## > Markscheme

1		
а	The total momentum stays the same when no external forces act on the system $\checkmark$	[2]
	The carts exert equal and opposite forces on each other so the net force is zero $\checkmark$	
b	$6.0 \times 3.0 + 0 = (3.0 + 6.0) \times v \Rightarrow v = 2.0 \text{ m s}^{-1} \checkmark$	[2]
	Change in KE: $\frac{1}{2} \times 3.0 \times 6.0^2 - \frac{1}{2} \times 9.0 \times (2.0)^2 = 36 \text{ J}$	

2			
а		A very small percentage of the incident alpha particles were scattered at very large scattering angles $\checkmark$	[2]
		This required a huge electric force that could only be provided if the positive charge of the atom was concentrated in a very small, massive object ✓	
b	I	$^{239}_{94}$ Pu $\rightarrow ^{235}_{92}$ U + $^{4}_{2}\alpha$	[2]
		Correct numbers for U✓	
	Ш	235 × 7.5909 + 4 × 7.0739 − 239 × 7.5603 ✓	[2]
		5.25 MeV ✓	

3			
а		In a transverse wave the displacement is at right angles to the direction of energy transfer   In a longitudinal wave the displacement is parallel to the direction of energy transfer	[2]
b	I	λ = 0.30 m ✓	[2]
		$v = f\lambda = 250 \times 0.30 = 75 \text{ m s}^{-1}$	

	II	d/cm  4 2 0 1 2 -4 -4	[2]
		Correct shape ✓ Correct period ✓	
С	I	P	[1]
	II		[1]

4			
а		Luminosity also depends on area 🗸	[2]
		Star Z has a much larger area than X ✓	
b	I	$\frac{L_{z}}{L_{v}} = \frac{4\pi\sigma R_{z}^{2} T_{z}^{4}}{4\pi\sigma R_{v}^{2} T_{v}^{4}} = 10^{6} \checkmark$ $\frac{R_{z}}{R_{v}} = \sqrt{10^{6} \times \frac{20000^{4}}{2500^{4}}} \checkmark$ $= 6.4 \times 10^{3}$	[3]
С	ı	X: by radiation pressure caused by fusion reactions ✓	[1]
	П	Y: by electron degeneracy pressure ✓	[1]

5		
а	Uniform lines from left to right in the interior $\checkmark$	[2]
	Edge effects ✓	
b	$E = \frac{V}{d} = \frac{240}{2.0 \times 10^{-2}} = 2.2 \times 10^4 \text{ N C}^{-1} \checkmark$	[1]
С	$qV = \frac{1}{2}mv^2 \Rightarrow v = \sqrt{\frac{2qV}{m}} \checkmark$ $\frac{v_p}{v_a} = \sqrt{\frac{q_p m_a}{q_a m_p}} = \sqrt{\frac{1}{2}} \times 4 = \sqrt{2} \checkmark$	[2]

Electromagnetic radiation with an infinite rage of wavelengths ✓	6			
II   $V = \frac{RnT}{3.0 \times 10^{-5}} \checkmark$   [2]   $V = \frac{8.31 \times 7.0 \times 270}{3.0 \times 10^{-5}} = 5.2 \times 10^{-2}  \text{m}^3 \checkmark$   [1]   $V = \frac{8.31 \times 7.0 \times 270}{3.0 \times 10^{-5}} = 5.2 \times 10^{-2}  \text{m}^3 \checkmark$   [1]   $V = \frac{8.31 \times 7.0 \times 270}{3.0 \times 10^{-5}} = 5.2 \times 10^{-2}  \text{m}^3 \checkmark$   [1]   $V = \frac{8.31 \times 7.0 \times 270}{3.0 \times 10^{-5}} = \frac{1.3 \times 10^{-5}}{5.2 \times 10^{-2}} = 2.5 \times 10^{-4}, \text{ which is very small } \checkmark$   [2]   $V = \frac{V_{\text{obsculse}}}{V_{\text{gas}}} = \frac{1.3 \times 10^{-5}}{5.2 \times 10^{-2}} = 2.5 \times 10^{-4}, \text{ which is very small } \checkmark$   [2]   $V = \frac{V_{\text{obsculse}}}{V_{\text{gas}}} = \frac{1.3 \times 10^{-5}}{5.2 \times 10^{-2}} = 2.5 \times 10^{-4}, \text{ which is very small } \checkmark$   [2]   $V = \frac{V_{\text{obsculse}}}{V_{\text{gas}}} = \frac{1.3 \times 10^{-5}}{5.2 \times 10^{-2}} = 2.5 \times 10^{-4}, \text{ which is very small } \checkmark$   [2]   $V = \frac{V_{\text{obsculse}}}{V_{\text{gas}}} = \frac{1.3 \times 10^{-5}}{5.2 \times 10^{-2}} = 2.5 \times 10^{-4}, \text{ which is very small } \checkmark$   [2]   $V = \frac{V_{\text{obsculse}}}{V_{\text{gas}}} = \frac{1.3 \times 10^{-5}}{5.2 \times 10^{-2}} = 2.5 \times 10^{-4}, \text{ which is very small } \checkmark$   [1]   $V = \frac{V_{\text{obsculse}}}{V_{\text{gas}}} = \frac{1.3 \times 10^{-5}}{5.2 \times 10^{-2}} = 2.5 \times 10^{-4}, \text{ which is very small } \checkmark$   [2]   $V = \frac{V_{\text{obsculse}}}{V_{\text{gas}}} = \frac{1.3 \times 10^{-5}}{5.2 \times 10^{-2}} = 2.5 \times 10^{-4}, \text{ which is very small } \checkmark$   [2]   $V = \frac{V_{\text{obsculse}}}{V_{\text{gas}}} = \frac{1.3 \times 10^{-5}}{5.2 \times 10^{-2}} = 2.5 \times 10^{-4}, \text{ which is very small } \checkmark$   [2]   $V = \frac{V_{\text{obsculse}}}{V_{\text{gas}}} = \frac{1.3 \times 10^{-5}}{5.2 \times 10^{-2}} = 2.5 \times 10^{-4}, \text{ which is very small } \checkmark$   [2]   $V = \frac{V_{\text{obsculse}}}{V_{\text{gas}}} = \frac{V_{\text{obsculse}}}{5.2 \times 10^{-2}} = \frac{V_{\text{obsculse}}}{5.2 \times 10^{-2}} = 2.5 \times 10^{-4}, \text{ which is very small } \checkmark$   [2]   $V = \frac{V_{\text{obsculse}}}{V_{\text{obsculse}}} = \frac{1.3 \times 10^{-5}}{5.2 \times 10^{-2}} = 2.5 \times 10^{-4}, \text{ which is very small } \checkmark$   [2]   $V = \frac{V_{\text{obsculse}}}{V_{\text{obsculse}}} = \frac{1.3 \times 10^{-5}}{5.2 \times 10^{-2}} = 2.5 \times 10^{-2}, \text{ which is very small } \checkmark$   [2]   $V = \frac{V_{\text{obsculse}}}{V_{\text{obsculse}}} = \frac{1.3 \times 10^{-5}}{5.2 \times 10^{-2}} = 2.5 \times 10^{-2}, \text{ which is very small } \checkmark$	а	ı	$N = 7.0 \times 6.02 \times 10^{23} = 4.2 \times 10^{24} \checkmark$	[2]
$V = \frac{8.31 \times 7.0 \times 270}{3.0 \times 10^3} = 5.2 \times 10^{-2}  \text{m}^3  \checkmark$   III   7 × 4 = 28 g \forall   One of the assumptions of the kinetic theory of gases states that the volume of the molecules is negligible compared to the volume of the gas \forall      Here \forall \frac{V_{\text{molecules}}}{V_{\text{gas}}} = \frac{1.3 \times 10^{-5}}{5.2 \times 10^{-2}} = 2.5 \times 10^{-4}, \text{ which is very small } \forall      c   \frac{P_1}{T_1} = \frac{P_2}{T_2} \times T_2 = T_1 \times \frac{P_2}{P_1} \forall      T_2 = 270 \times \frac{5.0}{3.0} = 450 \times \forall      d   P   \frac{V}{V_{\text{ordinate}}} = \frac{1.3 \times 10^{-5}}{3.0} = 3.1 \times 10^3 \text{ J kg}^{-1} \text{ K}^{-1} \forall      II   Realization that \textit{ Q = \Delta U \forall c}{\text{c}} = \frac{\Omega \times 32 \times 4850 - 270}{0.028 \times (450 - 270)} = 3.1 \times 10^3 \text{ J kg}^{-1} \times \forall      f   E = \frac{hc}{\times \times \times \text{ A \times 1 \text{ E \times } \times \text{ A \times 1 \text{ A \times 1 \text{ C \times 666.6} \times 667 \text{ nm \times } \text{ [2]}}{\times 1.24 \times 10^{-6}} = 666.6 \times 667 \text{ nm \times } \text{ [2]} \text{ max from} \text{ [2] max from} \text{ [2] max from} \text{ [2]}			$4.2 \times 10^{24} \times 3.0 \times 10^{-30} = 1.3 \times 10^{-5} \mathrm{m}^3$ $\checkmark$	
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I I land the second of the sec				IIIGA
With a peak determined by temperature ✓			With a peak determined by temperature ✓	
Radiation emitted by a body at some finite kelvin temperature 🗸			Radiation emitted by a body at some finite kelvin temperature 🗸	
Radiation with an intensity proportional to the 4th power of the kelvin temperature ✓				
II Helium has energy levels separated by 1.86 eV ✓ [3]		II	Helium has energy levels separated by 1.86 eV ✓	[3]
This energy difference is unique to helium ✓			This energy difference is unique to helium 🗸	
The dip implies that photons of this energy are absorbed by helium ✓			The dip implies that photons of this energy are absorbed by helium $\checkmark$	