| Question | Scheme | Marks |
|---|---|---|
| 1(a) | $r=\sqrt{(-4)^2+\left(-4\sqrt{3}\right)^2}=\ldots$ | M1 |
| | $\tan\theta=\dfrac{-4\sqrt{3}}{-4}\Rightarrow\theta=\tan^{-1}\left(\sqrt{3}\right)\pm\pi$ | M1 |
| | $8\left(\cos\left(-\dfrac{2\pi}{3}\right)+\mathrm{i}\sin\left(-\dfrac{2\pi}{3}\right)\right)$ | A1 |
| | | (3) |
| (b) | $z=r\mathrm{e}^{\mathrm{i}\theta}\Rightarrow\left(r\mathrm{e}^{\mathrm{i}\theta}\right)^3=-4-4\sqrt{3}\Rightarrow r^3\left(\mathrm{e}^{3\mathrm{i}\theta}\right)=8\mathrm{e}^{-\mathrm{i}\frac{2\pi}{3}}$ | |
| | $\Rightarrow r=\sqrt[3]{8}=2$ | M1 |
| | $3\theta=-\dfrac{2\pi}{3}\left(+2k\pi\right)\Rightarrow\theta=-\dfrac{2\pi}{9}+\left(\dfrac{2k\pi}{3}\right)$ | M1 |
| | So $z=2\mathrm{e}^{-\frac{8\pi}{9}\mathrm{i}},2\mathrm{e}^{-\frac{2\pi}{9}\mathrm{i}},2\mathrm{e}^{\frac{4\pi}{9}\mathrm{i}}$ | A1ft A1 |
| | | (4) |
| | | (7 marks) |

**Notes:**

**(a)**

**M1:** For a correct attempt at the modulus, implied by a correct modulus if no method seen and allow recovery if correct answer follows a minor slip in notation.

**M1:** For an attempt to find a value of $\theta$ in the correct quadrant. Accept $\tan^{-1}\left(\sqrt{3}\right)\pm\pi$ or $\tan^{-1}\left(\dfrac{1}{\sqrt{3}}\right)\pm\pi$

May be implied by sight of an of $-\dfrac{2}{3}\pi,\dfrac{4}{3}\pi,-\dfrac{5}{6}\pi,\dfrac{7}{6}\pi$.

**A1: cao** as in scheme, no other solution.

**(b)**

**M1:** Applies De Moivre's Theorem and proceeds to find a value for $r$ ie $\left(\text{their}\,8\right)^{\frac{1}{3}}$

**M1:** Proceeds to find at least one value for $\theta$ – ie their argument/3.

**A1ft:** At least two roots correct for their $r$ and $\theta$. (Must come from correct method, watch for correct roots coming from an incorrect angle due to errors.)

**A1:** All three correct roots and no others. Accept e.g $2\mathrm{e}^{\mathrm{i}-\frac{8\pi}{9}}$ as a slip in notation, so allow marks.