GCE 2005
January Series

ASSESSMENT and QUALIFICATIONS ALLIANCE

Mark Scheme

Physics Specification B

PHB5 Fields and their Applications

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.

Further copies of this Mark Scheme are available to download from the AQA Website: www.aqa.org.uk

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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**	
Very Poor QWC: the answer is disjointed, with significant errors in spelling, punctuation and grammar	**0**	**Max 2**

PHB5 Fields and their Applications

Question 1

(a)	(i)	Energy required to separate nucleons	**B1**	
		Difference in mass between nucleus and the sum of the individual nucleons	**B1**	
		Force between nucleons either responsible for holding nucleus together or with some extra detail such as effective range	**B1**	**3**
	(ii)	Change in BE / nucleon is 0.8 OR BE ? Nucleon for U235 or fission product found	**C1**	
		Multiplies BE by a nucleon number somewhere	**C1**	
		Answer in the range 160 –200 MeV –ignore any changes to J	**A1**	**3**
	(iii)	Attempts to find change in mass	**C1**	
		Change in mass is 0.272 u / 4.5(2) x 10^{28} kg	**C1**	
		Uses $E = mc^2$	**C1**	
		4.06 x 10^{-11}J	**A1**	**4**
(b)	(i)	use of $pV = nRT$	**C1**	
		correct substitution	**C1**	
		9.6(1) x 10^4 mol	**C1**	
		4.2(3) x 10^3 kg	**A1**	**4**
	(ii)	coolant is heated by fuel rods / in the core	**B1**	
		work is done on coolant by gas circulators	**B1**	
		there is an increase in the internal energy of the gas (equivalent to the sum of these	**B1**	
		heating done by coolant in the heat exchangers)	**B1**	
		no overall change in U in one complete cycle	**B1**	
		heating done by coolant in ht exchangers is equivalent to heating + working done to coolant	**B1**	
		heating done by coolant in heat exchangers is equivalent to U gained in rest of the cycle	**B1**	**Max 5**
		Use of physics terms is accurate, the answer is fluent/well argued with few errors in spelling, punctuation and grammar **and gains at least 3 marks for physics**	**B2**	
		Use of physics terms is accurate but the answer lacks coherence or the spelling, punctuation and grammar are poor **and gains at least 1 mark for physics**	**B1**	
		Use of physics terms is inaccurate, the answer is disjointed with significant errors in spelling, punctuation and grammar	**B0**	**7**
(c)	(i)	Principle of conservation of momentum equation in words or symbols	**B1**	
		Correct substitution seen e.g. 2.38 x 10^{-20} = 3.81 x 10^{-20} + 1.7 x $10^{-27}v$	**B1**	

		Evidence of correct manipulation seen e.g. –8.41 x 106 or 1.43 x 10-20 1.7 x 10-27	**B1**	3
	(ii)	correct use of ratios seen, involving velocities squared or use of ½ mv2 64%	**C1** **A1**	2
				Total 26 Marks

Question 2

(a)	(i)	Any similarity e.g. inverse square law for force	**B1**	**1**
	(ii)	Correct reference to attraction/repulsion or potential always negative in grav fields	**B1**	**1**
(b)		Use of $Gm_1m_2(1/r_1 - 1/r_2)$ Correct substitution $6.67 \times 10^{-11} \times 165 \times 5.97 \times 10^{24} (1/4.24 \times 10^{7} - 1/8.08 \times 10^{6})$ 6.58×10^{9} J – decrease	**C1** **C1** **A1**	**3**
(c)		use of geostationary orbit plus reason use of shorter orbit with reason further details of either e.g. low height of shorter orbit allows closer inspection of Earth's surface or why the higher orbit is geosynchronous	**B1** **B1** **B1**	**3**
				Total 8 Marks

Question 3

(a)	(i)	Lines of equipotential parallel to the plates Field lines perpendicular to plates, evenly spaced and with arrows upwards **Lack of clear labelling of at least one of the types of line loses 1 mark** Either field shown to be uniform	**B1** **B1** **B1**	**3**
	(ii)	KE = 8.8×10^{-17} J Use of ½ mv^2 Speed = 1.4×10^{7} m s^{-1} **ecf** Momentum = 1.27×10^{-23} kg m s^{-1} **ecf**	**B1** **C1** **A1** **B1**	**4**
(b)		Use of de Broglie wavelength = h/mv 5.2×10^{-11} m **ecf** diffraction of electrons necessary will work because wavelength is of same order as atomic separation (not just wavelength is too small)/argument consistent with their (a) (ii).	**C1** **A1** **M1** **A1**	**4**
				Total 11 Marks

Question 4

(a)		Force or acceleration directed towards mean position		**B1**	
		Force or acceleration proportional to displacement		**B1**	**2**
(b)	(i)	Following wave freely would be SHM (approximately)			
		Water waves have some other components of motion			
		Waves vary in height, amplitude, frequency		**B1**	
		Restraining force (from cables) stops force being proportional to displacement		**B1**	**2**
					Max 2
	(ii)	Power times 4 as power is proportional to square of amplitude		**B1**	**1**
	(iii)	Use of $2\pi fA$		**B1**	
		Use of $v = f\lambda$		**B1**	
		$f = 0.175$Hz		**B1**	
		Correct manipulation to give 3.74 m s^{-1} to at least 3 sf		**B1**	**4**
	(iv)	humps with gaps (similar to half wave rectification)		**B1**	
		period calculated as 5.7 s / $T = 1/f$ used		**B1**	
		$T = 5.7$ s marked on graph		**B1**	**3**
(c)		use of E = stress /strain		**C1**	
		area = 1.96 x 10^{-3} m or $\pi(2.5 \times 10^{-3})^2$		**C1**	
		correct substitution		**C1**	
		1.05 x 10^{-3} m		**A1**	**4**
					Total 16 Marks

Question 5

(a)	(i)	Use of $F = BIl$ condone lack of n		**C1**	
		Full correct substitution including n		**C1**	
		0.71(4) N		**A1**	**3**
	(ii)	torque = force x separation of forces		**C1**	
		0.027(1) Nm	**ecf**	**A1**	**2**
(b)	(i)	clockwise		**B1**	**1**
	(ii)	Brushes change contact to other half of split ring		**B1**	
		Reversal of current (causes reversal of direction of force) in one wire, or maintenance of direction on one side of rotor		**B1**	**2**
(c)	(i)	Maximum torque shown as **H**		**B1**	**1**
	(ii)	Force stays constant			
		(perpendicular) distance between forces reduces as rotor turns			

each variation takes half of a rotation explanation of discontinuity			
explains why it is always positive	**B1**		
explains why it's zero when coil is vertical	**B1**		
explains why it's max when coil is horizontal	**B1**	**3**	
Max 3			

Total 12 Marks

Question 6

(a)	Emf induced in rotor due to changing magnetic field		**B1**	
	Magnitude of induced emf is (proportional) to the rate of change of flux linkage		**B1**	
	Or reference to at least 2 of the individual factors			**2**
(b)	(i)	Correct method for gradient at 0.8 ms	**C1**	
		Rate of change of B = 19 T s^{-1}	**A1**	**2**
	(ii)	E = area of coil x rate of change of B	**C1**	
		0.053(0.0527) V	**A1**	**2**
	(iii)	$R=\rho l/A$	**C1**	
		Length of conductor = 0.22(2) m	**C1**	
		Use of $I=V/R$	**C1**	
		8.2(2) A	**A1**	**4**
(c)	DC motors compared with synchronous: work done against friction in brushes Wear due to friction or arcing			
	Power to weight ratio		**B1**	
	Reduced noise due to lighter weight		**B1**	
	Faster		**B1**	
	Cheaper through fuel efficiency or because of weight reduction **max 3**		**B1**	
	Regenerative braking		**B1**	
	With regenerative braking – KE of train not wasted …turned into (useful) electrical energy without – KE turned into heat / internal energy **max 2**		**B1**	
	Use of physics terms is accurate, the answer is fluent/well argued with few errors in spelling, punctuation and grammar **and gains at least 3 marks for physics**		**B2**	
	Use of physics terms is accurate but the answer lacks coherence or the spelling, punctuation and grammar are poor **and gains at least 1 mark for physics**		**B1**	
	Use of physics terms is inaccurate, the answer is disjointed with significant errors in spelling, punctuation and grammar		**B0**	**8**

Total 18 Marks

Question 7

(a)	(i)	Change in direction is a change of velocity/ acceleration	**M1**	
		Acceleration requires force	**A1**	**2**
	(ii)	Horizontal component of normal reaction of carriage or force of rail on wheel flange	**B1**	
		shown with correct position & direction	**B1**	**2**
(b)	(i)	Use of $F = mv^2/r$	**C1**	
		Nozomi : 6.3×10^4 N or correct attempt to determine the ratio of the two forces	**C1**	
		Hikari: 9.6×10^4 N or ratio is 0.66	**A1**	
		Similar error loses one mark		**3**
	(ii)	Acceleration is similar for both	**C1**	
		Suitable comment such as reference to passenger comfort/less likely to topple/won't have to tilt as much	**A1**	**2**
				Total 9 Marks

Paper Total 100 Marks