4. Ocean: 3 km = 3×10^5 cm

$$\text{Column depth} = 3\times10^5 \text{ cm} \cdot \left(\frac{1 \text{ g}}{\text{cm}^3}\right) \cdot \left(\frac{6.02\times10^{23}}{18 \text{ g}}\right)$$
$$= 1.00\times10^{28} \text{ cm}^{-2}$$

Escape rate: Use the diffusion-limited escape rate from problem 3 ($\Phi_e = 5.33\times10^8$ H atoms cm^{-2} s^{-1})

Ocean lifetime:
$$\tau = \frac{1.00\times10^{28} \text{ cm}^{-2}}{5.33\times10^8 \text{ cm}^{-2}\text{s}^{-1}} \frac{\text{s}^{-1}(2 \text{ H atoms/H}_2\text{O})}{}$$

$$= 3.75\times10^{19} \text{ s} \left(\frac{1 \text{ yr}}{3.16\times10^7 \text{ s}}\right)$$

$\tau = 1.2\times10^{12}$ yrs (about 100 times the age of the universe!)