PHYSICS 2C QUIZ 2 WINTER QUARTER 2018
PROF. HIRSCH

Formulas:

$T_3 = 273.16K = 0.01^o C$; water freezes/boils at $T = 0^o C = 32^o F \,/\, T = 100^o C = 212^o F$

$1cal = 4.1868J$; $N_A = 6.02 \times 10^{23}$

Thermal expansion: $\Delta L = L\alpha\Delta T$; $\Delta V = V\beta\Delta T$; $\beta = 3\alpha$

Heat capacity and specific heat: $Q = C\Delta T$; $Q = cm\Delta T$

Heat of vaporization, fusion: $Q = L_V m$; $Q = L_F m$

First law of thermodynamics: $\Delta E_{\text{int}} = Q - W$; $\text{d}E_{\text{int}} = dQ - dW$; $\text{W} = \int_{V_i}^{V_f} p\,dV$ work

Conduction: $\text{P}_{cond} = \frac{Q}{t} = kA\frac{T_H - T_L}{L}$; $R = \frac{L}{k}$ k,R=thermal conductivity, resistance

Radiation: $P_{rad} = \sigma\varepsilon AT^4$; $\sigma = 5.67 \times 10^{-8} W/m^2K^4$ $\varepsilon = 1$ for black body

Ideal gas: $PV = nRT = NkT = nN_A kT$; R=8.31J/molK ; $k = 1.38 \times 10^{-23} J/K$

Pressure: $P = \frac{Nm}{3V}(v^2)_{avg}$ Kinetic energy: $K_{avg} = \frac{1}{2}m(v^2)_{avg} = \frac{3}{2}kT$

Internal energy: $E_{\text{int}} = NK_{avg}$; $C_V = \frac{3}{2}R$ for monoatomic gas; $C_P = C_V + R$

C_V, C_P = molar heat capacity at constant volume, pressure

$C_V = \frac{f}{2}R$ for polyatomic gases with f degrees of freedom per molecule

Adiabatic expansion of ideal gas: $PV^\gamma = const$, $TV^{\gamma-1} = const$; $\gamma = C_P / C_V$

Distribution of molecular speeds: $P(v) = 4\pi(\frac{m}{2\pi kT})^{3/2} v^2 e^{-mv^2/(2kT)}$

Velocity distribution: $F(v_x, v_y, v_z) = f(v_x)f(v_y)f(v_z)$, $f(v_x) = (\frac{m}{2\pi kT})^{1/2} e^{-mv_x^2/(2kT)}$

Mean free path: $\lambda = 1/(\sqrt{2}\pi d^2 N/V)$, d=diameter ; $v_{rms} = \sqrt{(v^2)_{avg}}$

<u>Entropy:</u> $dS = dQ/T$ in a <u>reversible</u> process. S is a function of state. $\Delta S = \int_i^f dQ/T$

$\Delta S \geq 0$ for a <u>closed</u> system. = if reversible process, > if irreversible process

Ideal gas: $S(T,V) = nR\ln V + nC_v \ln T + const$

Heat engine: $\varepsilon = \frac{|W|}{|Q_H|}$; Carnot engine: $\varepsilon = 1 - \frac{|Q_L|}{|Q_H|} = 1 - \frac{T_L}{T_H}$

Refrigerator coefficient of performance $K = \frac{|Q_L|}{|W|}$; Carnot refrigerator $K_C = \frac{T_L}{T_H - T_L}$

Statistical view of entropy: $S = k\ln W$; $W = N!/(n_1!\ n_2!\ ....)$; $N! \approx N(\ln N) - N$

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Problem 1
In an ideal gas there are 5,000 molecules with velocity component v_x=100m/s for every 10,000 molecules that have v_x=0m/s.
Approximately how many molecules have v_x=200m/s for every 10,000 molecules that have v_x=0m/s? **A: 5,000; B: 2,500; C: 1,200; D: 600; E: 300**

Problem 2
You are ice skating while drinking a cup of tea, and spill your tea on the ice. The tea freezes. What is approximately the change in entropy of the universe in this process? Assume: 1) tea=water; 2) your cup has 200g of tea at 60ºC; 3) specific heat of water = 1cal/gºC; 4) heat of fusion of ice = 79.5 cal/g; 5) ice in ice skating rink is at temperature infinitesimally below 0ºC; 6) universe=tea+ice skating rink+stars+planets
A: 4cal/K; B: 14cal/K; C: 36cal/K; D: 58cal/K; E: 72cal/K

Problem 3
An ideal gas absorbs 20J of heat in the process of heating from 30ºC to 40ºC without change in volume. What is the change in its entropy?
A: 0.018J/K; B: 0.065J/K; C: 0.18J/K; D: 0.57J/K; E: 0.65J/K

Problem 4
n moles of a monatomic ideal gas initially at temperature T_1 expand adiabatically from initial volume V_1 to final volume $2V_1$. Then, heat is transferred to the gas until its temperature reaches again T_1, while not changing the volume. The entire process is reversible. In this entire process, the entropy of the environment decreases by

A: $\frac{1}{2}nR\ln 2$; **B:** $\frac{3}{2}nR\ln 2$; **C:** $2nR\ln 2$; **D:** $nR\ln 2$; **E:** $\frac{5}{2}nR\ln 2$

Problem 5
A Carnot engine operates reversibly at 25% efficiency releasing 60J of heat per cycle to the environment at room temperature (300K). What is the temperature of the heat reservoir from which it is absorbing heat? **A:240K B:300K; C:330K; D:360K; E:400K**

Problem 6
A Carnot air conditioner does 1J of work to remove 20J of heat from a room, when the outside temperature is 30ºC. If the outside temperature rises to 40ºC. approximately how much work does the air conditioner have to do to remove 20J of heat from the room, assuming the room stays at the same temperature?
A: 1.34J; B: 1.69J; C: 2.18J; D: 2.66J; E:3.12J

Problem 7 (for extra credit)
A box is divided into two halves of equal size. On the left side there are seven molecules, on the right side there is one molecule. Assume the partition is removed for a short time period and then restored. At the end there are five molecules on the left side and 3 molecules on the right side. Assuming the molecules are distinguishable, find the change in entropy in this process. **A: 0.69k; B: 1.39k C: 1.95k; D: 3.00k; E: 4.02k**