Just as $5 = 5R$ and $25 = 5Y$, so $19.60 = 9.6$ YR. See diagram, and refer to "A Practical Description of the Munsell System," by T. M. Cleland, for information concerning the Munsell notation.

The formula given will hold as long as the hues of the discs used are the same through any experiment, and as long as they are fairly close in hue relationship. The ratio given for reflection as $\dfrac{I\,6500}{I\,5000}$ may also

be improved by using $\sqrt{\dfrac{S\,(A \times B^2_{1.2.3}\ldots)}{100}}$.

The value, or brilliance scale, of the Munsell color discs follows approximately the square root of the reflection, that is, on a scale of grays 0 to 10, black to white, middle gray, or 5, reflects about 25 per cent. of the light falling on it, while the seventh gray step will reflect about 49 per cent. of light.

In the example given for hue we might work out the brilliance as follows (when white is N(eutral) 9/ , and black N1/):

$$\sqrt{\frac{(10 \times 4^2) + (15 \times 8^2) + (70 \times 1^2) + (5 \times 9^2)}{100}} = 3.99.$$

The brilliance, therefore, is 3.99 on a scale of equidistant steps from 0 to 10, black to white.

This formula, like the hue formula, may be used with confidence as long as the discs used in an experiment are of the same color. It will be closely approximate when other discs are used.

This material is passed on for the information of those who are using Munsell discs in their colorimetric work. Few people, although they use the papers, seem to realize the advantages that the Munsell notation offers for specifying and studying their color work.

<div style="text-align:right">

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SPECIAL ARTICLES

THE STRUCTURE OF BORON HYDRIDES

IF the idea of the pseudo-atom[1] is extended to the hydrides of boron it is possible to write formulae for these substances that conform more nearly to our usual notion of molecular structure than do formulae advanced up to date. It is not necessary to involve the K electrons[2] of the boron atom in the building of

[1] H. G. Grimm, *Z. f. El. Chem.*, 31, 475, (1925).

[2] E. D. Eastman, *J. Am. Chem. Soc.*, 44, 438–51 (1922) and E. Miller, *Z. f. El. Chem.*, 31, 382–5 (1925).

a complete octet of L-electrons, nor to assume boron tetra or pentavalent,[3] nor need four electron bonds be assumed.[4] In fact, on the scheme given below a whole boron chemistry can be conceived of in complete analogy to carbon chemistry.

Atom	Pseudo atoms in carbon chemistry	Pseudo atoms in boron chemistry
$=C-$	$=C=$	$=BH=$
$=N-$	$=CH-$	$=BH_2-$
$-O-$	$-CH_2-$	$-BH_3-$
$F-$	CH_3-	BH_4-

For example, the hydrides with two central atoms (either two carbon or two boron atoms) have on this theory the following structures:

<div style="text-align:center">HYDROCARBONS</div>

Ethane	CH_3-CH_3	C_nH_{2n+2}
Ethylene	$CH_2=CH_2$	C_nH_{2n}
Acetylene	$CH=CH$	C_nH_{2n-2}

<div style="text-align:center">HYDROBORONS</div>

....	BH_4-BH_4	B_nH_{3n+2}
Borethane	$BH_3=BH_3$	B_nH_{3n}
....	$BH_2=BH_2$	B_nH_{3n-2}

While Stock[5] compares B_2H_6 to ethane and assumes boron tetravalent it seems equally reasonable to make comparison with ethylene, as the following figures show:

<div style="text-align:center">COMPARISON OF PHYSICAL PROPERTIES</div>

	Melting point (°C)	Boiling point (°C)
C_2H_6	-172.0	-88.3
B_2H_6	-166.0	-92.0
C_2H_4	-169.4	-103.8

As far as the chemical behavior is concerned it is to be pointed out that the structure proposed for B_2H_6 differs from ethylene in the complexity of the positive change within an octet and so a difference in chemical behavior may be explained on this basis. That is, if the positions of the positive charges (B^{+++}, H^+, H^+ and H^+) within the octet are not further specified, then the bond holding the two radicals

[3] A. Stock, *Ber.*, 59, 2223–6 (1926) and J. A. Christiansen, *Z. f. allg. u. anorg. Chem.*, 160, 395–403 (1927) and J. Böeseken, *Ber.*, 58 (1) 268–70 (1925).

[4] M. Huggins, *J. Phys. Chem.*, 26, 833–5 (1922).

[5] A. Stock and Pohland, *Ber.*, 59, 2223–6 (1926).

BH$_3$ together is a (double) bond, as in ethylene or oxygen. The difference in chemical behavior of O$_2$, C$_2$H$_4$ and B$_2$H$_6$ must then be ascribed to the fact that in these three cases the positive charge within an octet consists of a single kernel in O$_2$, a carbon kernel and two protons in C$_2$H$_4$ and a boron kernel and three protons in B$_2$H$_6$.

The next step would be to locate the protons within the octet in some symmetrical fashion, but such a detailed picture is at present not necessary.

It is evident that the present view considers the completion of a stable shell (an octet) as the primary cause of chemical combination and the valency of an individual atom as a rather secondary phenomenon.

In the first instance, it is only necessary to consider the radicals BH$_3$, BH$_2$, etc., equivalent to CH$_2$, CH, etc. In both cases their positive charges are thought to be located inside of an octet of electrons. Further details of this theory will be published in another place.

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ON THE SPECTRUM OF DOUBLY IONIZED MAGNESIUM

AN investigation of the condensed spark discharge in vacuum between electrodes of pure metallic magnesium has revealed the levels of the most stable three configurations of the doubly ionized atom, isoelectronic with neon.

The transition frequencies and term separations were predicted to a high degree of accuracy by the X-ray doublet laws and a consideration of the first order screening numbers; the values were extrapolated from the arc spectrum of neon, which is well known from Paschen's famous analysis, and the first spark spectrum of sodium, recently analyzed independently by four different investigators (Bowen, *Phys. Rev.*, 31, 967, 1928; Frisch, *Zs. f. Phys.*, 49, 52, 1928; Laporte, *Nature*, 121, 941, 1928; Majamdar, *Ind. Jour. Phys.*, 2, 345, 1928).

The notation of the s − and p − terms follows that used by Paschen in neon. Several possible values have to be listed for the p − terms with inner quantum numbers 3 and 0; we hope that values for these terms may be selected unambiguously later by combinations with higher terms.

The key to the analysis was found in the resonance lines, $\lambda = 231.71$, $\nu = 431570$, int. $= 2$, and $\lambda = 234.25$, $\nu = 426890$, int. $= 1$, the stronger of which was recorded by Millikan and Bowen in their first report on extreme ultra-violet spectra (*Phys. Rev.*, 23, 1, 1924). All the other lines are new. All the expected transitions between the terms listed have been found,

with the exception of s$_2$–p$_{10}$, $\lambda_{calc} = 2881.2$, which lay outside the range investigated, and s$_4$ − p$_7$ and s$_4$ − p$_2$, whose intensity was expected to be low.

The terms of Mg III have the following relative values:

configuration	name	j-value	term value
2p^6	^{1}S	0	−425680
2p^{5}3s	s$_5$	2	0
	s$_4$	1	1216
	s$_3$	0	2193
	s$_2$	1	5881
2p^{5}3p	p$_{10}$	1	40589
	p$_9$	3	47906
			or 48480
			or 48625
	p$_8$	2	48888
	p$_7$	1	49822
	p$_6$	2	51935
	p$_5$	1	51980
	p$_4$	2	52270
	p$_3$	0	52328
			or 52780
	p$_2$	1	54608
	p$_1$	0	57290
			or 58432

The ionization potentials of magnesium are as follows:

Mg I 3s^2 ^{1}S$_0$ to Mg II 3s ^{2}S$_1$, 7.61 volts
Mg II 2p^{6}3s ^{2}S$_1$ to Mg III 2p^6 ^{1}S$_0$, 14.97 volts
Mg III 2p^6 ^{1}S$_0$ to Mg IV 2p^5 ^{2}p$_2$, 80 ± 2 volts

Most interesting in the neon-like isoelectronic sequences is the trend of the relative separations in the 2p^{5}3s "triplet" s$_5$(^{3}P$_2$), s$_4$(^{3}P$_1$), s$_3$(^{3}P$_0$). The relative separations ^{3}P$_1$ − ^{3}P$_2$: ^{3}P$_0$ − ^{3}P$_2$ are as follows:

"normal" .667
Ne I .537
Na II .564
Mg III .554

The downward curvature of this ratio might be taken as evidence against Hund's correlation of inverted terms to series limits. (See Mack, Laporte, and Lang, *Phys. Rev.*, 31, 748, 1928, esp. p. 763 for the analogous case of the d^{9}s triplets, and Shenstone, *Nature*, 121, 619, 1928, for a more general discussion of series limit correlation of inverted terms.)

A more complete report on the spectrum of Mg III will be published after a search for higher terms has been completed.

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