electromagnetic radiation. That is, photon mean free paths are long and photon transport through air is well approximated by the free particle limit.[10]

Photon energy is independent of photon speed. (All photons travel at the speed of light.) Therefore, the *equilibrium* rate of thermal energy transport by a photon gas is simply the product of equilibrium photon flux, $\dot{n}''_{pht}$, and the mean energy per photon, $\hat{\varepsilon}_{pht}$.[11]

$$\dot{e}''_{pht} = \dot{n}''_{pht}\,\hat{\varepsilon}_{pht} = \frac{n_{v,pht}c}{4}\,\hat{\varepsilon}_{pht} = \frac{u_{v,pht}c}{4} \qquad \text{(IIIE-16a)}$$

When we substitute the expression for the photon energy density developed in Unit IIID, eqn. IIID-6b, we obtain the *Stefan-Boltzmann Law*

$$\dot{e}''_{pht} = \dot{e}''_b(T) = \sigma T^4 \qquad \text{(IIIE-16b)}$$

where σ is the Stefan-Boltzmann constant

$$\sigma = \frac{2\pi^5 k^4}{15\,h^3 c^2} = 5.668 \cdot 10^{-8}\,\mathrm{W/(m^2K^4)} = 1.714 \cdot 10^{-9}\,\mathrm{BTU/(hr\ ft^2R^4)}$$

The Stefan-Boltzmann law represents the rate at which photons will be moving in all directions within an equilibrium enclosure. But heat transport only occurs when temperature differences are present, that is, for nonequilibrium conditions.

> Radiant Exchange within an enclosure containing an "optically thin" gas is governed by photon-wall collisions. Net transport results from the different rates at which surfaces emit and absorb photons. The maximum rate at which a surface can emit radiation is set by the Stefan-Boltzmann Law. A surface that emits at the maximum rate is called a *black body (or black surface)*. Since photon transport occurs within all media corresponding to their equilibrium temperature, a real surface emits at less than the black body rate in proportion to the rate at which photons approaching the surface from its interior are reflected back into the body. This percentage is a property of the surface called its *emittance (or emissivity)*.

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[10]Not only are photon-molecule collisions limited to certain specific molecules, they are strongly concentrated at certain specific frequencies. The effect of these preferred scattering and absorption bands are evidenced by two natural phenomena. The earth's blue sky is a result of atmospheric scattering of the "blue" from the solar spectrum. Thus the blue photons are incident from all directions, not just from the small solid angle at which the sun is observed. The red sunset is caused by selective absorption of the solar spectrum excluding the red wavelength by the far thicker atmosphere when solar radiation enters tangentially to the earth's surface.

[11]Thermal radiation transport refers to the transport of energy due to temperature differences, radiation heat transport. It excludes the transport of radiation generated by mechanical means, for example, by radio, TV, or microwave transmitters or by a laser. This is radiation work transport.

Ans. 11.

$$\lambda_{c,n-c} = \frac{M_c}{\sigma_{n-c}\,\rho_c\,N_A} = \frac{12\ \mathrm{g/(g\ mol)}}{4.10^{-24}\,\mathrm{cm^2/part} \cdot 1.6\ \mathrm{g/gm^3} \cdot 6.023 \cdot 10^{23}\,\mathrm{part/(g\ mol)}} = 3.1\ \mathrm{cm}$$