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Mark Scheme

Jan 2010

GCE

GCE Physics (6PH04/01)

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Edexcel Phyics Unit 4 Jan 10

Question Number	Answer	Mark
1	B	**1**
2	A	**1**
3	D	**1**
4	C	**1**
5	C	**1**
6(i)	B	**1**
6(ii)	C	**1**
7(i)	C	**1**
7(ii)	A	**1**
7(iii)	D	**1**

Question Number	Answer	Mark
8	QWC i and iii – Spelling of technical terms must be correct and the answer must be organised in a logical sequence Observations: Most alpha went straight through **(1)** Some deflected **(1)** (Very) few came straight back/large angle **(1)** Conclusions: Atom mainly (empty) space **(1)** Nucleus contains most of the mass **(1)** (Nucleus) very small/tiny **(1)** (Nucleus) charged /positive **(1)**	**QWC** **5 max**
	Total for question	**5**

Question Number	Answer	Mark
9	Current in coil generates magnetic field **(1)** Current drops/decreases **(1)** Change of flux [accept flux cut] **(1)** Rapid/quick/short time **(1)**	

	Large emf / 200 V induced **(1)** Field / flux linkage large due to many turns **(1)**	**4 max.**
	Total for question	**4**

Question Number	Answer	Mark
10(a)	Use of $E = V/d$ **(1)** Answer = 1.5×10^{5} V m^{-1} or N C^{-1} **(1)** Eg $E = 1.5 / 10 \times 10^{-6}$	**2**
10(b)	Opposite forces (act on either end of molecule) **(1)** Molecule rotates / aligns with field **(1)** - at top / + at bottom **(1)**	**3**
	Total for question	**5**

Question Number	Answer	Mark
11(a)	Straight lines (at least 4) touching proton **(1)** Equi spread (by eye) **(1)** Arrow on at least one pointing away from proton **(1)**	**3**
11(b)	Use of $F = k\,QQ/r^2$ [requires 2 subs to qualify as use] **(1)** Know $Q_p = 1.6 \times 10^{-19}$ (C) eg $QQ = (1.6 \times 10^{-19})^2$ **(1)** Answer = 7.9×10^{-8} N **(1)** Eg F = $8.99 \times 10^{9} (1.6 \times 10^{-19})^2 / (5.4 \times 10^{-11})^2$	**3**
	Total for question	**6**

Question Number	Answer	Mark
12(a)	Use of $F = mv/t$ or $F = ma$ **(1)** Answer = 2.0×10^{5} N **(1)** Eg $F = 12000 \times 57 / 3.5$	**2**
12(b)	Arrow down labelled mg / W **(1)** Arrow up labelled eg R /reaction / force from seat **(1)** Equal length vertical arrows from a clear single point **/** centre of mass and "bottom" **(1)**	**3**
12(c)	$4mg - mg$ OR $3mg$ **(1)** $(m)v^2/r$ seen **(1)** Answer = 110 (m) **(1)**	**3**

	Eg $3mg = mv^2 / r$ $r = (57)^2 / 3g$	
12(d)	Use of KE / PE conservation **(1)** Answer = 23 (m s^{-1}) **(1)** Eg $\frac{1}{2} m(57)^2 = \frac{1}{2} mv^2 + mg139$ $v^2 = \frac{1}{2}(57)^2 - 9.81 \times 139$	**2**
12(e)	Using (m)g only **(1)** Answer r = 54 m [allow ecf] **(1)** **Eg** $mg = mv^2 / r$ $r = (23)^2 / 9.81$	**2**
	Total for question	**12**

Question Number	Answer	Mark
13(a)	Charges **(1)** Movement of electrons from one plate to the other OR one plate becomes + the other – OR until pd across C equals V_{supply} **(1)**	**2**
13(b)(i)	Use of $Q = It$ (both 0.74 and 0.1/0.2) **(1)** Recognition of milli and Δt =0.1 **(1)** Eg $Q = 0.74 \times 10^{-3} \times 0.1 = 74 \times 10^{-6}$ C	**2**
13(b)(ii)	Use of $V = Q/C$ **(1)** Explains unit conversion **(1)** Eg $V = 278 \times 10^{-6} / 100 \times 10^{-6} = 2.78$ [accept μ/μ]	**2**
13(c)(i)	Recall of RC **(1)** Answer = 0.3 (s) **(1)** Eg $T = 3000 \times 0.0001$ **plus either** 1/e or 37% of initial **(1)** =0.23 - 0.27 (s) **(1)** **or** sub in formula $I = I_0 e^{-t/RC}$ **(1)** = 0.23 - 0.27 (s) **(1)** **or** Initial Tangent drawn **(1)**	

	Time constant = 0.2-0.3 (s) **(1)**	**4**
13(c)(ii)	Plot Ln *I* **/** Log *I* **(1)** Against *t* **(1)** (dependent on first mark) or Gradients of graph (1) Against I (1) (dependent on first mark) should be straight line **(1)** (dependent on previous 2)	**3**
	Total for question	**13**

Question Number	Answer	Mark
14(a)	$u\bar{d}$ identified **(1)**	**1**
14(b)	Conversion of G **(1)** Conversion of either eV or divided by c^2 **(1)** 2.5×10^{-28} (kg) **(1)** eg $m = 0.14 \times 10^9 \times 1.6 \times 10^{-19}$ / 9×10^{16}	**3**
14(c)	QWC i and iii – Spelling of technical terms must be correct and the answer must be organised in a logical sequence Electric fields: Electric field provides force on the charge/proton **(1)** gives energy to /work done / $E = qV$/ accelerate protons **(1)** Magnetic fields: Force on moving charge/proton **(1)** Produces circular path/centripetal force **(1)** labelled diagram showing Dees with E field indicated across gap OR B field through Dees (1) E field is reversed/alternates (1)	**QWC** **4** **1 max**
14(d)	QWC i and iii – Spelling of technical terms must be correct and the answer must be organised in a logical sequence	**QWC**

	momentum **(1)** Zero / negligible momentum before **(1)** To conserve momentum **(**fragments go in all directions) **(1)**	**3**
	Total for question	**12**

Question Number	Answer	Mark
15(a)(i)	measured thickness of lead 4-5 mm **(1)** measured radius 32 - 38 mm **(1)** Value between 38 – 57 mm **(1)** Eg actual radius = 35 mm x 6 mm/4.5 mm	**3**
15(a)(ii)	Use of $p = Bqr$ [any two values sub] **(1)** Answer range 9.1 x 10^{-21} - 1.4 x 10^{-20} N s or kg m s^{-1} [allow ecf]**(1)**	**2**
15(b)	Track gets more curved above lead / r smaller above lead **(1)** Must be slowing down / less momentum / loses energy **(1)** Up [dependent on either answer above] **(1)**	**3**
15(c)	Into page **(1)** [ecf out of page if down in b]	**1**
15(d)(i)	Division by 9.11 x 10^{-31} kg **(1)** Answer range 1.0 – 1.6 x 10^{10} m s^{-1} **(1)**	**2**
15(d)(ii)	greater than speed of light **(1)** (impossible) so mass must have increased **(1)**	**2**
	Total for question	**13**

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GCE

GCE Physics (6PH04/01)

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

Question Number	Answer	Mark
11	Use of $W=mg$ Use of $F=BIL$ B = 0.04 T	**(1)** **(1)** **(1)**
	Total for question 11	**3**

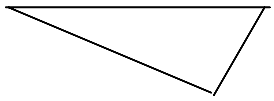
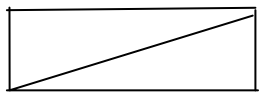
Question Number	Answer	Mark
12(a)	(Magnetic) Flux linkage	**(1)** **(1)**
12(b)	QWC (i and iii) – spelling of technical terms must be correct and the answer must be organised in a logical sequence Lenz's law / conservation of energy <u>induced</u> current/emf (direction) Opposes the <u>change</u> (that produced it)	 **(1)** **(1)** **(1)**
	Total for question	**5**

Question Number	Answer	Mark
13(a)	Conversion from per minute to per second Conversion from revolutions to radians <u>Example of calculation</u> 20 revolutions = 20 x 2π /60 (= 2.1 rads s^{-1})	**(1)** **(1)**
13(b)	Use of $r\omega^2$ Answer in range 6 – 13 ms^{-2}	**(1)** **(1)** **(1)**
	Total for question 13	**5**

Question Number	Answer	Mark
14	QWC i and iii – Spelling of technical terms must be correct and the answer must be organised in a logical sequence Momentum conservation Total/initial momentum = 0 Momentum of slime equal momentum of bacteria (Bacteria) moves in <u>opposite</u> direction [backwards or forwards OK] OR Force on slime Equal and opposite force (on bacteria) Cause rate of change of momentum / $\Delta mv/t$ /ma to bacteria (Bacteria) moves in <u>opposite</u> direction [backwards or forwards OK]	 **(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(max 4)**
	Total for question 14	**4**

Question Number	Answer	Mark
15(a)	At least 3 parallel straight lines <u>ALL</u> Equispaced (except ignore a large gap in middle) [be firm] Arrow left to right	**(1)** **(1)** **(1)**
15(b)	Use of *eV* [eg 1.6 x10^{-19} or 2000/4000] (=) ½ mv^2 Use of 2000	**(1)** **(1)** **(1)**
15(c)	Use of $v = s/t$ [eg = 1.5 / 23 (x 10^{-6})] (= 65000) Sub into previous equation m = 1.5 x 10^{-25} kg	**(1)** **(1)** **(1)**
15(d)	Some of the molecules in sample will travel further/less/not midway Duration of laser pulse Might emerge not horizontal Molecules may be doubly/integer ionised Time very small Not perfect vacuum / collides with other molecules	**(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(max2)**
	Total for question 15	**11**

Question Number	Answer	Mark
16(a)	(Trace) always positive/not negative/not below 0/ if it was AC the graph would be positive and negative Indicating one/same direction	**(1)** **(1)**
16(b)(i)	Capacitor stores charge/charges up (If voltage is constant) capacitor doesn't discharge	**(1)** **(1)**
16(b)(ii)	Recall of $E = ½ CV^2$ or use of Q=CV and QV/2 Substitution of C and any reasonable V [ignore power of 10 for C] eg $= ½\ 10 \times 10^{-6} \times 5.5^2/5.6^2$ $= 1.5 \times 10^{-4} - 1.6 \times 10^{-4}$ J	**(1)** **(1)** **(1)**
16(c)(i)	Capacitor charges up From the supply (then) Capacitor discharges Through circuit / exponentially	**(1)** **(1)** **(1)** **(1)** **(max 3)**
16(c)(ii)	Corresponding time interval for a change in V eg 6-7 ms for $\Delta V = 2V$ $V = V_o e^{-t/RC}$ or rearrangement seen [eg Ln 0.7 = 6×10^{-3} /RC] R approx 1700 Ω (allow 1600 – 1800) or Time constant = 14 – 20 ms T = RC seen R approx 1700 Ω (allow 1600 – 1800) or Corresponding time interval for a change in V eg 6-7 ms for $\Delta V = 2V$ Q = C V and I = Q/t seen R approx 1700 Ω (allow 1600 – 1800)	**(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)**
16(c)(iii)	Use larger capacitor	**(1)**
	Total for question 16	**14**

Question Number	Answer	Mark
17(a)	(Total / sum of) Kinetic energy conserved	**(1)**
17(b)	These diagrams could appear in part c and should be credited in (b)   [allow first mark for any triangle or parallelogram ie do not insist on right angle] right angle labelled or approximately by eye / diagonal should be labelled "before" or "initial" or appropriately recognisable as incoming particle	**(1)** **(1)**
17(c)	KE as formula eg ½ mu^2 = ½ mv^2 + ½ ms^2 / p^2 /2m = p^2 /2m + p^2 /2m Recognition of "Pythagoras"	**(1)** **(1)**
17(d)(i)	Electric field Does work on proton/applies a force /repel/attract qV / Fd / Eq	**(1)** **(1)** **(1)**
17(d)(ii)	Mass of incoming proton larger (than rest mass) Due to moving near speed of light/high speed/high energy/relativistic Alt answer : image not in plane of two protons after the event	**(1)** **(1)** **(2)** **(max 2)**
17(e)	Out of the plane of paper	**(1)**
	Total for question 17	**11**

Question Number	Answer	Mark
18(a)	2/3 that of a proton / 2/3 x 1.6 x 10^{-19} (C)	**(1)**
18(b)	Mass = 80 MeV/c^2 charge = +1/3	**(1)** **(1)**
18(c)	Recognition M means 10^6 Convert eV to J or divide by c^2 eg 4 x 10^6 x1.6 x 10^{-19} or /9x10^{16} Answer 7.1 x 10^{-30} (kg)	**(1)** **(1)** **(1)**
18(d)(i)	Kaon Meson Omega baryon	**(1)** **(1)**
18(ii)	K^- + p = K^+ + K^o + Ω^- [accept p or p^+ ;do not accept K for K^o ;signs must be top right]	**(1)** **(1)**
18(iii)	Kaon plus = u $\bar{s}$ Kaon neutral = d $\bar{s}$ or s $\bar{d}$ [both marks can be inferred if equation in d(ii) is fully written in quark combinations)	**(1)** **(1)**
18(iv)	QWC i and iii – Spelling of technical terms must be correct and the answer must be organised in a logical sequence Momentum conserved Charge conserved Energy / mass conserved E =mc^2 <u>Kinetic</u> Energy (of kaon minus) is responsible Momentum of three particles after = momentum of kaon before Total charge 0 / charge before and after is 0 Conservation of Baryon no, quark no, strangeness	 **(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(allow only 1 mark max from these 3)**
		5 max
	Total for question 18	**17**

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Mark Scheme (Results)
January 2011

GCE

GCE Physics (6PH04) Paper 01

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

Question Number	Answer	Mark
11(a)	Baryon (1)	**1**
11(b)	(+2/3 -1/3 + 2/3) = +1 / +1e / +e / (+)1.6 × 10^{-19} <u>C</u> (1) [Do not allow 1, 1e, e]	**1**
11(c)	($B^0 \rightarrow$) [No mark for LHS but must have an equation X = Y + Z] For RHS Λ^+ only [do not credit alternatives e.g. λ^+] (1) $\bar{p}$ only [do not credit alternatives e.g. p^-, $\bar{p}^{+/-}$] (1)	**2**
	Total for question 11	**4**

Question Number	Answer	Mark
12*	(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate) (After X) no tracks / track ceases (at X) / tracks can't be seen (after X) (1) [allow lines for tracks] (so) uncharged/neutral particles produced OR only charged particles give tracks . (1) At least one of the correct further events identified. [i.e. at the 'V' points] [in words or on diagram] (1) Both of the correct further events identified. (1)	**4**
	Total for question 12	**4**

Question Number	Answer	Mark
13(a)	Indication of vertical force(s) on sides AB or CD (1) [up or down is equivalent to vertical] Opposite vertical forces on AB and CD (1) Indication of anticlockwise rotation (1) [Allow full credit for a written description] (Commutator) switches current direction (1)	**4**
13(b)*	(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate) <u>Flux</u> (linkage) changes / <u>flux</u> is cut (1) Mention of <u>induced</u> e.m.f [allow induced voltage] (1) E.m.f increases with speed (1) Mention of Lenz's Law (1) (e.m.f./voltage) opposes current [not "reduces"] (1)	**Max 4**
	Total for question 13	**8**

Question Number	Answer	Mark
14(a)	Cannot be split further/has no internal structure / not made up of other particles (1)	**1**
14(b)	At least 4 radial straight lines [drawn with a ruler, need not touch particle] (1) Equispaced [very closely by eye] (1) Arrow pointing inwards (1) [ignore any words and mark the diagram only]	**3**
14(c)	Convert MeV to J [$\times 1.6 \times 10^{-13}$] (1) Divide by c^2 [$\div 9 \times 10^{16}$] (1) answer 205 - 214 (1) [Reverse calculation from 200 loses the third mark] <u>Example of calculation</u> 106 MeV = $106 \text{ x } 1.6 \text{ x} 10^{-13}$ J $= 106 \text{ x } 1.6 \text{ x} 10^{-13} \text{ J} / (3 \text{ x } 10^{8} \text{ m s}^{-1})^2$ ratio = $1.88 \text{ x } 10^{-28}$ kg / $9.11 \text{ x } 10^{-31}$ kg [May convert electron to 0.51 MeV]	**3**
14(d)	Use of $F = q^2/4\pi\varepsilon_0 r^2$ or $F = kq^2/r^2$ with $q = 1.6 \times 10^{-19}$ and $r = 2.7 \times 10^{-13}$ [ignore power of 10 error] (1) $F = (-)\ 3.2 \times 10^{-3}$ N (1) <u>Example of calculation</u> $F = (9 \times 10^{9} \text{ N m}^2 \text{ C}^{-2})(1.6 \times 10^{-19} \text{ C})^2 / (2.7 \times 10^{-13} \text{ m})^2$	**2**
14(e)	Mention of energy levels/states (1) Muon/electron jumps down / drops down /returns to original state (1) Large ΔE / large photon energy (hf) (1)	**3**
	Total for question 14	**12**

Question Number	Answer		Mark
15(a)(i)	Discharges / loses charge Idea that discharge is not instantaneous [e.g. over period of time, gradually, exponential]	(1) (1)	**2**
15(a)(ii)	Decay curve starting on *y*-axis and not reaching x-axis [no rise at the end] Initial current marked 2 mA X-axis labelled such that $T_{½}$ = 0.02 to 0.06 s	(1) (1) (1)	**3**
15(a)(iii)	<u>Same</u> graph On negative side of current axis/current in the opposite direction	(1) (1)	**2**
15(b)	Use of $W = ½\ CV^2$ / Use of $Q = CV$ and $W = ½\ QV$ $W = 5 \times 10^{-4}$ J <u>Example of calculation</u> $W = ½\ (10 \times 10^{-6}\ \text{F})\ (10\ \text{V})^2$ $W = 5 \times 10^{-4}$ J	(1) (1)	**2**
15(c)	Use of $\ln V/V_0 = (-)\ t/RC$ or $V = V_0\ e^{-t/RC}$ with V and V_0 correct t = 0.13 s <u>Example of calculation</u> ln(10 V/0.7 V) = t / 0.05 s t = 0.13 s	(1) (1)	**2**
	Total for question 15		**11**

Question Number	Answer	Mark
16(a)	Observations: Most alpha went straight through / undeflected (1) [Do not credit just “alphas go through”] Some / few deflected [not “reflected] (1) <u>Very</u> few / < 1 in 1000 came straight back / were deflected through very large angles (>90°) / were reflected (1)	**3**
16(b)(i)	Any mention of tubes (1) Alternating p.d. / a.c. p.d. /alternating electric field (1) Length of tubes increases (1)	**3**
16(b)(ii)	Use of $p = E/c$ with $c = 3 \times 10^{8}$ (1) (Use of de Broglie) $\lambda = h/p$ with $h = 6.6 \times 10^{-34}$ (1) wavelength = 6.2×10^{-17} m (1) <u>Example of answer</u> $p = 20 \times 1.6 \times 10^{-10}$ J / 3×10^{8} m s^{-1} = 1.1×10^{-17} N s Correct sub of h and p i.e. $\lambda = 6.6 \times 10^{-34} / 1.1 \times 10^{-17}$ N s	**3**
16(b)(iii)	Wavelengths need to be smaller than nuclei [allow same as / similar to – must be comparative] (1)	**1**
16(b)(iv)	Proton is not uniform / has space (1) Contains quarks (1) [ignore any reference to charge]	**2**
16(b)(v)	Kinetic energy is not conserved (1) [K.E. and momentum not conserved – do not credit]	**1**
	Total for question 16	**13**

Question Number	Answer	Mark
17(a)	Force on (charged) particles at right angles to motion (1) Causes circular motion [not spiral / curved] OR force/acceleration is centripetal (1) [credit first mark if clear from diagram]	**2**
17(b)(i)	Momentum: $p=mv$ or $r = mv/Be$ (1) $v = 2\pi r/T$ or $v = r\omega$ or $\omega = Be/m$ (1) Use of $f = 1/T$ or $\omega/2\pi$ (1) [allow q for e] <u>Example of calculation</u> $Ber = mv$ $Ber = m2\pi r/T$ $Be = m2\pi f$	**3**
17(b)(ii)	(Protons) accelerated / given energy, in the gaps / between D's/from one D to the other (1) Every half rotation/semicircle later (polarity of D's) needs a change (1)	**2**
17(b)(iii)	Relativistic effect / v approaching c/mass increases (1) so frequency decreases (1) [second mark consequent on first]	**2**
17(c)	must be accelerating due to circular motion (1) (Speed constant but) direction/velocity changing (1)	**2**
	Total for question 17	**11**

Question Number	Answer	Mark
18(a)*	(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate) Measurement of appropriate quantity e.g .height /distance /time (1) Calculate speed or inferred by an equation (1) Speed on impact (1) Statement of how method shows momentum has been conserved (1) [must include correct mention of mass and velocity] [correct description of measuring velocity directly with a sensor scores first two marks]	**4**
18(b)	Collisions inelastic / KE is transferred in collisions (1) to internal energy (of balls) [allow heat] / to KE of middle balls/to sound (1) Eventually stops because **all** energy is transferred (1)	**3**
	Total for question 18	**7**

Mark Scheme (Results)

June 2011

GCE Physics (6PH04) Paper 01
Physics on the Move

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

Question Number	Answer	Mark
11(a)	Identifying the equations $E_k = p^2/2m$ and $\lambda = h/p$ **OR** $\lambda = h/p$, $p = mv$ and $E_k = ½ mv^2$ **(1)** Any combination or rearrangement (conditional mark) **(1)** (do not give 2nd mark just for quoting equation given in question) (Do not credit a reverse argument i.e. starting with the given equation.) Example of derivation $p = 2mE_k$ $\lambda = h/\sqrt{(2mE_k)}$	**2**
11(b)	Correct sub of h^2 and m **(1)** Use of $E_k = eV$ **(1)** $\lambda = 2.5 \times 10^{-11}$ m **(1)** **OR** Use of $E_k = ½ mv^2$ (to find v =3.0 x10^7 (m s^{-1})) **(1)** Use of $\lambda = h/p$ with correct substitution for h and m **(1)** $\lambda = 2.5 \times 10^{-11}$ m **(1)** Example of calculation $\lambda = \sqrt{\dfrac{(6.63x10^{-34}\text{ J s})^2}{2(9.11\text{ x }10^{-31}\text{ kg})(2500\text{ V})(1.6\times10^{-19}\text{ C})}}$ $\lambda = 2.46 \times 10^{-11}$ m **OR** $v = \sqrt{\dfrac{2(2500\text{V})(1.6x10^{-19}\text{ C})}{9.1\text{ x }10^{-31}\text{ kg}}} = 3.0\text{ x}10^7$ λ= 6.63 x 10^{-34} J s / (9.1 x 10^{-31} kg)(3.0x10^7 m s^{-1})	**3**
	Total for question 11	**5**

Question Number	Answer		Mark
12(a)	Third column completed 4.04 and 3.50 Points plotted correctly **and** straight line drawn (ecf error in calculation for points plotted)	**(1)** **(1)**	**2**
12(b)	Any evidence of gradient (look at graph) Value between 0.061 and 0.066 (cm^{-1}) (ignore – sign) **Or** value between 6.1 and 6.6 (m^{-1})	**(1)** **(1)**	**2**
	Total for question 12		**4**

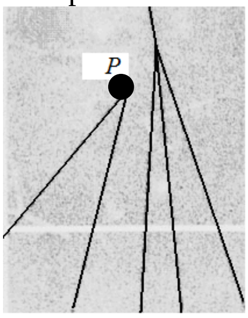
Question Number	Answer		Mark
13(a)	Method marks only Use of Q=CV with V =16 V Max value of C = 12000 (μF) μF means 10^{-6} conversion of μF to F <u>Example of calculation</u> C_{max} = 1.20 × 10000 = 12000 F C_{max} = 12000 F × 16 V Q_{max} = 0.192 C	 **(1)** **(1)** **(1)**	**3**
13(b)	Either use of ½ QV or ½ CV^2 Energy = 1.5 J <u>Example of calculation</u> W = ½ 0.192 C × 16 V Energy = 1.54 J	**(1)** **(1)**	**2**
	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 **Max 4** <u>Uniform</u> electric field (between plates) Force due to E **or** idea of attraction/repulsion (Ball has an) <u>acceleration</u> (**not** an increasing velocity) Which is constant/uniform (can be with reference to increasing velocity) Vertical line/ + and – values shows change in direction Inelastic collision/less energy after impact	 **(1)** **(1)** **(1)** **(1)** **(1)** **(1)**	**4**
	Total for question 14		**4**

Question Number	Answer		Mark
15(a)	Use of ½ mv^2 and mgh (do not credit use of $v^2 = 2as$ since a not constant, scores 0/2) velocity = 0.77 (m s^{-1})	**(1)** **(1)**	**2**
15(b)	Use of mv Correct momentum conservation statement Speed = 0.53 m s^{-1} (accept 0.56 m s^{-1} from use of show that value) Assumption: no external forces/ no air resistance/ no force on pivot/negligible resistance <u>Example of calculation</u> 320 g × 0.77 m s^{-1} = (320 g × v) + (55g × 1.4 m s^{-1}) Speed of bat = 0.53 m s^{-1}	**(1)** **(1)** **(1)** **(1)**	**4**
15(c)	Use of E_k = ½ mv^2 (allow mass in g or kg) Correct calculation of E_k before and after (95, 45, 54 to any power of ten (see below) (If 0.8 m s^{-1} and 0.56 m s^{-1}, values are 102, 50 and 54) Elastic. <u>Example of calculation</u> Before impact E_k bat = ½ 0.320 kg 0.77^2 (m $s^{-1})^2$ = 0.095J After impact E_k bat = ½ 0.320 kg 0.53^2 (m $s^{-1})^2$ = 0.045 J E_k ball = ½ 0.055 kg 1.4^2 (m $s^{-1})^2$ = 0.054 J	**(1)** **(1)** **(1)**	**3**
15(d)	**Max 2** x measured to nearest cm uncertainty in x gives an uncertainty in GPE / speed (of ball) difficulty of measuring a moving object some energy to sound comments on $E_{(k)}$ after › before relates uncertainty to conclusion made in (c)	 **(1)** **(1)** **(1)** **(1)** **(1)** **(1)**	**2**
	Total for Question 15		**11**

Question Number	Answer	Mark
16(a)	Radial lines (at least 4) most touching nucleus but not going through it (straight by eye) **(1)** Equispaced **(1)** Arrow pointing away from circle **(1)**	**3**
16(b)(i)	$F = Q_1 Q_2 / 4\pi\varepsilon r^2$ or $F = k Q_1 Q_2 / r^2$ **(1)** Charges are $79 \times 1.6 \times 10^{-19}$ and $2 \times 1.6 \times 10^{-19}$ **(1)** (values are 1.23×10^{-17} and 3.2×10^{-19})	**2**
16(b)(ii)	Marks can be scored for use of symbols, cell annotation or values $F = \Delta p/(\Delta)t$ **(1)** $(\Delta)v = (\Delta)p/m$ **(1)** $(D5) = D4 + \frac{(-)B5 \times C5}{6.64 \times 10^{-27}}$ **(1)** $(D5) = 1.24 \times 10^{7} + \frac{(-)20.2 \times 1 \times 10^{-21}}{6.64 \times 10^{-27}}$ $F/m = (-)\ 3.04 \times 10^{27}$ **OR** $a = F/m$ **(1)** $v = (u) + at$ **(1)** $(D5) = D4 + \frac{(-)B5 \times C5)}{6.64 \times 10^{-27}}$ **(1)** $(D5) = 1.24 \times 10^{7} + \frac{(-)20.2 \times 1 \times 10^{-21}}{6.64 \times 10^{-27}}$ $F/m = (-)\ 3.04 \times 10^{27}$	**3**
16(b)(iii)	$s = \frac{1}{2}(u+v)t$ accept $s = vt$ (with either D5 or D6) **Or** $s = ut + \frac{1}{2}at^2$ **(1)** $(s) = \frac{1}{2}(D5 + D6)*C6$ or values or other correct equations **(1)**	**2**
16(b)(iv)	Value in range 2.00 - 2.49($\times 10^{-14}$ m) **(1)**	**1**
***16(c)**	(QWC- Work must be clear and organised in a logical manner using technical wording where appropriate.) Atom mainly <u>empty</u> space **(1)** Charge is concentrated in the centre/in a nucleus/nucleus is charged **(1)** Mass is concentrated (at the centre) **Or** Dense/massive nucleus **(1)**	**3**
	Total for question 16	**14**

Question Number	Answer	Mark
17(a)	(Magnetic) force acts at right angles to ion motion/current **(1)** Force is the centripetal force **or** causing centripetal acceleration **or** direction of acceleration/force is to centre (of circle) **(1)**	**2**
17(b)	See $F = BQv$ **or** $r = p/BQ$ **(1)** $F = mv^2/r$ **or** $p = mv$ **(1)** $f = v/2\pi r$ **or** $f = \omega/2\pi$ **or** $T = 2\pi r/v$ **or** $T = 2\pi/\omega$ **(1)**	**3**
17(c)(i)	Identifies positive (field) above **and** below (the ion) **(1)** which repels the ion **(1)**	**2**
17(c)(ii)	$3 \times 32.0645 / 10 \times (10^6)$ **(1)** = 0.0000096(u) **(1)**	**2**
17(c)(iii)	Convert MeV to J **(1)** Convert J to kg **(1)** Convert kg to u **(1)** Mass loss = 0.0024(u) (and this is more than 0.00001u) **(1)** <u>Example of calculation</u> mass loss = 2.2 MeV x 1.6×10^{-13} J J to kg $3.52 \times 10^{-13} / 9 \times 10^{16}$ kg kg to u $3.91 \times 10^{-30} / 1.66 \times 10^{-27}$ u	**4**
	Total for question 17	**13**

Question Number	Answer		Mark
18(a)	to keep the time spent in each tube the same **Or** so that frequency of <u>alternating</u> pd/voltage constant (do not accept reference to ac currents)	**(1)**	**1**
18(b)(i)	At top of Λ  	**(1)**	**1**
18(b)(ii)	No <u>track/trail</u> to this point (as no charge) Then two tracks (as two charged particles)	**(1)** **(1)**	**2**
18(b)(iii)	$D^0 \Rightarrow k^+ + \pi^-$ Correct symbols , do not accept pi as a word Correct charge symbols as above, top right of each term. Wrong position or extra ones loses this mark (any extra particles or gamma 0/2)	 **(1)** **(1)**	**2**
***18(b)(iv)**	(QWC- Work must be clear and organised in a logical manner using technical wording where appropriate.) Charge: +1 -1= 0 (the positive sign must be used, 1 -1 = 0 is not enough) **Or** reference to positive and negative charges cancelling. Energy/mass/mass-energy: of D is equal to that of the new particles Momentum: Of D is equal to sum/total of momentum of new particles	 **(1)** **(1)** **(1)** **(1)** **(1)** **(1)**	**6**
18(c)(i)	$c\ \bar{u}$	**(1)**	**1**
18(c)(ii)	$u\bar{d}$ **or** $u\bar{s}$ **or** $c\bar{d}$ **or** $c\bar{s}$ (allow words)	**(1)**	**1**
	Total for question 18		**14**

Mark Scheme (Results)
January 2012

GCE Physics (6PH04) Paper 01
Physics on the Move

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

Question Number	Answer	Mark
11a	Space/area/region where a force acts on a charged particle **(1)** The force is the same at all points **Or** Field strength is constant **Or** Field lines equispaced **(1)** (accept diagram with a minimum of three equispaced parallel lines, with arrows for 2nd mark)	**2**
11b	Two <u>parallel</u> plates (accept wires for plates) **(1)** Connected to a potential difference **Or** potential difference is applied **(1)** Practical method to show force Eg seeds in tray of glycerol, **(1)** Charged foil on end of rule, Charged pith ball on thread, Beam of electrons (in teltron tube) Charged oil drops (do not credit charged object) (All 3 marks can be scored from a diagram. To score the third mark the set-up must be labelled.)	**3**
	Total for question 11	**5**

Question Number	Answer	Mark
***12**	(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate) Current in a wire produces a magnetic field **(1)** Identifies direction of B field around either wire **(1)** Eg Around wire so that it is into the page at the bottom of wire **Or** clockwise when looking from left (Each) wire is in the magnetic field of the other wire **(1)** A current-carrying wire in a magnetic field experiences a force **(1)** Mention of Fleming's left hand rule (accept motor rule) **Or** identifies neutral point between wires. **(1)** (Marks 1 and 2 and a labelled neutral point could be communicated using the diagram. For neutral point accept 'fields cancel' but not 'fields in opposite directions')	**5**
	Total for question 12	**5**

Question Number	Answer	Mark
***13**	(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate) **Max 5** **Observations:** Most alpha went straight through **(1)** Some deflected **(1)** Very few came straight back **Or** very few had a deflection > 90^o **Or** 1 in 8000 came straight back **(1)** (Do not credit responses in terms of 'bounced' or 'reflected'.) **Conclusions:** <u>Atom</u> mainly <u>empty</u> (space) **(1)** Charge is concentrated in the centre/in a nucleus/nucleus is charged **(1)** Mass is concentrated (at the centre) Or dense/massive nucleus **(1)**	**Max 5**
	Total for question 13	**5**

Question Number	Answer		Mark
14(a)	To curve the tracks/paths **Or** to produce a centripetal force/acceleration **Or** to allow particles to spiral **Or** to produce an arc **Or** to produce circular motion So that momentum/energy/charge/ velocity/mass can be investigated	**(1)** **(1)**	**2**
14(b)	The <u>radius</u> of curve gets less **Or** curvature increases (Because) particle slows down **Or** loses energy **Or** loses momentum	**(1)** **(1)**	**2**
14(c)	(Magnetic field) out of page	**(1)**	**1**
14(d)(i)	Does not leave a track **Or** there is only one visible track for μ^+ Clear demonstration of charge conservation in this situation	**(1)** **(1)**	**2**
14(d)(ii)	Reference to momentum Reference to change of direction of the visible path (Hence) another particle must have an equal but opposite change of momentum **Or** another particle produced to conserve momentum	**(1)** **(1)** **(1)**	**3**
	Total for question 14		**10**

Question Number	Answer		Mark
15(a)	Reference to magnetic flux (linkage) Magnet vibrates/moves Flux/field through the coil changes <u>Induces</u> emf / pd	**(1)** **(1)** **(1)** **(1)**	**4**
15(b)(i)	Use of $T = 2\pi/\omega$ for a revolution $\omega = 3.5$ rad s^{-1} <u>Example of Calculation</u> $\omega = 33 \times 2\pi$ rad/ 60 s $\omega = 3.5$ rad s^{-1}	**(1)** **(1)**	**2**
15(b)(ii)	ω / T / f remains constant $v = r\omega$ **Or** $C = 2\pi r$ So as the stylus moves towards the centre (tangential/linear) speed/velocity **Or** path length (per rotation) gets less	**(1)** **(1)** **(1)**	**3**
	Total for question 15		**9**

Question Number	Answer	Mark
16(a)(i)	Capacitor charges up **Or** p.d. across capacitor becomes (equal to) p.d. of cell **(1)** Negative charge on one plate and positive charge on the other **Or** opposite charges on each plate **Or** movement of electrons from one plate and to the other (around the circuit) **(1)** (Reference to positive charges moving or to charge moving directly between the plates negates the second mark)	**2**
16(a)(ii)	As capacitor charges current decreases **Or** As capacitor charges current drops to zero **Or** p.d. across capacitor becomes (equal to) p.d. of cell **(1)** No current through R (means no p.d.) **Or** $V_{\text{cell}} = V_{\text{capacitor}} + V_{\text{resistor}}$ **(1)**	**2**
***16(b)**	(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate) See Q=CV **(1)** As C increased then charge flows (**Or** more charge stored) on capacitor **(1)** So p.d. across R **(1)** Charge flow / current /output signal reversed when plates move apart **(1)** **Or** See Q=CV **(1)** As C increased p.d. across capacitor decreased **(1)** So p.d. across R must increase **(1)** p.d. reverses when plates move apart **(1)**	**4**
16(c)	Use of time constant =RC **Or** attempt to find half life **(1)** Time constant = 0.005 (s) **Or** $t_{½}$ = 0.0035 (s) **(1)** Use of $T = 1/f$ (to give T = 0.05 s for the lowest audible frequency) **(1)** Capacitor completes discharging/charging during cycle of signal **(1)** (last mark can only be gained if supported by calculations) ($f = 1/CR$ may be used to find the 'frequency of the microphone', rather than time. In this case candidates may just calculate f =200 Hz rather than a time. Only first 3 marks are available) <u>Example of calculation</u> $RC = 10 \times 10^{6}\ \Omega \times 500 \times 10^{-12}$ F RC = 0.005 s $F = 1/T = 1/20 = 0.05$ s	**4**
	Total for question 16	**12**

Question Number	Answer		Mark
17(a)	Same mass (do not credit similar mass) Opposite charges on nucleus **Or** atom not charged/neutral (do not credit 'atoms have opposite charges'. A correct statement in terms of charges on all four particles gets 2nd mark.) (Ignore references to Baryon number, Lepton number and quarks)	**(1)** **(1)**	**2**
17(b)	Use of $F = k Q_1 Q_2 / r^2$ Magnitude of both charges is 1.6×10^{-19} C Force = 8.2×10^{-8} N <u>Example of calculation</u> $F = 8.99 \times 10^{9}$ N m^2 C^{-2} $(1.6 \times 10^{-19}\text{ C})^2 / (5.3 \times 10^{-11})^2$ $F = 8.19 \times 10^{-8}$ N	**(1)** **(1)** **(1)**	**3**
17(c)	Atoms are not charged Magnetic / electric fields have no effect (Can't be contained in particle accelerators is not sufficient and ignore all comments about annihilation)	**(1)** **(1)**	**2**
17(d)(i)	Use of $E = mc^2$ Total mass involved is 2 mg (ignore powers of 10 error) Energy = 1.8×10^{11} (J) <u>Example of calculation</u> Energy = 2×10^{-6} kg $(3 \times 10^{8}\text{ m s}^{-1})^2$ Energy = 1.8×10^{11} J	**(1)** **(1)** **(1)**	**3**
17(d)(ii)	Need a lot of energy (to produce anti-matter)	**(1)**	**1**
	Total for question 17		**11**

Question Number	Answer		Mark
18(a)	Conversion of MeV to J Use of $E_k = ½\, mv^2$ Max velocity = 4.1×10^6 (m s^{-1}) <u>Example of calculation</u> $v = \sqrt{\dfrac{2 \times 1.2\text{Mev} \times 1.6 \times 10^{-13}\text{J}}{14 \times 1.66 \times 10^{-27}\text{kg}}}$ velocity = 4.06×10^6 m s^{-1}	**(1)** **(1)** **(1)**	**3**
18(b)(i)	Correct momentum of any particle seen e.g. N*ux* (must contain *u*) Correct equation from conservation of momentum (allow even if *u* not shown) Rearrange for z (dependent on second mark) <u>Example of calculation</u> N*ux* = 14*uy* + N*uz* N*z* = N*x* - 14*y*	**(1)** **(1)** **(1)**	**3**
18(b)(ii)	<u>Kinetic</u> energy is conserved	**(1)**	**1**
18(b)(iii)	See $½\, Nux^2$ **Or** $½\, Nuz^2$ **Or** $½\, 14uy^2$ Clear statement that E_k nitrogen atom = E_k neutron before – E_k neutron after **Or** E_k nitrogen atom = E_k lost by neutron	**(1)** **(1)**	**2**
18(c)(i)	Use of equation, N in the denominator must be included, given with $y = 3.0 \times 10^7$ **Or** $y = 4.1 \times 10^6$ In equation given use of: N + 1 with $y = 3.0 \times 10^7$ **Or** N + 14 with $y = 4.1 \times 10^6$ In equation given use of: N + 1 with $y = 3.0 \times 10^7$ **And** N + 14 with $y = 4.1 \times 10^6$ <u>Example of calculation</u> For hydrogen $2Nx = 3.0 \times 10^7 (N + 1)$ For nitrogen $2Nx = 4.1 \times 10^6 (N + 14)$ Equating gives $4.1 \times 10^6 (N + 14) = 3.0 \times 10^7 (N + 1)$ (so N = 1.06)	**(1)** **(1)** **(1)**	**3**
18(c)(ii)	Collision might not be elastic **Or** Speed (of particles) approaches speed of light (so mass increases)	**(1)**	**1**
	Total for question 18		**13**

Mark Scheme
(Results)

Summer 2012

GCE Physics (6PH04) Paper 01
Physics on the Move

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

Question Number	Answer	Mark
11(a)	Repulsive force (due to two positive/like charges) **(1)** An explicit statement relating force/repulsion to acceleration (allow F = ma) **(1)** [candidates might start with the acceleration needing a force, this is acceptable]	**2**
11(b)	At least four straight evenly spaced radial lines starting from the circle. **(1)** Arrow pointing away from centre **(1)**	**2**
	Total for question 11	**4**

Question Number	Answer	Mark
12	Considers momentum **(1)** Calculates momentum of xenon or spacecraft **(1)** Calculates a second momentum **Or** calculates speed of spacecraft **(1)** A statement that the prediction is correct **Or** a statement that the increase is (about) 8ms^{-1} **(1)** (only award this mark if based on correct calculations) (Calculation to find the speed of the Xenon or either mass scores **max 3**) <u>Example of calculation</u> Momentum of Xenon = 0.13 kg × 30000 m s^{-1} = 3900 kg m s^{-1} Momentum of spacecraft = 486 kg × 8 m s^{-1} = 3888 kg m s^{-1} **Or** Momentum of Xenon = 0.13 kg × 30000 m s^{-1} = 3900 kg m s^{-1} Momentum of spacecraft = 486 kg × v v= 3900 kg m s^{-1} / 486 kg = 8.02 m s^{-1}	4
	Total for question 12	**4**

Question Number	Answer		Mark
13	[Some candidates calculate energy × 2 and divide by 2 later on. Others omit use of 2. Both methods are correct] Uses only mass of 9.11×10^{-31} kg Use of $E = mc^2$ for 1 or 2 particles Use of $E = hf$ Use $c = f\lambda$ Wavelength = 2.43×10^{-12} m (Common wrong answers are 1.21×10^{-12} m and 0.60×10^{-12} m. These score 4 marks for correct method see below) Some candidates are getting the correct value using only $\lambda = h/p$ using the mass of the positron and the speed of light to find a momentum. This method scores1 for mass of electron/positron Some candidates are using $E = mc^2$ and $\lambda = h/p$ They could score the first two marks. <u>Example of calculation</u> $E = (9.11 \times 10^{-31}$ kg)x(9×10^{16} m^2 s^{-2}) = 8.2×10^{-14} J f = (8.2×10^{-14} J) / (6.63×10^{-34} Js) λ= (3×10^8 ms^{-1})/ (1.2×10^{20}s^{-1}) λ = 2.43×10^{-12} m	 **(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) **Max5** **Electric fields** • can be used to accelerate/deflect particles **(1)** • direction of force/deflection indicates (sign of) charge. **(1)** • $a = EQ/m$ **(1)** **Magnetic fields** • produce circular motion **Or** provides a centripetal force **Or** causes spirals/arc **(1)** • Direction of force/curvature/deflection indicates (sign of) charge. **(1)** • momentum/speed/mass found from radius/curvature **(1)** • $r = p/BQ$ **Or** $Bqv = mv^2/r$ **(1)**	**5**
	Total for question 14	**5**

Question Number	Answer	Mark
15(a)(i)	(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate there is a magnetic field in stator/(iron) core **Or** the core becomes an electromagnet **(1)** This field/flux is changing (due to the AC input) **(1)** *B* field (from the stator) passes through the rotor **(1)** (the changing magnetic flux/field leads to an) induced emf/pd **(1)**	**4**
15(a(ii)	Rotor experiences a <u>force</u> **Or** mention of FLHR **Or** $F = BIl$ **(1)** Due to the current in the **rotor** being in a magnetic field **Or** rotor becomes a magnet **(1)**	**2**
15(a)(iii)	**Max 2** Increase frequency (of current) **(1)** Increase (magnitude of) current **(1)** Add more turns (to either coil) **(1)**	**2**
15(b)(i)	T = 60/33(1,82 s) **Or** f =33/60 (0.55 s^{-1}) **(1)** Use of $\omega = 2\pi/T$ **Or** $w = 2\pi/f$ **(1)** ω= 3.5 rad s^{-1} **(1)** [11.4 rad s^{-1} scores 1; 3.2 x 10^{-3} rad s^{-1} scores 1; 11 π/10 rad s^{-1} scores 2] <u>Example of calculation</u> $\omega = (33 \times 2\pi)/ 60$ s ω= 3.5 rad s^{-1}	**3**
15(b)(ii)	Use of $a = r\omega^2$ **(1)** a = 1.5 ms^{-2} [allow ecf from (b)(i)] **(1)** [11.4 rad s^{-1} gives 16 m s^{-2}] <u>Example of calculation</u> $a = (0.125 \text{ m}) \times (3.5 \text{ rad s}^{-1})^2$ a = 1.5 m s^{-2}	**2**
	Total for question 15	**13**

Question Number	Answer		Mark
16(a)(i)	Use of $t=RC$ Use of $T=1/f$ **Or** $f = 1/t$ Comparison of 2.2 x10^{-4} (s) << 2.5 x10^{-3} (s) **Or** comparison of 400 (Hz)<< 4500 (Hz) **Or** reference to nRC (needed for complete discharge) where n = 3 – 11 **Or** $e^{-T/t}$ is a very small value	**(1)** **(1)** **(1)**	**3**
16(a)(ii)	See $C = Q/V$ **Or** $Q = CV$ See $Q = It$ See $t = 1/f$ **Or** $f = 1/t$ (Answers based on t = RC and V = IR scores 0)	**(1)** **(1)** **(1)**	**3**
16(a)(iii)	sub in $C = I/fV$ C = 2.7 μF Example of calculation $C = 5.4 \times 10^{-3}$ A/ (400 s^{-1} × 5.0 V) C = 2.7 μF	**(1)** **(1)**	**2**
16(a)(iv)	2.2 + 30% = 2.9 (μF) **Or** shows that 2.7 (uF) is +22% of 2.2 (uF) Within tolerance / consistent (2nd mark can only be awarded following an attempt at either of the above calculations) If candidates make an error in (iii) allow full ecf with a valid comment based on their values.	 **(1)** **(1)**	**2**
16(b)	Use of ½ CV^2 W = 3.4 × 10^{-5} J (allow ecf from (iii) or use of 2.2 μF→2.75 × 10^{-5} J) Example of calculation W = ½ 2.7 μF × $(5.0\text{ V})^2$ W = 3.4 × 10^{-5} J	**(1)** **(1)**	**2**
	Total for question 16		**12**

Question Number	Answer		Mark
17(a)	Disc/metal/cathode is heated (by a current) Thermionic emission (allow use of extremely high pd **and** a vacuum for 2 marks)	**(1)** **(1)**	**2**
17(b)	See $F=mv_{(v)}/t$ **Or** $F=ma$ and $v_{(v)}=at$ See $F=eE$ (accept F = EQ) See (time in field is) $t=l/v$ (This needs to be three clear statements) (Do not credit a units method)	**(1)** **(1)** **(1)**	**3**
17(c)	Find/measure horizontal distance from plates to screen Find/measure vertical displacement from centre of screen Use tan θ (this mark can be awarded if velocities are used rather than distances)	**(1)** **(1)** **(1)**	**3**
17(d)	Tan θ = vertical velocity / horizontal velocity **Or** v_v/v $v_v = \frac{Ee}{m} \times \frac{l}{v}$ and $v_H = v$ (conditional mark) (Do not credit a units method) .	**(1)** **(1)**	**2**
17(e)(i)	Magnetic rather than electric <u>force</u> **Or** *Bev/BQv* is the magnetic force **Or** $F = Bev/BqV$ (do not credit just $eE = Bev$)	**(1)**	**1**
17(e)(ii)	Mark for appreciation of magnetic force e.g. Force/acceleration now centripetal **Or** (causes) circular motion **Or** force/acceleration not vertical **Or** force/acceleration is not always in the same direction **Or** vertical force/acceleration not constant **Or** force/acceleration is at right angles to direction of motion, Mark for consequence Horizontal velocity no longer constant **Or** l/v = t not true	**(1)** **(1)**	**2**
	Total for question 17		**13**

Question Number	Answer		Mark
18(a)	A sensible comment such as: A reference to symmetry Quarks in pairs (in the particle generations) 6 leptons known but only 5 quarks (do not credit for each quark there has to be an anti-quark)	**(1)**	**1**
18(b)(i)	Same mass Opposite charge	**(1)** **(1)**	**2**
18(b)(ii)	Conserve momentum Initial (total) momentum is zero (Ignore reference to other conservation laws)	**(1)** **(1)**	**2**
18(c)(i)	Recognise (G)eV units of energy ($E = m c^2$ so) E/c = mc = momentum (conditional mark) **Or** recognise (G)eV/c^2 is unit of mass Momentum is mass x velocity (conditional mark)	**(1)** **(1)** **(1)** **(1)**	**2**
18(c)(ii)	Vectors added in sequence after μ_2 Direction and magnitude of J3 and J4 accurate Judge by eye and do not penalise missing arrows	**(1)** **(1)**	**2**
18(c)(iii)	94 - 99 (GeV/c)	**(1)**	**1**
18(c)(iv)	7 values added together including the value from (iii) **Or** total length of vectors and × 10 (method mark)	**(1)**	**1**
18(c)(v)	Value in (iv) or 300 divided by 2	**(1)**	**1**
18(c)(vi)	**Max 2** Large mass **Or** top quark (very) heavy Large amount of energy required **Or** issue of providing sufficient energy Availability of antimatter is poor Difficulty of storing antimatter	 **(1)** **(1)** **(1)** **(1)**	**2**
	Total for question 18		**14**

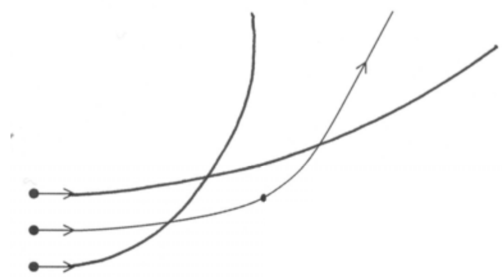
TOTAL MARKS FOR THIS PAPER = 80

Mark Scheme (Results)

January 2013

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

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**

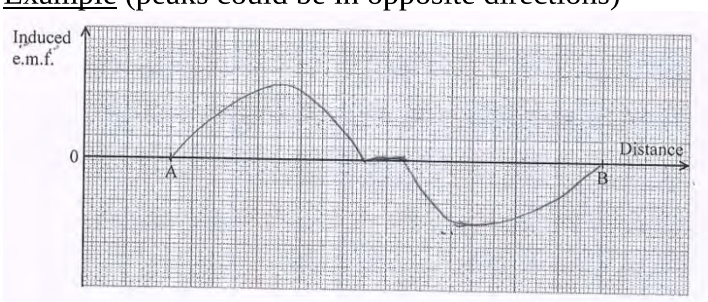
Question Number	Answer		Mark
11(a)	To prevent interaction/deflection/collision of the alpha particle with the air. [do not accept: 'don't get in the way' , 'cause ionisation', 'interfere with'. Looking for a definite interaction between the alpha and the air molecules. Accept air particles]	**(1)**	**1**
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 $\times 1.0 \times 10^{-10}$ 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 $E_k = 2.41 \times 10^{-17}$ 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$)(7.28 \times 10^{6}$ 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 $\times$ 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 $\times$ (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 = 6.0×10^{-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 $\bar{u}\,\bar{u}\,\bar{d}$ - ⅔e -⅔e + ⅓e = -e must be consistent with structure of $\bar{p}$ $\bar{n}$ consists of $\bar{d}\,\bar{d}\,\bar{u}$ + ⅓e + ⅓e - ⅔e = 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**

Mark Scheme (Results)

Summer 2013

GCE Physics 6PH04

Paper 01R: Physics on the Move

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

Question Number	Answer		Mark
***11**	(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate)		
	Alternating p.d. max 2		
	Electric field/ p.d. accelerates particles **Or** Electric field /p.d. gives particles energy	**(1)**	
	Constant time period **Or** constant frequency	**(1)**	
	Polarity of dees switches every half cycle **Or** P.d. switches every half cycle	**(1)**	
	Magnetic field max 2		
	Magnetic field/force at right angles to particles path	**(1)**	
	Maintains circular motion (whilst in dees) **Or** Experiences centripetal force/acceleration (whilst in dees)	**(1)**	
	Radius of circle increases as particles get faster	**(1)**	**4**
	Total for question 11		**4**

Question Number	Answer		Mark
***12**	(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate) No external/unbalanced/resultant force so momentum of system is conserved Rocket gains momentum in backward direction Module gains equal amount of momentum in forward direction Kinetic energy of the system increases (Some) chemical energy converted to KE **Alternative mark scheme** if candidate presumes that the initial total momentum is zero (Max 4) No external/unbalanced/resultant force so momentum of system is conserved Rocket and module have equal amount of momentum and move in opposite directions (after separation) Kinetic energy of the system increases (Some) chemical energy converted to KE	**(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)**	**5**
	Total for question 12		**5**

Question Number	Answer		Mark
13(a)	The <u>magnetic</u> field (must be) at right angles to the current	**(1)**	**1**
13(b)	All three units for force, length and current clearly identified (The unit of force is kg m s^{-2} **, t**he unit of current is A, the unit of length is m) T = kg A^{-1} s^{-2}	**(1)** **(1)**	**2**
13(c)	*Use* of $\rho = m/V$ Use of $mg = BIl$ B = 0.53 (T) (no u.e. as given in question for part (b)) <u>Example of calculation</u> $m = 2.7 \times 10^{3}\ \text{kg m}^{-3} \times 10\times 10^{-3}\ \text{m} \times 10\times 10^{-3}\ \text{m} \times l$ $m = 0.27 \times l$ $B = (0.27 \times l \times 9.81\ \text{m s}^{-2})/(5\ \text{A} \times l)$ $B = 0.53$ T	**(1)** **(1)** **(1)**	**3**
13(d)	(Magnetic field is) into paper/page	**(1)**	**1**
	Total for question 13		**7**

Question Number	Answer		Mark
14(a)(i)	Three quarks **Or** three antiquarks (accept the letter q to represent quarks)	**(1)**	**1**
14(a)(ii)	Quark and an antiquark (accept the letter q to represent quarks)	**(1)**	**1**
14(b)	Similarity: they have the same mass **Or** same magnitude of charge Difference: opposite charge	**(1)** **(1)**	**2**
14(c)(i)	Up and antistrange (in words or symbols, and can be in either order)	**(1)**	**1**
14(c)(ii)	μ^{-} + $_{\mu}$ $K^{-} \rightarrow \mu^{-} +\ _{\mu}$	**(1)** **(1)**	**2**
14(c)(iii)	Energy = 2 × 494 MeV eV to J conversion Energy = 1.58×10^{-10} (J) (division by c^2 and subsequent multiplication by c^2 is not penalised) <u>Example of calculation</u>	**(1)** **(1)** **(1)**	**3**

	Energy = $2 \times 494 \times 10^{6}$ eV $\times 1.6 \times 10^{-19}$ J eV^{-1} Energy = 1.58×10^{-10} J	
	Total for question 14	**10**

Question Number	Answer	Mark
15(a)	Use of $Q = It$ **(1)** Q = 2.8 C **(1)** <u>Example of calculation</u> $Q = 2.0 \times 10^{3}$ A $\times 1.4 \times 10^{-3}$ s Q = 2.8 C	**2**
15(a)(ii)	See $\tau = RC$ **(1)** $\tau = 3.0 \times 10^{-4}$ (s) **(1)** Relates time constant to the time for which current is required **(1)** <u>Example of calculation</u> $\tau = 0.50\Omega \times (600 \times 10^{-6}$ F) $\tau = 3.0 \times 10^{-4}$ s 1.4×10^{-3}s / 3.0×10^{-4} s = 4.7RC	**3**
15(b)(i)	Use of $Q = CV$ **(1)** V = 4700 V (e.c.f from (a)(i)) **(1)** <u>Example of calculation</u> V = 2.8V / (600×10^{-6} F) V = 4670 V	**2**
15(b)(ii)	Use of $W = ½\, QV$ **Or** $W = ½\, Q^2/C$ **Or** $W = ½\, CV^2$ **(1)** Use of $P = W/t$ **(1)** P = 4.7 MW (e.c.f. from (a)(i) and/or (b)(i)) **(1)** <u>Example of calculation</u> P = (2.8 C × 2.8 C) / ($2 \times 600 \times 10^{-6}$ F $\times 1.4 \times 10^{-3}$ s) P = 4.7 MW	**3**
	Total for question 15	**10**

Question Number	Answer		Mark
16(a)	Velocity/direction changing **Or** (object is) accelerating Force towards centre of circle	**(1)** **(1)**	**2**
16(b)	High(er) speed means large(r) force **Or** small(er) radius means large(r) force (For sharp bends) centripetal/resultant/required <u>force</u> would need to be greater than maximum frictional force **Or** (for sharp bends) friction cannot provide the (required) centripetal/resultant force	**(1)** **(1)**	**2**
16(c)(i)	Resolving forces vertically $\underline{N}\sin\theta = mg$ Resolving forces horizontally $\underline{N}\cos\theta = mv^2/r$ Division of vertical equation by horizontal equation to get correct answer	**(1)** **(1)** **(1)**	**3**
16(c)(ii)	Use of $\tan\theta = gr/v^2$ $\theta = 57^\circ$ <u>Example of calculation</u> $\tan\theta = (9.81\text{ m s}^{-2} \times 18.7\text{ m})/(11.0\text{ m s}^{-1})^2$ $\theta = 56.6^\circ$	**(1)** **(1)**	**2**
	Total for question 16		**10**

Question Number	Answer	Mark
17(a)	Arrow(s) downwards **(1)**	**1**
17(b)	Use of $E = V/d$ **(1)** Use of $F = EQ$ **(1)** $F = 5.1 \times 10^{-16}$ N **(1)** <u>Example of calculation</u> $F = (160\text{ V} \times 1.6 \times 10^{--19}\text{ C}) / 5.0 \times 10^{--2}\text{ m}$ $F = 5.12 \times 10^{-16}$ N	**3**
17(c)	Between the plates there is an acceleration/force which is vertical/upwards **(1)** Constant horizontal velocity **(1)** Outside the plates no (electric) field /force acts **(1)** **Or** Outside the plates speed so large that gravitational effect negligible	**3**
17(d)(i)	Release of (surface) electrons due to heating **(1)**	**1**
17(d)(ii)	Use of $E_k = ½mv^2$ **(1)** Use of $V = W/Q$ **(1)** p.d. = 410 V **(1)** <u>Example of calculation</u> $E_k = 9.11 \times 10^{-31}\text{ kg} \times (1.2 \times 10^{7}\text{ m s}^{-1})^2/2$ $E_k = 6.56 \times 10^{-17}$ J p.d. = $(6.56 \times 10^{-17}\text{ J})/(1.6 \times 10^{-19}\text{ C})$ p.d. = 410V	**3**
	Total for question 17	**11**

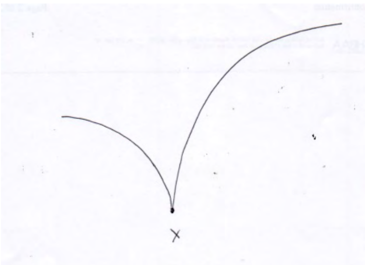
Question Number	Answer		Mark
18(a)	Use of NΦ = NBA $\Phi = 1.2 \times 10^{-3}$ Wb (accept T m^2) <u>Example of calculation</u> $\Phi = 200 \times 3.0 \times 10^{-2}$ T$\times 2.0 \times 10^{-4}$ m s^{-1} $\Phi = 1.2 \times 10^{-3}$ Wb	**(1)** **(1)**	**2**
18(b)(i)	Time = 0.125 (s) **Or** Time = 1/8 (s) Use of ε = (-)d(NΦ)/dt ε =(-)9.6 x 10^{-3} V (ecf NΦ from (a)) <u>Example of calculation</u> ε = 1.2$\times 10^{-3}$ Wb /0.125 s ε = 9.6 mV	**(1)** **(1)** **(1)**	**3**
18(b)(ii)	Maximum values when coil is horizontal **Or** maximum values when the coil is parallel to the magnetic field **Or** minimum value when coil vertical **Or** minimum value when the coil is perpendicular to the magnetic field e.m.f. determined by rate of change of flux **Or** see ε = (-)d(NΦ)/dt Greatest rate of change of flux as coil goes through horizontal **Or** greatest rate of change of flux occurs when θ=90° **Or** least rate of change of flux as it goes through vertical **Or** least rate of change of flux occurs when θ=0°	**(1)** **(1)** **(1)**	**3**
18(b)(iii)	Peaks would be smaller amplitude **Or** maximum e.m.f. smaller Rate of change of flux (linkage/cutting) less	**(1)** **(1)**	**2**
18(c)(i)	Energy required to turn generator Transferred from kinetic energy of the car	**(1)** **(1)**	**2**
18(c)(ii)	Greater rate of kinetic energy transfer/loss at high(er) speeds At slower/low speeds there is less/negligible braking effect (so car would not fully stop)	**(1)** **(1)**	**2**
	Total for question 18		**14**

Mark Scheme (Results)
Summer 2013

GCE Physics (6PH04)

Paper 01: Physics on the Move

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

Question Number	Answer	Mark
11	**Diagram:** Path curves in opposite sense **(1)** With a greater radius of curvature **(1)** [For Mp2 drawn line must start at X , upwards at less than 45^o to vertical and go above printed line. Look at curvature close to X, do not penalise if later it curves more/less.]  **Explanation: (these marks are independent of the diagram)** (Antihelium) has opposite charge (to proton) **Or** reference to proton +ve **and** antihelium -ve **(1)** See $r = p/BQ$ **(1)** r is doubled **Or** p/Q is doubled **(1)** [equation may appear near diagram.]	5
	Total for question 11	**5**

<table>
<tr><th>Question Number</th><th>Answer</th><th></th><th>Mark</th></tr>
<tr><td>12(a)</td><td>
<table>
<tr><th>Meson</th><th>Charge/e</th><th>Strangeness</th></tr>
<tr><td>$u\bar{s}$</td><td>+1</td><td>+1</td></tr>
<tr><td>$d\bar{s}$</td><td>0</td><td>+1</td></tr>
<tr><td>$s\bar{u}$</td><td>-1</td><td>-1</td></tr>
<tr><td>$s\bar{d}$</td><td>0</td><td>-1</td></tr>
</table>

1 mark for each correct row. Antiquark can be before quark.

(If the + are missing. e or 1.6×10^{-19} appears in charge column apply a 1 mark total penalty.)</td><td>(1)
(1)
(1)
(1)</td><td>4</td></tr>
<tr><td>12(b)</td><td>(Different) masses/lifetimes/stabilities/decay products
(accept mass-energy but not energy or weight)</td><td>(1)</td><td>1</td></tr>
<tr><td></td><td>Total for question 12</td><td></td><td>5</td></tr>
</table>

Question Number	Answer	Mark
13(a)(i)	Straight through, zero deflection, direction fired in. (Do not accept 'through' or 'directly behind' on its own) **(1)**	**1**
13(a)(ii)	(Atom consists) mainly/mostly of empty space **Or** Volume of atom very much greater than volume of nucleus. **(1)** (do not credit if part of a list)	**1**
13(b)	Most of the mass is in the nucleus/centre **(1)** [it is not enough to say that the nucleus is dense/concentrated. Looking for idea that nearly all of the atom's mass is in the nucleus] Nucleus/centre is charged **(1)** [ignore references to the charge being positive. Just saying the nucleus is positive does not get the mark.]	**2**
13(c)(i) E	Electrostatic/electromagnetic/electric/coulomb **(1)**	**1**
13(c)(ii)	Arrow starting on the path at closest point to the nucleus **(1)** Arrow pointing radially away from nucleus **(1)** (correct direction starting on the nucleus scores 2^{nd} mark only)	**2**
13(c)(iii)	Deflection starts earlier **(1)** Final deflection is greater **(1)** (paths should diverge)	**2**
	Total for question 13	**9**

Question Number	Answer		Mark
14(a)(i)	Capacitor, resistor, supply and switch all in series (ignore voltmeter) Voltmeter directly across capacitor	**(1)** **(1)**	**2**
14(a)(ii)	Datalogger allows large number of readings to be taken **Or** graph can be plotted directly/automatically **Or** simultaneous reading of *t* and *V* can be taken **Or** idea that people can't record quickly enough, (treat as neutral accuracy, precision misreading or human reaction time)	**(1)**	**1**
14(b)	Use of $C = Q/V$ $Q = 5.0 \times 10^{-4}$ C <u>Example of calculation</u> $Q = 100 \times 10^{-6}$ F $\times$ 5.0 V $Q = 5.0 \times 10^{-4}$ C	**(1)** **(1)**	**2**
14(c)(i)	Use of $I = \Delta Q/ \Delta t$ e.c.f their value of C from (b) I = 0.05 A (accept recalculation of *Q* using *V* = 4.90 or 4.95 V) <u>Example of calculation</u> $I = 5.0 \times 10^{-4}$ C / 10×10^{-3} s I = 0.05 A	**(1)** **(1)**	**2**
14(c)(ii)	tangent drawn at t = 0 $\Delta V/ \Delta t$ = 2000 - 3300 V s^{-1} Initial current = 0.22 - 0.28 A (MP2 & 3 can be scored even if no tangent drawn) (No credit for exponential calculation) <u>Example of calculation</u> $\Delta V/ \Delta t$ = 1.1 V/ 0.5 ms = 2200 V s^{-1} $I = (\Delta V/ \Delta t) \times C$ I = 2200 V s^{-1} $\times 100 \times 10^{-6}$ F I = 0.22 A	**(1)** **(1)** **(1)**	**3**
14(c)(iii)	Use of $V = IR$ using answer from (ii) correct evaluation of *R* (5V used with current range in (ii) gives 18 - 23 Ω) <u>Example of calculation</u> 5 V = 0.22 A × *R* *R* = 23 Ω	**(1)** **(1)**	**2**
	Total for question 14		**12**

Question Number	Answer		Mark
15(a)	At least three vertical lines spread over symmetrically over more than half of the plate length and touching both plates. (ignore edge ones that might curve) All equispaced and parallel [don't allow gaping to avoid oil drop] Arrow pointing downwards	**(1)** **(1)** **(1)**	**3**
15(b)	Negative / - / -ve (negative and/or positive does not get the mark)	**(1)**	**1**
15(c)	Upward force labelled: Electric (force) **Or** Electrostatic (force) **Or** force due to electric field **Or** electromagnetic (force) [do not accept repulsive/attractive force. If EQ used, the symbols must be defined] Downward force labelled: mg, weight, W, gravitational force (for both marks the lines must touch the drop and be pointing away from it. Ignore upthrust if drawn but one mark lost for each extra force added)	**(1)** **(1)**	**2**
15(d)(i)	E = 5100 V/ 2 cm Conversion of cm to m Use of $QE = mg$ (1.18×10^{-13} kg) $Q = 4.6 \times 10^{-19}$ C (E = 255 000 (V m^{-1}) scores MP1 & 2. unit conversion missed → $Q = 4.62 \times 10^{-17}$ C scores MP1 & 3 if V is halved → $Q = 9.23 \times 10^{-19}$ C scores MP1 ,2 & 3) <u>Example of calculation</u> $E = V/d$ $F = EQ = mg$ $Q = mg / E = mgd/V$ Q = (1.20×10^{-14} kg × 9.81m s^{-2}× 0.02 m) / (5100 V) Q = 4.62×10^{-19} C	**(1)** **(1)** **(1)** **(1)**	**4**
15(d)(ii)	Answer to (d)(i) divided by e 3 electrons **Or** sensible integer number less than 500 (answers with very large numbers of electrons can get MP1 only) <u>Example of calculation</u> Number of electrons = 4.62×10^{-19} C / 1.6×10^{-19} C Number = 2.9 i.e. 3 electrons.	**(1)** **(1)**	**2**
	Total for question 15		**12**

Question Number	Answer		Mark
***16(a)**	(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate) A clear statement that an alternating/changing current produces an alternating/changing magnetic field/flux Reference to the iron core becomes magnetised **Or** increases magnetic field the idea that the field produced in the core/wire is linked to the coil (e.m.f. produced) due to EM induction **Or** reference to induced e.m.f. **Or** Faraday's law in words (do not accept induced current/voltage on its own) [be careful not to credit the random use of words/phrases like, there is flux linkage, flux cutting takes place or the field lines are cut by the coil. Also watch out for candidates who think there is a current in the coil creating the flux linkage]	 **(1)** **(1)** **(1)** **(1)**	**4**
16(b)	(Constant current means) no change of flux (linkage) **Or** no changing (magnetic) field **Or** flux/ field is constant [do not credit 'flux won't be changing direction' or 'no flux linkage being cut' or alternating]	**(1)**	**1**
16(c)	More than one wire in cable Cable carries current in both directions **Or** Magnetic fields will cancel	**(1)** **(1)**	**2**
16(d)(i)	The larger the current the greater the (magnetic) flux/field (produced) **Or** the larger the change in current the larger the change in the (magnetic) flux/field gives a greater rate of change of flux **Or** bigger change in flux in the same time **Or** a greater (induced) e.m.f./voltage/reading	**(1)** **(1)**	**2**
16(d)(ii)	the idea that frequency changes the value of (induced) e.m.f/voltage/reading **Or** the idea that the frequency changes the rate of change of (magnetic)flux An understanding that there are now two factors (current and frequency) altering (induced) e.m.f/voltage/reading.	**(1)** **(1)**	**2**
	Total for question 16		**11**

Question Number	Answer		Mark
17(a)	Sum of momenta before (collision) = sum of momenta after (collision) **Or** the total momentum before (a collision) = the total momentum after (a collision) **Or** total momentum remains constant **Or** the momentum of a system remains constant Providing no external/unbalanced/resultant force acts **Or** in a closed system	 **(1)** **(1)**	**2**
17(b)(i)	Use of equation(s) of motion sufficient to get answer Initial speed = 1.1 (m s^{-1}) <u>Example of calculation</u> s = $(u + v)t/2$ 0.69 m = $(u + 0) \times 1.3$ s /2 u = 1.06 m s^{-1}	**(1)** **(1)**	**2**
17(b)(ii)	Constant acceleration/deceleration (accept constant force)	**(1)**	**1**
17(b)(iii)	Use of momentum = mv ecf v from (b)(i) Calculates momentum after collision using correct mass Speed of pellet = 117 or 124 or 129 (m s^{-1}) <u>Example of calculation</u> Momentum after = (97.31 + 0.84) g × 1.06 m s^{-1} = 104 g m s^{-1} Momentum before = momentum after Speed of pellet = 104 g m s^{-1} / 0.84 g = 124 m s^{-1}	**(1)** **(1)** **(1)**	**3**
***17(c)(i)**	(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate) Mention of momentum Pellet (bounces back so) has negative momentum /velocity **Or** momentum after = momentum of car - momentum of pellet Pellet undergoes a bigger momentum/velocity change **Or** mass of car is less	 **(1)** **(1)** **(1)**	**3**
17(c)(ii)	reference to greater horizontal momentum/force	**(1)**	**1**

17(d)	[The question says that the calculations are correct, the question is about the assumptions made. Do not credit a statement that the GPE is correct. MP1 is for the assumption that the KE after firing is the same as the max GPE. Do not credit energy loss due to air resistance or sound] $E_k \rightarrow E_{grav}$ of pendulum correct **Or** KE after collision is correct E_k in collision not conserved **Or** not an elastic collision **Or** inelastic collision (do not credit just 'KE is lost') Some energy becomes heat E_k (of pellet before collision)is greater than 0.16J	 **(1)** **(1)** **(1)** **(1)**	**4**
	Total for question 17		**16**