<table>
<tr><td>Question Number</td><td></td><td>Mark</td></tr>
<tr><td>1 (a)</td><td>Calculation leading to v = 18.1 (m s^{-1}) (1)

(A reverse argument gives 64.8 (km h^{-1}) and scores the mark)

<u>Example of calculation</u>
v = 65 000 m / 60 × 60 s
= 18.06 m s^{-1}</td><td>1</td></tr>
<tr><td>1 (b)(i)</td><td>Use of distance = speed × time (see the calculation or use of 3 km) (1)

Use of emission = distance × reading from graph (1)

Use of difference between emissions at different speeds for 1 or 3 cars (1)

(This mark may still be awarded if the difference is between a 5 m s^{-1} for 10 minutes journey and an 18 m s^{-1} for 10 minutes journey)

CO_2 emission = 0.72 kg (1)

(allow range 0.63 kg to 0.81 kg)

<table>
<tr><td>Journey</td><td>^{2} emission</td><td>Range</td><td>M</td></tr>
<tr><td>1 car 1 km</td><td>0.08 kg</td><td>0.07 to 0.09</td><td>1 (MP3)</td></tr>
<tr><td>3 cars 1 km</td><td>0.24 kg</td><td>0.21 to 0.27</td><td>1 (MP3)</td></tr>
<tr><td>1 car 3 km</td><td>0.24 kg</td><td>0.21 to 0.27</td><td>3 (MP1,2,&3)</td></tr>
<tr><td>1 car travelling for 10 minutes at 5 m s^{-1} and 18 m s^{-1}</td><td>(-) 1.164 kg</td><td>1.02 to 1.31</td><td>3 (MP1,2,&3)</td></tr>
<tr><td>3 cars travelling for 10 minutes at 5 m s^{-1} and 18 m s^{-1}</td><td>(-) 3.49 kg</td><td>3.06 to 3.93</td><td>3 (MP1,2 &3)</td></tr>
</table>

<u>Example of calculation</u>
Distance = 5 m s^{-1} × 10 × 60 s = 3000 m = 3 km
3 × 3 km × (0.26 kg km^{-1} – 0.18 kg km^{-1}) = 0.72 kg</td><td>4</td></tr>
<tr><td>1 (b)(ii)</td><td>Quantitative comparison of values 0.72 kg and 0.54 kg to indicate that the cyclist causes more CO_2 emissions
Or qualitative statement e.g. more carbon dioxide emitted when he cycles (1)
candidates answer must be consistent with their value from part (i)</td><td>1</td></tr>
<tr><td></td><td>Total for question</td><td>6</td></tr>
</table>

Question Number	Answer		Mark
2(a)	Temperature (of gas) [treat references to oil/room as neutral]	(1)	**2**
	Mass of air/gas **Or** number of atoms/molecules/moles of air/gas [accept amount of air/gas, number of particles of air/gas]	(1)	
2(b)	Assumption: idea that volume occupied by trapped air ∝ length of air in tube [e.g. volume = cross-sectional area × length]	(1)	**4**
	pL = a constant [accept pV = a constant] **Or** if p doubles, L halves	(1)	
	At least 2 pairs of p, L values correctly read from graph	(1)	
	Readings show that pL = 4500 (kPa cm) [± 100 kPa cm]		
	Or Readings show that p doubles when L is halved [Accept references to V instead of L]	(1)	
	Example of calculation p = 400 kPa, L = 11.0 cm pL=400 × 11.0 = 4400 p = 200 kPa, L = 23.0 cm pL=200 × 23.0 = 4600		
2(c)	Use of $pV=NkT$ [Allow use of pV=nRT **and** $N=n.N_A$]	(1)	**3**
	Conversion of temperature to kelvin	(1)	
	$N = 8.4 \times 10^{20}$ [Accept answers in range 8.1×10^{20} to 8.4×10^{20}]	(1)	
	[Answer in range but with an incorrect temperature conversion score max 2]		
	Example of calculation $N = \frac{450\times10^{3}\,\text{Pa}\times0.10\,\text{m}\times7.5\times10^{-5}\,\text{m}^{2}}{1.38\times10^{-23}\,\text{JK}^{-1}\times(273+20)\text{K}} = 8.35\times10^{20}$		
2(d)(i)	No change	(1)	**1**
2(d)(ii)	Similar curve	(1)	**2**
	Shifted higher **Or** shifted to the right [an annotated diagram can score full marks]	(1)	
	Total for question		**12**

Question Number	Answer		Mark
3(a)	Credit any sensible limitation Examples include: • blunt pencil, • protractor divisions only to one degree, • protractor of limited radius • method requires rays to be marked and then drawn on Limited precision – linked to limitation	**(1)** **(1)**	**2**
3(b)	Use of refractive index = ratio of speeds Speed = 2.0×10^8 m s^{-1} <u>Example of calculation</u> speed in plastic = 3.0×10^8 m $s^{-1} \div 1.52$ = 1.97×10^8 m s^{-1}	**(1)** **(1)**	**2**
3(b)(ii)	Use of sin $c = 1/\mu$, sin $c = 1/n$ (or equivalent, but must allow full solution if used correctly without further equations) critical angle = 41º <u>Example of calculation</u> sin $c = 1/1.52$ $c = 41$º	**(1)** **(1)**	**2**
***3(c)**	**(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate)** The light strikes the sides at an angle greater than the critical angle It undergoes <u>total</u> internal <u>reflect</u>ion It is reflected again It strikes the other end at less than the critical angle **Or** It is transmitted at the final boundary **Or** the ray has zero angle of incidence at the first end and is transmitted undeviated	 **(1)** **(1)** **(1)** **(1)**	**4**
	Total for question		**10**

Question Number	Answer		Mark
4(a)	Operable circuit with bulb and power supply variable to 12 V (ignore meters) Ammeter correctly positioned Voltmeter correctly positioned (voltmeter may be across ammeter as well, or whole circuit – but not across any additional resistive components such as a variable resistor)	**(1)** **(1)** **(1)**	**3**
4(b)(i)	The gradient of this graph is the rate of change of current with p.d. Resistance is the ratio of pd/current **Or** It is calculated using a value of pd ÷ the corresponding value of current **Or** it isn't a straight line so the gradient is not *R* (credit *R* not constant, so value at 6 V isn't applicable to other voltages)	**(1)** **(1)**	**2**
4(b)(ii)	Use of $R = V/I$ $R = 4.76\ \Omega$ <u>Example of calculation</u> $R = 6.00\ V / 1.26\ A$ $R = 4.76\ \Omega$	**(1)** **(1)**	**2**
***4(c)**	**(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate)** The resistance increases (Because) the temperature increases (accept heats up) Increasing the amplitude of the oscillation of the lattice ions Leading to more (frequent) collisions of electrons with lattice ions Allow converse marks for an explanation explicitly based on decreasing potential difference	 **(1)** **(1)** **(1)** **(1)**	**4**
	Total for question		**11**

Question Number	Answer		Mark
***5(a)**	**(QWC – Work must be clear and organised in a logical manner using technicalwording where appropriate)** a standing/stationary wave Waves from the generator are reflected at the end **Or** waves are travelling in both directions (When the two) waves (meet they) superpose/undergo superposition Producing points where the waves are in phase and points where they are in antiphase **Or** producing points of zero amplitude and points of maximum amplitude OR producing nodes and antinodes	**(1)** **(1)** **(1)** **(1)**	**4**
5 b)	Wavelength = 2 × 1.8 m Use of speed = wavelength x frequency Speed = 1200 m s^{-1} Example of calculation λ = 2 × 1.8 m v = 330 Hz × 3.6 m v = 1188 m s^{-1}	**(1)** **(1)** **(1)**	**3**
5(c)(i)	Point is a node, so zero amplitude OR Point is a node, so string not moving So no energy absorbed **Or** Waves continue to move after superposition	**(1)** **(1)**	**2**
5(c)(ii)	(Original frequency x 2) = 660 Hz	**(1)**	**1**
5(c)(iii)	Captured twice per cycle = 1320 Hz (allow ecf from (c) (iii)) If more than 1320 Hz will be captured at points other than max amplitude	**(1)** **(1)**	**2**
5(d)	Scale divisions of 20 Hz **Or** Wide pointer **Or** nominal output (only) Lack of precision (scale related) **Or** Lack of accuracy (output related)	**(1)** **(1)**	**2**
	Total for question		**14**