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Mark Scheme (Results)

Summer 2016

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.

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 e.g. '**and'** when two pieces of information are needed for 1 mark.

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 This does not apply in 'show that' questions or in any other question where the units to be used have been given, for example in a spreadsheet.

2.3 The mark will not be awarded for the same missing or incorrect unit only once within one clip in epen.

2.4 Occasionally, it may be decided not to insist on a 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.

2.5 The mark scheme will indicate if no unit error is to be applied by means of [no ue].

3. Significant figures

3.1 Use of too many significant figures in the theory questions will not be prevent a mark being awarded if the answer given rounds to the answer in the MS.

3.2 Too few significant figures will mean that the final mark cannot be awarded in 'show that' questions where one more significant figure than the value in the question is needed for the candidate to demonstrate the validity of the given answer.

3.3 The use of one significant figure might be inappropriate in the context of the question e.g. reading a value off a graph. If this is the case, there will be a clear indication in the MS.

3.4 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 mean that one mark will not be awarded. (but not more than once per clip). Accept 9.8 m s^{-2} or 9.8 N kg^{-1}

3.5 In questions assessing practical skills, a specific number of significant figures will be required e.g. determining a constant from the gradient of a graph or in uncertainty calculations. The MS will clearly identify the number of significant figures required.

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.

Question Number	Answer	Mark
1	B	**1**
2	C	**1**
3	A	**1**
4	D	**1**
5	C	**1**
6	D	**1**
7	C	**1**
8	C	**1**
9	A	**1**
10	B	**1**
	Total for Multiple Choice Questions	**10**

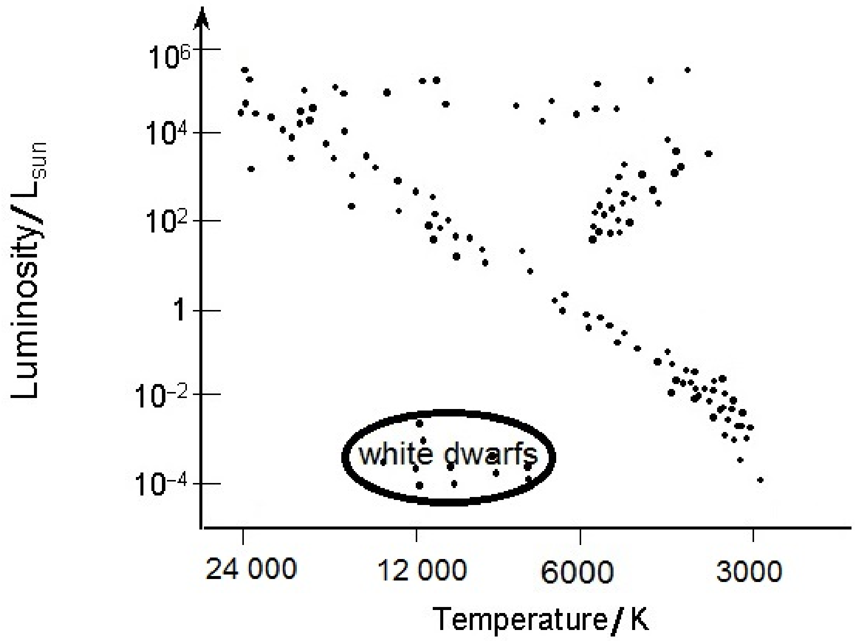
Question Number	Answer		Mark
11(a)	Use of $\Delta E = mc\Delta\theta$ $\Delta\theta = 20$ (K/°C) Water temperature = 38 °C [Accept 311 K] <u>Example of calculation</u> $\Delta\theta = \frac{\Delta E}{mc}$ $\therefore \Delta\theta = \frac{6200 \text{ J}}{0.075 \text{ kg} \times 4200 \text{ J kg}^{-1} \text{ K}^{-1}} = 19.7 \text{ K}$ $\therefore \theta = 18\ ^{\circ}\text{C} + 20\ ^{\circ}\text{C} = 38\ ^{\circ}\text{C}$	**(1)** **(1)** **(1)**	**3**
11(b)	Not all of the energy supplied by the heater will be transferred to the water **Or** Some of the energy supplied by the heater will be transferred to the surroundings [Accept heat instead of energy, accept lost to surroundings] [Do **not** accept heater is not 100% efficient] So the (output water) temperature will be lower (than the calculated value)	**(1)** **(1)**	**2**
	Total for Question 11		**5**

Question Number	Answer	Mark
12(a)	Use of $F = \frac{Gm_1m_2}{r^2}$ **Or** Use of $g = \frac{Gm}{r^2}$ with $F = mg$ **(1)** $\frac{F_{sun}}{F_{moon}} = 180$ **(1)** [Allow max 1 if only $g = \frac{Gm}{r^2}$ is used to find $\frac{g_S}{g_M} = 183$] Example of calculation: $\frac{F_{\text{sun}}}{F_{\text{moon}}} = \frac{m_{\text{sun}}}{m_{\text{moon}}} \times \left(\frac{r_{\text{moon}}}{r_{\text{sun}}}\right)^2 = \frac{2\times10^{30}\text{ kg}}{7\times10^{22}\text{ kg}} \times \left(\frac{3.8\times10^{8}\text{ m}}{1.5\times10^{11}\text{ m}}\right)^2 = 183$	**2**
12(b)(i)	$g = \frac{GM}{x^2}$ and $g = \frac{GM}{(x+D)^2}$ (on either side of the Earth's diameter D) **(1)**	**1**
12(b)(ii)	$x \gg D$ **Or** $(x + D) \approx x$ **(1)** So $\Delta g \approx 0$ [MP2 dependent upon MP1] **(1)** **Or** The distance of the Sun from the Earth is very large compared with the Earth's diameter **(1)** Hence the difference in *g* (at opposite sides of the Earth due to the Sun) is (very) small [MP2 dependent upon MP1] **(1)** [Accept *g* is approximately the same at both positions for MP2]	**2**
	Total for Question 12	**5**

Question Number	Answer		Mark
13(a)	Age of the universe = $1/H_0$ [Accept age of universe is inversely proportional to H_0] Since the measured value of the Hubble constant is smaller, our estimate of the age of the universe is now larger	**(1)** **(1)**	**2**
13(b)(i)	Dark matter cannot be detected via the em-interaction [accept light but do **not** accept radiation on its own] [accept cannot be seen] But it has mass **Or** But it exerts a gravitational force	**(1)** **(1)**	**2**
13(b)(ii)	(The increased proportion of dark matter may mean that) the gravitational force which reduces expansion may be larger **Or** the density of the universe may be greater than the critical density (Hence) the universe is more likely to reach a maximum size (before contracting) **Or** (Hence) the universe is more likely to be closed [Ignore references to 'Big Crunch']	 **(1)** **(1)**	**2**
	Total for Question 13		**6**

Question Number	Answer	Mark
14(a)	Use of $T = 2\pi\sqrt{\frac{m}{k}}$ and $f = \frac{1}{T}$ **(1)** Correct use of factor 4 in spring constant or mass **(1)** $f = 3.3$ Hz (accept unit s^{-1}) **(1)** Example of calculation: $k = 4 \times 450$ Nm^{-1} = 18 00 Nm^{-1} $T = 2\pi\sqrt{\frac{m}{k}} = 2\pi\sqrt{\frac{4.3\,\text{kg}}{1800\,\text{N m}^{-1}}} = 0.307\,\text{s}$ $f = \frac{1}{T} = \frac{1}{0.307\,\text{s}} = 3.26\,\text{Hz}$	**3**
14(b)	**Either** 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** (Resultant) 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 $F \propto -x$] **And** (The box undergoes simple harmonic motion because) the springs obey Hooke's law **(1)**	**3**
	Total for Question 14	**6**

Question Number	Answer	Mark
15(a)	Use of $pV = NkT$ **(1)** p = 1.1 × 10^5 (Pa) **(1)** <u>Example of calculation</u> $p = \frac{NkT}{V} = \frac{2.2\times10^{23}\times1.38\times10^{-23}\,\mathrm{J\,K^{-1}}\times293\,\mathrm{K}}{8.2\times10^{-3}\,\mathrm{m^3}} = 1.08\times10^5\,\mathrm{Pa}$	**2**
15(b)	Correct use of a factor of 50 **(1)** V = 0.019 m^3 [0.018 m^3 if 'show that' value used] **(1)** [Ratio method, $p_1V_1 = p_2V_2$ can score both marks, for this method apply ecf from ai] For candidates who take the number of molecules that remain in the canister into account: • Use of $v_{helium} = (50\times v_{balloon} + v_{canister})$ **(1)** • V = 0.0203 m^3 **(1)** <u>Example of calculation</u> $V = \frac{NkT}{p} = \frac{50\times2.2\times10^{23}\times1.38\times10^{-23}\,\mathrm{J\,K^{-1}}\times293}{2.3\times10^6\,\mathrm{Pa}} = 0.0193\,\mathrm{m^3}$	**2**
15(c)	There are fewer atoms (in the canister), so the collision rate with the walls decreases [accept molecules but not particles] **(1)** Hence the (overall) rate of change of momentum is less **(1)** Therefore there is a smaller force (on the container walls) **(1)** [dependent upon mp2]	**3**
	Total for Question 15	**7**

Question Number	Answer		Mark
16(a)	 Reverse temperature scale Approximately logarithmic	(1) (1)	2
16(b)(i)	Correct area identified [Area should include some of the white dwarf stars and not extend as far as the main sequence]	(1)	1
*16(b)(ii)	(QWC Spelling of technical terms must be correct and the answer must be organised in a logical sequence.) White dwarf stars are the (core) remnant of a red giant star There is no fusion occurring in the white dwarf They have a (relatively) small surface area so they are not very luminous [accept radius for surface area] They are (very) hot, and appear white (because they emit all visible wavelengths)	(1) (1) (1) (1)	4
	Total for Question 16		**7**

Question Number	Answer	Mark
17(a)(i)	Resonance is when a system is driven/forced (into oscillation) at its natural frequency **(1)** (Accept close to its natural frequency) This results in: A maximum energy transfer **(1)** **Or** a maximum/increasing amplitude **Or** a maximum efficiency of energy transfer	**2**
17(a)(ii)	the wavelength is larger (hence the frequency is smaller) **(1)**	**1**
17(b)(i)	(Damping is) the removal/dissipation of energy from an oscillation **(1)** (Hence) there is a decrease in the amplitude **(1)**	**2**
17(b)(ii)	As the gel changes size/shape it absorbs energy **(1)** The gel does not return to its original size/shape **(1)** So the energy is not returned (to the drum) **Or** the energy is dissipated (in the gel) **(1)** [dependent upon mp1 or mp2]	**3**
	Total for Question 17	**8**

Question Number	Answer		Mark
18(a)(i)	Use of $F = \dfrac{L}{4\pi d^2}$ L = 3.8 × 10^{26} (W) <u>Example of calculation</u> $L = 4\pi d^2 F = 4\pi(1.50\times10^{11}\,\text{m})^2 \times 1.36\times10^3\,\text{W m}^{-2} = 3.845\times10^{26}\,\text{W}$	**(1)** **(1)**	**2**
18(a)(ii)	Use of $L = 4\pi r^2 \sigma T^4$ r = 1.5 × 10^{10} m Allow full ecf from (i) [show that value gives 1.48 x 10^{10} m] <u>Example of calculation</u> $r = \sqrt{\dfrac{L}{4\pi\sigma T^4}} = \sqrt{\dfrac{100\times3.85\times10^{26}\,\text{W}}{4\pi\times5.67\times10^{-8}\,\text{W m}^{-2}\text{K}^{-4}\times(4000\,\text{K})^4}}$ $r = 1.45\times10^{10}\,\text{m}$	**(1)** **(1)**	**2**
18(b)(i)	(Observed wavelength is less, so) source is approaching Earth Use of $\dfrac{v}{c} = \dfrac{\Delta\lambda}{\lambda}$ $v = 7.82\times10^5\,\text{m s}^{-1}$ [accept v = 2.606 × 10^{-3} c] [incorrect value of λ in denominator gives v = 7.84 x 10^5 ms^{-1}] [If $v = 7.8\times10^5\,\text{m s}^{-1}$ or $v = 2.6\times10^{-3}c$, check denominator; unless 656.29 substituted then max 2] **Or** (Observed wavelength is less, so) source is approaching Earth Use of $z = \dfrac{\Delta\lambda}{\lambda}$ z = 2.606 × 10^{-3} [incorrect value of λ in denominator gives z = 2.612 x 10^{-3}] [If z = 2.6 × 10^{-3} check denominator; unless 656.29 substituted then max 2] <u>Example of calculation</u> $\Delta\lambda$ = (654.58 −656.29) nm = −1.71 nm $v = \dfrac{c\Delta\lambda}{\lambda} = \dfrac{3.0\times10^8\,\text{m s}^{-1}\times1.71\,\text{nm}}{656.29\ \text{nm}} = 7.82\times10^5\,\text{m s}^{-1}$	**(1)** **(1)** **(1)** **(1)** **(1)** **(1)**	**3**

18(b)(ii)	$\lambda_B < \lambda_Y$ **(1)** $\lambda_{max} \propto \frac{1}{T}$ therefore $T_B > T_Y$ (and statement is incorrect) **(1)** **Or** $\lambda_{max}T = \text{a constant}$, so the cooler the star the larger the value of λ_{max} **(1)** Wavelength of yellow light is greater than the wavelength of blue light, so statement is incorrect **(1)**	**2**
	Total for Question 18	**9**

Question Number	Answer	Mark
19(a)(i)	Top line correct **(1)** Bottom line correct **(1)** X is a proton **(1)** $^{1}_{0}\mathrm{n} + ^{14}_{7}\mathrm{N} \rightarrow ^{14}_{6}\mathrm{C} + ^{1}_{1}\mathrm{X}$	**3**
19(a)(ii)	We cannot know when a given nucleus will decay **Or** We cannot know which nucleus will decay next **(1)**	**1**
19(b)	Pairs of activity and times read from graph for at least 2 half lives and find mean **Or** Use $A = A_0 e^{-\lambda t}$ with values from graph and $t_{1/2} = \frac{ln2}{\lambda}$ **(1)** $t_{1/2}$ matches values from their graph **(1)** <u>Example of calculation</u> t = 0 year, A_0 = 240 Bq t = 17500 year, A_3 = 30 Bq $t_{1/2}$ = (17500 year)/3 = 5833 year	**2**
19(c)(i)	The background radiation will increase the recorded count rate **(1)** **Or** Background count rate has to be subtracted (from the count rate)	**1**
19(c)(ii)	Record count for a longer time **(1)** **Or** Repeat count and find an average	**1**

19(c)(iii)	Use of $\lambda t_{1/2} = \ln 2$ Use of $A = A_0 e^{-\lambda t}$ **Or** $N = N_0 e^{-\lambda t}$ t = 8650 year **Or** Use of $A = \frac{A_0}{2^x}$ Use of $x = \frac{t}{t_{1/2}}$ t = 8650 year [Accept 8600 y – 8700 y] [2.73 $\times 10^{11}$ s] <u>Example of calculation</u> $\lambda = \frac{\ln 2}{t_{1/2}} = \frac{0.693}{6000\,\text{year}} = 1.16 \times 10^{-4}\,\text{year}^{-1}$ $A = A_0 e^{-\lambda t}$ $\therefore 10.9\,\text{Bq} = 29.6\,\text{Bq} \times (\text{e}^{-1.16\times10^{-4}\,\text{year}^{-1}\times \text{t}})$ $t = 8649\,\text{year}$	**(1)** **(1)** **(1)** **(1)** **(1)** **(1)**	**3**
19(d)	The time scale is too long **Or** the half life is too short [accept too many half lives have passed] (So) the activity would be too small to measure (with sufficient accuracy) **Or** (Graph shows) the activity will fall to zero after 50 000 years **Or** (After 68 million years), the skull would not have significant carbon content	**(1)** **(1)**	**2**
*19(e)	(QWC Spelling of technical terms must be correct and the answer must be organised in a logical sequence.) Binding energy is the energy released when a nucleus is formed **Or** the energy required to split a nucleus into its constituent particles Binding energy is not a force **Or** We cannot overcome the binding energy [accept idea that it is the strong force that holds the (nucleons in the) nucleus together] Atoms do not undergo fission (nuclei do) Fission is when massive nuclei split into less massive nuclei	**(1)** **(1)** **(1)** **(1)**	**4**
	Total for Question 19		**17**

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