Rewarding Learning

ADVANCED
General Certificate of Education
2016

Physics

Assessment Unit A2 2

assessing

Fields and their Applications

[AY221]

THURSDAY 9 JUNE, AFTERNOON

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.

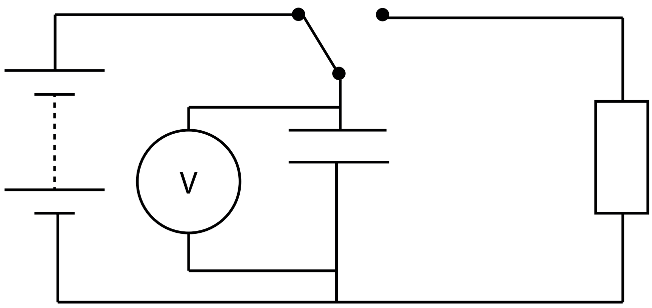
Note that this "correct answer" rule does not apply for formal proofs and derivations, which must be valid in all stages to obtain full credit.

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)**	**(i)**	Force of attraction	[1]		
			Proportional to (product of) masses	[1]		
			Inversely proportional to square of mass separation	[1]	[3]	
		(ii)	Stating $F = \frac{GMm}{d^2}$	[1]		
			Stating $F = mr\omega^2$	[1]		
			Algebra to obtain $T^2 = \frac{4\pi^2 d^3}{GM}$ or equivalent	[1]		
			Penalty [–1] for not using the symbols in **Fig 1.1**		[3]	
	(b)	**(i)**	$T^2 = \frac{4\pi^2 d^3}{GM} = \frac{4\pi^2(5.27\times10^8)^3}{(6.67\times10^{-11})(5.68\times10^{26})}$ subs	[1]		
			$T = 3.91 \times 10^5$ s ans	[1]		
			$T = 4.52$ days ECF* T/s	[1]	[3]	
			SE 0.071 days [2] and 1.43×10^{-4} days [2]			
		(ii)	$g = \frac{Gm}{r^2}$ equation	[1]		
			$g = \frac{(6.67\times10^{-11})(2.31\times10^{21})}{(7.64\times10^5)^2}$ subs	[1]		
			$g = 0.26$ (N kg^{-1}) ans	[1]	[3]	12
2	**(a)**		$E = \frac{Q}{4\pi\varepsilon_0 r^2}$ equation	[1]		
			$E = \frac{40\times10^{-6}(8.99\times10^9)}{(5\times10^{-2})^2}$ subs	[1]		
			$E = 1.44 \times 10^8$ (N C^{-1}) ans	[1]	[3]	
	(b)		$F = EQ = (1.44 \times 10^8)(60 \times 10^{-6})$ equation or subs	[1]		
			$F = 8640$ (N)/8630 ECF for E ans	[1]		
			Towards the +40 μC	[1]	[3]	6

								AVAILABLE MARKS
3	(a)	(i)	Charging circuit with no resistance		[1]			
			Discharging circuit with resistance		[1]			
			Symbol(s) for C, R, supply					
			Sample circuit for full marks					



[3]

		(ii)	Start discharge and stop clock/record voltage regularly		[1]		
			Record voltage every 10 seconds (or 5, 15, 20 s)		[1]	[2]	
	(b)	(i)	Evidence that $V_\tau = 0.37V_0$		[1]		
			τ = 56–60 (s) 56 s–64 s	ans	[1]	[2]	
			Alternative:				
			3 correct subs into $V = V_0\, C^{-\tau/CR}$		[1]		
			CR in range 56–64 s		[1]		
		(ii)	Total capacitance, $C_T = 4.72 \times 10^{-4}$ (F)	ECF τ	[1]		
			Capacitance = 1.42×10^{-3} (F)	ECF* C_T	[1]	[2]	9
4	(a)		$\Phi = BA$	eqn	[1]		
			$\Phi = (0.129)\pi(5 \times 10^{-3})^2$	subs	[1]		
			$\Phi = 1.01 \times 10^{-5}$ (Wb)	answer	[1]	[3]	
	(b)	(i)	$F = Bil$	eqn	[1]		
			$F = (0.01)\left(\frac{15}{2.4 \times 10^{-4}}\right)(0.013)$	subs	[1]		
			F = 8.1 (N) ECF I and B	answer	[1]	[3]	
			S $\Rightarrow$ 93.4 (N) [2]				
		(ii)	Out of (the plane of) the paper		[1]		
			Fleming's LH Rule or RH grip rule & motor effect/motor rule		[1]		
			Current flows down the rod (field L $\rightarrow$ R) or + $\rightarrow$ –		[1]	[3]	9
			Wrong direction $\rightarrow$ can only be awarded the second mark				

							AVAILABLE MARKS
5	**(a)**		E = BAN/t		[1]		
			E = 4.01 × 10^{-6}(25 × 10^3)(8.2 × 10^3)/(1)	subs	[1]		
			E = 823 (V)	ans	[1]	[3]	
	(b)	**(i)**	$V_S = \frac{V_P N_S}{N_P} = \frac{(230)(24)}{1104}$	eqn or subs	[1]		
			$V_S = \frac{(230)(24)}{1104} = 5\,(\text{V})$	answer	[1]	[2]	
		(ii)	$Eff = \frac{P_S}{P_P} = \frac{V_S I_S}{V_P I_P} = \frac{5.06}{5.98}$	eqn	[1]		
			$Eff = \frac{(4.6)(1.1)}{(230)(0.026)} = 0.85$		[1]	[2]	7
			S $\Rightarrow$ 0.15 [1]				

6 **(a)** **(i)**

Structure	Name
1	(Hot) cathode
2	positive electrode/anode
3	x-plates
4	y-plates
5	Fluorescent screen

[$\frac{1}{2}$] each – round down [2]

(ii)	Height of trace/amplitude in context, multiplied by		[1]		
	y-amp gain (or equivalent)		[1]	[2]	
	Accept 'multiplied by' on either mark line				
(b)	Time in field, $t = \left(\frac{0.12}{5.6 \times 10^7} =\right) 2.14 \times 10^{-9} s$	subs or ans	[1]		
	Electric field strength, $E = \frac{2500}{0.08} = \frac{V}{d}$		[1]		
	= 31250 N C^{-1}	ans	[1]		
	Acceleration $\left(a = \frac{Eq}{m} = \frac{(31250)(1.6 \times 10^{-19})}{9.11 \times 10^{-31}}\right)$ = 5.49 × 10^{15} m s^{-1}				
		ans ECF* *E*	[1]		
	Displacement $\left(s = \frac{1}{2}at^2 = \frac{1}{2}(5.49 \times 10^{15})(2.14 \times 10^{-9})^2\right) = 0.0126$				
		ans ECF* *a* & *t*	[1]	[5]	9

7 (a)

Particle	**Mass/u**	**Charge/C**	**Lepton number**	**Baryon number**
Electron	1/2000 or 1/1840 or 5.5×10^{-4}	-1.6×10^{-19}	+1	0
Positron	Consistent with above answer	$+1.6 \times 10^{-19}$	–1	0

[1] for each line with all responses correct [2]

(b) Dees/semicircular electrodes
Particles accelerated by voltage between dees
Fixed a.c. frequency for voltage
Magnetic field perpendicular to plane of particle motion/B-field causes deflection

Particles follow a spiral path
Radius increases (as velocity increases)

First four points + either [5]

Quality of written communication

2 marks
The candidate expresses ideas clearly and fluently, through well-linked sentences and paragraphs. Arguments are generally relevant and well structured. There are few errors of grammar, punctuation and spelling.

1 mark
The candidate expresses ideas clearly, if not always fluently. There are some errors in grammar, punctuation and spelling, but not such as to suggest weakness in these areas.

0 marks
The candidate expresses ideas satisfactorily, but without precision. Arguments may be of doubtful relevance or obscurely presented. Errors in grammar, punctuation and spelling are sufficiently intrusive to disrupt the understanding of the passage. [2]

(c) (i) Explanation:
All the mass is converted to energy/annihilation/conserve mass/energy [1]
Two gamma photons produced to conserve momentum [1] [2]

(ii) Calculation:

$E = \Delta mc^2$	eqn	[1]	
$E = (9.11 \times 10^{-31})(3 \times 10^8)^2$	subs	[1]	
$E = 8.20 \times 10^{-14}$ (J)	ans	[1]	
$E = 513$ (keV)	ans ECF* E/J	[1]	[4]

S $\Rightarrow$ 1025 (keV) $\rightarrow$ [3]
S $\Rightarrow$ 256 (keV) $\rightarrow$ [3]

AVAILABLE MARKS: 15

						AVAILABLE MARKS
8	**(a)**	**(i)**	$n \rightarrow p + e + \bar{\nu}_e$ $0 \rightarrow +1 + -1 + 0$ and charge on each side is zero		[1]	
		(ii)	$n \rightarrow p + e + \bar{\nu}_e$ $0 \rightarrow 0 + +1 + -1$ and lepton number on each side is zero		[1]	
	(b)		Non-leptons are hadrons/baryons Hadrons (baryons) have a quark structure (leptons are fundamental) or experience the strong force	[1] [1]	[2]	
	(c)	**(i)**	Weak (nuclear) force W– (boson)	[1] [1]	[2]	
		(ii)	(Decays into) an electron and an antineutrino		[1]	7
9	**(a)**	**(i)**	$\lambda = \frac{0.76}{2.5} = 0.304\,(\text{m})$	[1]		
			$f = \frac{v}{\lambda} = \frac{18.3}{0.304} = 60.2\ (\text{Hz})$	[1]		
			$60.2 \times 60 = 3612 = 3600$ to 2 dp	[1]	[3]	
		(ii)	$F = m\omega^2 x$ $(F = ma$ and $a = -\omega^2 x)$ — eqn(s) $\omega = 2\pi f = 120\pi$ (allow 120.4π) = 377 (rad s^{-1}) — ans $F = 0.12(120\pi)^2(0.086)$ — subs ECF* ω or a $F = 1467$ (N) (1480) — ans $S = 5.28 \times 10^6 \rightarrow$ [3]	[1] [1] [1] [1]	[4]	
	(b)	**(i)**	$E = ItV$ — eqn $0.03 = (13.6 \times 10^{-3})(1.20 \times 10^{-3})V$ — subs p.d. = 1838 (V) — ans	[1] [1] [1]	[3]	
		(ii)	$I = \frac{Q}{t}\left(= \frac{Ne}{t}\right)$ $Q = 1.63 \times 10^{-5}$ (C) — eqn $0.0136 = \frac{N(1.6 \times 10^{-19})}{1.2 \times 10^{-3}}$ — subs $N = 1.02 \times 10^{14}$ ECF for Q — ans	[1] [1] [1]	[3]	
	(c)		$92 = 10\log_{10}\frac{I}{10^{-12}} = 1.58 \times 10^{-3}\,(\text{W m}^{-2})$ — ans $\frac{1.58 \times 10^{-3}}{400} = 3.96 \times 10^{-6}\,(\text{W m}^{-2})$ ECF I/ W m^{-2} — ans $\left(\text{not } \frac{92}{400}\right)$ $dB = 10\log_{10}\frac{3.96 \times 10^{-6}}{10^{-12}} = 66$ ans ECF* reduced intensity	[1] [1] [1]	[3]	16
					Total	**90**