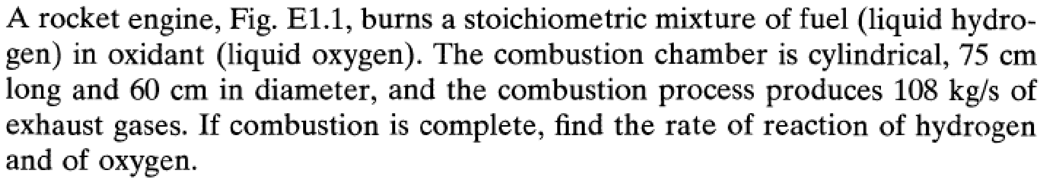
Tutorial sheet No: 1

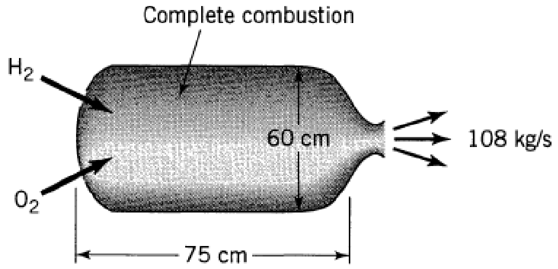
Q.1 For the reaction below, if NO_2 formed at 4 mol/m^3.s (r_{NO2}= 4 mol/m^3.s), what is the rate of formation of NO?

$$2NO + O_2 \rightarrow 2NO_2$$

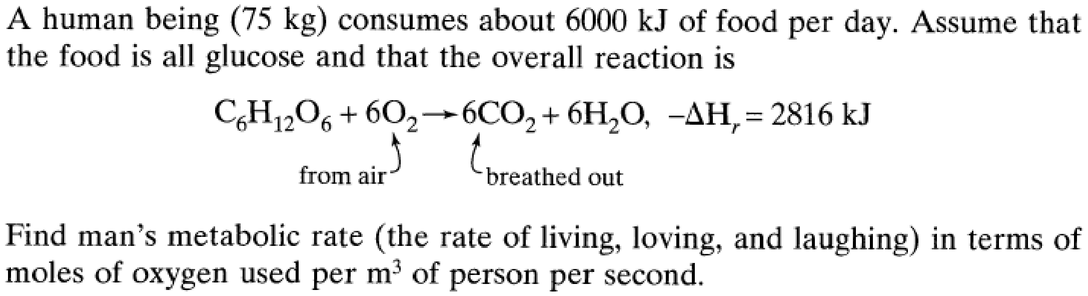
Q.2



A rocket engine, Fig. E1.1, burns a stoichiometric mixture of fuel (liquid hydrogen) in oxidant (liquid oxygen). The combustion chamber is cylindrical, 75 cm long and 60 cm in diameter, and the combustion process produces 108 kg/s of exhaust gases. If combustion is complete, find the rate of reaction of hydrogen and of oxygen.



Q.3



A human being (75 kg) consumes about 6000 kJ of food per day. Assume that the food is all glucose and that the overall reaction is

$$C_6H_{12}O_6 + 6\underset{\text{from air}}{O_2} \rightarrow 6\underset{\text{breathed out}}{CO_2} + 6H_2O, \quad -\Delta H_r = 2816 \text{ kJ}$$

Find man's metabolic rate (the rate of living, loving, and laughing) in terms of moles of oxygen used per m^3 of person per second.

Q.4

Calculate the activation energy for a certain first order reaction, the following data were obtained:

T(°C)	48.5	70.4	90.0
K(hr^{-1})	0.044	0.534	3.708

Answers to sh. 1

Q.1

$$\frac{r_{NO}}{-2}=\frac{r_{O_2}}{-1}=\frac{r_{NO_2}}{2} \Longrightarrow \frac{r_{NO}}{-2}=\frac{r_{NO_2}}{2}$$

$$\frac{r_{NO}}{-2}=\frac{4mol/m^3/s}{2}$$

$$r_{NO}=-2\left(\frac{4mol/m^3/s}{2}\right)=-4mol/m^3/s$$

Q.2

We want to evaluate

$$-r_{H_2}=\frac{1}{V}\frac{dN_{H_2}}{dt} \quad \text{and} \quad -r_{O_2}=\frac{1}{V}\frac{dN_{O_2}}{dt}$$

Let us evaluate terms. The reactor volume and the volume in which reac takes place are identical. Thus,

$$V=\frac{\pi}{4}(0.6)^2(0.75)=0.2121\ \text{m}^3$$

Next, let us look at the reaction occurring.

$$H_2+\frac{1}{2}O_2 \rightarrow H_2O$$

molecular weight: 2gm 16 gm 18 gm

Therefore,

$$H_2O\ \text{produced/s} = 108\ \text{kg/s}\left(\frac{1\ \text{kmol}}{18\ \text{kg}}\right) = 6\ \text{kmol/s}$$

So from Eq. (i)

$$H_2\ \text{used} = 6\ \text{kmol/s}$$
$$O_2\ \text{used} = 3\ \text{kmol/s}$$

and the rate of reaction is

$$\underline{\underline{-r_{H_2}}} = -\frac{1}{0.2121\ \text{m}^3} \cdot \frac{6\ \text{kmol}}{\text{s}} = \underline{\underline{2.829 \times 10^4 \frac{\text{mol used}}{(\text{m}^3\ \text{of rocket}) \cdot}}}$$

$$\underline{\underline{-r_{O_2}}} = -\frac{1}{0.2121\ \text{m}^3} \cdot 3\frac{\text{kmol}}{\text{s}} = \underline{\underline{1.415 \times 10^4 \frac{\text{mol}}{\text{m}^3 \cdot \text{s}}}}$$

Note: Compare these rates with the values given in Figure 1.3.

Q.3

We want to find

$$-r'''_{O_2} = -\frac{1}{V_{\text{person}}} \frac{dN_{O_2}}{dt} = \frac{\text{mol O}_2\ \text{used}}{(\text{m}^3\ \text{of person})\text{s}} \qquad \textbf{(i)}$$

Let us evaluate the two terms in this equation. First of all, from our life experience we estimate the density of man to be

$$\rho = 1000 \frac{\text{kg}}{\text{m}^3}$$

Therefore, for the person in question

$$V_{\text{person}} = \frac{75\ \text{kg}}{1000\ \text{kg/m}^3} = 0.075\ \text{m}^3$$

Next, noting that each mole of glucose consumed uses 6 moles of oxygen and releases 2816 kJ of energy, we see that we need

$$\frac{dN_{O_2}}{dt} = \left(\frac{6000\ \text{kJ/day}}{2816\ \text{kJ/mol glucose}}\right)\left(\frac{6\ \text{mol O}_2}{1\ \text{mol glucose}}\right) = 12.8 \frac{\text{mol O}_2}{\text{day}}$$

Inserting into Eq. (i)

$$-r'''_{O_2} = \frac{1}{0.075\ \text{m}^3} \cdot \frac{12.8\ \text{mol O}_2\ \text{used}}{\text{day}} \frac{1\ \text{day}}{24 \times 3600\ \text{s}} = \underline{\underline{0.002 \frac{\text{mol O}_2\ \text{used}}{\text{m}^3 \cdot \text{s}}}}$$

Note: Compare this value with those listed in Figure 1.3. ■