Chapter 1.1

All calculations here are made without a calculator so they may differ slightly from a calculator answer.

Q1 Taking the diameter of a proton to be order 10^{-15} m we find

$$\frac{10^{-15}}{3\times10^{8}}=0.3\times10^{-23}=3\times10^{-24}\approx10^{-24}\text{ s}.$$

Q2 The mass of the earth is about 6×10^{24} kg and the mass of a hydrogen atom about 2×10^{-27} kg so we need $\frac{6\times10^{24}}{2\times10^{-27}}=3\times10^{51}\approx10^{51}$.

Q3 From the table on page 5, $\frac{10^{17}}{10^{-43}}=10^{60}$.

Q4 $\frac{6.380\times10^{6}}{10^{-35}}=6\times10^{41}\approx10^{42}$.

Q5 A heartbeat lasts or 1 s so $\frac{75\times365\times24\times3600}{1}\approx8\times4\times2\times4\times10^{7}\approx2.6\times10^{9}\approx10^{9}$.

Q6 Using the table on page 4, $\frac{10^{41}}{10^{30}}=10^{11}$.

Q7 From the table on page 4, $\frac{10^{21}}{1.5\times10^{11}}\approx10^{10}$.

Q8 There are 300 g of water in the glass and hence $\frac{300}{18}\approx\frac{300}{20}=15$ moles of water. Hence the number of molecules is $15\times6\times10^{23}=90\times10^{23}\approx10^{25}$.

Q9 There are 6×10^{4} g of water in the body and hence $\frac{6\times10^{4}}{18}\approx0.3\times10^{4}=3\times10^{3}$ moles of water. Hence the number of molecules is $3\times10^{3}\times6\times10^{23}=18\times10^{26}\approx10^{27}$.

Q10 Taking a mass of 10^{53} kg for the universe and the mass of hydrogen molecule to be $2\times1.7\times10^{-27}\approx3\times10^{-27}$ kg we get $\frac{10^{53}}{3\times10^{-27}}\approx0.3\times10^{80}=3\times10^{79}\approx10^{79}$.

Q11 The mass is about 1.7×10^{-27} kg and the radius about 10^{-15} m so the density is

$$\frac{1.7\times10^{-27}}{\frac{4\pi}{3}\times(10^{-15})^3}\approx\frac{1.7\times10^{-27}}{4\times10^{-45}}=0.5\times10^{18}=5\times10^{17}\text{ kg m}^{-3}.$$

Q12 The distance to be travelled is 1.5×10^{11} m and so the time of travel is

$$\frac{1.5\times10^{11}}{3\times10^{8}}=0.5\times10^{3}=500\text{ s}=\frac{500}{60}\text{ min}=\frac{50}{6}\approx8\text{ min}.$$

Q13 Assuming a mass of 4000 kg for the elephant and apples of mass 0.150 kg we need

$$\frac{4000}{0.15}\approx\frac{4000}{0.2}=2\times10^{4}\text{ apples.}$$

Q14 See answer in the textbook.

Q15, 16, 17 See answers in textbook.

Q18 $v=\dfrac{15.68\times10^{-3}}{87.50\times10^{-9}}=1.792\times10^{5}\text{ m s}^{-1}$.

Q19 (a) $E=2.5\times1.6\times10^{-19}=4.0\times10^{-19}\text{ J}$. (b) $E=\dfrac{8.6\times10^{-18}}{1.6\times10^{-19}}=54\text{ eV}$.

Q20 $V=(2.8\times10^{-2})^{3}=2.2\times10^{-5}\text{ m}^{3}$.

Q21 $a=(588\times10^{-9})^{1/3}=8.38\times10^{-3}\text{ m}$.

Q22 $g=9.8\,\dfrac{\text{m}}{\text{s}^2}=9.8\,\dfrac{100\times\frac{1}{2.54}\times\frac{1}{12}\text{ ft}}{\text{s}^2}=32\text{ ft s}^{-2}$.

Q23 $V=125\times2.96\times10^{-5}\text{ m}^{3}$ and so

$$a=V^{1/3}=(125\times2.96\times10^{-5})^{1/3}=0.15467\text{ m}=15.467\text{ cm}=\frac{15.467}{2.54}=6.01\text{ in}.$$

Q24 $P=\dfrac{224\times10^{3}}{746}=300\text{ hp}$.

Q25 (a) 200 g, (b) 2 kg, (c) 400 g.

Q26 The distance to be travelled is 10^{21} m and so the time of travel is

$$\frac{10^{21}}{3\times10^{8}}=0.3\times10^{13}=3\times10^{12}\text{ s}=\frac{3\times10^{12}}{365\times24\times3600}\text{ yr}=\frac{3\times10^{12}}{4\times2\times4\times10^{6}}\approx\frac{1}{10}\times10^{6}=10^{5}\text{ yr}.$$

Q27 The mass is of order 10^{30} kg and the radius of order 10^{6} m so the density is of order

$$\frac{10^{30}}{\frac{4\pi}{3}(10^{7})^{3}}=\frac{10^{30}}{4\times10^{21}}=0.25\times10^{9}=2\times10^{8}\text{ kg m}^{-3}.$$

Q28 In SI units the acceleration is $\frac{100\times\frac{10^{3}}{3600}}{4}=\frac{\frac{10^{5}}{4\times10^{3}}}{4}=\frac{10^{2}}{16}\approx\frac{100}{20}=5\text{ m s}^{-2}$ so it is about half *g*.

Q29 Assuming a mass of 70 kg made out of water we have 7×10^{4} g of water in the body and hence $\frac{7\times10^{4}}{18}\approx0.5\times10^{4}=5\times10^{3}$ moles of water. Hence the number of molecules is $5\times10^{3}\times6\times10^{23}=30\times10^{26}\approx3\times10^{27}$. Each molecule contains 2 electrons from hydrogen and 8 from oxygen for a total of $10\times3\times10^{27}=3\times10^{28}$ electrons.

Q30 Assuming masses of 50 kg we have

$$F=\frac{GM_{1}M_{2}}{r^{2}}=\frac{6.7\times10^{-11}\times50^{2}}{1^{2}}\approx7\times10^{-11}\times25\times10^{2}\approx200\times10^{-9}\approx2\times10^{-7}\approx10^{-7}\text{ N}.$$

Q31 The ratio is

$$\frac{F_{e}}{F_{g}}=\frac{ke^{2}}{Gm^{2}}=\frac{9\times10^{9}\times(1.6\times10^{-19})^{2}}{6.7\times10^{-11}\times(9.1\times10^{-31})^{2}}\approx\frac{9\times10^{9}\times3\times10^{-38}}{7\times10^{-11}\times81\times10^{-62}}\approx\frac{3\times10^{44}}{63}\approx\frac{10^{44}}{20}\approx5\times10^{42}.$$

Q32 $f=cm^{x}k^{y}$. The units of *m* is kg i.e. M and those of *k* are

$$\frac{\text{N}}{\text{m}}=\frac{\text{kg m s}^{-2}}{\text{m}}=\text{kg s}^{-2}=\text{M T}^{-2}.$$ Hence

$$\text{T}=\text{M}^{x}(\text{M T}^{-2})^{y}=\text{M}^{x+y}\text{ T}^{2y}.$$

From this we deduce that

$$x+y=0$$

$$2y=1\Rightarrow y=\frac{1}{2}\Rightarrow x=-\frac{1}{2}$$

Thus, $f=c\sqrt{\frac{k}{m}}$.

Q33 See answers in the textbook.