Mark Scheme (Results)

Summer 2017

Pearson Edexcel International Advanced Level
in Physics (WPH05)
Paper 01 Physics from Creation to Collapse

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

Quality of Written Communication

Questions which involve the writing of continuous prose will expect candidates to:

- write legibly, with accurate use of spelling, grammar and punctuation in order to make the meaning clear
- select and use a form and style of writing appropriate to purpose and to complex subject matter
- Organise information clearly and coherently, using specialist vocabulary when appropriate.

Full marks will be awarded if the candidate has demonstrated the above abilities.
Questions where QWC is likely to be particularly important are indicated (QWC) in the mark scheme, but this does not preclude others.

Mark scheme notes

Underlying principle

The mark scheme will clearly indicate the concept that is being rewarded, backed up by examples. It is not a set of model answers.

For example:

(iii) Horizontal force of hinge on table top

66.3 (N) or 66 (N) **and** correct indication of direction [no ue] ✓ **1**
[Some examples of direction: acting from right (to left) / to the left / West / opposite direction to horizontal. May show direction by arrow. Do not accept a minus sign in front of number as direction.]

This has a clear statement of the principle for awarding the mark, supported by some examples illustrating acceptable boundaries.

1. Mark scheme format

1.1 You will not see 'wtte' (words to that effect). Alternative correct wording should be credited in every answer unless the ms has specified specific words that must be present. Such words will be indicated by underlining e.g. 'resonance'
1.2 Bold lower case will be used for emphasis.
1.3 Round brackets ( ) indicate words that are not essential e.g. "(hence) distance is increased".
1.4 Square brackets [ ] indicate advice to examiners or examples e.g. [Do not accept gravity] [ecf].

2. Unit error penalties

2.1 A separate mark is not usually given for a unit but a missing or incorrect unit will normally mean that the final calculation mark will not be awarded.
2.2 Incorrect use of case e.g. 'Watt' or 'w' will **not** be penalised.
2.3 There will be no unit penalty applied in 'show that' questions or in any other question where the units to be used have been given, for example in a spreadsheet.
2.4 The same missing or incorrect unit will not be penalised more than once within one question (one clip in epen).
2.5 Occasionally, it may be decided not to penalise a missing or incorrect unit e.g. the candidate may be calculating the gradient of a graph, resulting in a unit that is not one that should be known and is complex.
2.6 The mark scheme will indicate if no unit error penalty is to be applied by means of [no ue].

3. Significant figures

3.1 Use of an inappropriate number of significant figures in the theory papers will normally only be penalised in 'show that' questions where use of too few significant figures has resulted in the candidate not demonstrating the validity of the given answer.
3.2 The use of g = 10 m s^{-2} or 10 N kg^{-1} instead of 9.81 m s^{-2} or 9.81 N kg^{-1} will be penalised by one mark (but not more than once per clip). Accept 9.8 m s^{-2} or 9.8 N kg^{-1}

4. Calculations

4.1 Bald (i.e. no working shown) correct answers score full marks unless in a 'show that' question.

4.2 If a 'show that' question is worth 2 marks then both marks will be available for a reverse working; if it is worth 3 marks then only 2 will be available.

4.3 **use** of the formula means that the candidate demonstrates substitution of physically correct values, although there may be conversion errors e.g. power of 10 error.

4.4 **recall** of the correct formula will be awarded when the formula is seen or implied by substitution.

4.5 The mark scheme will show a correctly worked answer for illustration only.

4.6 Example of mark scheme for a calculation:

<u>'Show that' calculation of weight</u>

Use of L × W × H ✓

Substitution into density equation with a volume and density ✓

Correct answer [49.4 (N)] to at least 3 sig fig. [No ue] ✓
[If 5040 g rounded to 5000 g or 5 kg, do not give 3rd mark; if conversion to kg is omitted and then answer fudged, do not give 3rd mark]
[Bald answer scores 0, reverse calculation 2/3] **3**

Example of answer:

80 cm × 50 cm × 1.8 cm = 7200 cm^3

7200 cm^3 × 0.70 g cm^{-3} = 5040 g

5040 × 10^{-3} kg × 9.81 N/kg

= 49.4 N

5. Quality of Written Communication

5.1 Indicated by QoWC in mark scheme. QWC – Work must be clear and organised in a logical manner using technical wording where appropriate.

5.2 Usually it is part of a max mark, the final mark not being awarded unless the QoWC condition has been satisfied.

6. Graphs

6.1 A mark given for axes requires both axes to be labelled with quantities and units, and drawn the correct way round.

6.2 Sometimes a separate mark will be given for units or for each axis if the units are complex. This will be indicated on the mark scheme.

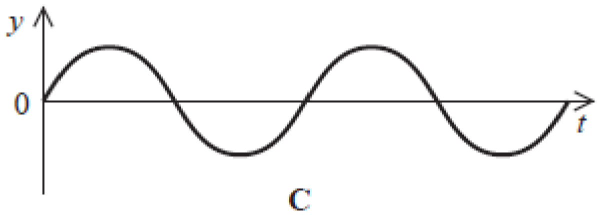
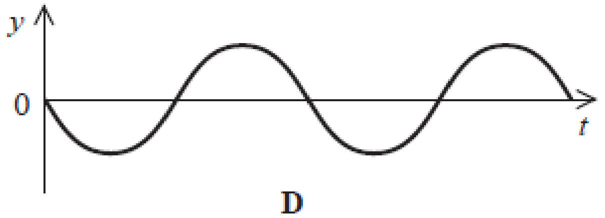
6.3 A mark given for choosing a scale requires that the chosen scale allows all points to be plotted, spreads plotted points over more than half of each axis and is not an awkward scale e.g. multiples of 3, 7 etc.

6.4 Points should be plotted to within 1 mm.

- Check the two points furthest from the best line. If both OK award mark.
- If either is 2 mm out do not award mark.
- If both are 1 mm out do not award mark.
- If either is 1 mm out then check another two and award mark if both of these OK, otherwise no mark.

For a line mark there must be a thin continuous line which is the best-fit line for the candidate's results.

Question Number	Answer	Mark
1	**C luminosity**	**1**
	Incorrect Answers: A – not the definition of a standard candle B – not the definition of a standard candle D – not the definition of a standard candle	
2	**B forced oscillation**	**1**
	Incorrect Answers: A – the table is being forced to oscillate by the phone C – resonance only happens at a particular frequency, the natural frequency of the table. Any oscillation of the table makes the sound louder. D – it is the sound waves set up in the air that makes the sound louder and these are not standing waves	
3	**D which nucleus will decay next**	**1**
	Incorrect Answers: A – the energy released in each decay is known B – this probability is known C – for a particular nuclide the same type of radiation is always emitted	
4	**C** **Molecular kinetic energy: stays constant** **Molecular potential energy: decreases**	**1**
	Incorrect Answers: A – the temperature is constant so molecular kinetic energy does not change B – the temperature is constant so molecular kinetic energy does not change and the wax is solidifying so the molecular potential energy must be decreasing D – the molecular kinetic energy does stay constant but because the wax is solidifying, the molecular potential energy must be decreasing	
5	**B the force is in the opposite direction to the velocity**	**1**
	Incorrect Answers: (all due confusion between the force that causes the damping and the force that causes the oscillation) A – true only some of the time for the damping force. Would be true for the force causing s.h.m. C – true only some of the time for the damping force D – this would increase the amplitude of the oscillation not reduce it as the damping force does.	
6	**A** **Mass: larger** **Temperature: higher**	**1**
	Incorrect Answers: (the top end of the main sequence is at the top left of the graph) B – the temperature scale is a reverse scale so the left hand end of the main sequence is a higher temperature than the Sun which is near the middle C – stars at the top end of the main sequence have larger masses than the Sun D – stars at the top end of the main sequence have larger masses than the Sun and higher temperatures	

7	**C the effect is too small for distant stars**	**1**
	Incorrect Answers: A – for nearby stars the effect is large B – the effect cannot be too large D – the effect decreases as the distance increases	
8	**C very high temperature**	**1**
	Incorrect Answers: (the question is only asking for an essential condition for any nuclei to fuse, not the conditions for sustained fusion) A – only true if sustained fusion is required B – not necessary for a single fusion to take place D – not essential to have either a large mass of fuel or a large mass nucleus.	
9	 **C**	**1**
	Incorrect Answers: (At any instant the velocity is the gradient of the displacement time curve, if velocity is a cosine curve as shown then displacement must be a sine curve) A – The velocity curve is a cosine curve therefore the displacement cannot also be a cosine curve. B – This is a negative cosine curve, the reflection of the velocity curve in the time axis. Displacement is not equal to minus the velocity. D – This is a negative sine curve and does not represent the correct relationship between velocity and displacement.	
10	 **D**	**1**
	Incorrect Answers: (At any instant the acceleration is the gradient of the velocity time curve, if velocity is a cosine curve as shown then acceleration must be a negative sine curve) A – The velocity curve is a cosine curve therefore the acceleration cannot also be a cosine curve. B – This is a negative cosine curve, the reflection of the velocity curve in the time axis. Acceleration is not equal to minus the velocity. C − This is a sine curve and does not represent the correct relationship between velocity and acceleration.	

Question Number	Answer	Mark
11	See $\Delta\lambda = 5$ (nm) (1) Use of $\frac{\Delta\lambda}{\lambda} = \frac{v}{c}$ (1) $v = 2.5 \times 10^6$ m s^{-1} [check that 595 is the denominator for this mark] (1) <u>Example of calculation</u> λ_1 = 595 nm, λ_2 = 590 nm, $\Delta\lambda$ = -5 nm $v = \frac{(-)5\,\text{nm}}{595\,\text{nm}} \times 3 \times 10^8\,\text{m s}^{-1} = 2.52 \times 10^6\,\text{m s}^{-1}$	**3**
	Total for question 11	**3**

Question Number	Answer		Mark
12(a)	Use of $\frac{1}{2}m\langle c^2\rangle = \frac{3}{2}kT$ **Or** $\frac{1}{2}m\langle c^2\rangle = \text{constant}$	(1)	
	$\langle c^2\rangle_X = 5.6\times10^4\,(\text{m}^2\text{s}^{-2})$	(1)	**2**
	[If a reasonable Kelvin temperature is estimated and used in the equation, can score MP1 only] Example of calculation $\frac{\langle c^2\rangle_X}{\langle c^2\rangle_K} = \frac{m_K}{m_X}$ $\langle c^2\rangle_X = \frac{(1.39\times10^{-25}\text{ kg})}{(2.18\times10^{-25}\text{ kg})}\times8.72\times10^4\text{ m}^2\text{s}^{-2} = 5.56\times10^4\text{ m}^2\text{s}^{-2}$		
***12(b)**	(QWC Spelling of technical terms must be correct and the answer must be organised in a logical sequence.)		
	The molecules/atoms move faster **Or** the (average) kinetic energy of molecules/atoms is greater	(1)	
	Collision rate of molecules/atoms with the glass bulb is larger **Or** there are more frequent collisions between the molecules/atoms and the glass bulb	(1)	
	There is more momentum change in each collision **Or** the rate of change of momentum is greater	(1)	**4**
	Therefore there is a larger force on the glass bulb (dependent upon mp2 or mp3)	(1)	
	[No credit for attempt to justify increase in pressure by using $pV = NkT$.] [Accept container/walls for glass bulb.]		
	Total for question 12		**6**

Question Number	Answer		Mark
13(a)(i)	Use of $\omega = \frac{2\pi}{T}$ ω = 8.3 ×10^{-16} (rad s^{-1}) <u>Example of calculation</u> $\omega = \frac{2\pi \text{ rad}}{240 \times 10^6 \times 3.15 \times 10^7 \text{ s}} = 8.31 \times 10^{-16} \text{ rad s}^{-1}$ [If 240 million not shown correctly in substitution and then answer fudged do not give 2nd mark]	(1) (1)	**2**
13(a)(ii)	Equate $F = \frac{GMm}{r^2}$ and $F = mr\omega^2$ Statement that G and M are constant and algebra to give final result <u>Example of calculation</u> $mr\omega^2 = \frac{GMm}{r^2}$ $\therefore\ \omega^2 = \frac{GM}{r^3}$ where G and M are constant $\therefore \omega^2 \propto \frac{1}{r^3}$	(1) (1)	**2**
13(a)(iii)	Use of $\omega^2 \propto \frac{1}{r^3}$ ω = 3.3×10^{-16} rad s^{-1} (allow full ecf for value from (i)) <u>Example of calculation</u> $\frac{\omega_2^{\ 2}}{\omega_1^{\ 2}} \propto \frac{r_1^{\ 3}}{r_2^{\ 3}} \therefore \omega_2 = \omega_1 \times \sqrt{\left(\frac{r_1}{r_2}\right)^3}$ $\therefore \omega_2 = 8.3 \times 10^{-16} \text{ rads}^{-1} \times \sqrt{\left(\frac{27\,000 \text{ ly}}{50\,000 \text{ ly}}\right)^3} = 3.29 \times 10^{-16} \text{ rad s}^{-1}$ [Use of ‘show that’ value gives 3.2 × 10^{-16} rad s^{-1}] [If substitute diameter instead of radius could score MP1 only]	(1) (1)	**2**

Question Number	Answer	Mark
13(b)	There must be dark matter **Or** there must be (additional) matter that cannot be observed **Or** there must be (additional) matter that does not emit em-radiation. (1) Idea that the mass of galaxy is greater than expected **Or** matter must be spread more uniformly through galaxy. (1)	**2**
	Total for question 13	**8**

Question Number	Answer	Mark
14(a)	**EITHER** Acceleration is: (directly) proportional to displacement from the equilibrium position (1) (always) acting towards the equilibrium position **Or** idea that acceleration is in the opposite direction to displacement (1) **OR** Force is: (directly) proportional to displacement from the equilibrium position (1) (always) acting towards the equilibrium position (1) **Or** idea that force is a restoring force e.g. "in the opposite direction" [Accept undisplaced point, fixed point, central point, centre for equilibrium position] [An equation with all symbols defined correctly is a valid response for both marks. e.g $a \propto -x$ or $F \propto -x$]	**2**
14(b)(i)	Mean time period calculated [see 19.07 (s) or working] (1) Use of $f = \frac{1}{T}$ (1) f = 2.62 (Hz) (1) <u>Example of calculation</u> $T = \frac{(18.9 + 19.2 + 19.1)\text{s}}{3 \times 50} = 0.381\text{s}$ $f = \frac{1}{0.381\text{s}} = 2.62\ \text{Hz}$	**3**
14(b)(ii)	Use of $\omega = 2\pi f$ (1) Use of $v = \omega A$ (1) $v = 6.2 \times 10^{-2}$ m s^{-1} (1) (ecf candidate's value of *f* from (i)) <u>Example of calculation</u> $\omega = 2\pi\,\text{rad} \times 2.62\,\text{s}^{-1} = 16.5\,\text{rad}\,\text{s}^{-1}$ $v = 16.5\,\text{rad}\,\text{s}^{-1} \times 0.375 \times 10^{-2}\,\text{m} = 6.17 \times 10^{-2}\,\text{m}\,\text{s}^{-1}$ [Use of 'show that' value gives 6.13×10^{-2} m s^{-1}] [Using *A* = 0.75 cm could score MP1 and MP2]	**3**
	Total for question 14	**8**

Question Number	Answer		Mark
15(a)	Use of $pV = NkT$	(1)	
	Conversion of temperature to kelvin	(1)	
	$N = 3.1 \times 10^{23}$	(1)	**3**
	<u>Example of calculation</u> $N = \frac{pV}{kT} = \frac{1.55 \times 10^5\ \mathrm{N\,m^{-2}} \times 8.18 \times 10^{-3}\ \mathrm{m^3}}{1.38 \times 10^{-23}\ \mathrm{m^2 kg s^{-2} K^{-1}} \times (273 + 20)\mathrm{K}} = 3.14 \times 10^{23}$		

Question Number	Answer		Mark
15(b)(i)	Use of energy conservation [$\Delta E_{\text{grav}} = \Delta E_{\text{k}}$] Use of $\Delta E_{grav} = mg\Delta h$ ΔE_{k} = 2.43 (J) <u>Example of calculation</u> $\Delta E_{\text{grav}} = 0.62\text{kg} \times 9.81\text{m s}^{-2} \times (1.8\text{m} - 1.4\text{m}) = 2.43\text{J}$	(1) (1) (1)	**3**
15(b)(ii)	**EITHER** Use of $\Delta E = mc\Delta\theta$ to find energy for temperature rise of 0.5°C Use of number of drops = $\frac{\Delta E}{\Delta E_{\text{k}}}$ For a rebound to 1.40 m, number of times ball must be dropped = 149 [Accept 150] [Use of 'show that' value gives 151] **Or** For a rebound to 1.60 m, number of times ball must be dropped = 297 [accept 298] **OR** Use of $\Delta E = mc\Delta\theta$ to find $\Delta\theta$ for one drop Use of number of drops = $\frac{0.5}{\Delta\theta}$ For a rebound to 1.40 m, number of times ball must be dropped = 149 [Accept 150] [Use of 'show that' value gives 151] **Or** For a rebound to 1.60 m, number of times ball must be dropped = 297 [accept 298] (ecf candidate's value of ΔE_{k} from (i) used to find minimum number of drops) <u>Example of calculation</u> $\Delta E = 0.62\,\text{kg} \times 1170\,\text{J kg}^{-1}\,\text{K}^{-1} \times 0.5\text{K} = 363\text{J}$ $\text{Number of bounces} = \frac{363\text{J}}{2.43\text{J}} = 149$	(1) (1) (1) (1) (1) (1)	**3**

Question Number	Answer	Mark
15b(iii)	No energy transfer to the surroundings [Accept (1) Ball rebounds to 140 m every time Ball rebounds to 160 m every time Ball rebounds to same height every time No energy lost to surroundings No energy is dissipated] [Accept heat for energy] [Do not accept No heat/energy lost Volume/mass of ball is constant Air behaves as an ideal gas Room temperature is constant No air leaks from the ball]	**1**
	Total for question 15	**10**

Question Number	Answer		Mark
***16(a)**	(QWC Spelling of technical terms must be correct and the answer must be organised in a logical sequence.)		
	α-radiation is very ionising, and so does not penetrate more than a few cm of air (making this radiation unsuitable) **Or** α-radiation is very ionising, and so does not penetrate the packaging (making this radiation unsuitable)	(1)	
	β-radiation is moderately ionising therefore cannot penetrate the metal instruments (so is unsuitable) Or β-radiation is moderately ionising but is stopped by a few mm aluminium/metal (so is unsuitable)	(1)	
	γ-radiation would be the most suitable because it will penetrate even thick lead **Or** γ-radiation would be the most suitable because it will penetrate the packaging and the metallic instruments	(1)	
	γ-radiation is weakly ionising, so we need a strong (enough) source to ensure sterilisation **Or** With γ-radiation most of the radiation passes right through, so good shielding will be needed	(1)	**4**

Question Number	Answer		Mark
16(b)(i)	Use of $\lambda t_{1/2} = \ln 2$	(1)	
	Use of $\frac{\Delta N}{\Delta t} = (-)\lambda N$	(1)	
	$\frac{\Delta N}{\Delta t} = 2.1 \times 10^5$ (Bq)	(1)	**3**
	<u>Example of calculation</u> $\lambda = \frac{\ln 2}{5.27 \times 3.15 \times 10^7 \text{ s}} = 4.18 \times 10^{-9} \text{ s}^{-1}$ $\frac{\Delta N}{\Delta t} = (-)4.18 \times 10^{-9} \text{ s}^{-1} \times 5.02 \times 10^{13} = 2.098 \times 10^5 \text{ s}^{-1}$		
16(b)(ii)	Use of $A = A_0 e^{-\lambda t}$ with λ in either s^{-1} or yr^{-1}	(1)	
	Correct rearrangement using logs	(1)	
	t = 25 (years)	(1)	**3**
	(allow full ecf from (i)) [Use of show that value for A_0 and λ = 4.2×10^{-9} s gives t = 24.3 yr]		
	<u>Example of calculation</u> $8.0 \times 10^3 \text{ Bq} = (2.1 \times 10^5 \text{ Bq}) e^{-4.17 \times 10^{-9} \text{s}^{-1} t}$ $\therefore t = \frac{\ln\left(\frac{8.0 \times 10^3 \text{ Bq}}{2.1 \times 10^5 \text{ Bq}}\right)}{-4.17 \times 10^{-9} \text{ s}^{-1}} = 7.84 \times 10^8 \text{ s}$ $t = 7.84 \times 10^8 \text{ s} / 3.15 \times 10^7 \text{ yr}^{-1} = 24.9$ yr		

Question Number	Answer	Mark
16(c)	**Max 2** The source should be handled with (long) tongs/forceps/tweezers (1) The source should be pointed away from people (1) Idea that exposure time should be minimised (1) The source should be stored in a lead lined box (when not required for the experiment) (1)	**2**
	Total for question 16	**12**

Question Number	Answer		Mark
17(a)(i)	$\text{Am} \rightarrow {}^{237}_{93}\text{Np} + {}^{4}_{2}\alpha$ Top line correct Bottom line correct	(1) (1)	**2**
***17(a)(ii)**	(QWC Spelling of technical terms must be correct and the answer must be organised in a logical sequence.) **Either** The alpha particle has a (much) smaller mass than the Np nucleus. (Hence) in order to conserve momentum the velocity of the α–particle is (much) greater than that of the Np nucleus. As kinetic energy depends upon velocity^2, the alpha particle has a much larger kinetic energy (than the Np nucleus) **Or** The alpha particle has a (much) smaller mass than the Np nucleus. N_p and alpha have equal (magnitude) momenta p $E_k = p^2/2m$ so alpha has much larger KE	(1) (1) (1) (1) (1) (1)	**3**
17(b)	Attempt at mass defect calculation Conversion to kg Use of $\Delta E = c^2 \Delta m$ B.E./nucleon = 1.2×10^{-12} (J) <u>Example of calculation</u> Δm = 241.00471 u –[(95 × 1.00728 u) + (241-95)×1.00866 u] Δm = 241.00471 u – 95.6916 u −147.26436 u = −1.95125 u $\Delta m = 1.95125 \times 1.66 \times 10^{-27}$ kg = 3.24×10^{-27} kg $\Delta E = (3.0 \times 10^8 \text{ m s}^{-1})^2 \times 3.24 \times 10^{-27} \text{ kg} = 2.92 \times 10^{-10} \text{ J}$ B.E./nucleon = $\dfrac{2.92 \times 10^{-10} \text{ J}}{241} = 1.21 \times 10^{-12} \text{ J}$	(1) (1) (1) (1)	**4**

Question Number	Answer	Mark
17(c)	(In fission) the nucleus splits to form less massive fragments (1) [Accept lighter fragments] The binding energy per nucleon increases (1) **Or** The (fission) fragments are higher up the B.E. per nucleon curve The increase in B.E per nucleon is quite small, but the large number of nucleons (in nuclides likely to undergo fission) means that the overall energy release is very large (1) [Accept only about 1 MeV per nucleon for ‘quite small’ and >200 MeV for ‘very large’)	**3**
	Total for question 17	**12**

Question Number	Answer		Mark
18(a)(i)	L/A = 70 (MW m^{-2}) [read from graph, allow 65 → 70] Use of $A = 4\pi r^2$ $L = 4.3 \times 10^{26}$ (W) [$3.96 \times 10^{26} \rightarrow 4.30 \times 10^{26}$] [Use of the Stefan Boltzmann equation could score MP2 and MP3 only] <u>Example of calculation</u> $L = 70\times10^{6}\ \mathrm{W\,m^{-2}} \times 4\pi \times \left(6.96\times10^{8}\ \mathrm{m}\right)^{2} = 4.26\times10^{26}\ \mathrm{W}$	(1) (1) (1)	**3**
18(a)(ii)	Use of $F = \dfrac{L}{4\pi d^2}$ F = 1.5×10^3 W m^{-2} (allow full ecf from (i)) [using the 'show that' value gives F = 1.4×10^3 W m^{-2}] <u>Example of calculation</u> $F = \dfrac{4.26\times10^{26}\ \mathrm{W}}{4\pi\left(1.50\times10^{11}\ \mathrm{m}\right)^{2}} = 1506\ \mathrm{W\,m^{-2}}$	(1) (1)	**2**
18(a)(iii)	Only half/part of the Earth is illuminated by the Sun at any one time The idea that the calculated value of F is for radiation meeting the atmosphere at 90°, which is only true one place (the value is less at all other positions).	(1) (1)	**2**

Question Number	Answer		Mark
18(b)(i)	Use of $\lambda_{max}T = 2.898 \times 10^{-3}$	(1)	
	$\lambda_{max} = 4.9 \times 10^{-7}$ (m)	(1)	**2**
	Example of calculation: $\lambda_{max} = \dfrac{2.898 \times 10^{-3}\ \text{mK}}{5900\ \text{K}} = 4.91 \times 10^{-7}\ \text{m}$		
18b(ii)	5×10^{-7} m is approximately the middle of the (visible) wavelength range	(1)	
	(So) all the (visible) wavelengths are included, producing white light [accept colours/frequencies for 'wavelengths']	(1)	**2**
	Total for question 18		**11**

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