

# ASTR 205: Stellar Astronomy

## Class Assignment 6: Mar 22 2018

1. Scuba divers in clear tropical waters can see objects as far as 50 meters away. What is the opacity  $\kappa$  of the water? Compare your number with the average

opacity in the Sun, which is  $8 \text{ m}^2 \text{ kg}^{-1}$ . In which environment could you see further?

2. We can get some insight into the chemical evolution of the Sun over its lifetime by calculating its mean molecular weight at different times. Do this for

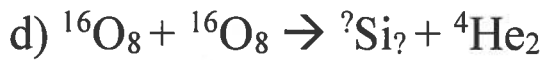
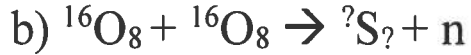
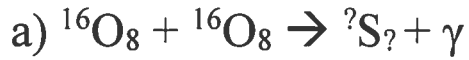
a) pure hydrogen

b) solar chemical composition  $X=0.70$ ,  $Y=0.28$ ,  $Z=0.02$ .

c) primeval chemical composition  $X=0.76$ ,  $Y=0.24$ ,  $Z=0$

d) the core of the Sun today, which has been converting  $\text{H} \rightarrow \text{He}$  for 4.6 Gyrs so that it is now about 60% He.

3. Oxygen burning in stars is very complex and has many channels. Here are just a few of them. Complete the following reaction sequences.



4. Assume that the Sun has uniform density and derives its luminosity from a steady contraction. What decrease in the Sun's radius would be required over historical times (say last 5000 years) to account for the Sun's constant luminosity over that time. Express your answer also as a fractional change in radius. Is there any chance we could detect this change?

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~~1~~

$$\lambda = 1 / k p$$

$$k = \frac{1}{\lambda p}$$

$$\lambda = \underline{\underline{50 \text{ m}}} \quad p(\text{seawater}) = 1029 \text{ Kg/m}^3$$

$$k = \frac{1 \text{ m}^2}{50 \text{ m} \times 1029 \text{ Kg m}}$$

$$= \frac{\text{m}^2}{\text{Kg}}$$
$$1.9 \times 10^{-5} \text{ m}^2/\text{Kg}$$

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$$S_{\text{un}} = 8 \text{ m}^2/\text{Kg}$$

$$\lambda_{S_{\text{un}}} = 1 / k p = \frac{1}{8 \times 1029} \frac{\text{m}^2}{\text{Kg}}$$

$$\lambda_{S_{\text{un}}} = 8.9 \times 10^{-5} \text{ m}$$

$\approx .01 \text{ mm}$ . (low because  
used average  $p$ .)

in any case are much farther in  
ocean.

Assignment 7: March ~~2018~~ <sup>22</sup>

$$2. \quad \frac{1}{\mu} = (2x + \frac{3}{4}y + \frac{1}{2}z)$$

$\frac{1}{\mu}$  = # particles/unit mass

$\therefore \mu = \text{mass/particle} = \text{particle wt.}$

(a)  $x=1, y=0, z=0 \Rightarrow$

$$\frac{1}{\mu} = 2 \Rightarrow \mu = \frac{1}{2} \text{ (proton mass)}$$

(b)  $x=0.7, y=0.28, z=.02.$

$$\begin{aligned} \frac{1}{\mu} &= (2 \times 0.7 + \frac{3}{4} \times 0.28 + \frac{1}{2} \times 0.02) \\ &= 1.62 \Rightarrow \mu = 0.62. \end{aligned}$$

(c)  $x=0.76, y=0.24, z=0.$

$$\begin{aligned} \frac{1}{\mu} &= (2 \times 0.76 + \frac{3}{4} \times 0.24) = \\ &= 1.52 + 0.18 = 1.70. \\ \mu &= 0.59 \end{aligned}$$

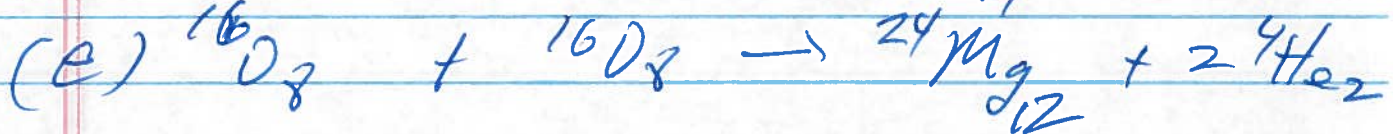
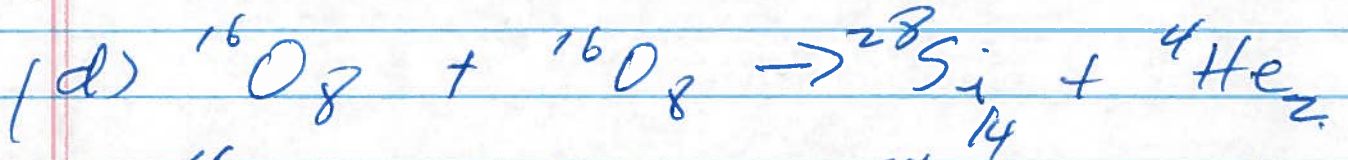
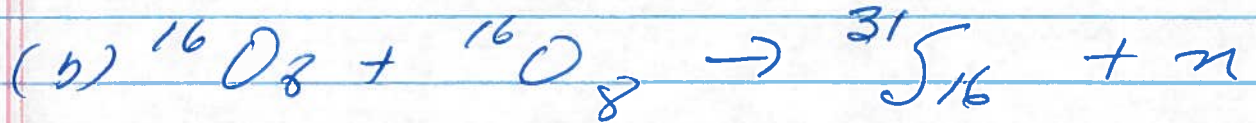
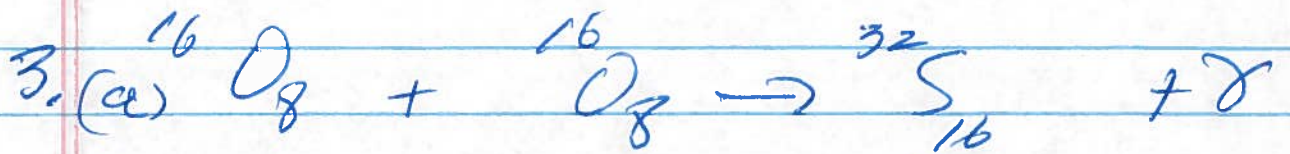
(d)  $x=0.38, y=0.60, z=.02.$   
 $\rightarrow$  (from  $y=0.60$ , take  $z=.02$ )

$$\begin{aligned} \therefore \frac{1}{\mu} &= (2 \times 0.38 + \frac{3}{4} \times 0.6 + \frac{1}{2} \times .02) \\ &= 1.22 \\ \Rightarrow \mu &= \underline{\underline{0.82}} \end{aligned}$$

(Compare  $c \rightarrow b \rightarrow d.$  see chemical evolution of Sun Hilroy)



A205



Oxygen burning has many channels. There are just a few of them.

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24. Energy output  $\dot{Q}_{\text{sun}} = 4 \times 10^{26} \text{ W (J s}^{-1}\text{)}$ .

$$5000 \text{ years} = 5000 \times 10^3 \times 10^7 \text{ s} \\ = 1.5 \times 10^{11} \text{ sec.}$$

$$\boxed{\text{So total energy emitted} = 6 \times 10^{37} \text{ J.}}$$

Get energy from contraction  
PE sphere =  $\frac{3GM^2}{5R}$

$$dPE = d\left(\frac{3GM^2}{5R}\right)$$

$$dPE = -\frac{3GM^2}{5R^2} dR.$$

$$6 \times 10^{37} \text{ J} = -\frac{3 \times 6.67 \times 10^{-11} \times (2 \times 10^{30})^2}{5 \times (7 \times 10^8)^2} dR$$

$$\therefore dR = -183,658 \text{ m.}$$

$$\boxed{dR = -183 \text{ Km.}}$$

$$\text{fractional change} = .00026$$

probably too small to measure. Hilroy