Stat Mech (PHYS 370) PS 1

Fall 2024 v1.0

In Phys 370 we start with thermodynamics, which is the study of macroscopic or system-wide quantities that characterize a physical system. In class we will discuss the beginnings of thermodynamics - systems, states, parameters, the equation of state - the most famous example being the ideal gas law

$$PV = NkT,$$

and the "First Law",

$$\Delta U = Q + W,$$

which is nothing other than conservation of energy. Read the book carefully since there is a wealth of important information such as the discussion of the meaning of these quantities "Q", "U", and "W". (How does Schroeder define "$U_{thermal}$"?)

The problems in Schroeder and range from simple to involved computations. Starting early will allow you to see how to allocate your time.

Reading: For this week read the Preface and most of Chapter 1 - read up to section 1.7.

Problems: All referenced problems are in Schroeder. Solutions are due on Thursday September 5 at the beginning of class.

(1) The Celsius scale is defined so that ice melts at 0°C and water boils at 100°C. The Fahrenheit scale is likewise defined so that ice melts at 32°F and water boils at 212°F. (All these are at standard conditions, mean sea level at one atmosphere of pressure.) Derive the formula from Celsius to Fahrenheit. (Optional: Derive the conversion from Fahrenheit to Celsius to complete the set.)

(2) Find the temperature in kelvin for
   (a) a healthy human at rest
   (b) the boiling point of water
   (c) the hottest daytime temperature you have experienced
   (d) the boiling point of liquid helium (-268.9°C)

(3) 1.5 Describe what type of thermometer you use

(4) 1.6 Hint: Think about touching a slice of bread and a metal fork at the same temperature (say before you dip them into a fondue pot), or see page 48 for a more visceral description. Feel free to discuss conductivities and/or heat capacities

(5) 1.8 (a) and (b) During the European heat wave in 2022 railroads buckled forming "sun kinks". In Vauxhall, London where the temperature was 48° C, a rail warped in the heat resulting in the closing of the line.

(6) 1.10 What's N for a room of air? This is an order of magnitude estimate but add more detail - and use a relation - that we discussed in class.

(7) 1.13

(8) 1.14 We'll use this later. Compute the weighted average using the molar masses of the gases, which are found on the period table, a copy of which is in the back of our text.

(9) 1.16 Instead of all the sites in (d) use the Hamilton College campus ($\sim$ 886 ft $\simeq$ 270 m), Mt. Marcy (5344 ft $\simeq$ 1629 m), and Schilthorn (2970 m) in the Swiss Alps.

(10) Estimate the number of degrees of freedom of methane CH_4 (in which the H's are arranged to be on the vertices of a tetrahedron)