

ESCI 241 – Meteorology
Answers to Selected Exercises for Lesson 1

1. From the ideal gas law $pV = nRT$, calculate how many molecules are contained in a cubic centimeter (cm^3) of air at a pressure of 1013.25 mb and a temperature of 15 °C? ($R = 8.3145 \text{ J}\cdot\text{mol}^{-1}\cdot\text{K}^{-1}$; $N_A = 6.022 \times 10^{23} \text{ molecules/mol}$)

Answer: $2.55 \times 10^{19} \text{ cm}^{-3}$ (make sure you kept track of your units)

2. How many oxygen molecules are there in a cm^3 of air at a pressure of 1013.25 mb and a temperature of 15 °C?

Answer: $5.35 \times 10^{18} \text{ cm}^{-3}$

7. Assuming a scale height of 8.1 km, how many molecules are in a cm^3 of air at the altitude where the air pressure is 500 mb? (Hint: density and the number of molecules per volume both decrease with height in the same way that pressure does)

Answer:

$$p/p_0 = \exp(-z/H) = 500\text{mb}/1013.25\text{mb} = 0.493$$

$$n/n_0 = \exp(-z/H) = 0.493$$

From problem 1 we know that $n_0 = 2.55 \times 10^{19} \text{ cm}^{-3}$; therefore, $n = 1.26 \times 10^{19} \text{ cm}^{-3}$

8. How many oxygen molecules are there in a cm^3 of air at the altitude where the air pressure is 500 mb? Explain why airplane cabins are pressurized.

Answer: $2.64 \times 10^{18} \text{ cm}^{-3}$

9. If the temperature at the ground is 15°C and the lapse rate is 4°C/km, what is the temperature at an altitude of 5000 m?

Answer: -5°C

10. If the atmosphere was incompressible (density constant at all altitudes), 100 km thick, and had a surface pressure of 1000 mb, at what altitude would the pressure be 250 mb? Sketch the graph of pressure vs. altitude for this case and discuss how it compares with the real atmosphere.

Answer: 75 km