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Mark Scheme (Results)

October 2019

Pearson 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.

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) <u>Horizontal force of hinge on table top</u>

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 sugn in front of number as direction.]

This has a clear statement of the principle of 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 the specific words that must be present. Such words will be indicated by underlining, e.g. <u>'resonance'</u>.

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 advise to examiners or examples, e.g. [Do not accept gravity] [ecf].

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2. Unit error penalties

2.1 A separate mark is not usually given for a unit but a missing or incorrect unit will normally cause the final calculation mark to be lost.

2.2 Incorrect use of case, e.g. 'Watt' or 'w' will not be penalised.

2.3 There will be no unit error penalty applied in 'show that' questions or in any other question where the units to be used have been given.

2.4 The same missing or incorrect unit will not be penalised more than once within a question.

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

Use of an inappropriate numberof 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.

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 candidates demonstrates subsistution 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 the 3rd mark; if conversion to kg is omitted then the answer is fudged, do not give 3rd mark.]

[Bald answer scores 0, reverse calculation 2/3]

Example of calculation:

V = 80 cm × 50 cm × 1.8 cm = 7200 cm^3

m = 7200 cm^3 × 0.70 g cm^{-3} = 5040 g

F = 5040 × 10^{-3} kg × 9.81 N/kg = 49.4 N

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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 the max mark.

6. Graphs

6.1 A mark 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 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 are OK, otherwise no mark.

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

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Question Number	Answer	Mark
1	**The only correct answer is D** ***A*** *is not correct because the size of the universe is not related to* H_0 ***B*** *is not correct because the size of the universe is not related to* H_0 ***C*** *is not correct because the age of the universe is equal to* $1/H_0$	**(1)**

Question Number	Answer	Mark
2	**The only correct answer is C** ***A*** *is not correct because the interior temperature of a star is not moderate* ***B*** *is not correct because the interior density of a star is not moderate* ***D*** *is not correct because neither density nor temperature is moderate*	**(1)**

Question Number	Answer	Mark
3	**The only correct answer is C** ***A*** *is not correct because the wavelength must be less than 780 nm* ***B*** *is not correct because the wavelength must be less than 780 nm* ***D*** *is not correct because the speed of light and the velocity of approach are wrongly substituted*	**(1)**

Question Number	Answer	Mark
4	**The only correct answer is B** ***A*** *is not correct because background count affects the accuracy* ***C*** *is not correct because increasing the distance reduces the count rate* ***D*** *is not correct because background count affects the accuracy*	**(1)**

Question Number	Answer	Mark
5	**The only correct answer is C** ***A*** *is not correct because the maximum velocity is given by* ωA ***B*** *is not correct because the maximum velocity is given by* ωA ***D*** *is not correct because the maximum velocity is given by* ωA	**(1)**

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Question Number	Answer	Mark
6	**The only correct answer is B** ***A*** *is not correct because maximum velocity increases as Aincreases* ***C*** *is not correct because maximum velocity increases as Aincreases* ***D*** *is not correct because maximum velocity increases as A increases*	**(1)**

Question Number	Answer	Mark
7	**The only correct answer is C** ***A*** *is not correct because (internal energy)* $\propto$ *(absolute temperature)* ***B*** *is not correct because (internal energy)* $\propto$ *(mean molecular KE)* ***D*** *is not correct because* $\langle c^2 \rangle \propto$ *(mean molecular KE)*	**(1)**

Question Number	Answer	Mark
8	**The only correct answer is A** ***B*** *is not correct because* $p \propto T/V$ ***C*** *is not correct because* $p \propto T/V$ ***D*** *is not correct because* $p \propto T/V$	**(1)**

Question Number	Answer	Mark
9	**The only correct answer is A** ***B*** *is not correct because* $F \propto L/d^2$ ***C*** *is not correct because* $F \propto L/d^2$ ***D*** *is not correct because* $F \propto L/d^2$	**(1)**

Question Number	Answer	Mark
10	**The only correct answer is B** ***A*** *is not correct because a should be a maximum when v is zero* ***C*** *is not correct because a should be a maximum when v is zero* ***D*** *is not correct because a should be negative for the first quarter cycle*	**(1)**

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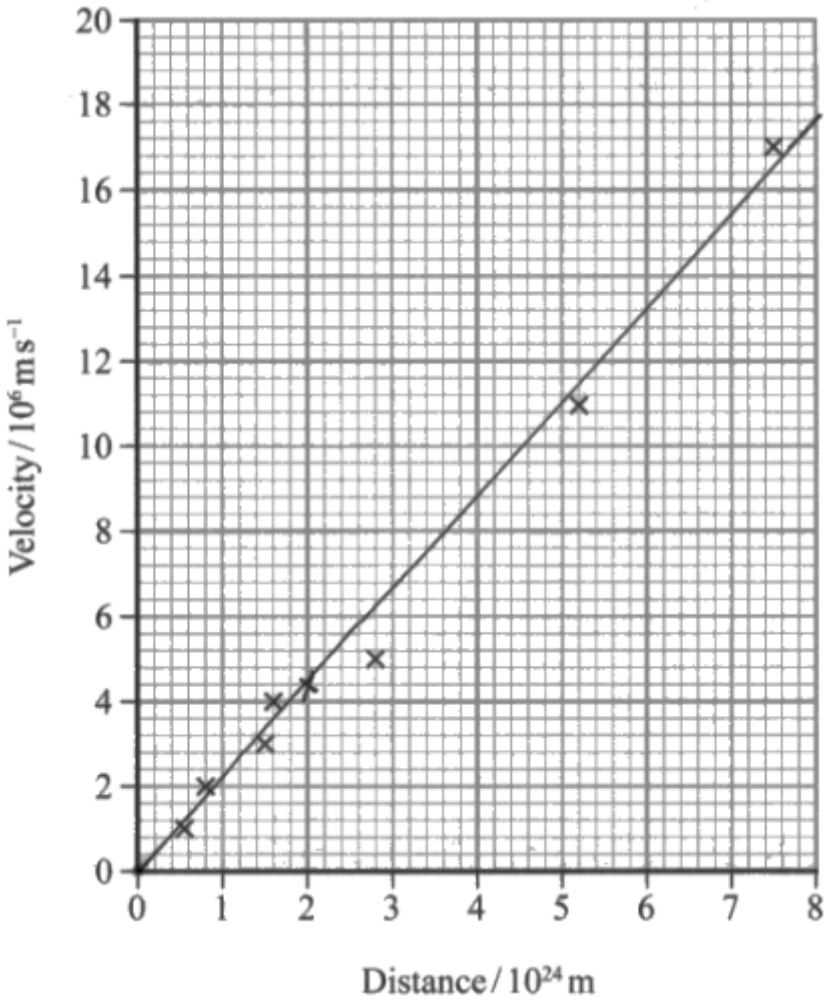
Question Number	Answer	Mark
11	Line of best fit drawn **(1)** Gradient calculated **(1)** (Gradient = H_0) so age of universe = 1 / gradient **Or** Use of $\text{time} = \frac{\text{distance}}{\text{velocity}}$ **(1)** Age of universe = 4.5×10^{17} (s) → 4.7×10^{17} (s) **(1)** **Max 3 marks if final answer is correct, but no best fit line drawn** <u>Example of calculation</u>  H_0 = gradient = $\frac{(17.6 \times 10^6 - 0) \text{ m s}^{-1}}{(8 \times 10^{24} - 0) \text{ m}} = 2.20 \times 10^{-18} \text{ s}^{-1}$ $t = \frac{1}{H_0} = \frac{1}{2.20 \times 10^{-18} \text{ s}^{-1}} = 4.545 \times 10^{17} \text{s}$	**4**
	Total for Question 11	**4**

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Question Number	Answer		Mark
12a	The internal energy increases (Molecular) kinetic energy stays constant, but potential energy increases	**(1)** **(1)**	**2**
12b	Use of $\Delta E = mc\Delta\theta$ Energy transferred from coffee = Energy transferred to milk Mass of milk = 0.11 kg [110 g] <u>Example of calculation</u> $m_{\text{milk}}c_{\text{milk}}\Delta\theta_{milk} = m_{\text{coffee}}c_{\text{coffee}}\Delta\theta_{\text{coffee}}$ $m_{\text{milk}} = \frac{45\times10^{-3}\text{ kg} \times 4200\text{ J kg}^{-1}\text{K}^{-1}\times (73.5\text{-}65.5)\text{ K}}{3900\text{ J kg}^{-1}\text{K}^{-1}\times (65.5\text{-}62.0)\text{K}}$ $= 0.111\text{ kg}$	**(1)** **(1)** **(1)**	**3**
	Total for Question 12		**5**

Question Number	Answer		Mark
13a	Use of $\lambda_{\text{max}}T = 2.898 \times 10^{-3}$ m K $\lambda_{\text{max}} = 9.4 \times 10^{-6}$ m <u>Example of calculation</u> $\lambda_{\text{max}} = \frac{2.898\times10^{-3}\text{m K}}{307\text{ K}} = 9.44 \times 10^{-6}\text{m}$	**(1)** **(1)**	**2**
13b	Use of $P = \sigma AT^4$ $P = 600\ W$ <u>Example of calculation</u> $P = \sigma AT_{\text{body}}^4$ $\therefore P = 5.67 \times 10^{-8}\text{ W m}^{-2}\text{ K}^{-4} \times 1.2\text{ m}^2(307\text{ K})^4$ $\therefore P = 604\text{W}$	**(1)** **(1)**	**2**
13c	(The infra-red image shows that) the man's skin temperature varies over his body (and so the temperature is an estimate) **Or** some parts of the body radiate at a higher rate than others The man absorbs thermal energy from the surroundings **Or s**ome emitted radiation would be reabsorbed **Or t**he surface area of man has been estimated	**(1)** **(1)**	**2**
	Total for Question 13		**6**

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Question Number	Answer		Mark
14a	Use of $F = \frac{GMm}{r^2}$ with $F = m\omega^2 r$	**(1)**	
	Use of $\omega = \frac{2\pi}{T}$	**(1)**	
	$r = 5.8 \times 10^{10}$ m	**(1)**	
	OR		
	Use of $F = \frac{GMm}{r^2}$ with $F = \frac{mv^2}{r}$	**(1)**	
	Use of $v = \frac{2\pi r}{T}$	**(1)**	
	$r = 5.8 \times 10^{10}$ m	**(1)**	**3**
	Example of calculation $\omega = \frac{2\pi \text{ rad}}{7.60 \times 10^6 \text{ s}} = 8.27 \times 10^{-7} \text{rad s}^{-1}$ $\frac{GMm}{r^2} = m\omega^2 r$ $\therefore r = \sqrt[3]{\frac{GM}{\omega^2}} = \sqrt[3]{\frac{6.67 \times 10^{-11} \text{N m}^2 \text{ kg}^{-2} \times 1.99 \times 10^{30} \text{ kg}}{(8.27 \times 10^{-7} \text{ s}^{-1})^2}}$ $\therefore r = 5.79 \times 10^{10}$ m		
14bi	Use of $F = \frac{GMm}{R^2}$ with $F = mg$	**(1)**	
	Algebra to show $g = \frac{GM}{R^2}$	**(1)**	**2**
	(Ignore use of r instead of R and use of m_1 and m_2)		
14bii	Use of $g = \frac{GM}{r^2}$	**(1)**	
	$g = 3.7$ N kg^{-1}	**(1)**	**2**
	(accept m s^{-2})		
	Example of calculation $g = \frac{6.67 \times 10^{-11} \text{N m}^{-2} \text{ kg}^{-2} \times 3.30 \times 10^{23} \text{kg}}{(2.44 \times 10^6 \text{ m})^2} = 3.70 \text{ N kg}^{-1}$		
	Total for Question 14		**7**

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Question Number	Answer		Mark
***15a**	**(QWC Spelling of technical terms must be correct and the answer must be organised in a logical sequence.)** One star changes its position (over the six-month period) This star is (much) closer to the Earth than the other stars The other stars stay in the same position as they are distant Changes in (relative) position are due to (stellar) parallax **Or** as the Earth moves around the Sun the relative position of stars changes	**(1)** **(1)** **(1)** **(1)**	**4**
15b	A standard candle is a (stellar) object of known luminosity (L) (accept locate an object of known luminosity) The (radiation) flux (F) of the candle/star is measured (at the Earth) $F = \frac{L}{4\pi d^2}$ is used to calculate the distance d (to the standard candle) (symbols must be defined) **Or** the inverse square law is used to calculate the distance (to the standard candle)	**(1)** **(1)** **(1)**	**3**
	Total for Question 15		**7**

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Question Number	Answer		Mark
16a	(For simple harmonic motion the) acceleration is: • (directly) proportional to displacement from equilibrium position • acceleration is in the opposite direction to displacement **Or** (always) acting towards the equilibrium position **OR** (For simple harmonic motion the resultant) force is: • (directly) proportional to displacement from equilibrium position • force is in the opposite direction to displacement **Or** (always) acting towards the equilibrium position (An equation with symbols defined correctly is a valid response for both marks For equilibrium position accept: undisplaced point/position **or** fixed point/position **or** central point/position)	**(1)** **(1)** **(1)** **(1)**	**2**
16b	Calculation of f or T [may be a substitution in calculation for ω] Use of $a_{max} = A\omega^2$ with $\omega = 2\pi f$ **or** $\omega = 2\pi/T$ a_{max} = 6100 m s^{-2} Example of calculation f = 1600 /5 s = 320 Hz $a_{max} = (2\pi \times 320\ s^{-1})^2 \times 1.5 \times 10^{-3} m = 6060\ m\ s^{-2}$	**(1)** **(1)** **(1)**	**3**
16c	The mechanism forces the table into oscillation Energy is transferred from the table top to the surrounding air [accept resonance occurs] A larger volume of air is set into oscillation (than that from just the mechanism, hence the sound is louder) (accept "more air" for "larger volume of air")	**(1)** **(1)** **(1)**	**3**
	Total for Question 16		**8**

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Question Number	Answer		Mark
*17a	**(QWC Spelling of technical terms must be correct and the answer must be organised in a logical sequence.)** Stars begin their life on the main sequence and evolve into red giant stars	**(1)**	**5**
	Red giant stars then evolve into white dwarf stars	**(1)**	
	So, if the stars are mainly on the main sequence, as in Y, the star cluster is young	**(1)**	
	If there are red giant stars, as in Z, the star cluster is older **Or** If there are stars in the top right of the diagram, as in Z, the star cluster is older	**(1)**	
	(accept above (and to the right of) the main sequence or annotation on diagram)		
	If there are white dwarf stars, as in X, the star cluster is the oldest **Or** If there are stars in the bottom left of the diagram, as in X, the star cluster is the oldest	**(1)**	
	(accept below (and to the left of) the main sequence or annotation on diagram)		
	If no other marks scored, award 1 mark maximum for a correct time sequence.		
17b	The luminosity (*L)* of a star is given by $L = \sigma 4\pi r^2 T^4$ **Or** the luminosity (*L)* of a star is given by $L = \sigma A T^4$	**(1)**	**3**
	For stars with the same luminosity: r^2T^4 is constant **Or** AT^4 is constant	**(1)**	
	T is greater for Rigel A, (so) *r* / *A* / Rigel A must be smaller	**(1)**	
	(accept correct converse statement)		
	OR		
	As Rigel A is hotter, it radiates more power per unit area	**(1)**	
	Same luminosity means same total power emitted	**(1)**	
	Rigel A has a smaller area, or is smaller	**(1)**	
	(MP3 dependent upon a correct reference to temperature)		

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Question Number	Answer	Mark
18ai	Use of $pV = NkT$ **(1)** Conversion of temperature to kelvin **(1)** $p = 3.85 \times 10^6$ (Pa) **(1)** (a reverse calculation leading to a value of *N*, *V* or *T* given in the question scores a max 2) <u>Example of calculation</u> $p = \frac{6.85 \times 10^{22} \times 1.38 \times 10^{-23}\ \text{J K}^{-1} (22+273)\ \text{K}}{7.25 \times 10^{-5}\ \text{m}^3} = 3.85 \times 10^6\ \text{Pa}$	**3**
18aii	Use of $pV = NkT$ **(1)** $\frac{N_{\text{tyre}}}{N_{\text{cylinder}}} = 2.8$ (hence 3 cylinders would be required) **(1)** (a reverse calculation can score both marks) <u>Example of calculation</u> $N = \frac{pV}{kT} = \frac{6.55 \times 10^5\ \text{Pa} \times 1.17 \times 10^{-3}\ \text{m}^3}{1.38 \times 10^{-23}\ \text{J K}^{-1} \times (22+273)\ \text{K}} = 1.88 \times 10^{23}$ $\frac{N_{\text{tyre}}}{N_{\text{cylinder}}} = \frac{1.88 \times 10^{23}}{6.85 \times 10^{22}} = 2.75$	**2**
18aiii	Not all the gas molecules will leave the cylinder **Or** Some gas escapes when filling the tyre **Or** Some gas escapes from the tyre **Or** Gas is not ideal **Or** Temperature may be less than 22 °C **(1)**	**1**
18b	Pressure is proportional to number of molecules **(1)** [Accept $p \propto N$] (The larger) nitrogen molecules escape at a lower rate (iso pressure falls more slowly) **(1)**	**2**
	Total for Question 18	**8**

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Question Number	Answer	Mark
19ai	$^{31}_{15}\mathrm{P} + {}^{2}_{1}\mathrm{H} \rightarrow {}^{32}_{15}\mathrm{P} + {}^{1}_{1}\mathrm{X}$ **(1)**	**1**
19aii	X is a proton / p **(1)** (accept (nucleus of) hydrogen)	**1**
19aiii	Attempt at mass difference calculation **(1)** Mass conversion to kg **(1)** Use of $\Delta E = c^2 \Delta m$ **(1)** $\Delta E = 1.0 \times 10^{-12}$ (J) **(1)** <u>Example of calculation</u> Δm= (30.973762 u + 2.014102 u) - (31.973907 u + 1.007276 u) $= 6.681 \times 10^{-3}$u $\therefore \Delta m = 6.681 \times 10^{-3} \times 1.66 \times 10^{-27}\text{kg} = 1.11 \times 10^{-29}\text{kg}$ $\therefore \Delta E = \left(3.0 \times 10^{8}\ \text{m s}^{-1}\right)^2 \times 1.11 \times 10^{-29}\ \text{kg} = 9.98 \times 10^{-13}\ \text{J}$	**4**
19bi	Count rate levels at an absorber density thickness of 390 mg cm^{-2} **(1)** Use of absorber density thickness = density × absorber thickness **(1)** Thickness of aluminium sheet = 1.4 mm [0.14 cm] **(1)** (credit 1.5 mm if absorber density thickness 400 mg cm^{-2} used) <u>Example of calculation:</u> 390 mg cm^{-2} = 2700 mg cm^{-3} × absorber thickness $\therefore \text{absorber thickness} = \frac{390\ \text{mg cm}^{-2}}{2700\ \text{mg cm}^{-3}} = 0.144\ \text{cm}$	**3**
19bii	The source emits gamma radiation (as well as beta radiation) **Or** The count rate has not been corrected for background count **Or** There is background radiation (contributing to the count) **(1)**	**1**
19biii	Keep source away from body e.g. handle the source with (long) tongs **(1)** Intensity of radiation decreases with distance **(1)** **OR** Use source for as short a time a possible **(1)** As the ionising effect is cumulative **(1)**	**2**

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19ci	Use of $\lambda t_{1/2} = \ln 2$ **(1)** Use of $\frac{dN}{dt} = -\lambda N$ **(1)** $\frac{dN}{dt} = (-)\ 7.4 \times 10^4$ Bq **(1)** Example of calculation $\lambda = \frac{0.693}{14.3 \times 86400\ \text{s}} = 5.61 \times 10^{-7}\text{s}^{-1}$ $\frac{dN}{dt} = 5.61 \times 10^{-7}\ \text{s}^{-1} \times 1.32 \times 10^{11} = 7.40 \times 10^4$ Bq	**3**
19cii	Use of $N = N_o e^{-\lambda t}$ **(1)** $\frac{dN}{dt} = 7.1 \times 10^4$ Bq (ecf from 19ci) **(1)** Example of calculation $N = N_o e^{-\lambda t}$ $\frac{dN}{dt} = 7.40 \times 10^4\ \text{Bq} \times e^{-5.61 \times 10^{-7}\ s^{-1} \times 86400\ \text{s}} = 7.06 \times 10^4$ Bq	**2**
	Total for Question 19	**17**

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