Teacher notes
Topic E

The density of all nuclei is approximately the same.

Experiments show that the radius of a nucleus of nucleon number A is given by $R = R_0 A^{\frac{1}{3}}$ where $R_0 = 1.2 \times 10^{-15}$ m. This means that the volume of a nucleus with nucleon number A is proportional to A:

$$V = \frac{4\pi}{3} R^3 = \frac{4\pi}{3} (R_0 A^{\frac{1}{3}})^3 = \frac{4\pi R_0^3 A}{3}$$

But the mass of the nucleus is also proportionate to A: it contains A nucleons, each of mass 1u approximately and so the mass is Au. Hence the density is

$$\rho = \frac{M}{V} = \frac{Au}{\frac{4\pi R_0^3 A}{3}} = \frac{3u}{4\pi R_0^3} = \frac{3 \times 1.66 \times 10^{-27}}{4\pi \times (1.2 \times 10^{-15})^3} \approx 2 \times 10^{17} \text{ kg m}^{-3}$$

and is independent of A.