Homework set 1, (partial solution collection)

2.26

The source of the excess CO_2 is that which is exhaled and which had as its source the O_2 that was inhaled and metabolized. Thus, to calculate how much CO_2 is added to the room, calculate how much O_2 is depleted. (This assumes a 1:1 molar ratio between CO_2 formed and O_2 used with little hydrogen oxidized to H_2O by inhaled oxygen. The ratio is actually about 1.2 O_2:1 CO_2.)

The air becomes lethal (due to CO_2) after 7% of the O_2 (to 1 sig. fig.) is removed, or

$$(10\text{ ft})(10\text{ ft})(20\text{ ft})\left(\frac{27\text{ L}}{1\text{ ft}^3}\right)(0.07) = 3800\text{ L of O}_2$$

A person breathes about 0.5 L of air 12 times per minute, and the air is about 20% O_2. Thus,

$$(12\text{ min}^{-1})(0.5\text{ L})(0.20) = 1.2\text{ L O}_2\text{ min}^{-1}$$

About 30% of this inhaled O_2 is absorbed in the lungs, so that a person typically uses

$$(0.30)(1.2\text{ L O}_2\text{ min}^{-1}) = 0.36\text{ L O}_2\text{ min}^{-1}$$

For a calm, quiet person about half this amount, or 0.2 L min^{-1} would be enough, where we have rounded to 1 sig. fig. Thus, one person could last

$$\left(\frac{3800\text{ L of O}_2}{0.2\text{ L min}^{-1}}\right)\left(\frac{1\text{ day}}{1440\text{ min}}\right) = 13\text{ days}$$

3.18 Consider a cyclic process involving a gas. If the pressure of the gas varies during the process but returns to the original value at the end, is it correct to write $\Delta H = q_P$?

No, it is not correct. For a cyclic process, $\Delta H = 0$, since H is a state function, but the heat, or q, associated with a process is not a state function and depends on the path. Depending on the path used to achieve the cyclic process it may take on a variety of values.

3.32 The equation of state for a certain gas is given by $P\left[(V/n) - b\right] = RT$. Obtain an expression for the maximum work done by the gas in a reversible isothermal expansion from V_1 to V_2.

Write P in terms of n, V, and T:

$$P = \frac{RT}{\frac{V}{n} - b} = \frac{nRT}{V - nb}$$

The maximum work done by the gas undergoing an isothermal expansion is

$$w = -\int_{V_1}^{V_2} P\,dV = -\int_{V_1}^{V_2} \frac{nRT}{V - nb}\,dV$$

$$= -nRT \ln (V - nb)\Big|_{V_1}^{V_2}$$

$$= -nRT \ln \frac{V_2 - nb}{V_1 - nb}$$