OXFORD AQA
INTERNATIONAL QUALIFICATIONS

INTERNATIONAL A-LEVEL
PHYSICS
PH03
Unit 3 Fields and their consequences

Mark scheme

January 2026

Version: 1.0 Final

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 www.oxfordaqa.com

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.

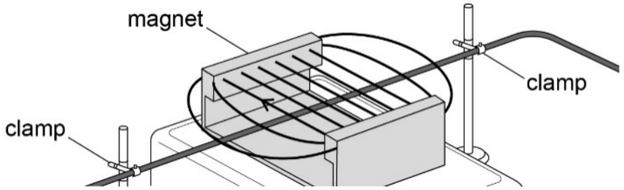
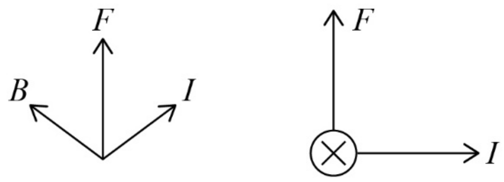
Question	Answers	Additional comments/Guidelines	Mark	AO
01.1	${}^{18}_{8}\mathrm{X}$ and ${}^{0}_{1}\beta^{+}$ and ${}^{0}_{0}\nu$ present in equation ✓	Do not allow anti-neutrino symbol Allow ν_e	1	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
01.2	Any **one** from: ✓ • use of $N = \dfrac{\text{mass}}{18 \times 10^{-3}} \times N_A$ • use of $A = \lambda N$ 2.1×10^{8} ✓ Bq ✓	$N = \dfrac{5.7 \times 10^{-14}}{18 \times 10^{-3}} \times 6.02 \times 10^{23} = 1.91 \times 10^{12}$ $A = 1.1 \times 10^{-4} \times 1.91 \times 10^{12} = 2.1 \times 10^{8}$ Bq Allow POT error for mp1 Allow decay s^{-1} or s^{-1} Do not allow counts per second or Hz Do not allow sec as abbreviation for second Allow equivalent units if correct, see examples below: 1.26×10^{10} decays min^{-1} 7.55×10^{11} decays $hour^{-1}$	3	1 × AO1 2 × AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
01.3	Use of $A = A_0 e^{-\lambda t}$ or $N = N_0 e^{-\lambda t}$ ✓ Correct conversion of A or N to mass ✓ 4.9×10^{-14} (kg) ✓	ecf from **01.2** Allow use of $M = M_0 e^{-\lambda t}$ using mass value λ and t must have consistent units for mp1 use of mass in exponential equation gains mp2 $M = 5.7 \times 10^{-14} \times e^{-1.1 \times 10^{-4} \times (5.0 \times 60 \times 60)}$ expect $M = 7.87 \times 10^{-15}$ kg mass decayed $= 5.7 \times 10^{-14} - 7.87 \times 10^{-15}$	3	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
01.4	The idea that the emitted beta-plus meets an electron and annihilates, producing (two) gamma photons ✓	Do not allow answers which explain in terms of the product undergoing further decay to produce gamma radiation	1	AO3
Total			**8**	

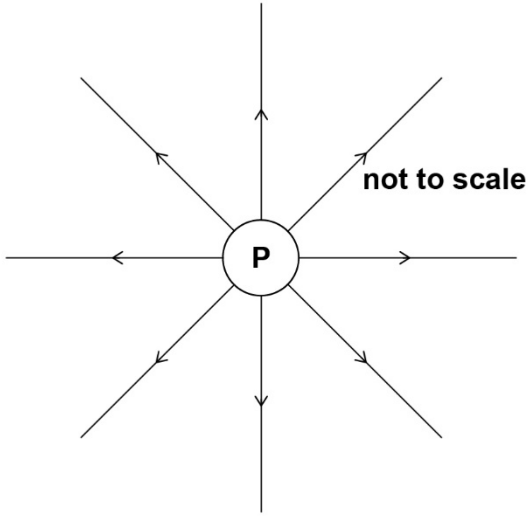
Question	Answers	Additional comments/Guidelines	Mark	AO
02.1	(The magnetic flux density) that produces a force of $1\ \mathrm{N}$ on a $1\ \mathrm{m}$ wire with a current of $1\ \mathrm{A}$ going through it ✓ …with the idea that the magnetic field and current are perpendicular to each other ✓	Allow per $1\ \mathrm{m}$ and per $1\ \mathrm{A}$ All of $1\ \mathrm{N}$, $1\ \mathrm{A}$ and $1\mathrm{m}$ are needed for mp1 **Alternative answer for mp1** using $F = Bqv$ (The magnetic flux density) that produces a force of $1\ \mathrm{N}$ on a $1\ \mathrm{C}$ charge travelling at a speed of $1\ \mathrm{m\ s^{-1}}$ through the field ✓ For this alternative, mp2 can be ‘velocity’ in place of ‘current’ OWTTE	2	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
02.2	Arrow drawn on **Figure 1** on a magnetic field line pointing towards the back pole **AND** an explanation which relates to Fleming's left-hand rule ✓ Force on the wire stated as being up (or shown in a labelled diagram) **AND** a reference made to Newton's third law ✓ Direction of current stated clearly and correctly in explanation (or shown in a diagram) ✓	  mp2 can be awarded for a clearly labelled force acting upwards on the wire in **Figure 1** or in a diagram in the answer showing the force acting upwards on the wire or on a labelled diagram for Fleming's left-hand rule. mp3 can be awarded for current direction shown on **Figure 1**. If more than one arrow is provided, it must be clear which is the magnetic field (and which is the current)	3	1 × AO1 1 × AO2 1 × AO4

Question	Answers	Additional comments/Guidelines	Mark	AO
02.3	Use of $F = B\,I\,l$ equated to mg ✓ 0.044 (T) ✓	Allow POT error on mp1 $B = \frac{mg}{Il} = \frac{0.45 \times 10^{-3} \times 9.81}{2.0 \times 5.0 \times 10^{-2}} = 0.0441\ \text{T}$	2	1 × AO2 1 × AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
02.4	The first wire has an additional force on it from the extended wire outside of the poles (and this gives an incorrect value of B when calculated) ✓ The idea that the vertical sections of the wire will not affect the reading on the balance / not have a **vertical** force on them ✓	For mp1 need to see an explanation of the additional force on the first wire Do not allow statements that the vertical sections of the wire are outside of the field (so there is no force on them)	2	AO4

Total			**9**

Question	Answers	Additional comments/Guidelines	Mark	AO
03.1	Lines drawn which are straight and evenly spaced around the proton by eye with arrows away from the centre ✓	Allow lines not drawn with a ruler if they are straight and symmetrical by eye  Lines must be drawn connected to P for the mark to be awarded If there are additional lines drawn, for example equipotentials, then no marks given unless labelling for the field lines is clear.	1	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
03.2	Use of $F_E = \frac{1}{4\pi\varepsilon_0}\frac{Q_1Q_2}{r^2}$ ✓ Use of $F_G = \frac{Gm_1m_2}{r^2}$ ✓ 2.3×10^{39} ✓	Condone the use of $\frac{kQq}{r^2}$ for mp1 but only if it rounds to 9×10^9 used for k $F_E = \frac{1}{4\pi\varepsilon_0} \times \frac{1.6\times10^{-19} \times 1.6\times10^{-19}}{(5.29\times10^{-11})^2}$ $= 8.23 \times 10^{-8}$ N $F_G = \frac{6.67\times10^{-11} \times 1.67\times10^{-27} \times 9.11\times10^{-31}}{(5.29\times10^{-11})^2}$ $= 3.63 \times 10^{-47}$ N Ignore minus signs for forces or final answer $\frac{electrostatic\ force}{gravitational\ force} = \frac{8.23 \times 10^{-8}}{3.63 \times 10^{-47}}$ $= 2.3 \times 10^{39}$	3	2 × AO1 1 × AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
03.3	Any **two** from: ✓✓ • equating $\frac{mv^2}{r}$ and $\frac{1}{4\pi\varepsilon_0}\frac{Q_1Q_2}{r^2}$ • $v = 2.2 \times 10^6$ (m s^{-1}) • use of $E_k = \frac{1}{2}mv^2$ **OR** rearranging bp1 to equal $\frac{1}{2}mv^2$ $E_k = \frac{1}{2}mv^2 = \frac{Q_1Q_2}{8\pi\varepsilon_o r}$ 2.2×10^{-18} (J) ✓	bp1 not awarded for alternative form of the electric force equation not on specification, eg $F = \frac{kQq}{r^2}$. $\frac{mv^2}{r} = \frac{1}{4\pi\varepsilon_0}\frac{Q_1Q_2}{r^2}$ $v = \sqrt{\frac{Q_1Q_2}{4\pi\varepsilon_0 rm}}$ $v = \sqrt{\frac{1.6\times10^{-19}\times1.6\times10^{-19}}{4\pi\varepsilon_0\times5.29\times10^{-11}\times9.11\times10^{-31}}}$ $v = 2.19 \times 10^6$ m s^{-1} $E_k = \frac{1}{2}\times9.11\times10^{-31}\times\left(2.19\times10^6\right)^2$ $E_k = 2.18\times10^{-18}$ J **Alternative approach** Use of $\left(V = \frac{1}{4\pi\varepsilon_0}\frac{Q}{r}\right.$ and $\left.W = QV\right)$ or $E_p = \frac{Q_1Q_2}{4\pi\varepsilon_0 r}$ seen ✓ $E_k = (-)\frac{E_p}{2}$ used ✓ 2.2×10^{-18} (J) ✓	3	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
03.4	Any **two** from: ✓✓ • uses $V = \frac{1}{4\pi\varepsilon_0}\frac{Q}{r}$ • uses $E_p = qV$ • uses $E_t = E_k + E_p$ and E_p is negative 2.2×10^{-18} (J) ✓	Condone the use of $V = \frac{kQ}{r}$ or $E_p = \frac{kQq}{r}$ for bp1 but only if it rounds to 9×10^9 used for k Use of $E_p = \frac{1}{4\pi\varepsilon_0}\frac{Qq}{r}$ gets bp1 and bp2 $V = \frac{1.6 \times 10^{-19}}{4\pi\varepsilon_0 \times 5.29 \times 10^{-11}} = 27.2\ \text{V}$ $E_p = (–)\ 1.6 \times 10^{-19} \times 27.2 = (–)\ 4.35 \times 10^{-18}\ \text{J}$ Allow ecf from **03.3** or use of 2.0×10^{-18} Allow 1 sf **Alternative approach** Allow energy required = E_k from **03.3** Condone 2×10^{-18} (J) (statements of energy required = E_k without a final answer is awarded 1 mark)	3	1 × AO1 2 × AO2

Total			**10**

Question	Answers	Additional comments/Guidelines	Mark	AO
04.1	3.7 (J) ✓	$E = \frac{1}{2}\frac{Q^2}{C} = \frac{1}{2} \times \frac{\left(3.7 \times 10^{-2}\right)^2}{185 \times 10^{-6}} = 3.7\ \text{J}$	1	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
04.2	Use of $C = \frac{Q}{V}$ or $V = IR$ ✓ 7.4 (A) ✓	Use of another capacitance equation to work out V is also appropriate for mp1, eg $E = \frac{1}{2}CV^2$ $V = \frac{Q}{C} = \frac{3.7 \times 10^{-2}}{185 \times 10^{-6}} = 200\ \text{V}$ $I = \frac{V}{R} = \frac{200}{27} = 7.4\ \text{A}$	2	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
04.3	Any **four** from: ✓✓✓✓ (explanation of initial rise) • the idea that current causes an increase in temperature of the lamp • the idea that the temperature rise is due to collisions between electrons and ions / atoms • the idea that the initial rise in intensity is due to the initial rise in temperature (explanation of later decrease) • the idea that the current from the discharging capacitor decreases with time • the idea that the decrease in temperature decreases the intensity of the light emitted.	condone power for current in bp4	4	2 × AO2 2 × AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
04.4	At least three read-offs from graph used (to find two ratios or test half-life twice) and all read off correctly to within half a square ✓ Valid test for exponential decrease and valid conclusion that it is not exponential decrease ✓	**Example 1** – ratio test at two fixed intervals of time: After 4 divisions of time from peak, intensity changes from 10 divisions to 5 After 4 further divisions from peak, intensity changes from 5 divisions to 4 divisions $\frac{10}{5} = 2$; $\frac{5}{4} = 1.25$ Values too different and so exponential decrease is not occurring **Example 2** – testing time for half-life After 4 divisions of time from peak the intensity halves from the peak of 10 divisions to 5 divisions After a further 4 divisions of time from the intensity of 5 divisions the intensity has only changed to 4 divisions so has not halved again Values for half-life too different and so exponential decrease is not occurring	2	1 × AO2 1 × AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
04.5	Resistance decreases which will make the discharge take less time, so the flash will not last as long / student is incorrect ✓	Allow “will make time constant shorter” or “will make the discharge quicker”	1	AO2
Total			**10**	

Question	Answers	Additional comments/Guidelines	Mark	AO
05.1	The (gravitational) field from the Earth and the Moon are acting in opposite **directions AND** are equal in **magnitude** ✓	Allow (gravitational) force instead of field	1	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
05.2	Equating $g = \frac{GM}{r^2}$ for Earth and Moon at P ✓ 7.2×10^{22} (kg) ✓	$\frac{G \times 5.98 \times 10^{24}}{(3.47 \times 10^{8})^2} = \frac{Gm}{(3.8 \times 10^{7})^2}$ $m = 7.17 \times 10^{22}$ kg	2	1 × AO1 1 × AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
05.3	Energy is required to move (a mass) from **P** to infinity **OR** The gravitational potential due to the Earth and the Moon are both negative and so when added together will not cancel or add to zero (but give a larger magnitude total instead) ✓		1	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
05.4	Evidence of tangent drawn on graph at 2.0×10^8 m ✓ Calculation of gradient shown ✓ Answer that rounds to 2 sf in range (-) 0.0085 to (-) 0.013 (N kg^{-1}) ✓	Allow POT error on mp2 Do not allow mp3 for answers in range but from an incorrect method shown	3	1 × AO1 2 × AO3

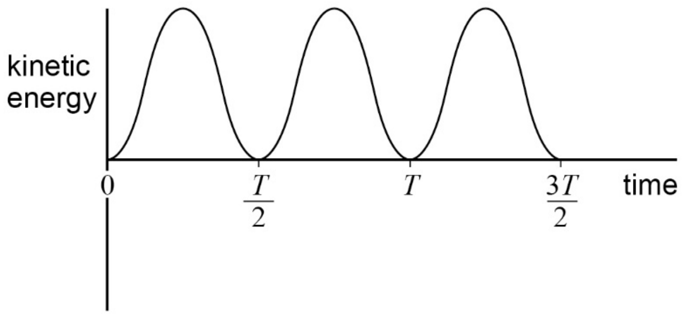
Question	Answers	Additional comments/Guidelines	Mark	AO
05.5	$\Delta V = 6.26 \times 10^7 - 1.3 \times 10^6$ $(= 6.13 \times 10^7)$ (Jkg^{-1}) ✓ $\Delta W = 950 \times \Delta V$ correctly calculated ✓	Allow in range 6.13 to 6.14×10^7 which relate to a read-off of 1.3×10^6 and 1.2×10^6 respectively For mp2, ecf can be given for the wrong change in potential, for example outside of above range, or for taking it between 6.26×10^7 and 4.0×10^6, to the surface of the Moon on the graph (or 3.85×10^6 using data in question) Do not allow mp2 for a change in potential to zero (i.e. if $950 \times V$ is calculated) Expected answer = 5.8×10^{10} J	2	1 × AO2 1 × AO3

Total			**9**

Question	Answers	Additional comments/Guidelines	Mark	AO
06.1	0.15 (s) ✓	$\frac{1}{4}T = \frac{1}{4} \times \frac{1}{1.7} = 0.147$ s	1	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
06.2	Use of $x = A \cos \omega t$ or $\omega = 2\pi f$ ✓ 0.20 (s) ✓	$\omega = 2\pi f = 2\pi \times 1.7 = \frac{17\pi}{5} = 10.68$ $x = A \cos \omega t$ $-1.8 = 3.6 \cos 10.68 \times t$ $t = 0.1961$	2	AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
06.3	Any **one** from: ✓ • use of max speed = ωA and $E_k = \frac{1}{2}mv^2$ • use of maximum E_k or total energy = $\frac{1}{2}m\omega^2 A^2$ 0.051 (kg) ✓	ecf from **06.2** max $E_k = \frac{1}{2}m\omega^2 A^2$ $m = \frac{2 \times E_k}{\omega^2 A^2} = \frac{2 \times 3.8 \times 10^{-3}}{10.68^2 \times (3.6 \times 10^{-2})^2} = 0.0514$	2	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
06.4	Graph shows maximum only at the halfway points between the scale markings and zero only at the scale markings ✓ Graph varies sinusoidally (by eye) between 0 and maximum ✓	 A line which is negative at any point scores 0 If the maxima noticeably vary by eye then do not award mp2	2	AO3

Total			**7**

Question	Answers	Additional comments/Guidelines	Mark	AO
07.1	Arrow from **J** towards the centre of the circular plate. The line of action of the arrow should pass through the centre of the coin and the centre of the plate (by eye) ✓		1	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
07.2	Any **two** from: ✓✓ • $F = 0.85\ mg$ • use of $m\omega^2 r$ • $2\pi r = 0.94$ 7.5 (rad s^{-1}) ✓	$r = \frac{0.94}{2\pi} = 0.1496$ $\omega^2 = \frac{0.85g}{r}$ is awarded both mp1 and mp2 $\omega^2 = \frac{0.85g}{r} = \frac{0.85 \times 9.81}{0.1496} = 55.74$ $\omega = 7.47$ rad s^{-1}	3	1 × AO1 2 × AO2

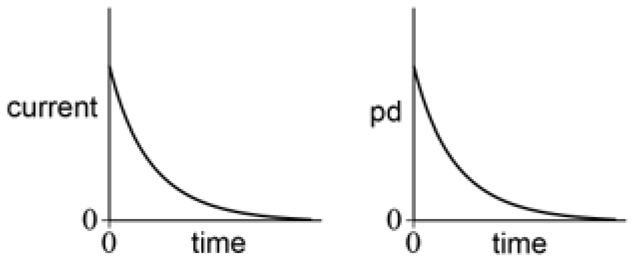
Question	Answers	Additional comments/Guidelines	Mark	AO
07.3	$\omega_2 > \omega_1$ ✓ Idea that $F = m\omega^2 r$ and F and m are constant Or reference to $\omega^2 = \frac{0.85g}{r}$ ✓	Allow $\frac{F}{m} = 0.85g$ for F and m are constant mp2 depends on mp1	2	AO2

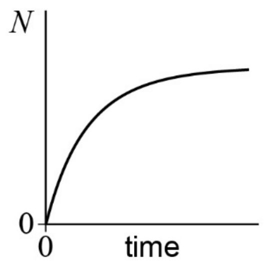
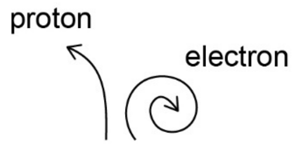
Total			**6**

Question	Answers	Additional comments/Guidelines	Mark	AO
08.1	Correct readings from graph: 0.38 to 0.40 T at 0.05 s and −0.38 to -0.40 T at 0.15 s OR ΔB = 0.76 to 0.80 T ✓ Use of $\varepsilon = \frac{\Delta BAN}{\Delta t}$ ✓ $\varepsilon_1 = 0$ (V) and $\varepsilon_2 =$ 0.96 (V) ✓	$\varepsilon = \frac{\Delta BAN}{\Delta t} = \frac{0.80\times1.5\times10^{-4}\times800}{0.10} = 0.96$ V Allow ε_2 consistent with their graph readings in range 0.91 to 0.96 V Ignore minus sign in final answers	3	1 × AO2 2 × AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
08.2	The idea that the amplitude is reduced because the (maximum) change in magnetic flux happens over a longer time ✓ The idea that the amplitude is reduced because there is a smaller (maximum) change in magnetic flux ✓ The frequency of the emf will reduce because $f = \frac{1}{T}$ ✓	Allow answers that use the $BAN\omega$ equation for mp1 and mp2 as long as the explanation is clear Allow references to peak emf in place of amplitude Allow “frequency and period are inversely proportional” for mp3 as an alternative to citing the equation	3	1 × AO2 2 × AO3

Total			**6**	

Question	Key	Answer	AO
09	**C**	$0.56\ \text{rad s}^{-1}$	AO2
10	**B**	The satellite accelerates towards the centre of the Earth.	AO1
11	**D**	π rad	AO1
12	**C**	2.2×10^{-2} J	AO2
13	**A**	$T_X < T_Y$ $E_X < E_Y$	AO3
14	**D**	14 s	AO2
15	**A**		AO3
16	**A**	$\frac{1}{2} C \varepsilon^2$	AO1

Question	Key	Answer	AO
17	A		AO3
18	B	$\frac{2\pi m}{BQ}$	AO2
19	B		AO3
20	D	to reduce the power wasted in transmission	AO1
21	C	ac with a peak-to-peak voltage of 50 V.	AO4
22	C	3200 V	AO2
23	D	5.7 A	AO1