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ASSESSMENT and QUALIFICATIONS ALLIANCE

General Certificate of Education

Physics 6456

Specification B

PHB5 Fields and their Applications

Mark Scheme

2008 examination - June series

Mark schemes are prepared by the Principal Examiner and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation meeting attended by all examiners and is the scheme which was used by them in this examination. The standardisation meeting ensures that the mark scheme covers the candidates' responses to questions and that every examiner understands and applies it in the same correct way. As preparation for the standardisation meeting each examiner analyses a number of candidates' scripts: alternative answers not already covered by the mark scheme are discussed at the meeting and legislated for. If, after this meeting, examiners encounter unusual answers which have not been discussed at the meeting they are required to refer these to the Principal Examiner.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of candidates' reactions to a particular paper. Assumptions about future mark schemes on the basis of one year's document should be avoided; whilst the guiding principles of assessment remain constant, details will change, depending on the content of a particular examination paper.

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NOTES
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.

e.c.f is used to indicate that marks can be awarded if an error has been carried forward (e.c.f. must be written on the script). This is also referred to as a ‘transferred error' or 'consequential marking'.

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.

c.n.a.o. is used to indicate that the answer must be numerically correct but the unit is only penalised if it is the first error or omission in the section (see below).

Only **one** unit penalty **(u.p.)** in this paper unless there is a mark allocated specifically for giving a correct unit in the marking. Note that the unit is only penalised in the final answer to the question.

Only **one** significant figure penalty **(s.f.)** in this paper.
Allow 2 or 3 s.f. unless otherwise stated. s.f. penalties include recurring figures and fractions for answers.

Marks should be awarded for **correct** alternative approaches to numerical question that are not covered by the marking scheme. A correct answer from working that contains a physics error (PE) should not be given credit. Examiners should contact the Team Leader or Principal Examiner for confirmation of the validity of the method, if in doubt.

Quality of Written Communication

Before accessing marks for the Quality of Written Communication (QWC) a candidate must first score a minimum of one mark for the physics that is being communicated – this will allow access to 1 mark for QWC. If the candidate scores more marks for physics (a minimum of two or three – depending upon the total mark for that part of the question) then this will allow access to 2 marks for QWC.

Good QWC: the answer is fluent/well argued with few errors in spelling, punctuation and grammar	**2**	
Poor QWC: the answer lacks coherence or spelling, punctuation and grammar are poor	**1**	**Max 2**
Very Poor QWC: the answer is disjointed, with significant errors in spelling, punctuation and grammar	**0**	

GCE Physics, Specification B, PHB5, Fields and their Applications

Question 1			
(a)	$v = \frac{2\pi r}{T}$ or ($2\pi rf$ and $f = \frac{1}{T}$) or ($v = r\omega$ and $\omega = \frac{2\pi}{T}$)	B1	3
	correct substitution $v = \frac{2\pi \times 5.9 \times 10^{12}}{248 \times 3.2 \times 10^{7}}$ $v = \frac{2\pi 5.9 \times 10^{12}}{7.94 \times 10^{9}}$	B1	
	4669 ($m\,s^{-1}$) (given to 3 or more s.f.)	B1	
	or		
	$\frac{GMm}{r^2} = \frac{mv^2}{r}$ or ($F = \frac{GMm}{r^2}$ and $F = \frac{mv^2}{r}$) or $v = \sqrt{\frac{GM}{r}}$	B1	
	correct substitution $v = \sqrt{\frac{6.7 \times 10^{-11} \times 2.0 \times 10^{30}}{5.9 \times 10^{12}}}$	B1	
	4765 ($m\,s^{-1}$) (given to 3 or more s.f.)	B1	
(b)	$\frac{GMm}{r} = \frac{1}{2}mv^2$ or ($E_p = \frac{GMm}{r}$ and $E_k = \frac{1}{2}mv^2$) or $v^2 = \frac{2GM}{r}$	C1	3
	substitution correct $v = \sqrt{\frac{2 \times 6.7 \times 10^{-11} \times 1.3 \times 10^{22}}{1200 \times 10^{3}}}$	C1	
	condone power of 10 error for radius		
	1200 (1205) $m\,s^{-1}$ (u.p.)	A1	
(c) (i)	$pV = nRT$ (or equation with values substituted)	C1	4
	n = (6.7 – 6.8) × 10^{-4} (mol)	A1	
(ii)	molecules leave the surface easily	B1	
	or molecules have velocities which are higher than the escape speed		
	or light molecules will escape		
	Pluto exerts a low gravitational force or has a low gravitational field strength	B1	
	or gases/substances may have liquefied/solidified	B1	
	temperature on Pluto is (very) **low**	B!	
		Total	**10**

Question 2			
(a) (i)	λ = 0.69/5700 (× 3.2 × 10^7) 3.8 × 10^{-12} seen (maybe seen in $A = \lambda N$)	**C1**	**5**
	9.5 (9.46) × 10^{18}	**A1**	
	Bq	**B1**	
(ii)	moles of carbon = 9.46 × 10^{18}/6 × 10^{23} = 1.6 × 10^{-5} mol **or** mass = moles × 14 g clearly stated or 1 mol = 14 g **or** realises that activity from (a) (i) is needed	**C1**	
	mass of carbon 14 per sec = 0.000221 g or 0.000222 g (2.21 × 10^{-4} g or 2.21 × 10^{-7} kg) allow e.c.f. from (i)	**A1**	
(b)	${}^{14}_{6}C \Rightarrow {}^{14}_{7}N + {}^{0}_{-1}\beta + {}^{0}_{0}\bar{\nu}e$ (condone no Z/A for anti neutrino)		**3**
	symbols with **antineutrino** shown	**B1**	
	Z correct for C, N and β	**B1**	
	A correct for C, N and β	**B1**	
(c) (i)	λ = 0.69/5700 or 1.21 × 10^{-4} e.c.f. for use of same incorrect λ from (a) (i)	**C1**	**5**
	0.52 = 0.75$e^{-\lambda t}$	**C1**	
	3000-3100 (3025-3058) (years) c.a.o.	**A1**	
(ii)	the estimated (approximate) age is too high boat is younger than has been estimated estimated age should be lower (than (c) (i)) the effect would lower the estimated/approximate age	**B1**	
	assumption of original activity (of 0.75 in equation) is too high or fewer atoms have (actually) decayed than has been assumed or activity change is (actually) lower than has been assumed	**B1**	
	or mathematical alternatives A_0 (in the estimate in (c) (i)) is too high ln (A/A_0) is too low (ln A_0/A is too high) so t is too high or the actual A_0 was lower than that assumed in (c) (i) ln (A/A_0) should be higher (ln A_0/A should be lower) so t should be lower	**B1** **B1**	
		Total	**13**

Question 3			
(a)	**similarity** **force** obeys inverse square law (allow $F \propto \frac{1}{r^2}$)	B1	2
	or potential/potential energy varies as 1/r		
	difference gravitational force only attractive/never repel		
	or electric field can be attractive or repulsive	B1	
	or gravitational potentials are only negative/never positive		
	or electric potentials can be positive or negative		
(b) (i)	$E_p = \frac{Qq}{4\pi\varepsilon_0 r}$ or $E_p = \frac{kQq}{r}$ and $k = \frac{1}{4\pi\varepsilon_0}$	B1	7
	correct substitution $E_p = \frac{2\times 79\times(1.6\times10^{-19})^2}{4\pi\times(8.9\times10^{-12})\times(6.5\times10^{-14})}$	B1	
	5.567×10^{-13} (J) (3 or more sig figs necessary)	B1	
(ii)	KE change = 7.2 × 10-13 – 5.6 × 10-13 = 1.6 × 10-13 J	C1	
	use of $E_k = ½\, mv^2$ (may use with wrong energy substituted)	C1	
	$v = 6.9\,(6.86) \times 10^6$ (m s^{-1}) assume m s^{-1} if no unit given	A1	
(iii)	same initial path – path deflects through greater angle and greater ‘closest distance of approach’	B1	
(c)	gold nucleus recoils/is repelled/gains energy/gains momentum	B1	3
	mass of gold nucleus (very) much greater than mass of alpha particle	M1	
	gold nucleus has much lower speed than the alpha particle or little energy transfer to the gold nucleus	A1	
		Total	**12**

Question 4			
(a)	correct substitutions to find initial and final mass **or** number of fissions possible/number of U atoms in 500 g = $\frac{500}{235}$ 6 × 10^{23} = 1.276 × 10^{24} or $\frac{500}{390 \times 10^{-27}}$	C1	3
	mass change per disintegration = 3.2 (3.18) × 10^{-28} kg	C1	
	total mass change = 406 × 10^{-6} kg (0.406 g)	A1	
(b) (i)	clear attempt to calculate mass of protons and neutrons	C1	6
	mass difference = 3.127 × 10^{-27} kg	C1	
	$E = mc^2$	C1	
	2.81 × 10^{-10} (J)	A1	
(ii)	divides their answer to (b) (i) by 235 or divides their answer to (b) (i) by 1.6 × 10^{-13} J	C1	
	e.c.f. their (b) (i) × 2.7 (2.66) × 10^{10}	A1	
	7.5 (7.47) MeV = 0 unless working shown		
(c)	**any 3** label E (for energy extraction)		max 6
	mentions coolant	B1	
	liquid (sodium or water) or gas (CO_2) removes energy/heat from the core	B1	
	coolant/hot gas/liquid then passes through a system/heat exchanger to produce steam	B1	
	steam used to drive turbines/generators	B1	
	power control		
	mentions control/boron rods	M1	
	neutrons have to be absorbed/fewer fission neutrons	M1	
	lower rods reduces power output	A1	
	At least 2 marks for physics + **Good QWC**	2	max 2
	At least 2 marks for physics + **Poor QWC**	1	
	At least 2 marks for physics + **Very Poor QWC**	0	
	1 mark for physics + sufficient attempt + **Good or Poor QWC**	1	
	1 mark for physics + insufficient attempt or **Very Poor QWC**	0	
	No marks for physics or **Very Poor QWC**	0	
		Total	**17**

Question 5			
(a)	identifies interaction between electric current/moving ions/charge and magnetic field	**B1**	**4**
	mention of (Flemings) left hand rule **or** force at right angles to field and current	**B1**	
	force on **ions/water** (molecules) to left/backwards	**B1**	
	equal and opposite force on the boat **or** motion of boat conserves momentum	**B1**	
(b) (i)	$E = V/d$ or 50/0.35 seen	**C1**	**6**
	E = 140 (143) V m^{-1} or N C^{-1} (u.p.)	**A1**	
(ii)	$R = \rho l/A$ or $R = 0.2 \times 0.35/1.2$	**B1**	
	R = 0.0583 Ω or R not calculated but substituted in next equation	**B1**	
	$I = V/R$ or 50/their R	**B1**	
	857 – 862.1 A	**B1**	
(c) (i)	**one u.p. in (c)**		**7**
	thrust (from one system) = BIL	**C1**	
	thrust (from one system) = 3 × 860 × 0.35 = 903 (900)	**C1**	
	3600 N	**A1**	
(ii)	power = Fv or their (i) × 7.5 e.c.f.	**C1**	
	27 kW if correct e.c.f.	**A1**	
(iii)	**two from**		
	internal energy of the water	**B1**	
	or ($I^2 R$)/power dissipation in or heating of water	**B1**	
	water gives KE		
	turbulence		
	friction/viscosity effects between water and system		
	energy losses/dissipated in coils/circuits of magnet		
	losses due to electrolysis		
(d)	2.4 (m s^{-2}) e.c.f. from 5 (c) (i)	**B1**	**2**
	correct curvature starting at their acceleration	**B1**	
		Total	**19**

Question 6			
(a)	direction of the force on a positively charged particle **or** direction in which a positive charge accelerates **or** direction in which a positive charge moves when placed in the field or moves from rest in the field	**B1**	**1**
(b)	diagram showing radial field lines (at least four) arrow shown from anode to cathode	**B1** **B1**	**2**
		Total	**3**

Question 7			
(a) (i)	$eV = ½mv^2$ or $E = eV$ and $E = ½mv^2$ $v = \sqrt{\frac{2eV}{m}}$	**B1**	**6**
	(correct substitution in a correct equation) e.g. $1.6 \times 10^{-19} \times 4000 = ½\ 9.1 \times 10^{-31}\ v^2$	**B1**	
	$3.8\ (3.75) \times 10^7$ (m s^{-1})	**B1**	
(ii)	$Bev = mv^2/r$	**C1**	
	correct substitution with r = 30 mm condone incorrect power of 10	**C1**	
	7.1 – 7.6 mT or mWb m^{-2} (u.p.) c.a.o.	**A1**	
(b)	**any 3**		**3**
	electrons need to orbit at a larger radius	**B1**	
	(from equation $Bev = mv^2/r$), $r \propto v$ (or v^2/r must be constant) if $\boldsymbol{B}$ (m and e) constant	**B1**	
	voltage must increase	**M1**	
	to increase velocity	**A1**	
		Total	**9**

Question 8			
	electrons oscillate around/in the cavity/primary coil **or** alternating/changing current in the cavity/primary coil	**B1**	**4**
	an **alternating/changing** current produces an **alternating/changing** magnetic flux/field	**B1**	
	there is a (changing/alternating) magnetic flux/field linking the coupling/secondary coil	**B1**	
	induced emf/current in (coupling/secondary) coil	**B1**	
	At least 2 marks for physics + **Good QWC** At least 2 marks for physics + **Poor QWC** At least 2 marks for physics + **Very Poor QWC** 1 mark for physics + sufficient attempt + **Good or Poor QWC** 1 mark for physics + insufficient attempt or **Very Poor QWC** No marks for physics or **Very Poor QWC**	**2** **1** **0** **1** **0** **0**	**max 2**
		Total	**6**

Question 9			
	photon energy = hf = 1.62-1.64 × 10^{-24} J or number of photons = $\frac{1100}{\text{photon energy}}$ or $\frac{1100}{hf}$	**C1**	**2**
	photon number = 1100/1.6 × 10^{-24} = (6.7 – 6.9) × 10^{26}	**A1**	
		Total	**2**

Question 10				
(a)	(i)	wavelength = c/f; $c = f\lambda$	C1	3
		0.12 (0.122) m	A1	
	(ii)	sketch drawn with 6 loops (e.c.f. for their wavelength)		
		condone 'sine wave' rather than loops with zero at X and Y	B1	
(b)		antinode indicated (letter **H**) on or near **XY**	B1	2
		H shown on vertical line through antinode	M0	
		most photons/maximum energy dissipated at the antinode/where amplitude is greatest	A1	
		or energy $\propto$ amplitude^2		
			Total	**5**

Question 11			
(a)	door/inside lined with metal	B1	2
	door fitted closely (to stop escape of waves)	B1	
(b)	inside cooked by conduction (of energy from hotter outer parts)	B1	2
	with liquids **convection** currents occur	B1	
		Total	**4**