

Question			Answer	Max mark	Additional guidance
10.	(a)		A (central) positively charged nucleus. (Negatively charged) electrons in (discrete) energy levels/shells (orbiting the nucleus, not radiating energy.) When an electron moves from one state to another, the energy lost or gained is done so ONLY in very specific amounts of energy. Each line in a spectrum is produced when an electron moves from one energy level/orbit/shell to another.	2	Any two correct answers Independent marks Accept: A clearly labelled diagram A (central) nucleus containing protons (and neutrons). Some indication of quantisation of energy Do not accept: Atom is mainly empty space. Nucleus is small compared to size of the atom. Any statement referring to photons and photon frequency is a consequence, not a feature.
	(b)		$E_2 - E_1 = hf \quad (1)$ $-1.36 \times 10^{-19} - (-5.45 \times 10^{-19}) = 6.63 \times 10^{-34} \times f \quad (1)$ $f = 6.17 \times 10^{14} \text{ Hz} \quad (1)$	3	Accept: 6.2, 6.169, 6.1689 Accept: $(\Delta)E = hf$ or $E_3 - E_1 = hf$ for formula mark anywhere Accept: $5.45 \times 10^{-19} - 1.36 \times 10^{-19}$ $= 6.63 \times 10^{-34} \times f$ for substitution mark Note: Correct $\Delta E = 4.09 \times 10^{-19} \text{ (J)}$ If $1.36 \times 10^{-19} - 5.45 \times 10^{-19}$ is shown for ΔE, maximum 1 mark for a correct formula.

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10.	(c)		$z = \frac{\lambda_o - \lambda_r}{\lambda_r} \quad (1)$ $z = \frac{661 - 656}{656} \quad (1)$ $(z = 7.62195122 \times 10^{-3})$ $z = \frac{v}{c} \quad (1)$ $7.62195122 \times 10^{-3} = \frac{v}{3.00 \times 10^8} \quad (1)$ $v = 2.29 \times 10^6 \text{ m s}^{-1} \quad (1)$	5	Accept: 2.3, 2.287, 2.2866 $z = \frac{\lambda_o - \lambda_r}{\lambda_r}$ anywhere, 1 mark $z = \frac{v}{c}$ anywhere, 1 mark Substitution of 3.00×10^8 (1) Alternative method: $\frac{v}{c} = \frac{\lambda_o - \lambda_r}{\lambda_r}$ $\frac{v}{3.00 \times 10^8} = \frac{661 - 656}{656}$ $v = 2.29 \times 10^6 \text{ m s}^{-1}$ Equating formula, (2) Substitution of wavelengths, (1) Substitution of 3.00×10^8 (1) Final answer (1)