Question Number	Answer	Mark
3(a)(i)	**Mark 3(a)(i) and (ii) holistically** **EITHER** • Measure the height from the paper to the top of the liquid (*v*) **(1)** • Measure the height from the paper to the filament/middle of the bulb **(1)** (*u* + *v*) **(1)** • Subtract *v* to give *u* **OR** **(1)** • Measure the height from the filament/middle of the bulb to the top of **(1)** the liquid (*u*) **(1)** • Measure the height from the paper to the filament/middle of the bulb (*u* + *v*) • Subtract *u* to give *v* **(1)** **(1)** **OR** **(1)** • Measure the height from the paper to the top of the liquid (*v*) • Move the ruler so that zero aligns with the lens • Measure the distance from the lens to the filament/middle of the bulb (*u*)	**3**
3(a)(ii)	• Identifies relevant source of uncertainty **(1)** • Suggest suitable approach to reduce/eliminate the uncertainty **(1)** <u>Examples</u> • Parallax error when measuring the height of the bulb/lens with the ruler • Use a set square from rule to bulb/lens • Metre rule not vertical • Use a set square to ensure metre rule is perpendicular to the base/paper • Zero error when measuring the height from the lens to the bulb • Check zero on the rule is aligned with top of the liquid • Filament sealed within glass, so cannot measure distance directly • Measure to the middle of the bulb	**2**

Question Number	Answer		Mark
3(b)(i)	• Use of $P = \frac{1}{u} + \frac{1}{v}$ • P = 4.30 (D) to 3 s.f. <u>Example of calculation</u> $P = \dfrac{1}{u} + \dfrac{1}{v}$ $P = \dfrac{1}{0.615\ \mathrm{m}} + \dfrac{1}{0.374\ \mathrm{m}} = 4.2998\ \mathrm{D}$ $P = 4.30\ \mathrm{D}$	**(1)** **(1)**	**2**
3(b)(ii)	• Use of $P = \frac{n_{lens} - n_{air}}{n_{air}} \left(\frac{1}{r}\right)$ • with n_{air} = 1 • n_{lens} = 1.3 Allow e.c.f from 3(b)(i) <u>Example of calculation</u> mean P = (4.28 D + 4.31 D + 4.30 D)/3 = 4.297 D $n_{\mathrm{lens}} = Pr + 1$ $n_{\mathrm{lens}} = (4.297\ \mathrm{D} \times 0.070\ \mathrm{m}) + 1$ $n_{\mathrm{lens}} = 1.3$	**(1)** **(1)** **(1)**	**3**
	Total for question 3		**10**