ASSESSMENT and QUALIFICATIONS ALLIANCE

Mark scheme
June 2002

GCE

Physics B

Unit PHB5

Unit 5: Fields and their Applications

Notes for guidance

Letters are used to distinguish between different types of marks in the scheme.

M indicates OBLIGATORY METHOD MARK
This is usually awarded for the physical principles involved, or for a particular point in the argument or definition. It is followed by one or more accuracy marks which cannot be scored unless the M mark has already been scored.

C indicates COMPENSATION METHOD MARK
This is awarded for the correct method or physical principle. In this case the method can be seen or implied by a correct answer or other correct subsequent steps. In this way an answer might score full marks even if *some* working has been omitted.

A indicates ACCURACY MARK
These marks are awarded for correct calculation or further detail. They follow an M mark or a C mark.

B indicates INDEPENDENT MARK
This is a mark which is independent of M and C marks.

Note: Where a correct answer only (c.a.o.) is required, this means that the answer must be as in the Marking Scheme, including significant figures and units.

Where an error carried forward (e.c.f.) is allowed by the Marking Scheme for an incorrect answer, e.c.f. must be written on the script if an error has been carried forward.

Instructions to Examiners

1 Give due credit to alternative treatments which are correct. Give marks for what is correct; do not deduct marks because the attempt falls short of some ideal answer. Where marks are to be deducted for particular errors specific instructions are given in the marking scheme.

2 Do not deduct marks for poor written communication. Refer the script to the Awardsmeeting if poor presentation forbids a proper assessment. In each paper candidates may be awarded up to two marks for the Quality of Written Communication in cases of required explanation or description. However, no candidate may be awarded more than the total mark for the paper. Use the following criteria to award marks:

2 marks: Candidates write with almost faultless accuracy (including grammar, spelling and appropriate punctuation); specialist terms are used confidently, accurately and with precision.

1 mark: Candidates write with reasonable and generally accurate expression (including grammar, spelling and appropriate punctuation); specialist terms are used with reasonable accuracy.

0 marks: Candidates who fail to reach the threshold for the award of one mark.

3 An arithmetical error in an answer should be marked A.E. thus causing the candidate to lose one mark. The candidate's incorrect value should be carried through all subsequent calculations for the question and, if there are no subsequent errors, the candidate can score all remaining marks (indicated by ticks). These subsequent ticks should be marked C.E. (consequential error).

4 With regard to incorrect use of significant figures, normally a penalty is imposed if the number of significant figures used by the candidate is one less, or two more, than the number of significant figures used in the data given in the question. Themaximum penalty for an error in significant figures is **one mark per paper**. When the penalty is imposed, indicate the error in the script by S.F. and, in addition, write S.F. opposite the mark for that question on the front cover of the paper to obviate imposing the penalty more than once per paper.

5 No penalties should be imposed for incorrect or omitted units at intermediate stages in a calculation or which are contained in brackets in the marking scheme. Penalties for unit errors (incorrect or omitted units) are imposed only at the stage when the final answer to a calculation is considered. The maximum penalty is **one mark per question**.

6 All other procedures, including the entering of marks, transferring marks to the front cover and referrals of scripts (other than those mentioned above) will be clarified at the standardising meeting of examiners.

Question 1

(a)(i)	E at $2R$ = 20 to 21 (NC^{-1}) i.e. no up (i.e. have used inverse square law possibly misreading the E axis)	B1	
	correct curvature with line through given point must not increase near tail (ignore below 6400 km)	B1	
	no intercept on distance axis and through correctly calculated point	B1	**3**
(ii)	determine the area under the graph between **A** and **B** **or** between the points (ignore any reference to $V = Ed$)	B1	**1**
(b)(i)	$E = q/4\pi\varepsilon_o r^2$ ($Q = 84 \times 4\pi\ 8.9 \times 10^{-12}\ (6400\ 000)^2$	C1	
	$(3.8–3.9) \times 10^5$ C	A1	**2**
(ii)	surface area of the Earth = 5.15×10^{14} (m^2) or: charge per square metre = total charge/ surface area of Earth (say be seen as a numerical substitution with wrong area)	C1	
	738 - 760 pC (m^{-2}) ecf for Q from (b)(i)	A1	**2**
	(i) answer is the same when unit is left in km since r^2 cancels so condone (ii) Use of $E = q/4\pi\varepsilon_o r$ followed by area = $4\pi r$ gives correct value but no marks		
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Question 2

(a)	there is a change in the magnetic flux/flux linkage/ magnetic field through a coil as the magnet passes it or the coil/wire cuts a magnetic field/flux lines	B1	**1**
(b)(i)	the cart has accelerated (between **A** and **B)** or is going faster/has more KE **(**at **B)**	B1	**1**
	the rate of cutting flux increases coil/wire cuts magnetic field faster induced emf (condone amplitude) is proportional to speed of magnet or increases with speed	B1	**2**
(ii)	the direction of the induced emf opposes the change producing it or mention of Lenz's law/or some attept to apply Fleming's RHR	C1	
	as the coil passes **A** the magnetic flux/field is increasing as the coil passes **B** the flux is decreasing	A1	**2**
(iii)	magnet is going faster (at **B**) or has accelerated (from **A** to **B**)	B1	
	the magnet takes less time to pass across the coil or the time for which the flux is changing is less	B1	**2**
(c)(i)	time for car to move from **A** to **B** = (0.14s to 0.155) s (**not** 0.16 s) **or** $v = s/t$ stated	B1	
	average speed = 0.05/(0.14 s to 0.155) = 0.32 to 0.36 (allow 2 or more sf only; no up)	B1	**2**
(ii)	$v^2 = u^2 + 2as$ calculation of v correct 0.55 or 0.63 ms^{-1} correct substitution of data allowing their v and their value from (i) or 0.3 and s = 0.25 m 0.37 to 0.60 ms^{-2}	M1 M1 M1 A1	
	$v = u + at$ calculation of v correct 0.55 or 0.63 ms^{-1} correct substitution of data allowing their value from (i) or 0.3 and t = 0.44±0.01s or 0.57±0.01 s 0.34 to 0.54 ms^{-2} (not allowed if t = 0.44 s)	M1 M1 M1 A1	
	$s = ut + ½ at^2$ use of t = 0.57±0.01 s correct substitution of data allowing t = 0.44±0.01 s or 0.57±0.01 s and u = their value from (i) or 0.3 and s = 0.25 m 0.24 to 0.52 ms^{-2} (not allowed if t = 0.44 s)	M1 M1 M1 A1	 **4**
(d)(i)	rate of change of area = vl or 0.29x 1.2 (x $10^{-2)}$ seen	C1	
	$3.5 \times 10^{-3}\ m^2s^{-1}$	A1	**2**
(ii)	rate of change of flux = 2.8x 10^{-4} ($T\ m^2s^{-1}$) (0.08 × their (i)) rate of change of flux (linkage) = induced voltage allow equation $V = N\Delta\phi/\Delta t$ or $\Delta\phi/\Delta t$ or BLv	C1 C1	
	33 or 34 mV ecf from (i) (9.9 × their (i))	A1	**3** **18**

Question 3

(a)

number of gamma ray photons per sec = $\frac{3.0 \times 10^7}{5}$ (= 6.0×10^6) B1

correct use of $4\pi r^2$; substitution of data $\frac{6.0 \times 10^6 \text{ or } 3.0 \times 10^7}{4 \times \pi \times 150^2}$ =21.2 B1

NB they may determine number per m^2 and divide by 10 000 **2**

(b)(i) decay constant = 0.69/12 = 0.0575 h^{-1} or 1.6×10^{-5} (or time =.5 half life) C1

dose = $21e^{-(6 \times 0.0575)}$ dose = $21/2^{0.5}$ C1

or new (gamma) activity = $6 \times 10^6 e^{-(6 \times 0.0575)}$

or new (total) activity = $3 \times 10^7 e^{-(6 \times 0.0575)}$

15 (gamma rays per cm^2 per second) Condone 14.8 – 14.9 (no up) A1 **3**

(ii) clear attempt to apply inverse square law C1

1.3 (1.26) m A1 **2**

(c) beta particles are more heavily ionising than gamma radiation B1

or loses energy rapidly by ionising the air/matter

beta particle range/penetration (in air) is low B1 **2**

or beta particle range is about 30 cm

or is less than 1.5 m

or is much lower than gamma radiation

NB: mention of not able to penetrate skin or clothing is talk out

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Question 4

(a)(i) e.g. the cost of installation or capital costs (allow a specific cost) B1

the cost of maintainance (allow a specific cost) B1

information carrying capacity leading to profitability **2**

(ii) use of raw materials B1

environmetal impact of mining for raw materials B1

visual impact of cables or setting up either system

destruction of habitats (not just will have environmental implications)

danger to astronauts undertaking maintenance

danger of satellite launch or re-entry **2**

may make reference to specific danger e.g. emissions (exhaust gases or transmitters)

or breaking up on re-entry

(iii)	labelled diagram showing communication by line of sight via satellite	B1	
	labelled diagram showing communication by diffracted waves round the earth's surface or refraction/reflection via ionosphere	B1	
	mention of diffraction of waves	M1	
	only long wavelengths (allow these wavelengths) will diffract (bend) round the Earth's surface	A1	
	high frequencies (short wavelength) the transmitter must 'see' the receiver/satellite or used for line of sight communication only	B1	
	mention of reflection or refraction by ionosphere/upper atmosphere	M1	
	only long wavelengths (allow these wavelengths) will be refracted/reflected by the ionosphere or high frequencies will pass through the ionosphere	A1	4
(b)(i)	$R = \rho L/A$	C1	
	0.27 Ω	A1	2
(ii)	power loss per m = 3.38×10^{-6} W {e.c.f.) × 2} or $(2.5 \times 10^{-3})^2 \times$ (b)(i)	C1	
	power loss permitted = 11 mW	C1	
	distance = 880/ their (b)(i) (3.2 to 3.3 km if correct throughout) or power loss in cable = 11 mW	A1	3
	resistance of cable = 1760 Ω (from $11 \times 10^{-3} = (2.5 \times 10^{-3})^2 R$		
	distance = 880/ their (b)(i) (3.2 to 3.3 km if correct throughout)		
(iii)	current in cable will be lower or shows current being transmitted to be 2.5 mA/4 = 0.625 mA	B1	
	energy/Power loss (per metre) will decrease or I^2R losses are smaller shows power loss (per m) to be 1/16 original loss (0.21 μW)	C1 A1	
	range will increase shows range to be 16 × greater **there must be at least one comment on the efficiency of the transformers** transformer efficiency mentioned	C1 A1 B1	
	discusses correctly one cause of power loss in transformers	B1 **Max**	 5
	the use of physics terms is accurate, the answer is fluent/well argued with few errors in spelling, punctuation and grammar **and 3 to 5** marks for physics		2
	the use of physics terms is accurate, the answer lacks coherence or the spelling, punctuation and grammar are poor **and 1 or 2** marks for physics.		1
	the use of physics terms is inaccurate, the answer is disjointed with significant errors is spelling, punctuation and grammar are poor		0
		max	2

(c)(i)	so that they remain above the same point on the equator/above the Earth's surface	B1	
	so that receiving dishes do not have to track the satellite or receivers can always point in the same direction or they are easily located or they can be accessed continually	B1	2
(ii)	(force on satellite =) GMm/r^2 or (acceleration) = GM/r^2 or (central force needed) $=mv^2/r$ or $mr\omega^2$ or (central acceleration) = v^2/r or $r\omega^2$ or $T^2 = 4\pi^2r^3/GM$	C1	
	equates correct equations	A1	
	period of orbit = $2\pi r/v$ or $\omega = 2\pi/T$	B1	
	correct manipulation and substitution (allow if $r^3 = 7.6 \times 10^{22}$ seen) or calculates v using $2\pi r/T$ and $\sqrt{GM/r}$ and shows them to be equal	B1	4
(iii)	$\Delta E_{grav}=GMm(1/r_1 - 1/r_2)$ or $\Delta V_{grav}=GM(1/r_1 - 1/r_2)$	C1	
	correct substitution ignoring k in km energy per kg = 53 MJ	C1	
	$1.3(3) \times 10^{11}$ J (cao)	A1	3
(iv)	distance travelled is approx imately 2 × (42000 km) (condone wrong unit) (allow any **total** distance between 70 000 and 84 000 km) **or** time to travel one way = 0.12 to 0.14 s calculated	C1	
	0.24 to 0.28 s	A1	2
			31

Question 5

(a)	hydrogen atoms attract one another or move together due to gravity	B1	
	the force is due to the mass of the hydrogen atoms	B1	
	forms a dense star/object	B1	
	as the atoms move together their potential energy decreases or work is done on the atoms	B1	
	allow the idea that energy from collapse allows fusion which releases energy or particles close enough to undergo fusion	B1	
	there is an increase in the (mean) kinetic energy of the atoms	B1	
	temperature is proportional to the mean kinetic energy of the atoms	B1 **max**	4
	the use of physics terms is accurate, the answer is fluent/well argued with few errors in spelling, punctuation and grammar **and 3 or 4** marks for physics		
	the use of physics terms is accurate, the answer lacks coherence or the spelling, punctuation and grammar are poor **and 1 or 2** marks for physics		2
	the use of physics terms is inaccurate, the answer is disjointed with significant errors is spelling, punctuation and grammar are poor		
			6

Question 6

(a)	$pV = nRT$ (condone N)	B1	
	number of moles of hydrogen per $m^3 = 2 \times 10^{29}/6 \times 10^{23} = 3.3 \times 10^5$	C1	
	p ($\times$ 1)= $3.3 \times 10^5 \times 8.3 \times 1 \times 10^8 = 2.7$ to 2.8×10^{14} Pa	A1	**3**
(b)	there is gravitational attraction (between the atoms)	M1	
	this is equal to the force on the atoms due to the gas pressure or this can overcome the gas pressure or this is large since the mass of the sun is large or this is what causes the pressure in the first place (owtte) (ignore any mention of the 'strong force')	A1	**2**
			5

Question 7

(a)	a neutrino is emitted	B1	
	necessary to conserve lepton number allow to conserve momentum or energy when positron is emitted **only if neutrino mentioned i.e. if first mark awarded**	B1	**2**
(b)(i)	any equation that shows 2Tr $\Rightarrow$ nHe + 2H (allow p instead of H) ignore any extra particles on RHS	C1	
	equation including Z and A numbers for the above particles even if they are incorrect and/or the equation is unbalanced likely response ${}^3_1\text{H} + {}^3_1\text{H} \Rightarrow {}^4_2\text{He} + {}^1_1\text{H} + {}^1_1\text{H}$ or $2\ {}^3_1\text{H} \Rightarrow {}^4_2\text{He} + 2\ {}^1_1\text{H}$ may use Tr for tritium	A1	**2**
(ii)	$e^+ + e^- \Rightarrow 2\gamma$ (or hf) (allow β or e symbol)	C1	
	${}^{0}_{-1}\text{e} + {}^{0}_{1}\text{e} \Rightarrow 2\gamma$ or $2\,{}^0_0\gamma$ do not allow p^+ unless stated to be a positron	A1	**2**
			6

Question 8

(a)(i)	**max 2 for the C marks** 2 type 1 = $2 \times 6.7 \times 10^{-14}$ J (13.4×10^{-14} J) or	C1	
	2 type 2 = $2 \times 8.8 \times 10^{-13}$ J (17.6×10^{-13} J) or $6.7 \times 10^{-14} + 8.8 \times 10^{-13} + 2.1 \times 10^{-12}$ + (3.2 or 6.4×10^{-13} allowing for gamma)	C1	
	total energy released = 4.0×10^{-12} J or 4.3 or 4.6×10^{-12} J	A1	**3**
(ii)	$E = mc^2$	C1	
	4.4×10^{-29} kg (ecf from (i)) (4.8 or 5.1×10^{-29} kg)	A1	**2**
(b)	$3.9 \times 10^{26}/4.0 \times 10^{-12} = 9.8 \times 10^{37}$ (ecf from (i)) (9.1 or 8.5×10^{37}) allow 1 sf (9 or 10×10^{37})	B1	**1**
			6

Question 9

(a)(i)	separation when the nuclei touch = 3.2×10^{-15} m $(1.5 + 1.7) \times 10^{-15}$ seen or charge on deuteron and tritium = 1.6×10^{-19} C or (potential energy at separation r) = $Qq/4\pi\varepsilon_o r$	C1 C1	
	energy needed = $\dfrac{1.6\times10^{-19}\times1.6\times10^{-19}}{4\pi\varepsilon_0(1.5+1.7)\times10^{-15}}$ = 7.2×10^{-14} J	A1	**3**
(ii)	(E =) 3/2 kT seen	C1	
	$T = 1.7 \times 10^{9}$ K or 3.3×10^{9} K (i.e. using energy = 7.2×10^{-14} or 3.6×10^{-14})	A1	**2**
(iii)	at a given temperature the molecules have a range of speeds/velocities/energies or atoms have a Maxwell/Bolzmann distribution of speeds or the value calculated is for a mean value of energy	C1	
	some atoms will have speed/velocity/energy larger than the mean.	A1	**2**
(b)(i)	no energy input is required or initial high current can be stopped	B1	
	energy from reaction: maintains temperature needed or provides energy for further fusion	B1	**2**
(c)	raw materials (allow named material) more readily available	B1	
	no radioactive materials released into environment so safer (not just by-product less harmful)	B1	**2**
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