Physics 3374/6351 Professor Scalise
Homework Assignment #1 Fall 2022

3374

1. Read Halliday, Resnick, and Walker chapters 18-20. Did you read all the pages?
2. Calculate:
   (a) the average translational kinetic energy of a neon atom at room temperature.
   (b) the average translational kinetic energy of a golfball at room temperature (in a gas of golfballs).
   (c) the root-mean-square speed of a neon atom at room temperature. What is the Mach number for this speed?
   (d) the root-mean-square speed of a golfball at room temperature (in a gas of golfballs).
3. Calculate the thermal energy in a cubic meter of air at room temperature and one atmosphere. Is it possible to extract this energy to charge your mobile phone? Explain.
4. Schroeder 1.33 [Use pressure and volume labels 1 and 2 as on figure 1.10(b)].

Problem 1.33. An ideal gas is made to undergo the cyclic process shown in Figure 1.10(a). For each of the steps A, B, and C, determine whether each of the following is positive, negative, or zero: (a) the work done on the gas; (b) the change in the energy content of the gas; (c) the heat added to the gas. Then determine the sign of each of these three quantities for the whole cycle. What does this process accomplish?

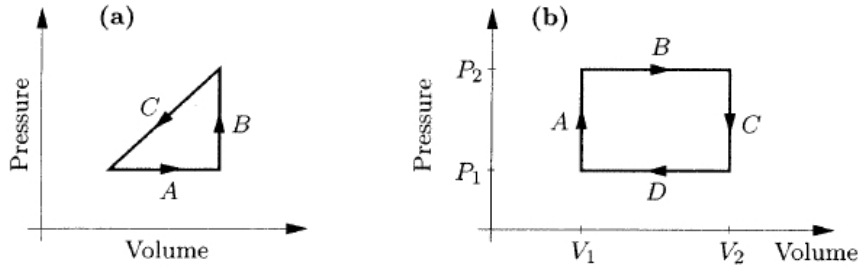

Figure 1.10. *PV* diagrams for Problems 1.33 and 1.34.

5. 500 grams of ice cubes at 0°C are placed in 1 liter of water at 20°C. The system then comes to equilibrium with no heat exchange with surroundings. Does the ice melt completely? If yes, find the temperature of the water in equilibrium. If not, find out how much ice remains in equilibrium.

6351

1. Explain clearly why Boltzmann's constant k_B is not a universal constant like the speed of light c or Planck's constant h or Newton's constant G. That is, alien scientists in a distant galaxy would discover the speed of light; they would express it in different

units, but it would be the same speed that we know. Similarly, the aliens would discover something like h, perhaps $2h$ or h/π, and it might be called ZbymG's constant, but Earth scientists would recognize the quantum of action. Not so with k_B. Why not?

2. Helium gas is heated in a process for which the molar heat capacity (neither c_V nor c_P) is 2R. During the process, the volume of the gas quadruples.

   (a) How does the absolute temperature of the gas change?

   (b) How does the pressure of the gas change?

3. Suppose there exists a relation among three coordinates x, y, and z such that $f(x, y, z) = 0$. What is

$$\left(\frac{\partial x}{\partial y}\right)_z \left(\frac{\partial y}{\partial z}\right)_x \left(\frac{\partial z}{\partial x}\right)_y \qquad ?$$

4. Even at low density, real gases are not ideal. One way to account for deviations from ideal behavior is the virial expansion

$$PV = nRT\left[1 + \frac{B(T)}{(V/n)} + \frac{C(T)}{(V/n)^2} + \cdots\right]$$

   For the van der Waals gas with equation of state

$$\left(P + \frac{an^2}{V^2}\right)(V - nb) = nRT,$$

   find the first two virial coefficients $B(T)$ and $C(T)$ in terms of a and b. Assume $\frac{nb}{V}$ is small and expand.

Bonus: Solve as much of the other class' assignment as you can.