicates limited understanding of some concepts such as binding energy, mass defects, limitations of Bohr's energy and ionization energy which are basic concepts in the topic of Atomic Physics.

Among those who scored higher marks (12 to 20 marks), only seven (7) candidates managed to respond correctly to each examined item, hence scoring all the marks allotted in the question. Those candidates were noted to have adequate knowledge and competences, therefore, they did well even in the question items which involved high cognitive levels such as items: (b)(ii) (synthesis), (c) (ii) (evaluation) and (d) (analysis). Nevertheless, these items were observed to challenge most of the candidates hence, led some of them to score marks less than 20. Extract 2.9.1 shows one of good responses in this question.

Extract 2.9.1

9.a i) There should be control rods
→ To control the number of bombarding particles (neutrons)

ii) presence of moderators
→ To slow down the motion of bombarding particles

iii) presence of coolants
→ to remove the excess heat produced during the fission

iv) presence of fuels
• are materials for production of energy (heat energy) e.g U^{235}.

BINDING ENERGY	MASS DEFECT
- Refers to minimum energy required to separate the nucleus into its corresponding nucleons (protons and neutrons)	- Refers to difference between the sum of masses of nucleons to that of an intact nucleus.
- It is given as $B.E = \Delta m c^2$	- It is given as $\Delta m = \Sigma m_{nucleons} -$ mass of nucleus.

9(ii)

Data given.

$M_p = 1.008u$

$M_n = 1.0087u$

$M\alpha = 4.0026u$

α-particle $= {}^4_2He$

$n_p = 2$

$n_{neutrons} = 4-2 = 2$

Total mass of nucleons

$M_p + m_n = 2 \times 1.0080 + 2 \times 1.0087$

mass total $= 4.0334u$

$M\alpha = 4.0026u$

Mass defect $(\Delta m) = 4.0334 - 4.0026 = 0.0308u$

given $1u = 931$ MeV.

If $1u = 931$ MeV

$0.0308u = ?\ E$

$E = \frac{931 \text{MeV} \times 0.0308u}{1u} = 28.6748$ MeV

Required $B/N = \frac{B.E}{\text{Nucleons}} = \frac{28.6748 \text{ MeV}}{4}$

$= 7.1687$ MeV/nucleon

∴ The B.E/nucleon of α-particle $= 7.1687$ MeV/nucleon.

9 a(ii) 2nd case. Required packing fraction

from

$$\text{Packing fraction} = \frac{\text{mass defect}}{\text{nucleon number}}$$

$$= \frac{0.0308}{4}$$

$$= 7.7 \times 10^{-3}\ u/\text{nucleon}$$

$\therefore$ packing fraction $= 7.7 \times 10^{-3}$ u / nucleon.

b)(i) Limitations of Bohr's model of hydrogen atom

- i) No justification was given to his theory of quantization of angular momentum of an electron revolving around the nucleus $mvr = \frac{nh}{2\pi}$.
- ii) He failed to explain the atomic spectrum of multi-electron elements.
- iii) He failed to explain the splitting of atomic spectrum when placed in electric field (Stark effect) and magnetic field (Zeeman effect) and presence of HYPERFINES LINE.

9 b(ii) Data given

an electron

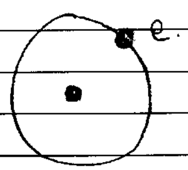
Mass = m

radius = r

Charge = e.

In a hydrogen atom model

Consider the diagram below.



Soln.

from Bohr's theory

$$mvr = \frac{nh}{2\pi} \quad \text{------ eqn(i)}$$

But electrostatic force provides necessary centripetal force.

$$\frac{mv^2}{r} = \frac{KZe^2}{r^2}.$$

squaring eq(i)

$$m^2v^2r^2 = \frac{n^2h^2}{4\pi^2}.$$

Divide by eq(ii)

$$\frac{m^2v^2r^2}{\frac{mv^2}{r}} = \frac{\frac{n^2h^2}{4\pi^2}}{\frac{KZe^2}{r^2}}.$$

9b(ii)

$$r = \frac{n^2h^2}{4\pi^2KZe^2m}.$$

but $K = \frac{1}{4\pi\varepsilon_0}$.

$$r = \frac{n^2h^2 \times 4 \times \pi \times \varepsilon_0}{4 \times \pi^2 \times Ze^2m}.$$

$$r = \frac{n^2h^2\pi\varepsilon_0}{}$$

$$r = \frac{n^2h^2\varepsilon_0}{Ze^2\pi m}.$$

but for hydrogen $Z = 1$

$$r = \frac{n^2h^2\varepsilon_0}{e^2\pi m}$$

$$\therefore \quad r = \frac{n^2h^2\varepsilon_0}{e^2\pi m}.$$

where

r = radius of orbit

h = planck constant

ε_0 = The permittivity of free space

e = charge

m = mass of electron.

2^{nd} part to find Bohr's radius

$n = 1$

$h = 6.63 \times 10^{-34} Js$

$\varepsilon_0 = 8.85 \times 10^{-12} Fm^{-1}$

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

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

$\pi = 3.14$

$$r = \frac{1^2 \times (6.63 \times 10^{-34})^2 \times 8.85 \times 10^{-12}}{(1.6 \times 10^{-19})^2 \times 3.14 \times 9.1 \times 10^{-31}}$$

$r = 5.318 \times 10^{-11} m$

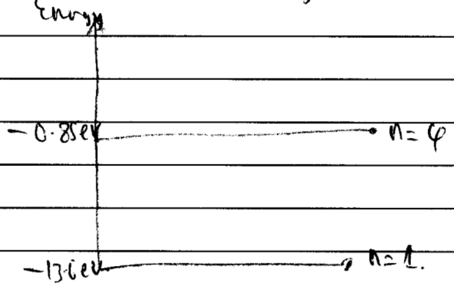
$\therefore$ Bohr's radius $= 5.318 \times 10^{-11} m$.

9c(i)

IONIZATION ENERGY	EXCITATION ENERGY
- refers to energy required to remove an electron from nuclear attractive force influence.	- refers to energy required to promote (transit) an electron to higher energy levels.
- To free the electron from nuclear attractive force	- The electron is still under nuclear attractive force.

ii) In the discharge tube, there are greater number of hydrogen atoms, that gain energy differently, thus are propoted to different energy level, thus they also emit energy differently which results into a large number of spectral lines

9d(i) from the diagram



1^{st} calc frequency

from planck's theory

$\Delta E = hf.$

$E_4 - E_1 = -0.85eV - -13.6eV.$

$\Delta E = 12.75 eV.$

In Joules $= 12.75 \times 1.6 \times 10^{-19} = 2.04 \times 10^{-8} J$

$E = hf$

$f = \frac{E}{h} = \frac{2.04 \times 10^{-8} J}{6.63 \times 10^{-34}} = 3.0769 \times 10^{15} Hz$

$f = 3.0769 \times 10^{15} Hz.$

$\therefore$ The frequency of radiation emitted $= 3.0769 \times 10^{15}$ Hz

2^{nd} part wavelength.

given

$c = 3 \times 10^8$

$f = 3.0769 \times 10^{15} Hz$

from

$c = f\lambda.$

$c = f\lambda$

$\lambda = \frac{c}{f}$

$\lambda = \frac{3\times10^{8}}{3.076\times10^{15}} = 9.75\times10^{-8}\,m$

$\therefore$ The wavelength of radiation emitted = $9.75\times10^{-8}\,m$

(ii) Required E at = $n = 5$

from

$E_n = -\frac{13.6}{n^2}$ for hydrogen

$n = 5$

$E_5 = -\frac{13.6\,eV}{5^2}$

$E_5 = -0.544\,eV$

$\therefore$ The energy at $n = 5$ is $-0.544\,eV$

Extract 2.9.1, a sample of an answer of a candidate who managed to provide a brief, precise explanations and systematic calculations to most of the question items.

In the case of those who scored low marks (0 to 6.5 marks), most of them gave correct responses to some items of the questions especially items (b)(i) and (c)(i). This might be due to the fact that concepts examined in these items are very familiar to learners as they are discussed in both Physics and Chemistry at both ordinary and advanced secondary school levels. However, most of them failed to provide correct answers for items (a) (i), (b) (ii), (c) (ii) and part (d) due lack of higher cognitive competences. Extract 2.9.2 shows the work of one of the candidates who had poor scores in this question.

Extract 2.9.2

9. (A) (i) Important features of a Nuclear reactor

(a)

(b)

(c)

(d)

(ii) Mass defect; Is the total mass of proton and neutron that presence in a nuclear reactor while

Bending energy → Is the energy requid to the mass of defect in the nuclear per nucleon.

(iii) Soln

Given that:

Mass of proton = 1.00804

mass of neutron = 1.00874

Mass of particle = 4.0026u.

total mass of nucleons = (mass of proton + Neutron)

= (1.0080 + 1.0087)u

= 2.01674

Mass defect = Mass of particle − total mass of neutrons

= (4.0026 − 2.0167)u

Mass defect = 1.98594

9. (iii) Binding Energy per nucleon.

$E = \frac{\text{mass defect}}{931 \text{ Mev}}$

from

$1u \longrightarrow 931 \text{Mev}$

$1.98594 \longrightarrow x$

$x = 931 \times 1.9859$

$= 1848.8729 \text{ Mev}$ Is a binding energy per nucleon.

Packing fraction of an Alpha particle.

${}^4_2He = 4.00264$

Packing fraction $= \frac{\text{Mass defect}}{\text{mass of alpha particle}}$

$p.f = \frac{1.9859}{4.00264}$

$p.f = 0.4962$

(B). (i) It show that the mass of electron $= 9.1 \times 10^{-31}$ kg.

(ii) The an electron of mass and charge revolved around the nucleus in a circular orbit of radius.

(iii) Bohr's model It express that the energy quantum number is $E = hf$.

9	(B) (ii) soln
	From
	$E = hf$
	but.
	$E_e = mg$
	$\frac{q}{\cancel{}} = \frac{m}{e}$.
	$eq = m$
	$e = \frac{m}{q}$
	$\frac{hfm}{q} = mg$
	$= Mgq = hfm$
	$q = \text{vendA}$
	$Mg\,\text{vendA} = hfm$
	$g\,\text{vendA} = hf$
	but
	~~$v = 2\pi f$.~~
	$h = \frac{c}{f}$
	$f \times g\,\text{vendA} = \frac{c}{f} \cdot f$ re
	$fg\,\text{vendA} = cf$
	$w = 2\pi f$.
	$r = \frac{\varepsilon h n}{4\pi^2 M_e}$
	but
	$\varepsilon_0 = 8.85 \times 10^{-12}\ fm^{-1}$
	$h = 6.63 \times 10^{-34}\ Js$
	$n = 1$.
	$M = 9.1 \times 10^{-31}\ kg$
	$e = 1.6 \times 10^{-19}\ C$.
	$r = \frac{8.85 \times 10^{-12} \times 6.63 \times 10^{-34} \times 1}{4 \times \pi^2 \times 9.1 \times 10^{-31} \times 1.6 \times 10^{-19}}$
	$r = 2.164 \times 10^{-4}\ m$
9	(c) (i) Ionization Energy → Is the Energy that ~~requird~~ required to the maximum potential energy of hydrogen atom to the ~~a~~ energy levels of the hydrogen specturm line.
	Excitation Energy → Is the maximum energy that required to the large number of Spectral lines (Excited state).

9. (C). (ii). This is simply because the hydrogen spectrum has a high Ionization Energy and has a high electronegative affinity and hence it contain a larger number of Spectral lines.

9 (d)(ii) Soln

$n_2 = 5$

$n_1 = 4$.

$\frac{1}{\lambda} = Rhc\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$.

From.

$E = hf$

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

$E = \frac{Rhc}{\lambda}$

$E = RhC\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$.

$E = 1.0974 \times 10^7 \times 6.63 \times 10^{-34} \times 3 \times 10^8 \left(\frac{1}{4^2} - \frac{1}{5^2}\right)$

$= 2.181933 \times 10^{-18}\left(\frac{1}{16} - \frac{1}{25}\right)$

$= 4.90934925 \times 10^{-20}$ J

Soln.

9 (D) (i) $n_2 = 4$

$n_1 = 3$

$h = 6.63 \times 10^{-34}$ Js

$R = 1.0974 \times 10^7\ m^{-1}$

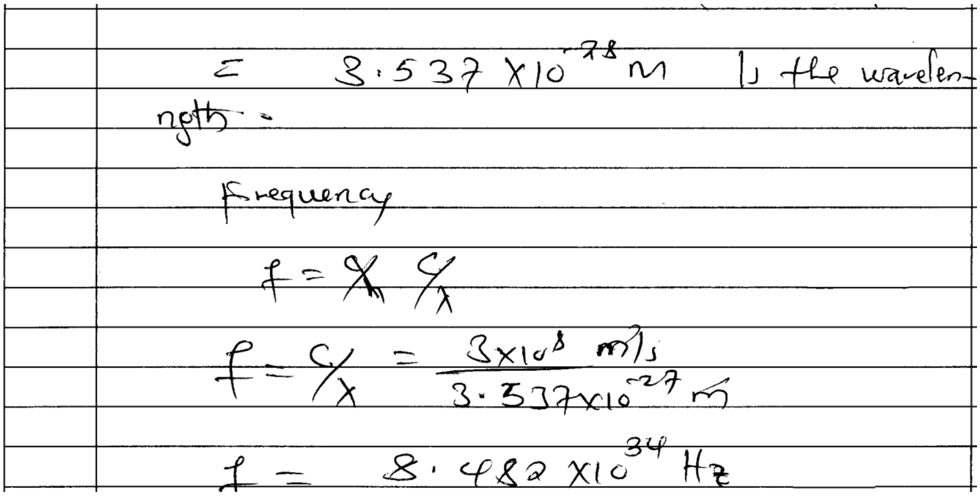
$f = ?$

$\frac{1}{\lambda} = ?$

Recall.

$\frac{1}{\lambda} = Rh\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$

$= 1.0974 \times 10^7 \times 6.63 \times 10^{-34}\left(\frac{1}{3^2} - \frac{1}{4^2}\right)$



$= 3.537 \times 10^{-28}$ m is the wavelength.

Frequency

$f = \cancel{\lambda}\ c/\lambda$

$f = c/\lambda = \dfrac{3\times10^{8}\ m/s}{3.537\times10^{-27}\ m}$

$f = 8.482 \times 10^{34}$ Hz

Extract 2.9.2, a sample of an answer of a candidate who gave incorrect responses to each part of the question. For example, in (d) (i), he/she used incorrect procedures and formulae to determine the frequency and wave length of the emitted radiation.

3.0 ANALYSIS OF THE CANDIDATES' PERFORMANCE PER TOPIC

In Physics 1 and 2 examination papers, a total of twelve (12) topics were tested. These topics were: Measurements, Fluid Dynamics, Vibrations and Waves, Atomic Physics, Heat, Properties of Matter, Electronics, Electromagnetism, Mechanics, Electrostatics, Environmental Physics and Current Electricity.

The analysis of the candidates’ responses in each topic shows that the performance on the topics of Measurements was 86.6 percent, Fluid Dynamics 81.5 percent and Vibrations and Waves 64.3 percent which reflect a good performance. Average performance was observed in the topics of Atomic Physics (57.8%), Heat (55%), Properties of Matter (53.5%) and Electronics (53.2%). Other topics in this category were Electromagnetism (43.5%), Mechanics (42%) and Electrostatics (37%). However, the topics of Environmental Physics and Current Electricity had 24.2 and 20.9 percent, respectively, indicating weak performance.

Some of the main reasons for an average performance include failure of the candidates to comprehend the concepts in some parts of the question items and lack of mathematical skills in performing calculations. On the other hand, weak performance was contributed by insufficient mastery of the content, lack of knowledge and mathematical ability in calculations. Other factors were misconception of ideas and failure to apply principles and laws of physics in the prescribed fields of study. Generally, most of them failed to provide a logical flow of ideas and were incompetent in conveying the acquired knowledge and skills to solve questions related to their daily life situations. The summary of the candidates' performance in all topics is shown in Appendix C.

4.0 CONCLUSION AND RECOMMENDATIONS

4.1 Conclusion

The candidates' performance in ACSEE in Physics Examination for 2018 was average. Most of the candidates who sat for the examination scored the passing marks allotted for each question especially those which involved the use of formulae, principles and laws of Physics in performing calculations. The performance on the questions which required detailed explanations were observed to be weak.

The analysis further addressed the challenges faced by the candidates who scored low marks. Incompetency in the English language use, failure to apply formulae and lack of carefulness when substituting the data in the given or formulated equations were among the factors which caused weak performance in the stated topics.

Generally, the analysis reveal that the candidates' performance in Physics subject has increased by only 0.7 percent as compared to the year 2017. This reflects a poor coverage of the content during the teaching and learning process as it was noted in Appendix A. It shows that only 3 out of the 12 topics that were examined had good performance contrary to the previous year (2017) that registered good performance in seven (7) out of twelve (12) topics. However, improvements of performance were observed on some topics, particularly, Mechanics and Electromagnetism as shown in Appendix B.

It is expected that the recommendations given through this analysis will be helpful to students, teachers and all educational stakeholders during the teaching and learning process for improving the performance of candidates in the future Examinations.

4.2 Recommendations

In order to improve the performance of prospective candidates in Physics Examination, it is recommended that:

(a) Students should be guided to work hard on mastering mathematical skills to improve their ability in solving questions which involve calculations for such questions are common in Physics Subject.

(b) Teachers should encourage students to read more subject related books along other English books and practice English Language in their day to day communications so as to improve their language proficiency.

(c) Students should read and understand theories, principles and laws of physics to enable them to relate the acquired knowledge and skills into their day to day activities.

(d) Teachers should apply student centred techniques by teaching through demonstrations and experimentations. Also they should assess all the topics as stipulated in the syllabus to enhance the learners' level of understanding on the subject matter.

(e) Teachers are advised to guide the students on how to identify the specific tasks of the questions and how to organise the concepts so as to respond correctly to the examination questions.

(f) The government, school administrators and other educational stakeholders should encourage in-service training to physics teachers so that they can exchange their experiences and share the teaching, learning and assessment materials.

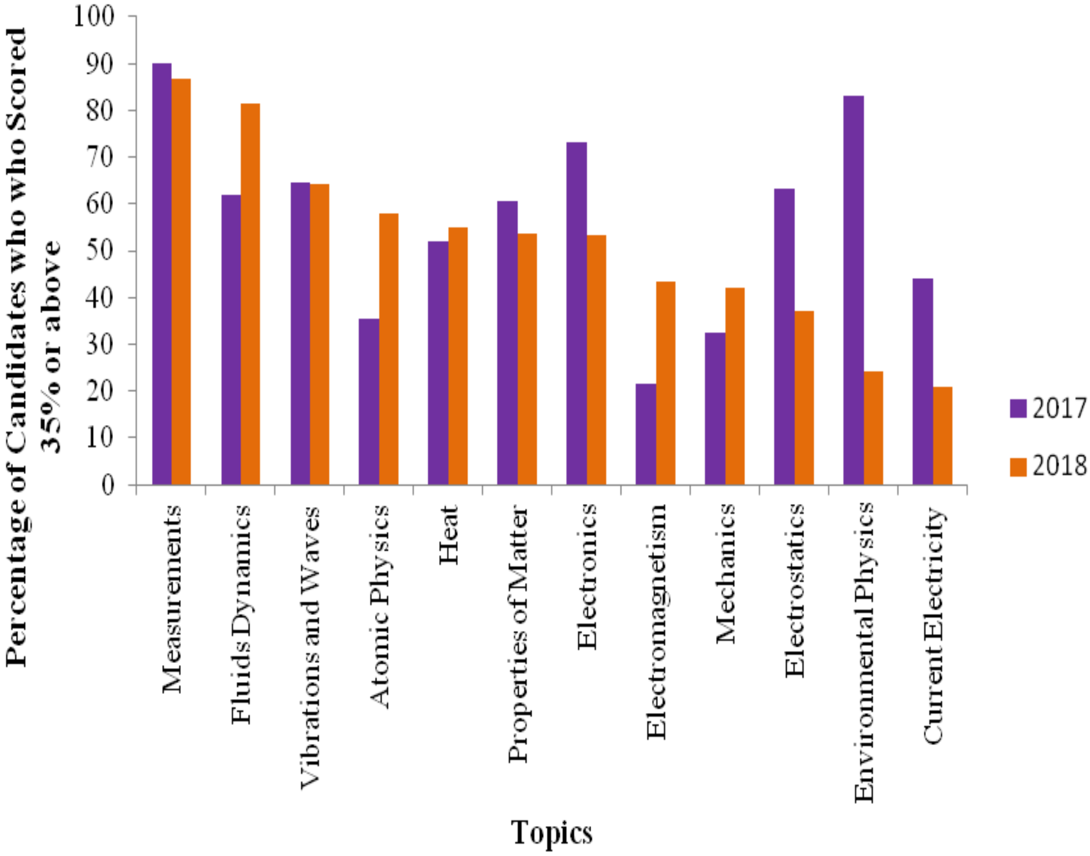
Appendix A

COMPARISON OF THE CANDIDATES' PERFORMANCE IN EACH TOPIC BETWEEN 2017 AND 2018

S/n.	Topic	2017 EXAMINATION PAPER			2018 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	Measurements	2	90.1	Good	1	86.6	Good
2	Fluids Dynamics	1	62.0	Good	1	81.5	Good
3	Vibrations and Waves	2	64.7	Good	2	64.3	Good
4	Atomic Physics	2	35.3	Average	2	57.8	Average
5	Heat	2	52.1	Average	2	55	Average
6	Properties of Matter	2	60.7	Good	2	53.5	Average
7	Electronics	3	73.3	Good	3	53.2	Average
8	Electromagnetism	1	21.5	Weak	1	43.5	Average
9	Mechanics	4	32.4	Weak	5	42	Average
10	Electrostatics	1	63.3	Good	1	37	Average
11	Environmental Physics	1	83.0	Good	1	24.2	Weak
12	Current Electricity	2	44.0	Average	2	20.9	Weak

Appendix B

A BAR CHART OF COMPARISON OF THE CANDIDATES' PERFORMANCE IN EACH TOPIC BETWEEN 2017 AND 2018



Appendix C

CANDIDATES' PERFORMANCE IN EACH TOPIC IN THE YEAR 2018