Q1: $P = 216$ yrs $\rightarrow P^2 = a^3$

$$a = P^{2/3}$$

$$\boxed{a = 36 \text{ AU}}$$

Aphelion distance $= a(1+e) \Rightarrow r_{ap}$ maximized when $\boxed{e=1}$

$$\therefore \boxed{r_{ap} = 2a = 72 \text{ AU}}$$

$\Rightarrow$ $e=1$ orbits are parabolic or radial. The comet would either plunge into the Sun or escape the Solar System. Either way, not periodic.

Q2: a) $v = 30{,}000$ m/s $\quad r = 4000$ m $\quad \rho_{H_2O} = 1000 \frac{kg}{m^3}$

$$E_k = \frac{1}{2}mv^2 \Rightarrow m = \rho V = \frac{4}{3}\pi r^3 \rho = 2.68 \times 10^{14} \text{ kg}$$

$$\therefore \boxed{E_K = 1.21 \times 10^{23} \text{ J}}$$

b) Energy $= 5000$ MT of TNT $= 5000 \times 4 \times 10^{15}$ J

$$\boxed{E_K = 2 \times 10^{19} \text{ J}}$$

$$\frac{1}{2}mv^2 = E_K$$

$$\boxed{m = \frac{2E_K}{v^2} = 4.44 \times 10^{10} \text{ kg}}$$

$$m = \rho V = \frac{4}{3}\pi r^3 \rho$$

$$r = \left(\frac{3m}{4\pi\rho}\right)^{1/3} \longrightarrow \boxed{r = 220 \text{ m} \rightarrow D = 440 \text{ m}}$$

Question 3 (/5)

$R_{ocean} = 30\,m \quad R_{mars} = 3.394 \times 10^6\,m$

- Calculate the volume of the ocean layer

$$V = \frac{4}{3}\pi\left((R_{mars} + R_{ocean})^3 - R_{mars}^3\right)$$
$$= 4.343 \times 10^{15}\ m^3$$

- The density of water is $\rho = 1000\ kg/m^3$

$$\rho = \frac{M}{V} \rightarrow M_{H_2O} = \rho V = 1000\,\frac{kg}{m^3} \times 4.343 \times 10^{15}\,m^3$$
$$= 4.343 \times 10^{18}\ kg$$

- Calculate mass of a $D = 2\,km$ comet:

$$M_c = \rho V_c = \rho \frac{4}{3}\pi\left(\frac{D}{2}\right)^3 = 4.189 \times 10^{12}\ kg$$

- The number of comets required is then;

$$N = \frac{M_{H_2O}}{M_c} = \frac{4.343 \times 10^{18}\ kg}{4.189 \times 10^{12}\ \frac{kg}{comet}}$$
$$= 1.037 \times 10^6\ comets$$

- Average time between impacts:

$$t_{AV} = \frac{1\ \text{billion years}}{1.037 \times 10^6\ \text{comets}} = 964\ \text{years}$$

Question 4

$V_{esc} = 8 m/s$ $\rho_{ast} = 3000 \, kg/m^3$

- calculate the mass: /5

$M = \rho V = \rho \cdot \frac{4}{3}\pi R^3$

- sub this into the escape speed formula:

$$V_{esc} = \sqrt{\frac{2GM}{R}} = \sqrt{\frac{2G\rho\frac{4}{3}\pi R^3}{R}} = \sqrt{2G\rho\frac{4}{3}\pi R^2}$$

$$R = \frac{V_{esc}}{\sqrt{2G\frac{4}{3}\pi\rho}} = \frac{8 \, m/s}{\sqrt{2G\frac{4}{3}\pi \, 3000 \, kg/m^3}} = 6179 \, m$$

Question 5

- from the textbook, Neptune's surface temperature is 59 K

$$\lambda_{max} = \frac{0.29 \, cm}{T} = 4.92 \times 10^{-3} \, cm$$

or ($3.97 \times 10^{-5} \, m$, $T = 73 \, K$)

↳ this falls into the infrared portion of the electromagnetic spectrum

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