General Physics II: Tutorial Material

Lecture 5 on Chapter 6 (Heat, energy, heat capacity)

1) How many joules and kilocalories are generated when the breaks are used to stop the car running at 95 km/h and weight 1200 kg?

2) An ideal gas is kept in a container with rigid walls. How can we reduce the pressure of the gas? How much work the gas will do during that process?

3) There are 20 kg of ice at $-10°C$ and 50 kg of water at $10°C$.

1. How much heat is needed to increase the temperature of the ice to $0°C$ and how much heat is needed to melt all the ice at $0°C$? How much heat is needed to decrease the temperature of water to $0°C$?
2. What is the thermal equilibrium state when the 20 kg of ice at$-10°C$ is put into the 50 kg of water at $10°C$?

Note that the specific heats of water and ice are, $1kcal/(kg\cdot C°)$ and $0.5kcal/(kg\cdot C°)$, respectively. Furthermore, heat of fusion for water is $80kcal/kg$ with a melting point at $0°C$.

4) An audience of 1800 people fill a concert hall with a volume of $22000m^3$. On average, each person emits 70 W of energy due to metabolism. The concert hall is well isolated and the air can be considered as an ideal gas of diatomic molecules. At the beginning of the concert, the temperature and pressure of the air in the hall are $20°C$ and 1 atm, respectively. With no ventilation, by how much will the temperature of the hall raise after two hours?

5) Heat transfer at constant pressure: A gas container is thermally isolated except for a small hole that ensures that the pressure inside the container is equal to the atmospheric pressure P_0. Initially, the container holds n_i moles of gas at a temperature T_i. The molar specific heat of the gas at constant pressure is C_P. The gas heated up to a temperature T_f by a resistive coil in the cylinder. As the gas temperature rises, some of the gas is released through the small hole. Neglect the specific heat of the heater and determine:

1. the volume V_0 of the container.
2. the number of moles leaving the container in this process.
3. the heat transfer Q_{if} to accomplish this process.

Compute the results for $P_0 = 10^5 Pa$, $n_0 = 10$ moles, $T_0 = 273K$, $c_P = 29.1J/K/mol$, $T_f = 293K$.

6)) Work on a van der Waals Gas: a mole of oxygen, considered as a van der Waals gas, undergoes an isothermal expansion at fixed temperature T_0 from an initial volume V_i to a final volume V_f. Determine the work W_{if} performed on the van der Walls gas in terms of the parameters a and b. Compute the work given:

$$T_0 = 273K, V_i = 22.3 \times 10^{-3} m^3, V_f = 3V_i, P_0 = 1.013 \times 10^5 Pa, a = 0.14Pa\ m^6, b = 3.2 \times 10^{-6} m^3 \quad (1)$$