Solutions

Each answer shows the steps, then the **result**.

2.1

- the **work done per unit mass** in bringing a small test mass from **infinity** to that point

2.2

- gravity is **attractive**, so it does the work as the mass moves in from infinity (where $\phi = 0$); the potential therefore becomes **negative**

2.3

- $\mathrm{J\ kg^{-1}}$

2.4

- $E_\mathrm{P} = -GMm/r$

3.1 B

- gravitational potential is defined as **zero** at infinity
- **A** would be a surface value; **C** is a typical Earth-surface ϕ; **D** is not the definition

3.2

- $\phi = -GM/R$

$$\phi = -\frac{(6.67\times10^{-11}\ \mathrm{N\ m^2\,kg^{-2}})(6.0\times10^{24}\ \mathrm{kg})}{6.4\times10^{6}\ \mathrm{m}} = \mathbf{-6.3\times10^{7}}\ \mathrm{J\ kg^{-1}}$$

3.3

- $E_\mathrm{P} = -GMm/r$

$$E_\mathrm{P} = -\frac{(6.67\times10^{-11}\ \mathrm{N\ m^2\,kg^{-2}})(6.0\times10^{24}\ \mathrm{kg})(1200\ \mathrm{kg})}{7.0\times10^{6}\ \mathrm{m}} = \mathbf{-6.9\times10^{10}}\ \mathrm{J}$$

3.4

- as r decreases, $-GMm/r$ becomes **more negative**
- the masses are more **tightly bound** — more work would be needed to separate them to infinity

3.5

- $\Delta E_\mathrm{P} = GMm(1/r_1 - 1/r_2)$

$$\frac{1}{r_1} - \frac{1}{r_2} = \frac{1}{7.0\times10^{6}\ \mathrm{m}} - \frac{1}{1.4\times10^{7}\ \mathrm{m}} = 7.14\times10^{-8}\ \mathrm{m^{-1}}$$

$$M = \frac{2.86\times10^{10}\ \mathrm{J}}{(6.67\times10^{-11}\ \mathrm{N\ m^2\,kg^{-2}})(1000\ \mathrm{kg})(7.14\times10^{-8}\ \mathrm{m^{-1}})} = \mathbf{6.0\times10^{24}}\ \mathrm{kg}$$