A-level
Physics

7408/3A-Paper 3 Section A
Mark scheme

June 2018

Version/Stage: 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 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 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.

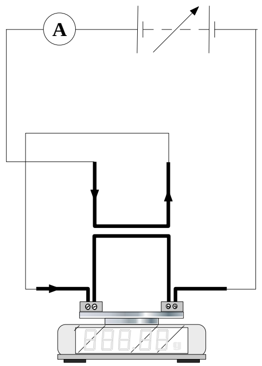
The exemplar materials used during standardisation will help you to determine the appropriate level. There will be an answer in the standardising materials which will correspond with each level of the mark scheme. This answer will have been awarded a mark by the Lead Examiner. You can compare the student's 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.

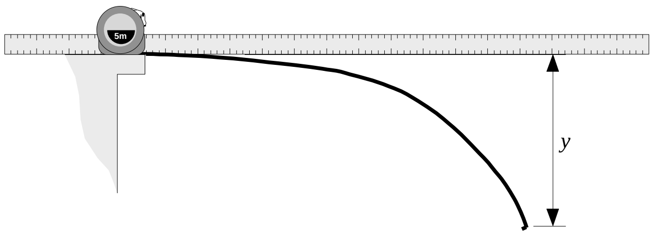
Indicative content in the mark scheme is provided as a guide for examiners. It is not intended to be exhaustive and you must credit other valid points. Students do not have to cover all of the points mentioned in the indicative content to reach the highest level of the mark scheme

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

Question	Answers	Additional Comments/Guidelines	Mark
01.1	attempt to apply principle of moments either about pivot or (LH) end of ruler $_1$✓ mass = 127(.04) (g) $_2$✓ assumption is that ruler is uniform / mass evenly distributed **OR** weight acts at the centre/mid-point/middle **OR** centre of mass / gravity is at the centre/mid-point/middle $_3$✓	for $_1$✓ for evidence of moments taken expect clockwise and anticlockwise moment; for moment about pivot expect to see either 29 or 49; for use of LH end of ruler expect 30 or 50 don't insist on seeing masses in kg, distances in m or the inclusion of 9.81 or g in the working; condone g seen on one side only rounding to 127 g earns $_1$✓ and $_2$✓	**3**
01.2	force on wire is upwards **OR** ↑ $_1$✓ current is **from P to Q** **OR** rightwards **OR** (left) to (the) right **OR** → $_2$✓ states direction of force and direction of current (or $_3$✓= 0) and makes a suitably justified deduction, eg using left-hand rule **OR** LH rule **AND** B is into the page **OR** into plane of **Figure 3 OR** ⊗ $_3$✓	for $_1$✓ condone 'motion is upwards' for $_2$✓ 'towards Q' **OR** 'positive to negative' are not enough allow logically correct (using LH rule) $_3$✓ for either downwards force with correct current **AND/OR** upwards force with wrong current increased flux density below wire is acceptable alternative to LH rule	**3**
01.3	gradient calculated from ΔM divided by ΔI, condone read off errors of ± 1 division; minimum I step ≥ 2.0 A $_1$✓ evidence of g = 9.81 or 9.8 correctly used in working for σ or B $_2$✓ $\lvert B \rvert$ in range 1.76×10^{-2} to 1.87×10^{-2} or 1.8×10^{-2} (T) $_3$✓	for $_1$✓ expect (–)0.28 (g A^{-1}); do not penalise for missing – sign for $_2$✓ look for σ = their gradient × 9.81 (× 10^{-3} N) **OR** $B = \dfrac{\text{their gradient} \times 9.81\left(\times 10^{-3}\right)}{15\left(\times 10^{-2}\right)}$; condone POT errors for $_3$✓CAO by correct method only; ignore – sign if provided; no limit on maximum sf	**3**

<table>
<tr><th>Question</th><th>Answers</th><th>Additional Comments/Guidelines</th><th>Mark</th></tr>
<tr><td>01.4</td><td>
<table>
<tr><th></th><th>Reduced</th><th>No effect</th><th>Increased</th></tr>
<tr><td>Force acting on wire</td><td></td><td>$_1$✓</td><td></td></tr>
<tr><td>Force acting on prism</td><td>$_2$✓</td><td></td><td></td></tr>
<tr><td>Gradient of graph</td><td>$_3$✓</td><td></td><td></td></tr>
<tr><td>Vertical intercept</td><td>$_4$✓</td><td></td><td></td></tr>
</table>
</td><td>$_1$✓ = 1 mark
$_2$✓ = 1 mark
$_3$✓<u>and</u> $_4$✓= 1 mark
allow any distinguishing mark as long as only one per row
for ✓ and × in same row ignore ×
for ✓ and ✓ in same row give no mark
ignore any crossed-out response unless only distinguishing mark on row</td><td>3</td></tr>
<tr><td>01.5</td><td>any complete circuit connecting the power supply in Figure 6 to X and to Y that produces currents in X and in Y that travel left to right $_1$✓
wiring correct so that X and Y are in series (see below) $_2$✓
</td><td>allow parallel circuit for $_1$✓ but reject use of additional power supply
if X and/or Y is/are short-circuited award no marks;
for impractical circuits eg voltmeter added in series, award no marks
ignore any current arrows added to diagram</td><td>2</td></tr>
</table>

Question	Answers	Additional Comments/Guidelines	Mark
01.6	strategy: states that readings of M (as the dependent variable) will be measured for different values of independent variable, I or d only $_1$✓ clearly identifies the correct control variable, d or I only; condone $\frac{d}{L}$ = constant if I varied **OR** I^2L **OR** IL = constant if d varied; it must be clear how the value of the control variable is known $_2$✓ states that L will be measured or gives value eg L = 5.0 cm $_3$✓ use of g to convert M reading to F; evidence may be found in expression for k $_4$✓	for $_1$✓ condone F identified as the dependent variable or as the balance reading; reject 'measure change in mass / change in F' failure to make M or F the dependent variable cannot score $_1$✓ or $_2$✓ for $_2$✓if d is being varied and I = 5.0 A is stated, this can be taken to mean I is the control variable and the value is known for $_1$✓ and for $_3$✓ insist that M and L are being read **OR** measured **OR** recorded for $_4$✓ 'work out force' is not enough; reject 'acceleration' for g	**MAX 3**
	analysis: suggests a plot with M or F [by itself or combined with another factor] on the vertical axis and some valid manipulation of their independent variable on the horizontal axis $_5$✓ identifies correctly how k can be found using the gradient of their graph; k must be the subject of the expression given $_6$✓ **OR** if suggesting a plot with log M or log F on the vertical axis etc identifying correctly how k can be found from the graph intercept $_6$✓ **OR** suggesting a plot with M or F on the vertical axis etc and identifying correctly how k is found using the area under the line $_{56}$✓ = 1 MAX	the intention to plot M against I^2 is taken to mean that M is the dependent variable and is plotted on the vertical axis examples: plot M against I^2 will earn $_5$✓ and then $k = \frac{g \times d \times \text{gradient}}{L}$ will earn $_6$✓ or plot F against $\frac{1}{d}$ will earn $_5$✓ and then $k = \frac{\text{gradient}}{I^2 \times L}$ will earn $_6$✓ (note that when F is the dependent variable g will not appear in the expression for k)	2
Total			**19**

Question	Answers	Additional Comments/Guidelines	Mark
02.1	technique: at least one instance seen where a metre ruler is made vertical using a set-square in contact with the floor $_1$✓ strategy: (use a metre ruler to) measure the height of the free end of the tape (above the floor) and the height of the tape at the bench [height of the bench]; y = <u>difference</u> between these heights $_2$✓ **OR** use a metre ruler or straight edge placed alongside the tape measure and overhanging the (horizontal) bench, eg  y is measured directly using this method using **additional** ruler $_1$✓ using **additional** ruler made vertical (as before) or using set-square placed against horizontal ruler $_2$✓	for $_1$✓ allow use of plumb line or spirit level; don't insist on the set-square being used against two mutually perpendicular faces of the metre ruler the floor is assumed to be horizontal if the deflection is found from the difference between two vertical measurements for $_2$✓ allow metre ruler B made horizontal by use of set-square against vertical ruler A; ruler B establishes vertical position of free end of tape; ruler A is used to measure y directly either or both marks can be earned for suitable annotation to **Figure 7** reject suggestions that y can be found without making at least one vertical measurement	2
02.2	(for $x \leq 70$ cm y is small so) <u>percentage</u>/<u>fractional</u> uncertainty in y is (too) large **OR** (for $x > 70$ cm) <u>percentage</u>/<u>fractional</u> uncertainty in y not (too) large ✓	<u>percentage</u> or <u>fractional</u> and in y are essential; accept 'error' for 'uncertainty'; reject 'small distances are hard to measure'	1

Question	Answers	Additional Comments/Guidelines	Mark
02.3	**continuous ruled** best-fit line drawn (at least) between1st and 6th points; line **must** pass below 2nd point and above 5th point; line **must** pass above 1st point and below 6th point $_1$✓ gradient calculated from their best-fit line; result, minimum 2 sf, in range 3.5 to 4.7 $_2$✓ result for *n* correctly rounded from their gradient to the nearest integer (expect n = 4) $_3$✓	for $_1$✓ 'pass below' is taken to mean below the intersection of the cross-hairs defining the position of a point; a line that intersects (any of) the cross-hairs of the 1st, 2nd, 5th or 6th points loses this mark for $_1$✓ the line must not be thicker than half a grid square, must not vary in thickness and must not be too faint; do not allow two lines unless these are drawn to calculate maximum and minimum gradients from which an average is then calculated for $_2$✓ accept answers to greater than 2 sf which round to 2 sf in range 3.5 to 4.7 do not penalise for small steps or read off errors for $_3$✓ it must be clear that final result is for *n* if this is not on the answer line allow ecf for unexpected gradient result that is then correctly rounded to the nearest integer if no line is drawn (losing $_1$✓ and $_2$✓) allow $_3$✓ if *n* given as nearest integer to a gradient result obtained using two points on **Figure 8**	3

<table>
<tr><th>Question</th><th>Answers</th><th>Additional Comments/Guidelines</th><th>Mark</th></tr>
<tr><td>02.4</td><td>log A = (y) intercept <u>seen</u>
OR
log A = log y when log $x = 0$
OR
log $y = n$ log x + log A (or correctly rearranged) <u>seen</u> $_1$✓

indirect method to find (vertical) intercept described, eg
using (values for) a <u>point on line</u>;
substitute into <u>equation</u> (for the line); allow ‘into $y = mx + c$’;
find log A (don’t penalise incorrect algebra) $_2$✓

$A = 10^{(y \text{ intercept})}$
OR
$A = 10^{(\log y - n \log x)}$ $_3$✓

treat ln A = (y) intercept in $_1$✓ as a slip and don’t penalise but then insist that following work is consistent, eg insist on
use of ln $y = n$ ln x + ln A (if seen) to earn $_2$✓
and
$A = e^{(y \text{ intercept})}$ to earn $_3$✓</td><td>for $_1$✓ allow sensible use of $y = mx + c$ idea;
reject ‘log A is where line crosses y axis’
for $_2$✓ allow ‘use a point on line to find x and y then sub into equation etc’;
accept valid similar triangles idea;
reject anything such as extrapolating the line to suggest that the intercept can be found directly;

for $_3$✓
accept ‘(take/find) anti-log of (log y) intercept’;
condone ‘inverse log of (log y) for anti-log’; reject ‘convert’
accept $A = 10^{(\log A)}$ providing $_1$✓ awarded
accept substitution of n, eg $A = 10^{(\log y - 4 \log x)}$
reject $A = 10^{(-y \text{ intercept})}$

alternative method:
using a <u>point on line</u> find log x, log y;
<u>anti-log</u> to find x, y $_1$✓
use $A = \frac{y}{x^n}$ (equation seen with A the subject or equivalent description of process) $_2$✓
repeat (to find A) using a <u>different point on line</u>;
calculate average (A) $_3$✓
reject averaging of x and y or of log x and log y</td><td>3</td></tr>
</table>

Question	Answers	Additional Comments/Guidelines	Mark
02.5	*A* evaluated using $A = \frac{y}{x^n}$ **OR** using $A = 10^{(\log y - n \log x)}$; correct substitution of *n* (from 02.3) and of *y* and *x* in cm from any row in **Table 2** (likely values shown opposite), *A* evaluated correctly to minimum 2 sf and correct POT $_1$✓ order of magnitude of A = –7 **OR** 10^{-7} (accept index or of power of ten) $_2$✓ cm^{-3} $_3$✓ **OR** $\text{cm}^{(1-n)}$ where *n* is result given for 02.3	for $_1$✓ ECF for non-integer *n* values that may be seen in working: *x*/cm | *y*/cm | *A* when *n* = 4 | *A* when *n* = 3.879 * 132.4 | 61.2 | 1.99E-07 | 3.60E-07 116.8 | 33.7 | 1.81E-07 | 3.22E-07 105.1 | 24.3 | 1.99E-07 | 3.50E-07 94.5 | 15.6 | 1.96E-07 | 3.39E-07 84.3 | 11.0 | 2.18E-07 | 3.72E-07 73.2 | 5.7 | 1.99E-07 | 3.34E-07 *equation of best-fit line gives vertical intercept = 3.879 for $_2$✓ accept 1×10^{-7} (cm^{-3}) but reject 1.0×10^{-7} or 2×10^{-7} etc; ECF order of magnitude correct for their value of *A*; POT must be consistent with unit given eg if cm^{-3} is converted into m^{-3}; for $_3$✓ CAO; use of non-integer, eg n = 3.6 requires *A* in $\text{cm}^{-2.6}$ withhold $_2$✓ and $_3$✓ if *A* is not evaluated	3
Total			**12**

Question	Answers	Additional Comments/Guidelines	Mark
02.5	alternative approaches: *A* evaluated from $A = \frac{y}{x^n}$ **OR** from $A = 10^{(\log y - n \log x)}$; correct substitution of *n* (from 02.3) and of *y* and *x* in (in m) etc; *A* evaluated correctly to minimum 2 sf and correct POT $_1$✓ order of magnitude of $A = -1$ **OR** 10^{-1} $_2$✓ m^{-3} $_3$✓ *A* evaluated from $A = \frac{y}{x^n}$ **OR** from $A = 10^{(\log y - n \log x)}$; correct substitution of *n* (from 02.3) and of *y* and *x* in (in mm) etc; *A* evaluated correctly to minimum 2 sf and correct POT $_1$✓ order of magnitude of $A = -10$ **OR** 10^{-10} $_2$✓ mm^{-3} $_3$✓	see tables below; ecf for wrong or non-integer value of *n*, ie for $\mathrm{cm}^{(1-n)}$	

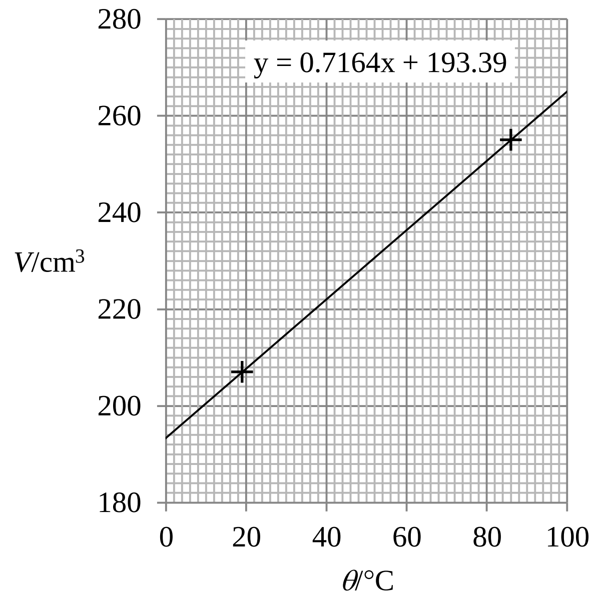
x/m	y/m	A when $n = 4$	A when $n = 3.879$ *
1.324	0.612	1.99E-01	2.06E-01
1.168	0.337	1.81E-01	1.85E-01
1.051	0.243	1.99E-01	2.00E-01
0.945	0.156	1.96E-01	1.94E-01
0.843	0.110	2.18E-01	2.13E-01
0.732	0.057	1.99E-01	1.91E-01

x/mm	y/mm	A when $n = 4$	A when $n = 3.879$ *
1324	612	1.99E-10	4.75E-10
1168	337	1.81E-10	4.26E-10
1051	243	1.99E-10	4.62E-10
945	156	1.96E-10	4.48E-10
843	110	2.18E-10	4.92E-10
732	57	1.99E-10	4.41E-10

ecf for wrong or non-integer value of *n*, ie for $\mathrm{cm}^{(1-n)}$

Question	Answers	Additional Comments/Guidelines	Mark
03.1	pressure (of air) in **Figure 9c** is greater than (pressure of air) in **Figure 9d** **OR** pressure in **Figure 9d** is lower than pressure in **Figure 9c** $_1$✓ (since) temperature is the same **OR** Boyle's Law applies **OR** PV = constant; $_2$✓ any suggestion that pressure is constant **OR** the volume is constant **OR** the temperature changes **OR** the amount of air in the flask increases as flask is raised loses both marks	for $_1$✓ must refer to either of the relevant figures or give other detail, eg 'when flask is lifted' so their meaning is unambiguous; allow 'when volume decreases pressure increases' but must be comparing **9c** with **9d** allow 'water pressure decreased in **9d**' treat 'air was compressed' (in **9c**) as neutral reject 'pressure released (in **9d**)' for $_2$✓ allow <u>mean</u> KE of molecules is the same accept $P \propto \frac{1}{V}$; allow nRT = constant; reject $PV = k$ (unless k = constant is also seen)	**2**
03.2	same (air) pressure $_1$✓ same mass of air $_2$✓ any suggestion that temperature is constant **OR** that volume is constant **OR** that pressure has changed **OR** the amount of air in the flask decreases as flask is moved from H to C loses both marks	for $_1$✓ and $_2$✓ accept constant/unchanged = same and condone 'assume same pressure/mass of gas' for $_2$✓accept same (number of) moles or same amount of gas no credit for stating 'volume increases as temperature increases' 'temperature is in equilibrium' is neutral	**2**

Question	Answers	Additional Comments/Guidelines	Mark
03.3	relevant quantity and instrument seen: volume(s) (of liquid) measured using a <u>measuring cylinder</u> **OR** graduated beaker $_1$✓ reject 'measuring beaker' and 'burette' eye level <u>with the bottom</u> of the meniscus (allow suitable sketch showing eye) $_2$✓ 'measure at eye level' **OR** 'eye level with graduation' **OR** 'eye perpendicular to graduation' are not enough to avoid <u>parallax</u> error $_3$✓ see alternative opposite; if both approaches are given record the mark to whichever scores most	alternative for $_1$✓mass (of liquid/flask) measured using a <u>balance</u> reject 'scales' and reject 'weigh/find weight/weigh the mass' for $_2$✓valid method to account for the mass of flask eg tare/zero balance (ECF 'scales') with (same) empty flask on balance and then measure mass of flask with liquid **OR** <u>subtract</u> mass of empty flask from mass of flask containing liquid; don't penalise 'weigh' twice **OR** ensure the balance is on a horizontal surface for $_3$✓find volume(s) using $V = \frac{m}{\rho}$; V must be subject	**3**
03.4	suitable vertical scale for their data points covering at least half the grid; false origin on the vertical scale correctly marked; vertical scale marked at sensible intervals, based around intervals of 1, 2, 4 or 5 etc; graduations no further than 2 major divisions apart $_1$✓ $19, 207$ plotted to nearest ½ grid square $_2$✓ $86, 255$ plotted to nearest ½ grid square $_3$✓	for $_1$✓ the two correct data points a suitable scale is $10\ \text{cm}^3$ for each major division an unmarked origin is be assumed to be (0, 0); if a broken scale symbol is not used and the V scale becomes non-linear, withhold the mark award $_{23}$✓ = 1 MAX for thick or poorly-marked points eg thicker than half a grid square; reject blobs, dots and circles	**3**
03.5	**continuous ruled** best-fit line of <u>positive</u> gradient through intersection of cross-hairs of their points ✓	apply same criteria for judging line quality as in **02.3**; don't penalise thick line if thick points are penalised in **03.4**	**1**

Question	Answers	Additional Comments/Guidelines	Mark
03.6	legitimate method to <u>calculate</u> horizontal intercept eg gradient calculated from ΔV divided by $\Delta\theta$ ie <u>numerical</u> evidence of 2 steps required; don't penalise read off errors or small steps reads (to within 1 grid square) **OR** uses a point on the line to calculate (with correct use of $y = mx + c$) the vertical intercept; sensible values are shown on the right $_1$✓ correct use of their vertical intercept and their gradient to calculate the horizontal intercept using $-1 \times$ vertical intercept divided by gradient $_2$✓ **OR** similar triangles, eg $\dfrac{255-207}{86-19} = \dfrac{207-0}{19-\theta}$ or similar seen $_1$✓ minimum $\Delta\theta$ = 86 – 19 (= 67as in example above) $_2$✓ result in range –260°C to –285°C $_3$✓ withhold mark for missing sign; no credit for unsupported answer	 in $_1$✓ condone V changed to m^3 when calculating gradient and finding intercept values for a graph with a negative gradient allow credit for $_1$✓ only = 1 MAX no credit for non-linear graph = 0 MAX data which may be seen in working include $V = 193\ cm^3$, $\theta = 0\ °C$; $V = 265\ cm^3$, $\theta = 100\ °C$; $V = 207\ cm^3$, $\theta = 19\ °C$; $V = 255\ cm^3$, $\theta = 86°\ C$	3
Total			**14**