Mark Scheme (Results)

January 2013

GCE Physics (6PH04) Paper 01
Physics On The Move

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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	B	**1**
3	D	**1**
4	C	**1**
5	D	**1**
6	B	**1**
7	C	**1**
8	A	**1**
9	B	**1**
19	C	**1**

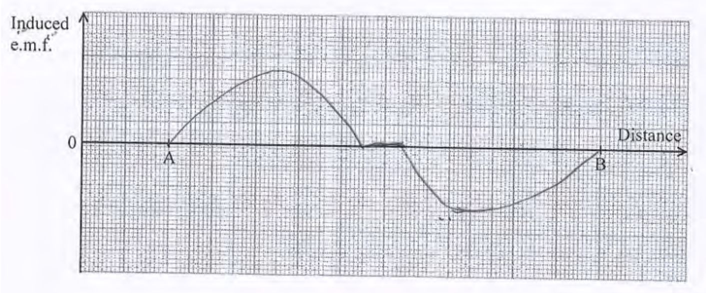
Question Number	Answer		Mark
11(a)	To prevent interaction/deflection/collision of the alpha particle with the air. [do not accept: 'don't get in the way' , 'cause ionisation', 'interfere with'. Looking for a definite interaction between the alpha and the air molecules. Accept air particles]	**(1)**	**1**
11(b)	**MAX TWO** Nucleus (very) much smaller than separation of nuclei **Or** nucleus (very) much smaller than the atom Nucleus is charged (don't penalise if candidate says positively charged) Nucleus is (very) dense **Or** nucleus is massive **Or** nucleus contains most of the mass (no credit for candidates referring to the atoms and not the nucleus.)	**(1)** **(1)** **(1)**	**2**
11(c)	**Top Particle** Path curves up with less deflection than for particle shown and must cross the printed line. **Or** a straight path. **Bottom Particle** Path curves up with more deflection than for particle shown Greatest curvature before greatest curvature of particle shown. (dependent mark) <u>Example</u> 	**(1)** **(1)** **(1)**	**3**
	Total for question 11		**6**

Question Number	Answer		Mark
12(a) (i)	Use of $\lambda = h/p$ and $p = mv$ **Or** $v = h/m\lambda$ Use of $m = 9.11 \times 10^{-31}$ kg $v = 7.28 \times 10^{6}$ m s^{-1} <u>Example of calculation</u> $\lambda = h/mv$ $v = 6.63 \times 10^{-34}$ J s /(9.11×10^{-31} kg $\times$ 1.0×10^{-10} m) $v = 7.28 \times 10^{6}$ m s^{-1}	**(1)** **(1)** **(1)**	**3**
12(a) (ii)	Use of $E_k = ½\, mv^2$ **Or** $E_k = p^2/2m$ **Or** see $E_k = 2.41 \text{ x } 10^{-17}$ J Divided by 1.60×10^{-19} $E_k = 151$ eV (accept values in range 150 – 152 eV) (ecf value of v from (a)) <u>Example of calculation</u> $E_k = ½\,(9.11 \times 10^{-31}$ kg)(7.28×10^{6} m s^{-1})^2 / (1.60×10^{-19} J eV^{-1}) $E_k = 151$ eV	**(1)** **(1)** **(1)**	**3**
12(b)	The wavelength is similar in size to the nucleus The wavelength /nucleus is (much) smaller / 10^{-15}m / 10^{-14} m (if value is not given, ‘wavelength is small’ or ‘wavelength is very small’ is not sufficient)	**(1)** **(1)**	**2**
	Total for question 12		**8**

Question Number	Answer		Mark
13(a)	Use of $v = 2\pi r/t$ **Or** $v = r\omega$ **and** $T = 2\pi/\omega$ $t = 1.5 \times 10^3$ s [24.6 minutes] <u>Example of calculation</u> $t = 2\pi r/v$ $t = (2\pi \times 61\text{ m}) / 0.26\text{ m s}^{-1}$ $t = 1473$ s	**(1)** **(1)**	**2**
13(b)	Use of $F = mv^2/r$ $F = 11$ N <u>Example of calculation</u> $F = 9.7 \times 10^3\text{ kg} \times (0.26\text{ m s}^{-1})^2 / 61\text{ m}$ $F = 10.7$ N	**(1)** **(1)**	**2**
13(c)(i)	Three arrows all pointing to the centre of the circle (accept free hand and lines of varying length)	**(1)**	**1**
***13(c)(ii)**	(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate) Maximum at C / bottom **and** Minimum at A / top At C contact/reaction force (R) greater than weight (accept $R - W = mv^2/r$ or $R = W + mv^2/r$) At A contact/reaction force is less than the weight. (accept $W - R = mv^2/r$ or $R = W - mv^2/r$) Any statement that centripetal force / acceleration is provided by weight/reaction **Or** centripetal force is the resultant force This is a qwc question so a bald statement of the equations can score the marks but to get full marks there must be clear explanation in words.	**(1)** **(1)** **(1)** **(1)**	**4**
	Total for question 13		**9**

Question Number	Answer		Mark
14(a)	Weight/W/mg vertically down Tension/T parallel to thread and pointing away Electrical (force) horizontal to left Accept electrostatic (force), repulsive (force), coulomb (force) repelling (force). Do **not** accept just F or drag All three correct 2 marks Any two correct 1 mark The lines must start on the ball and have arrow heads to indicate direction. Minus 1 mark for each extra force line. (Candidates who draw forces on M correctly but also include forces on N score 1)		**2**
14(b)(i)	Use of $T \cos 35° = mg$ **Or** $T \sin 55° = mg$ g to kg and × 9.81 Tension = 3.2×10^{-2} (N) <u>Example of calculation</u> $T \cos 35° = mg$ $T = (2.7 \times 10^{-3}\ \text{kg} \times 9.81\ \text{N kg}^{-1}) / \cos 35°$ $T = 0.0323$ N	**(1)** **(1)** **(1)**	**3**
14(b)(ii)	Equates electric force to $T \sin 35°$ **Or** $T \cos 55°$ **Or** $W \tan 35°$ **Or** use of pythagoras $F_E = 0.018$ **Or** 0.019 (N) ($F_E = 0.017$ N if show that value used. ecf T from (i) <u>Example of calculation</u> $F_E = 0.032 \times \sin 35°$ $F_E = 0.018$ N	**(1)** **(1)**	**2**
14(b)(iii)	Use of $F = Q^2/4\pi\varepsilon_0 r^2$ **Or** $F = kQ^2/r^2$ (ecf value of F from (ii) conversion cm to m $Q = (2.9 - 3.1) \times 10^{-7}$ C (candidates who half the value of r can score the first 2 marks) <u>Example of calculation</u> $Q^2 = Fr^2/k$ $Q^2 = (0.020\ \text{N}) \times (20.6 \times 10^{-2}\ \text{m})^2/(8.99 \times 10^9\ \text{N m}^2\ \text{C}^{-2})$ $Q = 3.07 \times 10^{-7}$ C	**(1)** **(1)** **(1)**	**3**
14(c)	Both balls would move through the same angle/distance **Or** the balls are suspended at equal angles (to the vertical) (Because) the force on both balls is the same	**(1)** **(1)**	**2**
	Total for question 14		**12**

Question Number	Answer		Mark
15(a)	Use of $Q = CV$ $Q = 0.18$ C <u>Example of calculation</u> $Q = 150 \times 10^{-6}$ F × 1200 V $Q = 0.18$ C	**(1)** **(1)**	**2**
15(b)	Use of $W = ½\, CV^2$ **Or** of $W = ½\, QV$ **Or** of $W = ½\, Q^2/C$ $W = 110$ J Allow ecf from (a) if ½ QV or ½ Q^2/C used <u>Example of calculation</u> $W = ½ \times 150 \times 10^{-6}$ F × (1200 V)^2 $W = 108$ J	**(1)** **(1)**	**2**
15(c)(i)	R = 86 (Ω) <u>Example of calculation</u> $R = V/I$ = 1200 V / 14 A $R = 85.7$ Ω	**(1)**	**1**
15(c)(ii)	$Q = 0.25\, Q_0$ **Or** $Q = 0.045$ C Use of RC (0.013 s) Use of $Q = Q_0\, e^{-t/RC}$ to give $t = 0.018$ s (show that value will give $t = 0.019$ s) [Use of ln 4 gives the correct answer if the − sign is ignored , scores 1 for use of RC use of ¾Q →3.7 × 10^{-3} s scores 1 mark] **Or** Use of RC Use of 2 × 0.69 × RC $t = 0.018$ s <u>Example of calculation</u> $Q = 0.25\, Q_0$ $Q = Q_0\, e^{-t/RC}$ $0.25\, Q_0 = Q_0\, e^{-t/RC}$ ln (0.25) = **-** t/ (86 Ω × 150 × 10^{-6} F) $t = 0.0178$ s	**(1)** **(1)** **(1)**	**3**
15(c)(iii)	Same charge (flows for shorter time) **OR** (Same charge flows for) shorter time	**(1)**	**1**
	Total for question 15		**9**

Question Number	Answer		Mark
16*(a)	(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate) **Max 6 from** Reference to changing/cutting of field/flux Induced e.m.f. proportional to rate of change/cutting of flux (linkage) (accept equation) Initial increase in e.m.f. as the magnet gets closer to the coil Identifies region of negative gradient with magnet going through the coil Indication that magnet's speed increases as it falls Negative (max) value › positive (max) value (this mark is dependent on awarding marking point 5) Time for second pulse shorter (this mark is dependent on awarding marking point 5) The areas of the two parts of the graph will be the same (since Nφ constant)	 **(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)**	**6**
16(b)	Two sequential pulses (if **not** two sequential pulses, scores zero) Pulses same height (+/- 3 mm squares) and width (by eye) Pulses in opposite directions Region of zero e.m.f. in the middle <u>Example</u> (peaks could be in opposite directions) 	**(1)** **(1)** **(1)** **(1)**	**4**
	Total for question 16		**10**

Question Number	Answer		Mark
17(a)	4 is the number of nucleons **Or** number of neutrons and protons **Or** mass number **Or** nucleon number 2 is the number of protons **Or** proton number **Or** atomic number	**(1)** **(1)**	**2**
17(b)(i)	(The particles are moving) close to the speed of light	**(1)**	**1**
17(b)(ii)	To create particle /antimatter **Or** To allow (large) repulsive forces to be overcome **Or** To break the particles (into their constituents)	**(1)**	**1**
17(b)(iii)	Mass = 4u (accept use of $4m_p$) Use of $E = mc^2$ Division by e Mass = 3.74 (GeV/c^2) (use of mass of proton instead of u → 3.76 GeV/c^2) <u>Example of calculation</u> mass = $4 \times 1.66 \times 10^{-27}$ kg = 6.64×10^{-27} kg $mc^2 = 6.64 \times 10^{-27}$ kg × (3×10^8 m $s^{-1})^2 = 6.0 \times 10^{-10}$ J 6.0×10^{-10} J / 1.6×10^{-19} Mass = 3.74 GeV/c^2	**(1)** **(1)** **(1)** **(1)**	**4**
17(b)(iv)	They meet matter (helium nuclei) and <u>annihilate</u>	**(1)**	**1**
17(b)(v)	Use of $E = hf$ ecf E from (iii) Frequency = 9.02×10^{23} Hz (using 3.74 GeV/c^2) (3.76 GeV/c^2 →9.07×10^{23} Hz 4 GeV/c^2 →9.65×10^{23} Hz) (half or double these values, due to a stray 2 can score 1st mark) (use of $\lambda=h/p$ scores 0) <u>Example of calculation</u> $f = 3.74 \times 10^9 \times 1.6 \times 10^{-19}$ J / 6.63×10^{-34} Js $f = 9.02 \times 10^{23}$ Hz	**(1)** **(1)**	**2**
17(c)(i)	<u>Quark</u> and <u>antiquark</u>	**(1)**	**1**
17(c)(ii)	$\bar{p}$ consists of $\bar{u}\,\bar{u}\,\bar{d}$ $-\frac{2}{3}e - \frac{2}{3}e + \frac{1}{3}e = -e$ must be consistent with structure of $\bar{p}$ $\bar{n}$ consists of $\bar{d}\,\bar{d}\,\bar{u}$ $+\frac{1}{3}e + \frac{1}{3}e - \frac{2}{3}e = 0$ must be consistent with structure of $\bar{n}$ (The sum must be clearly shown for marks 2 & 4)	**(1)** **(1)** **(1)** **(1)**	**4**
	Total for question 17		**16**
	Total for this paper		**80**

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