Mark Scheme (Results)

January 2013

GCE 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.

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] ✓ **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. '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.

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:

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

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

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

$= 49.4 \text{ N}$

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.

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

Question Number	Answer		Mark
11(a)	Pressure (of gas) Amount of gas **Or** mass of gas **Or** number of moles / molecules / atoms	**(1)** **(1)**	**2**
11(b)	Extending/extrapolating the line backwards The volume occupied by a gas will be zero at a particular temperature **Or** The graphs for different gases All cut the x axis at the same temp	**(1)** **(1)** **(1)** **(1)**	**2**
	Total for question 11		**4**

Question Number	Answer		Mark
12(a)	Use of $\lambda = \ln 2/t_{1/2}$ $\lambda = 1.22 \times 10^{-4}$ (yr^{-1}) [$\lambda = 3.86 \times 10^{-12}$ (s^{-1}), $\lambda = 2.31 \times 10^{-10}$ (min^{-1})] Use of $A = A_0 e^{-\lambda t}$ t = 950 (yr) [if $\lambda = 1.2 \times 10^{-4}$, then t = 960 (yr)] [credit answers that use a constant ratio method to find the number of half lives elapsed] Example of calculation $\lambda = \frac{0.693}{5700\text{ yr}} = 1.22 \times 10^{-4}\text{ yr}^{-1}$ $14.7\text{ s}^{-1} = 16.5\text{ s}^{-1} \times e^{-1.22\times10^{-4}\text{ yr}^{-1}\times t}$ $t = \frac{\ln\left(\frac{14.7\text{ s}^{-1}}{16.5\text{ s}^{-1}}\right)}{-1.22 \times 10^{-4}\text{ yr}^{-1}} = 947\text{ yr}$	**(1)** **(1)** **(1)** **(1)**	**4**
12 (b)	Initial value of count rate should be bigger than 16.5 min^{-1} **Or** greater count rate from living wood in the past [e.g. A/A_0 smaller] **Or** initial value of count rate underestimated in the calculation **Or** Initial number of undecayed atoms greater [e.g. N/N_0 smaller] Age of sample has been underestimated **Or** ship is older than 950 yr **Or** sample has been decaying for a longer time [If a calculation has been carried out to show that a greater value of initial activity leads to a greater age, then award both marks]	 **(1)** **(1)**	**2**
	Total for question 12		**6**

Question Number	Answer		Mark
13	Use of $\lambda_{max} T = 2.898 \times 10^{-3}$ m K T = 3400 (K) Use of $L = 4\pi r^2 \sigma T^4$ $r_B = 6.8 \times 10^{11}$ (m) [8.82×10^{11} m if T = 3000 K, 6.87×10^{11} m if T = 3400 K] r_B/r_S = 980 [1270 if T = 3000 K, 988 if T = 3400 K] <u>Example of calculation</u> $T = \frac{2.898 \times 10^{-3}\,\text{m K}}{850 \times 10^{-9}\,\text{m}} = 3410\,\text{K}$ $r_B = \sqrt{\frac{4.49 \times 10^{31}\,\text{W}}{4\pi \times 5.67 \times 10^{-8}\,\text{W m}^{-2}\text{K}^{-4} \times (3410\,\text{K})^4}} = 6.83 \times 10^{11}\,\text{m}$ $\frac{r_B}{r_S} = \frac{6.83 \times 10^{11}\,\text{m}}{6.95 \times 10^{8}\,\text{m}} = 983$	**(1)** **(1)** **(1)** **(1)** **(1)**	**5**
	Total for question 13		**5**

Question Number	Answer		**Mark**
14	**QWC – Work must be clear and organised in a logical manner using technical wording where appropriate** Standard candles are (stellar) objects of known luminosity Standard candle's brightness on earth is measured/known/found [accept apparent magnitude or flux in place of brightness] [Do not accept 'used' in place of 'measured'] Use inverse square law [$F=L/4\pi d^2$] **Or** use distance modulus method [M – m = 5log(d/10)] (Hence) distance to standard candle is calculated Dust layer will reduce brightness /magnitude/flux of Cepheid Cepheid will appear to be further away than it is [accept "star" for "standard candle" or for "Cepheid" for MP2 to MP6]	 **(1)** **(1)** **(1)** **(1)** **(1)** **(1)**	**6**
	Total for question 14		**6**

Question Number	Answer		Mark
15(a)(i)	Calculation of average time period [accept average time for 10T] Use of $f = \frac{1}{T}$ f = 1.5 Hz Example of calculation $T = \frac{t_1 + t_2 + t_3}{30} = \frac{(6.2 + 6.6 + 6.9)\text{s}}{30} = 0.657\,\text{s}$ $f = \frac{1}{0.657\,\text{s}} = 1.52\,\text{Hz}$	**(1)** **(1)** **(1)**	**3**
15(a)(ii)	Force (or acceleration): proportional to displacement from equilibrium position always acting towards the equilibrium position **Or** always in the opposite direction to the displacement [accept rest/centre point for “equilibrium position”] [both marks can be gained from an equation with terms clearly defined including a correct reference to the negative sign]	 **(1)** **(1)**	**2**
15(b)	There is (large) drag force [accept air resistance for drag] Producing a deceleration **Or** the oscillation is (heavily) damped **Or** energy is transferred/removed from the system [e.g. transferred to the surroundings.] [Do not accept “lost” for “transferred”]	**(1)** **(1)**	**2**
15(c)	Resonance Driven at a frequency equal/near the natural frequency of the wings [accept their answer to (a) as a numerical value] [for “driven” accept “forced/made to oscillate”]	**(1)** **(1)**	**2**
	Total for question 15		**9**

Question Number	Answer		Mark
16(a)	Calculate gradient of line Identify gradient with H **Or** use of v = Hd for a point on the line Use of t = 1/H $t = 4.5 \times 10^{17}$ s (accept answers in range 4.2×10^{17} s to 4.8×10^{17} s) **Alternative method:** Pair of d, v values read from the line Values chosen from the upper end of the line Use of t = d/v $t = 4.5 \times 10^{17}$ s [$\pm 0.3 \times 10^{17}$ s] [$t = 1.4 \times 10^{10}$ yr [$\pm 0.1 \times 10^{10}$ yr] <u>Example of calculation</u> $H = \text{gradient} = \frac{(11000-0)\times 10^{3}\,\text{m s}^{-1}}{(50-0)\times 10^{23}\,\text{m}} = 2.2\times 10^{-18}\,\text{s}^{-1}$ $t = \frac{1}{H} = \frac{1}{2.2\times 10^{-18}\,\text{s}^{-1}} = 4.5\times 10^{17}\,\text{s}$	(1) (1) (1) (1) (1) (1) (1) (1)	4
16* (b)	**QWC – Work must be clear and organised in a logical manner using technical wording where appropriate** Measure wavelength of light (from the galaxy) Compare it to the wavelength for a source on the Earth Reference to spectral line **o**r line spectrum Reference to Doppler effect/shift **Or** redshift *v* is found from: fractional change in wavelength equals ratio of speed of source to speed of light **Or** see reference to $\frac{\Delta\lambda}{\lambda} = \frac{v}{c}$ with terms defined **Or** see reference to $z = \frac{v}{c}$ with terms defined [accept answers in terms of frequency rather than wavelength]	(1) (1) (1) (1) (1)	5
16*(c)	**QWC – Work must be clear and organised in a logical manner using technical wording where appropriate** **Max 3** (Due to the) difficulty in making accurate measurements of distances to galaxies Hubble constant has a large uncertainty **Or** age = 1/H may not be valid as gravity is changing the expansion rate Because of the existence of dark matter Values of the (average) density/mass of the universe have a large uncertainty [accept not known] (Hence) measurements of the critical density of the Universe have a large uncertainty Dark energy may mean we don't understand gravity as well as we thought we did (so it's hard to predict how gravity will determine the ultimate fate)	 (1) (1) (1) (1) (1) (1)	3
	Total for question 16		**12**

Question Number	Answer		Mark
17(a)	The gravitational field strength [accept "g"] decreases **Or** the (gravitational) force on the satellite/object/mass decreases It is a centripetal force (and not a centrifugal force) The satellite is accelerating and so is not in balance	 **(1)** **(1)** **(1)**	 **3**
17(b)(i)	See $\frac{mv^2}{r} = \frac{GmM_E}{r^2}$ **Or** $m\omega^2 r = \frac{GMm}{r^2}$ $\therefore v^2 = \frac{GM_E}{r}$ **Or** $v = \sqrt{\frac{GM_E}{r}}$ GM_E is constant (and so v decreases as r increases) **Or** $v^2 \propto \frac{1}{r}$ **Or** $v \propto \frac{1}{\sqrt{r}}$	**(1)** **(1)** **(1)**	 **3**
17(b)(ii)	State $T = \frac{2\pi}{\omega}$ and $\omega = \frac{v}{r}$ **Or** $T = \frac{s}{v}$ and $s = 2\pi r$ Hence $T = \frac{2\pi r}{v}$ (so smaller v leads to a larger value of T) [Accept $T = \frac{2\pi GM_E}{v^3}$ for final mark]	**(1)** **(1)**	 **2**
17(c)	Use of $T = \sqrt{\frac{4\pi^2 r^3}{GM}}$ T = 5530 s [92 minutes] <u>Example of calculation</u> $T = \sqrt{\frac{4\pi^2 r^3}{GM}} = \sqrt{\frac{4\pi^2 (6360000\,\mathrm{m} + 400000\,\mathrm{m})^3}{6.67 \times 10^{-11}\,\mathrm{N\,m^2\,kg^{-2}} \times 5.98 \times 10^{24}\,\mathrm{kg}}} = 5530\,\mathrm{s}$	**(1)** **(1)**	 **2**
17(d)	**Max 2** As radius decreases: There is a transfer of gravitational potential energy to kinetic energy [Accept kinetic energy increases and gravitational potential energy decreases] Sum of kinetic and gravitational potential energy decreases **Or** satellite does work against frictional forces **Or** transfer of kinetic energy of satellite to thermal energy **Or** heating occurs	 **(1)** **(1)**	 **2**
	Total for question 17		**12**

Question Number	Answer		Mark
18 (a)(i)	$$N+\ \alpha \rightarrow {}^{17}_{8}O + {}_{1}p$$ All values correct	(1)	1
18(a)(ii)	In nuclear fission a chain reaction can be set up **Or** in a chain reaction the (total) energy released can be very large **Or** heavier/larger nuclei release much more energy **Or** a very high reaction rate releases much more energy	(1)	1
18 (b)	Attempt at mass deficit calculation Use of $\Delta E = c^2 \Delta m$ (Allow use of 1 u = 1.66×10^{-27} kg) Use of 1 MeV = 1.6×10^{-13} J (Allow use of 1u = 931.5 MeV/c^2) ΔE = 174 MeV <u>Example of calculation</u> $\Delta m = (390.29989 - 233.99404 - 152.64708 - (2 \times 1.67493)) \times 10^{-27}\ \text{kg}$ $\Delta m = 3.0891 \times 10^{-28}\ \text{kg}$ $\Delta E = (3.00 \times 10^{8}\ \text{m s}^{-1})^2 \times 3.0891 \times 10^{-28}\ \text{kg} = 2.780 \times 10^{-11}\ \text{J}$ $\Delta E = \dfrac{2.780 \times 10^{-11}\ \text{J}}{1.60 \times 10^{-13}\ \text{J MeV}^{-1}} = 173.8\ \text{MeV}$	(1) (1) (1) (1)	4
18 (c)(i)	Same number of protons [do not accept atomic/proton number], Different numbers of neutrons [do not accept mass/nucleon/neutron number]	(1) (1)	2
18(c)(ii)	Correct calculation for ω [see 6283 or 2000π or $\dfrac{60\,000 \times 2\pi}{60}$] a = (-) 5.9×10^{6} m s^{-2} <u>Example of calculation</u> $a = -\left(\dfrac{60000 \times 2\pi}{60\ \text{s}}\right)^2 \times 15 \times 10^{-2}\ \text{m} = 5.92 \times 10^{6}\ \text{m s}^{-2}$	(1) (1)	2
18(c)(iii)	**Max 2** Stiff/stiffness Strong/strength Low density	 (1) (1) (1)	2
18(d)	Use of ΔE = mcΔθ Rate at which energy is removed = 3.1×10^{9} (W) Use of the efficiency equation [must have 2.2×10^{9} (W) on top line] Efficiency = 42% [accept 0.42] <u>Example of calculation</u> $\Delta E = 70000\ \text{kg} \times 3990\ \text{J kg}^{-1}\ \text{K}^{-1} \times 11\text{K} = 3.07 \times 10^{9}\ \text{J}$ $\%\ \text{efficiency} = \dfrac{\text{useful power output}}{\text{total power input}} \times 100 = \dfrac{2.2 \times 10^{9}\ \text{W}}{(2.2 + 3.1) \times 10^{9}\ \text{W}} \times 100 = 41.5\%$	(1) (1) (1) (1)	4
	Total for question 18		**16**

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