Pearson

Mark Scheme (Results)

January 2018

Pearson Edexcel
International Adavanced 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) Horizontal force of hinge on table top

66.3 (N) or 66 (N) and correct indication of direction [no ue] [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.]	✓	1

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

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	**The only correct answer is D** ***A*** *is not correct, as deep space is at a temperature of about 3 K.* ***B*** *is not correct, as water becomes ice at about 273 K.* ***C*** *is not correct, as we have not yet reached absolute zero in the laboratory.*	**(1)**
2	**The only correct answer is B** ***A*** *is not correct, as the mass of an oxygen molecule is greater than that of a nitrogen molecule.* ***C*** *is not correct, as on average all the molecules have the same kinetic energy.* ***D*** *is not correct, as on average the speed of the nitrogen molecules is greater than the speed of the oxygen molecules.*	**(1)**
3	**The only correct answer is D** ***A*** *is not correct, as the inverse ratio has been calculated.* ***B*** *is not correct as the inverse ratio has been calculated but the amplitude ratio hasn't been squared.* ***C*** *is not correct, as the amplitude ratio hasn't been squared*	**(1)**
4	**The only correct answer is B** ***A*** *is incorrect, as this uses* $\frac{m_{brass}}{m_{gold}}$ *in the calculation.* ***C*** *is incorrect, as this calculates* $\frac{\Delta\theta_{gold}}{\Delta\theta_{brass}}$. ***D*** *is correct, as this uses* $\frac{c_{brass}}{c_{gold}}$ *in the calculation.*	**(1)**
5	**The only correct answer is C** ***A*** *is incorrect, as the rate of decay decreases as the number of unstable nuclei decreases.* ***B*** *is incorrect, as in addition to the rate of decay decreasing as the number of unstable nuclei decreases, it also decreases as the half-life increases.* ***D*** *is incorrect, as although the rate of decay increases as the number of unstable nuclei increases, it also decreases as the half-life increases.*	**(1)**

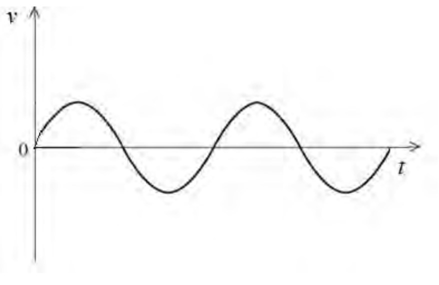
6	**The only correct answer is C** ***A*** *is incorrect, as radiation flux decreases with distance from the source and Q is further away than P.* ***B*** *is incorrect as radiation flux decreases with distance from the source and Q is further away than P* ***D*** *is incorrect as, the parallax angle for P is greater than that for Q and so P is closer than Q*	**(1)**
7	**The only correct answer is B** ***A*** *is incorrect, as X has a smaller amplitude than Y.* ***C*** *is incorrect, as Z has a smaller amplitude than Y.* ***D*** *is incorrect, as X and Z have a smaller amplitude than Y.*	**(1)**
8	**The only correct answer is D** ***A*** *is incorrect, as the cosmic background radiation suggests the Big Bang.* ***B*** *is incorrect, as the gravitational constant determines the strength of the gravitational interaction between two masses.* ***C*** *is incorrect, as a Hertzsprung-Russell diagram shows the way in which luminosity depends upon temperature for a range of stars.*	**(1)**
9	**The only correct answer is D** ***A*** *is incorrect, as the temperature scale is increasing from X to Y.* ***B*** *is incorrect, as the temperature scale is increasing from X to Y.* ***C*** *is incorrect, as although the temperature scale is linear and not logarithmic.*	**(1)**
10	**The only correct answer is B** ***A*** *is incorrect, as elastic deformation returns energy to the building* ***C*** *is incorrect, as stiffness is unrelated to energy dissipation.* ***D*** *is incorrect, as strength is unrelated to energy dissipation.*	**(1)**
	Total for multiple choice questions	**10**

Question Number	Answer		Mark
11	Use of $\frac{\Delta\lambda}{\lambda} = \frac{v}{c}$ At a speed of 1.3×10^{7} m s^{-1} Receding from Earth <u>Example of calculation</u> $v = \frac{\Delta\lambda}{\lambda} \times c = \frac{(507\text{-}486)\ \text{nm}}{486\ \text{nm}} \times 3.0\times10^{8}\ \text{m s}^{-1} = 1.30\times10^{7}\ \text{m s}^{-1}$	**(1)** **(1)** **(1)**	**3**
	Total for question 11		**3**

Question Number	Answer		Mark
12(a)	Use of $pV = NkT$ Conversion of **both** temperatures to kelvin $V = 5.7 \times 10^{-7}$ m^3 <u>Example of calculation</u> $\frac{p_1V_1}{T_1} = \frac{p_2V_2}{T_2}$ $\therefore V_2 = \frac{p_1T_2}{p_2T_1} \times V_1$ $\therefore V_2 = \frac{8.55\times10^{5}\ \text{Pa} \times (273+20)\ \text{K}}{1.02\times10^{5}\ \text{Pa} \times (273+5)\ \text{K}} \times 6.5 \times 10^{-8}\ \text{m}^3 = 5.74 \times 10^{-7}\ \text{m}^3$	**(1)** **(1)** **(1)**	**3**
12(b)	**EITHER** Bubble is **not** in thermal equilibrium with surroundings (due to rising quickly) **Or** temperature of bubble is **not** equal to the temperature of sea The final temperature is less than 20 ^{0}C **Or** the initial temperature is greater than 5 ^{0}C **OR** Some air dissolves in the water So N reduces [do not credit “air is assumed to be an ideal gas”, or “energy is transferred to surroundings”]	**(1)** **(1)** **(1)** **(1)**	**2**
	Total for question 12		**5**

Question Number	Answer		Mark
***13(a)**	(QWC Spelling of technical terms must be correct and the answer must be organised in a logical sequence.) Extremely high temperature (plasma) is required to give the nuclei enough energy for the electrostatic forces to be overcome. Need a large (plasma) density so that there is a high collision rate. If the plasma/nuclei should touch the container the temperature would drop (and fusion cease) So very strong magnetic fields are needed (dependent upon MP2 or MP3)	 **(1)** **(1)** **(1)** **(1)**	**4**
13(b)(i)	In the fusion process of low mass nuclei the mass per nucleon decreases The mass decrease (Δm) corresponds to an energy release (ΔE) according to $\Delta E = c^2 \Delta m$	**(1)** **(1)**	**2**
13(b)(ii)	Fe is the lowest point of the graph **Or** Fe has the smallest mass per nucleon So fusion of nuclei more massive than Fe will require energy input **Or** only elements with smaller nucleon number than Fe are suitable for fusion	**(1)** **(1)**	**2**
	Total for question 13		**8**

Question Number	Answer		Mark
14(a)	A standard candle is a (stellar) object of known luminosity	**(1)**	**1**
14(b)(i)	Log $\left(\frac{L}{L_{\text{Sun}}}\right)$ read from graph [2.8 → 2.85] Evidence of antilog being taken $L = 2.4 \times 10^{29}$ (W) [allow answers up to 2.75×10^{29}] Example of calculation $Log\left(\frac{L}{L_{\text{Sun}}}\right) = 2.8$ $\left(\frac{L}{L_{\text{Sun}}}\right) = 10^{2.8} = 631$ $\therefore L = 631 \times 3.85 \times 10^{26}\ \text{W} = 2.43 \times 10^{29}\ \text{W}$	**(1)** **(1)** **(1)**	**3**
14(b)(ii)	Use of $F = \frac{L}{4\pi d^2}$ $d = 2.4 \times 10^{22}$ m (full ecf from (i)) Example of calculation $d^2 = \frac{L}{4\pi F}$ $\therefore d = \sqrt{\frac{2.43 \times 10^{29}\ \text{W}}{4\pi \times 3.36 \times 10^{-17}\text{W m}^{-2}}} = 2.40 \times 10^{22}\ \text{m}$	**(1)** **(1)**	**2**
***14(c)**	(QWC Spelling of technical terms must be correct and the answer must be organised in a logical sequence.) The frequency /wavelength of a line in the spectrum emitted by the distant galaxy must be measured Determine the difference between this frequency/wavelength and the same line in a lab source The Doppler equation is used to determine the velocity of the galaxy (relative to the Earth) Hubble's law is used to determine the distance (of the galaxy from the Earth)	 **(1)** **(1)** **(1)** **(1)**	**4**
	Total for question 14		**10**

Question Number	Answer		Mark
15(a)	(For simple harmonic motion the) acceleration is: • (directly) proportional to displacement from equilibrium position • (always) acting towards the equilibrium position **Or** idea that acceleration is in the opposite direction to displacement **Or** (For simple harmonic motion the resultant) force is: • (directly) proportional to displacement from equilibrium position • (always) acting towards the equilibrium position **Or** idea that force is a restoring force e.g. "in the opposite direction" [accept towards undisplaced point/fixed point/central point for equilibrium position] [An equation with symbols including the minus sign defined correctly a valid response for both marks. e.g $a \propto -x$ or $F \propto -x$]	**(1)** **(1)** **(1)** **(1)**	**2**
15(b)(i)	Use of $\omega = \frac{2\pi}{T}$ $\omega = 0.85$ (rad s^{-1}) <u>Example of calculation</u> $\omega = \frac{2\pi}{T} = \frac{2\pi}{7.4\text{ s}} = 0.849\text{ rad s}^{-1}$	**(1)** **(1)**	**2**
15(b)(ii)	Use of $v = \omega A$ $v = 0.19$ m s^{-1} (full ecf from (i)) [Use of A = 11 cm gets MP1 only; use of "show that" value gives 0.176 m s^{-1}] <u>Example of calculation</u> $v = 0.85\text{ s}^{-1} \times 0.22\text{ m} = 0.187\text{ m s}^{-1}$	**(1)** **(1)**	**2**
15(b)(iii)	 Sine graph with constant amplitude Same period as displacement curve (dependent upon MP1) [For a minus sine graph with constant amplitude award MP1 only]	**(1)** **(1)**	
	Total for question 15		**8**

Question Number	Answer		Mark
16(a)	A star that is fusing hydrogen in its core (Accept "burning" for "fusing)	**(1)**	**1**
16(b)	These stars have a small/smaller surface area (and so are dwarf stars) [accept radius instead of surface area] They have a very high temperature and emit all visible wavelengths (so they appear white) [accept "are very hot" for "very high temperature"]	**(1)** **(1)**	**2**
16(c)	Sirius B has already evolved/changed from a main sequence star (to a red giant and to a white dwarf) So Sirius B had a shorter (main sequence) lifetime Therefore Sirius B must have used its hydrogen fuel more quickly **Or** Sirius B must have had a larger rate of fusion Hence there was a higher temperature and a greater density/pressure within Sirius B This implies much greater gravitational forces within the star (meaning a larger initial mass).	**(1)** **(1)** **(1)** **(1)** **(1)**	**5**
	Total for question 16		**8**

Question Number	Answer		Mark
17(a)	Use of $F = \frac{GMm}{r^2}$ **and** $F = m\omega^2 r$	**(1)**	
	[This mark may be awarded by seeing the two expressions equated]		
	Use of $\omega = \frac{2\pi}{T}$	**(1)**	
	$r = 1.7 \times 10^9$ m	**(1)**	
	Or		
	Use of $F = \frac{GMm}{r^2}$ **and** $F = \frac{mv^2}{r}$	**(1)**	
	[This mark may be awarded by seeing the two expressions equated]		
	Use of $v = \frac{2\pi r}{T}$	**(1)**	
	$r = 1.7 \times 10^9$ m	**(1)**	**3**
	<u>Example of calculation</u>		
	$\omega = \frac{2\pi}{T} = \frac{2\pi}{14 \times 86400\ \text{s}} = 5.19 \times 10^{-6}\ \text{rad s}^{-1}$		
	$\frac{GMm}{r^2} = m\omega^2 r$		
	$\therefore r = \sqrt[3]{\frac{6.67 \times 10^{-11}\ \text{N m}^2\ \text{kg}^{-2} \times 1.9 \times 10^{27}\ \text{kg}}{(5.2 \times 10^{-6}\ s^{-1})^2}} = 1.67 \times 10^9$ m		
17(b)(i)	$g_S = \frac{GM_S}{R^2}$	**(1)**	
	$g_J = -\frac{GM_J}{r^2}$	**(1)**	**2**
	[for MP2 g_J must be opposite sign to g_S]		

17(b)(ii)	g_J equated to g_S **Or** substitution into $\frac{R}{r} = \sqrt{\frac{M_S}{M_J}}$ $\frac{R}{r} = 32$ Example of calculation $\frac{g_J}{g_S} = \frac{\frac{GM_J}{r^2}}{\frac{GM_S}{R^2}} = \frac{M_J}{M_S} \times \frac{R^2}{r^2}$ $\frac{R}{r} = \sqrt{\frac{M_S}{M_J}} = \sqrt{\frac{2.0\times10^{30}kg}{1.9\times10^{27}kg}} = 32.4$	**(1)** **(1)**	**2**
17(b)(iii)	Use of candidate's ratio from (ii) $r = 2.3 \times 10^{10}$ m (ecf ratio from (ii)) Example of calculation $R + r = 7.8 \times 10^{11}$ m $32.4\, r + r = 7.8 \times 10^{11}$ m $r = 2.34 \times 10^{10}$ m	**(1)** **(1)**	**2**
17(c)	Use of $\lambda_{\max}T = 2.898 \times 10^{-3}$ $\lambda_{\max} = 2.9 \times 10^{-6}$ (m) This is in the infra-red region of the spectrum (Mark dependent upon an attempt at a calculation using Wien's law) Example of calculation $\lambda_{\max} = \frac{2.898\times10^{-3}\text{m K}}{(725 + 273)\text{ K}} = 2.90 \times10^{-6}$ m	**(1)** **(1)** **(1)**	**3**
	Total for question 17		**12**

Question Number	Answer		Mark
18(a)(i)	$^{222}_{86}\mathrm{Rn} \rightarrow ^{218}_{84}\mathrm{Po} + ^{4}_{2}\alpha$ Top line correct Bottom line correct	 **(1)** **(1)**	**2**
18(a)(ii)	Radon gas can be breathed in (Radon emits alpha particles) alpha particles are very ionising **Or** alpha particles have a high ionising power [Do not accept references to α-particles being breathed in; ignore general references to cancer or damage to cells]	**(1)** **(1)**	**2**
18(b)	Use of 1.60×10^{-19} to convert eV to J Use of $\Delta E = c^2 \Delta m$ $\Delta m = 9.94 \times 10^{-30}$ (kg) Example of calculation $\Delta E = 5.59 \times 10^{6}\ \mathrm{eV} \times 1.6 \times 10^{-19}\ \mathrm{J\ eV^{-1}} = 8.94 \times 10^{-13}\ \mathrm{J}$ $\Delta m = \frac{\Delta E}{c^2} = \frac{8.94\times10^{-13}\mathrm{J}}{(3\times10^{8}\ \mathrm{m\ s^{-1}})^2} = 9.938\times10^{-30}\mathrm{kg}$	**(1)** **(1)** **(1)**	**3**

18(c)(i)	Use of $\lambda = \frac{ln2}{t_{1/2}}$ Use of $\frac{\Delta N}{\Delta t} = (-)\lambda N$ $N = 4.5 \times 10^8$ (accept m^{-3} stated as unit) <u>Example of calculation</u> $\lambda = \frac{ln2}{t_{1/2}} = \frac{0.693}{3.30 \times 10^5 s} = 2.10 \times 10^{-6}\ s^{-1}$ $N = \frac{\frac{\Delta N}{\Delta t}}{\lambda} = \frac{950\ s^{-1}}{2.10 \times 10^{-6} s^{-1}} = 4.52 \times 10^8$	**(1)** **(1)** **(1)**	**3**
18(c)(ii)	Use of $N = N_0 e^{-\lambda t}$ [Allow use of $A = A_0 e^{-\lambda t}$] Evidence of taking logs $t = 7.4 \times 10^5$ s [ecf decay constant value from (c)(i)] <u>Example of calculation</u> $\ln\left(\frac{200\ \text{Bq}}{950\ \text{Bq}}\right) = -2.10\times10^{-6}\text{s}^{-1} \times t$ $t = \frac{1.56}{2.10\times10^{-6}\ \text{s}^{-1}} = 7.42\times10^5\ \text{s}$	**(1)** **(1)** **(1)**	**3**
18(c)(iii)	There are (many) more households for which the activity is less than 200 Bq m^{-3}	**(1)**	**1**
18(d)	The products of the decay must also be radioactive. The decay of these products produces alpha/beta/gamma radiation (contributing to the measured activity) (dependent mark). Max 1 mark for a reference to background radiation increasing the measured activity.	**(1)** **(1)**	**2**
	Total for question 18		**16**