Rewarding Learning

ADVANCED
General Certificate of Education
2018

Physics

Assessment Unit A2 2

assessing

Fields and their Applications

[AY221]

FRIDAY 8 JUNE, 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)** **(i)** $F_g = \frac{G m_e m_s}{r^2}$ [1]

$F_c = m_e\omega^2 r$ or in terms of T [1]

Algebra to obtain $r^3 \propto T^2$ [1] [3]

(ii) Correct values of (r^3 / T^2) for both planets [1]
Heading correct [1]
Average **k** = 3.33×10^{18} ($m^3 s^{-2}$) [1] [3]

Planet	Mean radius of orbit r/m	Period T/s	r^3/m^3	T^2/s^2	$(r^3/T^2)/m^3 s^{-2}$
Venus	1.08×10^{11}	1.94×10^7	1.26×10^{33}	3.76×10^{14}	3.35×10^{18}
Earth	1.49×10^{11}	3.16×10^7	3.31×10^{33}	9.99×10^{14}	3.31×10^{18}

Not required to obtain marks

(iii) $\left(k = \frac{Gm_s}{4\pi^2}\right)$

$m_s = \frac{k4\pi^2}{G}$

$m_s = \frac{(3.33 \times 10^{18}) \times 4\pi^2}{6.67 \times 10^{-11}}$ eqn or subs [1]

$= 1.97 \times 10^{30}$ kg [1] [2]

ecf from (a)(ii)

(b) **(i)** $g = \frac{GM_e}{r^2}$

$r^2 = \frac{(6.67 \times 10^{-11}) \times (5.98 \times 10^{24})}{7.97}$ eqn or subs [1]

$r^2 = 5.00 \times 10^{13}$ m

$r = 7.07 \times 10^6$ m [1]

Orbital height = $(7.07 - 6.37) \times 10^6$

$= 7.04 \times 10^5$ m [1] [3]

(ii) No. T for a geostationary satellite = 24 hours
or
No. Orbital height not equal to 3.59×10^7 m
or
No. Radius of orbit not equal to 4.23×10^7 m [1] 12

					AVAILABLE MARKS
2	**(a)** Force		[1]		
	per unit (positive) charge		[1]	[2]	
(b)	**(i)** $F_{QZ} = 8.99 \times 10^9 \dfrac{(25 \times 10^{-6} \times 15 \times 10^{-6})}{2^2}$	subs	[1]		
	$F_{QZ} = 0.84\,N$	ans	[1]		
	Towards left		[1]	[3]	
	(ii) $E = k\dfrac{Q}{d^2}$				
	$E_{ZQ1} = k\dfrac{(25 \times 10^{-6})}{x^2}$; $E_{ZQ2} = k\dfrac{(15 \times 10^{-6})}{(2-x)^2}$	either subs	[1]		
	$E_{ZQ1} = E_{ZQ2}$	equates	[1]		
	Elimination of k and rearrange $\sqrt{25}\,(2-x) = \sqrt{15}\,x$		[1]		
	$x = 1.13\,m$		[1]	[4]	9

AVAILABLE MARKS

3 **(a)** The capacitance of a capacitor is 1F when there is a potential difference of 1V across it and a charge of 1C is stored [1]

(b) **(i)** $E = \frac{1}{2}CV^2$ or $E = \frac{1}{2}QV$ and $Q = CV$ eqn [1]

$= \frac{1}{2} \times 20 \times 10^{-6} \times 12^2$ subs [1]

$= 1.44 \times 10^{-3}$ J [1] [3]

(ii) 2 time constants identified [1]
$\tau = CR = 3.6$ s [1]
$t = 3.6 \times 2 = 7.2$ s [1]

or

$V = V_0 e^{\frac{-t}{CR}}$ eqn [1]

$1.64 = 12.0 e^{\frac{-t}{(20 \times 10^{-6} \times 180 \times 10^3)}}$ subs [1]

$t = 7.16$ s [1] [3]

(c) **(i)** $\frac{1}{C_{Series}} = \frac{1}{20} + \frac{1}{20} + \frac{1}{20}$

$C_{Series} = 6.7\,\mu F$ [1]

$C_{parallel} = (6.7 + 20.0)\,\mu F = 26.7\,\mu F$ [1]

$\frac{1}{C_{total}} = \frac{1}{20} + \frac{1}{26.7}$

$C_{total} = 11.4\,\mu F$ [1] [3]

(ii) $Q_{total} = C_{total}V$ [1]

$= 11.4 \times 10^{-6} \times 12$ subs [1]

$= 137 \times 10^{-6}$ C [1] [3]

(iii) $V_A = Q_A/C_A = (137 \times 10^{-6})/(20 \times 10^{-6}) = 6.86$ V [1] 14
ecf from **(ii)**

			AVAILABLE MARKS
4 **(a)** **(i)** The direction of the induced emf is always such as to oppose the change producing it		[1]	
(ii) Current is induced in coil as magnet moves in – meter deflects	[1]		
Current flows to make right end of coil a north pole	[1]		
A current is induced in opposite direction – meter deflects in opposite direction.	[1]		
Current flows to make right end of coil a south pole	[1]		
Induced polarity attracts withdrawing magnetic pole/opposes approaching magnetic pole.	[1]	[5]	
(b) $\mathbf{E} = (-)\mathbf{N}\dfrac{\mathbf{d(BA)}}{\mathbf{dt}}$ or $E = Blv$	[1]		
$= (1.74 \times 10^{-5}) \times 34.1 \times 240$ subs	[1]		
$= 0.142\,V$	[1]	[3]	9
5 **(a)** **(i)** Type – step down		[1]	
(ii) Construction – primary coil and secondary coil – laminated soft iron core – more turns on primary than secondary any 2 points	[2]		
Workings – a.c. input to primary coil – produces a continually changing magnetic flux this is linked by iron core to secondary coil – a changing flux in the secondary is created – which induces an a.c. across secondary	[4]		
Quality of written communication	[2]	[8]	
(b) $\mathbf{P_{lost} = i^2\ R}$	[1]		
$= \mathbf{i^2\dfrac{\rho l}{A}}$ R in terms of ρ, l and A	[1]		
$= \mathbf{4i^2\dfrac{\rho l}{\pi d^2}}$ A in terms of $(\pi d^2/4)$	[1]	[3]	12

				AVAILABLE MARKS
6 **(i)**	Charge moving in a magnetic field will experience a force	[1]		
	Force is always perpendicular to path of electrons	[1]	[2]	
(ii)	Out of page		[1]	
(iii)	$\frac{1}{2} m_e v^2 = eV$	[1]		
	$v^2 = (2 \times 1.6 \times 10^{-19} \times 200)/(9.11 \times 10^{-31}) = 7.03 \times 10^{13}$ subs or value	[1]		
	$v = 8.38 \times 10^6 \text{ m s}^{-1}$	[1]	[3]	
(iv)	$Bev = \frac{m_e v^2}{r}$	[1]		
	$B = (9.11 \times 10^{-31} \times 8.38 \times 10^6)/(1.6 \times 10^{-19} \times 4 \times 10^{-2})$ subs	[1]		
	$= 1.2 \text{ mT}$	[1]	[3]	9
	ecf from (iii) **SE [2]/[3] if r = 8cm. B = 0.6 mT**			
7 **(a)**	Any **five** from: Particles accelerated across gaps Using a high frequency alternating supply Particles repelled from electrode they leave and attracted to next/synchronous acceleration Particles travel at constant velocity within electrodes Electrodes get longer since particles travel faster as they are accelerated along LINAC so time within each electrode is same Frequency of supply is kept constant Vacuum prevents accelerated particles being scattered by air particles		[5]	
(b)	$T = (12 \times 10^6)^{-1} = 8.33 \times 10^{-8} \text{ s}$	[1]		
	Time in electrode $= \frac{1}{2} \times (12 \times 10^6)^{-1} = 4.17 \times 10^{-8} \text{ s}$	[1]	[2]	7

AVAILABLE MARKS

8 (a) (i)

Fundamental force	Exchange particle
Strong nuclear	Gluon
Weak interaction	W^-, W^+, Z^0
Electromagnetic	Photon
Gravitational	Graviton

[4]

(ii) Any **one** from:
Hadrons feel the strong force, leptons do not
Hadrons have a quark structure/are composite, leptons are fundamental particles/have no structure [1]

(b) Conservation of charge Q:
LHS = 0 + 1 = 1; RHS = 0 + 1 + 1 + (–1) = 1 [1]
Charge conserved

Conservation of baryon number B:
LHS = 1 + 1 = 2; RHS = 1 + 1 + 1 + 0 = 3 [1]
Baryon number **not** conserved
Reaction cannot happen. [1] [3] 8

9 (a) R = 7.94/sin(48) = 10.68 m [1]

t = R/v = 10.68/0.7 = 15.26 s [1] [2]

(b) $Q = 1000 \times (10 \times 60) \times (50 \times 10^{-6}) = 30$ J [1]
$Q = mc\Delta\theta$

$c = 30/(1.47 \times 10^{-6} \times (52 - 47))$ subs [1]

$= 4.08 \times 10^{6}$ J kg^{-1} °C^{-1} [1] [3]

(c) (i) $n = \dfrac{1}{\sin C}$ eqn [1]

C = 35° [1] [2]

(ii) $E = hf = hc/\lambda$
$= (6.63 \times 10^{-34} \times 3 \times 10^{8})/1.1 \times 10^{-6}$ eqn or subs [1]

$= 1.81 \times 10^{-19}$ J [1]

= 1.13 eV [1] [3] 10

Total 90