Mark Scheme (Results)

Summer 2016

Pearson Edexcel GCE
in Physics (6PH05) 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) <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 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. '<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]
[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.
   6.5 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	A	**1**
2	D	**1**
3	D	**1**
4	A	**1**
5	C	**1**
6	C	**1**
7	D	**1**
8	B	**1**
9	D	**1**
10	D	**1**
	Total for Multiple Choice Questions	**10**

Question Number	Answer	Mark
11(a)	Use of $P = \frac{\Delta W}{\Delta t}$ **(1)** Use of $\Delta E = mc\Delta T$ **(1)** ΔT = 17 K **Or** ΔT = 17 °C **(1)** <u>Example of calculation</u> $\Delta W = P\Delta t = 650\,\text{W} \times (5 \times 60)\,\text{s} = 195\,000\,\text{J}$ $195\,000\,\text{J} = ((1.08\,\text{kg} \times 386\,\text{J kg}^{-1}\text{K}^{-1}) + (2.85\,\text{kg} \times 3890\,\text{J kg}^{-1}\text{K}^{-1}))\Delta T$ $\therefore \Delta T = \frac{195\,000\,\text{J}}{417\,\text{J K}^{-1} + 11090\,\text{J K}^{-1}} = 16.9\,\text{K}$	**3**
11(b)	Some (thermal) energy will be transferred to the surroundings **(1)** [accept heat, accept lost to the surroundings, do **not** accept lost, do **not** accept some energy is transferred to the pan]	**1**
	Total for Question 11	**4**

<table>
<tr><th>Question Number</th><th>Answer</th><th>Mark</th></tr>
<tr><td>12(a)</td><td>Either
Product of specific heat capacity and atomic mass checked (1)
All 3 materials checked (and product approximately the same) (1)

Or
At least 2 ratios of specific heat capacities calculated (1)
Corresponding ratios of atomic masses calculated (and approximately equal to specific heat capacity ratios) (1)

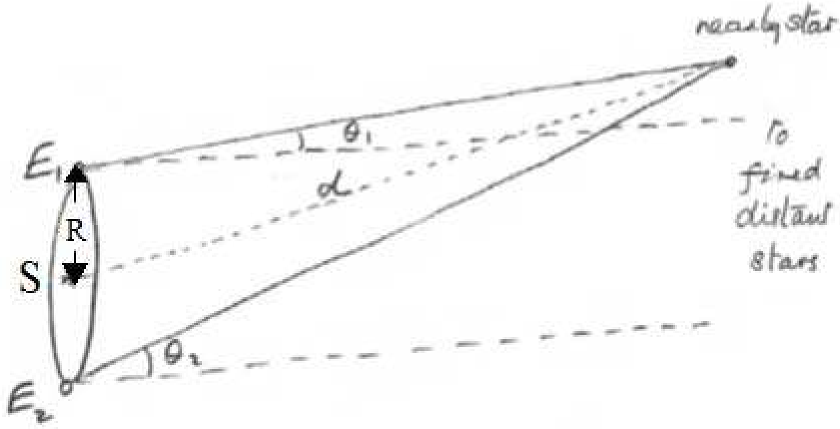
<u>Example of calculation</u>
<table>
<tr><th>Metal</th><th>S.h.c. / J kg^{-1} K^{-1}</th><th>Atomic mass / u</th><th>Product of s.h.c. and atomic mass</th></tr>
<tr><td>Aluminum</td><td>910</td><td>27.0</td><td>24600</td></tr>
<tr><td>Copper</td><td>386</td><td>63.5</td><td>24500</td></tr>
<tr><td>Silver</td><td>233</td><td>108</td><td>25200</td></tr>
</table></td><td>2</td></tr>
<tr><td>12(b)</td><td>If statement is correct,
Either
the energy to raise temperature of 1 kg is proportional to the number of atoms in 1 kg (1)
Number of atoms in 1 kg = 1/atomic mass (1)
Or
The larger the atomic mass the fewer the number of atoms in unit mass of material (1)
The fewer the number of atoms, the less energy needed to increase the temperature by unit amount (1)

If no other mark awarded, allow 1 mark for either a description of what internal energy is or a description of what specific heat capacity is.</td><td>2</td></tr>
<tr><td></td><td>Total for Question 12</td><td>4</td></tr>
</table>

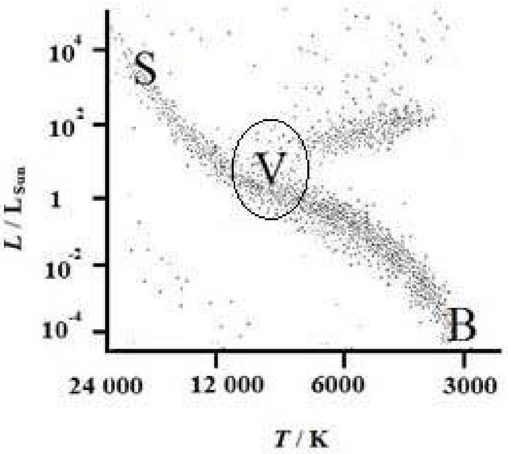
Question Number	Answer		Mark
13(a)	Use of $g = \frac{GM}{r^2}$ M = 4.5 × 10^{23} kg <u>Example of calculation</u> $M = \frac{gr^2}{G} = \frac{9.81\,\mathrm{N\,kg^{-1}} \times (1.74 \times 10^6\,\mathrm{m})^2}{6.67 \times 10^{-11}\,\mathrm{N\,m^2\,kg^{-2}}} = 4.45 \times 10^{23}\,\mathrm{kg}$	**(1)** **(1)**	**2**
13(b)	(the gravitational force on the Moon would be larger), but the centripetal acceleration would be independent of the mass of the Moon **Or** $r\omega^2 = \frac{GM}{r^2} \quad \therefore\ \omega^2 = \frac{GM}{r^3}$ (angular) velocity and hence *T* is independent of mass of Moon	 **(1)** **(1)**	**2**
13(c)	Gravitational forces on the seas/oceans/Earth would be greater **Or** Tidal variations would be more extreme [accept tides would be bigger, higher, larger, faster; do **not** accept tides would be stronger]	**(1)**	**1**
	Total for Question 13		**5**

Question Number	Answer	Mark
14(a)	Acceleration is: • (directly) proportional to displacement from 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 equilibrium position **(1)** • (always) acting towards the equilibrium position **Or** idea that force is a restoring force e.g. "in the opposite direction" **(1)** [accept towards undisplaced point/fixed point/central point for equilibrium position] [An equation with symbols defined correctly is a valid response for both marks. e.g $a \propto -x$ or $F \propto -x$]	**2**
14(b)	Use of $\omega = \frac{2\pi}{T}$ **(1)** Identifies amplitude of barrier (1.15 m) **(1)** Identifies maximum displacement of barrier from equilibrium position (0.55 m) **(1)** Use of $x = A\cos\omega t$ **(1)** Time available = 3.0 s **(1)** <u>Example of calculation</u> $\omega = \frac{2\pi}{T} = \frac{2\pi}{4.5} = 1.40\,\text{rad s}^{-1}$ $0.55\,\text{m} = 1.15\,\text{m}\cos 1.40\,\text{s}^{-1} t$ $\therefore t = 0.766\ s$ Time available = 4.5 s – (2 ×0.766 s) = 2.97 s	**5**
	Total for Question 14	**7**

Question Number	Answer	Mark
15(a)(i)	Alpha particles are very ionising **(1)** So alpha particles have very low penetrating power **Or** so alpha particles will be absorbed/stopped by the skin **(1)**	**2**
15(a)(ii)	Gamma rays are very penetrating **Or** Gamma rays will pass through the skin **(1)**	**1**
15(a)(iii)	Handled using (long) tongs **Or** never handled directly **Or** (closed source) pointed away from people **(1)** Kept in a <u>lead</u>-lined box (when not being used) **(1)**	**2**
15(b)	We cannot be sure which nuclei will decay **next/when** **(1)** **Or** All nuclei will (eventually) decay We know that the activity halves in a fixed period of time **(1)** **Or** We can calculate the activity using $A = A_0 e^{-\lambda t}$ **Or** We know that the activity decreases exponentially **Or** Probability of decay is constant for a source	**2**
	Total for Question 15	**7**

Question Number	Answer		Mark
16(a)(i)	**MAX 3**		
	The star is viewed from two positions at 6 month intervals **Or** opposite ends of its orbit diameter about the Sun	**(1)**	
	The change in angular position of the star against background of fixed stars is measured	**(1)**	
	Trigonometry is used to calculate the distance to the star [Do not accept Pythagoras]	**(1)**	
	The diameter/radius of the Earth's orbit about the Sun must be known	**(1)**	
	Full marks may be obtained from a suitably annotated diagram e.g 		
	[Accept 1 AU for R and the symmetrical diagram seen in many text books]		**3**
16(a)(ii)	(If stars are too far away) the angular displacement is too small to determine **Or** (If stars are too far away) the uncertainty in the angular displacement is too large [Accept the idea that stars appear not to move against the background of fixed/distant stars. Accept parallax angle for angular displacement.]	**(1)**	**1**
*16(b)	**(QWC Spelling of technical terms must be correct and the answer must be organised in a logical sequence.)**		
	The Pleiades cluster is closer to the Earth than was previously thought	**(1)**	
	So the stars are not as luminous as was previously thought	**(1)**	
	So the luminosity of similar stars in other galaxies have been overestimated	**(1)**	
	Hence the distances to other galaxies have been overestimated	**(1)**	**4**
	Total for Question 16		**8**

Question Number	Answer	Mark
17(a)(i)	Pressure and volume read from graph A **(1)** Conversion of temperature to kelvin **(1)** Use of $pV = NkT$ **(1)** $N = (2.8 \pm 0.2) \times 10^{30}$ **(1)** <u>Example of calculation</u> $N = \frac{pV}{kT} = \frac{2.5\times10^5\,Pa\times0.45\times10^5\,m^3}{1.38\times10^{-23}\,JK^{-1}\times(273+25)K} = 2.76\times10^{30}$	**4**
17(a)(ii)	Values read from A and B for constant pressure or constant volume **Or** p and V read from graph B and N used from (a)(i) **(1)** T = 540 K [±50K] [accept answers in ^{o}C within this range] **(1)** <u>Example of calculation</u> $\frac{p_1}{p_2} = \frac{T_1}{T_2}$ $T_B = T_A \times \frac{p_B}{p_A} = (273+25)\text{K} \times \frac{2.8\times10^5\,\text{Pa}}{1.55\times10^5\,\text{Pa}} = 538\,\text{K}$	**2**
***17(b)**	**(QWC Spelling of technical terms must be correct and the answer must be organised in a logical sequence.)** (Average) <u>kinetic</u> energy of molecules/atoms is less **Or** molecules/atoms slower **(1)** Collision rate with walls of container is smaller **(1)** There is less momentum/impulse (exchanged) per collision **Or** the rate of change of momentum is less **(1)** Therefore a smaller force on the container walls **(1)** (MP4 is dependent upon MP2 or MP3)	**4**
	Total for Question 17	**10**

<table>
<tr><th>Question Number</th><th>Answer</th><th></th><th>Mark</th></tr>
<tr><td>18(a)(i)</td><td>
<table>
<tr><th>Star</th><th>Type of Star</th></tr>
<tr><td>Spica (S)</td><td>Main sequence [accept blue giant]</td></tr>
<tr><td>Vega (V)</td><td>Main sequence [accept giant]</td></tr>
<tr><td>Barnard's Star (B)</td><td>Dwarf</td></tr>
</table>
</td><td>(1)
(1)</td><td>2</td></tr>
<tr><td>18(a)(ii)</td><td>S, V and B correctly marked


</td><td>(1)</td><td>1</td></tr>
<tr><td>18(b)</td><td>Use of $\lambda_{\max}T = 2.898\times10^{-3}$

$\lambda_{max} = 9.7 \times 10^{-7}$ m

This is in the infra-red region (so any visible light will be in red end of spectrum)

<u>Example of calculation</u>

$\lambda_{\max}T = 2.898\times10^{-3} = \frac{2.898\times10^{-3}\,\text{mK}}{3000\,\text{K}} = 9.66\times10^{-7}\,\text{m}$</td><td>(1)

(1)

(1)</td><td>3</td></tr>
<tr><td>18(c)</td><td>Use of $L = 4\pi r^2\sigma T^4$
Or use of $L = \sigma A T^4$ and $A = 4\pi r^2$

r = 1.8×10^9 m

<u>Example of calculation</u>

$r = \sqrt{\frac{L}{4\pi\sigma T^4}} = \sqrt{\frac{50.1\times3.85\times10^{26}\,\text{W}}{4\pi\times5.67\times10^{-8}\,\text{Wm}^{-2}\text{K}^{-4}\times(9500\,\text{K})^4}} = 1.82\times10^9\,\text{m}$</td><td>(1)

(1)</td><td>2</td></tr>
<tr><td>18(d)</td><td>The brightness of a source , F, is given by $F = \frac{L}{4\pi x^2}$ where L is the luminosity and x the distance to the source

Or reference to the inverse square law for brightness

If distance is increased, then the brightness decreases [dependent upon MP1]

Vega must be much closer than Spica</td><td>(1)

(1)

(1)</td><td>3</td></tr>
<tr><td></td><td>Total for Question 18</td><td></td><td>11</td></tr>
</table>

Question Number	Answer		Mark
19(a)	$^{14}_{7}N + ^{1}_{0}n \rightarrow ^{12}_{6}C + ^{3}_{1}H$ Top line correct Bottom line correct	 **(1)** **(1)**	**2**
19(b)(i)	Background radiation would increase the count rate (by a constant amount) **Or** Background count rate has to be subtracted (from the activity)	**(1)**	**1**
19(b)(ii)	Record the count for a long period of time **Or** Record the count more than once and find an average value	**(1)**	**1**
19(b)(iii)	Use of $\lambda t_{1/2} = \ln 2$ Use of $A = A_0 e^{-\lambda t}$ Correct time identified (65 years) $A_0 = 42$ Bq **Or** Use of $A = \frac{A_0}{2^x}$ Correct time identified (65 years) Use of $x = \frac{t}{t_{1/2}}$ $A_0 = 42$ Bq <u>Example of calculation</u> $\lambda = \frac{\ln 2}{t_{1/2}} = \frac{0.693}{12.3\,\text{year}} = 0.0563\,\text{year}^{-1}$ $A = A_0 e^{-\lambda t}$ $\therefore 1.08\text{Bq} = A_0 e^{-0.0563\text{year}^{-1} \times 65\text{year}}$ $A_0 = \frac{1.08\text{Bq}}{0.0257} = 42.1\,\text{Bq}$	**(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)**	**4**
19(c)(i)	Mass difference calculation Conversion to kg Use of $\Delta E = c^2 \Delta m$ $\Delta E = 2.8 \times 10^{-12}$ (J) <u>Example of calculation</u> $\Delta m = (3.0155 + 2.0136)\text{ u} - (4.0015 + 1.0087)\text{ u} = 0.0189\text{ u}$ $\Delta m = 0.0189\text{ u} \times 1.66 \times 10^{-27}\text{ kg u}^{-1} = 3.14 \times 10^{-29}\text{ kg}$ $\Delta E = c^2 \Delta m = (3 \times 10^8\text{ m s}^{-1}) \times 3.14 \times 10^{-29}\text{ kg} = 2.82 \times 10^{-12}\text{ J}$	**(1)** **(1)** **(1)** **(1)**	**4**

19(c)(ii)	**MAX 2** Very high temperatures [accept T~10^7 K] **(1)** so that nuclei have sufficient energy to come close enough to overcome electrostatic repulsion [accept reference to strong interaction] **(1)** A collision rate large enough to sustain fusion (from a very high density) **(1)**	**2**
	Total for Question 19	**14**

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