Chapter 8
The chemistry of global climate

Solution 1.

The partial pressure of water vapour $P_{v(H2O)}$ can be obtained from figure 8.2 on page 166, which is approximately 4.6 kPa. Temperature = 305 K

$$H_R / 100 \times P_{v(H2O)} = P_{actual(H2O)} \quad \text{(p. 165)}$$

$$0.83 \times 4.6 \text{ kPa} = 3.818 \text{ kPa}$$

$$3818 \text{ Pa} \times 1 \text{ m}^3 = n \times 8.314 \text{ J mol}^{-1} \text{ K}^{-1} \times 305 \text{ K}$$

$$n = 1.5057 \text{ moles of water}$$

$$18.02 \text{ g mol}^{-1} \times 1.5057 \text{ mol} = 27.1 \text{ g of water}$$

Solution 2.

Equation 8.4 (p. 169) is $F = \sigma T^4$, where

F = flux (energy emitted, in this case, from 1 m^2 of Earth)
T = average temperature (K) (of Earth) T = 290 K (see Table 8.2 on p.170)
σ = Stefan-Boltzmann constant = 5.67×10^{-8} W m^{-2} K^{-4} (p.169)

$$F = 5.67 \times 10^{-8} \text{ W m}^{-2} \text{K}^{-4} \times 290^4 = 401 \text{ W m}^{-2}$$

The flux from the Earth is 401 W m^{-2}.

The solar flux can be calculated as well. Assume the surface temperature of the Sun is 5800 K (p. 167).

$$F = 5.67 \times 10^{-8} \text{ W m}^{-2} \text{K}^{-4} \times 5800^4 = 6.42 \times 10^7 \text{ W m}^{-2}$$

Ratio of flux values solar flux : Earth flux

$$6.42 \times 10^7 \text{ W m}^{-2} \div 401 \text{ W m}^{-2} = 1.6 \times 10^5$$

The two calculations done above show that the solar flux is about 1.6×10^5 times greater than the flux from the Earth.

Solution 4.

$$1\ \text{Gt} = 10^9\ \text{t} \qquad 1\ \text{t} = 1000\ \text{kg} \qquad \therefore\ 8\ \text{Gt} = 8\text{x}10^{12}\ \text{kg} \qquad \text{(Appendix C.2)}$$

currently the atmospheric mixing ratio of CO_2 = 378 ppmv

Assume all C added to the environment ends up as CO_2 (a reasonable assumption).

Net annual addition of carbon to the atmosphere equals C added minus C taken up by the oceans and the terrestrial environment

$$8 \times 10^{12}\ \text{kg C} - 4 \times 10^{12}\ \text{kg C} = 4 \times 10^{12}\ \text{kg C}$$

The total amount of C already in the atmosphere can also be calculated:

The mass of total atmosphere is 5.27×10^{18} kg. The average molar mass of 'air' is 0.02896 kg mol^{-1} (p. 24).

This gives a total number of mol of all gases in the atmosphere:

$$5.27 \times 10^{18}\ \text{kg} \div 0.02896\ \text{kg mol}^{-1} = 1.82 \times 10^{20}\ \text{mol}$$

The number of mol of CO_2 (or equivalent mol of C), calculated using the current CO_2 mixing ratio is

$$\frac{\text{mol } CO_2}{1.82 \times 10^{20}\ \text{total mol}} \times 10^6 = 378\ \text{ppmv}$$

$$\text{mol of } CO_2 \text{ (or C)} = 6.880 \times 10^{16}$$

$$\text{Mass of C} = 6.880 \times 10^{16}\ \text{mol} \times 0.012011\ \text{kg mol}^{-1} = 8.263 \times 10^{14}\ \text{kg of C}$$

The total mass of C is the existing mass plus newly added C, from above:

$$8.263 \times 10^{14}\ \text{kg C} + 4 \times 10^{12}\ \text{kg C} = 8.303 \times 10^{14}\ \text{kg C}$$

$$8.303 \times 10^{14}\ \text{kg C} \div 0.012011\ \text{kg mol}^{-1} = 6.913 \times 10^{16}\ \text{mol of C}$$

(or mol of CO_2) and assuming total number of moles is unaffected

the new concentration of CO_2 is

$$\frac{6.913 \times 10^{16}}{1.82 \times 10^{20}} \times 10^{6} = 380 \text{ ppmv}$$

The yearly increase in atmospheric carbon dioxide mixing ratio (associated with anthropogenic additions) is predicted to be approximately 2 ppmv.

Solution 13.

Natural gas is a naturally occurring mixture of gaseous hydrocarbons, whose approximate composition is 85 % methane, 10 % ethane, 3 % propane, and 2%

butane. It is also possible that natural gas may contain other higher alkanes, but we will ignore these for this calculation.

The total number of moles of gas is determined by PV= nRT, assuming an atmospheric pressure and 288 K

$$n = 93100 \text{ mol}$$

moles of CH_4	=	79135	which process	79135 moles CO_2
moles of CH_3CH_3	=	9310		18620 moles CO_2
moles of $CH_3CH_2CH_3$	=	2793	which process	13965 moles CO_2
moles of $CH_3CH_2CH_2CH_3$	=	1862	which process	7448 moles CO_2

The total number of moles of CO_2 produced is approximately 120 000 mol or about 5.2 t.