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ASSESSMENT and QUALIFICATIONS ALLIANCE

General Certificate of Education

Physics 6456
Specification B

PHB5 Fields and their Applications

Mark Scheme

2006 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.

Notes for Examiners

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 Mark 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 questions that are not covered by the mark 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)		alpha decay Z-2 and A-4	**B1**	**4**
		beta decay Z+1 and A const	**B1**	
		2α's	**B1**	
		2α's and 4β's	**B1**	
(b)	(i)	time taken for half number of nuclei to decay time for activity to halve **not** sample/particles etc	**B1**	**7**
	(ii)	$T_{½} = 0.69/\lambda$	**C1**	
		0.0257 (minute^{-1})	**A1**	
	(iii)	$N = N_0 e^{-\lambda t}$	**C1**	
		candidate's substituted values (or 3.36 half-lives)	**C1**	
		correct use of ratio N/N_0 (or $0.5^{3.36}$)	**C1**	
		9.6% → 9.9%	**A1**	
		C1 for little longer than 3 half-lives		
				Total 11

Question 2				
(a)		good attempt at evenly spaced parallel lines (condone avoiding R symbol and edge effects)	**B1**	**2**
		minimum of 1 downward arrow (no upward ones)	**B1**	
(b)		defines beam (owtte)/ensures beam parallel/ions predictable path/fine beam/linear **not** focuses	**B1**	**1**
(c)	(i)	(region R) into page	**B1**	**10**
		(region S) out of page	**B1**	
	(ii)	electric force down	**B1**	
		magnetic force up	**B1**	
		allow C1 for F_E and F_B being opposite if B1s not scored	**B1**	
		electric force = EQ	**B1**	
		magnetic force = BQv	**B1**	
		equate and cancel Q (to give $v = E/B$)	**B1**	
		comment that mass not included in relation	**B1**	
	(iii)	hit below slit or attracted by bottom plate	**B1**	
		because $EQ > BQv$ now	**B1**	

(d)	mv^2/r	**C1**	**4**
	BQv	**C1**	
	$r = mv/BQ$ or 1.01 × any power of 10	**C1**	
	1.01 m	**A1**	
			Total 17

Question 3				
(a)	(i)	force per unit mass/force per kg	**B1**	**2**
	(ii)	$N\,kg^{-1}$ **not** ms^{-2} alone	**B1**	
(b)	(i)	GM/R^2 seen	**C1**	**6**
		$GM_Q/(3R)^2$ seen	**C1**	
		mass of Q = $9M$	**A1**	
	(ii)	passes through ($3R$, g) and falls off in curve	**M1**	
		two further points checked e.g., ($6R$,$g/4$) ($12R$, $g/16$)	**M1**	
		overall line quality – single smooth line (both Ms for this)	**A1**	
				Total 8

Question 4				
(a)	(i)	$N_s/N_p = V_s/V_p$	**C1**	**8**
		157 or 156 (integer value only)	**A1**	
	(ii)	each current = 2.5 A	**B1**	
		total current = 20 A	**B1**	
		R_t= 12V/20A (=0.60 Ω)	**B1**	
		or any other sensible method e.g. $P=V^2/R$ or $I = P/V$ etc **each step clearly shown**		
	(iii)	$P_p=P_s$ or $I_pV_p = I_sV_s$	**B1**	
		20 A × 12 V (or 8 × 30 W)	**M1**	
		240 W	**A1**	

(b)	flux density, linking bob, changes with bob's position **or** pendulum bob cuts magnetic field	**B1**	**4**
	induced voltage (across bob)	**B1**	
	eddy **or** circulating currents (in bob)	**B1**	
	current produces magnetic field and magnetic fields interact – dampens motion **or** clear statement of application of Lenz's law	**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 or 2 marks for physics + sufficient attempt + **Good or Poor QWC** 1 or 2 marks 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 14

Question 5				
(a)		LDR (correct symbol) with resistor in series	**B1**	**2**
		complete potential divider circuit with power supply (nothing else in circuit – condone voltage measurer)	**B1**	
(b)	(i)	use of (26 ± 2) mm for 2θ **or** (13 ± 1) mm for θ	**M1**	**6**
		range $2.60 \rightarrow 3.02$	**A1**	
	(ii)	$n\lambda = d\sin\theta$ seen	**M1**	
		substitution with correct powers $1.20 \times 10^{-5} \rightarrow 1.40 \times 10^{-5}$	**A1**	
		$1/d$ or number of lines m^{-1} calculated $71400 \rightarrow 833300$ needs unit	**B1**	
		conversion to number of lines mm^{-1} $71(.4) \rightarrow 83(.3)$ needs unit	**B1**	
				Total 8

Question 6				
(a)	(i)	strong nuclear force acts on all nucleons/both forces act on protons/mention of gluons as force carrier	**B1**	**6**
		strong nuclear force > electrostatic repulsion	**B1**	
	(ii)	neutrons spread the protons out/neutrons reduce electrostatic repulsion	**B1**	
	(iii)	strong nuclear force has short range	**M1**	
		if snf fell off more gradually bigger nuclei would have lower densities/…more rapidly still higher densities	**A1**	
		strong nuclear force acts on all nucleons	**M1**	
		attractive nature of snf means all nucleons in contact/close packed	**A1**	
		strong nuclear force becomes repulsive at very small separations	**M1**	
		prevents nuclei from becoming denser	**A1**	
		needs minimum of two M1s to score all three here	**max 3**	
(b)	(i)	$F_{\mathrm{E}} = \dfrac{Q_1 Q_2}{4\pi\varepsilon_0 r^2}$ or $F_E \propto k\dfrac{Q_1 Q_2}{r^2}$ with k defined	**C1**	**5**
		$1.59 \times 10^{2}\,\mathrm{N}$	**A1**	
		$F_{\mathrm{G}} = G\dfrac{m_1 m_2}{r^2}$	**C1**	
		$1.3 \times 10^{-34}\,\mathrm{N}$	**A1**	
	(ii)	can ignore gravitation when considering nuclear forces **or** gravitational force is much weaker than electrostatic force **not** e.c.f.	**B1**	
				Total 11

Question 7			
(a)	all frequencies or wavelengths emitted (in a certain range) – no breaks	**B1**	**1**
(b)	5.4 and 9.4 (each ±0.2) 0.54 → 0.61 or 1.64 → 1.85 **no unit**	**C1** **A1**	**2**
(c) (i)	(0.032–>0.034) (nm) shown $c=f\lambda$ seen or used (8.8–>9.4) × 10^{18} Hz c.a.o.	**C1** **C1** **A1**	**6**
(ii)	eV $\frac{1}{2}mv^2$ $v=\sqrt{\frac{2eV}{m}}$ scores **both** C marks 1.19 × 10^{8} ms^{-1}	**C1** **C1** **A1**	
			Total 9

Question 8			
(a)	in each case atoms are excited/supplied with energy electrons fall to lower energy level difference in energy between two levels emitted as photon OLS outer electrons excited to higher levels excited electrons decay to lower level CXR inner electrons ejected (outer) electrons fall to unoccupied level	**C1** **C1** **C1** **M1** **A1** **M1** **A1**	**max 4**
	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 or 2 marks for physics + sufficient attempt + **Good or Poor QWC** 1 or 2 marks for physics + insufficient attempt or **Very Poor QWC** No marks for physics or **Very Poor QWC**	**2** **1** **0** **1** **0** **0**	**max 2**
(b)	$\lambda = (7.2\pm0.2) \times 10^{-11}$ m hc/λ seen **or** (2.75 ± 0.08) × 10^{-15} (J) (17.2 ± 0.5) keV c.a.o.	**C1** **C1** **A1**	**3**
			Total 9

Question 9				
(a)		evacuation needed to prevent electrons from colliding with air **or** gas molecules (condone being absorbed by air)	**B1**	**4**
		electrons would lose energy or not reach the target	**B1**	
		lead (partially) absorbs X-rays not simply idea that electrons cannot penetrate lead	**B1**	
		safety precaution/harmful to operator	**B1**	
(b)	(i)	$40 \times 10^3 \times 150 \times 10^{-5}$ (= 60)	**B1**	**5**
	(ii)	59.4 J (or Js^{-1} or W) – needs unit to score	**B1**	
	(iii)	$P = \frac{mc\Delta\theta}{t}$ **or** $Q = mc\Delta\theta$	**C1**	
		correct substitutions irrespective of powers	**C1**	
		$2.36 \times 10^{-4}\,kg\,s^{-1}$ (e.c.f.)	**A1**	
(c)	(i)	$E = V/d$ **or** $40 \times 10^3/72 \times 10^{-3}$	**C1**	**4**
		5.56×10^5 ($V\,m^{-1}$) **not** 5.6×10^5	**A1**	
	(ii)	$F = eE$ **or** $1.6 \times 10^{-19} \times 5.56 \times 10^5$ (e.c.f.)	**C1**	
		8.89×10^{-14} N **or** 8.96×10^{-14} N	**A1**	
				Total 13