INTRODUCTION

1. On Teaching and Reading

This book is meant for two-semester course for graduate students of physics, materials science and chemistry.

On the whole, the first three parts are elementary, while the last four are more difficult. In each chapter, we start from the elementary, leading gradually to more advanced topics. The choice of material to be covered in the course would have to depend on the need and level of the students, and the opinion of the teacher. I suggest below some points to be noted in teaching and reading.

(a) It is important to discuss and anlyse different points of view. A dogmatic pedagogical approach would be most unwise. It would not be appropriate to skip any material in Parts I-III. Part VI is also general, and should not be omitted.

(b) Mathematical derivations should not be neglected. We have already avoided complicated calculation so that students should be fully capable of repeating every derivation in the book. The objective of the derivation is to instill an appreciation of the approximations, hypotheses and consequences.

(c) Each chapter ends with a set of problems. These include many exercises of a conventional variety, as well as many intended for discussions. The latter may not have 'standard' answers and often I do not know the answers myself. These discussion problems are important, and should not be neglected.

(d) The references listed are not strictly necessary as a part of the course. They provide direction of further study, or merely identify the sources of the tables and figures. My own view is that graduate courses should stress independent thinking about a problem before consulting references, with references serving only as a source of specific information. It is indeed necessary to have clear concepts in order to benefit from the literature. Of course, references are useful, especially in broadening one's views. Unfortunately, for students who are not native speakers of English, there is an unavoidable language barrier. (Nevertheless, I must emphasise that with a clear understanding of the concepts and a proper foundation, books and articles in English should present no great difficulty. Without clear concepts, the best ability in English would be of little use.) Therefore it is also the task of the teacher to introduce some extra material where possible.

(e) Difficulties encountered in the course can often be traced to a poor foundation in elementary concepts. The new material is seldom very difficult in itself, nor can the problems be blamed to the lack of reference books. It is extremely important to review elementary concepts periodically.

2. Units and Constants

For simplicity, we set Boltzmann's constant to be 1, so kT becomes T. The temperature T is regarded as an energy, and energy can be measured in temperature units. Planck's constant $\hbar$ is also set equal to 1. These constants are nevertheless restored wherever necessary, in order to exhibit their roles. The following units and constants may be used for conversion.

Boltzmann's constant $k = 1.38 \times 10^{-16}$ erg/K

$= 8.62 \times 10^{-5}$ eV/K

Avogadro's number $N = 6.02 \times 10^{23}$ mole^{-1}

Gas constant $R = Nk = 1.98$ cal deg^{-1} mole^{-1}

[Note: 1 eV $\approx 10^4$ K; 1 cal/mole $\approx$ 0.5 K/molecule]

Planck's constant $\hbar = 1.05 \times 10^{-27}$ erg sec

$h = 2\pi\hbar$

[Note: 1 eV/h = 2.42×10^{14} sec^{-1}]

Proton mass $= 1.67 \times 10^{-24}$ gm

Electron mass $= 9.11 \times 10^{-28}$ gm

Electron charge $= -e$

$e^2 = (4.80 \times 10^{-10})^2$ erg cm

Bohr radius $a = 0.529$ Å

Binding energy of hydrogen $= e^2/2a = 13.6$ eV

Bohr magneton $\mu_B = e\hbar/2mc = 9.27 \times 10^{-21}$ erg/gauss.

3. Mathematical Formulas

The formulas listed below are not meant to take the place of a proper table. They may nevertheless be useful when a table is not at hand.

(a) δ-function

$$\theta(x) = 1, \qquad x > 0 \quad ,$$
$$= \tfrac{1}{2}, \qquad x = 0 \quad ,$$
$$= 0, \qquad x < 0 \quad .$$

$$\frac{d}{dx}\theta(x) = \delta(x) \quad ,$$

$$\int_a^b \delta(x)dx = \theta(b) - \theta(a) \quad .$$

$$\delta(ax) = \frac{\delta(x)}{|a|}$$

$$\operatorname{sgn} x = \frac{x}{|x|} \quad ,$$

$$\frac{d}{dx}\operatorname{sgn} x = 2\delta(x) \quad .$$

$$\delta(x-a) = \frac{1}{2\pi}\int_{-\infty}^{\infty} dk\, e^{ik(x-a)}$$

$$\sum_{n=-\infty}^{\infty} \delta(x-a-nb) = \frac{1}{b}\sum_{m=-\infty}^{\infty} e^{i2\pi m(x-a)/b} \quad .$$ (Poisson sum formula).

(b) Useful formulas

$$\Gamma(n) = (n-1)!$$

$$\int_0^{\infty} dx\, x^n e^{-x} = \Gamma(n+1) = n!$$

$$\Gamma(1+n) = n\,\Gamma(n) \ .$$

$$\Gamma(\tfrac{1}{2}) = \sqrt{\pi} = 1.772 \ .$$

$$\Gamma(\tfrac{3}{2}) = \tfrac{1}{2}\sqrt{\pi} \ .$$

$$\ln \Gamma(1+x) = -Cx + O(x^2) \ ,$$

$$C = 0.5772 = -\int_0^\infty \mathrm{d}x\, e^{-x} \ln x \ .$$

$$N! = N^N e^{-N} (2\pi N)^{1/2} \left[1 + \frac{1}{12N} + \frac{1}{288N^2} + \dots\right].$$

$$\int_0^\infty \frac{\mathrm{d}x}{e^x+1} = \ln 2$$

$$\int_0^\infty \frac{x\,\mathrm{d}x}{e^x+1} = \frac{\pi^2}{12} \ .$$

$$\int_0^\infty \frac{x^2\,\mathrm{d}x}{e^x+1} = \frac{3}{2}\zeta(3), \ \zeta(3) = 1.202 \ .$$

$$\int_0^\infty \frac{x\,\mathrm{d}x}{e^x-1} = \frac{\pi^2}{6} \ .$$

$$\int_0^\infty \frac{x^2\,\mathrm{d}x}{e^x-1} = 2\zeta(3) \ .$$

$$\int_0^\infty \frac{x^3\,\mathrm{d}x}{e^x-1} = \frac{\pi^2}{15} \ .$$

$$\int_{-\infty}^\infty \mathrm{d}x\, e^{-x^2/2a^2}\, e^{-ikx} = \sqrt{2\pi}\, a\, e^{-1/2\, k^2 a^2} \ .$$

$$\tanh^{-1} x = \frac{1}{2} \ln \frac{1+x}{1-x} = x + \frac{x^3}{3} + \dots \ , \qquad |x| < 1 \ .$$

$$\coth^{-1} x = \frac{1}{x} + \frac{1}{3x^3} + \dots \ , \qquad |x| > 1 \ .$$

(c) Useful numbers

$\ln 2 = 0.693$,

$\ln 10 = 2.30$,

$\sqrt{\pi} = 1.77$.

$6! = 720$, $9! = 362\,880$, $12! \approx 4.8 \times 10^8$.

$2^{10} = 1024$, $2^{15} = 32\,768$, $2^{20} \approx 10^6$.