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INTERNATIONAL A-LEVEL

PHYSICS

PH03

Unit 3 Fields and their consequences

Mark scheme

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Mark schemes are prepared by the Lead Assessment Writer and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation events which all associates participate in and is the scheme which was used by them in this examination. The standardisation process ensures that the mark scheme covers the students' responses to questions and that every associate understands and applies it in the same correct way. As preparation for standardisation each associate analyses a number of students' scripts. Alternative answers not already covered by the mark scheme are discussed and legislated for. If, after the standardisation process, associates encounter unusual answers which have not been raised they are required to refer these to the Lead Examiner.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of students' 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 from oxfordaqaexams.org.uk

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Level of response marking instructions

Level of response mark schemes are broken down into levels, each of which has a descriptor. The descriptor for the level shows the average performance for the level. There are marks in each level.

Before you apply the mark scheme to a student's answer read through the answer and annotate it (as instructed) to show the qualities that are being looked for. You can then apply the mark scheme.

Step 1 Determine a level

Start at the lowest level of the mark scheme and use it as a ladder to see whether the answer meets the descriptor for that level. The descriptor for the level indicates the different qualities that might be seen in the student's answer for that level. If it meets the lowest level then go to the next one and decide if it meets this level, and so on, until you have a match between the level descriptor and the answer. With practice and familiarity you will find that for better answers you will be able to quickly skip through the lower levels of the mark scheme.

When assigning a level you should look at the overall quality of the answer and not look to pick holes in small and specific parts of the answer where the student has not performed quite as well as the rest. If the answer covers different aspects of different levels of the mark scheme you should use a best fit approach for defining the level and then use the variability of the response to help decide the mark within the level, ie if the response is predominantly level 3 with a small amount of level 4 material it would be placed in level 3 but be awarded a mark near the top of the level because of the level 4 content.

Step 2 Determine a mark

Once you have assigned a level you need to decide on the mark. The descriptors on how to allocate marks can help with this. The exemplar materials used during standardisation will help. There will be an answer in the standardising materials which will correspond with each level of the mark scheme. This answer will have been awarded a mark by the Lead Examiner. You can compare the student's answer with the example to determine if it is the same standard, better or worse than the example. You can then use this to allocate a mark for the answer based on the Lead Examiner's mark on the example.

You may well need to read back through the answer as you apply the mark scheme to clarify points and assure yourself that the level and the mark are appropriate.

Indicative content in the mark scheme is provided as a guide for examiners. It is not intended to be exhaustive and you must credit other valid points. Students do not have to cover all of the points mentioned in the Indicative content to reach the highest level of the mark scheme.

An answer which contains nothing of relevance to the question must be awarded no marks.

Question	Answers	Additional comments/Guidelines	Mark	AO
01.1	The work done per kilogram ✓ in bringing a mass from infinity to the surface (of Io) ✓ is -3.27×10^6 J kg^{-1}.	the idea of per kilogram can be seen in either MP1 or MP2 per unit mass is only sufficient for MP1 if Jkg^{-1} is seen as a unit Number is required for two marks, but partial credit can be given for either line without it.	2	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
01.2	use of $V = -\frac{GM}{r}$ to give 1.82×10^6 (m) ✓	at least 3sf	1	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
01.3	use of potential energy = mV OR use of $\frac{1}{2}mv^2$ ✓ adds initial gpe and initial ke ✓ to give $-8.9(4) \times 10^6$ (J kg^{-1}) ✓	algebra must be seen for MP1 condone sign for mp1 signs must be correct for mp2 condone no algebra for MP2 at least 2 sf	3	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
01.4	use of $E = -\frac{GMm}{r}$ ✓ subtracts radius of moon to give $h = 1.8 \times 10^5$ (m) ✓	 $h = 1.9 \times 10^5$ (m) if show-that data used	2	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
01.5	the height would be the same ✓ idea that mass of the projectile cancels out in the conservation of energy equation *or* both KE and GPE are directly proportional to mass ✓	 For MP2, accept shown algebraically, but do not credit algebra that includes GPE = mgh	2	AO2
Total			**10**	

Question	Answers	Additional comments/Guidelines	Mark	AO
02.1	Use of $F = kx$ and $F = mg$ seen or implied to give 521 (N m^{-1}) ✓	note: full credit for 2.1 and 2.2 can be given if candidates attempt them in reverse order 519 (Nm^{-1}) if a rounded mg used at least 3sf	1	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
02.2	Use of $T = 2\pi\sqrt{\frac{m}{k}}$ to give 0.80 (s) ✓	alternative $T = 2\pi\sqrt{\frac{x}{g}}$ but not pendulum equation condone 1sf	1	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
02.3	Use of $\omega = \frac{2\pi}{T}$ $(= 7.85 \text{ rad s}^{-1})$ ✓ Use of $E_{\text{oscillator}} = \frac{1}{2}m\omega^2A^2$ ✓ 0.42 (J) ✓ Alternative: use of $\frac{1}{2}kx_2^2 - \frac{1}{2}kx_1^2$ to calculate change in EPE: $\frac{1}{2}k\left(0.20^2 - 0.16^2\right)$ $(= 3.75 \text{ J})$ ✓ calculates change in GPE correctly $= -3.34$ (J) ✓ 0.41 (J) ✓	full marks can be awarded for: idea that energy of oscillator = max potential energy ✓ $E_{P\,max} = \frac{1}{2}kA^2$ ✓ 0.42 (J) ✓ accept 0.41 J or 0.42 J for full credit	3	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
02.4	Suitable axes scales and labels ✓ Sinusoidal shape (judged by eye) that is never below the x-axis ✓ Time period (of their graph) is $0.4\ \text{s}$ ✓ First peak kinetic energy matches candidate's **02.3** answer (eg $0.42\ \text{J}$) ✓	suitable scale means intervals annotated and going in 2s, 4s, etc. sinusoidal shape includes that the steepest part passes through the correct point, and peaks and troughs are curved ignore amplitudes decreasing allow any starting value of KE	4	AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
02.5	Any two: idea that force decreases (with subsequent cycles) ✓ idea that force varies within each cycle ✓ because damping force decreases with decreasing speed (or reverse argument)✓		2	AO3
Total			**11**	

Question	Answers	Additional comments/Guidelines	Mark	AO
03.1	the proportion of (radioactive) nuclei that decay per unit time✓ OR the probability of a (particular) nucleus decaying per unit time✓	accept per second for per unit time accept answer in terms of the symbol equation A = (-) λN if symbols are defined	1	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
03.2	Uses moles = mass in g/RAM and applies the 45% to give 1.1 (mol) ✓	(1.13 to 3 sf)	1	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
03.3	multiples number of C-12 moles by Avogadro's number OR calculates ratio correctly ✓ 1.2×10^{-12} ✓	for calculating ratio, expect to see 8.2 x 10^{11} / their number of C-12 atoms using 1 mol rounded gives 1.36×10^{-12}	2	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
03.4	Use of $A = \lambda N$ to obtain 3.2 (Bq) ✓		1	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
03.5	The ratio is lower in the wooden object because the number of carbon-14 atoms has decreased ✓ while the number of carbon-12 atoms stayed the same OR whereas in living wood, the number of carbon-14 atoms stays constant/is replaced✓		2	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
03.6	Use of $A = A_0 e^{-\lambda t}$ ✓ calculates time correctly (in s or yr)✓ 1600 (years) ✓ Alternative: calculates half life correctly (in s or yr) ✓ use of $2^n = A/A_0$ ✓ time = n x half life = 1600 (years) ✓	correct final answer scores all marks correct age in seconds scores 2 marks 1200 if 3 Bq used 1600 if 3.16 Bq used 1700 if 3.2 Bq used ecf from 3.4	3	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
03.7	Any **two**: Radioactivity is random *or* the activity is small compared to background ✓ The proportion of carbon in wood is not always 45% / can vary ✓ the object may have been made from old wood *or* the wood is older than the object ✓ the proportion of C-14 in the air is not exactly constant/is not exactly the value given ✓ the object may be contaminated with modern carbon ✓ the age is not old enough (compared to the half life) for the ratio/activity to change significantly ✓	do not accept the idea of chemical decay except as part of MP2 or MP5 clearly expressed idea of contamination must include mention of modern carbon condone the idea that there may be other radioactive isotopes (than C-14) in the sample (including by decay chain)	2	AO4
Total			**12**	

Question	Answers	Additional comments/Guidelines	Mark	AO
04.1	vertically downwards/towards **S** ✓		1	AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
04.2	into the page ✓		1	AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
04.3	electric force and magnetic force equated and substituted ✓	accept $qE = qvB$ seen (and rearranged) ✓ Do not credit if the charge symbols q are missing	1	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
04.4	Use of $E = \frac{V}{d}$ ✓ use of $v = \frac{E}{B}$ to give $v = 9.8 \times 10^3$ (m s^{-1}) ✓	condone POT error for MP1	2	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
04.5	net force/deflection is downwards/towards S ✓ the electric force (upward) is unchanged OR does not depend on speed ✓ the magnetic force (downward) has increased OR magnetic force is proportional to speed ✓	three marking points are independent if MP2 and MP3 are not awarded, one mark can be given for 'magnetic force is greater than electric force'	3	AO3
Total			**8**	

Question	Answers	Additional comments/Guidelines	Mark	AO
05.1	use of at least two independent relevant equations, one including Φ ✓ $\text{kg m}^2\text{ s}^{-2}\text{ A}^{-1}$ ✓	Expect to see eg $N\Phi = NBA$ and $F = BIL$ and $F = ma$ An alternative route could be $\varepsilon = \frac{\Delta N\Phi}{t}$ and $V = \frac{W}{Q}$ and $W = \frac{1}{2}mv^2$ full marks for correct final answer, units can be in any order ignore 'turns' in final answer	2	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
05.2	$(N)\Phi = (N)BA$ and $\varepsilon = \frac{\Delta(N)\phi}{\Delta t}$ both seen OR gradient = $\frac{\Delta B}{\Delta t}$ ✓ all combined ✓	reject $\frac{B}{t}$ and $\frac{(N)\phi}{t}$ without Δ or d symbols	2	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
05.3	Attempt to determine gradient (of a tangent) and substitutes their gradient into equation ✓ max gradient found with evidence seen on graph✓ 0.21 to 0.23 (V) ✓	For MP2, evidence must be a tangent drawn larger than half the graph's length/height; values taken from tangent must be more than half the axes' length apart expect to see gradient values in the range of 2.0 to 2.2	3	AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
05.4	(Very) large emf induced (at first and then drops to zero) ✓ opposite sign to the first reading ✓ emf related to large rate of change of flux linkage OR opposite sign related to Lenz's law ✓	allow reading has minus value condone rate of change of flux density in coil X	3	AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
05.5	laminations reduce energy loss/increase efficiency ✓ laminations limit/reduce (the magnitude of) the eddy currents (in the iron core)✓	condone reduce heating effect for MP1 do not allow 'prevents' or 'eliminates' eddy currents	2	AO4
Total			**12**	

Question	Answers	Additional comments/Guidelines	Mark	AO
06.1	use of $E = \frac{1}{2}CV^2$ leading to 6.1×10^{-2} (J) ✓	at least 2sf	1	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
06.2	Use of $V = V_0 e^{-\frac{t}{RC}}$ ✓ 1.5 (V) ✓		2	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
06.3	(half the) energy is dissipated in the resistor (in the charging circuit) ✓ reference to equation $E = \frac{1}{2}CV^2$ OR reference to area under QV graph being $\frac{1}{2}QV$ ✓	condone in the internal resistance of the battery for mp1	2	AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
06.4	converts $50\ \text{mW h}$ into J correctly (= 180 J) ✓ halves (= 90 J) and divides by 0.06 J to give 1500 ✓	unrounded version gives 1480 to 3 sf **ecf from 06.1**	2	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
06.5	Max 3 from greater duration OR brightness decreases more gradually ✓ because greater time constant (= RC) ✓ (initial) brightness is the same ✓ because initial voltage OR initial current is the same ✓	Reason must be related to the correct effect	3	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
06.6	fewer flashes can be delivered ✓ because the energy stored in the capacitor is greater ✓	MP2 is dependent on MP1	2	AO2
Total			**12**	

Question	Key
7	C
8	C
9	B
10	B
11	D
12	B
13	A
14	B
15	D
16	C
17	D
18	A
19	A
20	A
21	D