



Mark Scheme (Results)

January 2026

Pearson Edexcel International Advanced Subsidiary level
In Physics
Waves and Electricity
WPH12/01A

Edexcel and BTEC Qualifications

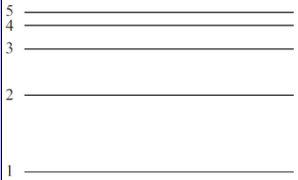

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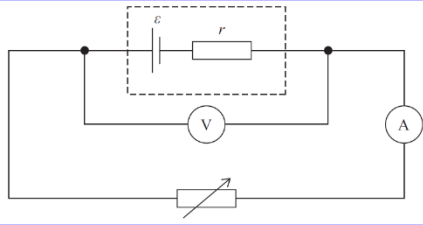
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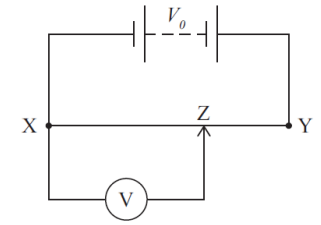
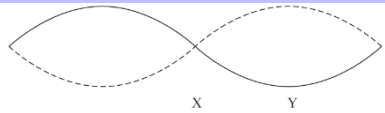
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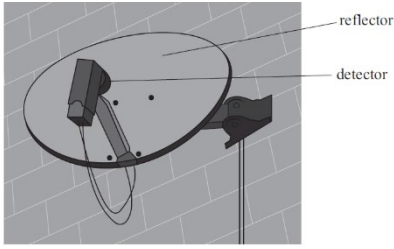
General Marking Guidance

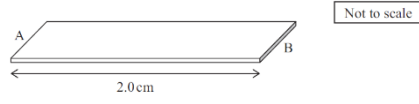
- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

Question Number	Answer	Additional Guidance	Mark
	Which of the following units is equivalent to the volt?		
1	<p>The only correct answer is C (J C⁻¹)</p> <p>A is not the correct answer because a volt is a joule per coulomb B is not the correct answer because a volt is a joule per coulomb D is not the correct answer because a volt is a joule per coulomb</p>		1
	<p>The diagram shows five energy levels in an atom.</p>  <p>Electromagnetic radiation is incident on the atom.</p> <p>Which transition would be caused by the absorption of the lowest frequency of radiation?</p>		
2	<p>The only correct answer is C (4 to 5)</p> <p>A is not the correct answer because this absorbs the highest energy so greatest frequency B is not the correct answer because the energy is greater than 4 to 5 so greater frequency D is not the correct answer because is the emission of a photon.</p>		1
	Which of the following graphs shows how current <i>I</i> varies with potential difference <i>V</i> for a negative temperature coefficient thermistor?		
3	 <p>The only correct answer is D ()</p> <p>A is not correct because this is the graph for a fixed resistor B is not correct because this is the graph for a filament lamp C is not correct because this graph does not match any component</p>		1
	The de Broglie wavelength for a moving electron is 5.47×10^{-10} m. Which of the following expressions gives the speed of the electron in ms⁻¹?		
4	<p>The only correct answer is A ($\frac{(6.63 \times 10^{-34})}{(9.11 \times 10^{-31})(5.47 \times 10^{-10})}$)</p> <p>B is not correct because $\lambda = \frac{h}{mv}$ C is not correct because $\lambda = \frac{h}{mv}$ D is not correct because $\lambda = \frac{h}{mv}$</p>		1

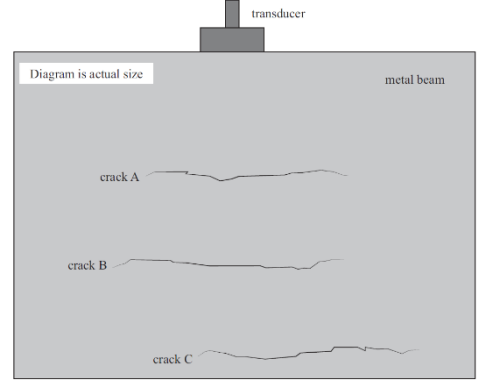
	<p>As temperature increases, the resistance of a negative temperature coefficient thermistor changes.</p> <p>Which of the following describes the reason for this change?</p>		
5	<p>The only correct answer is B (More conduction electrons are released)</p> <p>A is not correct because this is describing a property of metallic conductors not thermistors C is not correct because this is describing a property of metallic conductors not thermistors D is not correct because this is describing a property of metallic conductors not thermistors</p>		1
	<p>The diagram shows a circuit used to determine the internal resistance r and e.m.f. ε of a cell.</p> <p>Corresponding values of potential difference V and current I were taken after adjusting the variable resistor. A graph of V on the y-axis and I on the x-axis was plotted.</p> <p>Which of the following is correct?</p>		
6	<p>The only correct answer is D (The y-intercept of the graph is ε)</p> <p>A is not correct because the area under the graph does not give the energy dissipated by the cell B is not correct because the gradient of the graph is $-r$ C is not correct because V and I are not proportional</p>		1
	<p>The resistance of the variable resistor is R.</p> <p>Which of the following gives the current in the cell?</p>		
7	<p>The only correct answer is C ($\frac{\varepsilon}{(R+r)}$)</p> <p>A is not correct because $I = \frac{\varepsilon}{(R+r)}$ B is not correct because $I = \frac{\varepsilon}{(R+r)}$ D is not correct because $I = \frac{\varepsilon}{(R+r)}$</p>		1

	<p>Which of the following statements is correct for plane polarised light?</p>		
8	<p>The only correct answer is A (The oscillations are in a single plane, including the direction of energy transfer.)</p> <p>B is not correct because the oscillations include the direction of energy transfer C is not correct because the oscillations are in a single plane D is not correct because the oscillations are in a single plane</p>		1
	<p>The diagram shows a uniform wire XY across which a potential difference V_0 is applied.</p>  <p>Which of the following correctly shows the output potential difference across XZ?</p>		
9	<p>The only correct answer is A ($V = \frac{XZ}{XY} V_0$)</p> <p>B is not correct because potential difference is proportional to length of conductor C is not correct because potential difference is proportional to length of conductor D is not correct because potential difference is proportional to length of conductor</p>		1
	<p>The diagram below shows a standing wave on a string.</p>  <p>A standing wave is created when two progressive waves travelling in opposite directions combine.</p> <p>Which of the following correctly indicates the phase difference between the progressive waves at X and the phase difference between the progressive waves at Y?</p>		
10	<p>The only correct answer is B ($\pi, 2\pi$)</p> <p>A is not correct because at a node the phase difference is π and at an antinode the phase difference is 2π C is not correct because at a node the phase difference is π and at an antinode the phase difference is 2π D is not correct because at a node the phase difference is π and at an antinode the phase difference is 2π</p>		1

Question Number	Acceptable Answer	Additional Guidance	Mark
	<p>The image shows a satellite television dish.</p> <p>Electromagnetic radiation from a communications satellite is reflected from the reflector to the detector.</p>  <p>(a) The radiation used has a frequency of 12.6 GHz.</p> <p>Calculate the wavelength of the radiation.</p>		
11(a)	<p>Use of $v = f\lambda$ (1)</p> <p>Wavelength = 0.024 m = 2.4 cm (1)</p>	<p>Example of calculation</p> $\lambda = \frac{3.00 \times 10^8 \text{ m s}^{-1}}{1.26 \times 10^{10} \text{ Hz}} = 0.0238 \text{ m}$	2
	<p>The intensity of the radiation incident on the reflector is $4.8 \times 10^{-13} \text{ W m}^{-2}$.</p> <p>Calculate the power of the incident radiation.</p> <p>area of satellite dish = 0.27 m^2</p>		
11(b)	<p>Use of $I = \frac{P}{A}$ (1)</p> <p>Power = $1.3 \times 10^{-13} \text{ W}$ (1)</p>	<p>Example of calculation</p> $P = 4.8 \times 10^{-13} \text{ W m}^{-2} \times 0.27 \text{ m}^2 = 1.296 \times 10^{-13} \text{ W}$	2
	Total for question 11		4

Question Number	Acceptable Answer	Additional Guidance	Mark
	<p>A student investigates the resistance of the 'lead' in a pencil. A pencil is used to draw a rectangle, of length 2.0 cm and width 6.0 mm, on paper, creating a strip of unknown thickness t.</p>  <p>(a) The resistance of the strip between ends A and B is 55 kΩ resistivity of this pencil lead = $3.5 \times 10^{-5} \Omega\text{m}$ Show that the cross-sectional area of the strip of pencil lead is about $1 \times 10^{-11} \text{m}^2$</p>		
12(a)	<p>Use of $R = \frac{\rho l}{A}$ (1)</p> <p>Cross-sectional area = $1.3 \times 10^{-11} \text{ (m}^2\text{)}$ (to at least 2 sf) (1)</p>	<p><u>Example of calculation</u></p> $A = \frac{\rho l}{R} = \frac{3.5 \times 10^{-5} \Omega\text{m} \times 0.02 \text{ m}}{55000 \Omega} = 1.27 \times 10^{-11} \text{ m}^2$	2
	<p>(b) The pencil lead is made of a mixture of graphite and clay. The pencil has 50% graphite and 50% clay. charge carrier density n for pure graphite is $3.5 \times 10^{24} \text{ m}^{-3}$ Calculate the drift velocity for the charge carriers in the pencil lead when a potential difference of 6.0 V is applied across the strip from A to B. Assume the clay contributes no charge carriers.</p>		
12(b)	<p>Use of $R = V/I$ (1)</p> <p>Use of $I = nAvq$ with $q = 1.60 \times 10^{-19} \text{ C}$ (1)</p> <p>Correct use of factor of 2 (1)</p> <p>Drift velocity = 30 m s^{-1} (1)</p> <p>(e.c.f. from (a))</p>	<p>Factor of 2 can be introduced at any point Rounding mid-calculation can lead to correct answers from 30-31 m s^{-1} Show that value gives $v = 39 \text{ m s}^{-1}$</p> <p><u>Example of calculation</u></p>	4



		$I = \frac{V}{R} = \frac{6.0 \text{ V}}{55000 \Omega} = 1.09 \times 10^{-4} \text{ A}$ $v = \frac{1.09 \times 10^{-4} \text{ A}}{0.5 \times 3.5 \times 10^{24} \text{ m}^{-3} \times 1.3 \times 10^{-11} \text{ m}^2 \times 1.60 \times 10^{-19} \text{ C}} = 29.9 \text{ m s}^{-1}$	
	<p>(c) Pencil leads are made with a hardness from 9H (very hard) to 9B (very soft).</p> <p>Hard pencil leads have a higher proportion of clay.</p> <p>Explain how the resistance of the strip would be affected if it were drawn with a softer pencil.</p>		
12(c)	<p>(Softer pencil strip) has more charge carriers (per unit volume)</p> <p>Or (softer pencil strip) has lower resistivity</p> <p>Or (softer pencil strip) has higher current (1)</p> <p>Resistance would be lower (1) (MP2 dependent on MP1)</p>	<p>MP1 - Allow “thicker” or “larger cross-sectional area”</p> <p>Allow “<i>n</i> is greater”, “charge density is greater” for “more charge carriers”</p>	2
	Total for question 12		8


Question Number	Acceptable Answer	Additional Guidance	Mark
	<p>Ultrasound can be used to check for cracks in metal beams.</p> <p>A transducer emits a pulse of ultrasound into a metal beam. The same transducer detects the returning pulses.</p> <p>Part of a metal beam is shown. The beam contains 3 cracks, A, B and C.</p>  <p>The transducer detects a returning pulse from each crack.</p> <p>(a) Explain why there is a returning pulse from crack B.</p>		
13(a)	<p>Some of the pulse passes/refracts through crack A (1)</p> <p>(Some of the pulse) <u>reflects</u> from crack (B) (1)</p> <p>...due to a change of density (from metal to air) (1)</p>	<p>Allow “ultrasound” for “pulse”</p> <p>Allow “material” or “medium” for “density”</p>	3
	<p>(b) One pulse returns 1.4×10^{-5} s after being emitted by the transducer.</p> <p>Deduce whether the pulse has returned from crack A, crack B or crack C.</p> <p>You should take measurements from the diagram.</p> <p>speed of ultrasound in metal = 5900 ms^{-1}</p>		
13(b)	<p>Use of speed = distance/time (1)</p> <p>Correct factor of 2 in converting time or distance (1)</p> <p>Depth = 4.1 cm / 0.041 m, hence crack A (1)</p>	<p><u>Example of calculation</u></p> $\text{distance} = \text{speed} \times \text{time} = 5900 \text{ ms}^{-1} \times \frac{1.4 \times 10^{-5} \text{ s}}{2}$ $= 0.041 \text{ m}$	3

	(c) Explain why ultrasound used to detect cracks in metal beams usually has frequencies of MHz rather than kHz.		
13(c)	<p>EITHER MHz / <u>higher</u> frequency means <u>smaller</u> wavelength (1)</p> <p>Therefore greater level of detail possible Or Therefore smaller cracks can be detected Or Therefore less likely to diffract (1)</p> <p>OR kHz / <u>lower</u> frequency means <u>greater</u> wavelength (1)</p> <p>Therefore less detail possible Or Therefore cannot detect smaller cracks Or Therefore more likely to diffract (1)</p>	<p>Do not credit references to accuracy or precision</p> <p>Allow better resolution</p> <p>Allow poorer resolution</p>	2
	Total for question 13		8

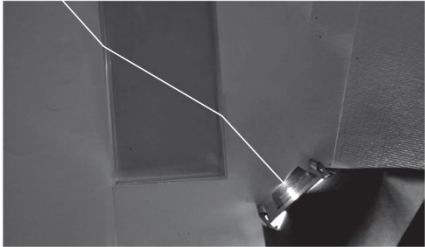
Question Number	Acceptable Answer	Additional Guidance	Mark
	<p>Drivers use car headlights to emit light in dark conditions.</p> <p>The graph shows how current I varies with the potential difference V for a car headlight.</p> <p>The headlight will emit light when it dissipates at least 35 W of power.</p> <p>(a) Determine the minimum potential difference for which the headlight will emit light.</p>		
14(a)	<p>Corresponding values from best fit line (1)</p> <p>Use of $P = VI$ to calculate P (1)</p> <p>Minimum potential difference = 9.0 (V) (1)</p>	<p><u>Example of calculation</u> At 9.0 V, $P = 9.0 \text{ V} \times 3.9 \text{ A} = 35.1 \text{ W}$</p>	3
	<p>(b) In a car, two headlights are connected in parallel with a 12.0 V battery. The battery has negligible internal resistance.</p> <p>(i) Explain the advantages of connecting the headlights in parallel with the battery rather than in series.</p>		
14(b)(i)	<p>(In parallel,) each headlight receives 12 V Or in series, each headlight receives 6 V Or p.d. in parallel is higher than p.d. in series Or (in parallel, combined) resistance is lower, so higher current Or in series, (combined) resistance is higher, so lower current (1)</p> <p>(In parallel,) headlights will have <u>higher</u> power/brightness Or in series, headlights will have <u>lower</u> power/brightness (1)</p>	<p>Allow “battery p.d.” or “battery e.m.f.” for “12 V”</p> <p>Can be implied from answer e.g. “series lamps are dim, parallel lamps are bright”</p>	

	(In parallel,) if one headlight breaks/fails, the other one stays on Or in series, if one headlight breaks/fails, the other one goes out (1)		3
	(ii) A student writes the following statement. When connected to the 12.0 V battery, the combined resistance of two headlights in parallel is one quarter of the combined resistance of two headlights in series. Deduce whether the student is correct. Your answer should include calculations using data from the graph.		
14(b)(ii)	Use of $R = V/I$ (1) Use of resistors in parallel formula to calculate R_T in parallel (1) $R_{\text{series}} = 2.9 \times R_{\text{parallel}}$ not $4 \times R_{\text{parallel}}$ so student not correct Or $R_{\text{parallel}} = 0.34 \times R_{\text{series}}$ not $0.25 \times R_{\text{series}}$ so student not correct Or $R_{\text{parallel}} = 1.3 (\Omega)$ and $R_{\text{series}} = 3.8 (\Omega)$ and student not correct (1)	Allow 0.35 instead of 0.34 <u>Example of calculation</u> (Using data from graph) R of single headlight in parallel = $\frac{V}{I} = \frac{12.0 \text{ V}}{4.6 \text{ A}} = 2.61 \Omega$ (for parallel headlights), $\frac{1}{R_T} = \frac{1}{2.61 \Omega} + \frac{1}{2.61 \Omega}$, so $R_T = 1.30 \Omega$ R of single headlight in series = $\frac{V}{I} = \frac{6.0 \text{ V}}{3.15 \text{ A}} = 1.90 \Omega$ (for series headlights), $R_T = 1.90 \Omega + 1.90 \Omega = 3.80 \Omega$ $3.80 / 1.30 = 2.9$, so is $2.9 \times R_{\text{parallel}}$, not $4 \times R_{\text{parallel}}$	3
	Total for question 14		9

Question Number	Acceptable Answer	Additional Guidance	Mark
	<p>The photograph shows a musical instrument called a harp.</p>  <p>When a harp string is plucked, transverse waves travel along the string forming a standing wave.</p> <p>(a) State what is meant by a transverse wave.</p>		
15(a)	<p>Oscillations / vibrations are perpendicular to the <u>direction</u> of energy transfer</p> <p>Or Oscillations / vibrations are perpendicular to the <u>direction</u> of wave travel</p> <p style="text-align: right;">(1)</p>		1
	<p>The string is initially made to vibrate at its lowest frequency but the string can also be made to vibrate at higher frequencies.</p>  <p>Add to the diagram in the answer book, to show the first stationary wave on the string when it is vibrating at a higher frequency.</p> <p>You should label any nodes and antinodes.</p>		
15(b)	<p>Shape of wave correct</p> <p>Node/N labelled at each end</p> <p>(At least) one correctly labelled antinode / A</p> <p style="text-align: right;">(1)</p> <p style="text-align: right;">(1)</p> <p style="text-align: right;">(1)</p>	<p><u>Example of diagram</u></p>	3

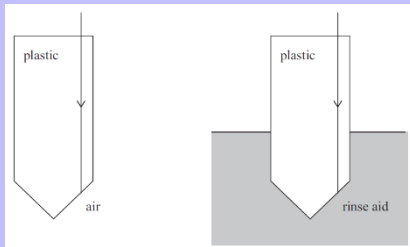
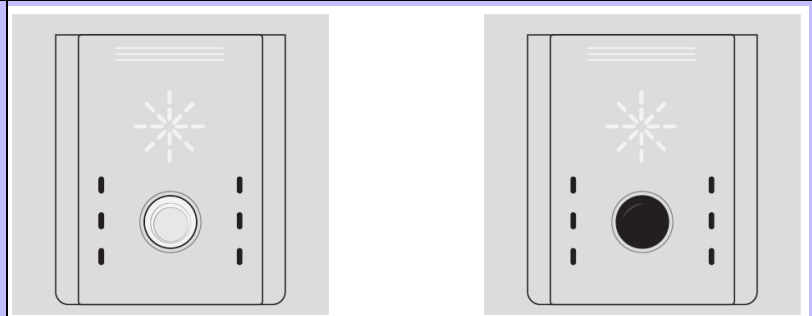
			
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	<p>For one string, the tension in the string is 41 N and the wave travels at a speed of 141 m s⁻¹.</p> <p>This string breaks and needs replacing with a new string.</p> <p>The table shows the mass of four new strings, A, B, C and D.</p> <table border="1" data-bbox="815 331 1140 595"> <thead> <tr> <th>String</th> <th>Mass of string / g</th> </tr> </thead> <tbody> <tr> <td>A</td> <td>1.5</td> </tr> <tr> <td>B</td> <td>3.1</td> </tr> <tr> <td>C</td> <td>4.4</td> </tr> <tr> <td>D</td> <td>6.3</td> </tr> </tbody> </table> <p>Each new string has a length of 1.5 m</p> <p>The new string is cut to the same length as the broken string, and is placed under the same tension.</p> <p>Deduce which new string, A, B, C or D, should be used to replace the broken string.</p>	String	Mass of string / g	A	1.5	B	3.1	C	4.4	D	6.3		
String	Mass of string / g												
A	1.5												
B	3.1												
C	4.4												
D	6.3												
<p>15(c)</p>	<p>Use of $v = \sqrt{\frac{T}{\mu}}$</p> <p>Calculation using $\mu = \frac{m}{l}$</p> <p>Mass of string = 3.1 (g), so string B</p> <p>Or calculates μ for more than one string in the table and compares to 2.1×10^{-3} (kg m⁻¹), with conclusion</p>	<p>(1)</p> <p><u>Example of calculation</u></p> $\mu = \frac{41 \text{ N}}{(141 \text{ m s}^{-1})^2} = 2.06 \times 10^{-3} \text{ kg m}^{-1}$ $m = 1.5 \text{ m} \times 2.06 \times 10^{-3} \text{ kg m}^{-1} = 3.09 \times 10^{-3} \text{ kg}$ <p>(1)</p> <p>(1)</p>	<p>3</p>										
	<p>Total for question 15</p>		<p>7</p>										

Question Number	Acceptable Answer	Additional Guidance	Mark
	<p>Dishwashing machines use a solution known as rinse aid to prevent water from leaving marks on the dishes as they dry.</p> <p>(a) A student carries out an experiment to determine the refractive index of rinse aid.</p> <p>The photograph shows a ray of light passing through a rectangular container of rinse aid. Determine the refractive index of the rinse aid.</p>  <p>You may ignore any effect from the container.</p>		
<p>16(a)</p>	<p>i measured as 48-53° and r measured as 31-36° (1)</p> <p>Use of $n_1 \sin \theta_1 = n_2 \sin \theta_2$ (1)</p> <p>refractive index consistent with calculation (at least 1 dp) (1)</p>	<p>Has to be from values within ranges in MP1</p> <p><u>Example of calculation</u></p> $n_2 = \frac{\sin 50^\circ}{\sin 34^\circ} = 1.37$	<p>3</p>

	<p>(b) The rinse aid is stored in a small reservoir in the dishwasher with an optical dipstick to indicate the level of the liquid. The dipstick is a clear plastic cylinder with a pointed end that dips into the liquid. Show that the critical angle for light in the plastic, when surrounded by rinse aid, is about 60°. speed of light in rinse aid = $2.22 \times 10^8 \text{ ms}^{-1}$ speed of light in plastic = $2.00 \times 10^8 \text{ ms}^{-1}$</p>		
<p>16(b)</p>	<p>Use of $n = \frac{c}{v}$</p> <p>Use of $n = \frac{1}{\sin C}$</p> <p>Or $n_1 \sin \theta_1 = n_2 \sin \theta_2$ with one of the $\theta = 90^\circ$ or $\sin \theta = 1$</p> <p>Or $\sin C = \frac{n_2}{n_1}$</p> <p>Critical angle = 64(°) (to at least 2 sf)</p>	<p>(1) Allow variations in use, such as $n_1 v_1 = n_2 v_2$, calculate the n for plastic, or calculation of relative n</p> <p>(1) Allow use of refractive index value from (a)</p> <p>(1) <u>Example of calculation</u> $n = \frac{2.22 \times 10^8 \text{ ms}^{-1}}{2.00 \times 10^8 \text{ ms}^{-1}} = 1.11$</p> $\sin C = \frac{1}{1.11} = 64.3^\circ$	<p>3</p>

The images below show the difference between the appearance, from above, of the dipstick when the reservoir is empty and when it is full.
 When the reservoir is empty, the dipstick is surrounded by air. It appears light because light from the surroundings is reflected back to the viewer.
 When the reservoir is full, the dipstick is surrounded by rinse aid and appears dark.
 The diagrams below show side views of the dipstick.



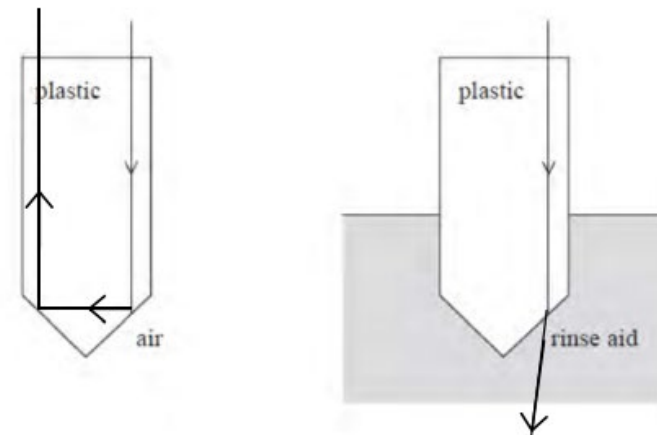
Complete the diagrams to show the paths of light when the rinse aid level is low and when it is high.

critical angle for plastic surrounded by air = 42°

16(c)

- Empty – TIR at first surface
- Empty – TIR at second surface and ray roughly parallel to first ray
- Full – shows refraction at first surface (allow if reflected ray also shown)
- Full – refraction away from normal at first surface

(1) Example of diagram

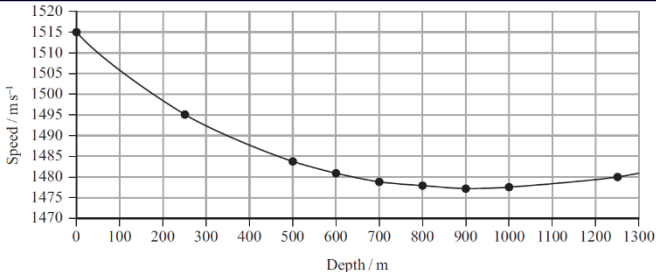
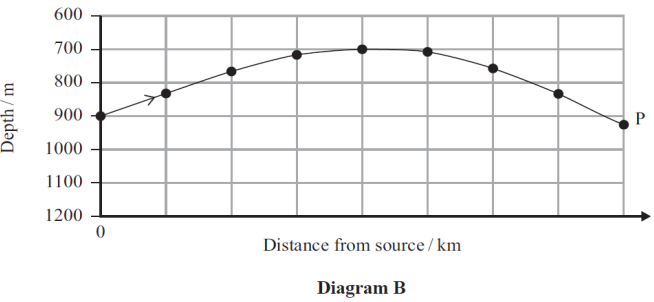


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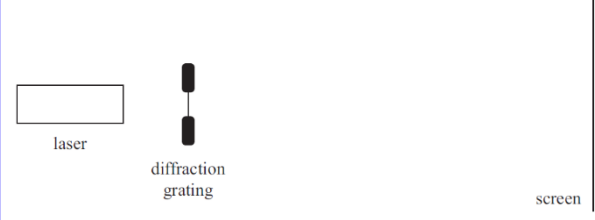
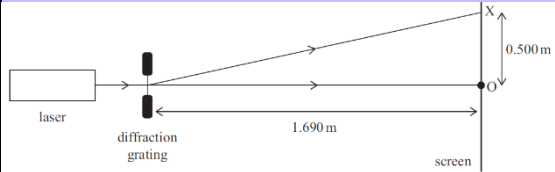
Total for question 16

10

Question Number	Acceptable Answer	Additional Guidance	Mark																				
	<p>The list of data, formulae and relationships for this paper states the following:</p> <p style="text-align: center;">Einstein's photoelectric equation $hf = \phi + \frac{1}{2}mv_{\max}^2$</p> <p>Describe the photoelectric effect, including an explanation of each of the terms, hf, ϕ and $\frac{1}{2}mv_{\max}^2$, in the equation.</p>																						
*17	<p>This question assesses a student's ability to show a coherent and logically structured answer with linkages and fully-sustained reasoning.</p> <p>Indicative content</p> <p>IC1 hf is <u>photon</u> energy</p> <p>IC2 ϕ is the <u>work function</u> Or ϕ is minimum energy required for emission of <u>electrons</u></p> <p>IC3 One photon interacts with one electron</p> <p>IC4 <u>Electron</u> emission only occurs if $hf > \phi$</p> <p>IC5 $\frac{1}{2}mv^2$ is the kinetic energy of the (emitted) <u>electron</u> (allow KE or E_k for "kinetic energy")</p> <p>IC6 "Max" applies to electrons at the surface of the metal Or Some electrons not at the surface require more energy in order to be emitted</p>	<p>Marks are awarded for indicative content and for how the answer is structured and shows lines of reasoning.</p> <p>The following table shows how the marks should be awarded for indicative content.</p> <table border="1" data-bbox="1220 651 1854 874"> <thead> <tr> <th>Number of indicative points seen in answer</th> <th>Number of marks awarded for indicative points</th> </tr> </thead> <tbody> <tr> <td>6</td> <td>4</td> </tr> <tr> <td>5-4</td> <td>3</td> </tr> <tr> <td>3-2</td> <td>2</td> </tr> <tr> <td>1</td> <td>1</td> </tr> <tr> <td>0</td> <td>0</td> </tr> </tbody> </table> <table border="1" data-bbox="1220 906 1975 1251"> <thead> <tr> <th></th> <th>Number of marks awarded for structure and lines of reasoning</th> </tr> </thead> <tbody> <tr> <td>Answer shows a coherent and logical structure with linkage and fully sustained lines of reasoning demonstrated throughout</td> <td>2</td> </tr> <tr> <td>Answer is partially structured with some linkages and lines of reasoning</td> <td>1</td> </tr> <tr> <td>Answer has no linkage between points and is unstructured</td> <td>0</td> </tr> </tbody> </table>	Number of indicative points seen in answer	Number of marks awarded for indicative points	6	4	5-4	3	3-2	2	1	1	0	0		Number of marks awarded for structure and lines of reasoning	Answer shows a coherent and logical structure with linkage and fully sustained lines of reasoning demonstrated throughout	2	Answer is partially structured with some linkages and lines of reasoning	1	Answer has no linkage between points and is unstructured	0	6
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Question Number	Acceptable Answer	Additional Guidance	Mark
	<p>The speed of sound in sea water varies with depth, as shown in diagram A.</p>  <p>Sound produced at a depth of 900 m initially travels towards the water surface. As the sound approaches a depth of 700 m, it changes direction and follows the path shown to the point P in diagram B.</p> <p>(a) Explain why the sound follows the path shown in diagram B.</p> <p>Your answer should refer to refraction and diagram A.</p>	 <p style="text-align: center;">Diagram B</p>	
18a	<p>Initially, the speed of sound increases Or Speed at 700m is greater than speed at 900m (1)</p> <p>Curving is due to the change in speed being gradual Or not a sudden change in direction as there is no sudden change in speed. (1)</p> <p>Waves are refracted away from the normal (from 900m to 700m) (1)</p> <p>Angle of incidence becomes equal/greater than critical angle Or angle of refraction becomes 90° (1)</p> <p>(So) total internal reflection takes place (at 700m) (1)</p>	<p>Accept TIR for total internal reflection Do not award MP5 if TIR related to another stated depth</p>	5

	<p>(b) Sound that travels in a straight line from the source to point P takes longer to arrive than sound that travels along the path shown in diagram B.</p> <p>Suggest why.</p>		
18b	<p>(Although the) straight line is a shorter<u>er</u> distance (1)</p> <p>Or (Although the) curved path is a longer<u>er</u> distance (1)</p> <p>Sound waves are travelling slower<u>er</u> on straight line (so reach the detector later)</p> <p>Or Sound waves are travelling faster<u>er</u> on curved path (so reach detector earlier) (1)</p>	Allow "path B" or "refracted path" for "curved path"	2
	<p>Suggest two factors that might cause the speed of sound to vary with the depth of the sea.</p>		
18(c)	<p>Any TWO from:</p> <p>(Change in) temperature (of the sea) (1)</p> <p>(Change in) pressure (in the sea) (1)</p> <p>(Change in) density/salinity (of the sea) (1)</p>		2
	Total for question 18		9

	Acceptable Answer	Additional Guidance	Mark
	<p>A laser, a diffraction grating and a screen are setup as shown. The laser emits monochromatic light.</p>  <p>When the laser is switched on, a series of bright dots is seen on the screen.</p>  <p>(a) The diagram below shows the position of the central dot at O. The next bright dot appears at position X.</p> <p>The diffraction grating has 450 lines per mm. Determine the wavelength of the light from the laser.</p>		
19(a)	<p>Calculates θ using \tan (1)</p> <p>Calculates d using $\frac{1}{\text{number of lines (per m)}}$ (1)</p> <p>Use of $n\lambda = d\sin\theta$ (1)</p> <p>$\lambda = 6.3 \times 10^{-7} \text{ m}$ (1)</p>	<p>Example of calculation</p> <p>$\tan \theta = \frac{0.500 \text{ m}}{1.690 \text{ m}}$, therefore $\theta = 16.5^\circ$</p> <p>$d = \frac{1}{450,000} = 2.22 \times 10^{-6} \text{ m}$.</p> <p>$\lambda = \frac{d\sin\theta}{n} = \frac{(2.22 \times 10^{-6} \text{ m})(\sin 16.5^\circ)}{1} = 6.31 \times 10^{-7} \text{ m}$ (1)</p>	4
	(b) Explain why a series of bright dots is seen on the screen.		
19(b)	<p>Path difference of $n\lambda$ or whole number of wavelengths (1)</p> <p>(Bright dots are where waves arrive) in phase (1)</p>	<p>Do not allow path difference of 0 or λ</p> <p>Allow phase difference of 0, 2π or $2n\pi$ for “in phase”</p>	

	So constructive interference/superposition takes place (1)		3
	(c) The laser is replaced by a source producing a parallel beam of bright white light. Suggest what would not be observed on the screen.		
19(c)	Any TWO from (There would not be a series of) bright dots (1) (There would not be just) a single frequency/ wavelength/ colour Or white light is made up of different frequencies / wavelengths / colours (1) (instead of a series of bright dots) you would see a white (dot at the) centre (1) (instead of a series of bright dots) you would see spectra either side of the central dot (1)	Allow “white light is seen at O”	2
	Total for question 19		9