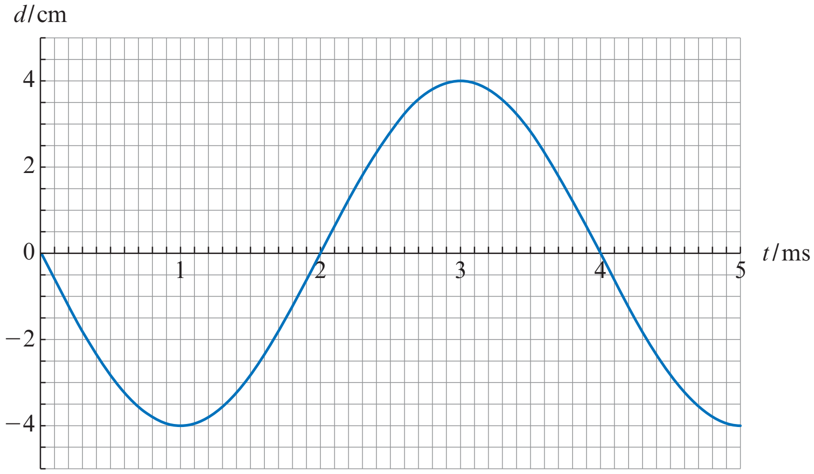
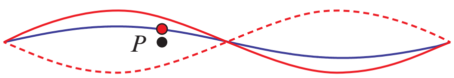
Markscheme

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

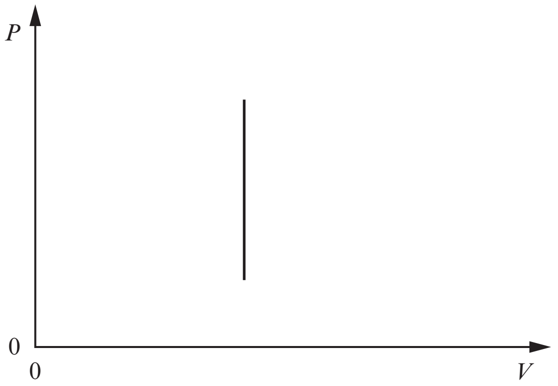
2				
a		A very small percentage of the incident alpha particles were scattered at very large scattering angles ✓ This required a huge electric force that could only be provided if the positive charge of the atom was concentrated in a very small, massive object ✓		[2]
b	I	${}^{239}_{94}\text{Pu} \rightarrow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

3				
a		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	$\lambda = 0.30\ \text{m}$ ✓ $v = f\lambda = 250 \times 0.30 = 75\ \text{m s}^{-1}$ ✓		[2]

	II	 Correct shape ✓ Correct period ✓		[2]
c	I	 ✓		[1]
	II	✓		[1]

4				
a		Luminosity also depends on area ✓ Star Z has a much larger area than X ✓		[2]
b	I	$\frac{L_Z}{L_Y} = \frac{4\pi\sigma R_Z^2 T_Z^4}{4\pi\sigma R_Y^2 T_Y^4} = 10^6$ ✓ $\frac{R_Z}{R_Y} = \sqrt{10^6 \times \frac{20000^4}{2500^4}}$ ✓ $= 6.4 \times 10^3$		[3]
c	I	X: by radiation pressure caused by fusion reactions ✓		[1]
	II	Y: by electron degeneracy pressure ✓		[1]

5				
a		Uniform lines from left to right in the interior ✓ Edge effects ✓		[2]
b		$E = \frac{V}{d} = \frac{240}{2.0 \times 10^{-2}} = 2.2 \times 10^4\ \text{N C}^{-1}$ ✓		[1]
c		$qV = \frac{1}{2}mv^2 \Rightarrow v = \sqrt{\frac{2qV}{m}}$ ✓ $\frac{v_p}{v_\alpha} = \sqrt{\frac{q_p m_\alpha}{q_\alpha m_p}} = \sqrt{\frac{1}{2}} \times 4 = \sqrt{2}$ ✓		[2]

6				
a	I	$N = 7.0 \times 6.02 \times 10^{23} = 4.2 \times 10^{24}$ ✓ $4.2 \times 10^{24} \times 3.0 \times 10^{-30} = 1.3 \times 10^{-5}\ \text{m}^3$ ✓		[2]
	II	$V = \frac{RnT}{P}$ ✓ $V = \frac{8.31 \times 7.0 \times 270}{3.0 \times 10^5} = 5.2 \times 10^{-2}\ \text{m}^3$ ✓		[2]
	III	$7 \times 4 = 28$ g ✓		[1]
b		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 ✓ Here $\frac{V_{\text{molecules}}}{V_{\text{gas}}} = \frac{1.3 \times 10^{-5}}{5.2 \times 10^{-2}} = 2.5 \times 10^{-4}$, which is very small ✓		[2]
c		$\frac{P_1}{T_1} = \frac{P_2}{T_2} \Rightarrow T_2 = T_1 \times \frac{P_2}{P_1}$ ✓ $T_2 = 270 \times \frac{5.0}{3.0} = 450$ K ✓		[2]
d		 Vertical straight line ✓		[1]
e	I	$\Delta U = \frac{3}{2}Rn\Delta T = \frac{3}{2} \times 8.31 \times 7.0 \times (450 - 270) = 15706$ J ✓		[1]
	II	Realization that $Q = \Delta U$ ✓ $c = \frac{Q}{m\Delta T} = \frac{15705}{0.028 \times (450 - 270)} = 3.1 \times 10^3\ \text{J kg}^{-1}\ \text{K}^{-1}$ ✓		[2]
f		$E = \frac{hc}{\lambda} \Rightarrow \lambda = \frac{hc}{E}$ ✓ $\lambda = \frac{1.24 \times 10^{-6}}{1.86} = 666.6 \approx 667$ nm ✓		[2]
g	I	[2] max from Electromagnetic radiation with an infinite rage of wavelengths ✓ With a peak determined by temperature ✓ Radiation emitted by a body at some finite kelvin temperature ✓ Radiation with an intensity proportional to the 4th power of the kelvin temperature ✓		[2] max
	II	Helium has energy levels separated by 1.86 eV ✓ This energy difference is unique to helium ✓ The dip implies that photons of this energy are absorbed by helium ✓		[3]