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Mark Scheme (Results)

January 2014

IAL Physics (WPH05)

Unit 5: 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] 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	 ✓ ✓ ✓	**3**

5. Quality of Written Communication

5.1 Indicated by QWC 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 QWC 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	C	**1**
2	D	**1**
3	A	**1**
4	B	**1**
5	C	**1**
6	C	**1**
7	C	**1**
8	B	**1**
9	A	**1**
10	A	**1**

Question Number	Answer		Mark
11	Use of $\frac{\Delta\lambda}{\lambda} = \frac{v}{c}$ v = 4.1 × 10^6 m s^{-1} [check for 587.5 in denominator if 2sf answer given] <u>Example of calculation:</u> $v = 3.00 \times 10^8\ \mathrm{m\,s^{-1}} \times \frac{(595.6 - 587.5)\times 10^{-9}\ \mathrm{m}}{587.5 \times 10^{-9}\ \mathrm{m}} = 4.14 \times 10^6\ \mathrm{m\,s^{-1}}$	**(1)** **(1)**	**2**
	Total for Question 11		**2**

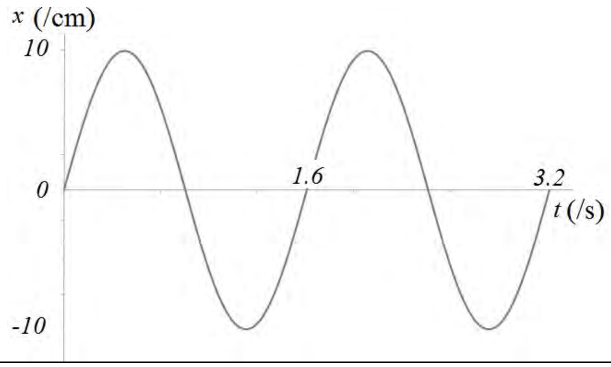
Question Number	Answer		Mark
12(a)	Correct conversion to Kelvin [at least one seen, don't credit 273 added to a temperature difference] Use of $pV=NkT$ [accept use of pV = nRT] Attempt at calculation of ΔN [accept attempt at calculation of Δn] ΔN = 6.7 × 10^{24} [accept 6.66, 6.6 , 6.0, 6 or 7, all with × 10^{24}] <u>Example of calculation:</u> $N_1 - N_2 = \frac{pV}{k}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)$ $\Delta N = \frac{101\times 10^3\ \mathrm{Pa} \times 2.5\mathrm{m}^3}{1.38\times 10^{-23}\ \mathrm{J\,K^{-1}}}\left(\frac{1}{(273+20)\mathrm{K}} - \frac{1}{(273+55)\mathrm{K}}\right) = 6.66\times 10^{24}$	**(1)** **(1)** **(1)** **(1)**	**4**
12(b)	Air behaves as an ideal gas **or** the volume remains constant **or** air must be dry [do not award mark if other incorrect answers quoted in addition to correct answer]	**(1)**	**1**
	Total for Question 12		**5**

Question Number	Answer		Mark
13(a)	Determine λ_{max} (from spectrum) [accept "peak wavelength" if linked with λ_{max}, but do not accept "maximum wavelength"] [λ_{max} may be described in words] Idea that Wien's law is used to calculate the temperature Use H-R diagram to determine the luminosity [do not accept references to Stefan's law for this mark]	**(1)** **(1)** **(1)**	**3**
***13(b)**	**QWC – Work must be clear and organised in a logical manner using technical wording where appropriate** **Max 3** Idea that distances to stars too far for parallax can be measured **[**accept bald statement that parallax cannot be used] Measure the brightness/flux/intensity, F, of the star Use inverse square law to calculate the distance [allow equation quoted as $d = \sqrt{\frac{L}{4\pi F}}$] [If you see reference to m – M = 5log d – 5, send to Review]	 **(1)** **(1)** **(1)**	**3**
	Total for Question 13		**6**

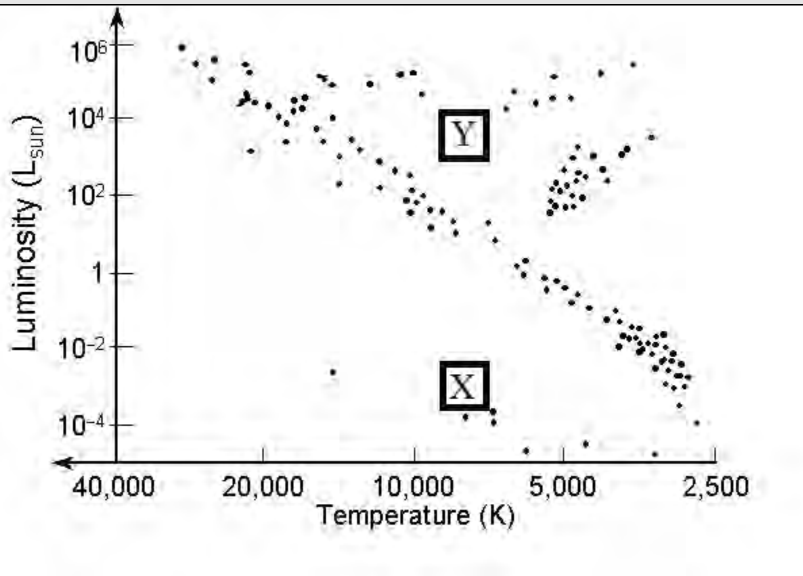
Question Number	Answer		Mark
14(a)(i)	Use of $\Delta E_{grav} = mg\Delta h$ Use of $\Delta E = mc\Delta\theta$ with their value of ΔE_{grav} $\Delta\theta$ = 0.63 (K) <u>Example of calculation</u> $mc\Delta\theta = mg\Delta h$ $\therefore \Delta\theta = \dfrac{9.81\,\text{m s}^{-2} \times 270\,\text{m}}{4200\,\text{J kg}^{-1}\,\text{K}^{-1}} = 0.63\ (\text{K})$	**(1)** **(1)** **(1)**	**3**
14(a)(ii)	Idea that the decrease in gravitational potential energy only results in an increase in the internal energy of the water [e.g all (gravitational potential) energy is transferred to thermal energy (of water)] [allow “no energy is transferred to the surroundings”, but not “no energy is lost to the surroundings”] [accept statement that no water rebounds] **Or** Air temperature is the same at the top and bottom of the waterfall	**(1)** **(1)**	**1**
14(b)	**Max 3** Idea that uncertainty in temperature readings is ± 0. 25 °C Statement that uncertainty in temperature difference may be ± 0.5 °C Comparison of 0.5 °C/0.25 °C with 0.6 °C **Or** attempt at calculation of percentage uncertainty with statement that it is too large Reference to assumptions about conditions top and bottom	**(1)** **(1)** **(1)** **(1)**	**3**
	Total for Question 14		**7**

Question Number	Answer		Mark
15(a)	α particles will be absorbed by the walls of the pacemaker (Because) they are very ionising	**(1)** **(1)**	**2**
15(b)	${}^{238}_{92}\mathrm{Pu} \rightarrow {}^{234}_{90}\mathrm{Th} + {}^{4}_{2}\alpha$ Top line correct Bottom line correct	 **(1)** **(1)**	 **2**
15(c)	Use of $\lambda t_{1/2} = \ln 2$ a correct value for λ [$\lambda = 7.88 \times 10^{-3}$ y^{-1} **or** 2.50×10^{-10} s^{-1}] **or** $\lambda = \ln 2 / t_{1/2}$ seen in an appropriate equation. Use of $A = A_0 e^{-\lambda t}$ [allow use of $N = N_0 e^{-\lambda t}$] $A = 7.34 \times 10^{10}$ Bq Use of $1\mathrm{eV} = 1.6 \times 10^{-19}$ J to convert energy to J P = 0.065 W [accept 0.06 W] <u>Example of calculation:</u> $\lambda = \frac{0.693}{88\ \mathrm{y}} = 7.88 \times 10^{-3}\ \mathrm{y}^{-1}$ $A = 9.3 \times 10^{10}\ \mathrm{Bq}\, e^{-7.88 \times 10^{-3}\ \mathrm{y}^{-1} \times 30\ \mathrm{y}}$ $A_0 = 7.34 \times 10^{10}$ Bq $P = 7.34 \times 10^{10}$ Bq × 5.5 MeV × 1.6×10^{-13} J MeV^{-1} = 0.0646 W	**(1)** **(1)** **(1)** **(1)** **(1)** **(1)**	 **6**
15(d)	**Max 2** [must have an advantage and a disadvantage to score 2 marks] **Advantage:** No (danger from) ionising radiation **Or** easier to dispose of (as no radioactive materials in lithium battery) **Disadvantage:** Lithium batteries do not last as long as plutonium power source **Or** lithium batteries would have to be replaced more often (requiring surgery)	 **(1)** **(1)** **(1)** **(1)**	 **2**
	Total for Question 15		**12**

Question Number	Answer		Mark
16(a)	Use of $g = (-)\dfrac{GM}{r^2}$ g = (−)1.3 N kg^{-1} [accept m s^{-2}] <u>Example of calculation</u> $g = \dfrac{6.67\times10^{-11}\,\text{N m}^2\,\text{kg}^{-2}\times4.8\times10^{22}\,\text{kg}}{\left(1.60\times10^{6}\,\text{m}\right)^2} = 1.25\,\text{N kg}^{-1}$	**(1)** **(1)**	**2**
16(b)	There is a gravitational force exerted (on Europa) by/towards Jupiter (which) provides the <u>centripetal</u> force [accept "acceleration" for "force"]	**(1)** **(1)**	**2**
16(c)	Equate $F = m\omega^2 r$ and $F = \dfrac{Gm_1m_2}{r^2}$ Use of $T = 2\pi/\omega$ $T = 3.1 \times 10^5$ s [85.3 h] **Or** Equate $F = \dfrac{mv^2}{r}$ and $F = \dfrac{Gm_1m_2}{r^2}$ Use of $T = 2\pi\, \text{r} / v$ $T = 3.1 \times 10^5$ s <u>Example of calculation</u> $\omega = \sqrt{\dfrac{6.7\times10^{-11}\,\text{N m}^2\,\text{kg}^{-2}\times1.9\times10^{27}\,\text{kg}}{\left(6.71\times10^{8}\,\text{m}\right)^3}} = 2.05\times10^{-5}\,\text{s}^{-1}$ $T = \dfrac{2\pi}{2.05\times10^{-5}\,\text{s}^{-1}} = 3.07\times10^{5}\,\text{s}$	**(1)** **(1)** **(1)** **(1)** **(1)** **(1)**	**3**
16(d)	Use of inverse square law **Or** use of $F = \dfrac{L}{4\pi d^2}$ $\dfrac{F_1}{F_2} = \dfrac{d_2^2}{d_1^2}$ Ratio = 27:1 [allow 27 **Or** correct ratios that have not been simplified] <u>Example of calculation</u> $\dfrac{F_{\text{Earth}}}{F_{\text{Jupiter}}} = \dfrac{d^2_{\text{Jupiter}}}{d^2_{\text{Earth}}} = (5.2)^2 = 27.0$	**(1)** **(1)** **(1)**	**3**
	Total for Question 16		**10**

Question Number	Answer		Mark
17(a)	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 [for equilibrium position accept: undisplaced point **Or** fixed point **Or** central point] **Or** 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" [for equilibrium position accept: undisplaced point **Or** fixed point **Or** central point] [An equation with symbols defined correctly is valid for both marks. e.g. $a \propto -x$ **or** $F \propto -x$]	**(1)** **(1)** **(1)** **(1)**	**2**
17(b)	Sinusoidal graph [shape not starting point is important] at least 1.5 cycles [symmetrical, but tolerate a small decrease in amplitude] T = 1.6 (s) Amplitude marked as 10 (cm) **Or** A/B marked <u>Example of calculation:</u> $T = \dfrac{1}{0.625\ \text{s}^{-1}} = 1.60\ (\text{s})$ 	**(1)** **(1)** **(1)** **(1)**	**4**
17(c)	Use of $\omega = 2\pi f$ Use of $v_{max} = (\pm)\omega A$ $v = \pm\ 0.39\ \text{m s}^{-1}$ <u>Example of calculation:</u> $\omega = 2\pi \times 0.625 = 3.93\ \text{s}^{-1}$ $v = 3.93\ \text{s}^{-1} \times 0.1\ \text{m} = 0.393\ \text{m s}^{-1}$	**(1)** **(1)** **(1)**	**3**

17(d)	The archer should aim so that the arrow hits the apple when it is at maximum displacement [accept A or B] Idea that the apple is momentarily at rest at A and B [accept has minimum velocity]	**(1)** **(1)**	**2**
***17(e)**	**(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate)** Although total energy remains constant Energy is dissipated **Or** energy is transferred to thermal energy [accept heat] As work is done against frictional forces [accept "air resistance" for "frictional forces"]	**(1)** **(1)** **(1)**	**3**
	Total for Question 17		**14**

Question Number	Answer		Mark
18(a) **(i)** **(ii)**	 Initial position in white dwarf region final position must be at a greater luminosity [anywhere above a horizontal line going through position of their X]	**(1)** **(1)**	**2**
18(b)(i)	${}^{1}_{1}\text{p} + {}^{1}_{1}\text{p} \rightarrow {}^{2}_{1}\text{H} + {}^{0}_{1}\text{e}^{+} \left(+ {}^{0}_{0}\nu_{e} \right)$ [accept e **Or** $\bar{e}$ **Or** β^{+} **Or** β for e^{+}] [Accept D for H]	**(1)**	**1**
18(b)(ii)	Attempt at mass difference calculation Attempt at conversion from (M)eV to J $\Delta E = 6.6 \times 10^{-14}$ J <u>Example of calculation:</u> ΔE= (938.27 × 2) - 1875.62 - 0.51 = 0.41 MeV $\Delta E = 0.41 \text{ MeV} \times 1.6 \times 10^{-13} \text{ J MeV}^{-1} = 6.56 \times 10^{-14}$ J	**(1)** **(1)** **(1)**	 **3**
18(c)	Idea that very high densities are needed to give a collision rate which will sustain the fusion process Extremely high temperatures needed: to give protons/nuclei speeds/K.E. sufficient to overcome (electrostatic) repulsive forces for protons/nuclei to come close enough together for fusion to occur **Or** for protons/nuclei to come close enough together for the strong (nuclear) force to act	**(1)** **(1)** **(1)**	 **3**

***18(d)**	(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate) (Hydrogen) fuel for fusion is virtually unlimited, Fission relies upon (uranium) a relatively limited resource Fusion results in few/no radioactive products (Radioactive) products produced in fission present significant storage/disposal / transportation problems For a given mass of fuel, the energy released by fusion is greater than the energy released by fission [accept greater energy density for fusion reactions]	 **(1)** **(1)** **(1)** **(1)** **(1)**	5
	Total for Question 18		**14**