Question			Expected Answers	Marks	Additional guidance
1	**a**		(n) numb of **<u>moles</u>** (T) **absolute** temperature OR thermodynamic temp OR temp measured in **Kelvin**	B1 B1	 Accept **K** for Kelvin
	b	**i**	(When gas is heated) molecules gain KE/move faster this would cause more collisions/<u>sec</u> (with the walls) collisions exert more force/greater change in momentum per collision For constant pressure fewer collisions/sec are required Constant pressure is achieved by the increase in volume OR with a bigger volume there are fewer collisions/sec	B1 B1 B1 B1 B1 *max 4*	If no reference to <u>rate</u> of collisions, max of 3 marks This must be explained fully but can be done with reference to $P = (1/3)\rho <c^2>$
		ii	correct substitution in pV/T = constant: OR V/T = constant e.g. $1.2\text{x}10^{-4}$ /**293** = V/**363** V= (363/293)x$1.2\text{x}10^{-4}$ = **$1.49\ \text{x}10^{-4}$** m^3.	 C1 A1	 Both temps must be in Kelvin. Allow $1.5 \times 10^{-4}\ \text{m}^3$
	c		Use of $1/2m<c^2> = 3/2\ kT$ Correct substitution: $\sqrt{<c^2>} = \sqrt{(3kT/m)} = \sqrt{(3\text{x}1.38 \times 10^{-23}\text{x}363/4.7\text{x}10^{-26})}$ $\sqrt{<c^2>}$ = **565** ms^{-1}	C1 C1 A1	If 90^0 C is used $\sqrt{<c^2>} = 282\ \text{ms}^{-1}$ and scores 2 marks Allow 570 ms^{-1} If they do not square root, they get 319225 ms^{-1} and score 2 marks
			Total	**11**	

Question			Answer	Marks	Guidance
2	**(a)**		Quantum / packet of (electromagnetic) <u>energy</u> Any <u>one</u> from: Can travel in a vacuum / has speed of 3×10^8 <u>m s^{-1} in a vacuum</u> / has no charge / has no (rest) mass / causes ion-isation / has momentum	B1 B1	**Allow**: Particle of <u>energy</u> **Allow**: Travels at the speed of light / *c* <u>in a vacuum</u>
	(b)	**(i)**	number per second = $4.8 \times 10^{-3}/1.6 \times 10^{-19}$ number per second = 3.0×10^{16} s^{-1}	M1 A0	**Note**: This must be seen to gain a mark
		(ii)	(incident power =) $150 \times 10^3 \times 4.8 \times 10^{-3}$ or (incident power =) $3.0 \times 10^{16} \times 150 \times 10^3 \times 1.6 \times 10^{-19}$ ($P = mc[\Delta\theta/\Delta t]$) $0.99 \times 720 = 0.0086 \times 140 \times [\Delta\theta/\Delta t]$ rate of temperature increase = 590 (°C s^{-1})	C1 C1 A1	**Note** an incident power of 720 (W) scores this C1 mark **Note**: Answer to 3 sf is 592 (°C s^{-1}) **Allow**: 2 marks for 598 (°C s^{-1}) or 600 (°C s^{-1}); 99% omitted **Allow**: 2 marks for 1.97×10^{-14} (°C s^{-1}); 3.0×10^{16} omitted
		(iii)	(photon energy = maximum KE of electron) $E = 150 \times 10^3 \times 1.6 \times 10^{-19}$ or $E = 2.4 \times 10^{-14}$ (J) $2.4 \times 10^{-14} = \frac{6.63\times10^{-34}\times3.0\times10^{8}}{\lambda}$ (Allow any subject) wavelength = 8.3×10^{-12} (m)	 C1 A1	 **Allow**: $E = 720/3.0 \times 10^{16}$ **Allow**: 1 mark 8.3×10^{-10} (m); $E = 2.4 \times$ <u>10^{-16}</u> (J) used
	(c)		Contrast material / iodine is injected (into the vessels) Any <u>one</u> from: The contrast material • large attenuation / absorption coefficient • has high *Z* (atoms) (and hence reveal the outline of the blood vessels)	B1 B1	**Not**: barium for this B1 mark **Not** 'large μ'
			Total	**10**	