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Mark Scheme (Results)

June 2011

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.

Physics Specific Marking Guidance

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:

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.]

This has a clear statement of the principle for awarding the mark, supported by some examples illustrating acceptable boundaries.

Mark scheme format

- Bold lower case will be used for emphasis.
- Round brackets ( ) indicate words that are not essential e.g. "(hence) distance is increased".
- Square brackets [ ] indicate advice to examiners or examples e.g. [Do not accept gravity] [ecf].

Unit error penalties

- A separate mark is not usually given for a unit but a missing or incorrect unit will normally cause the final calculation mark to be lost.
- Incorrect use of case e.g. 'Watt' or 'w' will not be penalised.
- 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.
- The same missing or incorrect unit will not be penalised more than once within one question but may be penalised again in another question.
- 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.
- The mark scheme will indicate if no unit error penalty is to be applied by means of [no ue].

Significant figures

- 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.
- Use of an inappropriate number of significant figures will normally be penalised in the practical examinations or coursework.
- Using $g = 10\ m\ s^{-2}$ **will** be penalised.

Calculations

- Bald (i.e. no working shown) correct answers score full marks unless in a 'show that' question.
- Rounding errors will not be penalised.
- 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.
- 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.
- recall of the correct formula will be awarded when the formula is seen or implied by substitution.
- The mark scheme will show a correctly worked answer for illustration only.

Question Number	Answer	Mark
1	A	**1**
2	D	**1**
3	A	**1**
4	D	**1**
5	C	**1**
6	D	**1**
7	C	**1**
8	B	**1**
9	D	**1**
10	A	**1**

Question Number	Answer		Mark
11(a)	(A star/astronomical) object of known luminosity (due to some characteristic property of the star/object)	**(1)**	**1**
11(b)	Use of $F = L/4\pi d^2$ $F = 1.09 \times 10^{-7}$ W m^{-2} <u>Example of calculation</u> $F = \frac{L}{4\pi d^2} = \frac{8.94 \times 10^{27}\,\text{W}}{4\pi(8.08 \times 10^{16}\,\text{m})^2} = 1.0896 \times 10^{-7}\,\text{W m}^{-2}$	**(1)** **(1)**	**2**
	Total for question 11		**3**

Question Number	Answer		Mark
12(a)	See $F = mg$ and $F = (-)GmM/r^2$ Equate and cancel m on either side	**(1)** **(1)**	**2**
12(b)	Substitute into $g = GM/r^2$ to obtain $g = 9.78$ N kg^{-1} [condone m s^{-2}] <u>Example of calculation</u> $g = \frac{GM}{r^2} = \frac{6.67 \times 10^{-11}\,\text{N m}^2\,\text{kg}^{-2} \times 5.97 \times 10^{24}\,\text{kg}}{(6.38 \times 10^6\,\text{m})^2} = 9.783\,\text{N kg}^{-1}$	**(1)**	**1**
	Total for question 12		**3**

Question Number	Answer		Mark
13(a)	Use of $P=IV$ $I = 9.1$ A <u>Example of calculation</u> $I = \frac{P}{V} = \frac{2100\ \text{W}}{230\ \text{V}} = 9.13\ \text{A}$	**(1)** **(1)**	**2**
13(b)(i)	Use of $\Delta E = mc\Delta\theta$ (for t =1s) $\theta = 51^{o}$C or 324 K <u>Example of calculation</u> $\Delta\theta = \frac{\Delta E}{mc} = \frac{2100\ \text{J}}{0.068\ \text{kg} \times 1010\ \text{J kg}^{-1}\ {}^{o}\text{C}^{-1}} = 30.6\ {}^{o}\text{C}$ $\theta = 30.6 + 20 = 50.6\ {}^{o}$C	**(1)** **(1)**	**2**
13(b)(ii)	Thermal energy (is transferred) to <u>air</u> (molecules) Kinetic energy [E_k] of (air) molecules is increased	**(1)** **(1)**	**2**
	Total for question 13		**6**

Question Number	Answer		Mark
14(a)(i)	Use of p/T= a constant $p = 1.8 \times 10^5$ (Pa) (no ue) <u>Example of calculation</u> $\frac{p_2}{T_2} = \frac{p_1}{T_1}$ $\therefore p_2 = \frac{(273+40)\ \text{K} \times 1.65 \times 10^5\ \text{Pa}}{(273+20)\ \text{K}} = 1.76 \times 10^5\ \text{Pa}$	**(1)** **(1)**	**2**
14(a)(ii)	Air behaves as an ideal gas / mass of air remains constant / number of molecules remains constant/same amount of air/number of moles remains constant/no air escapes	**(1)**	**1**
14(b)	Use of $V = 4\pi r^3/3$ Use of $pV = NkT$ $N = 1.5 \times 10^{22}$ <u>Example of calculation</u> $V = \frac{4\pi r^3}{3} = \frac{4\pi(\frac{0.225\ \text{m}}{2})^3}{3} = 5.96 \times 10^{-3}\ \text{m}^3$ $N = \frac{pV}{kT} \therefore \Delta N = \frac{V(p_2 - p_1)}{kT}$ $\Delta N = \frac{5.96 \times 10^{-3}\ \text{m}^3 (1.76 \times 10^5 - 1.65 \times 10^5)\ \text{Pa}}{1.38 \times 10^{-23}\ \text{J K}^{-1} \times 313\ \text{K}}$ $\Delta N = 1.52 \times 10^{22}$	**(1)** **(1)** **(1)**	**3**
	Total for question 14		**6**

Question Number	Answer	Mark
15(a)	Force (or acceleration): • (directly) proportional to displacement **(1)** • always acting towards the equilibrium position **(1)**	**2**
15(b)	Use of $\omega = 2\pi f$ OR $\omega = 2\pi/T$ **(1)** Use of $v = A\omega \sin\omega t$ OR $v = A\omega$ **(1)** $v = 0.35 \text{ m s}^{-1}$ **(1)** [If 5 cm or 10 cm is substituted instead of 2.5 cm then still award second mark] <u>Example of calculation</u> $\omega = 2\pi \text{ rad} \times \left(\frac{10}{4.5 \text{ s}}\right) = 14.0 \text{ rad s}^{-1}$ $v = 2.5 \times 10^{-2} \text{m} \times 14.0 \text{ s}^{-1} = 0.35 \text{ m s}^{-1}$	**3**
15(c)	Any **THREE** from • Node at fixed end or antinode at free end **(1)** • Distance from node to antinode = $\lambda/4$ **(1)** • As (vibrating) length increases, wavelength increases **(1)** • Reference to $v = f\lambda$ **(1)** • The shorter the ruler the higher the frequency **(1)**	**Max 3**
	Total for question 15	**8**

Question Number	Answer		Mark
16(a)(i)	Use of $\lambda = \ln 2/t_{½}$ Use of $dN/dt = -\lambda N$ $dN/dt = 7.6 \times 10^{13}$ (Bq) (no ue) <u>Example of calculation</u> $\lambda = \frac{\ln 2}{138 \times 24 \times 60 \times 60\ s} = 5.81 \times 10^{-8}\ s^{-1}$ $\frac{dN}{dt} = -\lambda N = -5.81 \times 10^{-8}\ s^{-1} \times 1.3 \times 10^{21} = 7.55 \times 10^{13}\ s^{-1}$	**(1)** **(1)** **(1)**	**3**
16(a)(ii)	Conversion from MeV to J Use of $P = \Delta W/\Delta t$ $P = 64$ (W) (no ue) <u>Example of calculation</u> $P = 7.55 \times 10^{13}\ s^{-1} \times 5.3 \times 1.6 \times 10^{-13} = 64\ W$	**(1)** **(1)** **(1)**	**3**
16(b)(i)	5% factor seen Use of $P = 4\pi r^2 \sigma T^4$ $T = 970\ K$ <u>Example of calculation</u> $T = \sqrt[4]{\frac{3.2\ W}{4\pi(2.25 \times 10^{-3}\ m)^2 \times 5.67 \times 10^{-8}\ W\ m^{-2} K^{-4}}}$ $T = 971\ K$	**(1)** **(1)** **(1)**	**3**
16(b)(ii)	Use of $\lambda_{max} T = 2.898 \times 10^{-3}$ $\lambda_{max} = 3.0 \times 10^{-6}$ m <u>Example of calculation</u> $\lambda_{max} = \frac{2.898 \times 10^{-3}\ m\ K}{971\ K} = 3.0 \times 10^{-6}\ m$	**(1)** **(1)**	**2**
16(b)(iii)	Infrared	**(1)**	**1**
16(c)	Alphas are highly ionising (therefore) will not penetrate the skin (and enter the body)	**(1)** **(1)**	**2**
	Total for question 16		**14**

Question Number	Answer	Mark
17(a)(i)	Use of m =1.67 x 10^{-27} kg **(1)** Use of ½ $m\langle c^2\rangle$ = 3/2 kT **(1)** c_{rms} = 2,800(m s^{-1}) (no ue) **(1)** <u>Example of calculation</u> $\langle c^2\rangle = \frac{3kT}{m} = \frac{3 \times 1.38 \times 10^{-23}\ \mathrm{J\,K^{-1}} \times 310\ \mathrm{K}}{1.0087 \times 1.66 \times 10^{-27}\ \mathrm{kg}} = 7.66 \times 10^6\ \mathrm{m^2\,s^{-2}}$ $\langle c^2\rangle = 7.66 \times 10^6\ \mathrm{m^2\,s^{-2}}$ $c_{rms} = \sqrt{7.66 \times 10^6\ \mathrm{m^2 s^{-2}}} = 2.77 \times 10^3\ \mathrm{m\,s^{-1}}$	**3**
17(a)(ii)	$^{235}_{92}\mathrm{U} + ^{1}_{0}\mathrm{n} \rightarrow ^{236}_{92}\mathrm{U} \rightarrow ^{138}_{55}\mathrm{Cs} + ^{96}_{37}\mathrm{Rb} + 2 \times ^{1}_{0}\mathrm{n}$ Nucleon, proton numbers correct [236, 55] **(1)** Number of neutrons correct [2] **(1)**	**2**
17(a)(iii)	Attempt at calculation of mass defect **(1)** Use of $\Delta E = c^2 \Delta m$ OR use of 1 u = 931.5 MeV **(1)** Use of $fission\ \ rate = \frac{power\ \ output}{energy\ per\ fission}$ **(1)** Fission rate = 8.8 × 10^{19} s^{-1} **(1)** <u>Example of calculation</u> $\Delta m = (235.0439 - 137.9110 - 95.9343 - 1.0087)\ \mathrm{u}$ $\Delta m = 0.1899 \times 1.66 \times 10^{-27}\ \mathrm{kg} = 3.15 \times 10^{-28}\ \mathrm{kg}$ $\Delta E = (3 \times 10^8\ \mathrm{m\,s^{-1}})^2 \times 3.15 \times 10^{-28}\ \mathrm{kg} = 2.84 \times 10^{-11}\ \mathrm{J}$ Fission rate $= \frac{2.5 \times 10^9\ \mathrm{W}}{2.84 \times 10^{-11}\ \mathrm{J}} = 8.8 \times 10^{19}\ \mathrm{s^{-1}}$	**4**

*17(b)(i)	(QWC- Work must be clear and organised in a logical manner using technical wording where appropriate.) Max THREE from first 5 marking points • Very high temperatures (>10^7 K)needed **(1)** • To overcome electrostatic repulsion / forces **(1)** • <u>Nuclei</u> come close enough to fuse / for strong (nuclear) force to act **(1)** • Very high densities needed **(1)** • (Together with high nuclei speeds) this gives a sufficient collision rate **(1)** • (Very high) temperatures lead to confinement problems **(1)** • Contact with container causes temperature to fall (and fusion to cease) **(1)**	Max 4
17(b)(ii)	$^{2}_{1}D + {}^{2}_{1}D \rightarrow {}^{3}_{1}H + {}^{1}_{1}X$ X is a proton [accept hydrogen nucleus] **(1)**	1
17(b)(iii)	Any **TWO** from • (Hydrogen) fuel for fusion is (virtually) unlimited whereas fission relies upon (uranium) a relatively limited resource **(1)** • Fusion results in few radioactive products, but radioactive products produced in fission present significant disposal problems **(1)** • For a given mass of fuel, the energy released by fusion is greater than the energy released by fission **(1)**	Max 2
	Total for question 17	**15**

Question Number	Answer		Mark
18(a)(i)	Gravitation OR gravity OR gravitational attraction / pull / force	(1)	1
18(a)(ii)	Use of $F = Gm_1m_2/r^2$ F = 4.2 × 10^{35} (N) (no u.e.) <u>Example of calculation</u> $F = \frac{Gm_1m_2}{r^2}$ $F = \frac{6.67\times10^{-11}\ \text{N m}^2\text{kg}^{-2}\ (1.6\times10^{39}\ \text{kg})(4.0\times10^{37}\ \text{kg})}{(3.2\times10^{15}\ \text{m})^2}$ $F = 4.17\times10^{35}$ N	(1) (1)	2
18(a)(iii)	Use of $F = m\omega^2 r$ or $F = mv^2/r$ Use of $T = 2\pi/\omega$ or $T = 2\pi r/v$ T = 108 (years) [accept 107 – 111 years] (no ue) [If r^3 appears in solution, max 1 mark out of 3. If $\omega = \sqrt{\frac{G(M+m)}{(R+r)^3}}$ used, then full credit may be given. This method leads to T = 109 years] <u>Example of calculation</u> $\omega = \sqrt{\frac{4.2\times10^{35}\ \text{N}}{(1.6\times10^{39}\ \text{kg})\times7.7\times10^{13}\ \text{m}}}$ $\omega = 1.85\times10^{-9}\ \text{rad s}^{-1}$ $T = \frac{2\pi\ \text{rad}}{1.85\times10^{-9}\ \text{rad s}^{-1}} = 3.40\times10^{9}\ \text{s}$ $T = \frac{3.40\times10^{9}\ \text{s}}{365\times24\times60\times60\ \text{s year}^{-1}} = 108\ \text{years}$	(1) (1) (1)	3

*18(b)(i)	(QWC- Work must be clear and organised in a logical manner using technical wording where appropriate.) Radiation (is received) with a longer/stretched wavelength (compared to that emitted) OR lower/smaller frequency **(1)** This indicates that distant galaxies are receding / distance between galaxies is increasing/galaxies are moving apart **(1)** (Hence) the universe is expanding / provides evidence for Big Bang **(1)**	3
18(b)(ii)	The rotational motion (of the black holes) is small compared with that due to the overall recession **(1)** (So) both black holes are still moving away OR (hence) the overall effect when the black hole is approaching is to cause a small reduction in the observed red (rather than a blue) shift **(1)** ALTERNATIVE APPROACH: Reference to plane of orbit being perpendicular to line of sight from the Earth **(1)** Therefore there is no change in wavelength due to rotation of black holes **(1)**	2
18(b)(iii)	Use of $z = v/c$ **(1)** Use of $v = H_0 d$ **(1)** $d = 7.1 \times 10^{25}$ m **(1)** <u>Example of calculation</u> $v = Zc = 0.38 \times 3 \times 10^8 \text{ m s}^{-1} = 1.14 \times 10^8 \text{ m s}^{-1}$ $d = \frac{1.14 \times 10^8 \text{ m s}^{-1}}{1.6 \times 10^{-18} \text{ s}^{-1}} = 7.13 \times 10^{25}$ m	3
	Total for question 18	**14**

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