Application of the New equation of state to the Joule-Thomson effect

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In a recent paper⁽¹⁾ I proposed an equation of state which equally satisfies the three criteria for state equations: RT_c/p_cV_c, T_B/T_c and $T_c/p_c\cdot(dp/dT)_c$. One more criterion with technical importance is the Joule-Thomson effect which is formulated thermodynamically

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1) This *Bulletin*, **26**, 78 (1953).

by the aid of van der Waals' equation of state, but results in a qualitative formula:

$$\mu=\frac{2a_{corr}/RT-b_{corr}}{C_p},\quad a_{corr}=\frac{27R^2T_c^2}{64p_c},$$

$$b_{corr}=\frac{RT_c}{8p_c}\qquad\ldots(1)$$

where μ is the Joule-Thomson coefficient, C_p the molecular heat, R the gas constant, and T the temperature, these together with a_{corr} and b_{corr} being expressed in liters, atmospheres, moles, deg. absolute.

I will communicate in this letter the applicability of my equation of state to this problem.

Taking my equation, $p+a/V^{2-}=RT/(V-b)$, in the deduction of the above formula, it readily follows that

$$\mu=\frac{2aV^{\varepsilon'}/RT-b}{Cp},\ a=3p_cV_c^2,$$

$$b=V_c/3,\qquad\ldots(2)$$

here a, b &c. are expressed in the same units as above.

It is noticed here that ε in the preceding paper where V is expressed in cc./mole, and ε' denoted here where V is expressed in liter/mole are related by $\varepsilon=\varepsilon'\times\log V/(\log V+3)$.

From International Critical Tables III, V, and Henning's " Warmetechnische Richtwerte", five available data of H_2, CO_2, N_2, O_2 and air can be taken, among which, however, only air may serve as a test case for pressure effect.

To compare with (2—ε) directly from the equation of state, the test for its validity being the present purpose, estimate ε' from formula (2) and transform it into ε, from which (2—ε) from formula (2) is obtained.

Hydrogen

	0°C	100°C
(2—ε) from formula (2)	1.979	2.005
(2—ε) from equation of state	2.000	2.009
	(p=50 atm.)	(p=50 atm.)
Divergence in %	1.1	0.2

Carbon dioxide

	0°C	100°C
(2—ε) from formula (2)	1.890	1.910
(2—ε) from equation of state	1.900	1.930
	(extrapolated)	(p=50−1000 atm.)
Divergence in %	0.5	1.0

Nitrogen

	0°C	100°C
(2—ε) from formula (2)	1.944	1.965
(2—ε) from equation of state	2.007	2.039
	(p=50−1000 atm.)	(p=50−1000 atm.)
Divergence in %	3.1	3.6

Oxygen

	0°C	100°C
(2—ε) from formula (2)	1.941	1.959
(2—ε) from equation of state	1.967	2.026
	(p=36−62 atm.)	(p=100−1000 atm.)
Divergence in %	1.3	3.3

Air at 0°C

	p (atm.)			
	1	20	60	100
(2—ε) from formula (2)	1.977	1.969	1.973	1.987
(2—ε) from equation of state	1.987	1.997	2.000	2.002
Divergence in %	0.5	1.4	1.4	0.8

Air at 100°C

	p (atm.)			
	1	20	60	100
(2—ε) from formula (2)	1.995	1.995	2.005	2.019
(2—ε) from equation of state	1.986	2.019	2.025	2.029
Divergence in %	0.4	1.2	1.0	0.5

The agreements between these two are fairly good as seen from the above tables, and even the greatest divergence arising in the cases of N_2 and O_2 is less than 4%, where the mean values of $(2-\varepsilon)$ from the equation of state at 50 or 100—1000 atms. are presumably the same as those at 1 atm. These results lead to the conclusion that the Joule-Thomson effect is formulated with accuracy by making use of my equation of state.

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