Statistics

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<th>LA</th>
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Multiple-choice questions

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<td>B</td>
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<td>B</td>
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<th>12</th>
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<tr>
<td>Correct response</td>
<td>C</td>
<td>D</td>
<td>B</td>
<td>C</td>
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General comments

Candidates were required to demonstrate ability in all three areas of the syllabus: Knowledge of subject matter (K), Scientific processes (SP) and Complex reasoning processes (CRP). Only limited trade-offs can be applied if candidates demonstrate uneven levels of achievement.

Knowledge of subject matter

The 15 multiple-choice questions in Paper One: Part A were designed to cover the full range of syllabus topics, as much as possible. All candidates responded to all questions, with varying results. Two candidates achieved full marks and a further three candidates responded incorrectly to only one question. Overall, 15 candidates responded correctly to 10 or more questions.

The Knowledge of subject matter questions in Paper One: Part B were designed to provide candidates with as much variety as possible, and to allow candidates to demonstrate how they respond using mathematics and natural world phenomena. Questions ranged from written to diagrammatic and from simple to more challenging. Many candidates responded successfully, showing a good understanding of the concepts and laws of physics.
Paper One: Part B — Question 6 related to a concept that some candidates appeared to be unfamiliar with. The response from one candidate, who correctly used a diagram as suggested, is reproduced below.
Scientific processes

The Scientific Processes questions in Paper One: Part B proved to be a stumbling block for some candidates. These questions required interpretations of data and experimental results. Responses to Question 7 and Question 12 required candidates to describe investigations in either written form or by use of a circuit diagram. For Question 12, many candidates were unable to set up a circuit where a component was to be tested and then failed to analyse the given data.

Complex reasoning processes

Paper Two provided a range of Complex reasoning processes contextual questions from topics across the syllabus. The questions in Part A were “simple”, and designed so most candidates could respond. The questions in Part B were more difficult, and designed to discriminate. All of the Complex reasoning processes questions were multi-step and often open-ended. Many candidates showed a range of problem-solving skills. Candidates who achieved a Sound Level of Achievement or better were able to respond successfully to questions in both Part A and Part B.

In dealing with these types of questions, candidates are encouraged to make a start and then work step by step in order to solve the problem.

Characteristics of good responses

Generally, candidates showed a good understanding of the concepts and principles of physics. They used formulas confidently and showed working and appropriate mathematical and communication skills where required. Responses to questions which were well set out allowed partial credit to be awarded.

Almost without exception, candidates responded to all questions on both papers.

Common weaknesses

Many candidates had difficulty in responding to Scientific processes questions. To prepare for these questions, prospective candidates must be exposed to a range of experimental skills and suitable data analysis. Exercises using secondary data for analysis, graphing skills, gradients and areas under a curve would be beneficial. Equally important is working with vectors, conversion of units, making judgments about the conduct of experiments and drawing conclusions.

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.
Question 1

$L = 26.5 \pm 0.4 \text{ cm}$
$W = 18.7 \pm 0.4 \text{ cm}$

a) $L + W = 45.2 \pm 0.8 \text{ cm}$

b) $L - W = 7.8 \pm 0.8 \text{ cm}$

(3 marks)
(1½ marks each)
Question 2

\[ d = 32.4 \text{ m} \]
\[ V_B = 5 \text{ m/s} \]
\[ V_w = 2 \text{ m/s} \]

Since the triangles are similar for velocity and distance travelled.

\[ \frac{V_w}{2} = \frac{V_B}{5} \]

Then \[ \frac{x}{2} = \frac{32.4}{5} \]

\[ x = 130 \text{ m} \] the distance down the shore.

There were a number of correct solutions; please be flexible with marking.
Question 3

Graph of Potential Energy vs Time.

(a) (3 marks) Graph — Labelled Axes, Curve.

(b) (i) \( PE = 6.7 \, J \)

(ii) At 4.5 s, \( PE = 0 \) as the trolley will be on the horizontal plane.
m = 62.62 kg

\( F_g = 257 \text{ N} \)

\( F_f = 71.0 \text{ N} \)

The nett force acting on the sprinter,

\[ F_n = F_g - F_f \]

\[ = 257 - 71.0 \]

\[ = 186 \text{ N} \quad (1) \]

The sprinter's acceleration

\[ a = \frac{F}{m} \]

\[ = \frac{186}{62} \]

\[ = 3.00 \text{ m/s}^2 \quad (1') \]

NOTE: SIGNIFICANT FIGURES

only penalise once
Question 5.

\[ u = 28.5 \text{ m/s} \]
\[ v = 0 \]
\[ s = 0.0950 \text{ m} \]
\[ a = ? \]

Using \[ v^2 = u^2 + 2as \]

The acceleration applied by the glove, \[ a = \frac{v^2 - u^2}{2s} \]

\[ = \frac{0 - 28.5^2}{2 \times 0.095} \]

\[ = -812.25 \text{ m/s}^2 \]

\[ = -437.5 \text{ m/s}^2 \]

(2 marks)
Question 6.

Diagram (i)

assuming the train's velocity remains constant and does not stop suddenly, the bag should land exactly below where it started.

The bag and the train have the same horizontal velocity.
Initially, the coin is obscured from the observer because of the cup and light rays travel in a straight line (1 mark).

After the clear liquid is added, light rays from the coin will be refracted towards the observer at the liquid/air interface (1 mark).

Since the observer believes that light travels in a straight line, the coin apart from coming onto view appears as a virtual image (2 marks).
Question 8

\[ f = 57.5 \text{ Hz} \]
\[ \lambda = 3.25 \text{ m} \]

\[ v = f \lambda \]
\[ = 57.5 \times 3.25 \]
\[ = 187.0 \text{ m/s} \]

(1 mark)
Question 9.

Using Snell’s law:

\[ n_1 \sin \theta_1 = n_2 \sin \theta_2 \]

\[ \frac{\sin \theta_1}{\sin \theta_2} = \frac{n_2}{n_1} = \frac{V_1}{V_2} \]

\[ \therefore \quad \frac{\sin \theta_a}{\sin \theta_L} = \frac{V_a}{V_L} \quad (1) \]

\[ V_L = V_a \times \frac{\sin \theta_L}{\sin \theta_a} \quad (1) \]

\[ = 3 \times 10^8 \times \frac{\sin 43}{\sin 65} \]

\[ = 2.3 \times 10^8 \text{ m/s} \quad (1) \]

The speed of the light in the liquid.
Question 10  SC. PROCESS.

a) (i.) PD = 0, A is the central maximum

(ii.) PD = \frac{\lambda}{2} = 1.5 \text{ cm}, B is the first minimum

b) since \( W = \frac{\lambda L}{d} \) \\
\( \lambda = \) wave length \\
\( L = \) separation between the slits and screen \\
\( d = \) slit width

(i.) \( AB \) increases.

(ii.) \( AB \) increases.

(iii.) if \( L \) decreases, then the distance \( AB \) decreases

(1 mark each question)
Question 11

(a.) \[ W = qV \]
\[ = 1.6 \times 10^{-19} \times 100 \]
\[ = 1.6 \times 10^{-17} \text{ J} \] \(\text{(2)}\)

(b.) Since \( KE = \frac{1}{2} m v^2 \)

Then \[ v = \sqrt{\frac{2Km}{m}} \]
\[ = \sqrt{\frac{2 \times 1.6 \times 10^{-19}}{9.11 \times 10^{-31}}} \] \(\text{(1)}\)
\[ = 5.9 \times 10^6 \text{ m/s} \] \(\text{(1)}\)
Question 12

Current vs Voltage for a Diode

Current ($\times 10^{-3} A$)

60
50
40
30
20
10

0.1 0.2 0.5 0.6 0.7 (V)

As the voltage across the diode increases, the current gradually increases.

(1 mark)
The gradient of the $I$ vs $V$ graph ($\frac{I}{V}$) is the reciprocal of resistance.

Initially (0-0.2 V) the resistance is very high and no current flows.

From (0.2-0.4 V) the current gradually increases to 3 mAmps.

As the voltage increases to 0.7 Volts and above the resistance across the diode becomes negligible as can be seen from the large amount of current able to pass through the diode.

(2 marks) (Discussion)
Question 13.

\[ B = 6.5 \times 10^{-4} \, T \]
\[ I = 2.5 \, A \]
\[ l = 0.105 \, m \]
\[ \theta = 63^\circ \]

Using
\[ F = BIl \sin \theta \]

\[ = 6.5 \times 10^{-4} \times 2.5 \times 10^{-5} \times \sin 63^\circ \]

\[ = 1.5 \times 10^{-4} \, N \] out of the page using the R.H. rule

(2 marks)
Question 14

a) \[ _{90}^{230}\text{Th} \rightarrow _{86}^{226}\text{Ra} + _{2}^{4}\text{He} \] (2)

b) \[ _{83}^{210}\text{Bi} \rightarrow _{84}^{210}\text{Po} + _{-1}^{0}\text{e} \] (2)
(a) \[ W_f = 7.71 \times 10^{-19} \text{ J} \]

\[ \lambda = 1.60 \times 10^{-7} \text{ m} \]

\[ W = h \nu \]

\[ \therefore \nu = \frac{W}{h} = \frac{7.71 \times 10^{-19}}{6.63 \times 10^{-34}} \]

\[ = 1.16 \times 10^{15} \text{ Hz} \]

(1 mark)

(b) \[ KE_{max} = h \nu - W \]

\[ = \frac{hc}{\lambda} - W \]

\[ = \frac{6.63 \times 10^{-34} \times 3 \times 10^8}{1.60 \times 10^{-7}} - 7.71 \times 10^{-19} \]

\[ = 1.24 \times 10^{-18} - 7.71 \times 10^{-19} \]

\[ = 4.69 \times 10^{-19} \text{ J} \]

(2 marks)
Question 16

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</tr>
<tr>
<td>2</td>
<td>-3.39 eV</td>
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<td>3</td>
<td>-1.51 eV</td>
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<td>-0.88 eV</td>
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<td>5</td>
<td>-0.54 eV</td>
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<tr>
<td>6</td>
<td>-0.38 eV</td>
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</table>
5c. Proceses.

Question 16.

(a.) Minimum Ionisation Energy

\[ E = 13.58 \pm V \]  
\[ (1.) \]

(b.) Since \( E = hf \)

\[ f = \frac{E}{h} = \frac{13.58 \times 1.6 \times 10^{-19}}{6.63 \times 10^{-34}} \]

\[ = 3.28 \times 10^{15} \text{ Hz} \]  
\[ (1+) \]

(c.) \[
\begin{array}{ccc}
3 & \downarrow & -0.88 \text{ eV} \\
\downarrow & & \downarrow \\
2 & \downarrow & -1.51 \text{ eV} \\
\downarrow & & \downarrow \\
1 & \downarrow & -3.39 \text{ eV}
\end{array}
\]

\[ E_1 = -0.88 - (-1.51) = 0.63 \text{ eV} \]  
\[ (1.) \]

\[ E_2 = -0.88 - (-3.39) = 2.51 \text{ eV} \]  
\[ (1.) \]

\[ E_3 = -1.51 - (-3.39) = 1.88 \text{ eV} \]  
\[ (3 \text{ marks}) \]
Displacement for the journey = 3.9 km.

Time taken to find the blue-fin tuna: time = 0725 - 0525 = 2 hours.

Average speed = \( \frac{4.5 + 2.5 + 1.5}{2} = \frac{8.5}{2} = 4.25 \text{ km/hr} \) (1)

Average velocity = \( \frac{3.9}{2} = 1.95 \text{ km/hr, or E40°S.} \) (2)

The speed and velocity differ in magnitude because velocity depends on displacement. Velocity needs to be described with direction.

Scale.
1 km = 2 cm
Part A  Question 2

Average jump time: \[
\frac{3.715 + 3.716 + 3.720 + 3.721 + 3.729}{5}
\]

\[= 18.603 \div 5\]

\[= 3.721 \text{ s.} \quad (2)\]

Assuming that the jumpers have an initial velocity of 0 and fall downwards,

\[u = 0, \quad a = -9.8 \text{ m/s}^2, \quad t = 3.721 \text{ s.}\]

Using

\[s = ut + \frac{1}{2}at^2 \quad (1)\]

\[= 0 + \frac{1}{2} \times 9.8 \times (3.721)^2\]

\[= -67.8 \text{ m,}\]

The cliff is 67.8 m above sea-level. \(\quad (2)\)
\[ m = 1.30 \text{ tonnes} = 1.30 \times 10^3 \text{ kg} \]

The car's velocity
\[ v = 64.8 \text{ Km/hr} = 3.6 = 18.0 \text{ m/s} \quad (1) \]

Power
\[ = \frac{mgh}{t} \]
\[ = \frac{mg \Delta h \sin \theta}{t} \]
\[ = mgv \sin \theta \quad (2) \]
\[ = 1.30 \times 10^3 \times 9.80 \times 18.0 \sin 10 \]
\[ = 39.821 \text{ W} \]
\[ = 39.8 \text{ kW} \quad (2) \]
\[ \lambda_1 = 4.55 \times 10^{-7} \]

\[ L = 2.45 \text{ m} \]
\[ W = 5.60 \text{ mm} = 5.60 \times 10^{-3} \text{ m} \]

Rearranging \[ W = \frac{\lambda L}{d} \]

to find \( d \), the slit width

\[ d = \frac{\lambda L}{W} = \frac{4.55 \times 10^{-7} \times 2.45}{5.60 \times 10^{-3}} \]

\[ = 1.99 \times 10^{-4} \text{ m} = 0.199 \text{ mm} \]

When using red light, where \( \lambda_r = 6.75 \times 10^{-7} \)

The bandwidth will increase due to the longer wavelength. \( W = \frac{\lambda L}{d} \)

\[ W = \frac{6.75 \times 10^{-7} \times 2.45}{0.199 \times 10^{-3}} \]

\[ = 0.00831 \text{ m} \]

\[ = 8.31 \text{ mm} \]
Value of Gold = $7000 billion = $7000 \times 10^9$

Lb ounce Gold = $1400$

Lb ounce = 28.35 grams

Weight of gold as of February, 2011

\[
= \frac{7000 \times 10^9 \times \frac{28.35 \text{ g}}{10^3 \text{ g}}} {\frac{1400 \text{ lb}}{10^3 \text{ lb}}} \times \frac{1 \text{ kg}}{1000 \text{ g}}
\]

\[
= \frac{1.4175 \times 10^8 \text{ kg}}{}
\]

Since the gold is 19.3 times as dense as water

\[
\rho_{\text{Au}} = 19.3 \times 10^3 \text{ kg/m}^3
\]

and using

\[
\rho = \frac{m}{V}
\]

The gold would occupy a volume of

\[
V = \frac{m} {\rho} = \frac{1.4175 \times 10^8} {19.3 \times 10^3}
\]

\[
= 7345 \text{ m}^3
\]
Paper Two: Part B

Part B   Question 1

\[ u = 162 \text{ km/hr} \div 3.6 = 45.0 \text{ m/s} \]
\[ h = 1.45 \text{ m}. \]

\[ v = 45 \sin 30^\circ \]
\[ v = 45 \cos 30^\circ \]

assuming that the catcher is catching the ball 1.45 m above the ground.

\[ u = v = 45 \sin 30^\circ \]
\[ v = 0 \]
\[ a = -9.8 \text{ m/s}^2 \]
\[ t = ? \]

The time the ball will be in the air
\[ = 2 \times 2.30 = 4.60 \text{ s}. \]  \(1\)

The horizontal distance the ball covers
\[ = v \times t \]
\[ = 45 \cos 30^\circ \times 4.60 \]

\[ = 179 \text{ m}. \]

The catcher should stand 175 m away from the throwing machine.  \(1\)
Part B Question 2

For the components in parallel

\[ R_{\text{II}} = \frac{1}{\frac{1}{30} + \frac{1}{14.2}} = \frac{1}{\frac{1}{30} + \frac{1}{20}} = \frac{5}{60} = \frac{1}{12} \]

\[ R_{\text{II}} = 12 \Omega \]

The total resistance of the circuit

\[ R_{\text{Tot}} = 10 + 12 + 2 \]

\[ = 24 \Omega \] (1)

The current flowing in the circuit

\[ I_{\text{Tot}} = \frac{V}{R_{\text{Tot}}} = \frac{12}{24} = 0.5 \text{ amps} \] (1)

Voltage across \( 10\Omega \)

\[ V = 10 \times 0.5 = 5 \text{ V} \] (1)

Voltage across \( L_1 \)

\[ V = 2 \times 0.5 = 1 \text{ V} \] (1)

\[ \therefore \text{ Voltage across } 11 = 12 - 6 = 6 \text{ V} \]

Current through 30\( \Omega \)

\[ I = \frac{6}{30} = 0.2 \text{ amps} \] (1)

Current through 18\( \Omega \) + \( L_2 \)

\[ I = 0.5 - 0.2 = 0.3 \text{ amps} \]

and \[ V_{L_2} = 0.3 \times 2 = 0.6 \text{ V} \] (1)

\[ P_{L_1} = I_1 \times V_1 = 1 \times 0.5 = 0.500 \text{ W} \]

\[ P_{L_2} = I_{L_2} \times V_{L_2} = 0.3 \times 0.6 = 0.180 \text{ W} \] (1)
Part B  Question 3

Use

\[ F = \frac{k_1 q_1 q_2}{d^2} \]

(a) The charge on Earth

\[ q_E = \frac{F r_E}{k_2 q_2} \]

\[ = \frac{1.0 \times 10^{-4}}{9 \times 10^9 \times 1 \times 10^{-6}} \times (6.37 \times 10^8)^2 \]

\[ q_E = 4.5 \times 10^5 \text{ C} \] (2) since this attracts a positive charge, this is a charge from electrons, i.e., negative.

The number of excess electrons on the Earth’s surface

\[ = \frac{4.5 \times 10^5}{1.6 \times 10^{-19}} = 2.82 \times 10^{24} \text{ electrons} \] (1)

(b) The Earth’s electric field strength

\[ E = \frac{F}{q} = \frac{1.0 \times 10^{-4}}{1 \times 10^{-6}} \]

\[ = 1.0 \times 10^2 \text{ N/C} \] (2)
Engine Force, \( F_E = 26700 \, N \)

Space shuttle, \( m_s = 95.0 \, t = 95000 \, \text{kg} \)

The force was applied for \( t = 4.20 \, s \).

\[
\text{use } F \Delta t = m(v-u) \\
\begin{align*}
26700 \times 4.2 &= 95000 \, (v-u) \\
26700 \times 4.2 &= 95000 \, (v-u) \quad \text{The change in velocity} \\
1.18 \, \text{m/s} &= (v-u) \\
\end{align*}
\]

Since the change in KE

\[
= \frac{1}{2} m (v^2-u^2) \\
= \frac{1}{2} m (v+u)(v-u)
\]

\( v-u \) has been determined, but from the information given, \( v+u \) and subsequently \( v^2-u^2 \) cannot be determined. \( \) 

\( \) 

(2 must include justification)