Ideal Gases and Kinetic Theory

1. Complete the following table:

Variable	Meaning	Units
P	pressure	Pa or kPa
V	volume	m^3
T	temperature	K
n	number of moles	mol
N	number of molecules	molecules
K_{av}	average kinetic energy	J
v_{RMS}	root mean square speed of a gas molecule	m/s
U	internal energy of a monotomic ideal gas	J

2. Complete the following table:

Constant	Meaning	Numeric value	Units
K	Boltzmann constant	1.38×10^{-23}	J/K
N_A	Avogadro's number	6.023×10^{23}	molecules/mol
R	universal gas constant	8.31	J/mol K

3. Write the equations of state for an ideal gas.

   $PV = nRT = NkT$

4. What is the mathematical relationship among R, k, and N_A?

   $R = N_A k$

5. Write the equation for Boyle's law. Under what situation is this law valid?

   $P_i V_i = P_f V_f$, valid when temperature and the number of molecules are constant.

6. Write the equation for Charles' law. Under what situation is this law valid?

   $\frac{V_i}{T_i} = \frac{V_f}{T_f}$, valid when pressure and the number of molecules are constant.

7. Write the equations for pressure in the kinetic theory of gases.

$$P = \frac{1}{3}\left(\frac{N}{V}\right)2K_{av} = \frac{2}{3}\left(\frac{N}{V}\right)\left(\frac{1}{2}mv^2\right)_{av}$$

8. Write the equations for kinetic energy.

$$K_{av} = \left(\frac{1}{2}mv^2\right)_{av} = \frac{3}{2}kT$$

9. Write the equation for the RMS speed of a gas molecule.

$$v_{RMS} = \sqrt{(v^2)_{avg}} = \sqrt{\frac{3kT}{(M/N_A)}} = \sqrt{\frac{3N_AkT}{M}} = \sqrt{\frac{3RT}{M}}$$

10. Write the equation for the internal energy of a monatomic ideal gas.

$$U = \frac{3}{2}nRT = \frac{3}{2}NkT$$