Marking Schemes

This document was prepared for markers' reference. It should not be regarded as a set of model answers. Candidates and teachers who were not involved in the marking process are advised to interpret its contents with care.

General Marking Instructions

1. It is very important that all markers should adhere as closely as possible to the marking scheme. In many cases, however, candidates may have obtained a correct answer by an alternative method not specified in the marking scheme. In general, a correct answer merits ***the answer mark*** allocated to that part, unless a particular method has been specified in the question.

   In the marking scheme, alternative answers and marking guidelines are in rectangles.

2. In the marking scheme, answer marks or 'A' marks are awarded for a correct numerical answer with a unit. If the answer should be in km, then cm and m are considered to be wrong units.

3. In a question consisting of several parts each depending on the previous parts, method marks or 'M' marks are awarded to steps/methods or substitutions correctly deduced from previous answers.

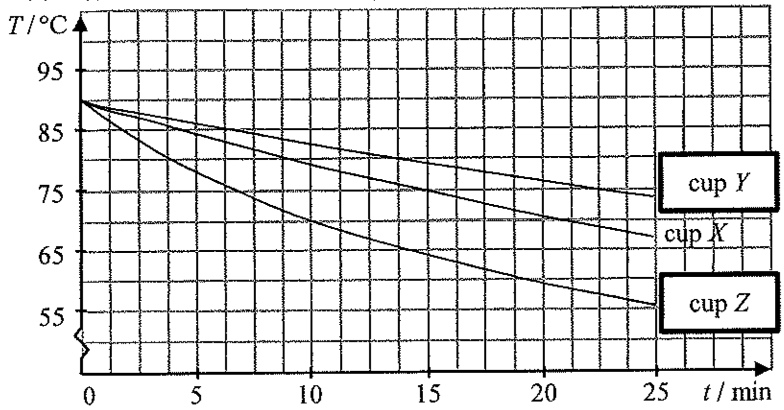
4. In cases where a candidate answers more questions than required, the answers to all questions should be marked. However, the excess answer(s) receiving the lowest score(s) will be disregarded in the calculation of the final mark.

Paper 1 Section A

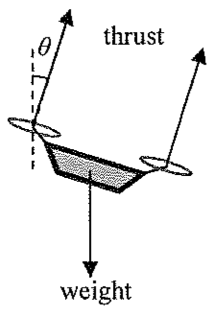
Question No.	Key	Question No.	Key
1.	A (76)	26.	B (65)
2.	B (54)	27.	A (61)
3.	D (80)	28.	C (26)
4.	C (56)	29.	B (34)
5.	A (51)	30.	A (45)
6.	B (47)	31.	C (63)
7.	B (84)	32.	A (50)
8.	B (49)	33.	C (83)
9.	D (61)		
10.	D (32)		
11.	A (46)		
12.	D (75)		
13.	C (67)		
14.	A (52)		
15.	B (70)		
16.	C (71)		
17.	D (67)		
18.	B (63)		
19.	C (55)		
20.	A (72)		
21.	C (44)		
22.	D (64)		
23.	C (24)		
24.	D (28)		
25.	D (54)		

Note: Figures in brackets indicate the percentages of candidates choosing the correct answers.

Paper 1 Section B

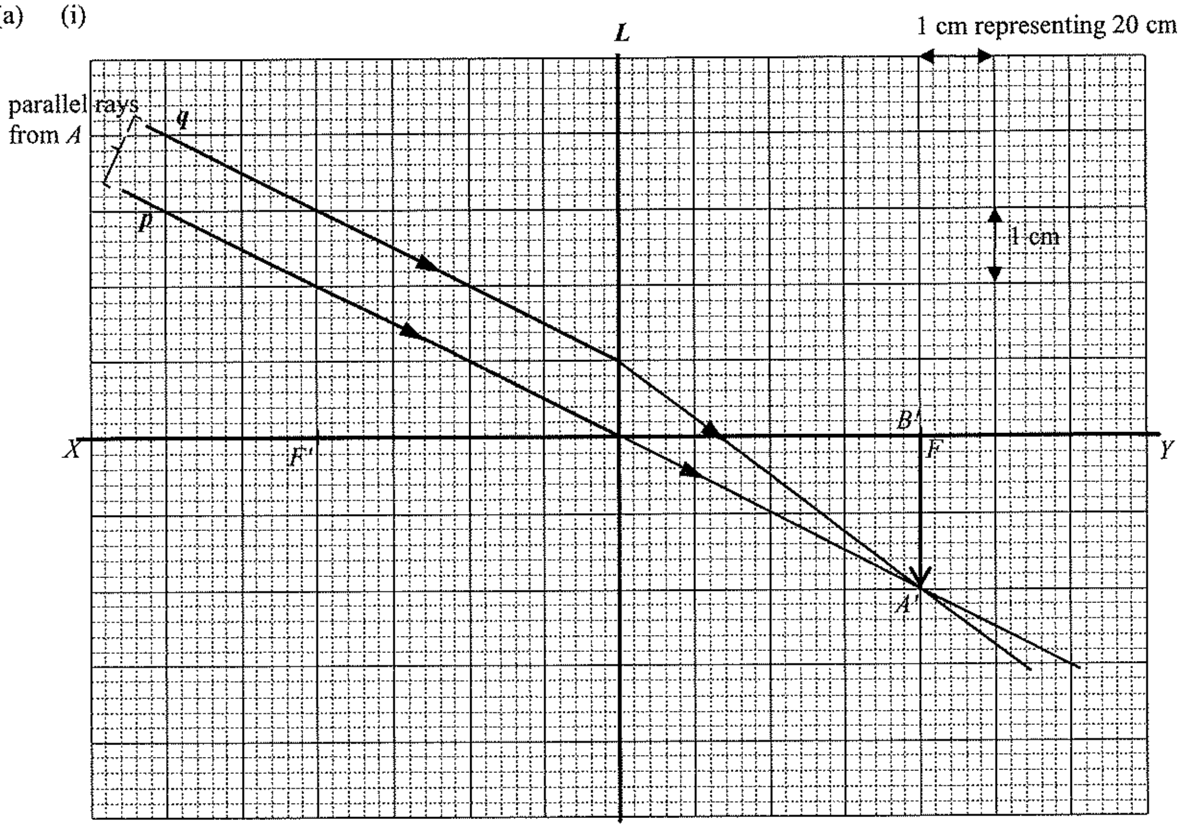
Solution	Marks	Remarks
1. (a) Fair test (otherwise the initial temperature would affect the result).	1A	
	1	
(b) Temperature difference between hot water and the surroundings (room temperature) decreases as time elapses.	1A	
Rate of energy loss / heat loss becomes smaller, hence rate of temperature drop is smaller and the curve becomes less steep.	1A	
	2	
(c) (i) The graphs of T against t 	1A	
	1	
(ii) Comparing to cup X as a control,	1A	
Cup Y: The shiny surface of aluminium foil is a poor emitter / good reflector of radiation (thus reduces heat lost to surroundings).	1A	
Cup Z: No lid allows convection through air / surroundings.	1A	
Or No lid enhances heat lost by evaporation / convection / contacting with air / surroundings.	1A	
	3	
(d) Polystyrene / foam plastic or foam / wood	1A	
	1	

Solution	Marks	Remarks
2. (a) (i) (I) $pV = nRT$		
$(1.0\times10^5)(6.0\times10^{-4}) = n(8.31)(300)$	1M	
$n = 0.0240674$		
number of molecules		
$N = nN_A$		
$= (0.0240674)(6.02\times10^{23})$		
$= 1.448857\times10^{22} \approx 1.45\times10^{22}$	1A	
(II) average kinetic energy of gas molecules		
$E_K = \frac{3}{2}\left(\frac{R}{N_A}\right)T$		
$= \frac{3}{2}\left(\frac{8.31}{6.02\times10^{23}}\right)(300)$	1M	
$= 6.211794\times10^{-21}\text{ J} \approx 6.21\times10^{-21}\text{ J}$	1A	
	4	
(ii) (I) N and E_K remain unchanged.	1A+1A	
	2	
(II) $E_K = \frac{1}{2}mc_{\text{r.m.s.}}^2$		
$\frac{1}{2}m(600)^2 = \frac{1}{2}(\frac{1}{5}m)c_{\text{r.m.s.}}^2$	1M	
$\Rightarrow c_{\text{r.m.s.}} = \sqrt{5}\times600$		
$= 1341.6408\text{ m s}^{-1} \approx 1340\text{ m s}^{-1}$	1A	
	2	
(b) As gas C diffuses into the upper jar, its molecules collide with the air molecules and	1A	
thus describe a zig-zag path / not along a straight path.	1A	
	2	

Solution	Marks	Remarks
3. (a) According to Newton's third law of motion, force on air streams and the thrust on the quadcopter are (equal and) opposite, with magnitude given by F = rate of change of momentum (of air streams). Therefore the thrust (upward) on the quadcopter balances its weight for a certain speed of air streams.	1A 1A 2	
(b) (i) Volume of air streams propelled in 1 s $V = 0.284\ v$ m_a = density × volume $= 1.20 \times 0.284\ v = 0.3408\ v$	1M 1A 2	
(ii) Weight of quadcopter = rate of change of momentum of air streams $1.38\ g = m_a v - 0$ $1.38 \times 9.81 = (0.3408\ v) \times v$ (From (b)(i)) $v^2 = 39.723592$ $v = 6.302665\ \text{m s}^{-1} \approx 6.30\ \text{m s}^{-1}$	1M 1A 2	For $g = 10\ \text{m s}^{-2}$, $v = 6.363408\ \text{m s}^{-1} \approx 6.36\ \text{m s}^{-1}$
(c) (i) 	2A 2	
(ii) centripetal force required $F = \frac{1.38 \times 15^2}{50}$ $= 6.21\ \text{N}$	1M 1A 2	
(iii) Let T = total thrust on the quadcopter Vertical: $T\cos\theta = 1.38\ g$ ($g = 9.81\ \text{m s}^{-2}$) Horizontal: $T\sin\theta = 6.21\ \text{N}$ (From (c)(ii)) On solving the two equations, $\tan\theta = 0.458716$ $\theta = 24.641662° \approx 24.6°$	1M 1A 2	Accept $\tan\theta = \frac{\text{centripetal force}}{\text{weight}}$ For $g = 10\ \text{m s}^{-2}$, $\tan\theta = 0.45$ $\theta = 24.227745° \approx 24.2°$

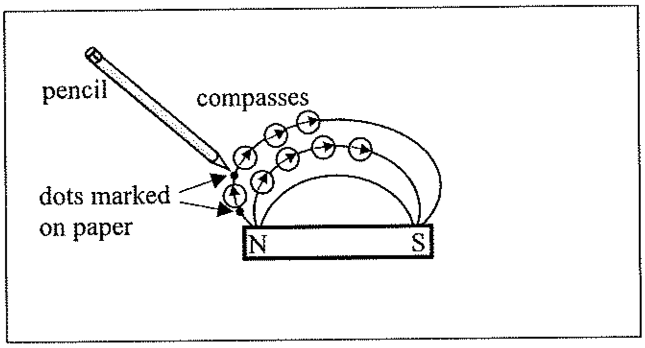
Solution	Marks	Remarks
4. (a) $\frac{1}{2}mv^2 = mgh$		
$= (50)(9.81)(1.5)$	1M	
$= 735.75 \text{ J} \approx 736 \text{ J}$	1A	For $g = 10 \text{ m s}^{-2}$, K.E. = 750 J
	2	
(b) (i) Kinetic energy and potential energy (of the athlete) change to elastic potential energy (of the trampoline).	2A	
	2	
(ii) $\bar{F}d = mgh + mgd$ [Or $\bar{F}d = \frac{1}{2}mv^2 + mgd$]	1M	
$\bar{F} = \frac{50(9.81)(1.5+0.40)}{0.40}$		
$= 1839.375 + 490.5$		
$= 2329.875 \text{ N} \approx 2330 \text{ N}$	1A	For $g = 10 \text{ m s}^{-2}$, $\bar{F} = 2375 \text{ N}$
Or		
$\bar{F} = \frac{1}{0.40}[735.75 + (50)(9.81)(0.40)]$	1M	
$\approx 2330 \text{ N}$	1A	
	2	

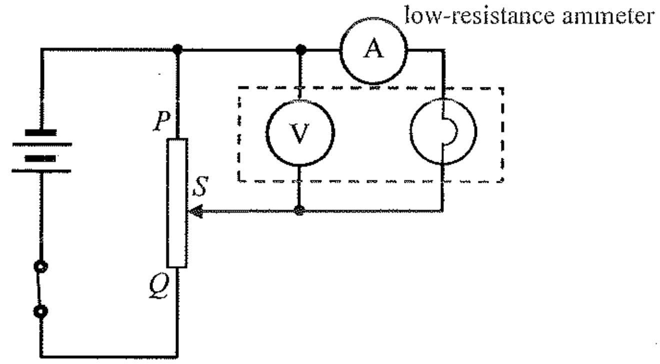
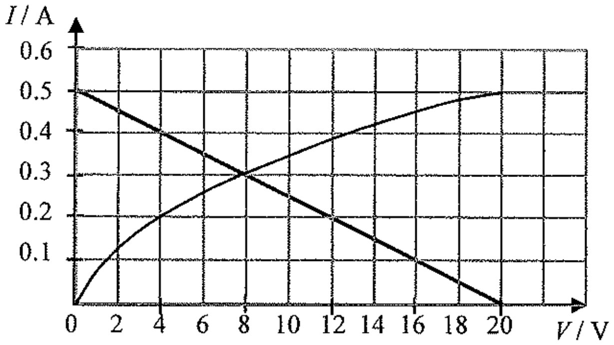
Solution	Marks	Remarks
5. (a) (i)		1 cm representing 20 cm

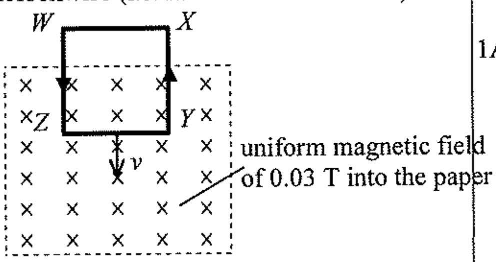


Solution	Marks	Remarks
refracted rays of p, q correctly drawn and	1A	
A' correctly marked.	1A	
image $A'B'$ correctly marked.	1A	
	3	
(ii) Image $A'B'$ of a distant object, say, a building is real and therefore it can be captured	1A	
by a screen (placed at the focal plane).	1A	
	2	
(b) (i) Ratio by similar triangles, $\frac{\text{height of } AB}{\text{object distance}} = \frac{\text{height of } A'B'}{\text{focal length / image distance}}$ $= \frac{2}{4\times 20} = \frac{1}{40}$	1M	Accept height of image $A'B'$: 1.8 cm ~ 2.2 cm
$= 0.025$	1A	
	2	
(ii) $\frac{\text{height of } AB}{\text{object distance}} = \frac{1}{40} = 0.025$ Height of $AB = 0.025 \times 200 = 5$ m	1A	
	1	

Solution	Marks	Remarks
6. (a) Sound waves having the same frequency / wavelength and a constant phase difference (or always in phase / in opposite phase) are coherent.	1A	
	1	
(b) (i) When the sound waves from A and B meet at various positions along OY, interference occurs.		
At positions where the two waves are in phase, constructive interference occurs and gives maximum (loudness).	1A	
At positions where the two waves are in opposite phase, destructive interference occurs and gives minimum (loudness).	1A	
	2	
(ii) Any ONE: • due to background noise • due to reflection of unwanted sound from the wall, floor etc. • the intensity of sound waves from A and B reaching P are NOT equal as $AP < BP$ therefore cancellation is incomplete.	1A	
	1	
(c) Path difference at Q $3\lambda/2 = 2.58 - 2.17$ $= 0.41$ m	1M	
$\therefore\ \lambda = 0.27333333$ m ≈ 0.273 m $v = f\lambda$ $= (1200)(0.273)$ $= 328$ m s^{-1}	1A	Accept 327.6 m s^{-1} to 328 m s^{-1}
	2	
(d) Path difference Δ at any position along OY from A and B is less than AB (i.e. $\Delta = n\lambda < AB$) max. $\Delta = 0.80$ m $= \frac{0.8}{0.273}\lambda \approx 2.93\lambda$	1M	
i.e. max. $\Delta < 3\lambda$ As path difference cannot be equal to $3\lambda, 4\lambda, \cdots$, therefore no more maximum beyond R.	1A	
	2	
(e) increases	1A	
	1	

Solution	Marks	Remarks
7. (a) (i) *A*: south pole (S) *B*: south pole (S)	1A	
	1	
(ii) (Towards) bottom / downwards	1A	
	1	
(iii) Iron filings come into physical contact with the magnet will never come off / are difficult to get rid of.	1A	
	1	
(b) (i) Successively place the compasses on the paper near one pole (say N) of the magnet such that the tip of each compass needle follows / lines up with the tail of the compass ahead.	1A	
Diagram 	1A	
Denote the tip and tail (of each compass) with dots on the paper using the pencil <u>or</u> remove the compasses one by one and trace the (direction of) field line.	1A	
Draw / sketch a smooth curve representing a field line by joining up the series of dots/segments going from one pole to the other.	1A	
Repeat the above process by starting from different points around the magnet to get another/several field line(s).	1A	
	5	
(ii) Any ONE: • Compass is sensitive enough to explore very weak magnetic field such as the Earth's field. • The drawing can show the direction of the field lines / the drawing of the field will still be on the paper after removing the magnet. • It is difficult to draw individual field line separately in iron-filing method even if the filings are sprinkled very thinly and evenly.	1A	
	1	

Solution	Marks	Remarks
8. (a) (i) 	1A	
	1	
(ii) Brightness increases.	1A	
	1	
(b) (i) Resistance $= \frac{V}{I} = \frac{20}{0.5}$	1M	
$= 40\ \Omega$	1A	
	2	
(ii) As the applied voltage V increases, current I / electrical power increases	1A	
and this raises the filament's temperature, thus the resistance R of the filament / bulb increases.	1A	
Or the electrons collide with the increasingly vibrating atoms / lattice ions (of the filament) which impede their flow, i.e. R increases.	1A	
	2	
(c) (i) 	1M	Correct straight line intersects the curve at (8, 0.3)
Current = 0.3 A (at V = 8 V)	1A	
	2	
(ii) Power consumed $= IV$ $= (0.3)(8)$	1M	e.c.f. from (c)(i)
$= 2.4$ W	1A	
	2	

Solution	Marks	Remarks
9. (a) Induced current is anticlockwise (i.e. in the direction *ZYXW*)	1A	
	1	
(b) Current $I = \frac{\varepsilon}{R} = \frac{Blv}{R}$ [Or $\varepsilon = \frac{N\Delta\Phi}{\Delta t} = \frac{B\Delta A}{\Delta t} = Blv = IR$]		
$0.01 = \frac{0.03(0.10)v}{4\times 0.15}$	1M	
$v = 2.0\ \text{m s}^{-1}$	1A	
Or Power input $P = Fv = I^2R$ $(IlB)v = I^2R$ $Blv = IR$ $(0.03)(0.10)\,v = (0.01)(4\times 0.15)$ $v = 2.0\ \text{m s}^{-1}$	 1M 1A	
	2	
(c) (i) $V_{YZ} = I\,(R_{ZW} + R_{WX} + R_{XY})$	1M	
$= 0.01(0.15 + 0.15 + 0.15)$ $= 0.0045$ V ($= 4.5$ mV)	1A	
Or $V_{YZ} = \varepsilon - IR_{YZ}$ $= Blv - IR_{YZ}$ $= 0.03(0.10)(2.0) - 0.01(0.15)$ $= 0.0045$ V	 1M 1A	
	2	
(ii) As there is voltage drop (IR_{YZ}) within / across *YZ*, V_{YZ} is less than the induced e.m.f. across *YZ* ($\varepsilon = Blv$)	1A	Note: $\varepsilon - IR_{YZ} = V_{YZ}$ $\varepsilon = 0.006$ V
	1	
10. (a) Decrease in mass in the reaction (for two $^2_1$H) $\Delta m = (2\times 2.014102) - (3.016029 + 1.008665)$	1M	
$= 4.028204 - 4.024694 = 0.003510$ u Maximum energy released by 1 mole of hydrogen nuclides $= \left(\frac{6.02\times 10^{23}}{6420\times 2}\right)\times (0.003510\times 931\ \text{MeV})$	1M	
$= 1.532104\times 10^{20}$ (MeV) $\approx 1.53\times 10^{20}$ (MeV)	1A	
	3	
(b) $^2_1\text{H} + {}^2_1\text{H} \rightarrow \underline{{}^3_1\text{H} + {}^1_1\text{H}}$ (or $\underline{{}^1_1\text{p}}$)	1A	
	1	
(c) Any TWO: - Unlike fission, the fuel (hydrogen) for fusion is abundant and widely available. - Unlike fission, the products of fusion reactions are not radioactive. - Much larger amount of energy is produced by fusion (for equal mass of fuel).	2A	
	2	

Paper 2

Section A : Astronomy and Space Science

1. B (64%)	2. A (39%)	3. C (23%)	4. D (56%)
5. A (55%)	6. C (37%)	7. C (42%)	8. B (46%)

Solution	Marks	Remarks
1. (a) Gravitational acceleration on a celestial body's surface is given by		
$g = \frac{GM}{R^2}$ (as $F = \frac{GMm}{R^2} = mg$) $\therefore \frac{g_M}{g_E} = \left(\frac{M_{Moon}}{M_{Earth}}\right)\left(\frac{R_{Earth}}{R_{Moon}}\right)^2$	1M	
$= (0.0123)(\frac{1}{0.273})^2 = 0.165036 \approx 0.165$ (3 sig. fig.)	1A	Accept 0.164 ~ 0.166
	2	
(b) (i) Let r be the distance of N from the Earth's centre,		
$\frac{GM_{Earth}m}{r^2} = \frac{GM_{Moon}m}{(D-r)^2}$ or $\frac{GM_{Earth}}{r^2} = \frac{GM_{Moon}}{(D-r)^2}$	1M	
$\frac{D-r}{r} = \sqrt{\frac{M_{Moon}}{M_{Earth}}} = \sqrt{0.0123}$		
$r = \frac{1}{1+\sqrt{0.0123}}D = 0.900167\ D \approx 0.90\ D$	1A	Accept 0.89 D ~ 0.91 D
	2	
(ii) The required kinetic energy = increase in gravitational potential energy	1M	
$\frac{1}{2}mv^2 = m(6.12 \times 10^7)$ $v = 11063.453\ m\ s^{-1} \approx 11.1\ km\ s^{-1}$	1A	Accept 11.0 km s^{-1} ~ 11.2 km s^{-1}
	2	
(c) (i) redshift	1A	
	1	
(ii) $v = f\lambda$ $3 \times 10^8 = 20 \times 10^6\ \lambda_c$ $\lambda_c = 15$ m	1M/1A	
radio waves / short waves	1A	
	2	
(iii) Period: I	1A	
	1	

Section B : Atomic World

1. A (26%)	2. D (40%)	3. C (45%)	4. A (33%)
5. B (53%)	6. D (46%)	7. C (49%)	8. B (18%)

Solution	Marks	Remarks
2. (a) (i) As wavelength / frequency / energy of photon remains unchanged, the same maximum kinetic energy KE_{max} for the electrons emitted.	1A	
The range does not depend on the intensity of incident light, i.e. remains unchanged.	1A	
	2	
(ii) Assuming all incident photons cause emission of electrons, maximum no. of electrons emitted in 1 second		
$= \frac{(0.050)(1.00\times10^{-4})}{4.97\times10^{-19}} = 1.00603622 \times 10^{13}$	1M	
$\approx 1.01 \times 10^{13}$	1A	Accept $1.00 \times 10^{13} \sim 1.01 \times 10^{13}$
	2	
(b) $KE_{max} = eV_s$ (or q_eV_s) $1.9 \times 10^{-19} = eV_s$	1M	
$V_s = \frac{1.9\times10^{-19}}{1.60\times10^{-19}}$ $= 1.1875\text{ V} \approx 1.19\text{ V}$	1A	
	2	
(c) Threshold wavelength $\lambda_0 = 6.6 \times 10^{-7}$ m (from graph)	1M	
Work function $= \frac{hc}{\lambda_0} = \frac{(6.63\times10^{-34})(3.00\times10^{8})}{6.6\times10^{-7}}$ $= 3.0136 \times 10^{-19}$ J	1M	
$= \frac{3.0136\times10^{-19}}{1.60\times10^{-19}} = 1.88$ (eV)	1A	Accept 1.87 (eV) ~ 1.93 (eV)
Or Work function $= \frac{hc}{\lambda} - KE_{max}$	1M	
$= \frac{(6.63\times10^{-34})(3.00\times10^{8})}{4\times10^{-7}} - 1.9 \times 10^{-19}$	1M	
$= 1.92$ (eV)	1A	
	3	
(d) decrease	1A	
	1	

Section C : Energy and Use of Energy

1. A (74%)	2. A (26%)	3. D (57%)	4. C (46%)
5. C (29%)	6. D (42%)	7. B (74%)	8. D (82%)

Solution	Marks	Remarks
3. (a) (i) Output power = 38 × 10 = 380 W	1M/1A	
Input power = 1000 × 1.934 = 1934 W		
Efficiency = $\frac{380}{1934} \times 100\%$		
= 19.648397% ≈ 19.6 %	1A	Accept 19.5 % ~ 20 %
	2	
(ii) No. of panels for producing 10 kW		e.c.f. from (a)(i)
= $\frac{10000}{380}$ = 26.315789 ≈ 26	1M/1A	
26 panels can be installed, i.e. minimum area		
= 26 ×1.934 m^2 = 50.284 m^2 ≈ 50.3 m^2	1A	Accept 50.2 m^2 ~ 50.3 m^2
	2	
(b) (i) It converts direct current (DC) to alternating current (AC).	1A	
	1	
(ii) 10 kW × 4.5 h × 365 = 16425 (kW h)	1A	Accept 16200 (kW h) ~ 16500 (kW h)
	1	
(iii) The solar panel is not always facing the sun.	1A	
Or The sunlight may be blocked by nearby objects.	1A	
Or The efficiency of the inverter is not 100%.	1A	
	1	
(iv) 200000 + 5000 × t = 5 × 10000 × t	1M	
t = 4.44 (years)	1A	Accept 4.4 (years) ~ 4.5 (years)
	2	
(c) Solar panels / cells are silent during operation	1A	
Or lower maintenance cost / installation cost	1A	
Or comparatively safer as solar panels do not have movable parts	1A	
	1	

Section D : Medical Physics

1. C (54%)	2. D (71%)	3. B (41%)	4. B (56%)
5. A (55%)	6. A (56%)	7. C (58%)	8. D (46%)

Solution	Marks	Remarks
4. (a) (i) acoustic impedance = density × speed $= 1040 \times 1630$ $= 1.6952 \times 10^6$ kg m^{-2} s^{-1} $\approx 1.70 \times 10^6$ kg m^{-2} s^{-1} (Rayl)	1A	
	1	
(ii) $\frac{\sin\theta_{air}}{\sin\theta_{skin}} = \frac{\text{speed of sound in air}}{\text{speed of sound in skin}} = \frac{340}{1520}$	1M	
$\sin\theta_{skin} = \frac{1520}{340} \times \sin 5° = 0.39$ $\Rightarrow \theta_{skin} = 22.93° \approx 22.9°$	1A	
	2	
(iii) Refraction distortions occur when the ultrasound beam is bent from its original direction as it passes through a boundary between tissues having different sound speeds.	1A	
(One would assume that the beam goes straight in ultrasound scans and does not know that the sound path has been altered due to refraction.) It results in improper positioning and/or brightness of echoes displayed in ultrasound images.	1A	
	2	
(b) (i) Radionuclide image (bone scan) – radioactive γ source (radio-pharmaceutical) is injected to the body and carried to target organs.	1A	
Different concentration of γ source in the body gives different brightness in image.	1A	
Chest X-rays – X-rays are produced by an X-ray tube. When X-rays pass through the body from outside, they are absorbed by different tissues. The different attenuation of X-rays gives different brightness in image.	1A	
	3	
(ii) (Explain in terms of selective uptake of radionuclide and functional information of the organ.) Radio-pharmaceutical targets the bone / organ due to selective uptake as (bone) hot spots.	1A	
Hence bone scan / RNI detects function (or physiology) due to the metabolic uptake of the radio-pharmaceutical rather than anatomy as do X-rays. It helps to locate where the cancer has been spread.	1A	
	2	