Multiple Choice Answers

Q1: D
Q2: D
Q3: B
Q15: C
Q22: B

2(a)(i)	Final value of *d* in the range 4.0 cm to 8.0 cm with unit.
2(a)(ii)	Absolute uncertainty in *d* in range 0.2 cm to 0.6 cm Correct method of calculation to find percentage uncertainty e.g. absolute uncertainty / value from **2(a)(i)**) × 100. If repeated readings have been taken, then the uncertainty can be half the range if the working is clearly shown, but NOT zero if values are equal.
2(b)	Value of *L* in the range 85.0 cm to 100.0 cm with unit (somewhere)
2(c)(i)	**Raw** values of *h* to the nearest millimetre with unit (seen somewhere)
	Value of final *t* in the range 1.0 s to 5.0 s with unit
	Evidence of repeated measurements of *t*
2(c)(ii)	Value of *a* calculated correctly
2(c)(iii)	Justification for significant figures in *a* linked to significant figures in *L* and *t*.
2(d)	Second values of *h* **and** *t*.
	Second value of *t* **greater** than first value of *t*
2(e)	Two values of *k* calculated correctly. The final *k* values must not be written as fractions or given to only one significant figure.
2(f)	Calculation of percentage difference between candidate's two *k* values **and** comparison of percentage difference with 15%, leading to a consistent conclusion.

2(g)(i)	**1 mark for each point up to a maximum of 4.** A Two readings are not enough to draw a conclusion **or** not enough *k* values to draw a conclusion B Difficulty with measuring *d or diameter* with reason e.g. parallax / base / bottom of the bottle is not uniform / edges of the base / bottom of the bottle is curved C Difficult to set / measure the value of *L* / length with a reason e.g. difficult to place the bottle in the exact same place each time / cannot judge the centre line of the bottle / parallax error D Difficult to measure *h* or height with a reason e.g. bottle distorts view of water / refraction effects / parallax error / non-uniform shape (of bottle) E Difficulty with the bottle rolling / moving down the rulers (in a straight line) with a reason e.g. rulers bend / ruler(s) move (when bottle is rolling) / rulers are not parallel / bottle is not uniform (shape) / wooden strip is not parallel to the bench / rulers are not at the same height F Difficult to measure *t* / time with a reason e.g. knowing or judging when bottle reaches the end of rulers
2(g)(ii)	**1 mark for each point up to a maximum of 4.** A Take more readings (for different values of ***h***) and plot a graph **or** take more readings and compare *k* values B Use caliper C Method to hold the bottle at the start / top of rulers e.g. (card) stop D Use a straight-sided / uniform (diameter) bottle E Use a (single) plank / ramp **or** method of fixing rulers (to wooden strip or bench) e.g. adhesive putty, tape G Improved timing method e.g. video (record / film) and with a timer in view / use frame-by-frame

1(a)	Value of *P* in range 5.00 to 15.00 s, with unit seen somewhere
	Evidence of repeated measurement of *P*
1(b)	Six sets of readings of *z* (different values) and *P* with correct overall trend and without help scores 5 marks, five sets scores 4 marks etc. Correct trend is *P* decreases as *z* increases.
	Range: at least one reading of $z \leqslant 10$ g **and** at least one reading of $z \geqslant 70$ g
	Column headings: Each column heading must contain a quantity and a unit where appropriate. The presentation of quantity and unit must conform to accepted scientific convention e.g. $1 / \sqrt{M}$ ($g^{-½}$)
	Consistency: All raw values of *P* must be given to the nearest 0.01 s or **all** to the nearest 0.1 s.
	Significant figures: All values of $1 / \sqrt{M}$ must be given to 3 s.f. or 4 s.f.
	Calculation: $1 / \sqrt{M}$ calculated correctly

1(c)(i)	Axes: Axes must be labelled **with the correct quantities.** Scales must be chosen so that the plotted points occupy at least half the graph grid in both the *x* and *y* directions. Scale markings are no more than 2 cm (one large square) apart. Sensible scales must be used, no awkward scales (e.g. 3:10 or fractions).
	Plotting of points: All observations **in the table** must be plotted on the grid. Diameter of plotted points must be $\leqslant$ half a small square. Points must be plotted to an accuracy of half a small square in both *x* and *y* directions.
	Quality: General trend of points must be negative. All points in the table must be plotted (at least 5) for this mark to be awarded. It must be possible to draw a straight line that is within $\pm$ 0.001 $g^{-1/2}$ on the $1 / \sqrt{M}$ axis of **all** plotted points.
1(c)(ii)	Line of best fit: 'Best fit' is judged by the balance of all points on the grid (at least 5 points) about the candidate's line. There must be an even distribution of points either side of the line along the full length. Lines must not be kinked or thicker than half a square. Some candidates may choose to identify an anomalous point. If they identify **one** point as anomalous (e.g. by circling or labelling) then this point is to be disregarded when judging the line of best fit. There must be at least 5 points left after the anomalous point is disregarded.

1(c)(iii)	Gradient: Gradient sign on answer line consistent with graph drawn. The hypotenuse of the triangle used should be greater than half the length of the drawn line. Both read offs must be accurate to half a small square in both the *x* and *y* directions. Method of calculation must be correct, not $\Delta x / \Delta y$.
1(c)(iii)	*y*-intercept: **Either** Intercept read directly from the graph, with read off at $x = 0$, accurate to half a small square in *y* direction. **Or** Correct read off from a point on the line is substituted into $y = mx + c$ or an equivalent expression. Read-off accurate to half a small square in both *x* and *y* directions
1(d)	Value of *a* = candidate's gradient value **and** Value of *b* = candidate's y-intercept value. The values must not be written as fractions or given to only one significant figure.
	Units for *a* and *b* correct and consistent with readings (e.g. $g^{½}s^{-1}$ for *a* and s^{-1} for *b*)