



**ROBERT C. PLUMB**

Worcester Polytechnic Institute  
Worcester, Massachusetts 01609

# chemical principles exemplified

## Blue Skies and the Tyndall Effect

*Illustrating the scattering of radiation by individual, randomly arranged, molecules*

*Contribution by Professor Milton Kerker,  
Clarkson College of Technology*

The scattering of light, known as the Tyndall effect, is often said to be indicative of the presence of colloidal particles. However, John Tyndall noted in 1869 that when the particles were sufficiently small the scattered light was blue and that the explanation of the blue color of the sky might be sought in this phenomenon.

Lord Rayleigh in 1871 offered a particularly simple argument. He assumed the scattering particles consisted of the air molecules themselves which, under the influence of the oscillating light field, underwent an oscillation, thereby reradiating the light in all directions. Simple arguments showed that the intensity of this secondary or scattered radiation could be expressed as

$$I = f(m) \frac{V^2}{r^2 \lambda^n} I_0 \quad (1)$$

Here,  $f(m)$  is some function of refractive index, a dimensionless quantity,  $V$  is the volume,  $r$  is the distance from the scattering particle,  $I_0$  is the intensity of the incident radiation, and  $\lambda$  is the wavelength. Rayleigh proposed that an exponent  $n = 4$  was required for  $\lambda$  in order that the above equation be dimensionally correct. It is this inverse fourth power dependence upon wavelength which causes the blue end of the visible spectrum to be more strongly scattered, giving the sky its characteristic color. The sun, of course, acquires its yellow hue because the transmitted beam by which we view it has had some of the blue light scattered away.

Rayleigh had actually compared the spectral composition of the blue of the sky with that of direct sunlight prior to developing his theory. By remarkably simple yet accurate experiments, he had been able to show that the intensity of skylight did vary with the inverse fourth power of the wavelength rather than the inverse second power as required by other theories.

As for the composition of the scattering particles in the atmosphere, previous writers had taken for granted

that these consisted of water or ice. Rayleigh took exception to this. Maxwell had directed his attention to the possibility that the molecules of air itself might be the scattering particles, and Rayleigh (1899) later published calculations which indicated "that the light scattered from molecules would suffice to give us a blue sky, not so very greatly darker than that actually enjoyed."

## General References

LORD RAYLEIGH, *Phil. Mag.*, **41**, 107, 274, 447 (1871).

LORD RAYLEIGH, *Phil. Mag.*, **47**, 375 (1899).

JOHN TYNDALL, *Phil. Mag.*, **37**, 384; **38**, 156 (1869).

## Lithium Spectrum

*Illustrating chemical identification by flame tests*

*Contribution by Professor Hubert N. Alyea,  
Princeton University*

The vivid carmine red emission spectrum of lithium salts can be a useful and sometimes unexpected source of information.

## Chicken a la Twice

R. W. Wood, the famous Johns Hopkins physicist, relates how, when he was a graduate student in Germany, he complained to his housekeeper that the soup she was serving him had been made from the previous day's chicken bones.

"Ach, nein," she demurred.

"Watch!" he retorted.

He took from his pocket an alcohol burner, ignited it, and in its flame held a platinum wire which he had dipped into the soup. A deep red lithium flame shot up.

"Yesterday," he told the embarrassed hausfrau, "I sprinkled lithium chloride on my chicken bones before you removed the plate to the kitchen. Today the lithium is in the soup."

So was the hausfrau.

## Secret's Out

The United States exploded the first H bomb on November 1, 1952 near Eniwetok Atoll in the Pacific. Descriptions of the explosion sent in letters home by sailors of the naval task force were unexpectedly and unintentionally revealing, and caused some consternation among those guarding the secrecy of H bomb construction. The phrase, "... it turned a brilliant red . . .," quoted on the front page of the New York Times told scientists who could interpret it that the fusible chemical compound used in the bomb was lithium hydride.

The exempla are designed to show fundamental chemical principles in operation. They deal with phenomena in which students have intrinsic interest; they apply abstract ideas to easily visualized situations. All of us have our pet anecdotes and illustrations which we know will attract the students' interest. Your contributions and suggestions are invited. They may be sent to the author.

## Airline Stewardesses and Boyle's Law

### *Illustrating Boyle's law*

*Contribution by T. C. Loose, North Yarmouth Academy*

Boyle's law is usually well understood by students; however, the following anecdotes will certainly enliven its presentation.

When stewardesses on British Overseas Airways Corp. planes complained that their skirts fitted on the ground but not in the air, a BOAC spokesman blamed it all on Sir Robert Boyle's Law. This law says that if the quantity and temperature of a gas remains constant, its volume will vary inversely with pressure.

The application of the law to the skirts is simple: air pressure decreases as an airplane ascends, and thus the pressure on the gas in a stewardess's stomach lessens, which means the volume of the gas increases. In other words, her tummy bulges.

British stewardesses now wear adjustable skirts.

... *New York Herald Tribune* (1964)

## "With Non-Puncture Bra She'd Be in Orbit Now"

LOS ANGELES (AP)—What happens to a stewardess wearing an inflatable bra when the cabin of her jet plane is depressurized?

Just what you're thinking, Herman. Inflation.

As Los Angeles Times columnist Matt Weinstock told it Friday, this set of potentially explosive circumstances occurred recently on a Los Angeles-bound flight. He gallantly withheld the identity of girl and airline.

"When she had, ahem, expanded to about size 46," Weinstock wrote, "she frantically sought a solution. Somehow she found a woman passenger who had a small hatpin and stabbed herself strategically."

"However, another passenger, a man of foreign descent, misunderstood. He thought she was trying to commit hara-kiri the hard way. He grappled with her trying to prevent her from punching the hatpin in her chest."

"Order was quickly restored, but laughter still is echoing along the airlines."

Weinstock says it really happened.

Good thing they don't make these bras puncture-proof.

... *Associated Press* (1967)