You have 2.32 grams of MCO_3 where M is some unknown metal. Upon heating this material, it reacts, giving off carbon dioxide. You collect the carbon dioxide in a balloon and when the material has finished reacting, you find that the volume of the balloon is 453 mL. Assuming that the lab is located at sea level and that the temperature is 25°C, what is the identity of the metal M?

$MCO_3 \rightarrow CO_2 + MO$

$$n_{CO_2} = \frac{(1\,atm)(0.453\,L)}{(0.08206\,\frac{L\,atm}{mol\,K})(298.15\,K)} = 0.0185\ mol\ CO_2 \rightarrow 0.0185\ mol\ MCO_3$$

$$\text{molar mass } MCO_3 = \frac{2.32g}{0.0185\ mol} = 125.3\,g/mol - \underbrace{12.01\,g/mol}_{-C} - \underbrace{48.00\,g/mol}_{3\times O}$$

$= 65.3\,g/mol$ for $M \Rightarrow \underline{\underline{Zn}}$

The carbon-hydrogen single bond in CH_4 has a bond dissociation energy of 413 kJ/mol. The process of photolysis involves molecules absorbing light of sufficient energy to cleave covalent bonds- each photon can cleave one bond. You have a 1.72 L container filled with CH_4 gas and the pressure in this container is 75.3 Pa (the temperature is 23.7 °C). If you want to turn the CH_4 into atoms via photolysis, at what wavelength do you need to set your laser? Assuming your laser has a power of 35 mW, how long will it take to photolyze all of the CH_4?

$$413\,\frac{kJ}{mol} \times \frac{1000\,J}{kJ} \times \frac{1\,mol}{6.02\times10^{23}\ bonds} = 6.86\times10^{-19}\,J \text{ to break 1 bond}$$

$$E_{photon} = 6.86\times10^{-19}\,J = \frac{hc}{\lambda} \rightarrow \lambda = \frac{(6.626\times10^{-34}\,J\,sec)(3\times10^{8}\,m/sec)}{6.86\times10^{-19}\,J}$$

$\lambda = 2.9\times10^{-7}\,m$ or $\underline{290\,nm}$

$$n_{CH_4} = \frac{(75.3\,Pa \times \frac{1\,atm}{101325\,Pa})(1.72\,L)}{(0.08206\,\frac{L\,atm}{mol\,K})(296.85\,K)} = 5.25\times10^{-5}\ mol\ CH_4$$

$\downarrow$

2.1×10^{-4} mol C-H bonds

$\downarrow$

86.7 J needed

$$86.7\,J \times \frac{1\,sec}{0.035\,J} = 2477\ sec$$

Ethanol (CH_3CH_2OH) can be burned and used as a fuel to replace gasoline. The density of ethanol is 789 kg/m^3. You have a Jeep that is rigged to collect the water produced by combustion and filter it to make it drinkable (this might be useful if you are driving in the desert). Your Jeep can get 17.5 miles per gallon using ethanol as a fuel and you decide to take it in the Baja 500 race (which is 500 miles). How many gallons of water will you make during the course of the race?

$$C_2H_6O + 3O_2 \rightarrow 2CO_2 + 3H_2O$$

$$500 \text{ miles} \times \frac{1 \text{ gal}}{17.5 \text{ miles}} \times \frac{3.7 \text{ L}}{\text{gal}} \times \frac{1 \text{ m}^3}{1000 \text{ L}} \times \frac{789 \text{ kg}}{\text{m}^3} \times \frac{1000 \text{ g}}{\text{kg}} \times \frac{1 \text{ mol } C_2H_6O}{46 \text{ g}} = 1813 \text{ mol } C_2H_6O$$

$$1813 \text{ mol } C_2H_6O \times \frac{3 \text{ mol } H_2O}{1 \text{ mol } C_2H_6O} \times \frac{18.02 \text{ g}}{1 \text{ mol } H_2O} \times \frac{1 \text{ mL}}{1 \text{ g}} \times \frac{1 \text{ L}}{1000 \text{ mL}} \times \frac{1 \text{ gal}}{3.7 \text{ L}} = 26.5 \text{ gallons } H_2O$$