

Paper 2

Section A : Astronomy and Space Science

1. D (31%)	2. A (35%)	3. A (53%)	4. C (44%)
5. B (43%)	6. C (36%)	7. D (44%)	8. B (59%)

Marks

1. (a) (i) $L_S = \sigma T_S^4 (4\pi R_S^2)$ 1M
 $L = \sigma T^4 (4\pi R^2)$

$\therefore \frac{L_S}{L} = \frac{T_S^4 R_S^2}{T^4 R^2}$ 1M

$R = \left(\frac{T_S}{T}\right)^2 \left(\frac{L}{L_S}\right)^{\frac{1}{2}} R_S$ 2

(ii)

Sun	$T_S = 5780 \text{ K}$	L_S	R_S
Betelgeuse	$T = 3650 \text{ K}$	$L = 126000 L_S$	R

$R = \left(\frac{5780}{3650}\right)^2 \left(\frac{126000 L_S}{L_S}\right)^{\frac{1}{2}} R_S$ 1M
 $= 890 R_S$ 1A 2

(b) (i) \therefore Same brightness measured and brightness $= \frac{L}{4\pi d^2}$ or $\propto \frac{L}{d^2}$ or L increases with d , 1M
 d is larger $\rightarrow L$ is larger. (for d taken as (197+45) pc)

i.e. for Betelgeuse, $\therefore L \propto R^2$ 1A 2 $\therefore R$ increases.

Or

$M = m - 5(\log_{10} d - 1)$ or $M = m - 5(\log_{10} \frac{d}{10})$

(M : absolute magnitude , m : apparent magnitude)

(ii) The parallax measurement ($d = \frac{1}{p}$, accurate to within ~ 100 pc) is too small or d is too large (too far away), ($\sim (1/200)'' = 5$ milliarcsec). 1A 1

(c) $L = 10^9 L_S$, brightness $= \frac{(0.01 \times 10^9 L_S)}{4\pi d^2}$ 1M

$d = 200 \times 206265 \text{ AU} = 41253000 \text{ AU}$ 1M

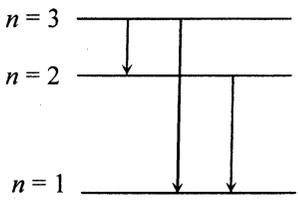
Brightness $= \frac{(0.01 \times 10^9)}{41253000^2} \frac{L_S}{4\pi(1\text{AU})^2} = \frac{(0.01 \times 10^9)}{41253000^2}$ brightness of the Sun 1A
 $= 5.88 \times 10^{-9}$ brightness of the Sun 3

Section B : Atomic World

1. D (34%)	2. A (47%)	3. B (51%)	4. C (64%)
5. C (53%)	6. A (75%)	7. B (60%)	8. D (47%)

Marks

2. (a) The negative sign means that:
- the electron is "bound" to the atom
 - the force between the nucleus and electron is attractive
 - work has to be done to remove the electron to infinity
- } ANY ONE 1A 1
- (b)
- The angular momenta of the electrons are whole number multiples of $\frac{h}{2\pi}$, i.e. quantized.
 - The electrons are in stable orbits without emitting radiation.
 - The electrons can occupy certain discrete orbits only. / Total energy of the atom is quantized / Energy levels are discrete.
 - The atom can only emit or absorb radiation in the form of a photon when an electron jumps from one energy level to another.
- } ANY TWO 2A 2
- (c) (i) Energy = hf
- $$= \frac{hc}{\lambda} = \frac{6.63 \times 10^{-34} \times 3 \times 10^8}{102.8 \times 10^{-9}} = 1.93 \times 10^{-18} \text{ J}$$
- $$= 1.93 \times 10^{-18} / (1.60 \times 10^{-19}) = 12.09 \text{ (eV)}$$
- $$\Delta E = 12.09 \text{ eV} = -\left(\frac{1}{n^2} - \frac{1}{1^2}\right) 13.6 \text{ eV}$$
- $$n^2 = \frac{1}{1 - \frac{12.09}{13.6}}$$
- $$n^2 = 9.007 \Rightarrow n = 3$$
- 1A 1M 1A 3
- (ii) The energy of UV = 100.0 nm does not match the differences between ground state of hydrogen and other energy levels. 1A 1
- (iii) There are three possible transitions
The hydrogen atom is in excited state $n = 3$.
- $$E_3 = -\frac{13.6}{3^2} \text{ eV} = -1.51 \text{ eV}$$
- $$E_2 = -\frac{13.6}{2^2} \text{ eV} = -3.40 \text{ eV}$$
- $$E_1 = -\frac{13.6}{1^2} \text{ eV} = -13.60 \text{ eV}$$
- $3 \rightarrow 1 \quad \Delta E = 12.09 \text{ eV} (= -1.51 - (-13.6))$
 $3 \rightarrow 2 \quad \Delta E = 1.89 \text{ eV} (= -1.51 - (-3.40))$
 $2 \rightarrow 1 \quad \Delta E = 10.2 \text{ eV} (= -3.40 - (-13.6))$


- 1M 1A 3
- The transition from $3 \rightarrow 2$ corresponds to visible light as 1.89 eV is within the corresponding range. 1A 3

Section C : Energy and Use of Energy

1. A (80%)	2. C (54%)	3. D (43%)	4. C (64%)
5. B (82%)	6. B (68%)	7. C (76%)	8. A (26%)

		<u>Marks</u>
3.	(a) Maximum solar power per unit area reaching the Earth = $1366 \times (1 - 0.268)$ = 1000 W m^{-2} or W	1A <u>1</u>
	(b) Solar energy / radiation / radiant energy / light energy → electrical energy. Adhere a transparent anti-reflection film to the solar cell panel. Methods involving tracking the sun to receive maximum sun light Mirrors/lens to reflect/collect sun light to the solar cells	1A } ANY ONE 1A <u>2</u>
	(c) (i) Solar power received by each solar cell = $1000 \text{ W m}^{-2} \times 0.0172 \text{ m}^2$ = 17.2 W	1M
	Electrical power delivered by each solar cell = $17.2 \text{ W} \times 0.12$ = 2.064 W	1M
	Number of solar cells required = $\frac{7.35 \text{ kW} \times 4}{2.064 \text{ W}}$ = 14244	1A <u>3</u>
	(ii) - To limit/minimize the weight of the aircraft. - Limited area for installing the solar cells. - It is the batteries to deliver maximum power to the engines, the solar cells are for charging the batteries.	} ANY ONE 1A <u>1</u>
	(d) Energy comes from natural resources / processes that are replenished constantly.	1A
	Wind power as (northeast and southwest) monsoons prevail in Hong Kong (during winter and summer).	1A 1A <u>3</u>

Section D : Medical Physics

1. A (46%)	2. C (46%)	3. B (55%)	4. B (17%)
5. C (56%)	6. D (52%)	7. D (46%)	8. A (18%)

Marks

4. (a) (i) Let v be the speed of ultrasound in soft tissue
 v_b be the speed of ultrasound in bone
 t be the time of travel of ultrasound in soft tissue
 t_b be the time of travel of ultrasound in bone
- We have $\frac{v_b t_b / 2}{vt / 2} = \frac{5.8}{2.0}$ or $\frac{v_b t_b}{vt} = \frac{5.8}{2.0}$ 1M
- $(\frac{v_b}{v})(\frac{3}{2}) = 2.9$
- $\frac{v_b}{v} = 1.93$ 1A 2
- (ii) From (i), $v_b = 1.93 \times 1580 \text{ m s}^{-1} = 3055 \text{ m s}^{-1}$ 1M
- \therefore for bone $Z = \rho c$ 1M
 $7.78 \times 10^6 = \rho (3055)$ 1A 3
 $\rho = 2547 \text{ kg m}^{-3}$
- (b) (i) Reflection of ultrasound at tissue boundary/when entering another tissue. 1A
 The brightness/amplitude/strength in a B-scan image is proportional to the intensity of the reflected ultrasound signal/change in acoustic impedance. 1A
 Distance/depth calculated from time for signal to return to ultrasound transducer./When traces are joined, a 2D/planar image of the scanned area is formed. 1A 3
- (ii) Advantages (ANY ONE): 1A
- relatively safe (as no ionizing radiation involved)
 - readily accessible
 - can detect the movement of an organ in real time
- Limitations (ANY ONE): 1A
- limited tissue penetration, particularly through bones or air-filled structures
 - field-of-view (FOV) of ultrasound is smaller compared to other methods of imaging 2