AS

PHYSICS
7407/1

Paper 1

Mark scheme

June 2023

Version: 1.0 Final

236A7407/1/MS

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; ie 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.

<table>
<tr><th>Question</th><th>Answers</th><th>Additional Comments/Guidance</th><th>Mark</th><th>AO</th></tr>
<tr><td>01.1</td><td>2 rows correct ✓
3 rows correct ✓✓</td><td>
<table>
<tr><th></th><th>K^-</th><th>p</th><th>Ω^-</th><th>K^0</th><th>Y</th></tr>
<tr><td>Rest energy / MeV</td><td>493.8</td><td>938.3</td><td>1672</td><td>497.8</td><td>493.8</td></tr>
<tr><td>Baryon number</td><td>0</td><td>+1</td><td>+1</td><td>0</td><td>0</td></tr>
<tr><td>Charge</td><td>-1e</td><td>+1e</td><td>-1e</td><td>0</td><td>+1e</td></tr>
<tr><td>Strangeness</td><td>-1</td><td>0</td><td>-3</td><td>+1</td><td>+1</td></tr>
</table>
Y’s charge: Allow 1 or +1 or $+1e$
Y’s strangeness: Allow +1 or 1</td><td>2</td><td>AO2.1f
AO2.1e</td></tr>
</table>

Question	Answers	Additional Comments/Guidance	Mark	AO
01.2	$1672 \times 10^6 \times 1.6(0) \times 10^{-19}$ **OR** Correct conversion of: 1672 MeV to 1.672×10^9 (eV) **OR** Correct conversion of: 1 MeV to 1.6×10^{-13} (J) ✓ 2.68×10^{-10} (J) ✓	MP1 allow POT error in attempted conversion of eV to J where 1672×1.6 is seen. Condone correct conversion of 1672 MeV or 1 MeV seen in an otherwise incorrect expression. Accept answer correctly rounded to at least 2 sf. Calculator answer 2.6752×10^{-10} (J)	2	AO1.1a AO1.1b

Question	Answers	Additional Comments/Guidance	Mark	AO
01.3	Idea that the rest energy of the products is **greater** than the rest energy of the reactants. ✓ Idea that kinetic energy of the reactants is **greater** than the kinetic energy of the products ✓ **Alternative**: The rest energies of reactants + their (additional) **kinetic energy** = rest energies of the products✓✓	MP1 allow: Rest energy of reactants = 1432.1 (MeV) **and** rest energy of products = 2663.6 (MeV) or 1231.5 MeV seen. MP2 allow: The additional energy (1231.5 MeV) comes from the kinetic energy of the reactants.(Allow the idea that products don't have any kinetic energy). MP2 must relate to kinetic energy: speed / velocity / momentum is insufficient (treat as neutral). **Max 1** for the idea that the rest energies are not equal and **kinetic energy** of the particles accounts for the difference.	2	AO2.1b AO3.1b

<table>
<tr><th>Question</th><th>Answers</th><th>Additional Comments/Guidance</th><th>Mark</th><th>AO</th></tr>
<tr>
<td>01.4</td>
<td>
MP1: Applies conservation of baryon no. correctly to at least one decay✓
MP2:
Writes first or second decay in terms of quark compositions.
OR
Identifies decay is via weak interaction
OR
Ξ^0 has a strangeness $= -2$ or states quark structure as ssu✓
MP3:
The Λ^0 has a strangeness $= -1$
OR
Writes first two decays in terms of quark compositions.✓
MP4 :
(Quark composition $\Lambda^0 =$) uds
OR
writes 3rd decay in terms of quark compositions✓
</td>
<td>
MP1
Λ^0 is a baryon or Λ^0 consists of 3 quarks (condone any 3) or Λ^0 has a baryon number = 1 OR
Ξ^0 is a baryon or Ξ^0 consists of 3 quarks (condone any 3) or Ξ^0 has a baryon number = 1
MP2:
<table>
<tr><td>Decay 1</td><td>Ω^-(sss)</td><td>Ξ^0(uss)</td><td>π^- (d$\bar{u}$)</td></tr>
<tr><td>B</td><td>1</td><td>1</td><td>0</td></tr>
<tr><td>S</td><td>–3</td><td>–2</td><td>0</td></tr>
<tr><td>Q</td><td>–1</td><td>0</td><td>–1</td></tr>
<tr><td>Decay 2</td><td>Ξ^0 (uss)</td><td>Λ^0 (uds)</td><td>π^0 (u$\bar{u}$ or d$\bar{d}$)</td></tr>
<tr><td>B</td><td>1</td><td>1</td><td>0</td></tr>
<tr><td>S</td><td>–2</td><td>–1</td><td>0</td></tr>
<tr><td>Q</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>Decay 3</td><td>Λ^0(uds)</td><td>P(uud)</td><td>π^- (d$\bar{u}$)</td></tr>
<tr><td>B</td><td>1</td><td>1</td><td>0</td></tr>
<tr><td>S</td><td>–1</td><td>0</td><td>0</td></tr>
<tr><td>Q</td><td>0</td><td>+1</td><td>–1</td></tr>
</table>
An answer of uds scores MP1 and MP4.
Must see MP2 and MP3 to award these marks.
Award 1 mark if strangeness quoted as positive in both MP2 and MP3 where MP2 and MP3 otherwise not awarded.
Working can be shown on the equations above 01.4.
Writes all 3 decays in terms of quarks scores all 4 marks.
</td>
<td>4</td>
<td>4 × AO3.1b</td>
</tr>
</table>

Question	Answers	Additional Comments/Guidance	Mark	AO
01.5	Use of $E = \frac{hc}{\lambda}$ **OR** $E = hf$ **and** $c = f\lambda$ ✓ 1.59×10^{-11} (J) ✓	Condone POT error in any substituted values. Accept any answer correctly rounded to at least 2 sf. **Max 1** mark for otherwise correct answer with POT error. **Max 1** mark for an answer of 7.956×10^{-12} (J) (Correct use of equation but divided energy by two.) **Max 1** mark for an answer of 2.55×10^{-30} (J) (Assumes that 1.59×10^{-11} is in eV and attempts to convert to J.) Calculator display = 1.5912×10^{-11} (J)	2	AO1.1a AO2.1b

Question	Answers	Additional Comments/Guidance	Mark	AO
01.6	$e^- + \overline{\nu}_e$ ✓	Tick in 2nd box only	1	AO3.1b

Total			**13**

Question	Answers	Additional Comments/Guidance	Mark	AO
02.1	**A** and **B** are in antiphase or π rad out of phase or $180°$ out of phase ✓ (difference in distance travelled =) 178 (nm) or 2×89 (nm) **OR** **A** and **B** travel different distances **OR** There is a path difference **OR** states the path difference = $(n + \frac{1}{2})\ \lambda$ ✓ The path difference is half of a wavelength (of the light in the thin layer) ✓	Condone: **A** and **B** are **completely** out of phase. Allow a description of one being a peak when other is a trough. **MP2 Alternative**: thickness of layer is ¼ of wavelength (of light in layer) **or** 89 nm is a ¼ of the wavelength (of light in layer) **or** journey through layer is ½ of wavelength (of light in layer) Condone path difference = $n\lambda$ where $n \neq 0$ **MP2 and MP3** time-based alternative: **MP2** it takes (some) time for **B** to travel through medium (before meets **A**) **MP3** time taken to travel this (half wavelength) equals half of the period. Do not accept half of a wavelength out of phase.	3	3 × AO2.1a

Question	Answers	Additional Comments/Guidance	Mark	AO
02.2	Correctly reads off 0.93 and (–)0.37 **Or** Adds their two read-offs provided one is negative✓ 0.56 ✓	Allow a range of 0.90 to 0.95 for A's read off and a range of (–)0.35 to (–)0.40 for B's read off. Allows values of 0.9 and (–)0.4 for read-offs. Look to graph for read-offs. Answer in range 0.59 to 0.53 Answer to 2 sf answer here. An answer of 0.6 or 0.5 scores **1 mark maximum.**	2	AO1.1b AO2.1f

Question	Answers	Additional Comments/Guidance	Mark	AO
02.3	Use of $T = \frac{1}{f}$ **OR** Fraction of a cycle determined: $\frac{137}{360}$ or $\frac{8\text{ (squares)}}{21(.3)\text{ (squares)}}$ or 0.38 seen ✓ $(t =) \frac{137}{360} \times T$ *seen* **OR** $(t =) \frac{8\text{ (squares)}}{21(.3)\text{ (squares)}} \times T$ seen **OR** $(t =) \frac{137}{360} \times \frac{1}{4.72 \times 10^{14}}$ *seen* ✓ $(t =)\ 8.1 \times 10^{-16}$ (s) ✓ must include valid supporting work	$(T =) \frac{1}{4.72 \times 10^{14}}$ OR $(T =) 2.12 \times 10^{-15}$ (s) seen Condone use of their T in **MP2** Equation has been rearranged and t would be the subject. Condone use of their decimal fraction of a cycle in **MP2**. Expect to see decimal fraction of 0.38 or 0.37 Answer to at least 2 significant figures Alternative: **MP1** finds wavelength above surface (636 nm) and determines fraction of wavelength corresponding to fraction of cycle (242 nm) **MP2** divides the fraction of the wavelength by the speed of the light above the surface. **MP3** answer to at least 2 significant figures. Accept any answer to 2 significant figures that would round to 8.1×10^{-16} (s). Use of λ = 356 nm is incorrect. Only **MP1** is available for fraction of a cycle. • Do not allow answers where $c = f\lambda$ is used to determine $c = 1.68 \times 10^8$ m s^{-1}. • Do not allow use $\frac{135.5}{356} \times T$ OR $\frac{135.5}{356} \times \frac{1}{4.72 \times 10^{14}}$ in MP2	3	AO1.1a 2 × AO2.1b

Question	Answers	Additional Comments/Guidance	Mark	AO
02.4	Use of speed = $\frac{\text{distance}}{\text{time}} = \frac{2\times 89\times 10^{-9}}{8.06\times 10^{-16}}$ ✓ (Speed =) 2.2×10^{8} (m s^{-1}) ✓ Use of $n_s = \frac{c}{c_s}$ ✓ $n_s = 1.36$ or 1.4 ✓ **OR** Use of $\frac{t}{T}\times\lambda = 178\times 10^{-9}$ ✓ $\lambda = 468$ nm ✓ Use of $c_s = f\lambda$ and $n_s = \frac{c}{c_s}$ ✓ $n_s = 1.36$ or 1.4 ✓ **OR** Use of $\frac{137}{360}\times\lambda = 178\times 10^{-9}$ ✓ $\lambda = 468$ nm ✓ Use of $c_s = f\lambda$ and $n_s = \frac{c}{c_s}$ ✓ $n_s = 1.36$ or 1.4 ✓	**Their incorrect *t* must round to 8 x 10^{-16} (s). for ecf.** Condone POT in MP1 **OR** condone use of 89 nm for distance. (Will give an answer for n of 2.72 or 2.7) Condone use of their c_s in MP3 Where 3 sf answer seen, range is 1.35 to 1.37 Allow 2 marks maximum for an answer for n of 1.79 or 1.8 with working. (Error in use of of λ = 356 nm) . Condone as an **ECF on MP4.** Condone POT in MP1 **OR** condone use of 89 nm for fraction of wavelength. (Will give an answer for n of 2.72 or 2.7) Condone use of their λ in MP3 Where 3sf answer seen, range is 1.35 to 1.37 Condone POT in MP1 **OR** condone use of 89 nm for fraction of wavelength. (Will give an answer for n of 2.72 or 2.7) Condone use of their λ in MP3 Where 3sf answer seen, range is 1.35 to 1.37 Allow an ECF in MP4 for one arithmetical error / transcription error. Where $t = 8\times 10^{-16}$ is used: Speed = 2.225×10^{8} m s^{-1} Wavelength in layer = 471 nm Refractive index = 1.35	4	2 × AO2.1b 2 × AO3.1a
Total			**12**	

<table>
<tr><th>Question</th><th>Answers</th><th>Additional Comments/Guidance</th><th>Mark</th><th>AO</th></tr>
<tr><td>03</td><td>The mark scheme gives some guidance as to what statements are expected to be seen in a 1- or 2-mark (L1), 3- or 4-mark (L2) and 5- or 6-mark (L3) answer. Guidance provided in section 3.10 of the ‘Mark Scheme Instructions’ document should be used to assist marking this question.
<table>
<tr><th>Mark</th><th>Criteria</th></tr>
<tr><td>6</td><td>All 3 areas covered in some detail.
6 marks can be awarded even if there is an error and/or parts of one aspect missing.</td></tr>
<tr><td>5</td><td>A fair attempt to analyse all 3 areas. If there are several errors or missing parts, then 5 marks should be awarded.</td></tr>
<tr><td>4</td><td>Two areas successfully discussed, or one discussed and two others covered partially. Whilst there will be several gaps, there should only be an occasional error.</td></tr>
<tr><td>3</td><td>One area discussed and one discussed partially, or all 3 covered partially. There are likely to be several errors and omissions in the discussion.</td></tr>
<tr><td>2</td><td>Only one area discussed or makes a partial attempt at 2 areas.</td></tr>
<tr><td>1</td><td>None of the 3 areas covered without significant error.</td></tr>
<tr><td>0</td><td>No relevant analysis.</td></tr>
</table></td><td>The following points are likely to be present.
Area A (unpolarised)
- Oscillations (or vibrations) of particles / fields perpendicular to direction of energy propagation
- wave’s oscillations (or vibrations) exist in more than a single plane
Area B (polarisation)
- (only) transverse waves can be polarised
- (oscillations) restricted to a single plane
- where the plane and direction of propagation are coplanar / labelled diagram seen indicating polarised wave’s oscillation in single plane and perpendicular to the direction of propagation.
Area C (polaroid)
- Polaroid sunglasses absorb the horizontal component of the light / the light reflected from the water’s surface is (nearly all) absorbed by Polaroid sunglasses.
- Polaroid transmits the vertical component of the light from submerged objects.
- because the light from the submerged objects is unpolarised 50% passes through sunglasses to the eye.
- Idea that reduces surface reflection more than light from submerged objects.</td><td>6</td><td>4 × AO1.1a
2 × AO3.1a</td></tr>
</table>

Total			**6**

Question	Answers	Additional Comments/Guidance	Mark	AO
04.1	Attempts to set forces equal with double a component of tension. **OR** Attempts to set forces equal with single horizontal component of tension ($T\cos\theta$) ✓ ($T=$) 310 (N) ✓	Expect to see $F = 2T\cos 75$ **OR** $80 = T\cos 75$ Condone $F = 2\,T\sin 75$ **OR** $160 = 2\,T\sin 75$ OR F = 2T sin (their acute angle) OR F = 2T cos (their acute angle) **OR** $\frac{80}{\sin 75}$ seen **and** 83 N on answer line. Condone $F = T\cos 75$ **OR** $160 = T\cos 75$ **OR** ($T=$) $\frac{160}{\cos 75}$ with 620 N on answer line An answer of 83 N due to F and T being interchanged obtains zero marks. Alternative closed triangle (75-75-30) of forces An attempted use of Sine or Cosine Rule seen with correct closed triangle **MP1** Accept answer correctly rounded to at least 2 sf. Answer = 309 (N) to 3 sf Calculator display= 309.0962644	2	2 × AO2.1f

Question	Answers	Additional Comments/Guidance	Mark	AO
04.2	Read off for $F = 208$ N **OR** use of $F = ma$ ✓ (a =) 9900 (m s^{-2}) ✓	Range for read-off is 208 N to 210 N In use of $F = ma$: • must see substitution for F and m • condone either POT error in *m* or F outside range but not both. Accepted range = 9900 to 10000 Penalise 1×10^4 N as a 1 sf answer.	2	AO1.1a AO2.1b

Question	Answers	Additional Comments/Guidance	Mark	AO
04.3	Area under graph calculated in J for either s = 0.10 m or s = 0.385 m ✓ s_r = 0.385 m ✓	s = 0.385 m is approximately 64 blocks, 1 J per block (64 J) s = 0.10 m gives 8 blocks at 1 J per block (8 J) Or $\frac{1}{2} \times 0.1 \times 160 = 8$ J (less than 64 J) Range for s_r between 0.38 m and 0.385 m Do not accept $W=Fs$ for **MP1** Do not accept $s_r = 0.4$ m for **MP2**	2	2 × AO3.1b

Question	Answers	Additional Comments/Guidance	Mark	AO
04.4	(Energy transferred to arrow =) 0.82×64 **OR** converts $190\ \text{km h}^{-1}$ to $52.8\ \text{m s}^{-1}$ or working seen ✓ Use of $E_k = \frac{1}{2} mv^2$ ✓ $m = 0.038$ (kg) ✓	Energy transferred to arrow = 52.48 $52.8 = 52.\dot{7} = \frac{475}{9}$ accept any answer that rounds to 53 Use of is: • A rearranged expression where m would be subject. • Substitution: condone one error in the substitution either v **or** E_k where m would be subject (condone rounding error in v) Do not accept their power ($F\ v$) equal to $\frac{1}{2} mv^2$ Accept answer correctly rounded to at least 2 sf. $m = 2.2 \times 10^{-16}$ kg where incorrect v of 6.84×10^{8} is used. (Worth 2 marks) (one error in v) $m = 0.056$ kg where incorrect Ek is used ($\frac{64}{0.82} = 78$) (Worth 2 marks) (one error in Ek) Calculator display = 0.03768093075	3	2 × AO1.1a AO2.1b

Total			**9**

Question	Answers	Additional Comments/Guidance	Mark	AO
05.1	(Use of volume (per sec) =) $\frac{\pi d^2}{4} \times 17.2$ ✓ Use of $\rho = \frac{m}{V}$ ✓ (mass per second =) 0.389 (kg s^{-1}) ✓	(Volume per second =) 19.45 (m^3 s^{-1}) $= \frac{774\pi}{125}$ $$\frac{\pi d^2}{4} \times 17.2 = \frac{9\pi}{25} \times 17.2$$ Substitutes their volume (per second) and density where $\frac{m}{t}$ would be subject. Do not award MP2 if 2 errors are made in substitution. Answer seen to at least 2 sf. Calculator display = 0.3890548342	3	AO1.1a 2 × AO2.1b

Question	Answers	Additional Comments/Guidance	Mark	AO
05.2	Use of $F = \frac{m}{t} \times v$ or (F =) 6.69 N or 6.708 (N) or 6.88 (N) **OR** Use of $W=mg$ **OR** statement: Upward force = weight ✓ Applies condition for equilibrium by setting $F = mg$ **OR** $6.69 = 3.72\ m$ *or* $6.708 = 3.72\ m$ or $6.88 = 3.72\ m$ ✓ (m =) 1.80 (kg) ✓	Possible ECF from **05.1** where their m rounds to 0.4 kg. $W = 3.72m$ seen or $3.72m$ as the subject of a force equation. Do not allow 3.72 x 0.4 as use of W=mg . Accept answer correctly rounded to at least 2 sf. F= 6.88 N where $\frac{m}{t} = 0.4$ m=1.85 kg or 1.8 kg	3	AO1.1a 2 × AO2.1b

Question	Answers	Additional Comments/Guidance	Mark	AO
05.3	Use of $E = Pt$ OR converts kWh to J ✓ (=) 11% ✓	$(E =)$ 340 × 39 **or** 13260 (J) (0.035 kWh =) 35 × 3600 **or** 126000 (J) **Alternative MP1** converts to any of the following units of energy. • 0.34 (kW) x 0.0108 (h) **or** 0.00368 (kWh) • 0.035 kWh = 35 (Wh) • 340 $(W) \times \frac{13}{1200}$ (h) **or** $\frac{221}{60}$ (Wh) *or* 3.683 (Wh) Or equivalent e.g W mins Do not accept incorrect unit. Do not accept incorrect subject. **MP2** Do not allow answers obtained using incorrect power $(\frac{126000}{39})$ $\frac{340}{incorrect\ power}$ such as $\frac{340}{\frac{126000}{39}}$ Accept answer correctly rounded to at least 2 sf. Calculator display = 10.5238	2	AO1.1a AO2.1b

Question	Answers	Additional Comments/Guidance	Mark	AO
05.4	Incorrect: • this will increase weight **OR** helicopter must provide a greater lift **OR** (more mass therefore) greater GPE (for same height) **OR** (more mass therefore) greater KE (for same speed) **OR** idea that more energy is required. ✓ • the helicopter must displace more (atmospheric) gas (every second to produce greater lift force) **OR** blades must spin faster✓ • the helicopter must do more work every second (so will transfer stored energy at a greater rate) **OR** the helicopter needs more power to fly✓ **OR** Incorrect: • this will increase weight ✓ • atmosphere is too thin and can't displace sufficient mass of gas per second **OR** blades can't spin **fast enough**✓ • can't get off ground due to insufficient lift force ✓	Do not accept increase in resistive forces or increase in drag for increase in weight. **Must state that it is incorrect for all 3 marks**. Maximum of 2 marks for suggestions that more than doubles flight time. Accept lift or thrust or upward force. A maximum of 1 mark for **MP3** and **MP1** where only mark seen is : idea that more energy is required. **MP2** can be scored independent of this.	3	3 × AO3.1b

Question	Answers	Additional Comments/Guidance	Mark	AO
05.5	Use of an appropriate equation of motion: $v = u + at$ ✓ $(t =)$ 0.15 (s) ✓	By correct substitution including signs **or** correct rearrangement to make t subject. Accept answer correctly rounded to at least 2 sf. Calculator display = 0.14784946236559	2	AO1.1a AO2.1b

Question	Answers	Additional Comments/Guidance	Mark	AO
05.6	Use of $v^2 = u^2 + 2as$ **OR** Use of $v = u + at$ **and** $s = ut + \frac{1}{2}at^2$ **ECF** **OR** $mg\Delta h = \frac{1}{2}mv^2 - \frac{1}{2}mu^2$ ✓ $(h =)\ 0.61\ (\text{m})$ ✓ **ECF**	**MP1** (Downward journey) Allow $s = 0.65\text{m}$ $2.2^2 = 0^2 + 2\times 3.72 \times s$ **OR** $2.2 = 0 + 3.72\ t$ **and** $s = 0 + \frac{1}{2} 3.72\ t^2$ **ECF** **OR** $m\times 3.72\times \Delta h = \frac{1}{2} m 2.2^2$ MP1 (Upward journey) Allow s=0.041 m obtained from $s = 0.55\times 0.15 - \frac{1}{2} 3.72\times 0.15^2$ **ECF** **OR** $0^2 = 0.55^2 - 2\times 3.72 \times s$ Check possible **ECF** for t from **05.5** used in calculation. Condone sign suppression in **MP1** where answer of 0.65 m or 0.041 m or $0.6(1)\text{ m}$ is seen. Accept answer correctly rounded to at least 2 sf. Calculator display = 0.60987903225806	2	AO1.1a AO2.1b

Question	Answers	Additional Comments/Guidance	Mark	AO
05.7	Student is correct: Weight is the only force acting on the helicopter. **OR** Acceleration = (-)3.72 ms^{-2} ✓ Due to **<u>Newton's 2nd law</u>** , the acceleration acts in the **same direction** as the weight (which is always downwards). **OR** Due to **<u>Newton's 2nd law</u>** , the acceleration is **constant** because the (mass and) weight are **constant** ✓	MP1 statement that the object is in freefall. Where (resultant) force is mentioned must be identified as weight. Where acceleration is quoted must have correct unit. Accept $F=ma$ as a statement of Newton's 2nd law. MP2 Accept no mention of force being weight where mass is included their answer, for e.g.: Due to **<u>Newton's 2nd law</u>** the acceleration is constant because the force **and** mass are constant. Neutral for statements that refer to deceleration / acceleration. Do not accept arguments based on drag or air resistance affecting the motion of the helicopter. **Zero marks** for statement that indicates the **acceleration varies**. Must state that student is correct **or** that the acceleration is constant to gain 2 marks.	2	AO1.1a AO2.1a

Total			**17**

Question	Answers	Additional Comments/Guidance	Mark	AO
06.1	Amount of **chemical energy** transferred / converted to **electrical energy** for 1 C of charge (through the battery). **OR** Work done in moving 1 C of charge **whole way** round circuit✓	Allow: (The emf is) the terminal pd (of the battery) when there is no current in the battery.	1	AO1.1a

Question	Answers	Additional Comments/Guidance	Mark	AO
06.2	Use of $Q = It$ **OR** Use of $Q = Ne$ ✓ $(N =)\ 6.1 \times 10^{20}$ ✓	Substitutes for I and t. $(Q =)\ 0.044 \times 37 \times 60$ **OR** $(Q =)\ 0.044 \times 2220$ **OR** $(Q =)\ 97.68$ (C) $(N =) \frac{\text{their } Q}{1.6 \times 10{-}19}$ or $(N =)\ 6.25 \times 10^{18}$ x their Q their Q must have supporting work which identifies it as Q Accept answer correctly rounded to at least 2 sf. Calculator display = 6.105 x 10^{20}	2	AO1.1a AO2.1b

<table>
<tr><th>Question</th><th>Answers</th><th>Additional Comments/Guidance</th><th>Mark</th><th>AO</th></tr>
<tr><td>06.3</td><td>Read off $V = 3.4$ V when $I = 44$ (mA) ✓

Use of $P = VI$ ✓

(P =) 0.15 (W) ✓</td><td>Accept any of the following pairs of values:
<table>
<tr><th>I (mA)</th><th>V (V)</th><th>P (W)</th></tr>
<tr><td>4 to 6</td><td>2.8</td><td>0.011 to 0.017</td></tr>
<tr><td>8 to 12</td><td>2.9</td><td>0.023 to 0.035</td></tr>
<tr><td>12 to 15</td><td>3</td><td>0.036 to 0.045</td></tr>
<tr><td>20</td><td>3.1</td><td>0.062</td></tr>
<tr><td>22 to 26</td><td>3.2</td><td>0.070 to 0.083</td></tr>
<tr><td>40 to 47</td><td>3.4</td><td>0.136 to 0.160</td></tr>
<tr><td>64 to 72</td><td>3.6</td><td>0.23 to 0.26</td></tr>
<tr><td>96 to 100</td><td>3.8</td><td>0.36 to 0.38</td></tr>
</table>
Substitutes a voltage between 2.8 V and 3.8 V and a corresponding current value from table.
Expect to see a consistent power in range quoted for that voltage.
Condone POT error in sub for current and its subsequent power. In MP1 and MP2

OR Uses $I = 0.044$ (A) and $3\,V < V < 4$V and obtaining a consistent answer.

Accept answer correctly rounded to at least 2 sf.
MP3 must be 0.15 (W) or 0.150 (W) or 0.1496 (W) .</td><td>3</td><td>2 × AO1.1a
AO2.1b</td></tr>
</table>

Question	Answers	Additional Comments/Guidance	Mark	AO
06.4	**MP1**✓ Use of $V = IR$: (to find lost volts $= Ir =$) 0.044×1.5 OR 0.066 V **OR** $(\frac{\varepsilon}{I} =)\ \frac{12}{0.044}$ (To find total resistance = $\frac{3000}{11}$ or 272.7 (Ω)) **MP2**✓ (Total resistance – r = R =) $\frac{5967}{22}$ or **271.2 (Ω)** **OR** (Pd across R =) 271.2 × 0.044 or 11.9328 V or their $R \times 0.044$ **OR** (Total pd across LEDs =) 3 × 3.4 or 10.2 V **ECF** **OR** (Resistance of an LED =) $\frac{3.4}{0.044}$ or 77.3 (Ω) **ECF** **OR** (Resistance of an LED = $\frac{P}{I^2}$ =) $\frac{0.15}{0.044^2}$ or 77.3 or 77.48 (Ω) **ECF** **MP3**✓ (Total resistance of 3 LEDs =) 3 × 77.3 **or** 231.9 **or** 232.438 (Ω) **or** 3 x their resistance of one LED **OR** (Pd across **R** =) 12 – their total pd across LED – their lost volts or 1.734 (V) **OR** **R** = R – 3 × their resistance of one LED **OR** (R of **R** =) $\frac{\text{their pd across unknown resistor}}{0.044}$ or $\frac{1.734}{0.044}$ **MP4**✓ (R of **R** =) 39(.4) (Ω) or 38.8 (Ω)	**Alternative** **MP1** Use of $\varepsilon = I(R + r)$ by substituting for ε, I and r (where R is external resistance) **MP2** Rearrange $\varepsilon = I(R + r)$ to find R = **271.2 (Ω)** Condone POT in any of the working for **MP1**, **MP2** and **MP3**. Condone answers in range 38.5 Ω to 39.7 Ω Treat use of their V from **06.3** as an ECF e.g. An answer of 53 (Ω) gains **4 marks** (uses V= 3.2 V) Other consistent uses of their V identifiable in **06.3** can achieve **4 marks**.	4	AO1.1a 3 × AO2.1b

Question	Answers	Additional Comments/Guidance	Mark	AO
06.5	**MP1** lost volts = 3.5×1.5 or $5.25\ \mathrm{V}$ OR Current in LEDs = $8\ \mathrm{mA}$ (when $V = 2.9\ \mathrm{V}$) OR LEDs require $8.7\ \mathrm{V}$ to light✓ **MP2** terminal pd $= 6.75\ \mathrm{V}$✓ **MP3** **LEDs won't light**: -because terminal pd is less than $8.7\ \mathrm{V}$ -because pd across LED is less than $2.5\ \mathrm{V}$, therefore, no current in LEDs -because pd across **R** is zero as the resistance of LED is much greater the **R**, therefore, no current in LEDs -Resistor **R** would require a pd of $0.315\ \mathrm{V}$. Therefore, total pd required $= 9.01\ \mathrm{V}$ is greater than terminal pd. -their pd across each LED is below switch-on voltage (of $2.9\ \mathrm{V}$)✓	Allow between $8\ \mathrm{mA}$ and $10\ \mathrm{mA}$ for this read-off. **MP3** gives a valid reason why $6.75\ \mathrm{V}$ is insufficient. **Needs to state LEDS won't light for to gain MP3.**	3	3 × AO3.1b

Total			Mark
			13