Statistics

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<th>Year</th>
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<th>Level of achievement</th>
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General comments


Part A consisted of 15 multiple-choice questions and eleven short-response questions covering all syllabus topics. Marks allocated were in proportion to syllabus topic weightings.

Part B contained eight Scientific processes questions assessed by criteria specific to each question. In Part B, candidates were required to respond to all eight questions.

Paper Two assessed Complex reasoning processes and contained six questions assessed by specific criteria. Candidates were required to respond to all six questions.

Paper One Part A — Knowledge of subject matter

Candidates were required to demonstrate their knowledge and ability regarding simple application of the syllabus topics. Many responses indicated that candidates had attempted to learn information without a full understanding of the underlying principles and processes.

Section 1 — Multiple-choice questions

<table>
<thead>
<tr>
<th>Question</th>
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<tr>
<td>Correct option</td>
<td>B</td>
<td>C</td>
<td>B</td>
<td>A</td>
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<td>B</td>
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<td>D</td>
<td>C</td>
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<td>D</td>
<td>D</td>
<td>B</td>
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<td>C</td>
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Section 2 — Short response

Question 1
Most candidates clearly understood the notion of significant figures and could apply it in the situation given.

Question 2
Candidates generally converted percentage errors into absolute errors with few problems.

Question 3
Candidates did not always recognise the need for a minimum mass, with some giving a mass slightly larger than necessary. Most coped with the vector resolutions required in the problem, but some had clearly not learned or revised the process properly.

Question 4
This question posed limited challenges for candidates once the format was recognised.

Question 5
While some candidates added up mass incorrectly, the problem was recognisable and generally attempted successfully.

Question 6
Most candidates were partially successful in answering this question, perhaps as a result of the requirement to understand the text. Not all candidates addressed both aspects of the question (refraction and velocity). Some did not understand how the behaviour would change regardless, simply giving the wrong response.

Question 7
Despite the complexity of the question, most candidates addressed this successfully to some degree. It is a standard question type and one of the first to be practised within the topic. Some small confusion occurred as a result of having to convert units.

Question 8
While some candidates may not have recognised the problem type or understood which equation to use, those that did had little problem with the simple and straightforward formula substitution.

Question 9
Candidates were generally successful with this problem, although the need to read the information from an actual appliance label with its range of extra values (rather than a sample label with only required values) showed some candidates were only comfortable with direct substitution into the formula, and did not fully understand the concept.

Question 10
As in Question 8, candidates who recognised the information in the problem did well in substituting into the required formula.

Question 11
It was apparent that not all candidates had practised this type of problem. Errors included not successfully managing the numbers of protons and neutrons and not correctly identifying the resultant nuclei.
Paper One Part B — Scientific processes

Question 1
The concept involved was quite straightforward, though some candidates had problems successfully interpreting the meaning of the graphs. The language used to justify their choice was not always expressed in terms of the necessary variables.

Question 2
Despite the simple nature of the required response, not all candidates completed this successfully. Some did not seem able to navigate through the information given to set up the problem, despite this using basic circuit theory. Others were unable to synthesise the circuit information to produce the correct response.

Question 3
Candidates generally answered this question successfully. Some candidates did not appreciate that the diagrams were of the same object drawn in different ways, nor were they able to integrate the diagrams to produce the required response. More practice in visualisation may assist candidates with this type of problem.

Question 4
There was some variability in the success of candidates in this problem. Given it was a square graph and that the superposition was therefore straightforward, this indicates that some candidates need more practice in this type of problem. The extra step in first working out the new positions of the wave may provide a focus for question rehearsal.

Question 5
Candidates typically responded satisfactorily to this question and, considering it is a standard plot of data, this is expected. Some candidates did struggle with correct scaling of the graph. One candidate halved the time instead of the count.

Question 6
Candidates generally developed a solid experimental framework showing that they understood most of what was required. There was a general lack of specificity, however, demonstrated by insufficient use of proper terminology including ‘variable’, ‘control’, ‘hypothesis’; and by the lack of a good data collection system. Candidates would have benefited from more written or verbal discussion around experimental design with attention to sufficient detail and correct use of scientific language.

Question 7a
As in Question 2, there was a significant amount of information for candidates to process. Unlike Question 2, most did this well and accurately.

Question 7b
Some candidates did not correctly relate the variables, despite being given the equation to do so. The requirement to synthesise information and apply it to the graph was not met by some.

Question 8
This question was not well answered generally, with candidates showing a poor understanding of what the graph physically represented. Those who did understand the representation gave the correct response, indicating the skill was in the interpretation rather than the reading of the graph.
Paper Two — Complex reasoning processes

Question 1
It was clear that some candidates got lost very quickly in the requirements of the question, despite it being answered in part by most candidates. Finding the difference between points A and B proved problematic, though the steps leading up to it were not a source of confusion.

Question 2
Candidates often got lost within the question, having to move from calculating the area under the graph to using the area to determine time. More practice in analysing graphs in sections would have been useful.

Question 3
While some candidates were successful, many simply applied the wrong formula, or the right formula in the wrong way. As in Question 2, the ability to analyse in sections seemed weak for these candidates.

Question 4
This was generally done well, though a surprising number of candidates could not move from a velocity expressed in metres per second to a total distance in a total time at that velocity as given by the physical change in the rocket.

Question 5
This was well done by some candidates, who were clearly comfortable rearranging the necessary equations and properly resolving vectors. Most candidates struggled to adopt an approach that worked, getting some of the way to the response but falling short.

Question 6
Candidates who made the connection between the weight of the bar and the force required to counter this generally did well. The use of the appropriate equation was straightforward, although some candidates did not move from the mass per unit length given to assume one metre.

Sample solutions

The following solutions are not necessarily prescriptive model responses and are not necessarily the only way of solving a problem. Other approaches and problem-solving strategies may be just as acceptable.
Paper One: Part A

Part A Question 1

\[ a. \quad 4 \]

\[ b. \quad 4 \quad \text{(\(\frac{1}{2}\) each)} \]

\[ c. \quad 2 \]

\[ d. \quad 4 \]

Part A Question 2

\[ a. \quad 45.6 \times 0.014 = 0.638 \]

\[ \quad \frac{45.6 \pm 0.7}{(\frac{1}{2} \text{ for 0.638})} \text{ this is not rounding, it is error control} \]

\[ b. \quad 745 \times 0.12 = 0.894 \]

\[ \quad 7.45 \pm 0.9 \quad (1) \]

Part A Question 3

\[ 15N \]

\[ mg \]

\[ 2^\circ \]

Will move when \( mg \sin 30 \geq 15 \) \( (2) \)

\[ m > 15 \]

\[ g \sin 30 \]

\[ 2U \quad 2kg \quad (1) \]

(Accept use of equal sign)
Part A  Question 4

\[ m = 500 \text{ kg} \]
\[ \Delta v = -25 \text{ m/s} \]
\[ t = 5 \times 10^{-3} \text{ s} \]

\[ F = m \Delta \frac{v}{t} \]

\[ = \frac{500 \times 25}{5 \times 10^{-3}} \]
\[ = 2.5 \times 10^6 \text{ N} \]

Part A  Question 5

Work done = energy gained

\[ W = \frac{mv^2}{2} \]

\[ = \frac{780 \times 9.8 \times 400}{2} \]
\[ = 2.74 \times 400 \text{ J} \]

\[ P = \frac{W}{t} \]

\[ = \frac{2.74 \times 400}{6} \]
\[ = 4573.3 \text{ W} \]
Part A  Question  6

The red light will be refracted more than the green light. (OUTTE)

As the medium B is denser than A, the wavelength would decrease. (OUTTE)

Part A  Question  7

\[ \lambda = \frac{\lambda_0}{n} = \frac{0.035 \times 4 \times 10^{-6}}{2.5} = 4 \times 10^{-8} \text{ m} \] (1)

Part A  Question  8

\[ \omega = g \frac{V}{r^2} = \frac{1.5 \times 10^{-5} \times 4 \times 10^3}{6 \times 10^2} = 6 \times 10^2 \text{ J} \] (1)
\[
P = VI
\]
\[
I = \frac{P}{V}
\]
\[
\text{when } V = 240 \text{ V} \quad P = 1800 \text{ W}
\]
\[
I = \frac{1800}{240} = 7.5 \text{ A}
\]
\[
V = IR
\]
\[
R = \frac{V}{I}
\]
\[
= \frac{240}{7.5} = 32 \Omega
\]

**OR**

\[
P = 1650 \text{ W}
\]
\[
I = \frac{1650}{280} = 7.3 \text{ A}
\]
\[
V = IR
\]
\[
R = \frac{V}{I}
\]
\[
= \frac{280}{7.3} = 32 \Omega
\]

*Similar method*
Part B

Question 10

\[ q = 1.6 \times 10^{-9} \, \text{C} \]
\[ \theta = 30^\circ \]
\[ u = 3.0 \times 10^{-6} \, \text{m/s} \]
\[ B = 4.0 \times 10^{-7} \, \text{T} \]
\[ F = ? \]

\[ F = B q u \sin \theta \]
\[ = 4.0 \times 10^{-7} \times 3 \times 10^{-6} \times 1.6 \times 10^{-6} \times 0.5 \]
\[ = 9.6 \times 10^{-20} \, \text{N} \]

Part A

Question 11

a. \[ ^2 \text{H} + ^2 \text{H} \rightarrow ^{X} \text{H} + ^1 \text{n} \]

LHS: \[ ^2 \text{H} + ^2 \text{H} \]
\[ \Rightarrow ^3 \text{He} \quad (1) \]

b. \[ ^{235} \text{U} + ^{0} \text{p} \rightarrow ^{141} \text{Ba} + ^{X} \text{He} + ^3 \text{He} \]

LHS: \[ ^{235} \text{U} + ^{0} \text{p} \]

RHS: \[ ^{141} \text{Ba} + ^{X} \text{He} + ^3 \text{He} \]  

Require \[ ^{144} \text{U} - ^{88} \text{O} = ^{56} \text{Fe} \]

\[ 192 - 56 \text{P} = 36 \text{P} \]

\[ 92 \times \frac{92}{56} \]

\[ X = \frac{92}{56} \, \text{Kr} \quad (1) \]
Paper One: Part B

Note: Question 2 appears out of order overleaf.

Part B Question 1

This graph shows a change in velocity / acceleration, and that a net force is therefore in effect. As the velocity is decreasing over time the force, being a vector, must be acting to some degree in the opposite direction to the velocity vector.

Part B Question 3

a. 2

b. 2

The answer for both the number of reflections and refractions is two, as the light ray first enters the diamond from the top, then reflects internally twice at the bottom, and then exits the diamond from the top.

Part B Question 4

The resultant graph shows addition of the two original pulses in their new positions. The front of the positive displacement wave has moved to 3 and the front of the negative displacement wave has moved to 6.
At least 2 wavelengths required. 2 marks for 1.
Part B Question 5

One mark for each axis labelled - Time in min on x and Count on y
One mark for Curve drawn - best fit through points
One mark for indicating the half count on the graph (about 275)
One mark for reading of the half-life. Depending on line of best fit, but should be close to 57 minutes.

Question 5

A racquet (either spelling fine) could be held in place by a vice positioned somewhere along its handle, with the plane of the racket being horizontal.

The face of the racquet could be mapped into segments of, say 4 squares on a side to indicate variation in where the face could contact a tennis ball.

A tennis ball could be held in position above the racquet directly above each of these segments, and dropped from a fixed height. The height of rebound would indicate the impulse given to the ball by the racket.

The position and release of the ball could be constant across the various segments of the racquet face by the use of a retort stand and clamp. Rebound height could be captured by a video camera.

If one place on the racquet delivered greater impulse, the hypothesis would be supported. If no places did, the hypothesis would be falsified.

(1 – for describing the experiment)

Variables controlled: Height of drop, racquet used, ball used, position of clamping (1)

Independent variable: Target segment (1)

Dependent variable: Rebound height (1)

If the variables are identified in the text, that is acceptable. Maximum 2 marks if the description is sufficient but the variables are not specifically identified.
Part B Question 7

a. Microwave (1)

b. Maximum for 5000K = 0.5 eV
   = \frac{8 \times 10^{-20}}{6.63 \times 10^{-34}} = 1.2 \times 10^{14} \text{ eV} (1)

In the red (1)

Part B Question 8

$\frac{40}{1} = \frac{\infty}{1}$

As the horizontal axis represents displacement (not time), and as it is given that the wave is moving from left to right, students need to understand that the graph shape is moving from left to right. They need only then move the graph slightly to the right to anticipate the change in pressure at any given location.
Paper Two

Question 1

\[ V_T = \sqrt{80} + \sqrt{20} = 14.8 \]

\[ R_T = 48 \, \Omega \]

\[ V = I \times R \]

\[ I = \frac{V}{R} = \frac{100}{48} = 2.08 \, A \quad (1) \]

\[ V_2 = 100 - V_1 \quad (i) \]

\[ = 100 - 2.5 \]

\[ = 97.5 \, V \]

\[ V_8 = 100 - V_4 \quad (i) \]

\[ = 100 - 33.3 \]

\[ = 66.7 \, V \]

\[ V_4 - V_8 = 75 - 66.7 \, V \]

\[ = 8.3 \, V \quad (1) \]
Question 2

**Cart A:**

In the first 40 s, 

\[ \frac{a \times 40}{2} = 400 \text{ m} \]  

(1)

for the remainder:

\[ 20 \times t = 100 \]

\[ t = 5 \text{ s} \]

\[ \therefore \text{ total time of } 45 \text{ s} \]  

(1)

**Cart B:**

In the first 20 s, 

\[ \frac{a \times 20}{2} = 150 \text{ m} \]  

(1)

for the remainder:

\[ 15 \times t = 350 \]

\[ t = 23.3 \text{ s} \]

\[ \therefore \text{ total time of } 43.3 \text{ s} \]  

(1)

\[ \text{Cart B wins!} \]  

(1)
\[ \alpha = 1.5 \]

\[
\frac{\sin \theta_c}{\sin 90} = 1.5
\]

\[
\therefore \theta_c = \sin^{-1}(1/1.5) = 41.8^\circ \quad (1)
\]

Using 41.8 as \( \sin \theta_i \); \( \quad (1) \)

\[
\frac{\sin \theta_i}{\sin \alpha} = 1.5 \quad (1)
\]

\[
\sin \theta_i = 1.5 \times \sin (41.8^\circ)
\]

\[
\therefore \theta_i = 88.9^\circ \quad (1)
\]
\[ \Delta P \text{ for gas} = 3000 \times 50 = 150,000 \text{ Ns} \] (i)

\[ \therefore \Delta P \text{ for rocket} = 150,000 = 20,000 \text{ Ns} \] (i)

\[ v = -7.5 \text{ m/s} \] (i) - for negative

This \( \Delta P \) must be constant over 10 s;

\[ 10 \times -7.5 = -75 \text{ m/s} \] (i)
Question 5

\[ \theta = 38^\circ \]
\[ v_{xt} = v_e \cos 38^\circ \]
\[ s_{ht} = 64 \text{ m} \]
\[ v_{xh} = v_e \sin 38^\circ \]
\[ v_e = ? \]

For maximum height,
\[ t = \frac{v_e}{g} \]
\[ t = \frac{6.66}{9.8} \]  
\[ \therefore \text{ total time for flight } = \frac{2 \times 6.66}{9.8} \]

For horizontal displacement,
\[ v_{xt} = 64 \div 6.66 \]
\[ = 64 \div \frac{2 \times 6.66}{9.8} \]
\[ \therefore v_e \cos 38^\circ = 64 \times \frac{9.8}{2 \times 6.66} \]

Range:
\[ x^2 = \frac{64 \times 9.8}{\cos 38^\circ \times 2 \times \sin 38^\circ} \]
\[ = 646.4 \]
\[ \therefore v_e = \frac{25.42 \text{ m/s}}{} \]
Question 6

\[ M = 0.1 \, \text{kg} \quad F = ma \]
\[ I_1 = 100 \, \text{A} \quad \Rightarrow 0.98 \, \text{N} \]
\[ d = 1\, \text{mm} = 1 \times 10^{-3} \, \text{m} \]

\[ k = 1 \, \text{m} \, \text{(using a unit length)} \, \, (1) \]
\[ B = \frac{k I_1}{r} \quad \Rightarrow F = BI_2 L \, \, (1) \]
\[ \Rightarrow F = \frac{k I_1 I_2 L}{d} \, \, (1) \]

\[ I_2 = \frac{F d}{k I_1 B} \]
\[ = \frac{0.98 \times 1 \times 10^{-3}}{2 \times 10^{-7} \times 100 \times 1} \, \, (1) \]
\[ = 49 \, \text{A} \, \, (1) \]