Rewarding Learning

ADVANCED
General Certificate of Education
2019

Physics

Assessment Unit A2 2

assessing

Fields, Capacitors and Particle Physics

[APH21]

FRIDAY 24 MAY, MORNING

MARK SCHEME

Subject-specific Instructions

In numerical problems, the marks for the intermediate steps shown in the mark scheme are for the benefit of candidates who do not obtain the final correct answer. A correct answer and unit, if obtained from a valid starting-point, gets full credit, even if all the intermediate steps are not shown. It is not necessary to quote correct units for intermediate numerical quantities.

Note that this "correct answer" rule does not apply for formal proofs and derivations, which must be valid in all stages to obtain full credit.

Do not reward wrong physics. No credit is given for consistent substitution of numerical data, or subsequent arithmetic, in a physically incorrect equation. However, answers to later parts of questions that are consistent with an earlier incorrect numerical answer, and are based on physically correct equation, must gain full credit. Designate this by writing **ECF** (Error Carried Forward) by your text marks.

The normal penalty for an arithmetical and/or unit error is to lose the mark(s) for the answer/unit line. Substitution errors lose both the substitution and answer marks, but 10^n errors (e.g. writing 550 nm as 550×10^{-6} m) count only as arithmetical slips and lose the answer mark.

				AVAILABLE MARKS
1 **(a)**	1 C (of charge)	[1]		
	per volt	[1]	[2]	
(b) **(i)**	equal charge on each	[1]		
	$C_1V_1 = C_2V_2$	[1]		
	330 μF	[1]	[3]	
	Alternative:			
	$Q = 2.64 \times 10^{-3}$			
	or $C = \frac{Q}{8}$ or subs of C values with Q to get V			
(ii)	220 μF	[1]		
	$\frac{1}{2}CV^2$	[1]		
	Subs (ecf C value)	[1]		
	0.016 J	[1]	[4]	
	alternative			
	$\frac{1}{2}CV^2$	[1]		
	$0.5 \times 660 \times 4^2$	[1]		
	$0.5 \times 330 \times 8^2$	[1]		
	0.016 J	[1]		9
2 **(a)**	region/volume/space	[1]		
	where body with particular property or nature experiences a force (accept listing all properties)	[1]	[2]	
(b) **(i)**	**Fig. 2.1** +2 μC charge	[1]		
	Fig. 2.2 4 kg mass	[1]	[2]	
(ii)	radial field	[1]		
	weakens as moves away/spacing increases	[1]		
	strength decreases with $1/r^2$ (gets [2])			
	accept both have infinite range			
	field around mass only attractive, around charge attractive/repulsive			
	accept shield against E field, not g field	[1]	[3]	7
3 **(a)**	$F = k\,Q_1Q_2/r^2$	[1]		
	subs in one equation	[1]		
	sum of 2 forces	[1]		
	1.6×10^5 N	[1]		
	direction right	[1]	[5]	
	SE: 9.6×10^4 [4] with correct direction,			
	4×10^4 with correct direction [4]			
(b)	to the left of –2 μC	[1]		
	outside the charges for balancing in terms of charge/to get 2 forces in opposite directions	[1]		
	to the left of 2 μC to balance in terms of magnitude/further away from the 8 because it is largest charge	[1]	[3]	8

				AVAILABLE MARKS
4	**(a)** eV or $\frac{1}{2}mv^2$	[1]		
	equating $eV = \frac{1}{2}mv^2$	[1]		
	correct subs with 1.6×10^{-19} and 9.11×10^{-31}	[1]	[3]	
	(b) correct subs in equation	[1]		
	$m = 9.31 \times 10^{-31}$ kg	[1]		
	difference in m values or $m/m_e = 1.022$	[1]		
	2.2% increase	[1]	[4]	
	SE: 2.15% from incorrect % calc [3], 4.5% or 12.3% [3]			

(c) particles accelerated in electric fields/between electrodes/by p.d/between cavities
repelled from one electrode and attracted towards the next
frequency (of a.c. supply) increases as v increases
(dipole) magnets cause particles to follow (circular) path
mag field strength increases as v increases
(quadrupole) magnets focus beam

Response	Marks
Candidates identify clearly **5 or 6** of the points above relating to the operation of a synchrotron. There is widespread and accurate use of appropriate scientific terminology. Presentation, spelling, punctuation and grammar are excellent. They use the most appropriate form and style of writing. Relevant material is organised with clarity and coherence.	[5]–[6]
Candidates identify clearly **3 or 4** of the points above relating to the operation of a synchrotron. Presentation, spelling, punctuation and grammar are sufficiently competent to make meaning clear. They use appropriate form and style of writing. There is good reference to scientific terminology.	[3]–[4]
Candidates identify clearly **1 or 2** of the points above relating to the operation of a synchrotron. There may be some errors in their spelling, punctuation and grammar but form and style are of a satisfactory standard. They have made some reference to specialist terms.	[1]–[2]
Response is not worthy of credit.	[0]

[6] 13

5	**(a)** Example of a lepton, e.g. electron	[1]		
	Example of a hadron, e.g. proton, neutron	[1]		
	hadrons feel strong nuclear force (accept strong interaction), leptons do not	[1]		
	hadrons are composite, leptons fundamental	[1]	[4]	
	(b) (proton positive, $\bar{\upsilon}$ and n neutral, X is positive) +1	[1]		
	($\bar{\upsilon}$ has lepton no –1, p and n zero, X is anti-lepton) −1	[1]		
	(p and n are baryons, $\bar{\upsilon}$ is not, X not a baryon) 0	[1]		
	X is a positron	[1]	[4]	
	(c) (i) $n \rightarrow p + e^- + \bar{\upsilon}_e$ (or $d \rightarrow u + e^- + \bar{\upsilon}_e$)		[1]	
	(ii) weak nuclear force/weak interaction		[1]	10

						AVAILABLE MARKS
6	(a)	(i)	$F = Eq$ or $F = Vq/d$	[1]		
			$F = Bqv$ (accept BIl)	[1]		
			Correct directions, F_E upwards, F_B downwards	[1]	[3]	
		(ii)	forces equated **and** $V/d = Bv$ or $E = Bv$	[1]		
			subs	[1]		
			$2.3 \times 10^5\ m\,s^{-1}$	[1]	[3]	
	(b)	(i)	out of the page		[1]	
		(ii)	radius will vary with mass of particle/ion (as q, B, v constant)	[1]		
			greater mass strike detector nearer the bottom (or vice versa)	[1]	[2]	
		(iii)	$B = mv/rq$ or $Bqv = \frac{mv^2}{r}$	[1]		
			$r = 2 \times 10^{-2}\,m$	[1]		
			$m = 6\,u$	[1]		
			subs	[1]		
			$0.15\,T$	[1]	[5]	14
			SE: 9×10^{25} [4], 0.075 [4], 0.174 [4], 0.087 [3], 0.16 [3], 0.32 [4]			
7	(a)	(i)	orbit above equator (of Jupiter)	[1]		
			same period/period of 1 day/same angular velocity	[1]		
			same direction	[1]	[3]	
		(ii)	$F = \frac{GMm}{r^2}$	[1]		
			$F_C = mr\,(\frac{4\pi^2}{T^2})$	[1]		
			T in seconds (3.6×10^4)	[1]		
			correct subs into eqn	[1]		
			$r = 1.61 \times 10^8$ m	[1]		
			$h = 8.9 \times 10^7$ m	[1]	[6]	
		(iii)	$v = 2\pi r/T$ or $v = r\omega$ or $v = \sqrt{\frac{GM}{r}}$	[1]		
			subs to get $v = 2.8 \times 10^4\,m\,s^{-1}$	[1]	[2]	
	(b)		$g = GM/r^2$	[1]		
			4.89	[1]		
			$W = mg = 1467$ N	[1]	[3]	14
			(or use of $F_C = W$)			

						AVAILABLE MARKS
8	(a)		sketch to include primary coil and secondary coil (laminated iron) core more turns in secondary coil	[1] [1] [1]	[3]	
	(b)	(i)	$N_s/N_p = I_p/I_s$ 0.045 × 20 = 0.9 A	[1] [1]	[2]	
		(ii)	P = I × V output power = 22.5 × 0.955 = 21.5 kW V = 477 500 V (or 22 500/0.9 = 25 000, (25 000 × 20) × 0.955 = 477 500 V ecf from 0.9 in **(b)(i)** if this method used) SE: 5 × 10^5 [2], 5.24 × 10^5 [2]	[1] [1] [1]	[3]	
		(iii)	(Any 3 of 4) • flux leakage/loss wind both coils on one limb of core/on top of each other • eddy currents in core cause heating laminate core • (resistance) heating in coils thicker/lower resistivity wire/coolant • hysteresis (soft) iron	 [1] [1] [1] [1] [1] [1] [1] [1]	[6]	14
9	(a)	(i)	Faraday's Law – induced emf is proportional to the rate of change of flux or equal to the rate of change of flux linkage/total flux		[1]	
		(ii)	Lenz's Law – Direction of the induced effect is such that it opposes the change that is causing it		[1]	
	(b)	(i)	time too short to take readings		[1]	
		(ii)	leaving – moving quicker rate of change increases Induced N pole at top of coil as magnet approaches/repels on entry Polarity reverses as magnet leaves/attracts on leaving Direction of current/emf reverses	[1] [1] [1] [1] [1]	[5]	
		(iii)	1. (both) peaks greater values/emf greater and (both) shorter times 2. peaks greater values (same time)	[1] [1] [1]	[3]	11
					Total	**100**