OCR
RECOGNISING ACHIEVEMENT

GCE

Physics B

Advanced GCE **G495**

Field and Particle Pictures

Mark Scheme for June 2010

Oxford Cambridge and RSA Examinations

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Question			Expected Answers	Marks	Additional Guidance
1	a		B	1	
	b		$(9.0 \times 10^{9} \times 3.2 \times 10^{-19} \times 1.3 \times 10^{-17})/(1.0 \times 10^{-13})^{2}$ **(1)** = 3.7(44) (N) **(1)**	2	Award 2 marks for bald correct value **Allow** 4 (N), **not** 3.8. Ignore figures after 3.7 e.g. accept 3.75 Power of ten error: 1 mark max. **not** 3.7×10^{-13} as this comes from not squaring the denominator.
2	a		(Equipotential lines are) closer together	1	
	b		Outward and at right angles to equipotentials	1	Judge right angle by eye. Both features needed.
	c		1×10^{6}	1	Accept more sig figs
3	a		Complete flux loop contained in the core	1	
	b		5	1	
4			B = 0.05 / (2 x 0.3) **(1)** = 0.08 **(1)**	2	Award 2 marks for bald correct value **not** 1/12 for 2nd mark (must calculate) Power of ten error: 1 mark max.
5			C	1	
6	a		$^{4}_{2}$X **(1)** α/alpha (particle) / helium nucleus **(1)**	2	**not** 'helium' or 'helium atom'
	b		Do not penetrate glass / short range in air / AW	1	**not** 'do not penetrate skin'; must mention glass or air
7	a		$6 \times 10^{-3} \times 5$ **(1)** = 0.03% **(1)**	2	Award 2 marks for bald correct value Award 1 for any risk x exposure calculation i.e. 6 x 5 with any powers of ten
	b		$6 \times 10^{-3} \times 15$ **(1)** = 0.09 **(1)**	2	Award 2 marks for bald correct value Award 1 for any mass x exposure calculation i.e. 15 x 6 with any powers of ten
8			udd / up, down, down	1	Allow any order **not** +2/3, -1/3,-1/3
			Total	**19**	

Question			Expected Answers	Marks	Additional Guidance
9	a		Lepton number conserved **(1)** Charge conserved **(1)**	2	Incorrect physics can cancel either or both marks.
	b		$t = 9 \times 10^{3} / (0.98 \times 3 \times 10^{8})$ $= 3.1 \times 10^{-5}$ s	1	Look for clear working including 0.98 or own answer (e.g. 3.06×10^{-5}) For information: $0.98 \times 3 \times 10^{8} = 2.94 \times 10^{8}$
	c		Time = 20 half lives **(1)** followed by calculation $½^{20}$ **(1)** = 9.5×10^{-7} or 9.5×10^{-5} % **(1)** Accept between 20 and 21 half-lives giving values between 9.5×10^{-5} % and 4.8×10^{-5} %	3	Need own value. Accept correct bald answer for three marks. Or: $N/No = \exp -(0.693 \times 30 \times 10^{-6} / 1.5 \times 10^{-6})$ **(2)** $= 9.6 \times 10^{-7}$ or 9.6×10^{-5} % **(1)** Or: Calculation of λ (4.6×10^{5}) **(1)** followed by clear use of equation **(1)** followed by correct evaluation of proportion **(1)** Accept use of between 30 and 31μs giving values between 9.6×10^{-7} to 6.0×10^{-7} Using ln2 instead of 0.693 gives range 9.5×10^{-7} to 6.0×10^{-7}
	d	i	3.9(4) or 4	1	
		ii	Half life = $31 \times 10^{-6} / 4$ **(1)** $= 7.8 \times 10^{-6}$ **(1)**	2	Need own value. Accept answers in range 7.5×10^{-6} to 7.9×10^{-6} s Allow answers in μs Allow ecf. Accept reverse argument Allow correct alternative methods using data elsewhere in question.
	e		Half life = $1.5 \times 10^{-6}/(1- 0.98^{2})^{0.5}$ **(1)** $= 7.54 \times 10^{-6}$ **(1)** Comparison with d(ii) **(1)**	3	Comparison of half-life values without relativity calculation scores 1 max. One mark for $\gamma = 0.199$
			Total	**12**	

Question			Expected Answers	Marks	Additional Guidance
10	a	i	Sinusoidal shape of correct frequency and constant amplitude **(1)** In-phase with current **(1)**	2	Drawing over current line is given two marks Drawing over induced emf line is given 1 mark
		ii	Any two from: Induced emf is zero when (rate of) change of flux is zero **(1)** (Rate of change of) flux is proportional to (rate of change of) current **(1)** Rate of change of flux or current is zero at maximum **(1)**	2	No mark awarded for quoting Faraday's Law or repeating the stem Don't accept 'minimum' for zero Accept clear link between flux and current (don't insist on use of 'proportional')
	b	i	Max rate of change $= 2\pi \times 50 \times 6 \times 10^{-4} \times 7 \times 10^{-2}$ **(1)** $= 0.013$ (Wb s^{-1}) **(1)**	2	For information: max flux = $6 \times 10^{-4} \times 7 \times 10^{-2} = 4.2 \times 10^{-5}$ Award 2 marks for bald correct value
		ii	Max emf = 0.013x 300 **(1)** = 3.9 (V) **(1)**	2	Ignore sign. Allow 3, 3.0, 3.96, 3.9, 4, 4.0 ecf from b(i) Award 2 marks for bald correct value
	c		Max two marks from: • (Larger) eddy currents **(1)** • Eddy currents set up flux **(2)** • Eddy current flux interacts with / opposes primary flux **(2)** • Eddy currents produce energy losses **(2)** And max two marks from: • Maximum flux reduced **(1)** • When max flux reduced the max rate of change of flux is also reduced. **(1)**	3	Allow reverse arguments based on merits of laminated core.
			Total	**11**	

Question			Expected Answers	Marks	Additional Guidance
11	a		Rest energy = $9.1 \times 10^{-31} \times 9 \times 10^{16} = 8.19 \times 10^{-14}$ J (1) $= 8.19 \times 10^{-14} / 1.6 \times 10^{-19} = 0.51$ MeV AW (1) Ratio =100/0.51 = 196 (1) Or reverse argument: $9.1 \times 10^{-31} \times 9 \times 10^{16} = 8.19 \times 10^{-14}$ J (1) $\tilde{}$ $100 \times 10^{6} \times 1.6 \times 10^{-19} = 1.6 \times 10^{-11}$ J **(1)** $1.6 \times 10^{-11} / 200 = 8.0 \times 10^{-14}$ J (1)	3	Look for own value, **not** 200
	b		$3 \times 10^{9} / 100 \times 10^{6} = 30$	1	Many will calculate values first Accept any answer that would round to 30 to 2 sf Allow any correct fraction eg 3000/100
	c		Arrow to the left and perpendicular to the direction of motion	1	Judge by eye
	d	i	$Bev = mv^2/r$ **(1)** (Be = mv/r B = mv/er)	1	Mark given for equivalence of Bev and mv^2/r Accept q or Q instead of e
		ii	$B = 3 \times 10^{9} \times 1.6 \times 10^{-19} / (3 \times 10^{8} \times 1.6 \times 10^{-19} \times 89)$ **(1)** $= 0.1(12)$(T) **(1)**	2	Award 2 marks for bald correct value Power of ten error: 1 mark max
			Total	**8**	

Question			Expected Answers	Marks	Additional Guidance
12	a	i	4×10^{-9} or 4 n(m)	1	
		ii	One full wavelength drawn at n=2 level	1	
	b		Use of $\lambda = h / mv$ and $E_k = ½ mv^2$ or $(mv)^2/2m$ **(1)** Correct algebra leading to $E_k = h^2/2m\lambda^2$ **(1)**	2	ora
	c		Wavelength has halved **(1)** therefore $1/\lambda^2$ gone up by a factor of four or λ^2 has quartered **(1)**	2	
	d	i	One correct energy calculation giving 6.0×10^{-20} or 1.5×10^{-20} (J) **(1)** Energy difference = 4.5×10^{-20} (J) **(1)** Or Energy = $(h^2/2m) \times (1/\lambda_2^2 – 1/\lambda_1^2)$ **(1)** = $2.4 \times 10^{-37} \times 1.9 \times 10^{17}$ = 4.5×10^{-20} (J) **(1)** Or use of $3h^2/2m\lambda_1^2$ **(1)** leading to correct answer **(1)**	2	Award 2 marks for bald correct value Allow ecf for incorrect wavelength in a (i)
		ii	Frequency of absorbed photon = $4.5 \times 10^{-20} / 6.6 \times 10^{-34} = 6.8 \times 10^{13}$ (Hz) **(1)** Corresponding wavelength = $3 \times 10^8 / 6.8 \times 10^{13} = 4.4 \times 10^{-6}$ (m) **(1)** Comment consistent with calculated value e.g. 'it is outside range of visible wavelengths'. **(1)** ora based on wavelength within range of 400 – 700 nm: Correct choice of initial wavelength **(1)** Frequency calculation 7.5×10^{14} - 4.3×10^{14} (Hz) **(1)** Energy calculation within range 4.9×10^{-19} – 2.8×10^{-19} (J) **(1)** Or Correct choice of frequency in range 7.5×10^{14} - 4.3×10^{14} (Hz) **(2)** Energy calculation within range 4.9×10^{-19} – 2.8×10^{-19} (J) **(1)**	3	Use of 5×10^{-20} gives 7.6×10^{13} Hz, giving wavelength of 4.0×10^{-6} m. Allow ecf Correct use of hc/E gets first 2 marks. (substitution and evaluation) Up to 2 marks can be awarded for correct calculation based on wavelength outside correct range. Correct use of hc/λ gets last two marks (substitution and evaluation) Penalise contradiction in final comment **(-1)** Penalise contradiction in final comment **(-1)**
			Total	**11**	

Question			Expected Answers	Marks	Additional Guidance
13	a		C	1	
	b	i	Electrons moved from ball onto the cloth	1	
		ii	Number = 5.0×10^{-6} / 1.6×10^{-19} **(1)** $= 3.1(25) \times 10^{13}$ **(1)**	2	Two marks for correct bald answer
		iii	$-5(.0) \times 10^{-6}$ (C)	1	Correct sign and magnitude.
		iv	Glass is an insulator/ poor conductor OR charge does not move (freely) through/on glass	1	
			Total	**6**	
14	a		Electrical/ potential energy (lost) = kinetic energy (gained)	1	Accept implied equality (eg potential energy turned into kinetic energy)
	b	i	Correct re-arrangement: $v = (2eV/m)^{1/2}$ **(1)** $= 3.8 \times 10^{7}$ (ms^{-1}) **(1)**	2	Accept 3.75×10^{7} not 3.7×10^{7} Two marks for correct bald answer. Allow one mark max if POT error
		ii	Final velocity = 2 x average = 2 x s/t ⇨ $t = (2 \times 0.1)/(3.8 \times 10^{7})$ **(1)** ⇨ $= 5.3 \times 10^{-9}$ s **(1)**	2	Two marks for correct bald answer. Values in range 5.26×10^{-9} – 5.33×10^{-9} ecf
		iii	e.g. uniform acceleration / non-relativistic/ initial speed zero/constant force/uniform field	1	**not** ' no collisions'. **not** 'travel in straight lines'
			Total	**6**	

Question			Expected Answers	Marks	Additional Guidance
15	a		No. of electrons per m^3 = (8900/0.064) x 6.0 x 10^{23} **(1)** = 8.3 x 10^{28} **(1)**	2	Need calculated value. Two marks for correct bald answer. Accept 8.4 x 10^{28} accept 8 x 10^{28} **not** 8.0 x 10^{28}
	b	i	G = σA / l = (5.9x10^7 x 0.5 x10^{-6})/ 3.0 **(1)** = 9.8 (S) **(1)**	2	Need calculated value. Two marks for correct bald answer
		ii	I = G.V = 9.8 x 1.5 = 15 (A)	1	Accept 14.7 or 14.8 (A)
			Total	**5**	
16	a		From eqn [2}, $v^2 \alpha m^{-1}$ **(1)** so larger m => smaller v **(1)** OR: Rearranged equation : $v^2 = 3kT/m$ **(1)** so larger m => smaller v **(1)** OR: Same k.e. **(1)** so larger m => smaller v **(1)**	2	Second mark dependent on first. Allow 'heavier' molecules or 'molecules that weigh more'. **not** 'larger molecules'.
	b		1.41 or $2^{1/2}$	1	
	c		v = $(3kT/m)^{1/2}$ **(1)** = 1.2 x 10^5 m s^{-1} **(1)** OR: v = (3 x 1.4 x 10^{-23} x 300/9.1 x 10^{-31})$^{1/2}$ **(1)** v = 1.2 x 10^5 m s^{-1} **(1)**	2	Accept unrounded answer
	d		Any two from: No force/field in one particular direction **(1)** Motion/direction is random **(1)** no net movement of charge/electrons **(1)**	2	
			Total	**7**	

Question			Expected Answers	Marks	Additional Guidance
17	a		Units of j are A m^{-2} **(1)** Units of σ are Ω^{-1} m^{-1} (or S m^{-1}) and units of E are V m^{-1} **(1)** units of product σE are V Ω^{-1} m^{-2} **(1)**	3	Accept dimensionally consistent units as alternatives Accept dimensional analysis
	b		$J = I/A$ substitution **(1)** $E = V/L$ substitution **(1)** Completing the argument**(1)**	3	e.g giving $I/A = \sigma E$ or I/A proportional to E eg giving $I/A = \sigma$ V/L or I/A proportional to V/L Award marks for three correct algebraic stages with correct conclusion eg I is proportional to V, or $I = GV$ or $I = V/R$
	c		$\tau = (\sigma m) / (N e^2)$ **(1)** $= 5.9 \times 10^7 \times 9.1 \times 10^{-31} / (1 \times 10^{29} \times (1.6 \times 10^{-19})^2)$ **(1)** $\Rightarrow \tau = 2.1 \times 10^{-14}$ s **(1)**	3	Need calculated value. Three marks for correct bald answer. Rearrangement can be implicit. N can be in range 8(.3) x 10^{28} or 1 x 10^{29} σ can be 5.9 x 10^7 or 6 x 10^7 Answers in range: 2.10 x 10^{-14} to 2.67 x 10^{-14}. Also accept 1sf answer 2 x 10^{-14} Max 2 marks if power of ten error
	d		Initial horizontal line **(1)** Positive gradient commencing at or before 5 K (curve or straight line) **(1)**	2	Line can be along horizontal axis
			Total	**11**	
18	a		Fluids flow and current flows	1	AW idea of analogy between fluids and currents
	b		One observation from: • (alpha) particles (rarely) scattered backwards **(1)** • most (alpha) particles pass through undeflected **(1)** theoretical consequence: mass or (positive) charge (of atom) concentrated (in small volume) **(1)**	2	second mark is dependent on first. **not** named other particle instead of alpha (eg not proton, electron etc)
	c		It 'explained' Ohm's Law/ explains why metals are (good) conductors.	1	Allow correct answers referring to opacity and/or reflectivity of metals.
			Total	**4**	

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