9(a)	difference between mass of nucleus and mass of (constituent) nucleons
	when nucleons are separated to infinity
9(b)	Δm = (2 × 2.013553) – (4.001505) (u) (= 0.025601 u)
	$E = c^2\Delta m$
	energy from one He-4 nucleus= $0.025601 \times 1.66 \times 10^{-27} \times (3.00 \times 10^8)^2$ $(= 3.82 \times 10^{-12}$ J)
	energy to form 1.00 mol= $3.82 \times 10^{-12} \times 6.02 \times 10^{23}$ $= 2.30 \times 10^{12}$ J
9(c)(i)	$L = 1.09 \times 10^{11} \times (3.00 \times 10^8)^2$
	$= 9.81 \times 10^{27}$ W
9(c)(ii)	$L = 4\pi\sigma r^2 T^4$ $9.81 \times 10^{27} = 4\pi \times 5.67 \times 10^{-8} \times (1.19 \times 10^9)^2 \times T^4$
	T = 9930 K
9(d)	standard candles have known luminosity
	radiant flux intensity (from star) measured (on the Earth)
	distance found from $F = L / (4\pi d^2)$

2(a)	gradient = n y-intercept = lg k
2(b)	<table><tr><th>lg μ</th><th>lg λ</th></tr><tr><td>0.66 or 0.663 ± 0.04</td><td>2.70 or 2.699</td></tr><tr><td>0.73 or 0.732 ± 0.03</td><td>2.90 or 2.903</td></tr><tr><td>0.92 or 0.924 ± 0.02</td><td>3.51 or 3.505</td></tr><tr><td>1.04 or 1.041 ± 0.04</td><td>3.85 or 3.845</td></tr><tr><td>1.20 or 1.204 ± 0.03</td><td>4.40 or 4.398</td></tr><tr><td>1.26 or 1.255 ± 0.02 or ± 0.03</td><td>4.58 or 4.580</td></tr></table>
	Values of lg μ and lg λ correct as shown above.
	Uncertainties in lg μ correct as shown above.
2(c)(i)	Six points from **(b)** plotted correctly. Must be within half a small square. Diameter of points must be less than half a small square.
	Error bars in lg μ plotted correctly. All error bars must be plotted. Total length of bar must be accurate to less than half a small square and symmetrical.

2(c)(ii)	Straight line of best fit drawn. Thickness of the line must be less than half a small square. Do not accept line from top point to bottom point. Line must pass between (0.82, 3.20) and (0.84, 3.20) **and** between (1.13, 4.20) and (1.16, 4.20).
	Worst acceptable straight line drawn (steepest or shallowest possible line that passes through all the error bars). Thickness of the line must be less than half a small square. All error bars must be plotted.
2(c)(iii)	Gradient determined with clear substitution of data points into $\Delta y / \Delta x$. Distance between data points must be greater than half the length of the drawn line.
	Gradient determined of worst acceptable line with clear substitution of data points into $\Delta y / \Delta x$. uncertainty = (gradient of line of best fit – gradient of worst acceptable line) **or** uncertainty = ½ (steepest worst line gradient – shallowest worst line gradient)
2(c)(iv)	*y*-intercept determined by substitution of correct point with consistent power of ten in *m* and *x* into $y = mx + c$.
	y-intercept of worst acceptable line determined by substitution into $y = mx + c$. uncertainty = *y*-intercept of line of best fit – *y*-intercept of worst acceptable line **or** uncertainty = ½ (steepest worst line *y*-intercept – shallowest worst line *y*-intercept) Do not allow methods using a false origin.

2(d)	Value of *k* determined using *y*-intercept. $k = 10^{y\text{–intercept}}$
	$n =$ gradient **and** *n* and *k* given to 2 or 3 significant figures.
	absolute uncertainty in *n* = absolute uncertainty in gradient **and** absolute uncertainty in *k* = ($10^{y\text{-intercept}} - 10^{y\text{-intercept of WAL}}$) Correct method must be seen.
2(e)	*M* determined to a minimum of 2 significant figures from **(d)** or **(c)(iii)** and **(c)(iv)** with correct substitution **and** correct power(s) of ten. Do not accept incorrect POT for *n* or *k*. Correct substitution must be seen. $\mu = \sqrt[n]{\frac{\lambda}{k}} = \sqrt[\text{gradient}]{\frac{0.46}{\textbf{(d)}}}$ **or** $\lg \mu = \frac{\lg 0.46 - y\text{-intercept}}{\text{gradient}}$ **or** $\lg \mu = \frac{\lg 0.46 - \lg k}{\text{gradient}}$ **and** $M = \mu \times 2.0 \times 10^{30}$