## Reference Books

1. **Modern Physics:** K.S. Krane; John Wiley 1998, 2nd Edition
2. **Introduction to Modern Physics**: F.K. Richtmyer, E.H. Kennard, John N. Cooper; Tata Mc Graw Hill 1976 6th edition

3. **Quantum Physics:** R. Eisberg and R. Resnik John Wiley 2002; 2nd Edition
4. **Concepts of Modern Physics:** Arthur Beiser; Mc Graw Hill International,1987 4th Ed.

5. **Introduction to Modern Physics:** H.S.Mani and G.K.Mehta; Affiliated East-West 1988
6. **Elements of Modern Physics:** S. H. Patil; Tata Mc Graw Hill 1984

## Evaluation Scheme

- In-semester (60%)
  - Two Announced Tests (30% total)
  - One Mid-semester (30%)
  - All tests and mid-sem are compulsory and no re-exam or compensation in any form will be given on any ground whatsoever.
- End-semester (40%)

## Attendance Policy

- Attendance is compulsory but would not affect grades.
- Warning
  - Attendance is helpful in understanding the subject.
  - Students with poor attendance find it difficult to cope with tests and often land up with poor grades or even fail the course.

## Warning

- It would be presumed that any announcement about test/ quizzes etc. made in the class will reach everyone.
- No notice may be circulated for that.

## Modern Physics *(How Modern?)*

- Not really so modern.
- Seeds were grown more than a century ago.

## Degrees of Freedom

- Equipartition law involved the use of the concept of degrees of freedom.
- The degree of freedom can be Translational, Rotational or Vibrational.

## Distribution of Energy

At a finite temperature T, the energy is distributed as follows, where k is Boltzmann Constant.

$\boxed{\frac{1}{2}kT}$ For each Translational and Rotational degree of freedom

$\boxed{kT}$ For each Vibrational degree of freedom

## Specific Heat of Gases

Specific Heat deals with the increase of temperature as heat is being consumed by the system. We deal with Molar Specific Heat at constant volume $C_v$.

$$C_v = \left(\frac{\partial \varepsilon}{\partial T}\right)_V$$

## Monatomic Gases

Consider Monatomic gases like inert gases. Only translation of molecules are possible.

$$d.f. = 3N_A$$

$$\varepsilon = 3N_A \times \frac{1}{2}kT$$

$$C_v = \frac{3}{2}N_A k = \frac{3}{2}R$$

R is gas constant. R= 8.31 J/(mole.K)

## Diatomic Gases

Rigid Molecule

$$\boxed{\begin{aligned} \varepsilon &= 5N_A \times \frac{1}{2}kT \\ C_v &= \frac{5}{2}N_A k = \frac{5}{2}R \end{aligned}}$$

Flexible Molecule

$$\boxed{\begin{aligned} \varepsilon &= 5N_A \times \frac{1}{2}kT + N_A kT \\ C_v &= \frac{7}{2}N_A k = \frac{7}{2}R \end{aligned}}$$

## Experimental Data

- A good agreement for monatomic gases.
- For diatomic gases one gets a value of 2.5 R at room temperature. But tends to increase for many of them with increase of T, approaching a value of 3.5 R.

## Hydrogen Gas

Hydrogen gas shows 1.5 R around 100K and ~2.5 R around room temperature. Increases and tends to 3.5 R around 1000K, before dissociating.

## Dulong and Petit law

- The specific heat of all solids is 3R.
- Can be derived on the basis of equipartition law.

$$\varepsilon = 3N_A \times kT$$

$$C_v = \frac{d\varepsilon}{dT} = 3N_A k = 3R$$

## Experiment

- Good agreement at RT for a very large number of solids.
- At low temperature approaches zero.
- At high temperature approaches 3R.
- A low temperature $C_v \propto T^3$.
- Some excitations other than vibration can also contribute in some specific solids.