Paper 2

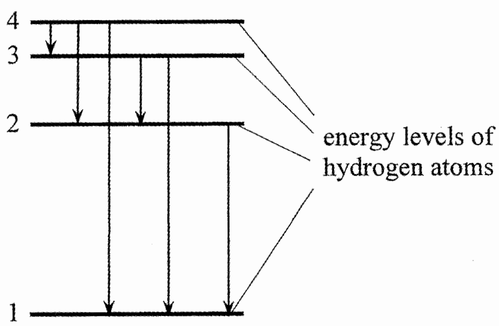
Section A : Astronomy and Space Science

1. A(34%)	2. C(53%)	3. D(57%)	4. B(46%)
5. B(40%)	6. C(60%)	7. A(46%)	8. D(52%)

Solution	Marks	Remarks
1. (a) (i) radial velocity is the component of the star's velocity along the observer's line of sight / velocity along the observer direction or the line joining the star and the observer.	1A	
	1	
(ii) Point D	1A	
	1	
(b) $v_1 = 180 \text{ km s}^{-1}$	1A	
$v_1 = \frac{2\pi r_1}{T} = \frac{2\pi r_1}{40\times60\times60}$ (Period T = 40 hr)	1M	
$r_1 = 4.125 \times 10^6$ km or 4.125×10^9 m	1A	
From figure, $v_2 = 120 \text{ km s}^{-1}$; and by ratio or similar calculation gives $r_2 = 2.75 \times 10^6$ km or 2.75×10^9 m	1A	
	4	
(c) $\frac{Gm_1m_2}{(r_1+r_2)^2} = m_1(\frac{2\pi}{T})^2 r_1 = \frac{m_1v_1^2}{r_1}$ $[\omega = \frac{2\pi}{T}]$	1M	
$\frac{(6.67\times10^{-11})\,m_2}{(4.125\times10^9+2.75\times10^9)^2} = \frac{(180\times10^3)^2}{4.125\times10^9}$		
Therefore, $m_2 = 5.57 \times 10^{30}$ kg	1A	
	2	
(d) $\frac{v_r}{c} = \frac{\Delta\lambda}{\lambda} = \frac{0.5\text{ nm}}{656.28\text{ nm}} \Rightarrow v_r = 228.3 \text{ km s}^{-1} > 180 \text{ km s}^{-1}$;	1M	
Or $\frac{\Delta\lambda}{\lambda} = \frac{v_r}{c} = \frac{180\times10^3}{3\times10^8} \Rightarrow \Delta\lambda = 0.394 \text{ nm} < 0.5 \text{ nm}$;	1M	
therefore NOT suitable. Accept using 120 km s^{-1}, $\Delta\lambda = 0.263 \text{ nm} < 0.5 \text{ nm}$	1A	
	2	

Section B : Atomic World

1. D(40%)	2. A(42%)	3. D(62%)	4. B(66%)
5. C(47%)	6. C(44%)	7. A(42%)	8. B(36%)

Solution	Marks	Remarks
2. (a) - the electron is considered as a particle revolving around the nucleus in definite orbits/circular motion; or - the centripetal force is provided by the Coulomb force; or - the electron's motion obeys Newton's laws of motion	1A	
	1	
(b) lowest energy level or most stable state	1A	
	1	
(c) $p = \frac{h}{\lambda} = \frac{hc}{\lambda} \cdot \frac{1}{c}$	1M	
$p = \frac{E}{c}$	1A	
	2	
(d) (i) $E_4 = -\frac{13.6}{4^2} = -0.85$ eV , $\Delta E_{1 \to 4} = E_4 - E_1 = -0.85 - (-13.6) = 12.75$ eV $E_5 = -\frac{13.6}{5^2} = -0.544$ eV , $\Delta E_{1 \to 5} = E_5 - E_1 = -0.544 - (-13.6) = 13.056$ eV	1M	
12.75 eV < 12.9 eV < 13.06 eV, therefore at most to the 3rd excited state ($n = 4$).	1A	
Alternatively : $\Delta E = E_n - E_1 = -13.6\left(\frac{1}{n^2} - \frac{1}{1^2}\right) = 12.9$ eV	1M	
$n = 4.41$ and as n is an integer, it can at most take $n = 4$ (3rd excited state).	1A	
	2	
(ii) $mvr_n = \frac{nh}{2\pi} \Rightarrow 2\pi r_n = \frac{nh}{mv} = n\lambda$ (from postulate)	1M	
When $n = 4$, $2\pi(0.053)(4^2) = 4\lambda$ Therefore, $\lambda = 1.33$ nm	1A	
Alternatively: $r = (0.053)\ 4^2$ nm $= 0.848$ nm $= 8.48 \times 10^{-10}$ m	1M	
$\frac{1}{4\pi\varepsilon_0} \cdot \frac{e^2}{r^2} = \frac{mv^2}{r} \Rightarrow v^2 = \frac{1}{4\pi\varepsilon_0} \cdot \frac{e^2}{r} \cdot \frac{1}{m} = 9 \times 10^9 \times \frac{(1.6 \times 10^{-19})^2}{8.48 \times 10^{-10}} \cdot \frac{1}{9.11 \times 10^{-31}}$ $\Rightarrow v = 5.46 \times 10^5$ m s^{-1}		
$\lambda = \frac{h}{mv} = \frac{6.63 \times 10^{-34}}{(9.11 \times 10^{-31})(5.46 \times 10^5)} = 1.33 \times 10^{-9}$ m $= 1.33$ nm	1A	
	2	
(iii) 	2A	
	2	

Section C : Energy and Use of Energy

1. A(33%)	2. D(50%)	3. B(67%)	4. C(21%)
5. B(28%)	6. C(28%)	7. C(47%)	8. A(32%)

Solution	Marks	Remarks
3. (a) (i) Time required $= \dfrac{\text{heat to remove } (mc\Delta T)}{\text{cooling capacity}}$	1M	
$= \dfrac{[(20.0\times3.0)\times1.2]\times1000\times(33-25)}{6.80\times1000}$		
$= \dfrac{576000}{6800} = 85$ s (1.42 min. or 0.0236 hr)	1A	
	2	
(ii) **ANY ONE**: Heat has to be removed from wall, furniture etc. / Heat transferred from outside to the room has to be removed / Other reasonable factors such as bad air ventilation for air-conditioner / Doors or windows are not closed properly / Installation position is facing west or exposed to sunlight directly, etc. / Heat gain from surroundings / Poor conductor (air) lengthens the time for heat transfer	1A	
	1	
(b) (i) $P_{in} = \dfrac{2525}{1200} = 2.1$ (kW) or 2100 W	1A	
	1	
(ii) $\dfrac{\text{cooling capacity}}{\text{electrical power input}}$ (COP) $= \dfrac{6.80}{2.1} = 3.24$	1M/1A	
Conservation of energy is not violated.	1A	
For each joule of electrical energy consumed by the air-conditioner/compressor, 3.24 J of heat will be transferred/removed, but not created, by the air-conditioner.	1A	
	3	
(c) (i) $(C \rightarrow) B \rightarrow A \rightarrow D$	1A	
component B (or condenser)	1A	
	2	
(ii) reverse the direction of flow of refrigerant	1A	
Or interchange/swap the positions of B (condenser) and D (evaporator) or A (expansion valve) and C (compressor)		
	1	

Section D : Medical Physics

1. B(47%)	2. D(45%)	3. D(26%)	4. D(29%)
5. B(64%)	6. C(58%)	7. A(50%)	8. A(60%)

Solution	Marks	Remarks
4. (a) (i) A: eardrum B: semi-circular canals C: cochlea D: oval window	1A	
C (cochlea) is for discriminating different frequencies of incoming sound waves / convert sound waves to nerve signals / auditory sensor cells inside send signals to brain.	1A	
	2	
(ii) $25 \div 20 = 1.25$ (i.e. 25% increase)	1M/1A	
	1	
(b) (i) 60 (phons)	1A	
The ear is less sensitive (compared to 1~2 kHz frequency) to sound of low or high frequencies / more sensitive to middle frequencies / need a higher sound intensity to give the same loudness at high and low frequencies.	1A	
	2	
(ii) Curve C.	1A	
Curve shifted upwards such that a greater intensity level for threshold of hearing (or giving the same loudness sensation), especially significant in kHz range.	1A	
	2	
(c) Change in sound intensity level		
$L_1 = 10 \log \frac{80}{I_0}$	1M	
$L_2 = 10 \log \frac{2.5 \times 10^{-5}}{I_0}$		
$L_2 - L_1 = 10 \log \frac{80}{2.5 \times 10^{-5}}$	1M	
$= -65$ (dB)	1A	Accept ± 65 dB
Alternatively: Assume $I_0 = 10^{-12}$ W m^{-2}		
$L_1 = 10 \log \frac{80}{10^{-12}} = 139.03$ dB	1M	
$L_2 = 10 \log \frac{2.5 \times 10^{-5}}{10^{-12}} = 74.03$ dB		
$L_2 - L_1 = -65$ (dB)	1M+1A	
Or $10 \log \left(\frac{I_{\text{noise reduced}}}{I_{\text{original}}}\right)$		
$= 10 \log \left(\frac{2.5 \times 10^{-5}}{80}\right)$	2M	
$= -65$ dB		
∴ reduced by 65 (dB)	1A	
	3	