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ASSESSMENT and QUALIFICATIONS ALLIANCE

General Certificate of Education

Physics 6456

Specification B

PHB5 Fields and their Applications

Mark Scheme

2007 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**	

PHB5 Fields and their Applications

Question 1			
(a) (i)	radial field lines drawn (≥ 6)	**B1**	
	arrows pointing away from charge	**B1**	
(ii)	circular equipotentials drawn	**M1**	**5**
	radii correct (1:2:4 by eye)	**A1**	
(iii)	permittivity of free space (condone air)	**B1**	
(b)	penalise incorrect unit once in the question		
(i)	to prevent charge loss/it is an insulator/poor conductor	**B1**	
(ii)	force = 0.0015 × 9.8 or $F = k\Delta L$ or $F = kx$	**C1**	
	(or substitution ignore powers of 10)		
	extension = 81.7 (82) mm	**A1**	
(iii)	$E = V/d$ or numerical equivalent ignoring powers of 10	**C1**	
	267 000 (270 000) V m^{-1} (N C^{-1})	**A1**	**8**
(iv)	extra force = 8.1 × 10-4 N **or** (4.5 × 10^{-3} × 0.18) (condone powers of 10)	**C1**	
	$F = EQ$ **or** 4.5 × 10^{-3} × 0.18 = (b) (iii) × Q (condone powers of 10)	**C1**	
	$Q = 3.0 \times 10^{-9}$ C (ignore s.f.; condone 1 s.f.) $\frac{8.1\times10^{-4}}{(b)(iii)}$	**A1**	
(c) (i)	$T = 2\pi\sqrt{\frac{m}{k}}$ **or** correct substitution with incorrect power of 10	**B1**	
	$T = 2\pi\sqrt{\frac{0.0015}{0.18}}$	**B1**	
	$T = 0.57$ s	**B1**	**5**
(ii)	graph showing amplitude decreasing with time	**M1**	
	allow a displacement – time or **curved** amplitude time graph with axes labelled correctly for the graph drawn		
	clear indication of amplitude either by *A-t* graph or amplitude labelled on displacement-time graph	**A1**	
			Total 18

Question 2				
(a)	(i)	substitution of data for two correct or determines R_0	C1	
		substitution for all three correct and clearly stated that R_0 is the same (1.20×10^{-15} m) in all three cases	A1	
	(ii)	R_0 is radius of one nucleon or nucleus mass $= 1.7 \times 10^{-27} A$ (A = 4, 11 or 25)	C1	
		density = mass/volume (m/V)	C1	
		volume of nucleon = $4/3\pi r^3$ (7.24×10^{-45} m^3)	C1	
		or nuclear volume = $4/3\pi R^3$ (for a selected nucleus)		6
		density of nucleus = $(2.3 - 2.4) \times 10^{17}$ kg m^{-3} (up)	A1	
		explicit statements not needed but must be seen in calculation		
		e.g. $\dfrac{1.7\times10^{-27}\times9}{\frac{4}{3}\pi\times(2.5\times10^{-15})^3}$ *would gain first 3 B marks*		
		use of a power of 2 instead of 3 would gain first 2B marks only		
(b)	(i)	energy released when nucleus is formed from its constituent protons and neutrons (nucleons)	B1	
		or energy needed to split up nucleus into individual protons and neutrons		
	(ii)	total binding energy = 23 × 8.11 = 186.53 MeV	B1	5
		energy in J = $187 \times 10^6 \times 1.6 \times 10^{-19}$ = 2.98 or 2.99×10^{11} J	B1	
	(iii)	$E = mc^2$	C1	
		3.33×10^{-28} kg	A1	
(c)		wavelength = nuclear diameter of manganese $= 9.2 \times 10^{-15}$ m	C1	
		momentum = $h/\lambda = 7.17 \times 10^{-20}$ (N s)	C1	4
		$E_k = p^2/2m$ or velocity = $1.05\text{-}1.06 \times 10^7$ m s^{-1}	C1	
		3.7(4) -3.8(1) $\times 10^{-13}$ J	A1	
(d)	(i)	$Z = 26$	B1	
		A = 56	B1	4
	(ii)	λ = 0.69/half life or 0.69/2.6	C1	
		$7.37 - 7.41 \times 10^{-5}$ (s^{-1}) (no up)	A1	
				Total 19

Question 3			
(a) (i)	$F = \frac{mv^2}{r}$ or $F = BQv$	C1	
	$B = \frac{mv}{Qr}$ or $F = 2.04 \times 10^{-19}$ N	C1	
	1.1 (1.06) × 10^{-5} T (Wb m^{-2}) (up)	A1	5
(ii)	when KE increases B has to increase	B1	
	equation shows that $B \propto v$ (if m, Q and r are constant)	B1	
	or to increase F because as v increases centripetal force ($\frac{mv^2}{r}$) has to increase		
(b)	$pV = nRT$	C1	
	correct substitution ($n = \frac{1\times10^{-13}\times1}{8.3\times300}$)	C1	4
	number of moles per m^3 = 4.0 (2) × 10^{-17} **or** $n \times 6 \times 10^{23}$ seen or implied	C1	
	number of atoms = 2.4 (1) × 10^7 c.n.a.o.	A1	
(c)	a elastic collisions mentioned	B1	
	b energy increases KE of **gas atoms** or accelerates the **gas atoms**/increases their velocity/momentum	B1	
	c ionisation mentioned	B1	
	d (energy) removing electrons from gas atoms	B1	max 4
	e excitation mentioned	B1	
	f (energy) causing electrons in gas atoms to move into higher energy levels	B1	
	g protons may be absorbed by the nucleus of the gas atoms (not by molecules or atoms)	B1	
	At least 2 marks for physics + **Good QWC**	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	max 2
	1 mark for physics + insufficient attempt or **Very Poor QWC**	0	
	No marks for physics or **Very Poor QWC**	0	
			Total 15

Question 4			
(a)	time between 2 magnets passing coil = 71-76 ms	C1	3
	time for 1 revolution = 284-304 ms (4 × their time between pulses)	C1	
	number of revs per minute = 208-211	A1	
(b) (i)	movement of magnet changes **flux** (linkage) with coil	B1	6
	voltage induced proportional to **rate of change of flux** (linkage) or use flux cutting idea	B1	
(ii)	peak voltage = 1.5 × 5 mV = 7.5 (mV)	C1	
	induced emf = $\frac{\Delta(\varphi N)}{\Delta t}$ **or** rate of change of flux = induced emf/*N*	C1	
	2.1(4) × 10^5	A1	
	Wb s^{-1} (T m^2 s^{-1})	B1	
(c)	(direction of) **induced current** (allow voltage/emf) opposes the change	B1	max 3
	pulse produced as magnet enters and leaves coil (owtte)	B1	
	idea of magnet being **repelled as it approaches** and **attracted as it leaves**	B1	
	clearly links this to the direction of current in the coil (i.e. current is in opposite directions)	B1	
(d)	higher peaks (similar amplitude + and -)	B1	max 3
	positive and negative peaks close together	B1	
	narrower/sharper peaks	B1	
	sets of peaks closer together	B1	
			Total 15

Question 5			
(a) (i)	$\frac{GMm}{r^2} = \frac{mv^2}{r}$ or $v = \sqrt{\frac{GM}{r}}$	C1	5
	correct substitution (condone incorrect power of 10 for r)	C1	
	$v = 3890\,\text{m s}^{-1}$	A1	
(ii)	$T = \frac{2\pi r v}{v}$	C1	
	$T = 4.3 \times 10^4$ s (11.93 h)	A1	
(b)	$\Delta Ep = GMm\left[\frac{1}{r_1} - \frac{1}{r_2}\right]$	C1	3
	correct substitution (condone incorrect power of 10 for r)	C1	
	81 GJ (e.c.f.)	A1	
(c)	a fuel needed to raise fuel/spacecraft (as well as satellite) or increases the mass/weight of the satellite	C1	max 5
	b energy of fuel becomes PE/KE of remaining	A1	
	fuel/spacecraft (as well as PE of satellite)	B1	
	c spent fuel given momentum/KE	B1	
	d satellite given KE as well as PE or energy to move satellite without changing height	B1	
	e (energy lost due to) friction between spacecraft and atmosphere	B1	
	f combustion (or use of) of fuel is not perfectly efficient (allow engines inefficient) *or* **fuel energy wasted** as internal energy/heat light and sound	B1	
	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	**15**

Question 6			
(a) (i)	2.021×10^7 m (from $0.06742 \times 2.998 \times 10^8$) (e.c.f.)	**B1**	
(ii)	height = 2.020×10^7 m (from 26600-6400 km) or $0.06738 \times 2.998 \times 10^8$) (e.c.f.)	**B1**	**4**
(iii)	attempt to use of Pythagoras theorem or angles	**B1**	
	64×10^4 m (636-640 km) c.a.o.	**B1**	
(b)	time for wave to travel 1 m = $1/2.998 \times 10^8$ = 3.3 ns no s.f. penalty	**B1**	
	to pinpoint position to nearest m must measure to precision approximately that required for wave to travel 1 m	**B1**	**max 2**
	recognises that e-m waves travel at very high speed	**B1**	
		Total	**6**

Question 7			
(a)	**quartz/receiver clock** is not accurate	**B1**	
	need to synchronise **receiver** clock with satellite clock	**B1**	**max 2**
	fourth signal enables correction to the **receiver** clock	**B1**	
(b)	signals **reflected** off mountains and buildings or do not travel directly to the receiver (owtte)	**B1**	
	waves travel slower through (influenced by) the ionosphere (allow signal affected by different atmospheric conditions)	**B1**	**3**
	satellite position not accurately known/almanac data incorrect	**B1**	
		Total	**5**

Question 8			
(a) (i)	signal has to penetrate the ionosphere	B1	
(ii)	photon energy = *hf* or clear correct use of ratios or statement that photon energy from caesium is larger	C1	3
	caesium radiation has 5.8(5.83) (≈ 6) × photon energy or energy of photon from caesium is 5×10^{-24} J larger than HF photon	A1	
(b)	appropriate sketch showing sequences of 0s and 1s and statement explaining that a digital signal consists of a sequence of 0s and 1s	C1	2
	either 2 different sequences of 0s and 1s and statement explaining that their sketches show different sequences or a sequence of 0s and 1s and explanation that a particular sequence of 0s and 1s is the unique feature	A1	
(c)	period of oscillation from caesium is not influenced **by physical conditions**	B1	2
	period of oscillation of quartz depends on physical dimension and/or temperature	B1	
		Total	**7**