

气体膨胀系数

Gas Expansion Factor

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1. How to measure and calculate Gas Expansion Factor

$$S_i(T) = CX_i(T)\sigma_i(E)D_i\Phi_p(E)F(k, T, P)$$

In flow tube or JSR experiments, $F(k, T, P)$ means gas expansion factor (GEF).

$$\frac{S_i(T_2)}{S_i(T_1)} = \frac{X_i(T_2)}{X_i(T_1)} \frac{F(k, T_2, P)}{F(k, T_1, P)}$$

$$\text{Set } FKT(T_2, T_1) = \frac{F(k, T_2, P)}{F(k, T_1, P)}$$

$$\frac{X_i(T_2)}{X_i(T_1)} = \frac{S_i(T_2)}{S_i(T_1)} / FKT(T_2, T_0)$$

If pure gas (e.g. Argon or Krypton) was used, $X_i(T_2) = X_i(T_1)$, then:

$$FKT(T_2, T_1) = \frac{S_i(T_2)}{S_i(T_1)}$$

Thus, we can measure GEF by comparing signals of Krypton at different temperatures.

Since there are many autoionization peaks for Krypton, we take a strategy that scanning Photoionization Efficiency Curve (PIE) to reduce errors from autoionization's influence.

The signal $S_i(T)$ is in direct proportion to molecule numbers $n_i(T)$ that was absorbed into the ionization chamber through quartz nozzle. Thus:

$$FKT(T_2, T_1) = \frac{S_i(T_2)}{S_i(T_1)} = \frac{n_i(T_2)}{n_i(T_1)}$$

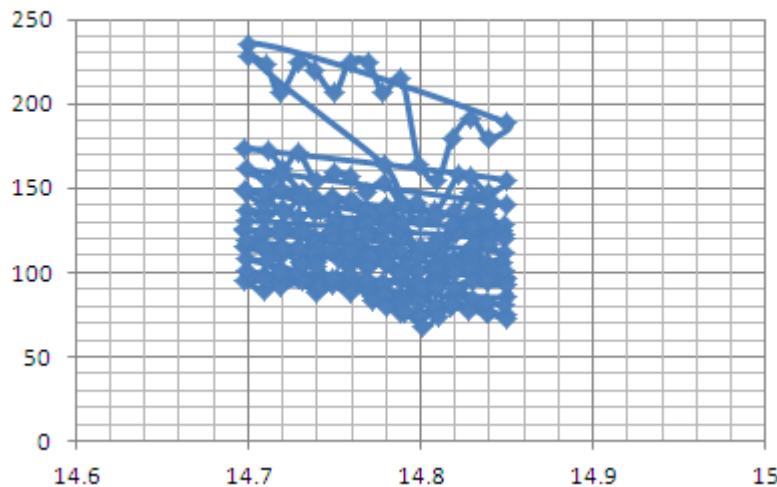
Here's one experimental condition:

Krypton/Argon=10/990 SCCM, Energy range: 14.7~14.84eV, 0.01eV/step, 30sec/point.

$$T_0 = 298.15 \text{ K}, P_{T_0} = 760 \text{ Torr.}$$

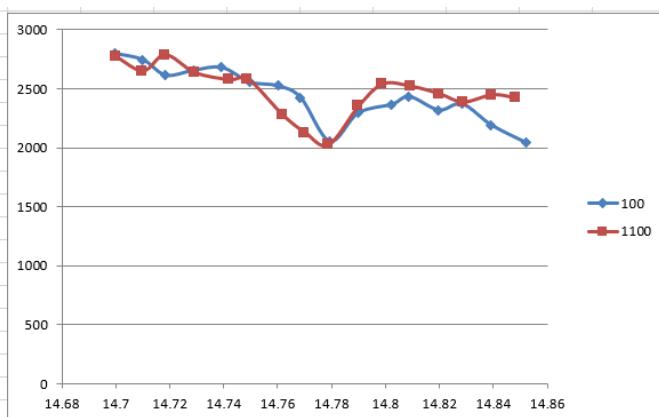
Results are shown below:

Kr

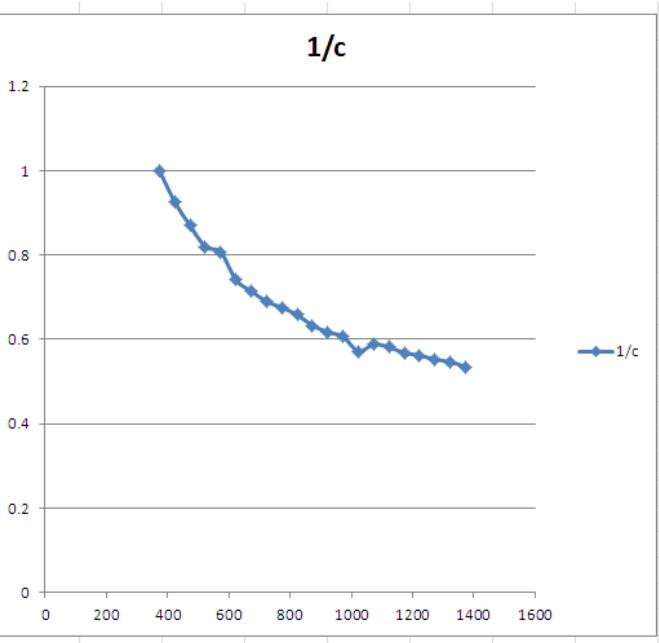


Set $T_1=100^\circ\text{C}=373.15 \text{ K}$. Compare signals between T_2 and T_1 , getting the ratio:

T1	100	T2	1100
Energy (e ⁻)	83.904	Energy (e ⁻)	83.904
14.69954	2800	14.69988	1153
14.70993	2746	14.70993	1103
14.7184	2614	14.71823	1160
14.72877	2656	14.72915	1097
14.7392	2680	14.7421	1072
14.74956	2556	14.74888	1074
14.76001	2524	14.76183	947
14.76846	2422	14.77011	885
14.7792	2053	14.77869	842
14.78974	2293	14.78999	980
14.80233	2367	14.79885	1057
14.8087	2433	14.80934	1049
14.81958	2318	14.82001	1022
14.82826	2370	14.82869	993
14.83905	2191	14.83956	1019
14.85194	2041	14.84818	1008



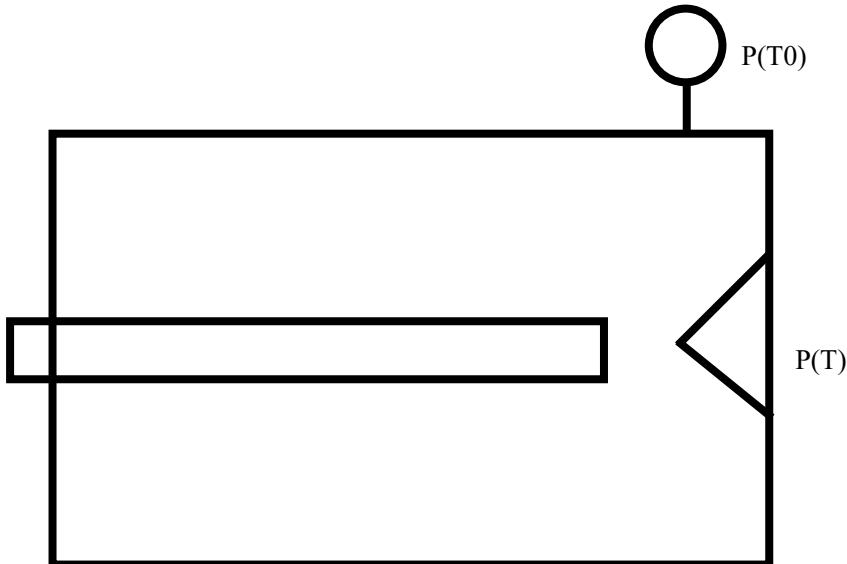
T(°C)	T(K)	c	1/c
0	273.15		
50	323.15		
100	373.15	1	1
150	423.15	1.08	0.925926
200	473.15	1.15	0.869565
250	523.15	1.22	0.819672
300	573.15	1.24	0.806452
350	623.15	1.35	0.740741
400	673.15	1.4	0.714286
450	723.15	1.45	0.689655
500	773.15	1.48	0.675676
550	823.15	1.52	0.657895
600	873.15	1.58	0.632911
650	923.15	1.62	0.617284
700	973.15	1.65	0.606061
750	1023.15	1.75	0.571429
800	1073.15	1.7	0.588235
850	1123.15	1.72	0.581395
900	1173.15	1.76	0.568182
950	1223.15	1.78	0.561798
1000	1273.15	1.81	0.552486
1050	1323.15	1.83	0.546448
1100	1373.15	1.87	0.534759



This picture shows the scheme of the flow tube reactor:

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During experiment, the pressure measured by the gauge keeps constant, but the pressure at the outlet of flow tube varied with temperature changes.

This experimental result should meet the ideal gas law. Thus, we can fit this curve with this equation:

$$FKT(T_2, T_1) = \frac{S_i(T_2)}{S_i(T_1)} = \frac{n_i(T_2)}{n_i(T_1)} = \frac{P_{T_2} \cdot T_1}{P_{T_1} \cdot T_2}$$

We assume $P_T = P_{T_0} + m\Delta T = P_{T_0} + m(T - T_0)$ in this temperature region.

$$FKT(T_2, T_1) = \frac{P_{T_0} + m(T_2 - T_0) \cdot T_1}{P_{T_0} + m(T_1 - T_0) \cdot T_2}$$

The fit below shows well.

$T_0 = 298.15$ K, the room temperature; $P_{T_0} = 760$ Torr or other pressure as the experiment.

If you want to set the FKT “1” at a specific start temperature, change T_1 .

