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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 Assessment Writer.

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

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	Marking guidance	Mark	Comments
01.1	Equates centripetal force with gravitational force: $\frac{mv^2}{r} = \frac{GMm}{r^2}$ seen ✓ Correct manipulation leading to $v = \sqrt{\frac{GM}{R+h}}$ e.g. $v^2 = \frac{GM}{R+h}$ seen **OR** $v^2 = \frac{GM}{r}$ with $r = R + h$ stated ✓	2	Allow 1 mark only for answers that start with $R+h$ substituted for r
01.2	Use of ½ mv^2 eg ($\frac{1}{2} \times 450 \times \frac{6.67 \times 10^{-11} \times 5.98 \times 10^{24}}{(6.37 \times 10^6 + 640000)}$) **or** Calculation of v (expect 7.5×10^3 m s^{-1}) ✓ 1.3×10^{10} (J) ✓	2	Condone POT error for 1st mark or for omission of R

Question	Marking guidance	Mark	Comments
01.3	Use of $V = \frac{-GM}{r}$ for 640 km or 705 km eg $\frac{-6.67 \times 10^{-11} \times 5.98 \times 10^{24}}{(6.37 \times 10^{6} + 640000)}$ ✓ Use of $\Delta W = m\Delta V$ ✓ 2.4×10^{8} (J) ✓ **OR** Uses $g = \frac{Gm}{r^2}$ ✓ Uses $\Delta E_p = mg\Delta h$ ✓ 2.4×10^{8} (J) ✓	3	Condone POT error or negative sign omission for 1st mark V at 640 km: 5.69×10^{7} (J kg^{-1}) V at 705 km: 5.64×10^{7} (J kg^{-1}) Allow first 2 marks for obtaining $\Delta V = 5.2 \times 10^{5}$ (J kg^{-1}) or calculating one PE: 2.54×10^{10} or 2.56×10^{10} (J) Expect g = 8.12 (at 640 km) and 7.97 (at 705 km)
01.4	KE decreases **OR** PE increases ✓ (But) KE change < PE change ✓	2	

Question	Marking guidance	Mark	Comments
02.1	Use of $\theta = \frac{\text{arc length}}{r}$ eg $\frac{12}{17} = 0.71$ ✓	1	
02.2	Use of $\omega = \frac{\theta}{t}$ (with any time from graph) **OR** use of $t = 0.12$ ✓ 5.8 or 5.9 (rad s^{-1}) ✓	2	
02.3	Idea that sheet doesn't clear light gate (after 18 swings) ✓	1	
02.4	Max 3 from: ✓✓✓ Change in flux/flux linkage (in sheet) induces an emf (Which) induces a current Description of Lenz's law or that a force opposes the motion Force acting on a current-carrying conductor **OR** Reference to I^2R losses Energy losses come from E_k of sheet	3	Allow "cuts magnetic field lines" or change in magnetic flux density. Condone minor discrepancies in description of Lenz's law

Question	Marking guidance	Mark	Comments
03.1	At least 4 straight vertical lines with even spacing ✓ Arrows pointing upwards ✓	2	Condone reasonable freehand drawing
03.2	Use of $E = \frac{V}{d}$ ✓ 6.0×10^5 (N C^{-1}) ✓	2	Condone POT error for first mark
03.3	2 marks for use of 3 formulae; 1 mark for use of 2 formulae: $C = \frac{A\varepsilon_0\varepsilon_r}{d}$ $C = \frac{Q}{V}$ $E = \frac{V}{d}$	2	Must see a final expression of $\frac{Q}{\varepsilon_0\varepsilon_r A}$ Zero marks for use of radial field formula.
03.4	Attempt to determine an area using dimensions in Fig. 5 ✓ 3.2×10^{-7} (C) ✓	2	Allow ecf for their 03.2

Question	Marking guidance	Mark	Comments
03.5	Insulating ✓ Polarisable ✓	2	Allow descriptions of “polarisable”
03.6	E reduced ✓ so pd decreases as d constant ✓ **OR** C increased ✓ so pd decreases as Q constant ✓	2	

Question	Marking guidance	Mark	Comments
04.1	Into plane of the paper ✓	1	
04.2	KE or speed or velocity increases/proton accelerates ✓ (Because) work is done on proton by electric field **OR** electric field exerts a force on proton (in direction of travel) ✓	2	Accept a description of proton being attracted/repelled by a dee
04.3	Speed/KE constant **OR** only direction changes **OR** velocity changes **OR** moves in (semi-) circle ✓ (Because) magnetic field produces a force (due to motion of proton) **OR** magnetic force acts (on proton) ✓ Force/acceleration acts at $90°$ to path/velocity **OR** reference to Fleming's Left Hand rule **OR** centripetal force/acceleration acts (on proton) ✓	3	MP1 is for describing motion moving from B to C. MP2 is for explaining origin of force. MP3 is for describing magnetic force as a centripetal force. Accept arguments supported by relevant formulae. Don't give credit for formulae alone. Penalise contradictions within marking points.
04.4	Use of $v = \omega r$ **OR** $E_k = \frac{1}{2}mv^2$ ✓ Use of both formulae PLUS correct manipulation ✓	2	

Question	Marking guidance	Mark	Comments
04.5	Converts 10 MeV to 1.6×10^{-12} (J) ✓ Substitution into $E_k = \frac{(BqR)^2}{2m}$ or B made the subject $\sqrt{\frac{2mE_k}{q^2R^2}}$ or $\frac{\sqrt{2mE_k}}{qR}$ ✓ 1.4 (T) ✓	3	Condone POT error. Condone 10 (MeV) for E_k. Condone 1.675×10^{-27} or 1.661×10^{-27} for m. Allow 1.3 (T).

Question	Marking guidance	Mark	Comments
05.1	Identifies gradient as (negative of) decay constant ✓ Correct data extraction to get gradient ✓ Converts to s ✓ Final >1sf answer that rounds to 3×10^{-6} (s^{-1}) ✓ **OR** Reads ln(A) = 22.44 at t = 0 to get $A_0 = 5.57\times10^{9}$ (Bq) ✓ Halves A_0 and takes log (expect 21.75) ✓ Reads off t at their value (expect 62-63 hours) and converts to s (expect 2.2×10^{5} s) ✓ Uses $\lambda = \frac{ln2}{T_{1/2}}$ to get >1sf value that rounds to 3×10^{-6} (s^{-1}) ✓ **OR** $\ln(A) = \ln(A_0) - \lambda t$ or $\ln\left(\frac{A}{A_0}\right) = -\lambda t$ seen ✓ Correct data extraction correct ✓ Substitutes values into log equation ✓ Final >1sf answer that rounds to 3×10^{-6} (s^{-1}) ✓	4	Expect gradient to be -1.12×10^{-2} i.e. ln(A), and pair of corresponding values for ln(A_0) and t

05.2	Reads 22.44 from graph at $t = 0$ ✓ Takes exponential of their reading (expect 5.57×10^{9} (Bq)) ✓ Use of $A = \lambda N$ (eg $5.57\times10^{9}/3\times10^{-6}$) ✓ 1.8×10^{15} or 1.9×10^{15} ✓	4	3×10^{-6} gives 1.87×10^{15}; 3.125×10^{-6} gives 1.80×10^{15}

05.3	Use of $m = \frac{N}{N_A}$.RAM **OR** $N \times \text{RAM} \times u$ e.g. $2\times10^{15} \times 67 \times 1.661\times10^{-27}$ ✓ Answer beginning with 2.0 or 2.1 or 2.2 seen ✓ Consistent power and unit e.g $\times10^{-7}$ g, $\times10^{-10}$ kg ✓	3	MP3 is only for a valid method.

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

Question	Key
21	B
22	A
23	A
24	C
25	A
26	A
27	D
28	C
29	A
30	D
31	A
32	A
33	C
34	C
35	D