AQA

A-LEVEL
PHYSICS
7408/2

Paper 2

Mark scheme

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2 2 6 A 7 4 0 8 / 2 / M S

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 aqa.org.uk

Physics - Mark scheme instructions to examiners

1. General

The mark scheme for each question shows:

- the marks available for each part of the question
- the total marks available for the question
- the typical answer or answers which are expected
- extra information to help the Examiner make his or her judgement and help to delineate what is acceptable or not worthy of credit or, in discursive answers, to give an overview of the area in which a mark or marks may be awarded.

The extra information is aligned to the appropriate answer in the left-hand part of the mark scheme and should only be applied to that item in the mark scheme.

At the beginning of a part of a question a reminder may be given, for example: where consequential marking needs to be considered in a calculation; or the answer may be on the diagram or at a different place on the script.

In general the right-hand side of the mark scheme is there to provide those extra details which confuse the main part of the mark scheme yet may be helpful in ensuring that marking is straightforward and consistent.

2. Emboldening

2.1 In a list of acceptable answers where more than one mark is available 'any **two** from' is used, with the number of marks emboldened. Each of the following bullet points is a potential mark.
2.2 A bold **and** is used to indicate that both parts of the answer are required to award the mark.
2.3 Alternative answers acceptable for a mark are indicated by the use of **or**. Different terms in the mark scheme are shown by a / ; eg allow smooth / free movement.

3. Marking points

3.1 Marking of lists

This applies to questions requiring a set number of responses, but for which candidates have provided extra responses. The general principle to be followed in such a situation is that 'right + wrong = wrong'.

Each error / contradiction negates each correct response. So, if the number of errors / contradictions equals or exceeds the number of marks available for the question, no marks can be awarded.

However, responses considered to be neutral (often prefaced by 'Ignore' in the mark scheme) are not penalised.

3.2 Marking procedure for calculations

Full marks can usually be given for a correct numerical answer without working shown unless the question states 'Show your working'. However, if a correct numerical answer can be evaluated from incorrect physics then working will be required. The mark scheme will indicate both this and the credit (if any) that can be allowed for the incorrect approach.

However, if the answer is incorrect, mark(s) can usually be gained by correct substitution / working and this is shown in the 'extra information' column or by each stage of a longer calculation.

A calculation must be followed through to answer in decimal form. An answer in surd form is never acceptable for the final (evaluation) mark in a calculation and will therefore generally be denied one mark.

3.3 Interpretation of 'it'

Answers using the word 'it' should be given credit only if it is clear that the 'it' refers to the correct subject.

3.4 Errors carried forward, consequential marking and arithmetic errors

Allowances for errors carried forward are likely to be restricted to calculation questions and should be shown by the abbreviation ECF or *conseq* in the marking scheme.

An arithmetic error should be penalised for one mark only unless otherwise amplified in the marking scheme. Arithmetic errors may arise from a slip in a calculation or from an incorrect transfer of a numerical value from data given in a question.

3.5 Phonetic spelling

The phonetic spelling of correct scientific terminology should be credited (eg fizix) **unless** there is a possible confusion (eg defraction/refraction) with another technical term.

3.6 Brackets

(…..) are used to indicate information which is not essential for the mark to be awarded but is included to help the examiner identify the sense of the answer required.

3.7 Ignore / Insufficient / Do <u>not</u> allow

'Ignore' or 'insufficient' is used when the information given is irrelevant to the question or not enough to gain the marking point. Any further correct amplification could gain the marking point.

'Do **not** allow' means that this is a wrong answer which, even if the correct answer is given, will still mean that the mark is not awarded.

3.8 Significant figure penalties

Answers to questions in the practical sections (7407/2 – Section A and 7408/3A) should display an appropriate number of significant figures. For non-practical sections, an A-level paper may contain up to 2 marks (1 mark for AS) that are contingent on the candidate quoting the **final** answer in a calculation to a specified number of significant figures (sf). This will generally be assessed to be the number of sf of the datum with the least number of sf from which the answer is determined. The mark scheme will give the range of sf that are acceptable but this will normally be the sf of the datum (or this sf -1).

An answer in surd form cannot gain the sf mark. An incorrect calculation **following some working** can gain the sf mark. For a question beginning with the command word 'Show that…', the answer should be quoted to **one more** sf than the sf quoted in the question eg 'Show that X is equal to about 2.1 cm' –

answer should be quoted to 3 sf. An answer to 1 sf will not normally be acceptable, unless the answer is an integer eg a number of objects. In non-practical sections, the need for a consideration will be indicated in the question by the use of 'Give your answer to an appropriate number of significant figures'.

3.9 Unit penalties

An A-level paper may contain up to 2 marks (1 mark for AS) that are contingent on the candidate quoting the correct unit for the answer to a calculation. The need for a unit to be quoted will be indicated in the question by the use of 'State an appropriate SI unit for your answer'. Unit answers will be expected to appear in the most commonly agreed form for the calculation concerned; strings of fundamental (base) units would not. For example, 1 tesla and 1 Wb m^{-2} would both be acceptable units for magnetic flux density but 1 kg m^2 s^{-2} A^{-1} would not.

3.10 Level of response marking instructions

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

Determining 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. i.e. if the response is predominantly level 2 with a small amount of level 3 material it would be placed in level 2.

The exemplar materials used during standardisation will help you to determine the appropriate level. 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	Combining and making use of $Q = Pt$ and $Q = mc\Delta\theta$ equations without the need to make t the subject. ✓1 $t = 27$ (s) ✓2	✓1 numerical errors are ignored for this mark. Provided the temperature difference is correct then subsequent changes that involve 273 ^{0}C can be ignored. ✓2 $t = (1.2 \times 450)\frac{(125-20)}{2100}$ No ecf for the second mark but correct answer gains both marks Condone use of c_{water} for c_{metal}.	2	2 x AO2 3.6.2.1

Question	Answers	Additional comments/Guidelines	Mark	AO
01.2	(The power supplied in time t raises the temperature of m kg of water and converts it to steam) Use of appropriate equation. ✓1 Correct evaluation of Δm or P. No ecf. ✓2 Deduction that claim is false (consistent with their value) supported by their calculated quantity OR Deduction that their calculated quantity is greater / smaller than required ✓3	The award of MP3 is dependent on the award of MP1 OR MP2. Evidence for MP1 can be seen in MP2 via the correct answers in the exemplars below. Condone error in time / temperature change / POT for MP1. Use of m from the metal is not condoned ✓1 $Pt = mc_w\Delta\theta + ml$ OR $P = \frac{mc_w\Delta\theta+ml}{t}$ ✓2 Several methods can be followed including in 1 minute 2100×60 $= \Delta m \times 4200 \times (100 - 20) + \Delta m \times 2.3 \times 10^6$ $\Delta m = 0.048$ kg min^{-1} OR in one second 2100 $= \Delta m \times 4200 \times (100 - 20) + \Delta m \times 2.3 \times 10^6$ $\Delta m = 0.00080$ kg s^{-1} OR $P =$ $= \frac{0.060 \times 4200 \times (100 - 20) + 0.060 \times 2.3 \times 10^6}{60}$ $P = 2.6(4) \times 10^3$ W OR Comparing the energy supplied in time eg in a minute (126000 J) with energy needed (138000 + 20160 = 158000 J) OR	3	2 x AO3 1 x AO1 3.6.2.1

		Calculation of time taken to obtain 60 g of steam = 75.3 s. ✓3 So claim is not true. 0.048 kg min^{-1} is smaller than 60 g min^{-1} OR 0.00080 kg s^{-1} = 48 g min^{-1} is smaller than 60 g min^{-1} OR 2.6×10^3 W is greater (than 2.1 kW / power available) OR time to generate 60 g of steam is too long. (The most common ecf will be to leave out the raising of the water temperature before changing the water to steam giving calculated values of Δm = 0.055 kg min^{-1}, or Δm = 0.00091 kg s^{-1} or $P = 2.3 \times 10^3$ W)		

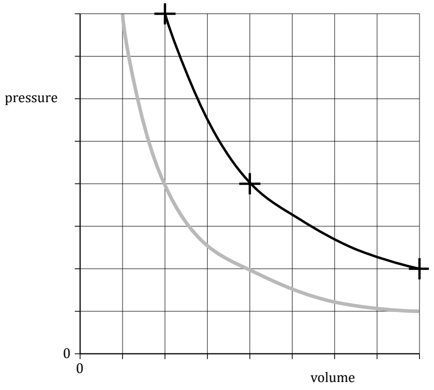
Total			**5**

Question	Answers	Additional comments/Guidelines	Mark	AO
02.1	Any two from ✓✓ • Volume of molecules/particles is negligible/small compared to the volume of the container • Collision time is negligible/small compared to the time between collisions • Collisions are elastic or kinetic energy is conserved • There are negligible/no forces between molecules/particles except during collisions	Reference to the volume occupied by the gas must be clear for the first point. So 'volume of gas' is not enough. Condone missing reference to "except during collisions" in bullet 4. Condone "Newtonian mechanics apply"	2	2 x AO1 3.6.2.3

Question	Answers	Additional comments/Guidelines	Mark	AO
02.2	There is a change in velocity/momentum for the molecules (at the wall) because the direction has changed ✓1 Relates MP1 to Newton I OR II ✓2 (Uses Newton III to) link the force on the wall and the force on the molecule ✓3	The essence of the Newton law must be given in the context of the gas. Just quoting a Newton law is not enough for a mark. Do not accept "rate of change of momentum" in MP1. Condone "bounces from wall" for "changes direction". Collision is not a change in direction. Accept reference to changing velocity/momentum/direction in MP2.	3	3 x AO2 3.6.2.3

Question	Answers	Additional comments/Guidelines	Mark	AO
02.3	Use of $E_k = \frac{3}{2}kT$ to find a temperature OR Using $pV = \frac{1}{3}Nm(c_{rms})^2$ with $E_k = \frac{1}{2}m(c_{rms})^2$ to find N ✓1 Correct substitution into $PV = nRT$ to find n OR Correct substitution into $N = \frac{3}{2}\frac{PV}{E_k}$ to find N (= 1.7 x10[25])✓2	✓1 $T = \frac{2\times}{3\times}\frac{6.7\times10^{-21}}{1.38\times10^{-23}} = 324\ \text{K}$ ✓2 for use of the equation. $n = \left(\frac{PV}{RT} = \frac{220\times10^3\times0.35}{8.31\times324}\right)$ or $N = \frac{3}{2}\times\frac{220\times10^3\times0.35}{6.7\times10^{-21}}$	3	1 x AO1 2 x AO2 3.6.2.2 3.6.2.3

	amount of gas = 29 (mol) ✓$_3$ (28.6 mol)	✓$_3$ no ecf, correct answer only If no other marks are awarded, award one mark: for an unsupported final answer of 1.7 x 10^{25} which is the number of molecules. OR for converting a number of molecules into moles using their $n = \frac{N}{N_A}$		

Question	Answers	Additional comments/Guidelines	Mark	AO
02.4	Drawn graph with concave shape always above existing graph passing through at least one of the data points. (data points are shown as crosses on the graph) ✓ Passing through coordinates (2,8), (4,4) and (8,2) ✓ (coordinates refer to cm intervals on the graph)	Drawn line must be $\pm$ 1 small square (2 mm) of a data point to count.  Condone a poor quality line.	2	2 x AO2 3.6.2.2
Total			**10**	

Question	Answers	Additional comments/Guidelines	Mark	AO
03.1	MAX 2 from: ✓✓ the (excess) electrons move onto/are located on the (outer) surface the (excess) electrons are equally spaced (conditional on the first point being awarded) (because) the electrons mutually repel	Condone "like charges repel" in the context of electrons.	2	2 x AO3 3.7.3.1

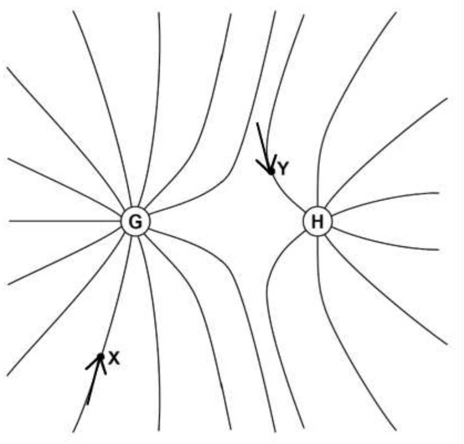
Question	Answers	Additional comments/Guidelines	Mark	AO
03.2	The triangle used to find the gradient covers more than 50% of the horizontal scale. ✓1 Finding the gradient from their tangent ✓2 $2.0 \pm 0.3 \times 10^6$ ✓3 (correct answer within limits only and to better than 1 sf) Unit N C^{-1} **or** V m^{-1} ✓4	✓2 eg gradient at 0.30 m $E = -\left(\frac{0 - -1.2 \times 10^6}{0.6 - 0}\right)$ (Ignore minus sign and PoT errors but numerical substitutions must be accurate Condone answer to more than 3 sf. Condone 'kg m s^{-3} A^{-1}' for unit. (Any alternative method that does not use the relationship violates the rubric e.g. $V = kQ/r$ $E = kQ/r^2$ so $E = V/r$ $E = 060 \times 10^6 \div 0.30$ However, MP3 and MP4 can be awarded)	4	2 x AO1 2 x AO2 MS 3.4 3.1.1

Question	Answers	Additional comments/Guidelines	Mark	AO
03.3	(Alternative A finding the charge held by the sphere) Use of $V = \frac{Q}{4\pi\varepsilon_o r}$ for any data point Or using *E* from part 03.2 Use of $E = \frac{Q}{4\pi\varepsilon_o r^2}$ with *E* at 0.3 m ✓$_{1,a}$ $Q = 2.0 \times 10^{-5}$ (C) ✓$_{2,a}$ $C\ (= Q/V = 2.0 \times 10^{-5} / 1.8 \times 10^6) = 1.1 \times 10^{-11}$ (F) ✓$_{3.a}$ (2 sf at least) OR (Alternative B without need to evaluate Q) Using or referring to both equations $C = Q/V$ and $V = \frac{Q}{4\pi\varepsilon_o r}$ ✓$_{1,b}$ $C(\ = 4\pi\varepsilon_0 r\ ) = 4\pi \times 8.85 \times 10^{-12} \times 0.100$ ✓$_{2,b}$ $C = 1.1 \times 10^{-11}$ (F) ✓$_{3.b}$ (at least 2 sf needed)	The marks must come from one alternative not a mixed route. Do not award credit for solutions based on parallel-plate capacitor equation. ✓$_{1,a}$ $Q = 4\pi\varepsilon_o rV =$ $4\pi \times 8.85 \times 10^{-12} \times 0.100 \times 1.8 \times 10^6$ OR $Q = 4\pi\varepsilon_o r^2 E =$ $4\pi \times 8.85 \times 10^{-12} \times 0.30^2 \times 2.0 \times 10^6$ OR ✓$_{1b}$ Combining equations to give $C = 4\pi\varepsilon_0 r$ For MP1 condone a starting point of $C = 4\pi\varepsilon_0 r$	3	2 x AO2 1 x AO3 3.7.3.3

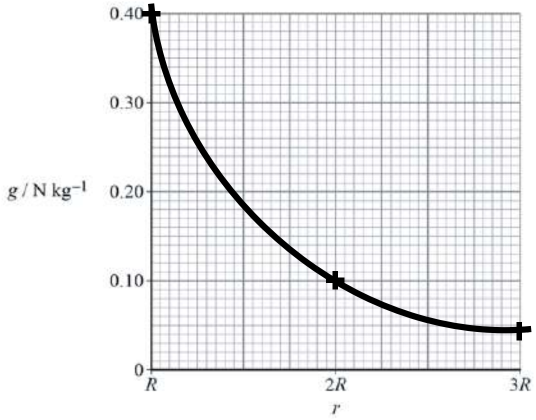
Question	Answers	Additional comments/Guidelines	Mark	AO
03.4	($E = \frac{CV^2}{2}$) Calculate the energy stored at 1.0×10^6 V ✓1 Making use of any one of the energy stored equations $E = \frac{QV}{2} = \frac{CV^2}{2} = \frac{Q^2}{2C}$ to calculate the energy stored when fully charged. = 18 (J) ✓2 change in electrical energy = 18 – 5.5 = 12.5 (J) ✓3	✓1 The calculation can use C as an ecf from **03.3** or taken as 1×10^{-11}. $E = \frac{1.1\times10^{-11}\times(1.0\times10^6)^2}{2}$ = 5.5 J OR 5.0 J when using 1×10^{-11} F ✓2 Allow ecf from **03.3** for example $E = \frac{1\times10^{-11}\times(1.8\times10^6)^2}{2} = 16.2$ J $E = \frac{(2.0\times10^{-5})^2}{2\times1\times10^{-11}}$ = 20 J note different values from different forms of the E equation because of rounding and data choice ✓3 Allow ecf from the previous two answers and may be positive or negative Accept alternative routes based on calculation of two separate energies and a difference When no other marks awarded, credit one mark for an attempt to calculate an energy difference provided one correct energy equation seen.	3	1 x AO2 2 x AO3 3.7.4.3

Total			12

Question	Answers	Additional comments/Guidelines	Mark	AO
04.1	G has greater mass with evidence from diagram✓$_1$ Explanation based on gravitational field strength or gravitational potential✓$_2$	E.g. ALTERNATIVE A G has greater mass because null point is closer to H ✓$_1$ G field equals that of H at a greater distance from null than H ✓$_2$ ATERNATIVE B G has greater mass because the density of field lines is greater ✓$_1$ Density of field lines depends on mass ✓$_2$ Allow arguments based on potential maximum at null point.	2	2 x AO3 3.7.2.2

Question	Answers	Additional comments/Guidelines	Mark	AO
04.2	The lines given tangential arrows at X and Y that flow towards **G** and **H** respectively. ✓ 	Condone arrow heads only but if arrows are drawn in full they must not follow a curved line. Arrows are acceptable if drawn alongside X and Y but must not be further away than the **X** or **Y** label.	1	AO1 3.7.2.2

Question	Answers	Additional comments/Guidelines	Mark	AO
04.3	$R = \left(\left\{\frac{GM}{g}\right\}^{1/2} = \left\{\frac{6.67\times10^{-11}\times2.0\times10^{20}}{0.40}\right\}^{1/2}\right) = 1.8\times10^{5}$ (m) ✓		1	AO2 3.7.2.2

Question	Answers	Additional comments/Guidelines	Mark	AO
04.4	Sketch must pass through coordinates (R, 0.40), ($2R$, 0.10) and ($3R$, 0.044) ✓	Must be within one ½ small division of coordinates requested. If plotted points differ a little from the line drawn then plotted points take priority.  	1	AO2 3.7.2.3

Question	Answers	Additional comments/Guidelines	Mark	AO
04.5	ALTERNATIVE A (The area underneath) represents the energy transferred/work done (for an object) of $1\ \text{kg}$ / unit mass ✓$_{1a}$ OR (area is) energy transferred to/work done on the object per unit mass when it is moving from *R* to 2*R* ✓$_{1a}$✓$_{2a}$ ALTERNATIVE B change in gravitational potential ✓$_{1b}$ OR increase in gravitational potential when moving from *R* to 2*R* ✓$_{1b}$✓$_{2b}$	Accept reverse direction 2*R* to *R* with appropriate direction of energy transfer/gravitational potential. In each alternative, the first answer is only awarded MP1. The second, fuller answer scores MP1 and MP2. *R* may be given as 1.8×10^5	2	2 x AO2 3.7.2.3

Question	Answers	Additional comments/Guidelines	Mark	AO
04.6	Use of $F = \frac{GMm}{r^2}$ to find the force between **P** and **H** ✓1 ($F_{(PH)} = 1.8 \times 10^{13}$ N) (Calculation of the resultant force Use of $F_{total} = \left(F_{(PH)}{}^2 + F_{(PG)}{}^2\right)^{1/2}$) ✓2 $\left(F_{total} = \left[\left(1.8 \times 10^{13}\right)^2 + \left(6.4 \times 10^{12}\right)^2\right]^{1/2}\right)$ $F_{total} = 1.9 \times 10^{13}$ ✓3 Use of $a = \frac{F}{m} = \frac{1.9\times10^{13}}{2.0\times10^{20}} = 9.4$ to 9.5×10^{-8} (m s^{-2}) ✓4	✓1 $F_{(PH)} = \frac{6.67\times10^{-11}\times3.0\times10^{25}\times2.0\times10^{20}}{\left(1.5\times10^{11}\right)^2}$ ✓2 Mark is for the use of the equation allowing for ecf from candidate's force calculation. ✓3 Correct answer only, no ecf this interim calculation may be subsumed in the next mark. ✓4 Allow ecf from F_{total} Condone the vector addition of the acceleration to obtain the answer acc^n due to G = 3.91x10^{-8} m s^{-2} acc^n due to H = 8.9 x10^{-8} m s^{-2}	4	2 x AO1 2 x AO2 3.7.2.1 (synop)

Question	Answers	Additional comments/Guidelines	Mark	AO
04.7	The resultant force is not (centripetal and continually) directed towards the centre of **H**. OR A circular orbit does not follow a gravitational equipotential (owtte) ✓	Condone lack of “resultant” The answer can focus on the conditions necessary for circular motion eg the need for a centripetal force. Or At different locations on a circular path the total gravitational potential energy is different which requires energy which is not provided. NB stating that the force is not perpendicular to the motion does not count as a full explanation as the motion has not been established.	1	AO3 3.7.2.3 (synop)
Total			**12**	

Question	Answers	Additional comments/Guidelines	Mark	AO
05.1	Core – idea that it provides greater linkage/increases linkage of magnetic flux/field (from the primary coil to the secondary coil compared to an air core)✓$_1$ OWTTE Secondary coil – (a conductor) has a varying/alternating/changing magnetic flux/field passing through/linking with it ✓$_2$ OWTTE Producing an induced emf / induces an emf that is determined by the number of turns in (the primary and) the secondary coils ✓$_3$ OWTTE	✓$_1$ This can be expressed using terms such as "channels/directs/concentrates/focuses/funnels". In MP1 the reference to an air core can be inferred. Condone " links all/most flux". ✓$_2$ 'varying' is important for this mark. ✓$_3$ errors may cancel this mark eg 'this increases the power output', will not gain this mark. Do not allow reference to "induced voltage" or "induced current" in MP3. When no other mark awarded, MAX 1 for "this is a step-up transformer/the voltage is less on the primary than on the secondary because there are more secondary turns than primary turns"	3	3 x AO1 3.7.5.6

Question	Answers	Additional comments/Guidelines	Mark	AO
05.2	MAX 3 Design feature 1✓$_{1a}$ Link to efficiency ✓$_{1b}$ Design feature 2✓$_{2a}$ Link to efficiency ✓$_{2b}$ Award ✓$_a$ only once for "thin sheets/ laminations of iron are used".	For each example ✓$_b$ is contingent on ✓$_a$ Example A ✓$_a$ The (sheets) of material **M /** laminations are made from insulator/high resistivity material ✓$_b$ reduces/limits (eddy) currents or charge flowing in the core. Example B: ✓$_a$ thin sheets/ laminations of iron are used ✓$_b$ so smaller emf's are induced in the core Example C ✓$_a$ thin sheets/ laminations of iron are used ✓$_b$ so resistance is high causing lower (eddy) currents If no other marks awarded, give 1 MAX for ✓ Iron is used which magnetises and demagnetises easily OR ✓ Eddy currents produce a magnetic field that opposes the magnetic field supplied to the core	3 max	1 x AO1 2 x AO3 3.7.5.6

Question	Answers	Additional comments/Guidelines	Mark	AO
05.3	If the voltage is lower/$33\ \mathrm{kV}$ then power is transmitted at high current. So energy/power is wasted/lost in the cable by (I^2R) heating. ✓1 OWTTE If the voltage is made too high this will create major insulation/isolation difficulties. ✓2 OWTTE	These two points can be expressed the other way round. They could state why the voltage needs to be high and then why it should not be low. Do not accept ‘changes affect the resistance (of the cable)’. In ✓2 accept “taller pylons”, “transformers that have better insulation against spark/flash over”, “more expensive equipment”	2	1 x AO1 1 x AO3 3.7.5.6

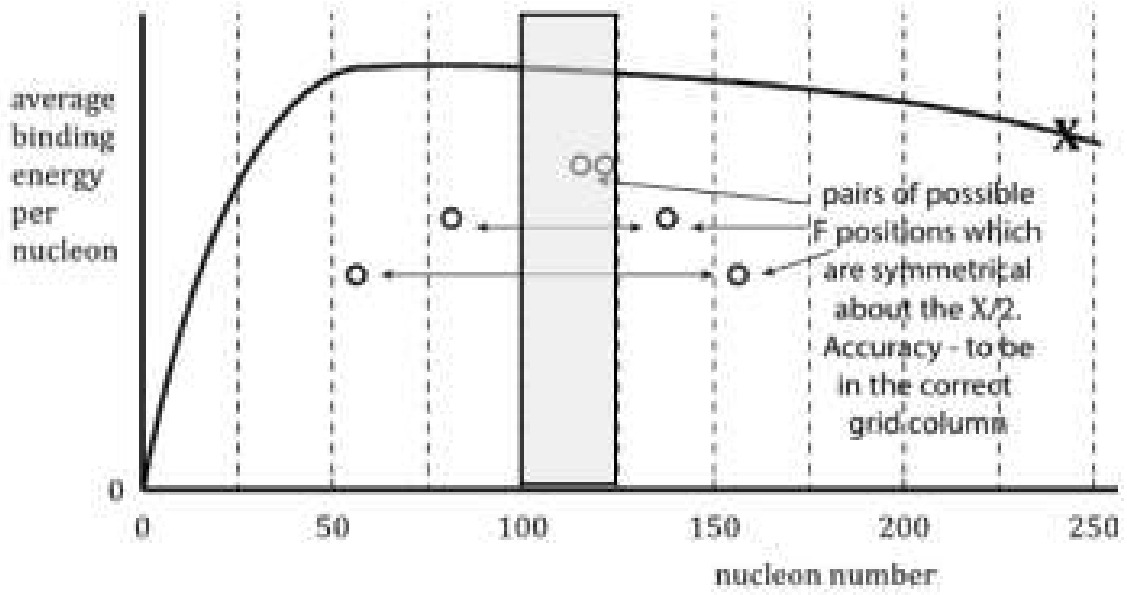
Question	Answers	Additional comments/Guidelines	Mark	AO
05.4	Correct use of efficiency $\eta = \frac{\text{power}_{\text{out}}}{\text{power}_{\text{in}}}$ once ✓$_1$ Correct use of $I = P/V$ with their values once at any point ✓$_2$ I = 3200 (A) (correct answer only, no ecf) ✓$_3$	✓$_1$ examples could be: power at 132 kV = 72 / 0.98 = 73.5 MW OR at transmission line start = 73.5 / 0.94 = 78.2 MW OR at 25 kV = 78.2 / 0.98 = 79.8 MW OR in single stage Power at 25 kV = 72 / (0.94 × 0.98^2) = 79.8 MW) ✓$_2$ eg at consumers $I = 72 \times 10^6 / 11 \times 10^3$ = 6545 A (Calculator value: 3190.16 A)	3	3 x AO2 3.7.5.6

Total			**11**

Question	Answers	Additional comments/Guidelines	Mark	AO
06.1	Energy required/work done to separate the nucleus ✓ into its individual nucleons/protons and neutrons ✓ OR Energy given out when a nucleus is formed ✓ from its individual nucleons/protons and neutrons ✓	MP2 can only be awarded when there is some reference to energy via MP1. Alternative words may be used instead of 'separate' but when used they must convey the correct idea. If no other marks are awarded, condone the idea that "binding energy is how much greater the rest energy/mass of the constituent nucleons is than that of the nucleus" for one mark.	2	2 x AO1 3.8.1.6

Question	Answers	Additional comments/Guidelines	Mark	AO
06.2	Statement of binding energy/mass defect = (mass of nucleons) – (mass of nucleus) ✓₁ (which may be seen from a full equation with data or implied from clear statements of what numbers represent) Standing alone or contained in the binding energy equation show the total mass of nucleon constituents of ${}^{56}_{26}\mathrm{Fe}$. ✓₂ the correct binding energy converted to MeV = 490 ± 10 (MeV) Or use of data booklet values and $E=mc^2$ = 340 ± 10 (MeV) ✓₃	Use of Data Booklet values leads to a correct answer of 338 (337.6) MeV. Allow 340±10 RB TO CONFIRM. ✓₁ condone simple numerical errors such as powers of 10 if mark comes from substituted equation. ✓₂ for giving data to at least 4 sig figs but calculations can use less. Examples looked for are $26 \times 1.673 \times 10^{-27} + 30 \times 1.675 \times 10^{-27}$ (= 9.375×10^{-26} kg) OR $26 \times 938.257 + 30 \times 939.551$ (= 52580 MeV) OR $26 \times 1.00728 + 30 \times 1.00867$ (= 56.44938 u) ✓₃ no ecf. and mark is only available if the mass of a neutron and proton are different in part 2. Might see	3	3 x AO2 3.8.1.6

		$(9.375 \times 10^{-26} - 9.288 \times 10^{-26}) \times 931.5 / 1.661 \times 10^{-27}$ = 488 ± 2 MeV OR $52580 - (9.288 \times 10^{-26} \times 931.5 / 1.661 \times 10^{-27})$ = 492 ± 2 MeV OR $\{56.44938 - 9.288 \times 10^{-26} / 1.661 \times 10^{-27}\} \times 931.5$ = 495 ± 2 MeV OR when the calculation involves the use of $E=mc^2$ 338 ± 2 MeV Note calculations may vary being dependant on how may sig figs are retained and how many individual stages of calculation are used.		

Question	Answers	Additional comments/Guidelines	Mark	AO
06.3	Both $\mathbf{F_1}$ and $\mathbf{F_2}$ to be to the right of the peak and marked on the graph or *x*-axis ✓$_1$ $\mathbf{F_1}$ and $\mathbf{F_2}$ to be in correct grid regions t symmetrical about half the nucleon number corresponding to **X**. ✓$_2$ 	Note that an **F** position cannot have a nucleon lower than the peak. So the 3 examples shown indicate the possible range of an answer. The position of F_1 and F_2 are taken from the centre of the cross or blob drawn by the candidate. The range of each grid region includes the boundary dotted line. ✓$_1$ If it is clear that nucleon numbers of F_1 and F2 add to 240 give mark The circles shown in the diagram show the horizontal positions – to gain the marks the circles have to be on the line or the x-axis.	2	2 x AO2 3.8.1.6

Question	Answers	Additional comments/Guidelines	Mark	AO
06.4	The starting point of the fission fragments is given the first mark ✓$_1$ (normally the initial decay mode is) β^- ✓$_2$ Moves closer to the stable region as: a neutron changes to a proton OR position (on the graph) moves down and to the right✓$_3$	✓$_1$ fission fragments have a high N/Z ratio OR fission fragments are positioned above/left of the line plot in Fig 11 too many neutrons is not given a mark – high N/Z ratio or neutron rich terms must be used ✓$_2$ Mark may be given in isolation but the minus must be indicated The discussion of the decay and positioning of F_1 and F_2 must be the same. Any differences will be marked as a contradiction. ✓$_3$ the mark could be seen on Fig 11	3	1 x AO1 2 x AO3 3.8.1.4

Total			**10**

Question	Key	Answer
07	A (AO2)	150 K
08	D (AO2)	pressure of the gas — internal energy of the gas
09	D (AO2)	$\frac{R}{\sqrt{2}}$ — $2M$
10	B (AO1)	2.7×10^{-6} rad s^{-1}
11	B (AO2)	$\sqrt{2gR}$
12	C (AO2)	$2\pi\sqrt{\frac{R^3}{GM}}$
13	D (AO2)	the orbital period of the satellite
14	A (AO2)	$\frac{R}{8}$
15	B (AO2)	$2\sqrt{2}u$
16	A (AO1)	135 μJ
17	A (AO2)	1.3×10^{-2} **X** to **Y**
18	C (AO2)	After a time T the pd across the capacitor is 1.5 V.
19	C (AO2)	$9C$

20	C (AO2)	$2E$
21	D (AO2)	$\frac{1}{e^4}$
22	B (AO2)	3.9×10^{-2} T
23	B (AO2)	$\frac{1}{4f}$
24	B (AO2)	P
25	C (AO1)	Some particles were deflected through angles greater than 90°.
26	A (AO1)	Is it deflected by a magnetic field? yes yes no
27	C (AO2)	15.6 g
28	B (AO2)	10 s^{-1} and 10^2 s^{-1}.
29	C (AO1)	the existence of gamma radiation
30	D (AO1)	When it is absorbed it makes the absorber radioactive.
31	C (AO1)	Slow neutrons are required for this induced fission.