

Chapter 14

Short answer questions

1. This question is about how the density of air varies with the height above the Earth's surface.

At sea level the density of the atmosphere is about 1.2 kg m^{-3} .

Consider nitrogen at a temperature of 300 K .

- (a) Show that the average energy of a particle at this temperature is about $4.1 \times 10^{-21} \text{ J}$.
- (b) Show that the energy E required to lift a nitrogen molecule of a mass $4.6 \times 10^{-26} \text{ kg}$ to a height 3000 m above sea level is about $1.4 \times 10^{-21} \text{ J}$.
- (c) Show that the Boltzmann factor $e^{-E/kT}$ for the energy E found in part (b) at a temperature of 300 K is about 0.71 .

Fig. 1 shows a graph of density of air against height above sea level. The atmospheric pressure is assumed to remain constant with height in this model.

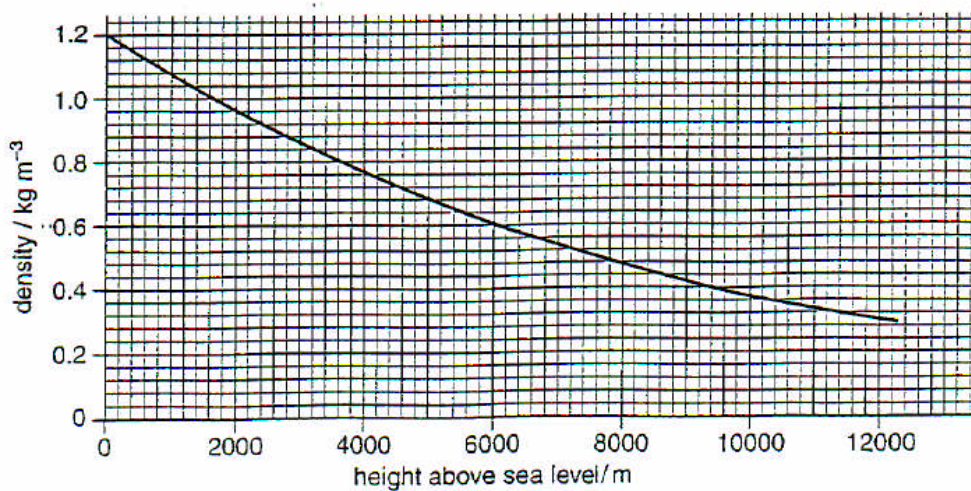


Fig. 1

(d) (i) The graph shows that the density decreases with increasing height. Explain how the Boltzmann factor helps to account for this fact

(ii) Propose and carry out a test to decide whether the density falls exponentially with height above sea level.

Proposed test:

Calculation:

Conclusion:

(e) In fact, atmospheric pressure decreases with height above sea level. Explain why this makes the Boltzmann factor become smaller with height above sea level.