Paper 2

Section A : Astronomy and Space Science

1. C (55%)	2. B (52%)	3. C (55%)	4. B (51%)
5. D (62%)	6. D (61%)	7. A (53%)	8. A (65%)

Solution	Marks	Remarks
1. (a) (i) $\frac{GMm}{r^2} = \frac{mv^2}{r}$	1M	
$v^2 = \frac{GM}{r}$		
	1	
(ii) $T = \frac{2\pi r}{v}$	1M	
$T^2 = \frac{4\pi^2 r^2}{v^2}$		
$= \frac{4\pi^2 r^2}{\left(\frac{GM}{r}\right)}$ from (i)	1M	
$= \frac{4\pi^2}{GM} r^3$		
	2	
(b) (i) By $\frac{\Delta\lambda}{\lambda_0} \approx \frac{v}{c}$		
$\Delta\lambda \approx \frac{v}{c}\lambda_0 = \frac{1.23\times10^5}{3\times10^8}\times 21.106$	1M	
$= 8.65346 \times 10^{-3}$ cm		
$\lambda = \lambda_0 - \Delta\lambda$		
$= 21.106 - 8.65346 \times 10^{-3}$		
$= 21.097$ cm	1A	
	2	
(ii) $T = \frac{2\pi r}{v}$		
$= \frac{2\times3.14\times(3.98\times10^{20})}{1.23\times10^5}$		
$= 2.03 \times 10^{16}$ s (or 6.42×10^8 yr)	1A	
	1	

Solution	Marks	Remarks
1. (b) (iii) For the hydrogen gas orbiting the M33 Galaxy at X, $T^2 = \frac{4\pi^2}{GM} r^3$ ……(1) where T is the answer in (b)(ii), M is the mass of the M33 Galaxy and r is the distance between position X and the centre of the galaxy. Consider the Earth orbiting around the Sun, $T_S^2 = \frac{4\pi^2}{GM_S} r_S^3$ ……(2) where T_S = 1 year, r_S = 1 AU and M_S is the solar mass.	1M	
$\frac{(1)}{(2)}$ and we have $\frac{T^2}{T_S^2} = \frac{M_S r^3}{M r_S^3}$ $M = \frac{T_S^2 r^3}{T^2 r_S^3} M_S$	1M	
$= \left(\frac{3.16\times10^7}{2.03\times10^{16}}\right)^2 \left(\frac{3.98\times10^{20}}{1.50\times10^{11}}\right)^3 M_S$ $= 4.526 \times 10^{10}\ M_S \approx 4.53 \times 10^{10}\ M_S$	1A	
Alternative method: Use $T^2 = \frac{4\pi^2}{GM} r^3$ to find the mass of M33 $M = \frac{4\pi^2\,(3.98\times10^{20})^3}{G(2.03\times10^{16})^2} = 9.055 \times 10^{40}$ kg	1M	
Use $T_S^2 = \frac{4\pi^2}{GM_S} r_S^3$ to find solar mass $M_S = \frac{4\pi^2\,(1.5\times10^{11})^3}{G(3.16\times10^7)^2} = 2.0 \times 10^{30}$ kg	1M	
Then $M = 4.526 \times 10^{10}\ M_S$	1A	
	3	
(iv) Dark matter / a (super) massive black hole / non-luminous object exists in the galaxy.	1A	
	1	

Section B : Atomic World

1. B (70%)	2. A (30%)	3. C (57%)	4. C (60%)
5. B (52%)	6. A (64%)	7. A (70%)	8. D (70%)

Solution	Marks	Remarks
2. (a) When an atom transits from a higher energy level to a lower one, a photon with energy equals to the energy difference between the levels is emitted.	1A	
Since energy levels are quantized, the energy (and thus wavelength) of the photons emitted can take some discrete values only.	1A	
	2	
(b) (i) Line X belongs to the ultra-violet region.	1A	
	1	
(ii) energy = $\frac{hc}{\lambda e}$		
$= \frac{(6.63\times10^{-34})(3\times10^{8})}{(366\times10^{-9})(1.60\times10^{-19})}$	1M	
= 3.40 eV	1A	
	2	
(iii) The radiation would be absorbed,	1A	
and the hydrogen atoms ionized.	1A	
	2	
(c) (i) The transition from $n = 3$ to $n = 2$. (i.e. from 2nd to 1st excited state)	1A	
	1	
(ii) From line X, we have		
$\frac{1}{366} = R(\frac{1}{2^2} - 0)$	1M	
$R \approx 0.0109$ (nm^{-1}) (or 1.09×10^{7} m^{-1})		
For line Y,		
$\frac{1}{\lambda} = R(\frac{1}{2^2} - \frac{1}{3^2})$		
$\lambda = 658.8$ nm	1A	
Alternative method: $R = \frac{13.6\text{ eV}}{hc}$ $= \frac{13.6\times(1.6\times10^{-19})}{(6.63\times10^{-34})(3\times10^{8})}$ $= 1.094\times10^{7}$ (m^{-1})		
$E = E_2 - E_3$; $h\frac{c}{\lambda} = 13.6\left(\frac{1}{2^2} - \frac{1}{3^2}\right)$ eV $= 13.6\left(\frac{1}{2^2} - \frac{1}{3^2}\right)\times1.6\times10^{-19}$	1M	
$\frac{1}{\lambda} = R(\frac{1}{2^2} - \frac{1}{3^2})$; $\lambda = 6.58\times10^{-7}$ m	1A	
	2	

Section C : Energy and Use of Energy

1. B (63%)	2. C (89%)	3. B (75%)	4. D (73%)
5. C (57%)	6. D (38%)	7. *	8. A (52%)

Solution	Marks	Remarks
3. (a) (i) The refrigerant flows from indoor to outdoor through the compressor.	1A	
	1	
(ii) The refrigerant condenses / changes from gas to liquid.	1A	
It releases the heat/internal energy to the environment.	1A	
	2	
(b) (i) Total surface area = $(4 \times 2) \times 4 + (2 \times 2) \times 2 = 40\ \text{m}^2$	1M	
Cooling capacity = rate of heat gain		
$= \kappa \dfrac{A(T_H - T_C)}{d} = 0.03 \dfrac{40(50)}{0.08}$	1M	
$= 750$ W	1A	
	3	
(ii) The compartment absorbs heat by radiation,	1A	The compartment also absorbs heat from the engine / exhaust system.
the exterior surface temperature of the refrigerated compartment is higher than 35 °C.	1A	
Thus, the interior will be higher than −15 °C.		
	2	
(c) Light emitting diode (LED) has a long life time	1A	
and very high efficacy.	1A	
	2	

*This item was deleted.

Section D : Medical Physics

1. A (69%)	2. C (40%)	3. B (72%)	4. D (58%)
5. B (57%)	6. A (72%)	7. C (65%)	8. D (53%)

Solution	Marks	Remarks
4. (a) X-ray is produced when fast electrons hit a heavy metal target.	1A	
	1	
(b) CT scan is better at mapping soft tissues / differentiating between overlying structures in the body / making 3D images	1A	
	1	
(c) (i) The effective dose of CT scan is much higher because multiple X-ray images are taken for a CT scan.	1A	
	1	
(ii) Equivalent background radiation dose $= 1.85 \times \frac{1.5}{0.02}$ $= 138.75$ days	1A	
	1	
(d) (i) The lung cavity is filled with air / There is a large difference in density between the lung cavity and bone	1A	
	1	
(ii) $I = I_0 e^{-(\mu_1 x_1 + \mu_2 x_2 + \mu_3 x_3)}$		
$\frac{I}{I_0} = e^{-(0.1 \times 19.8 + 0.18 \times 8.8 + 0.48 \times 4.4)}$	1M+1M	
$= e^{-5.676} = 3.43 \times 10^{-3}$	1A	
	3	
(e) I do not agree because a CT scan may cause ionization (changes) in cells / damage DNA of the foetus.	1A	
An ultrasound scan can be used for checking a foetus.	1A	
	2	