1. (a) power (received) proportional to area **(1)**
collecting area proportional to d^2 **(1)** 2

(b) energy per unit area at dish = $\frac{7.5\times10^{-16}}{\pi(60)^2}$ **(1)**

total energy = $\frac{7.5\times10^{-16}}{\pi(60)^2}\times 4\pi(2.5\times10^{28})^2$ **(1)**

= 5.2×10^{38} W **(1)** 3

[5]

2. (a) $\frac{\lambda}{20} = 0.05$ and $\lambda = 1.0$ m **(1)** 1

(b) $\theta = \frac{\lambda}{D}$ **(1)**

$= \frac{0.06}{76} = 7.9\times10^{-4}$ rad **(1)** 2

(c) advantage 1:

power $\propto D^2$ $\therefore$ much more power detected by larger diameter telescope **(1)**

larger ratio of power detected = $\left(\frac{76}{13}\right)^2 = 34$ **(1)**

advantage 2:

resolving power $\propto D$ $\therefore$ larger diameter has greater resolving power **(1)**

ratio of resolving power = $\frac{76}{13} = 5.8$ **(1)**

(inverse accepted if angle referred to) 4

[7]

3. 3 marks for any of the following 3 features

- compared with optical reflecting telescopes, radio telescopes:
- are much longer
- have a much lower resolving power
- are not as affected by the atmosphere and so their positioning is less critical
- have only one reflecting surface rather than two
- have a similar structure in that a concave reflecting surface reflects the em radiation to a detector at the focal point 3

explanations of resolving power

radio telescopes have a lower resolving power:

because the ratio of wavelength to telescope diameter is larger **(1)**

because radio wavelengths are very much larger than optical wavelengths (even though the diameters of radio telescopes are larger) **(1)**

explanations of collecting power:

collecting power depends on the area of the objective which is much larger for radio telescopes (depends on the square of the diameter) **(1)** 3

[6]