The Blue Planet

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Abstract - *The color of the sky is (blue) is due to the recombination of the atomic nitrogen. Nitrogen is the main umbrella protects earth from extremely high- energy electromagnetic radiation its wavelength below 126nm. Nitrogen is characterized by the highest value for Bond dissociation energy (BDE or D0 =945KJ/mole) among all of the earth's elements and compounds that are formed from one step, so it absorbs the wavelength of the entire photons below 126 nm (its energy more than 945KJ/mole) from very high altitude. The temperature of atomic nitrogen recombination (molecular nitrogen formation) is 8217 K. The color of the blackbody at 8217k is blue. Each individual of the diatomic nitrogen at the moment its formation from its constituent atoms can be considered to represent as a blackbody at a temperature of 8217 K. This is why the earth looks blue even when viewed from outer space.*

Key Words: The color of the sky, Why the earth look blue from outer space, Nitrogen photodissociation, Atmospheric photodissociation, Black body radiation.

1. INTRODUCTION

1.1 Nitrogen dissociation

The BDE of nitrogen is 945 kJ/mol. Photon its energy more than 9.84 eV (its wavelength less than 126 nm or more than $1.576 * 10^{-18}$ J) when collides nitrogen molecule containing two nitrogen atoms (N_2), splitting them into individual atomic nitrogen. This is known as the photodissociation process. The photodissociation of molecular nitrogen is an isothermal process, that is, the breaking-Up triple covalent bond of the nitrogen molecule is not accompanied by any rise in temperature. This does not mean that the energy of absorbed photon is canceled, but photon energy has been stored in the atomic nitrogen in the form enthalpy of formation. The enthalpy of formation of atomic nitrogen is + 472.5 Joules per mole.

$N_2 + h\nu$ (<126nm) → 2N ($\Delta_f H$=472.5 kJ/mol) T=const.

The process of nitrogen dissociation is reverse, that is, atomic nitrogen may be reacted with each other to produce molecular nitrogen once again (recombine) with thermal energy release to the surroundings. The released thermal energy is equal to the BED of N_2;

2N ($\Delta_f H$=472.5 kJ/mol) → N_2 +945 kJ/mol ($\Delta_r H$ = heat)

This exothermic reaction is occurring in a wide area in the earth's atmosphere, especially in the thermosphere layer. This is the reason for the rise in temperature in this layer which may be reached to 1500°C. The proportion of atoms to molecules increase with altitude and at 120km the concentration of oxygen as atoms approximately equals that of dioxygen molecule and substantial portion of nitrogen is also present as atoms. [1] Nitrogen molecular formation from its constituent atoms (triple covalent bond creation) is an exothermic process; therefore, this process is accompanied by temperature rise. The temperature of atomic nitrogen recombination (the reaction of two atomic nitrogen) can be predicted for each of the molecule at a moment of its formation by calculation entropy change for both system and surroundings.

Formation molecular nitrogen from its atoms is a spontaneous process, that is, the total entropy change of this process must be positive;

$\Delta S_{total} = (S^0_{pr.} - S^0_{reac.})_{system} + \Delta S_{surroundings} > 0$

$\Delta S_{total} = (S^0_{N2} - S^0_{2N}) + D_0 N_2$ J/TK > 0

$_{total} = \Delta S$ 191 J/K mol-2*153 J/K mol) +945000 J/T > 0

For simplicity, we suppose the process at equilibrium state, that is $\Delta S_{total} = 0$ J/K

(191 J/K mol -2 *153/K mol) + 945000 J/T =0

T= 8217 K (bluish-white)

By the same way the temperature of molecular oxygen formation can be predicted;

$O_2 + h\nu$ (<240nm) → 2O ($\Delta_f H$=249 kJ/mol) T=const.

2O ($\Delta_f H$=249 kJ/mol) → O_2+498 kJ/mol ($\Delta_r H$= heat)

$\Delta S_{total} = (S^0 O_2 - S^0 2O) + D_0 O_2$ J/TK

T= 4282 K (yellowish-white)

The temperature of the Ozone molecule formation is 833 K (dull red).

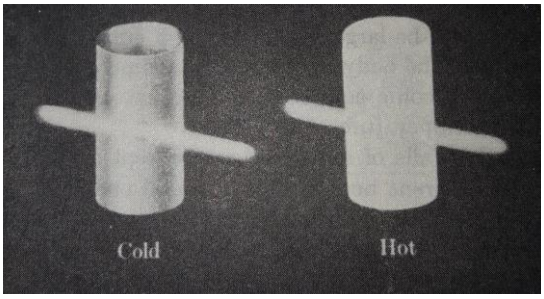
1.2- Black body theory

The absorption and emission radiation by a hole in hollow tungsten cylinder is shown in Fig1. The light streak across the center of the figure is incandescent filament maintained at constant color temperature for comparison purposes. When the cylinder is cold the hole is darker than any other part and actually appears black, but when the cylinder is heated sufficiently, the hole is brighter than the body the tube and matches the reference filament. Such a hole is absorber-emitter is called a black body. Black body can be made from bright objects. A bundle of sewing needles held with their points directed toward the eye looks remarkably black. A pile of razor blades at least 1/16 inch thick also looks black when viewed from the sharp side. [2]

The radiant energy emitted by black body depends on the body's temperature. At a low temperatures the rate of radiations is small and the radiant energy is chiefly of relatively long wave length. As the temperature is increased, the rate of radiations increases very rapidly, in proportion to the 4^{th} power of the absolute temperature. At the same time, the relative amount of radiant energy of short wave length increases. The wave length of the most intense wave shifts toward shorter wave length, with increasing temperature (Fig.2).

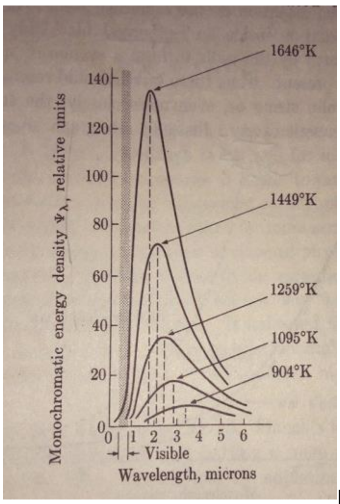
At room temperature of 25°C (298 K), most of the radiation emitted by a body is in the infrared region of the electromagnetic spectrum. As the temperature increases to 500°C, black body emit significant amounts of visible light. It could be viewed in the dark as a "ghostly" grey. At a temperature of 800°C, a body emits enough visible light to be self-luminous and appears 'red-hot'. By far the larger part of the energy emitted, however, is still carried by infrared waves. At 3000°C, which is about the temperature of an incandescent lamp filament, the radiant energy contains enough of the shorter wave length so that the body appears nearly ''white-hot''. [3]

With rising temperature, the body becomes bluish-white. When the body appears blue, it is emitting a substantial fraction of its ultraviolet radiation and even traces of x ray.



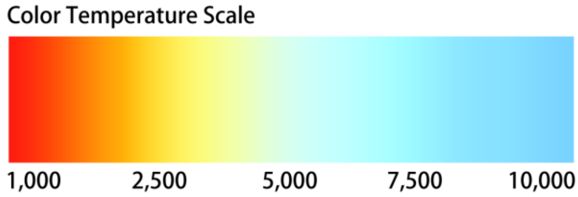
[2]

Fig. 1-Radiationfrom a hollow tungsten cylinder.



[2]

Fig.2-the distribution of energy in the spectrum of the radiation from a blackbody at different temperatures.



[3]

Fig.3- Black body electromagnetic spectrum in wid range of temperature

1.3- the Blueness of the sky

During the day, the sky appears to be blue because of the continuously of nitrogen molecules formation from its atoms (atomic nitrogen formation). Every single molecule of nitrogen at moment its formation is considered as an individual thermal energy source with a temperature of 8217 K. The black body at 8217 Kelvin, according to the blackbody spectrum, gives a blue color. Although the nitrogen is making up 78% of earth's atmosphere, however, its percentage in the form of atoms in the atmosphere is less than atoms of oxygen. The low atomic nitrogen concentrations in the atmosphere are due to the narrow band of the solar electromagnetic radiation that nitrogen absorbs (100-126nm) compared with that absorbed by oxygen (100-240nm).

Nitrogen, and unlike oxygen, its photodissociation process rate depends on the <126 nm photon concentrations and not on its concentrations in the atmosphere, therefore, the photodissociation processes of nitrogen ended at a very high altitude (120km). The blue sky, which we are seeing, is more than 120km apart.

2.4-Near sunset or sunrise sky color

For few minutes after sunset (or before sunrise), the sun continues to send its radiation pass through the stratosphere. Near sunset or sunrise, sunlight passes through a much longer path in the stratosphere, hence, the phtodissociation of oxygen reaches a peak level, so, atomic oxygen concentrations levels increase and the ozone formation reached its climax. The temperature of molecular ozone formation is 833K. The color of the blackbody at 833k is dull red. The reddish light of the sunset and sunrise belongs to the ozone molecular formation. The light that creates in the stratosphere in the time of sunrise and sunset is mingled of dull-red belong to ozone formation and yellowish-white to the oxygen molecular formation.

2.5- Night falls gradually

Atomic oxygen concentrations in the stratosphere are night. [5] Atomic nitrogen and oxygen in the thermosphere, and unlike oxygen atoms in the stratosphere, may be dropped gradually in the nighttime. The air pressure in the thermosphere (0.001mb) is very low compared to that in the stratosphere (200-50mb), therefore, the processes of forming molecular nitrogen and molecular oxygen may be continued after sunset but at a very low rate, so it may take a relatively over long period of time before the nitrogen and oxygen atoms are being exhausted. In the nighttime, the sky is not completely dark, even in the midnight, however, somehow there still is visible light to be generated via molecular formation in the thermosphere (duple and triple covalent bonds creation for oxygen and nitrogen respectively) but at very low concentrations.

2-The uneven blueness of the sky

2.1-Heat capacity change

The temperature of nitrogen molecular formation (8217 Kelvin) is calculated based on the ambient temperature of 298 Kelvin, while the nitrogen molecular formation in the atmosphere is carried out at a wide range of temperatures. The differences in ambient temperature lead to differences in the heat capacities (CP) values of the reactants and products, therefore, the higher ambient temperature causes increase in heat capacity (CP) values which, in turn, lead to increase in enthalpy of reaction (ΔrH=released energy) with a fixed number of moles;

$$\Delta_r H_T = \Delta_r H_{298K} + \int_{298K}^{T} \Delta \, Cp \, dT \quad (4)$$

It can be simplified to

$$\Delta_r H_T = \Delta_r H_{298K} + \Delta (Cp)^* (T - 298)$$

Using above equation could predict enthalpy of reaction (ΔrH) for any chemical reaction at any temperature (one step reaction). According to above equation BDE of nitrogen at a temperature of 1500 Kelvin is 951,888 J. The temperature of nitrogen molecular formation at 1500 Kelvin is 8277 Kelvin, so, this degree of temperature is located on a bluer area of the electromagnetic spectrum. The unevenness of the blueness of the atmosphere is attributed to the variation in temperature of the thermosphere zones in which the molecular nitrogen is formed (temperature in thermosphere layer vary between500 – 1500 Kelvin). By the same method can predict the oxygen molecular formation temperature in different thermal conditions.

2.2-Oxygen thermal dissociation

The term of thermal dissociation refers to the chemical reactions caused by heat in which chemical compounds are broken down into at least two other substances. In most cases, these reactions are endothermic, so heat is needed to break chemical bonds in the compound undergoing dissociation. Practically, it is found experimentally that the oxygen begins to dissociate but at a low rate when heated to 3000 Kelvin. However, oxygen is completely dissociated when heated to a temperature of 5000 Kelvin. This is what newly is found in one of the Russian laboratories. Thermal dissociation of oxygen in laboratory supports calculations that depend on the process entropy change.

3-The conclusion

Significant amounts of the visible light are created in the earth's atmosphere through photodissociation and recombination processes for nitrogen and oxygen. It is ($O_2 \rightleftarrows 2O$ and $N_2 \rightleftarrows 2N$) cycles in earth's atmosphere by which oxygen and nitrogen are continually converting the invisible high- energy electromagnetic radiations to longer wavelengths and fall within the visible electromagnetic spectrum. Photodissociation of diatomic molecules to atoms is a process of Electromagnetic Radiation Decaying. The outside of the earth's atmosphere is somehow dark even when the sun is shining is due to the lack of the visible electromagnetic radiations (more than 400nm).

4-REFERENCES

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