Sem-II - Thermal Physics

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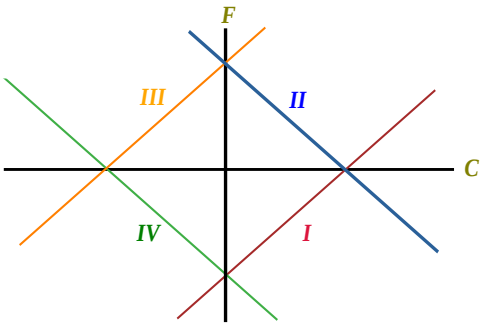
Assignment I: Thermo-Calorimetry & Kinetic Theory

Submission due date: 15/05/2025

Q.1) **(a)** At what temperature do the Fahrenheit and Celsius scale display the same reading? **(b)** In figure shown beside, identify which line represents $\frac{C}{5} = \frac{F-32}{9}$? Justify your answer. **(c)** In a constant volume gas thermometer, pressure of air at $0°C$ is $80cm$ and at $100°C$ is $109.3cm$. Calculate the temperature of a hot bath in which when the thermometer is immersed shows a pressure of $100cm$.



Q.2) **(a)** Air in a Wilson's cloud chamber at $20°C$ is abruptly expanded to 1.4 times its initial volume. Calculate the final temperature. Given γ of air is 1.4. **(b)** At $10^6 dynes/cm^2$ pressure, a gas with $\gamma = 1.4$ expands isothermally until its volume is double of the initial volume. After that, it adiabatically expands until its volume is redoubled. Calculate the final pressure of the gas.

Q.3) **(a)** Calculate the number of molecules/cc of an ideal gas at $27°C$ and at pressure of $20mm$ of mercury. Given, density of mercury is $13.6gm/cc$ and mean kinetic energy of a molecule at $27°C$ is $4 \times 10^{-21} Joules$. **(b)** At what temperature will the root mean squared velocity of a gas will become half of its value at $0°C$?

Q.4) **(a)** At what value of speed c will the Maxwell's velocity distribution F_c will yield same magnitude for a mixture of Hydrogen and Helium gases at $27°C$? **(b)** Find $\langle \frac{1}{c} \rangle$ using F_c. **(c)** Molecular mass of an ideal gas of Oxygen is 32. Calculate average velocity ($\bar{c}$), root mean square velocity (c_{rms}) and most probable velocity (c_m) of the gas at $27°C$. **(d)** Convince yourself that $\frac{RT}{M} = \frac{P}{\rho}$ where symbols have their usual meaning. Using that, calculate $\bar{c}, c_{rms}, c_m$ of the molecules of the gas at density $1.293 \times 10^{-3} gm/cc$ at $76cm$ of Mercury pressure. **(e)** The quantity $(c - \bar{c})^2 = c^2 - 2c\bar{c} + \bar{c}^2$ is the *squared deviation* of atomic speed from the average speed. Calculate the average value of this using F_c and obtain the root mean squared deviation.

Q.5) **(a)** Estimate the size of a Helium atom assuming its mean free path is $28.5 \times 10^{-6} cm$ at N.T.P. and density is $0.178 gm/liter$ at N.T.P. and the mass of Helium atom is $6 \times 10^{-24} gm$. **(b)** The diameter of a gas molecule is $3 \times 10^{-8} cm$. Calculate the mean free path at N.T.P. Given $k_B = 1.38 \times 10^{-16} ergs/°C$. **(c)** Find the diameter of a molecule of Benzene if its mean free path is $2.2 \times 10^{-8} m$ and the number of Benzene molecules per unit volume is $2.79 \times 10^{25} molecules/m^3$.