1. Вычисление коэффициентов уравнения $y = a + bx$ при помощи МНК, для зависимости L от k в углекислом газе.

Для 2909 Гц:

Formula for $< xy >$:

$(1 \cdot 3 + 2 \cdot 47 + 3 \cdot 96 + 4 \cdot 146 + 5 \cdot 196)/5$

Formula for $< x >$:

$(1 + 2 + 3 + 4 + 5)/5$

Formula for $< y >$:

$(3 + 47 + 96 + 146 + 196)/5$

Formula for $< x^2 >$:

$(1^2 + 2^2 + 3^2 + 4^2 + 5^2)/5$

Formula for $< y^2 >$:

$(3^2 + 47^2 + 96^2 + 146^2 + 196^2)/5$

$y = a + bx$

$b = \frac{<xy>-<x><y>}{<x^2>-<x>^2} = \frac{389.80-3.00 \cdot 97.60}{11.00-9.00} = 48.50$

$a =< y > -b < x >= 97.60 - 48.50 \cdot 3.00 = -47.90$

$\sigma_b = \frac{1}{\sqrt{n}} \sqrt{\frac{<y^2>-<y>^2}{<x^2>-<x>^2} - b^2} = \frac{1}{2.236} \sqrt{\frac{14233.200195-9525.759766}{11.000000-9.000000} - 48.500} = 0.542325$

$\sigma_a = \sigma_b \sqrt{< x^2 > - < x >^2} = 0.542325 \sqrt{11.000000 - 9.000000} = 0.766964$

Для 2096 Гц:

Formula for $< xy >$:

$(1 \cdot 0 + 2 \cdot 58 + 3 \cdot 117 + 4 \cdot 181 + 5 \cdot 240)/5$

Formula for $< x >$:

$(1+2+3+4+5)/5$

Formula for $< y >$:

$(0+58+117+181+240)/5$

Formula for $< x^2 >$:

$(1^2+2^2+3^2+4^2+5^2)/5$

Formula for $< y^2 >$:

$(0^2+58^2+117^2+181^2+240^2)/5$

$y = a + bx$

$b = \frac{<xy>-<x><y>}{<x^2>-<x>^2} = \frac{478.20-3.00 \cdot 119.20}{11.00-9.00} = 60.30$

$a =< y > -b < x >= 119.20 - 60.30 \cdot 3.00 = -61.70$

$\sigma_b = \frac{1}{\sqrt{n}} \sqrt{\frac{<y^2>-<y>^2}{<x^2>-<x>^2} - b^2} = \frac{1}{2.236} \sqrt{\frac{21482.800781-14208.639648}{11.000000-9.000000} - 60.300} = 0.444810$

$\sigma_a = \sigma_b \sqrt{< x^2 > - < x >^2} = 0.444810 \sqrt{11.000000 - 9.000000} = 0.629056$

Для 2506 Гц:

Formula for $< xy >$:

$(1 \cdot 5 + 2 \cdot 52 + 3 \cdot 105 + 4 \cdot 157 + 5 \cdot 208)/5$

Formula for $< x >$:

$(1+2+3+4+5)/5$

Formula for $< y >$:

$(5+52+105+157+208)/5$

Formula for $< x^2 >$:

$(1^2 + 2^2 + 3^2 + 4^2 + 5^2)/5$

Formula for $< y^2 >$:

$(5^2 + 52^2 + 105^2 + 157^2 + 208^2)/5$

$y = a + bx$

$b = \frac{<xy> - <x><y>}{<x^2> - <x>^2} = \frac{418.40 - 3.00 \cdot 105.40}{11.00 - 9.00} = 51.10$

$a =< y > -b < x >= 105.40 - 51.10 \cdot 3.00 = -47.90$

$\sigma_b = \frac{1}{\sqrt{n}} \sqrt{\frac{<y^2> - <y>^2}{<x^2> - <x>^2} - b^2} = \frac{1}{2.236} \sqrt{\frac{16333.400391 - 11109.160156}{11.000000 - 9.000000} - 51.100} = 0.426770$

$\sigma_a = \sigma_b \sqrt{< x^2 > - < x >^2} = 0.426770 \sqrt{11.000000 - 9.000000} = 0.603544$

Для 3038 Гц:

Formula for $< xy >$:

$(1 \cdot 6 + 2 \cdot 51 + 3 \cdot 96 + 4 \cdot 140 + 5 \cdot 185)/5$

Formula for $< x >$:

$(1 + 2 + 3 + 4 + 5)/5$

Formula for $< y >$:

$(6 + 51 + 96 + 140 + 185)/5$

Formula for $< x^2 >$:

$(1^2 + 2^2 + 3^2 + 4^2 + 5^2)/5$

Formula for $< y^2 >$:

$(6^2 + 51^2 + 96^2 + 140^2 + 185^2)/5$

$y = a + bx$

$b = \frac{<xy> - <x><y>}{<x^2> - <x>^2} = \frac{376.20 - 3.00 \cdot 95.60}{11.00 - 9.00} = 44.70$

$a = < y > - b < x > = 95.60 - 44.70 \cdot 3.00 = -38.50$

$\sigma_b = \frac{1}{\sqrt{n}} \sqrt{\frac{<y^2> - <y>^2}{<x^2> - <x>^2} - b^2} = \frac{1}{2.236} \sqrt{\frac{13135.599609 - 9139.359375}{11.000000 - 9.000000} - 44.700} = 0.076638$

$\sigma_a = \sigma_b \sqrt{< x^2 > - < x >^2} = 0.076638 \sqrt{11.000000 - 9.000000} = 0.108382$

2. Вычисление коэффициентов уравнения $y = a + bx$ при помощи МНК, для зависимости L от k в воздухе.

Для 3475 Гц:

Formula for $< xy >$:

$(1 \cdot 5 + 2 \cdot 48 + 3 \cdot 99 + 4 \cdot 148 + 5 \cdot 198)/5$

Formula for $< x >$:

$(1 + 2 + 3 + 4 + 5)/5$

Formula for $< y >$:

$(5 + 48 + 99 + 148 + 198)/5$

Formula for $< x^2 >$:

$(1^2 + 2^2 + 3^2 + 4^2 + 5^2)/5$

Formula for $< y^2 >$:

$(5^2 + 48^2 + 99^2 + 148^2 + 198^2)/5$

$y = a + bx$

$b = \frac{<xy> - <x><y>}{<x^2> - <x>^2} = \frac{396.00 - 3.00 \cdot 99.60}{11.00 - 9.00} = 48.60$

$a =< y > -b < x >= 99.60 - 48.60 \cdot 3.00 = -46.20$

$\sigma_b = \frac{1}{\sqrt{n}} \sqrt{\frac{<y^2>-<y>^2}{<x^2>-<x>^2} - b^2} = \frac{1}{2.236} \sqrt{\frac{14647.599609-9920.160156}{11.000000-9.000000} - 48.600} = 0.593212$

$\sigma_a = \sigma_b \sqrt{< x^2 > - < x >^2} = 0.593212 \sqrt{11.000000 - 9.000000} = 0.838929$

Для 4052 Гц:

Formula for $< xy >$:

$(1 \cdot 0 + 2 \cdot 40 + 3 \cdot 81 + 4 \cdot 120 + 5 \cdot 160)/5$

Formula for $< x >$:

$(1 + 2 + 3 + 4 + 5)/5$

Formula for $< y >$:

$(0 + 40 + 81 + 120 + 160)/5$

Formula for $< x^2 >$:

$(1^2 + 2^2 + 3^2 + 4^2 + 5^2)/5$

Formula for $< y^2 >$:

$(0^2 + 40^2 + 81^2 + 120^2 + 160^2)/5$

$y = a + bx$

$b = \frac{<xy>-<x><y>}{<x^2>-<x>^2} = \frac{320.60-3.00 \cdot 80.20}{11.00-9.00} = 40.00$

$a =< y > -b < x >= 80.20 - 40.00 \cdot 3.00 = -39.80$

$\sigma_b = \frac{1}{\sqrt{n}}\sqrt{\frac{<y^2>-<y>^2}{<x^2>-<x>^2} - b^2} = \frac{1}{2.236}\sqrt{\frac{9632.200195-6432.039551}{11.000000-9.000000} - 40.000} = 0.126263$

$\sigma_a = \sigma_b\sqrt{< x^2 > - < x >^2} = 0.126263\sqrt{11.000000 - 9.000000} = 0.178563$

Для 5111 Гц:

Formula for $< xy >$:

$(1 \cdot 0 + 2 \cdot 34 + 3 \cdot 69 + 4 \cdot 101 + 5 \cdot 135)/5$

Formula for $< x >$:

$(1 + 2 + 3 + 4 + 5)/5$

Formula for $< y >$:

$(0 + 34 + 69 + 101 + 135)/5$

Formula for $< x^2 >$:

$(1^2 + 2^2 + 3^2 + 4^2 + 5^2)/5$

Formula for $< y^2 >$:

$(0^2 + 34^2 + 69^2 + 101^2 + 135^2)/5$

$y = a + bx$

$b = \frac{<xy>-<x><y>}{<x^2>-<x>^2} = \frac{270.80-3.00 \cdot 67.80}{11.00-9.00} = 33.70$

$a =< y > -b < x >= 67.80 - 33.70 \cdot 3.00 = -33.30$

$\sigma_b = \frac{1}{\sqrt{n}}\sqrt{\frac{<y^2>-<y>^2}{<x^2>-<x>^2} - b^2} = \frac{1}{2.236}\sqrt{\frac{6868.600098-4596.840332}{11.000000-9.000000} - 33.700} = 0.195245$

$\sigma_a = \sigma_b\sqrt{< x^2 > - < x >^2} = 0.195245\sqrt{11.000000 - 9.000000} = 0.276118$

Для 3890 Гц:

Formula for $< xy >$:

$(1 \cdot 0 + 2 \cdot 40 + 3 \cdot 81 + 4 \cdot 120 + 5 \cdot 160)/5$

Formula for $< x >$:

$(1 + 2 + 3 + 4 + 5)/5$

Formula for $< y >$:

$(0 + 40 + 81 + 120 + 160)/5$

Formula for $< x^2 >$:

$(1^2 + 2^2 + 3^2 + 4^2 + 5^2)/5$

Formula for $< y^2 >$:

$(0^2 + 40^2 + 81^2 + 120^2 + 160^2)/5$

$y = a + bx$

$b = \frac{<xy>-<x><y>}{<x^2>-<x>^2} = \frac{320.60-3.00 \cdot 80.20}{11.00-9.00} = 40.00$

$a =< y > -b < x >= 80.20 - 40.00 \cdot 3.00 = -39.80$

$\sigma_b = \frac{1}{\sqrt{n}} \sqrt{\frac{<y^2>-<y>^2}{<x^2>-<x>^2} - b^2} = \frac{1}{2.236} \sqrt{\frac{9632.200195-6432.039551}{11.000000-9.000000} - 40.000} = 0.126263$

$\sigma_a = \sigma_b \sqrt{< x^2 > - < x >^2} = 0.126263 \sqrt{11.000000 - 9.000000} = 0.178563$

3. Вычисление коэффициентов уравнения $y = a + bx$ при помощи МНК, для зависимости f от k.

Для воздуха:

Formula for $< xy >$:

$(6{\cdot}1071{+}7{\cdot}1280{+}8{\cdot}1501{+}9{\cdot}1713{+}10{\cdot}1922{+}12{\cdot}2312{+}14{\cdot}2598{+}15{\cdot}2805)/8$

Formula for $< x >$:

$(6 + 7 + 8 + 9 + 10 + 12 + 14 + 15)/8$

Formula for $< y >$:

$(1071 + 1280 + 1501 + 1713 + 1922 + 2312 + 2598 + 2805)/8$

Formula for $< x^2 >$:

$(6^2 + 7^2 + 8^2 + 9^2 + 10^2 + 12^2 + 14^2 + 15^2)/8$

Formula for $< y^2 >$:

$(1071^2 + 1280^2 + 1501^2 + 1713^2 + 1922^2 + 2312^2 + 2598^2 + 2805^2)/8$

$y = a + bx$

$b = \frac{<xy>-<x><y>}{<x^2>-<x>^2} = \frac{21027.75-10.13{\cdot}1900.25}{111.88-102.52} = 191.1$

$a =< y > -b < x >= 1900.25 - 191.01 \cdot 10.13 = -33.71$

$\sigma_b = \frac{1}{\sqrt{n}}\sqrt{\frac{<y^2>-<y>^2}{<x^2>-<x>^2} - b^2} = \frac{1}{2.828}\sqrt{\frac{3953733.500000-3610950.000000}{111.875000-102.515625} - 191.008} = 4.189659$

$\sigma_a = \sigma_b\sqrt{< x^2 > - < x >^2} = 4.189659\sqrt{111.875000 - 102.515625} = 12.817463$

Для углекислого газа:

Formula for $< xy >$:

$(5{\cdot}1003{+}7{\cdot}1322{+}8{\cdot}1501{+}9{\cdot}1673{+}10{\cdot}1803{+}12{\cdot}2350{+}13{\cdot}2505{+}17{\cdot}3159)/8$

Formula for $< x >$:

$(5 + 7 + 8 + 9 + 10 + 12 + 13 + 17)/8$

Formula for $< y >$:

$(1003 + 1322 + 1501 + 1673 + 1803 + 2350 + 2505 + 3159)/8$

Formula for $< x^2 >$:

$(5^2 + 7^2 + 8^2 + 9^2 + 10^2 + 12^2 + 13^2 + 17^2)/8$

Formula for $< y^2 >$:

$(1003^2 + 1322^2 + 1501^2 + 1673^2 + 1803^2 + 2350^2 + 2505^2 + 3159^2)/8$

$y = a + bx$

$b = \frac{<xy>-<x><y>}{<x^2>-<x>^2} = \frac{21729.00-10.13\cdot 1914.50}{115.13-102.52} = 185.95$

$a =< y > -b < x >= 1914.50 - 185.95 \cdot 10.13 = 31.78$

$\sigma_b = \frac{1}{\sqrt{n}}\sqrt{\frac{<y^2>-<y>^2}{<x^2>-<x>^2} - b^2} = \frac{1}{2.828}\sqrt{\frac{4104154.500000-3665310.250000}{115.125000-102.515625} - 185.948} = 5.319453$

$\sigma_a = \sigma_b\sqrt{< x^2 > - < x >^2} = 5.319453\sqrt{115.125000 - 102.515625} = 18.889210$

4. Вычисление коэффициентов уравнения $y = a + bx$ при помощи МНК, для зависимости f от k.

Для $T = 303,2$ ***K*:**

Formula for $< xy >$:

$(1 \cdot 256 + 2 \cdot 502 + 3 \cdot 752 + 4 \cdot 1005 + 5 \cdot 1246)/5$

Formula for $< x >$:

$(1 + 2 + 3 + 4 + 5)/5$

Formula for $< y >$:

$(256 + 502 + 752 + 1005 + 1246)/5$

Formula for $< x^2 >$:

$(1^2 + 2^2 + 3^2 + 4^2 + 5^2)/5$

Formula for $< y^2 >$:

$(256^2 + 502^2 + 752^2 + 1005^2 + 1246^2)/5$

$y = a + bx$

$b = \frac{<xy>-<x><y>}{<x^2>-<x>^2} = \frac{2753.20-3.00 \cdot 752.20}{11.00-9.00} = 248.30$

$a =< y > -b < x >= 752.20 - 248.30 \cdot 3.00 = 7.30$

$\sigma_b = \frac{1}{\sqrt{n}} \sqrt{\frac{<y^2>-<y>^2}{<x^2>-<x>^2} - b^2} = \frac{1}{2.236} \sqrt{\frac{689117.000000-565804.875000}{11.000000-9.000000} - 248.300} = 0.799214$

$\sigma_a = \sigma_b \sqrt{< x^2 > - < x >^2} = 0.799214 \sqrt{11.000000 - 9.000000} = 1.130260$

Для $T = 313,2$ ***K*:**

Formula for $< xy >$:

$(1 \cdot 267 + 2 \cdot 514 + 3 \cdot 768 + 4 \cdot 1024 + 5 \cdot 1280)/5$

Formula for $< x >$:

$(1 + 2 + 3 + 4 + 5)/5$

Formula for $< y >$:

$(267 + 514 + 768 + 1024 + 1280)/5$

Formula for $< x^2 >$:

$(1^2 + 2^2 + 3^2 + 4^2 + 5^2)/5$

Formula for $< y^2 >$:

$(267^2 + 514^2 + 768^2 + 1024^2 + 1280^2)/5$

$y = a + bx$

$b = \frac{<xy> - <x><y>}{<x^2> - <x>^2} = \frac{2819.00 - 3.00 \cdot 770.60}{11.00 - 9.00} = 253.60$

$a =< y > -b < x >= 770.60 - 253.60 \cdot 3.00 = 9.80$

$\sigma_b = \frac{1}{\sqrt{n}} \sqrt{\frac{<y^2> - <y>^2}{<x^2> - <x>^2} - b^2} = \frac{1}{2.236} \sqrt{\frac{722457.000000 - 593824.312500}{11.000000 - 9.000000} - 253.600} = 0.820387$

$\sigma_a = \sigma_b \sqrt{< x^2 > - < x >^2} = 0.820387 \sqrt{11.000000 - 9.000000} = 1.160203$

Для $T = 323,2$ ***K*:**

Formula for $< xy >$:

$(1 \cdot 270 + 2 \cdot 520 + 3 \cdot 773 + 4 \cdot 1034 + 5 \cdot 1283)/5$

Formula for $< x >$:

$(1 + 2 + 3 + 4 + 5)/5$

Formula for $< y >$:

$(270 + 520 + 773 + 1034 + 1283)/5$

Formula for $< x^2 >$:

$(1^2 + 2^2 + 3^2 + 4^2 + 5^2)/5$

Formula for $< y^2 >$:

$(270^2 + 520^2 + 773^2 + 1034^2 + 1283^2)/5$

$y = a + bx$

$b = \frac{<xy>-<x><y>}{<x^2>-<x>^2} = \frac{2836.00-3.00\cdot 776.00}{11.00-9.00} = 254.00$

$a =< y > -b < x >= 776.00 - 254.00 \cdot 3.00 = 14.00$

$\sigma_b = \frac{1}{\sqrt{n}}\sqrt{\frac{<y^2>-<y>^2}{<x^2>-<x>^2} - b^2} = \frac{1}{2.236}\sqrt{\frac{731214.812500-602176.000000}{11.000000-9.000000} - 254.000} = 0.825379$

$\sigma_a = \sigma_b\sqrt{< x^2 > - < x >^2} = 0.825379\sqrt{11.000000 - 9.000000} = 1.167262$

Для $T = 333,2$ ***K*:**

Formula for $< xy >$:

$(1 \cdot 275 + 2 \cdot 524 + 3 \cdot 780 + 4 \cdot 1027 + 5 \cdot 1301)/5$

Formula for $< x >$:

$(1 + 2 + 3 + 4 + 5)/5$

Formula for $< y >$:

$(275 + 524 + 780 + 1027 + 1301)/5$

Formula for $< x^2 >$:

$(1^2 + 2^2 + 3^2 + 4^2 + 5^2)/5$

Formula for $< y^2 >$:

$(275^2 + 524^2 + 780^2 + 1027^2 + 1301^2)/5$

$y = a + bx$

$b = \frac{<xy>-<x><y>}{<x^2>-<x>^2} = \frac{2855.20-3.00\cdot 781.40}{11.00-9.00} = 255.50$

$a =< y > -b < x >= 781.40 - 255.50 \cdot 3.00 = 14.90$

$\sigma_b = \frac{1}{\sqrt{n}}\sqrt{\frac{<y^2>-<y>^2}{<x^2>-<x>^2} - b^2} = \frac{1}{2.236}\sqrt{\frac{741186.187500-610586.000000}{11.000000-9.000000} - 255.500} = 1.993737$

$\sigma_a = \sigma_b\sqrt{< x^2 > - < x >^2} = 1.993737\sqrt{11.000000 - 9.000000} = 2.819570$