Big Exam #1 Use both sides. Put your name at the end

#1. Hey, did you know that a Ton is not just a unit of mass, it's also a unit of *power* for AC or refrigeration. Back in the day, people would just buy ice to keep things cool in their insulated food space. So, if they got a ton of ice per day, then the latent heat of fusion would be absorbed each day as the ice melted. The accepted conversion is 1 T = 12,000 BTU/hr. Please show that this is about correct, and in the process, please convert to kW.

$$P = 1T = \frac{E}{t} = \frac{mL}{\text{Day}} \xleftarrow{} \frac{(\text{Heat of Fusion of } H_2O)}{\text{Day}}$$

$$= \frac{1000\,\cancel{kg} \cdot \frac{80\,\cancel{cal}}{\cancel{g}} \left(\frac{4.2\,J}{\cancel{cal}}\right)\left(\frac{1000\,\cancel{g}}{\cancel{kg}}\right)}{24\,\cancel{hr}\left(\frac{60\,\cancel{min}}{\cancel{hr}}\right)\left(\frac{60\,s}{\cancel{min}}\right)}$$

$$\approx \frac{10^6 \cdot 330\,J}{24 \cdot 3600\,s} \approx \frac{10^5}{24}\overset{\sim 1}{\left(\frac{3300}{3600}\right)} W \approx 4000\,W$$

~25 of $\frac{1}{4}$ of 100

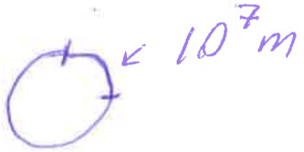
$$P = \frac{E}{t} = \frac{12000\,\overset{1055\,J}{BTU}}{hr} \approx \frac{12 \times 10^6\,J}{3600\,s}$$

$$= \frac{12 \times 10^6}{3.6 \times 10^3}\,W \approx 3\tfrac{1}{2}\,kW$$

#2 Let's say we did the equitable thing and split up the earth's surface area equally among all people. Direct noon sunlight on the equator is about 1000 W/m^2.

a) Estimate the amount of land, ocean and fresh water surface area each of us gets
b) Estimate the amount of power we would absorb at noon.
c) Estimate the amount of energy we would absorb in a year.

a) $$\frac{\text{Area}}{\text{Person}} = \frac{\text{Total Area}}{\text{Global Population}} \approx \frac{4\pi r^2}{7.4\times10^9 \text{ people}}$$



$2\pi r = 4\times10^7$ m $r = \frac{2}{\pi}\times10^7$ m r^2

$$\text{Area} = 4\pi\left(\frac{4}{\pi^2}\times10^{14}\,m^2\right)$$

$$= \frac{16}{\pi}\times10^{14}\,m^2 \approx 5\times10^{14}\,m^2$$

$$\frac{\text{Area}}{\text{Person}} \approx \frac{5\times10^{14}\,m^2}{7.4\times10^9 \text{ people}} \approx \frac{.7\times10^5\,m^2}{\text{cap}} \approx \frac{7\times10^4\,m^2}{\text{cap.}}$$

that's 7 hectares ... or 7+ football fields

Water ~ $\left(\frac{2}{3}\right)$ ~ 4 hectares, land ~ 2 hectares,
fresh water ~1% of water so ~ $4\times10^2\,m^2$ ~ $400\,m^2$

b) $$P = \frac{E}{t} = \text{Intensity} \times \text{Area} \approx \cancel{7\times10^4}\ 10^3\,\frac{W}{\cancel{m^2}} \cdot 7\times10^4\,\cancel{m^2} \approx 70\text{ MW}$$

c) $$E = P_{ave}\cdot t = 70\text{ MW}\left(\frac{1}{4}\right)\overset{\text{cloud cover}}{\left(\frac{1}{2}\right)}\cdot\underbrace{\pi\times10^7\,s}_{\sim\text{year}} \approx 30\times10^7\,\underset{J}{\overset{10^6}{\text{MW}}\text{s}}$$

because total area = $4\pi r^2$ ~~but~~
cross sectional area to sun = πr^2

$$\approx 3\times10^{14}\,J$$

Name