Question			Expected response	Max mark	Additional guidance
10.	(a)		A (central) positively charged nucleus. **OR** When an electron moves from one state to another, the energy lost or gained is done so ONLY in very specific amounts of energy. **OR** Each line in a spectrum is produced when an electron moves from one energy level/orbit/shell to another.	**1**	Do not accept: Atom is mainly empty space. Nucleus is small compared to size of atom. Any statement referring to photons and photon frequency is a consequence, not a feature.
	(b)	(i)	If an electron is in an excited state it can return to a lower energy level. When it does this, it emits a photon. **(1)** Different transitions produce different lines/ frequencies (of photons). **(1)**	**2**	Accept: When an electron drops down a level it releases energy. If absorption described - 0 marks.
		(ii)	(For the brighter lines) more electrons are making those transitions (per second). **(1)** (Therefore), there are more <u>photons</u> (per second) emitted (of that specific energy and so produce brighter lines). **(1)**	**2**	**INDEPENDENT MARKS** Do not accept: greater brightness due to greater frequency/energy of the photons. 'More electrons release more photons' on its own – MAX 1 mark
	(c)	(i)	10	**1**	
		(ii)	$E_2 - E_1 = hf$ **(1)** $-0.871\times10^{-19} - (-5.45\times10^{-19}) = 6.63\times10^{-34} \times f$ **(1)** $f = 6.91\times10^{14}$ Hz **(1)**	**3**	Accept: 6.9, 6.906, 6.9065 Accept: $(\Delta)E=hf$ **OR** $E_4 - E_1 = hf$ Note: $\Delta E = 4.579\times10^{-19}$ (J) Accept: $5.45\times10^{-19} - 0.871\times10^{-19} = 6.63\times10^{-34} \times f$ for energy substitution mark If $0.871\times10^{-19} - 5.45\times10^{-19}$ is shown for ΔE, maximum (**1 mark)** for **relationship**.
		(ii) (B)	486 nm **(1)**	**1**	Accept: 4.86×10^{-7} m

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10.	(c)	(ii) (C)		**5**	Or consistent with (c)(ii)(B) Accept: 4.9, 4.933, 4.9332
			$z = \frac{v}{c}$ **(1)**		$z = \frac{v}{c}$ anywhere, 1 mark
			$z = \frac{4.52 \times 10^6}{3.00 \times 10^8}$ **(1)**		
			$z = \frac{\lambda_o - \lambda_r}{\lambda_r}$ **(1)**		$z = \frac{\lambda_o - \lambda_r}{\lambda_r}$ anywhere, 1 mark
			$\frac{4.52 \times 10^6}{3.00 \times 10^8} = \frac{\lambda_o - 486 \times 10^{-9}}{486 \times 10^{-9}}$ **(1)**		substitution of 486×10^{-9} **(1)** Accept: 486
			$\lambda_o = 4.93 \times 10^{-7}$ m **(1)**		Alternative method: $\frac{v}{c} = \frac{\lambda_o - \lambda_r}{\lambda_r}$ $\frac{4.52 \times 10^6}{3.00 \times 10^8} = \frac{\lambda_o - 486}{486}$ $\lambda_o = 4.93 \times 10^{-7}$ m Equating formula, **(2)** Substitution of v and c **(1)** Substitution of λ_r **(1)** Final answer **(1)**