Question			Expected response	Max mark	Additional guidance
5.	(a)	(i)	$f_o = f_s\left(\frac{v}{v \pm v_s}\right)$ **(1)** $f_o = 440\left(\frac{340}{340-31}\right)$ **(1)** $f_o = 480$ Hz **(1)**	**3**	Accept: 500, 484, 484.1 Accept: $f_o = f_s\left(\frac{v}{v - v_s}\right)$
		(ii)	Less than **(1)** Statement that there are fewer wavefronts per second. **OR** The wavefronts are further apart **OR** The wavelength increases **OR** diagram showing wavefronts closer together ahead of the car and further apart behind it. **(1)** or any similar response	**2**	**MUST JUSTIFY** Accept: "It is less than" Do not accept: "Sound is less than" on its own. Accept: Waves or wave crests in place of wavefronts. Can be justified by calculation. Significant figure rule suspended for this calculation. Can be justified by explaining the use of the '+' version of the relationship. In a diagram, there must be an implication of direction of travel. Do not accept: Any answer that implies that the frequency/wavelength of the sound produced by the siren itself is changing.
	(b)	(i)	T = 0.5 s	**1**	

Question			Expected response	Max mark	Additional guidance
5.	(b)	(ii)	When the red LEDs are forward biased the blue LEDs are reverse biased (or vice versa). **(1)** LEDs (only) light when forward biased **(1)**	**2**	**INDEPENDENT MARKS** Accept: The red and blue LEDs are connected the opposite way round. LEDs will (only) conduct in one direction **OR** Red LEDs conduct during one half of the cycle the blue LEDs conduct during the other half of the cycle. Do not accept: 'different direction' alone.
	(b)	(iii) (A)	$v = f\lambda$ $3.00\times10^{8} = f\times625\times10^{-9}$ **(1)** $E = hf$ both relationships anywhere **(1)** $E = 6.63\times10^{-34}\times\left(\frac{3.00\times10^{8}}{625\times10^{-9}}\right)$ **(1)** $E = 3.18\times10^{-19}$ J **(1)**	**4**	Accept 3.2, 3.182, 3.1824 1 mark for **both** relationships 1 mark for **each** substitution 1 mark for final answer Alternative method: $E = \frac{hc}{\lambda}$ **(1)** $E = 6.63\times10^{-34}\times\left(\frac{3.00\times10^{8}}{625\times10^{-9}}\right)$ **(1),(1)** $E = 3.18\times10^{-19}$ J **(1)** Do not accept: $E_2 - E_1 = hf$
		(iii) (B)	The (energy) band gap in a blue LED is greater. **(1)** The <u>photons</u> of blue light have more energy (than the photons of red light). **(1)**	**2**	Accept: Converse arguments. If no mention of band gap, 0 marks. Accept: The <u>photons</u> of blue light have a higher frequency (than the photons of red light). **OR** The <u>photons</u> of blue light have a smaller wavelength (than the photons of red light).