8(a)	packet / quantum of <u>energy</u>
	of electromagnetic radiation
8(b)(i)	$E = c^2\Delta m$
	$\Delta m = (4.274 \times 10^6 \times 1.60 \times 10^{-19}) / (1.66 \times 10^{-27} \times (3.00 \times 10^8)^2)$ (= 0.00458 u)
	m = 233.915174 + 4.000407 + 0.00458 = 237.92016 u
8(b)(ii)	$E = hc / \lambda$ **or** $E = hf$ **and** $c = f\lambda$
	$(4.274 - 4.200) \times 1.60 \times 10^{-13} = (6.63 \times 10^{-34} \times 3.00 \times 10^8) / \lambda$
	$\lambda = 1.7 \times 10^{-11}$ m
8(b)(iii)	(true) energy of gamma photon is smaller so (true) wavelength is larger
8(c)	(anti)neutrinos are emitted during beta decay
	particles emitted during beta decay carry varying amounts of energy, so energy of gamma photon is also variable (between decays)

8(a)	• quantum of energy
	• of electromagnetic radiation
8(b)(i)	$(\Delta)E = hc / \lambda$
	$\lambda = (6.63 \times 10^{-34} \times 3.00 \times 10^8) / (1.96 \times 1.60 \times 10^{-19})$
	$= 6.3 \times 10^{-7}$ m
8(b)(ii)	number per unit time = power / energy per photon $= (1.0 \times 10^{-2}) / (1.96 \times 1.60 \times 10^{-19})$ $= 3.2 \times 10^{16}$ s^{-1}
8(b)(iii)	*either*: force = rate of change of momentum *or*: $F = \Delta p / t$
	$p = E / c$
	half the photons have change in momentum p, the other half have change in momentum $2p$
	$F = [(1.96 \times 1.60 \times 10^{-19}) / (3.00 \times 10^8)] \times 3.2 \times 10^{16} \times [(2 + 1) / 2]$ $= 5.0 \times 10^{-11}$ N

8(a)(i)	$p = E / c$
	$E = hc / \lambda$ and completion of algebra leading to $p = h / \lambda$
8(a)(ii)	wavelength = $(6.63 \times 10^{-34}) / (9.5 \times 10^{-28}) = 700 \times 10^{-9}$ m so red
8(b)(i)	power = intensity × area
	number per unit time = $(160 \times 2.5 \times 10^{-6}) / (9.5 \times 10^{-28} \times 3.00 \times 10^8) = 1.4 \times 10^{15}$ s^{-1}
8(b)(ii)	pressure = force / area
	force = rate of change of momentum $= 2 \times 9.5 \times 10^{-28} \times 1.4 \times 10^{15}$
	pressure = $(2 \times 9.5 \times 10^{-28} \times 1.4 \times 10^{15}) / (2.5 \times 10^{-6})$ $= 1.1 \times 10^{-6}$ Pa
8(c)	photons have greater momentum **or** fewer photons per unit time
	greater photon momentum but smaller number of photons (per unit time) so pressure is the same