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Mark Scheme (Results)

Summer 2015

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] [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. '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:

$80 \text{ cm} \times 50 \text{ cm} \times 1.8 \text{ cm} = 7200 \text{ cm}^3$

$7200 \text{ cm}^3 \times 0.70 \text{ g cm}^{-3} = 5040 \text{ g}$

$5040 \times 10^{-3} \text{ kg} \times 9.81 \text{ N/kg}$

$= 49.4 \text{ N}$

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.

6.1 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	D	**1**
2	A	**1**
3	B	**1**
4	A	**1**
5	C	**1**
6	C	**1**
7	B	**1**
8	D	**1**
9	B	**1**
10	D	**1**

Question Number	Answer		Mark
11(a)	Top line correct Bottom line correct $^{60}_{28}\mathrm{Ni} + {}^{0}_{-1}\beta^{-}$	**(1)** **(1)**	**2**
11(b)	β radiation is quite penetrating as it is moderately ionising γ radiation is very penetrating as it is weakly ionising [idea that γ radiation is more penetrating than β radiation as γ radiation is less ionising than β radiation for max 1] [accept references to materials that would absorb the radiation e.g. 0.5 cm, a few mm of aluminium for β particles, thick lead, thick concrete for γ radiation etc]	**(1)** **(1)**	**2**
11(c)	Idea that the radiation (from the source) may damage healthy cells/DNA	**(1)**	**1**
	Total for question 11		5

Question Number	Answer		Mark
12(a)	Use of $\Delta E = mc\Delta\theta$	**(1)**	
	Use of $P = \dfrac{\Delta E}{\Delta t}$ with data from first section of graph [up to 240s]	**(1)**	
	$P = 54\,(\mathrm{W})$ [accept answers in the range 53 – 55]	**(1)**	**3**
	<u>Example of calculation:</u> $\dfrac{\Delta\theta}{\Delta t} = \dfrac{(29-25)\,\mathrm{K}}{(10-150)\,\mathrm{s}} = 0.0286\,\mathrm{K\,s^{-1}}$ $\dfrac{\Delta E}{\Delta t} = mc\dfrac{\Delta\theta}{\Delta t} = 0.75\,\mathrm{kg} \times 2500\,\mathrm{J\,kg^{-1}\,K^{-1}} \times 0.0286\,\mathrm{K\,s^{-1}} = 53.6\,\mathrm{W}$		
12(b)	The temperature is staying constant although energy [(latent) heat] is still being transferred from the chocolate	**(1)**	
	Idea that the potential energy of the chocolate molecules decreases (resulting in a decrease in internal energy)	**(1)**	**2**
12(c)	Lower rate of temperature fall (must be) due to larger specific heat capacity	**(1)**	
	because thermal energy is transferred to the surroundings at the same rate [dependent mark]	**(1)**	
	Or Idea that the solid is nearer to temperature of surroundings than the liquid	**(1)**	
	So rate of energy transfer to surroundings must be (slightly) less	**(1)**	**2**
	Total for question 12		**7**

Question Number	Answer		Mark
13(a)(i)	We cannot predict which <u>nucleus</u> will decay next **Or** we cannot know when an individual <u>nucleus</u> will decay **Or** there is a fixed probability of each <u>nucleus</u> decaying within a given time	**(1)**	**1**
13(a)(ii)	The average/mean time taken for the number of (unstable) nuclei/atoms to halve **Or** the average time taken for the activity (of the source) to halve	**(1)**	**1**
13(b)(i)	Use of $\lambda t_{1/2} = \ln 2$ Use of $\frac{dN}{dt} = (-)\lambda N$ $\frac{dN}{dt} = 2.34 \times 10^{15}$ (Bq) <u>Example of calculation:</u> $\lambda = \frac{\ln 2}{t_{1/2}} = \frac{0.693}{2.16\times10^{4}\,\mathrm{s}} = 3.21\times10^{-5}\,\mathrm{s}^{-1}$ $\frac{dN}{dt} = \lambda N = 3.21\times10^{-5}\,\mathrm{s}^{-1}\times7.3\times10^{19} = 2.34\times10^{15}\,\mathrm{s}^{-1}$	**(1)** **(1)** **(1)**	**3**
13(b)(ii)	Use of $A = A_0 e^{-\lambda t}$ **Or** use of $N = N_0 e^{-\lambda t}$ A = 1.5×10^{14} Bq [1.4×10^{14} Bq if "show that" value used] [Accept candidate's value for λ and check their answer for ecf credit] [Apply ecf for responses that use a value of A_0 that would round to the 'show that' value] [Allow calculation of number of half lives elapsed and use of $A = A_0\left(\frac{1}{2}\right)^{t/t_{1/2}}$ for mp1] <u>Example of calculation:</u> $\mathrm{A} = \mathrm{A}_0 e^{-\lambda t} = 2.34\times10^{15}\,\mathrm{Bq}\times \mathrm{e}^{-3.2\times10^{-5}\,\mathrm{s}^{-1}\times86400\,\mathrm{s}} = 1.46\times10^{14}\,\mathrm{Bq}$	**(1)** **(1)**	**2**
	Total for question 13		**7**

Question Number	Answer	Mark
14(a)(i)	Binding energy is the energy released when a nucleus is formed from its component nucleons **Or** binding energy is the energy required to split a nucleus into its component nucleons **(1)**	**1**
14(a)(ii)	For energy to be released the binding energy (per nucleon) must increase **(1)** The binding energy per nucleon only increases for light nuclei **Or** the binding energy per nucleon only increases if the nucleus formed has $A < 56$ **(1)** [accept converse argument]	**2**
***14(b)**	QWC – Work must be clear and organised in a logical manner using technical wording where appropriate (For fusion to occur) there must be a (very) high temperature so that protons/nuclei have sufficient (kinetic) <u>energy</u> to overcome the (electrostatic) repulsion **(1)** So that the protons/nuclei come close enough for fusion to take place **Or** so that the protons/nuclei come close enough for the strong nuclear force to act **(1)** There must be a (very) high density so that a sufficient collision rate is maintained. **(1)** The (enormous) gravitational forces acting in stars create a very high temperature and density **(1)**	**4**
	Total for question 14	**7**

Question Number	Answer		Mark
15(a)	See $F = \frac{Gm_1m_2}{r^2}$ **and** $F = \frac{mv^2}{r}$	**(1)**	
	Equate expressions, $M = \frac{v^2r}{G}$ stated or implied	**(1)**	
	$M = 1.8 \times 10^{41}$ kg	**(1)**	**3**
	<u>Example of calculation:</u> $\frac{GMm}{r^2} = \frac{mv^2}{r}$ $\therefore M = \frac{v^2r}{G} = \frac{(220\,000\,\mathrm{m\,s^{-1}})^2 \times 2.5 \times 10^{20}\,\mathrm{m}}{6.67 \times 10^{-11}\,\mathrm{N\,m^2\,kg^{-2}}} = 1.81 \times 10^{41}\,\mathrm{kg}$		
15(b)(i)	Reference to $v^2 = \frac{GM}{r}$ **Or** $v^2 \propto \frac{M}{r}$	**(1)**	
	Mass stays constant so an increase in r leads to decrease in v **Or** increase in M is less than increase in r, so velocity of star decreases	**(1)**	
	Alternative scheme: (Assuming the mass stays approximately constant)		
	Force varies (with distance) according to inverse square law, so the force on the star would be less	**(1)**	
	[For inverse square law accept $F = \frac{Gm_1m_2}{r^2}$ or $F \propto \frac{1}{r^2}$]		
	$F = \frac{Mv^2}{r}$ and the decrease in force is greater than the increase in orbit radius, so the velocity of the star decreases.	**(1)**	**2**
15(b)(ii)	Idea that <u>mass</u> of galaxy is greater than expected	**(1)**	
	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)**	**2**
	Total for question 15		**7**

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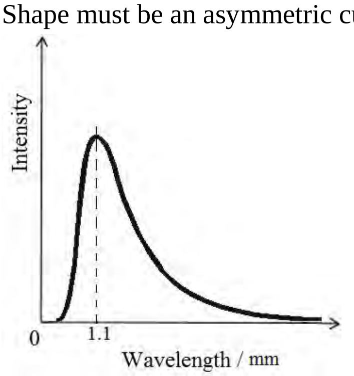
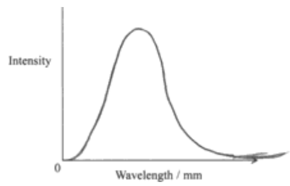
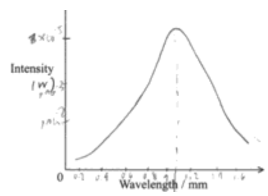
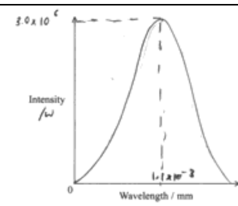
Question Number	Answer		Mark
16(a)	Flux varies with distance according to inverse square law [For inverse square law accept $F = \frac{L}{4\pi d^2}$ or $F \propto \frac{1}{d^2}$] Flux of each star decreases by a factor of 4 as distance is doubled, but number of stars increases by a factor of 4. **Or** Attempt to use $F = \frac{L}{4\pi d^2}$ with either $d = 2r$ or $L = 4L$ Correct algebra to show F stays constant. (Dependent mark)	**(1)** **(1)** **(1)** **(1)**	**2**
16(b)(i)	Use of $L = \sigma A T^4$ where $A = 1\ \text{m}^2$ $L/A = 3.0 \times 10^{-6}\ (\text{W m}^{-2})$ Example of calculation: $L/A = \sigma T^4 = 5.67 \times 10^{-8}\ \text{W m}^{-2}\ \text{K}^{-4} \times (2.7\ \text{K})^4 = 3.01 \times 10^{-6}\ \text{W m}^{-2}$	**(1)** **(1)**	**2**
16(b)(ii)	Use of $\lambda_{max} T = 2.898 \times 10^{-3}$ $\lambda_{max} = 1.1 \times 10^{-3}$ m Curve with peak at candidates value for λ_{max} labelled or in the correct position Shape must be an asymmetric curve and must not have intensity at λ=0  Example of calculation: $\lambda_{max} = \frac{2.898 \times 10^{-3}\ \text{m K}}{2.7\ \text{K}} = 1.07 \times 10^{-3}\ \text{m}$ Examples of graphs that do not meet the "shape" criterion:	**(1)** **(1)** **(1)** **(1)**	**4**

	  		
16(b)(iii)	Peak of curve would be higher **Or** (maximum) intensity would be greater **Or** graph would be shifted upwards Peak would be shifted to a smaller wavelength [allow curve would be shifted to the left]	**(1)** **(1)**	**2**
16(c)	Idea that there has not been enough time for light from very distant stars to arrive at the Earth	**(1)**	**1**
	Total for question 16		**11**

Question Number	Answer		Mark
17(a)(i)	$V_{in} = 5.9 \times 10^{-3}$ m^3 and $V_{out} = 1.3 \times 10^{-3}$ m^3 **Or** $\Delta V = 4.6 \times 10^{-3}$ m^3 Use of $pV = NkT$ $N = 1.1 \times 10^{23}$ <u>Example of calculation:</u> $N = \frac{pV}{\mathrm{kT}} = \frac{1.02\times10^{5}\ \mathrm{Pa}\times(5.9-1.3)\times10^{-3}\ \mathrm{m}^{3}}{1.38\times10^{-23}\ \mathrm{J\,K^{-1}}\ (273+37)\ \mathrm{K}} = 1.10\times10^{23}$	**(1)** **(1)** **(1)**	**3**
17(a)(ii)	Use of $\frac{1}{2}m\langle c^2\rangle = \frac{3}{2}kT$ $E_{\mathrm{k,\,tot}} = 710$ J [apply ecf for responses that use a value of N that would round to the ‘show that’ value] <u>Example of calculation:</u> $E_{k,tot} = N\times\frac{3}{2}kT = 1.1\times10^{23}\times1.5\times1.38\times10^{-23}\ \mathrm{J\,K^{-1}}\times(273+37)\ \mathrm{K} = 706\ \mathrm{J}$	**(1)** **(1)**	**2**
17(a)(iii)	Internal energy is the sum of kinetic and potential energy of the (molecules/atoms in the) air The molecules/atoms (in an ideal gas) have no potential energy	**(1)** **(1)**	**2**
17(b)(i)	Oxygen molecules (are more massive than nitrogen molecules and) have a lower mean square speed than the nitrogen molecules. Because $\frac{1}{2}m\langle c^2\rangle$ is the same for each type of molecule **Or** average/mean kinetic energy is the same for each type of molecule	**(1)** **(1)**	**2**

*17(b)(ii)	QWC – Work must be clear and organised in a logical manner using technical wording where appropriate Both gases occupy the same volume V and are at the same temperature T As pressure $p = \frac{NkT}{V}$ then $p \propto N$ the number of molecules The contribution to pressure exerted by each gas is determined by the number of molecules (of that gas) [accept statement that 80% of the molecules in the gas are nitrogen molecules and so nitrogen accounts for 80% of the pressure for mp3]	 **(1)** **(1)** **(1)**	**3**
	Total for question 17		**12**

Question Number	Answer		Mark
18(a)	Use of $F = k\Delta x$ (ignore reference to any minus signs) k = 1560 (N m^{-1}) <u>Example of calculation:</u> $k = \frac{mg}{\Delta x} = \frac{35\,\text{kg} \times 9.81\,\text{N kg}^{-1}}{0.22\,\text{m}} = 1560\,\text{N m}^{-1}$	**(1)** **(1)**	**2**
18(b)(i)	Use of $F = m\omega^2 x$ and F = (-)$k\Delta x$ Use of $\omega = 2\pi f$ f = 1.1 Hz [apply ecf for responses that use a value of k that would round to the 'show that' value] [Candidates who quote $T = 2\pi\sqrt{\frac{m}{k}}$, then use $f = \frac{1}{T}$ and get the correct answer score full marks. If their answer incorrect, could score mp2 only] <u>Example of calculation:</u> $m\omega^2 x = k\,\Delta x$ $\therefore \omega = \sqrt{\frac{k}{m}} = \sqrt{\frac{1560\,\text{N m}^{-1}}{35\,\text{kg}}} = 6.68\,\text{s}^{-1}$ $f = \frac{\omega}{2\pi} = \frac{6.68\text{s}^{-1}}{2\pi} = 1.06\,\text{Hz}$	**(1)** **(1)** **(1)**	**3**
18(b)(ii)	Use of $v_{\text{max}} = \omega A$ **Or** Use of $v_{\text{max}} = 2\pi f A$ v_{max} = 1.4 m s^{-1} ecf their value of ω or f [if A = 0.22 then max 1 for calculation] Max velocity is at the equilibrium position [accept centre/mid-point of oscillation] <u>Example of calculation:</u> $v_{\text{max}} = \omega A = 6.68\,\text{s}^{-1} \times 0.21\text{m} = 1.40 \text{ m s}^{-1}$	**(1)** **(1)** **(1)**	**3**
18(c)(i)	Resonance [accept resonating/resonates] (By using her knees) she is forcing herself into oscillation at a frequency close or equal to the natural frequency of the system So the transfer of energy becomes very efficient **Or** there is maximum/large energy transfer	**(1)** **(1)** **(1)**	**3**

*18(c)(ii)	QWC – Work must be clear and organised in a logical manner using technical wording where appropriate For shm there must be a (resultant) force/ acceleration proportional to displacement from the equilibrium position [Accept undisplaced point/fixed point/central point for equilibrium position] When she loses contact with the trampoline the (only) force is the weight **Or** When she loses contact with the trampoline the acceleration is g Weight/g is constant (so not shm) **Alternative scheme for those who consider the direction of the force/acceleration rather than its magnitude** For shm there must be a force/acceleration that is always directed towards the equilibrium position When she loses contact with the trampoline the (only) force is the weight **Or** When she loses contact with the trampoline the acceleration is g Weight/g is always directed downwards (so not shm)	**(1)** **(1)** **(1)** **(1)** **(1)** **(1)**	**3**
	Total for question 18		**14**

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