<div align="center">

cases

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Denote $p^{\min} := p^{\min\{0, v_2 + v_{11}\}}$

Denote $\rho := (1 - p^{-1})$

Denote $f(p, t)$ the p and t product $p^{7v_1 + 10v_2 + 11v_3 + 7v_4 + \min\{v_1, v_4\}} t^{4v_1 + 6v_2 + 6v_3 + 4v_4}$

1   Case 1

$v_3 > v_1 \geq v_4 > v_2 \geq 0$

$\Rightarrow v_{11} \geq -v_2 - v_1$

$\Rightarrow \alpha := \min\{v_2, v_2 + v_{11} + v_1\} = \begin{cases} v_2, & v_{11} \geq -v_1 \\ v_2 - 1, v_2 - 2, \ldots, & v_{11} < -v_1 \end{cases}$

$\Rightarrow f(p, t) = p^{7v_1 + 10v_2 + 11v_3 + 7v_4 + v_4} t^{4v_1 + 6v_2 + 6v_3 + 4v_4} = p^{7v_1 + 10v_2 + 11v_3 + 8v_4} t^{4v_1 + 6v_2 + 6v_3 + 4v_4}$

For $v_{11} \geq -v_2$, we have $p^{\min}(1 + \alpha\rho)\mu(a_{11}) = p^{v_2}(1 + v_2\rho)$.

For $-v_1 \leq v_{11} \leq -v_2 - 1$, we have $p^{\min}(1 + \alpha\rho)\mu(a_{11}) = \sum_{-v_1}^{-v_2 - 1} p^{v_2}\rho(1 + v_2\rho) = p^{v_2}(v_1 - v_2)\rho(1 + v_2\rho) = p^{v_2}(v_1 - v_2)\rho + p^{v_2}v_2(v_1 - v_2)\rho^2$.

For $-v_2 - v_1 \leq v_{11} \leq -v_1 - 1$, we have $p^{\min}(1 + \alpha\rho)\mu(a_{11}) = \sum_{-v_2 - v_1}^{-v_1 - 1} p^{v_2}\rho(1 + \alpha\rho) = \sum_{i=1}^{v_2} p^{v_2}\rho(1 + (v_2 - i)\rho) = p^{v_2}v_2\rho + p^{v_2}v_2^2\rho^2 - p^{v_2}\binom{v_2 + 1}{2}\rho^2$.

So we have $\sum_{v_{11} \geq -v_2 - v_1} = p^{v_2}(1 + v_2\rho + (v_1 - v_2)\rho + v_2(v_1 - v_2)\rho^2 + v_2\rho + v_2^2\rho^2 - \frac{(v_2 + 1)v_2}{2}\rho^2) = p^{v_2}(1 + v_1\rho + v_2 v_1\rho^2 + v_2\rho - \frac{v_2^2}{2}\rho^2 - \frac{v_2}{2}\rho^2)$. We compute the differences between v_1, v_2, v_3, v_4,

$v_3 \overset{d}{>} v_1 \overset{c}{\geq} v_4 \overset{b}{>} v_2 \overset{a}{\geq} 0$

Thus, we substitute $v_1 \to a + b + c$, $v_2 \to a$, $v_3 \to a + b + c + d$, $v_4 \to a + b$, and compute series with the new variables as indices, where $a, c \geq 0$ and $b, d \geq 1$.

2   Case 2

$v_1 \geq v_3 \geq 0$

$v_1 \geq v_4 > v_2 \geq 0$

$\Rightarrow v_{11} \geq -v_2 - v_3$

$\Rightarrow \alpha := \min\{v_2, v_2 + v_{11} + v_1\} = \begin{cases} v_2, & v_{11} \geq -v_1 \\ v_2 - 1, v_2 - 2, \ldots, & v_{11} < -v_1 \end{cases}$

$\Rightarrow f(p, t) = p^{7v_1 + 10v_2 + 11v_3 + 7v_4 + v_4} t^{4v_1 + 6v_2 + 6v_3 + 4v_4} = p^{7v_1 + 10v_2 + 11v_3 + 8v_4} t^{4v_1 + 6v_2 + 6v_3 + 4v_4}$

We have two sub cases.

2.1 Sub case 2.1

$-v_2 - v_3 \geq -v_1 \Rightarrow v_1 \geq v_2 + v_3$

Here there is no phase transition, because the phase transition occurs at $-v_1 - 1 < -v_2 - v_3 \leq v_{11}$

For $v_{11} \geq -v_2$, we have $p^{\min}(1 + \alpha\rho)\mu(a_{11}) = p^{v_2}(1 + v_2\rho)$.

For $-v_2 - v_3 \leq v_{11} \leq -v_2 - 1$, we have $p^{\min}(1+\alpha\rho)\mu(a_{11}) = \sum_{-v_2-v_3}^{-v_2-1} p^{v_2}\rho(1+ v_2\rho) = p^{v_2}v_3\rho(1 + v_2\rho) = p^{v_2}v_3\rho + p^{v_2}v_3v_2\rho^2$.

So we have $\sum_{v_{11} \geq -v_2 - v_3} = p^{v_2}(1 + v_2\rho + v_3\rho + v_2v_3\rho^2)$.

We compute the differences between v_1, v_2, v_3, v_4, we have several arrangements,

1. $v_1 \overset{d}{\geq} v_2 + v_3 \overset{a}{\geq} v_3 \overset{c}{\geq} v_4 \overset{b}{>} v_2 \overset{a}{\geq} 0$

   Thus, we substitute $v_1 \to 2a + b + c + d$, $v_2 \to a$, $v_3 \to a + b + c$, $v_4 \to a + b$, and compute series with the new variables as indices, where $a, c, d \geq 0$ and $b \geq 1$.

2. $v_1 \overset{d}{\geq} v_2 + v_3 \overset{c}{\geq} v_4 \overset{b}{>} v_3 \overset{a}{>} v_2 \overset{e}{\geq} 0$

   But $v_2 + v_3 - c - b = v_3 \Rightarrow v_2 = v_2 + v_3 - v_3 = b + c$

   Thus, we substitute $v_1 \to a + 2b + 2c + d$, $v_2 \to b + c$, $v_3 \to a + b + c$, $v_4 \to a + 2b + c$, and compute series with the new variables as indices, where $c, d \geq 0$ and $a, b \geq 1$.

3. $v_1 \overset{d}{\geq} v_2 + v_3 \overset{c}{\geq} v_4 \overset{b}{>} v_2 \overset{a}{\geq} v_3 \overset{e}{\geq} 0$

   But $v_2 + v_3 - c - b = v_2 \Rightarrow v_3 = v_2 + v_3 - v_2 = b + c$

   Thus, we substitute $v_1 \to a + 2b + 2c + d$, $v_2 \to a + b + c$, $v_3 \to b + c$, $v_4 \to a + 2b + c$, and compute series with the new variables as indices, where $a, c, d \geq 0$ and $b \geq 1$.

4. $v_1 \overset{d}{\geq} v_4 \overset{c}{>} v_2 + v_3 \overset{a}{\geq} v_2 \overset{b}{\geq} v_3 \overset{a}{\geq} 0$

   Thus, we substitute $v_1 \to 2a + b + c + d$, $v_2 \to a + b$, $v_3 \to a$, $v_4 \to 2a + b + c$, and compute series with the new variables as indices, where $a, b, d \geq 0$ and $c \geq 1$.

5. $v_1 \overset{d}{\geq} v_4 \overset{c}{>} v_2 + v_3 \overset{a}{\geq} v_3 \overset{b}{>} v_2 \overset{a}{\geq} 0$

   Thus, we substitute $v_1 \to 2a + b + c + d$, $v_2 \to a$, $v_3 \to a + b$, $v_4 \to 2a + b + c$, and compute series with the new variables as indices, where $a, d \geq 0$ and $b, c \geq 1$.

2.2 Sub case 2.2

$-v_2 - v_3 < -v_1 \Rightarrow v_1 < v_2 + v_3$

For $v_{11} \geq -v_2$, we have $p^{\min}(1 + \alpha\rho)\mu(a_{11}) = p^{v_2}(1 + v_2\rho)$.

For $-v_1 \leq v_{11} \leq -v_2 - 1$, we have $p^{\min}(1 + \alpha\rho)\mu(a_{11}) = \sum_{-v_1}^{-v_2-1} p^{v_2}\rho(1 + v_2\rho) = p^{v_2}(v_1 - v_2)\rho(1 + v_2\rho) = p^{v_2}(v_1 - v_2)\rho + p^{v_2}(v_1 - v_2)v_2\rho^2$.

For $-v_2 - v_3 \leq v_{11} \leq -v_1 - 1$, we have $p^{\min}(1 + \alpha\rho)\mu(a_{11}) = \sum_{-v_2-v_3}^{-v_1-1} p^{v_2}\rho(1 + \alpha\rho) = \sum_{i=1}^{v_2+v_3-v_1} p^{v_2}\rho(1 + (v_2 - i)\rho) = p^{v_2}(v_2 + v_3 - v_1)\rho + p^{v_2}(v_2 + v_3 - v_1)v_2\rho^2 - p^{v_2}\binom{v_2+v_3-v_1+1}{2}\rho^2$.

So we have $\sum_{v_{11} \geq -v_2 - v_3} = p^{v_2}(1 + v_2\rho + (v_1 - v_2)\rho + (v_1 - v_2)v_2\rho^2 + (v_2 + v_3 - v_1)\rho + (v_2 + v_3 - v_1)v_2\rho^2 - \frac{(v_2+v_3-v_1+1)(v_2+v_3-v_1)}{2}\rho^2) = p^{v_2}(1 + v_2\rho + v_3\rho - \frac{v_2^2}{2}\rho^2 + \frac{v_2 v_1}{2}\rho^2 - \frac{v_3^2}{2}\rho^2 + \frac{v_3 v_1}{2}\rho^2 + \frac{v_1 v_2}{2}\rho^2 + \frac{v_1 v_3}{2}\rho^2 - \frac{v_1^2}{2}\rho^2 - \frac{v_2}{2}\rho^2 - \frac{v_3}{2}\rho^2 + \frac{v_1}{2}\rho^2) = p^{v_2}(1 + v_2\rho + v_3\rho - \frac{v_2^2}{2}\rho^2 + v_2 v_1\rho^2 - \frac{v_3^2}{2}\rho^2 + v_3 v_1\rho^2 - \frac{v_1^2}{2}\rho^2 - \frac{v_2}{2}\rho^2 - \frac{v_3}{2}\rho^2 + \frac{v_1}{2}\rho^2)$.

We compute the differences between v_1, v_2, v_3, v_4, we have several arrangements,

1. $v_2 + v_3 \overset{d}{>} v_1 \overset{c}{\geq} v_3 \overset{b}{\geq} v_4 \overset{a}{>} v_2 \overset{e}{\geq} 0$

   But $v_2 + v_3 - d - c = v_3 \Rightarrow v_2 = c + d$

   Thus, we substitute $v_1 \to a + b + 2c + d$, $v_2 \to c + d$, $v_3 \to a + b + c + d$, $v_4 \to a + c + d$, and compute series with the new variables as indices, where $b, c \geq 0$ and $a, d \geq 1$.

2. $v_2 + v_3 \overset{d}{>} v_1 \overset{c}{\geq} v_4 \overset{b}{>} v_3 \overset{a}{>} v_2 \overset{e}{\geq} 0$

   But $v_2 + v_3 - d - c - b = v_3 \Rightarrow v_2 = v_2 + v_3 - v_3 = b + c + d$

   Thus, we substitute $v_1 \to a + 2b + 2c + d$, $v_2 \to b + c + d$, $v_3 \to a + b + c + d$, $v_4 \to a + 2b + c + d$, and compute series with the new variables as indices, where $c \geq 0$ and $a, b, d \geq 1$.

3. $v_2 + v_3 \overset{d}{>} v_1 \overset{c}{\geq} v_4 \overset{b}{>} v_2 \overset{a}{\geq} v_3 \overset{e}{\geq} 0$

   But $v_2 + v_3 - d - c - b = v_2 \Rightarrow v_3 = v_2 + v_3 - v_2 = b + c + d$

   Thus, we substitute $v_1 \to a + 2b + 2c + d$, $v_2 \to a + b + c + d$, $v_3 \to b + c + d$, $v_4 \to a + 2b + c + d$, and compute series with the new variables as indices, where $a, c \geq 0$ and $b, d \geq 1$.

3 Case 3

$v_3 > v_1 \geq 0$
$\quad v_4 > v_1 \geq 0$
$\quad v_4 > v_2 \geq 0$
$\Rightarrow v_{11} \geq -v_2 - v_1$
$\Rightarrow \alpha := \min\{v_2, v_2 + v_{11} + v_4\} = \begin{cases} v_2, & v_{11} \geq -v_4 \\ v_2 - 1, v_2 - 2, \ldots, & v_{11} < -v_4 \end{cases}$
$\Rightarrow f(p, t) = p^{7v_1 + 10v_2 + 11v_3 + 7v_4 + v_1} t^{4v_1 + 6v_2 + 6v_3 + 4v_4} = p^{8v_1 + 10v_2 + 11v_3 + 7v_4} t^{4v_1 + 6v_2 + 6v_3 + 4v_4}$
We have two sub cases

3.1   Sub case 3.1

$-v_2 - v_1 \geq -v_4 \Rightarrow v_2 + v_1 \leq v_4$

There is no phase transition here, since $v_{11} \geq -v_2 - v_1 \geq -v_4$

For $v_{11} \geq -v_2$, we have $p^{\min}(1 + \alpha\rho)\mu(a_{11}) = p^{v_2}(1 + v_2\rho)$.

For $-v_2 - v_1 \leq v_{11} \leq -v_2 - 1$, we have $p^{\min}(1+\alpha\rho)\mu(a_{11}) = \sum_{-v_2-v_1}^{-v_2-1} p^{v_2}\rho(1+ v_2\rho) = p^{v_2}v_1\rho + p^{v_2}v_1v_2\rho^2$.

So we have $\sum_{v_{11} \geq -v_2 - v_1} p^{\min}(1 + \alpha\rho)\mu(a_{11}) = p^{v_2}(1 + v_2\rho + v_1\rho + v_1v_2\rho^2)$.

We have several arrangements,

1. $v_4 \overset{d}{\geq} v_1 + v_2 \overset{c}{\geq} v_3 \overset{b}{>} v_2 \overset{a}{>} v_1 \overset{e}{\geq} 0$

   But $v_1 + v_2 - c - b = v_2 \Rightarrow v_1 = v_1 + v_2 - v_2 = b + c$

   Thus, we substitute $v_1 \to b + c$, $v_2 \to a + b + c$, $v_3 \to a + 2b + c$, $v_4 \to a + 2b + 2c + d$, and compute series with the new variables as indices, where $c, d \geq 0$ and $a, b \geq 1$.

2. $v_4 \overset{d}{\geq} v_1 + v_2 \overset{a}{\geq} v_2 \overset{c}{\geq} v_3 \overset{b}{>} v_1 \overset{a}{\geq} 0$

   We substitute $v_1 \to a$, $v_2 \to a + b + c$, $v_3 \to a + b$, $v_4 \to 2a + b + c + d$, and compute series with the new variables as indices, where $a, c, d \geq 0$ and $b \geq 1$.

3. $v_4 \overset{d}{\geq} v_1 + v_2 \overset{c}{\geq} v_3 \overset{b}{>} v_1 \overset{a}{\geq} v_2 \overset{e}{\geq} 0$

   But $v_1 + v_2 - c - b = v_1 \Rightarrow v_2 = v_1 + v_2 - v_1 = b + c$

   We substitute $v_1 \to a + b + c$, $v_2 \to b + c$, $v_3 \to a + 2b + c$, $v_4 \to a + 2b + 2c + d$, and compute series with the new variables as indices, where $a, c, d \geq 0$ and $b \geq 1$.

4. $v_4 \overset{d}{>} v_3 \overset{c}{\geq} v_1 + v_2 \overset{a}{\geq} v_1 \overset{b}{\geq} v_2 \overset{a}{\geq} 0$

   We substitute $v_1 \to a + b$, $v_2 \to a$, $v_3 \to 2a + b + c$, $v_4 \to 2a + b + c + d$, and compute series with the new variables as indices, where $a, b, c \geq 0$ and $d \geq 1$.

5. $v_4 \overset{d}{>} v_3 \overset{c}{>} v_1 + v_2 \overset{a}{\geq} v_2 \overset{b}{>} v_1 \overset{a}{\geq} 0$

   We substitute $v_1 \to a$, $v_2 \to a + b$, $v_3 \to 2a + b + c$, $v_4 \to 2a + b + c + d$, and compute series with the new variables as indices, where $a \geq 0$ and $b, c, d \geq 1$.

6. $v_3 \overset{d}{\geq} v_4 \overset{c}{>} v_1 + v_2 \overset{a}{\geq} v_2 \overset{b}{>} v_1 \overset{a}{\geq} 0$

   We substitute $v_1 \to a$, $v_2 \to a + b$, $v_3 \to 2a + b + c + d$, $v_4 \to 2a + b + c$, and compute series with the new variables as indices, where $a, d \geq 0$ and $b, c \geq 1$.

7. $v_3 \overset{d}{\geq} v_4 \overset{c}{>} v_1 + v_2 \overset{a}{\geq} v_1 \overset{b}{\geq} v_2 \overset{a}{\geq} 0$

   We substitute $v_1 \to a + b$, $v_2 \to a$, $v_3 \to 2a + b + c + d$, $v_4 \to 2a + b + c$, and compute series with the new variables as indices, where $a, b, d \geq 0$ and $c \geq 1$.

3.2 Sub case 3.2

$-v_2 - v_1 < -v_4 \Rightarrow v_2 + v_1 > v_4$

For $v_{11} \geq -v_2$, we have $p^{\min}(1 + \alpha\rho)\mu(a_{11}) = p^{v_2}(1 + v_2\rho)$.

For $-v_4 \leq v_{11} \leq -v_2 - 1$, we have $p^{\min}(1 + \alpha\rho)\mu(a_{11}) = \sum_{-v_4}^{-v_2 - 1} p^{v_2}\rho(1 + v_2\rho) = p^{v_2}(v_4 - v_2)\rho + p^{v_2}(v_4 - v_2)v_2\rho^2$.

For $-v_2 - v_1 \leq v_{11} \leq -v_4 - 1$, we have $p^{\min}(1 + \alpha\rho)\mu(a_{11}) = \sum_{-v_2 - v_1}^{-v_4 - 1} p^{v_2}\rho(1 + v_2\rho) = \sum_{i=1}^{v_1 + v_2 - v_4} p^{v_2}\rho(1 + (v_2 - i)\rho) = p^{v_2}(v_1 + v_2 - v_4)\rho + p^{v_2}(v_1 + v_2 - v_4)v_2\rho^2 - p^{v_2}\binom{v_1 + v_2 - v_4 + 1}{2}\rho^2$.

So we have $\sum_{v_{11} \geq -v_2 - v_1} p^{\min}(1 + \alpha\rho)\mu(a_{11}) = p^{v_2}(1 + v_2\rho + (v_4 - v_2)\rho + (v_4 - v_2)v_2\rho^2 + (v_1 + v_2 - v_4)\rho + (v_1 + v_2 - v_4)v_2\rho^2 - \frac{(v_1 + v_2 - v_4 + 1)(v_1 + v_2 - v_4)}{2}\rho^2) = p^{v_2}(1 + v_1\rho + v_2\rho + v_1 v_2\rho^2 - \frac{v_1^2}{2}\rho^2 - v_2 v_1\rho^2 + v_4 v_1\rho^2 - \frac{v_2^2}{2}\rho^2 + v_4 v_2\rho^2 - \frac{v_4^2}{2}\rho^2 - \frac{v_1}{2}\rho^2 - \frac{v_2}{2}\rho^2 + \frac{v_4}{2}\rho^2)$

We have several arrangements,

1. $v_1 + v_2 \overset{d}{>} v_4 \overset{c}{>} v_3 \overset{b}{>} v_2 \overset{a}{>} v_1 \overset{e}{\geq} 0$

   But $v_1 + v_2 - d - c - b = v_2 \Rightarrow v_1 = v_1 + v_2 - v_2 = b + c + d$

   Thus, we substitute $v_1 \to b + c + d$, $v_2 \to a + b + c + d$, $v_3 \to a + 2b + c + d$, $v_4 \to a + 2b + 2c + d$, and compute series with the new variables as indices, where $a, b, c, d \geq 1$

2. $v_1 + v_2 \overset{d}{>} v_4 \overset{c}{>} v_2 \overset{b}{\geq} v_3 \overset{a}{>} v_1 \overset{e}{\geq} 0$

   But $v_1 + v_2 - d - c = v_2 \Rightarrow v_1 = v_1 + v_2 - v_2 = c + d$

   Thus, we substitute $v_1 \to c + d$, $v_2 \to a + b + c + d$, $v_3 \to a + c + d$, $v_4 \to a + b + 2c + d$, and compute series with the new variables as indices, where $b \geq 0$ and $a, c, d \geq 1$

3. $v_1 + v_2 \overset{d}{>} v_4 \overset{c}{>} v_3 \overset{b}{>} v_1 \overset{a}{\geq} v_2 \overset{e}{\geq} 0$

   But $v_1 + v_2 - d - c - b = v_1 \Rightarrow v_2 = v_1 + v_2 - v_1 = b + c + d$

   Thus, we substitute $v_1 \to a + b + c + d$, $v_2 \to b + c + d$, $v_3 \to a + 2b + c + d$, $v_4 \to a + 2b + 2c + d$, and compute series with the new variables as indices, where $a \geq 0$ and $b, c, d \geq 1$

4. $v_1 + v_2 \overset{d}{>} v_3 \overset{c}{\geq} v_4 \overset{b}{>} v_2 \overset{a}{>} v_1 \overset{e}{\geq} 0$

   But $v_1 + v_2 - d - c - b = v_2 \Rightarrow v_1 = v_1 + v_2 - v_2 = b + c + d$

Thus, we substitute $v_1 \to b + c + d$, $v_2 \to a + b + c + d$, $v_3 \to a + 2b + 2c + d$, $v_4 \to a + 2b + c + d$, and compute series with the new variables as indices, where $c \geq 0$ and $a, b, d \geq 1$

5. $v_1 + v_2 \overset{d}{>} v_3 \overset{c}{\geq} v_4 \overset{b}{>} v_1 \overset{a}{\geq} v_2 \overset{e}{\geq} 0$

But $v_1 + v_2 - d - c - b = v_1 \Rightarrow v_2 = v_1 + v_2 - v_1 = b + c + d$

Thus, we substitute $v_1 \to a + b + c + d$, $v_2 \to b + c + d$, $v_3 \to a + 2b + 2c + d$, $v_4 \to a + 2b + c + d$, and compute series with the new variables as indices, where $a, c \geq 0$ and $b, d \geq 1$

6. $v_3 \overset{d}{\geq} v_1 + v_2 \overset{c}{>} v_4 \overset{b}{>} v_2 \overset{a}{>} v_1 \overset{e}{\geq} 0$

But $v_1 + v_2 - c - b = v_2 \Rightarrow v_1 = v_1 + v_2 - v_2 = b + c$

Thus, we substitute $v_1 \to b + c$, $v_2 \to a + b + c$, $v_3 \to a + 2b + 2c + d$, $v_4 \to a + 2b + c$, and compute series with the new variables as indices, where $d \geq 0$ and $a, b, c \geq 1$

7. $v_3 \overset{d}{\geq} v_1 + v_2 \overset{c}{>} v_4 \overset{b}{>} v_1 \overset{a}{\geq} v_2 \overset{e}{\geq} 0$

But $v_1 + v_2 - c - b = v_1 \Rightarrow v_2 = v_1 + v_2 - v_1 = b + c$

Thus, we substitute $v_1 \to a + b + c$, $v_2 \to b + c$, $v_3 \to a + 2b + 2c + d$, $v_4 \to a + 2b + c$, and compute series with the new variables as indices, where $a, d \geq 0$ and $b, c \geq 1$

4 Case 4

$v_4 > v_1 \geq v_3 \geq 0$
$\quad v_4 > v_2 \geq 0$
$\quad \Rightarrow v_{11} \geq -v_2 - v_3$
$\quad \Rightarrow \alpha := \min\{v_2, v_2 + v_{11} + v_4\} = \begin{cases} v_2, & v_{11} \geq -v_4 \\ v_2 - 1, v_2 - 2, \ldots, & v_{11} < -v_4 \end{cases}$
$\quad \Rightarrow f(p, t) = p^{7v_1 + 10v_2 + 11v_3 + 7v_4 + v_1} t^{4v_1 + 6v_2 + 6v_3 + 4v_4} = p^{8v_1 + 10v_2 + 11v_3 + 7v_4} t^{4v_1 + 6v_2 + 6v_3 + 4v_4}$
We have two sub cases

4.1 Sub case 4.1

$-v_2 - v_3 \geq -v_4 \Rightarrow v_2 + v_3 \leq v_4$
There is no phase transition here, since $v_{11} \geq -v_2 - v_3 \geq -v_4$
For $v_{11} \geq -v_2$, we have $p^{\min}(1 + \alpha\rho)\mu(a_{11}) = p^{v_2}(1 + v_2\rho)$.
For $-v_2 - v_3 \leq v_{11} \leq -v_2 - 1$, we have $p^{\min}(1 + \alpha\rho)\mu(a_{11}) = \sum_{-v_2 - v_3}^{-v_2 - 1} p^{v_2}\rho(1 + v_2\rho) = p^{v_2}v_3\rho(1 + v_2\rho) = p^{v_2}v_3\rho + p^{v_2}v_2v_3\rho^2$.
So we have $\sum_{v_{11} \geq -v_2 - v_3} p^{\min}(1 + \alpha\rho)\mu(a_{11}) = p^{v_2}(1 + v_2\rho + v_3\rho + v_2v_3\rho^2)$.
We have several arrangements,

1. $v_4 \overset{d}{\geq} v_2 + v_3 \overset{c}{\geq} v_1 \overset{b}{\geq} v_3 \overset{a}{>} v_2 \overset{e}{\geq} 0$

   But $v_2 + v_3 - c - b = v_3 \Rightarrow v_2 = v_2 + v_3 - v_3 = b + c$

   Thus, we substitute $v_1 \rightarrow a + 2b + c$, $v_2 \rightarrow b + c$, $v_3 \rightarrow a + b + c$, $v_4 \rightarrow a + 2b + 2c + d$, and compute series with the new variables as indices, where $b, c, d \geq 0$ and $a \geq 1$

2. $v_4 \overset{d}{\geq} v_2 + v_3 \overset{c}{\geq} v_1 \overset{b}{\geq} v_2 \overset{a}{\geq} v_3 \overset{e}{\geq} 0$

   But $v_2 + v_3 - c - b = v_2 \Rightarrow v_3 = v_2 + v_3 - v_2 = b + c$

   Thus, we substitute $v_1 \rightarrow a + 2b + c$, $v_2 \rightarrow a + b + c$, $v_3 \rightarrow b + c$, $v_4 \rightarrow a + 2b + 2c + d$, and compute series with the new variables as indices, where $a, b, c, d \geq 0$.

3. $v_4 \overset{d}{\geq} v_2 + v_3 \overset{a}{\geq} v_2 \overset{c}{>} v_1 \overset{b}{\geq} v_3 \overset{a}{\geq} 0$

   Thus, we substitute $v_1 \rightarrow a + b$, $v_2 \rightarrow a + b + c$, $v_3 \rightarrow a$, $v_4 \rightarrow 2a + b + c + d$, and compute series with the new variables as indices, where $a, b, d \geq 0$ and $c \geq 1$.

4. $v_4 \overset{d}{>} v_1 \overset{c}{\geq} v_2 + v_3 \overset{a}{\geq} v_2 \overset{b}{\geq} v_3 \overset{a}{\geq} 0$

   Thus, we substitute $v_1 \rightarrow 2a + b + c$, $v_2 \rightarrow a + b$, $v_3 \rightarrow a$, $v_4 \rightarrow 2a + b + c + d$, and compute series with the new variables as indices, where $a, b, c \geq 0$ and $d \geq 1$.

5. $v_4 \overset{d}{>} v_1 \overset{c}{\geq} v_2 + v_3 \overset{a}{\geq} v_3 \overset{b}{>} v_2 \overset{a}{\geq} 0$

   Thus, we substitute $v_1 \rightarrow 2a + b + c$, $v_2 \rightarrow a$, $v_3 \rightarrow a + b$, $v_4 \rightarrow 2a + b + c + d$, and compute series with the new variables as indices, where $a, c \geq 0$ and $b, d \geq 1$.

4.2 Sub case 4.2

$-v_2 - v_3 < -v_4 \Rightarrow v_2 + v_3 > v_4$

For $v_{11} \geq -v_2$, we have $p^{\min}(1 + \alpha\rho)\mu(a_{11}) = p^{v_2}(1 + v_2\rho)$.

For $-v_4 \leq v_{11} \leq -v_2 - 1$, we have $p^{\min}(1 + \alpha\rho)\mu(a_{11}) = \sum_{-v_4}^{-v_2-1} p^{v_2}\rho(1 + v_2\rho) = p^{v_2}(v_4 - v_2)\rho(1 + v_2\rho) = p^{v_2}(v_4 - v_2)\rho + p^{v_2}v_2(v_4 - v_2)\rho^2$.

For $-v_2 - v_3 \leq v_{11} \leq -v_4 - 1$, we have $p^{\min}(1 + \alpha\rho)\mu(a_{11}) = \sum_{-v_2-v_3}^{-v_4-1} p^{v_2}\rho(1 + \alpha\rho) = \sum_{i=1}^{v_2+v_3-v_4} p^{v_2}\rho(1 + (v_2 - i)\rho) = p^{v_2}(v_2 + v_3 - v_4)\rho + (v_2 + v_3 - v_4)v_2\rho^2 - \binom{v_2+v_3-v_4+1}{2}\rho^2$.

So we have $\sum_{v_{11} \geq -v_2 - v_3} p^{\min}(1 + \alpha\rho)\mu(a_{11}) = p^{v_2}(1 + v_2\rho + (v_4 - v_2))\rho + v_2(v_4 - v_2)\rho^2 + (v_2 + v_3 - v_4)\rho + (v_2 + v_3 - v_4)v_2\rho^2 - \frac{(v_2+v_3-v_4+1)(v_2+v_3-v_4)}{2}\rho^2) = p^{v_2}(1 + v_2v_4\rho^2 + v_2\rho + v_3\rho + v_3v_2\rho^2 - v_4v_2\rho^2 - \frac{v_2^2}{2}\rho^2 - v_2v_3\rho^2 + v_2v_4\rho^2 - \frac{v_3^2}{2}\rho^2 + v_3v_4\rho^2 - \frac{v_4^2}{2}\rho^2 - \frac{v_2}{2}\rho^2 - \frac{v_3}{2}\rho^2 + \frac{v_4}{2}\rho^2)$.

We have several arrangements,

1. $v_2 + v_3 \overset{d}{>} v_4 \overset{c}{>} v_1 \overset{b}{\geq} v_2 \overset{a}{\geq} v_3 \overset{e}{\geq} 0$

   But $v_2 + v_3 - d - c - b = v_2 \Rightarrow v_3 = v_2 + v_3 - v_2 = b + c + d$

   Thus, we substitute $v_1 \to a + 2b + c + d$, $v_2 \to a + b + c + d$, $v_3 \to b + c + d$, $v_4 \to a + 2b + 2c + d$, and compute series with the new variables as indices, where $a, b \geq 0$ and $c, d \geq 1$

2. $v_2 + v_3 \overset{d}{>} v_4 \overset{c}{>} v_1 \overset{b}{\geq} v_3 \overset{a}{>} v_2 \overset{e}{\geq} 0$

   But $v_2 + v_3 - d - c - b = v_3 \Rightarrow v_2 = v_2 + v_3 - v_3 = b + c + d$

   Thus, we substitute $v_1 \to a + 2b + c + d$, $v_2 \to b + c + d$, $v_3 \to a + b + c + d$, $v_4 \to a + 2b + 2c + d$, and compute series with the new variables as indices, where $b \geq 0$ and $a, c, d \geq 1$

3. $v_2 + v_3 \overset{d}{>} v_4 \overset{c}{>} v_2 \overset{b}{>} v_1 \overset{a}{\geq} v_3 \overset{e}{\geq} 0$

   But $v_2 + v_3 - d - c = v_2 \Rightarrow v_3 = v_2 + v_3 - v_2 = c + d$

   Thus, we substitute $v_1 \to a + c + d$, $v_2 \to a + b + c + d$, $v_3 \to c + d$, $v_4 \to a + b + 2c + d$, and compute series with the new variables as indices, where $a \geq 0$ and $b, c, d \geq 1$

5 Case 5

$v_2 \geq v_4 > v_1 > v_3 \geq 0$
$\qquad \Rightarrow v_{11} \geq -v_2 - v_3$
$\qquad \Rightarrow \alpha := \min\{v_4, v_2 + v_{11} + v_4\} = \begin{cases} v_4, & v_{11} \geq -v_2 \\ v_4 - 1, v_4 - 2, \ldots, & v_{11} < -v_2 \end{cases}$
$\qquad \Rightarrow f(p, t) = p^{7v_1 + 10v_2 + 11v_3 + 7v_4 + v_1} t^{4v_1 + 6v_2 + 6v_3 + 4v_4} = p^{8v_1 + 10v_2 + 11v_3 + 7v_4} t^{4v_1 + 6v_2 + 6v_3 + 4v_4}$
For $v_{11} \geq -v_2$, we have $p^{\min}(1 + \alpha\rho)\mu(a_{11}) = p^{v_2}(1 + v_4\rho)$.
For $-v_2 - v_3 \leq v_{11} \leq -v_2 - 1$, we have $p^{\min}(1 + \alpha\rho)\mu(a_{11}) = \sum_{-v_2 - v_3}^{-v_2 - 1} p^{v_2}\rho(1 + \alpha\rho) = \sum_{i=1}^{v_3} p^{v_2}\rho(1 + (v_4 - i)\rho) = p^{v_2}(v_3\rho + v_3 v_4\rho^2 - \binom{v_3 + 1}{2}\rho^2)$.
So we have $\sum_{v_{11} \geq -v_2 - v_3} p^{\min}(1 + \alpha\rho)\mu(a_{11}) = p^{v_2}(1 + v_4\rho + v_3\rho + v_3 v_4\rho^2 - \frac{(v_3 + 1)v_3}{2}\rho^2) = p^{v_2}(1 + v_4\rho + v_3\rho + v_3 v_4\rho^2 - \frac{v_3^2}{2}\rho^2 - \frac{v_3}{2}\rho^2)$.
$\qquad v_2 \overset{d}{\geq} v_4 \overset{c}{>} v_1 \overset{b}{\geq} v_3 \overset{a}{\geq} 0$
Thus, we substitute $v_1 \to a + b$, $v_2 \to a + b + c + d$, $v_3 \to a$, $v_4 \to a + b + c$, and compute series with the new variables as indices, where $a, b, d \geq 0$ and $c \geq 1$

6 Case 6

$v_2 \geq v_4 > v_1 \geq 0$
$\qquad v_3 > v_1 \geq 0$
$\qquad \Rightarrow v_{11} \geq -v_2 - v_1$

$$\Rightarrow \alpha := \min\{v_4, v_2 + v_{11} + v_4\} = \begin{cases} v_4, & v_{11} \geq -v_2 \\ v_4 - 1, v_4 - 2, \ldots, & v_{11} < -v_2 \end{cases}$$

$$\Rightarrow f(p,t) = p^{7v_1+10v_2+11v_3+7v_4+v_1}t^{4v_1+6v_2+6v_3+4v_4} = p^{8v_1+10v_2+11v_3+7v_4}t^{4v_1+6v_2+6v_3+4v_4}$$

For $v_{11} \geq -v_2$, we have $p^{\min}(1 + \alpha\rho)\mu(a_{11}) = p^{v_2}(1 + v_4\rho)$.

For $-v_2-v_1 \leq v_{11} \leq -v_2 - 1$, we have $p^{\min}(1+\alpha\rho)\mu(a_{11}) = \sum_{-v_2-v_1}^{-v_2-1} p^{v_2}\rho(1+$

$\alpha\rho) = \sum_{i=1}^{v_1} p^{v_2}\rho(1 + (v_4 - i)\rho) = p^{v_2}(v_1\rho + v_1 v_4\rho^2 - \binom{v_1+1}{2}\rho^2)$.

So we have $\sum_{v_{11} \geq -v_2-v_1} p^{\min}(1 + \alpha\rho)\mu(a_{11}) = p^{v_2}(1 + v_4\rho + v_1\rho + v_1 v_4\rho^2 -$

$\frac{(v_1+1)v_1}{2}\rho^2) = p^{v_2}(1 + v_4\rho + v_1\rho + v_1 v_4\rho^2 - \frac{v_1^2}{2}\rho^2 - \frac{v_1}{2}\rho^2)$.

We have several arrangements,

1. $v_2 \overset{d}{\geq} v_4 \overset{c}{>} v_3 \overset{b}{>} v_1 \overset{a}{\geq} 0$

   Thus, we substitute $v_1 \to a$, $v_2 \to a + b + c + d$, $v_3 \to a + b$, $v_4 \to a + b + c$, and compute series with the new variables as indices, where $a, d \geq 0$ and $b, c \geq 1$

2. $v_2 \overset{d}{\geq} v_3 \overset{c}{\geq} v_4 \overset{b}{>} v_1 \overset{a}{\geq} 0$

   Thus, we substitute $v_1 \to a$, $v_2 \to a + b + c + d$, $v_3 \to a + b + c$, $v_4 \to a + b$, and compute series with the new variables as indices, where $a, c, d \geq 0$ and $b \geq 1$

3. $v_3 \overset{d}{>} v_2 \overset{c}{\geq} v_4 \overset{b}{>} v_1 \overset{a}{\geq} 0$

   Thus, we substitute $v_1 \to a$, $v_2 \to a + b + c$, $v_3 \to a + b + c + d$, $v_4 \to a + b$, and compute series with the new variables as indices, where $a, c \geq 0$ and $b, d \geq 1$

7 Case 7

$v_2 \geq v_4 \geq 0$

$v_3 > v_1 \geq v_4 \geq 0$

$\Rightarrow v_{11} \geq -v_2 - v_1$

$\Rightarrow f(p,t) = p^{7v_1+10v_2+11v_3+7v_4+v_4}t^{4v_1+6v_2+6v_3+4v_4} = p^{7v_1+10v_2+11v_3+8v_4}t^{4v_1+6v_2+6v_3+4v_4}$

$$\Rightarrow \alpha := \min\{v_4, v_2 + v_{11} + v_1\} = \begin{cases} v_4, & v_{11} \geq v_4 - v_1 - v_2 \\ v_4 - 1, v_4 - 2, \ldots, & v_{11} < v_4 - v_1 - v_2 \end{cases}$$

There are no two sub cases here, because the phase transition occurs at $v_{11} = v_4 - v_1 - v_2 - 1$, thus

if $v_4 = 0$ then the transition would be at $v_{11} = -v_2 - v_1 - 1 < -v_2 - v_1$, which is a contradiction.

For $v_4 \geq 1$ the transition would be at $a_{11} \geq -v_2 - v_1$, which is always true for this case.

For $v_{11} \geq -v_2$, we have $p^{\min}(1 + \alpha\rho)\mu(a_{11}) = p^{v_2}(1 + v_4\rho)$.

For $v_4-v_1-v_2 \leq v_{11} \leq -v_2 - 1$, we have $p^{\min}(1+\alpha\rho)\mu(a_{11}) = \sum_{v_4-v_1-v_2}^{-v_2-1} p^{v_2}\rho(1+$

$v_4\rho) = \sum_{i=1}^{v_1-v_4} p^{v_2}\rho(1 + v_4\rho) = p^{v_2}(v_1 - v_4)\rho(1 + v_4\rho) = p^{v_2}(v_1 - v_4)\rho + p^{v_2}(v_1 - v_4)v_4\rho^2$.

For $-v_1 - v_2 \leq v_{11} \leq v_4 - v_1 - v_2 - 1$, we have $p^{\min}(1 + \alpha\rho)\mu(a_{11}) = \sum_{-v_1-v_2}^{v_4-v_1-v_2-1} p^{v_2}\rho(1 + \alpha\rho) = \sum_{i=1}^{v_4} p^{v_2}\rho(1 + (v_4 - i)\rho) = p^{v_2}v_4\rho + p^{v_2}v_4^2\rho^2 - p^{v_2}\binom{v_4+1}{2}\rho^2$.

So we have $\sum_{v_{11} \geq -v_2-v_1} p^{\min}\mu(a_{11}) = p^{v_2}(1+v_4\rho+(v_4-v_1)\rho+(v_4-v_1)v_4\rho^2+v_4\rho+v_4^2\rho^2 - \frac{v_4(v_4-1)}{2}\rho^2) = p^{v_2}(1 + 3v_4\rho - v_1\rho + 2v_4^2\rho^2 - v_1v_4\rho^2 - \frac{v_4^2}{2}\rho^2 + \frac{v_4}{2}\rho^2)$

We have several arrangements,

1. $v_2 \overset{d}{\geq} v_3 \overset{c}{>} v_1 \overset{b}{\geq} v_4 \overset{a}{\geq} 0$

   Thus, we substitute $v_1 \to a + b$, $v_2 \to a + b + c + d$, $v_3 \to a + b + c$, $v_4 \to a$, and compute series with the new variables as indices, where $a, b, d \geq 0$ and $c \geq 1$

2. $v_3 \overset{d}{>} v_2 \overset{c}{>} v_1 \overset{b}{\geq} v_4 \overset{a}{\geq} 0$

   Thus, we substitute $v_1 \to a + b$, $v_2 \to a + b + c$, $v_3 \to a + b + c + d$, $v_4 \to a$, and compute series with the new variables as indices, where $a, b \geq 0$ and $c, d \geq 1$

3. $v_3 \overset{d}{>} v_1 \overset{c}{\geq} v_2 \overset{b}{\geq} v_4 \overset{a}{\geq} 0$

   Thus, we substitute $v_1 \to a + b + c$, $v_2 \to a + b$, $v_3 \to a + b + c + d$, $v_4 \to a$, and compute series with the new variables as indices, where $a, b, c \geq 0$ and $d \geq 1$

8 Case 8

$v_2 \geq v_4 \geq 0$
$\quad v_1 \geq v_4 \geq 0$
$\quad v_1 \geq v_3 \geq 0$
$\quad \Rightarrow v_{11} \geq -v_2 - v_3$
$\quad \Rightarrow \alpha := \min\{v_4, v_2 + v_{11} + v_1\} = \begin{cases} v_4, & v_{11} \geq v_4 - v_1 - v_2 \\ v_4 - 1, v_4 - 2, \ldots, & v_{11} < v_4 - v_1 - v_2 \end{cases}$
$\quad \Rightarrow f(p, t) = p^{7v_1+10v_2+11v_3+7v_4+v_4}t^{4v_1+6v_2+6v_3+4v_4} = p^{7v_1+10v_2+11v_3+8v_4}t^{4v_1+6v_2+6v_3+4v_4}$

There are two sub cases here

8.1 Sub case 8.1

$-v_2 - v_3 \geq v_4 - v_1 - v_2 \Rightarrow -v_3 \geq v_4 - v_1 \Rightarrow v_1 \geq v_3 + v_4$

For $v_{11} \geq -v_2$, we have $p^{\min}(1 + \alpha\rho)\mu(a_{11}) = p^{v_2}(1 + v_4\rho)$.

For $-v_2-v_3 \leq v_{11} \leq -v_2 - 1$, we have $p^{\min}(1+\alpha\rho)\mu(a_{11}) = \sum_{-v_2-v_3}^{-v_2-1} p^{v_2}\rho(1+v_4\rho) = \sum_{i=1}^{v_3} p^{v_2}\rho(1 + v_4\rho) = p^{v_2}(v_3\rho + v_3v_4\rho^2)$.

So we have $\sum_{v_{11} \geq -v_2-v_3} p^{\min}(1 + \alpha\rho)\mu(a_{11}) = p^{v_2}(1 + v_4\rho + v_3\rho + v_3v_4\rho^2)$.

We have several arrangements,

1. $v_1 \overset{d}{\geq} v_3 + v_4 \overset{a}{\geq} v_3 \overset{c}{>} v_2 \overset{b}{\geq} v_4 \overset{a}{\geq} 0$

   But $e = v_2 + v_3 - v_3 = v_2 = a + b$.

   Thus, we substitute $v_1 \to 2a + b + c + d$, $v_2 \to a + b$, $v_3 \to a + b + c$, $v_4 \to a$, and compute series with the new variables as indices, where $a, b, d \geq 0$ and $c \geq 1$

2. $v_1 \overset{d}{\geq} v_3 + v_4 \overset{c}{\geq} v_2 \overset{b}{\geq} v_3 \overset{a}{\geq} v_4 \overset{e}{\geq} 0$

   But $v_3 = v_3 + v_4 - c - b \Rightarrow v_4 = b + c$

   Thus, we substitute $v_1 \to a + 2b + 2c + d$, $v_2 \to a + 2b + c$, $v_3 \to a + b + c$, $v_4 \to b + c$, and compute series with the new variables as indices, where $a, b, c, d \geq 0$.

3. $v_1 \overset{d}{\geq} v_3 + v_4 \overset{c}{\geq} v_2 \overset{b}{\geq} v_4 \overset{a}{>} v_3 \overset{e}{\geq} 0$

   Thus, we substitute $v_1 \to a + 2b + 2c + d$, $v_2 \to a + 2b + c$, $v_3 \to a + b + c$, $v_4 \to b + c$, and compute series with the new variables as indices, where $b, c, d \geq 0$ and $a \geq 1$

4. $v_1 \overset{d}{\geq} v_2 \overset{c}{>} v_3 + v_4 \overset{a}{\geq} v_4 \overset{b}{>} v_3 \overset{a}{\geq} 0$

   Thus, we substitute $v_1 \to 2a + b + c + d$, $v_2 \to 2a + b + c$, $v_3 \to a$, $v_4 \to a + b$, and compute series with the new variables as indices, where $a, d \geq 0$ and $b, c \geq 1$

5. $v_1 \overset{d}{\geq} v_2 \overset{c}{>} v_3 + v_4 \overset{a}{\geq} v_3 \overset{b}{\geq} v_4 \overset{a}{\geq} 0$

   Thus, we substitute $v_1 \to 2a + b + c + d$, $v_2 \to 2a + b + c$, $v_3 \to a + b$, $v_4 \to a$, and compute series with the new variables as indices, where $a, b, d \geq 0$ and $c \geq 1$

6. $v_2 \overset{d}{>} v_1 \overset{c}{\geq} v_3 + v_4 \overset{a}{\geq} v_3 \overset{b}{\geq} v_4 \overset{a}{\geq} 0$

   Thus, we substitute $v_1 \to 2a + b + c$, $v_2 \to 2a + b + c + d$, $v_3 \to a + b$, $v_4 \to a$, and compute series with the new variables as indices, where $a, b, c \geq 0$ and $d \geq 1$

7. $v_2 \overset{d}{>} v_1 \overset{c}{\geq} v_3 + v_4 \overset{a}{\geq} v_4 \overset{b}{>} v_3 \overset{a}{\geq} 0$

   Thus, we substitute $v_1 \to 2a + b + c$, $v_2 \to 2a + b + c + d$, $v_3 \to a$, $v_4 \to a + b$, and compute series with the new variables as indices, where $a, c \geq 0$ and $b, d \geq 1$

8.2 Sub case 8.2

$-v_2 - v_3 < v_4 - v_1 - v_2 \Rightarrow -v_3 < v_4 - v_1 \Rightarrow v_1 < v_3 + v_4$

For $v_{11} \geq -v_2$, we have $p^{\min}(1 + \alpha\rho)\mu(a_{11}) = p^{v_2}(1 + v_4\rho)$.

For $v_4-v_1-v_2 \leq v_{11} \leq -v_2 - 1$, we have $p^{\min}(1+\alpha\rho)\mu(a_{11}) = \sum_{v_4-v_1-v_2}^{-v_2-1} p^{v_2}\rho(1+v_4\rho) = p^{v_2}((v_1 - v_4)\rho + (v_1 - v_4)v_4\rho^2)$.

For $-v_2 - v_3 \leq v_{11} \leq v_4 - v_1 - v_2 - 1$, we have $p^{\min}(1 + \alpha\rho)\mu(a_{11}) = \sum_{-v_2-v_3}^{v_4-v_1-v_2-1} p^{v_2}\rho(1 + \alpha\rho) = \sum_{i=1}^{v_3+v_4-v_1} p^{v_2}\rho(1 + (v_4 - i))\rho) = p^{v_2}((v_3 + v_4 - v_1)\rho + (v_3 + v_4 - v_1)v_4\rho^2 - \binom{v_3+v_4-v_1+1}{2}\rho^2)$.

So we have $\sum_{v_{11} \geq -v_2-v_3} \rho(1+\alpha\rho) = p^{v_2}(1+v_4\rho+(v_1-v_4)\rho+(v_1-v_4)v_4\rho^2 + (v_3 + v_4 - v_1)\rho + (v_3 + v_4 - v_1)v_4\rho^2 - \frac{(v_3+v_4-v_1+1)(v_3+v_4-v_1)}{2}\rho^2) = p^{v_2}(1+v_3\rho+ v_4\rho - \frac{v_3^2}{2}\rho^2 + v_1v_3\rho^2 - \frac{v_4^2}{2} + v_1v_4\rho^2 - \frac{v_1^2}{2} - v_3\rho^2 - v_4\rho^2 + v_1\rho^2)$.

We have several arrangements,

1. $v_3 + v_4 \overset{d}{>} v_1 \overset{c}{\geq} v_3 \overset{b}{>} v_2 \overset{a}{\geq} v_4 \overset{e}{\geq} 0$

   But $v_3 + v_4 - d - c = v_3 \Rightarrow v_4 = c + d$.

   Thus, we substitute $v_1 \to a + b + 2c + d$, $v_2 \to a + c + d$, $v_3 \to a + b + c + d$, $v_4 \to c + d$, and compute series with the new variables as indices, where $a, c \geq 0$ and $b, d \geq 1$

2. $v_3 + v_4 \overset{d}{>} v_1 \overset{c}{\geq} v_2 \overset{b}{\geq} v_3 \overset{a}{\geq} v_4 \overset{e}{\geq} 0$

   But $v_3 + v_4 - d - c - b = v_3 \Rightarrow v_4 = b + c + d$.

   Thus, we substitute $v_1 \to a + 2b + 2c + d$, $v_2 \to a + 2b + c + d$, $v_3 \to a + b + c + d$, $v_4 \to b + c + d$, and compute series with the new variables as indices, where $a, b, c \geq 0$ and $d \geq 1$.

3. $v_3 + v_4 \overset{d}{>} v_1 \overset{c}{\geq} v_2 \overset{b}{\geq} v_4 \overset{a}{>} v_3 \overset{e}{\geq} 0$

   But $v_3 + v_4 - d - c - b = v_4 \Rightarrow v_3 = b + c + d$.

   Thus, we substitute $v_1 \to a + 2b + 2c + d$, $v_2 \to a + 2b + c + d$, $v_3 \to b + c + d$, $v_4 \to a + b + c + d$, and compute series with the new variables as indices, where $b, c \geq 0$ and $a, d \geq 1$

4. $v_3 + v_4 \overset{d}{\geq} v_2 \overset{c}{>} v_1 \overset{b}{\geq} v_4 \overset{a}{>} v_3 \overset{e}{\geq} 0$

   But $v_3 + v_4 - d - c - b = v_4 \Rightarrow v_3 = b + c + d$.

   Thus, we substitute $v_1 \to a + 2b + c + d$, $v_2 \to a + 2b + 2c + d$, $v_3 \to b + c + d$, $v_4 \to a + b + c + d$, and compute series with the new variables as indices, where $b, d \geq 0$ and $a, c \geq 1$

5. $v_3 + v_4 \overset{d}{\geq} v_2 \overset{c}{>} v_1 \overset{b}{\geq} v_3 \overset{a}{\geq} v_4 \overset{e}{\geq} 0$

   But $v_3 + v_4 - d - c - b = v_3 \Rightarrow v_4 = b + c + d$.

   Thus, we substitute $v_1 \to a + 2b + c + d$, $v_2 \to a + 2b + 2c + d$, $v_3 \to a + b + c + d$, $v_4 \to b + c + d$, and compute series with the new variables as indices, where $a, b, d \geq 0$ and $c \geq 1$

6. $v_2 \overset{d}{\geq} v_3 + v_4 \overset{c}{>} v_1 \overset{b}{\geq} v_4 \overset{a}{>} v_3 \overset{e}{\geq} 0$

But $v_3 + v_4 - c - b = v_4 \Rightarrow v_3 = b + c$.

Thus, we substitute $v_1 \to a + 2b + c$, $v_2 \to a + 2b + 2c + d$, $v_3 \to b + c$, $v_4 \to a + b + c$, and compute series with the new variables as indices, where $b, d \geq 0$ and $a, c \geq 1$

7. $v_2 \overset{d}{\geq} v_3 + v_4 \overset{c}{>} v_1 \overset{b}{\geq} v_3 \overset{a}{\geq} v_4 \overset{e}{\geq} 0$

But $v_3 + v_4 - c - b = v_3 \Rightarrow v_4 = b + c$.

Thus, we substitute $v_1 \to a + 2b + c$, $v_2 \to a + 2b + 2c + d$, $v_3 \to a + b + c$, $v_4 \to b + c$, and compute series with the new variables as indices, where $a, b, d \geq 0$ and $c \geq 1$

8. $v_2 \overset{d}{>} v_1 \overset{c}{\geq} v_3 + v_4 \overset{a}{\geq} v_4 \overset{b}{>} v_3 \overset{a}{\geq} 0$

Thus, we substitute $v_1 \to 2a + b + c$, $v_2 \to 2a + b + c + d$, $v_3 \to a$, $v_4 \to a + b$, and compute series with the new variables as indices, where $a, c \geq 0$ and $b, d \geq 1$

9. $v_2 \overset{d}{>} v_1 \overset{c}{\geq} v_3 + v_4 \overset{a}{\geq} v_3 \overset{b}{\geq} v_4 \overset{a}{\geq} 0$

Thus, we substitute $v_1 \to 2a + b + c + d$, $v_2 \to 2a + b + c$, $v_3 \to a + b$, $v_4 \to a$, and compute series with the new variables as indices, where $a, b, c \geq 0$ and $d \geq 1$

Checking all the cases by the 4! arrangements.

1. $v_1 \geq v_2 \geq v_3 \geq v_4 \geq 0$

   $v_1 \geq v_3 + v_4 \geq v_2 \geq v_3 \geq v_4 \geq 0$ (8.1.2)

   $v_1 \geq v_2 > v_3 + v_4 \geq v_3 \geq v_4 \geq 0$ (8.1.5)

   $v_3 + v_4 > v_1 \geq v_2 \geq v_3 \geq v_4 \geq 0$ (8.2.2)

2. $v_1 \geq v_2 \geq v_4 > v_3 \geq 0$

   $v_1 \geq v_3 + v_4 \geq v_2 \geq v_4 > v_3 \geq 0$ (8.1.3)

   $v_1 \geq v_2 > v_3 + v_4 \geq v_4 > v_3 \geq 0$ (8.1.4)

   $v_3 + v_4 > v_1 \geq v_2 \geq v_4 > v_3 \geq 0$ (8.2.3)

3. $v_1 \geq v_3 > v_2 \geq v_4 \geq 0$

   $v_1 \geq v_3 + v_4 \geq v_3 > v_2 \geq v_4 \geq 0$ (8.1.1)

   $v_3 + v_4 > v_1 \geq v_3 > v_2 \geq v_4 \geq 0$ (8.2.1)

4. $v_1 \geq v_3 \geq v_4 > v_2 \geq 0$

   $v_1 \geq v_2 + v_3 \geq v_3 \geq v_4 > v_2 \geq 0$ (2.1.1)

   $v_2 + v_3 > v_1 \geq v_3 \geq v_4 > v_2 \geq 0$ (2.2.1)

5. $v_1 \geq v_4 > v_2 \geq v_3 \geq 0$

   $v_1 \geq v_2 + v_3 \geq v_4 > v_2 \geq v_3 \geq 0$ (2.1.3)

   $v_1 \geq v_4 > v_2 + v_3 \geq v_2 \geq v_3 \geq 0$ (2.1.4)

   $v_2 + v_3 > v_1 \geq v_4 > v_2 \geq v_3 \geq 0$ (2.2.3)

6. $v_1 \geq v_4 > v_3 > v_2 \geq 0$

   $v_1 \geq v_2 + v_3 \geq v_4 > v_3 > v_2 \geq 0$ (2.1.2)

   $v_1 \geq v_4 > v_2 + v_3 \geq v_3 > v_2 \geq 0$ (2.1.5)

   $v_2 + v_3 > v_1 \geq v_4 > v_3 > v_2 \geq 0$ (2.2.2)

7. $v_2 > v_1 \geq v_3 \geq v_4 \geq 0$

   $v_2 > v_1 \geq v_3 + v_4 \geq v_3 \geq v_4 \geq 0$ (8.1.6)

   $v_3 + v_4 \geq v_2 > v_1 \geq v_3 \geq v_4 \geq 0$ (8.2.5)

   $v_2 \geq v_3 + v_4 > v_1 \geq v_3 \geq v_4 \geq 0$ (8.2.7)

   $v_2 > v_1 \geq v_3 + v_4 \geq v_3 \geq v_4 \geq 0$ (8.2.9)

8. $v_2 > v_1 \geq v_4 > v_3 \geq 0$

   $v_2 > v_1 \geq v_3 + v_4 \geq v_4 > v_3 \geq 0$ (8.1.7)

   $v_3 + v_4 \geq v_2 > v_1 \geq v_4 > v_3 \geq 0$ (8.2.4)

   $v_2 \geq v_3 + v_4 > v_1 \geq v_4 > v_3 \geq 0$ (8.2.6)

   $v_2 \geq v_3 + v_4 > v_1 \geq v_4 > v_3 \geq 0$ (8.2.8)

9. $v_2 \geq v_3 > v_1 \geq v_4 \geq 0$ (7.1)

10. $v_2 \geq v_3 \geq v_4 > v_1 \geq 0$ (6.2)

11. $v_2 \geq v_4 > v_1 \geq v_3 \geq 0$ (5)

12. $v_2 \geq v_4 > v_3 > v_1 \geq 0$ (6.1)

13. $v_3 > v_1 \geq v_2 \geq v_4 \geq 0$ (7.3)

14. $v_3 > v_1 \geq v_4 > v_2 \geq 0$ (1)

15. $v_3 > v_2 > v_1 \geq v_4 \geq 0$ (7.2)

16. $v_3 > v_2 \geq v_4 > v_1 \geq 0$ (6.3)

17. $v_3 \geq v_4 > v_1 \geq v_2 \geq 0$

    $v_3 \geq v_4 > v_1 + v_2 \geq v_1 \geq v_2 \geq 0$ (3.1.7)

    $v_1 + v_2 > v_3 \geq v_4 > v_1 \geq v_2 \geq 0$ (3.2.5)

    $v_3 \geq v_1 + v_2 > v_4 > v_1 \geq v_2 \geq 0$ (3.2.7)

18. $v_3 \geq v_4 > v_2 > v_1 \geq 0$

   $v_3 \geq v_4 > v_1 + v_2 \geq v_2 > v_1 \geq 0$ (3.1.6)

   $v_1 + v_2 > v_3 \geq v_4 > v_2 > v_2 \geq 0$ (3.2.4)

   $v_3 \geq v_1 + v_2 > v_4 > v_2 > v_1 \geq 0$ (3.2.6)

19. $v_4 > v_1 \geq v_2 \geq v_3 \geq 0$

   $v_4 \geq v_2 + v_3 \geq v_1 \geq v_2 \geq v_3 \geq 0$ (4.1.2)

   $v_4 > v_1 \geq v_2 + v_3 \geq v_2 \geq v_3 \geq 0$ (4.1.4)

   $v_2 + v_3 > v_4 > v_2 \geq v_3 \geq 0$ (4.2.1)

20. $v_4 > v_1 \geq v_3 > v_2 \geq 0$

   $v_4 \geq v_2 + v_3 \geq v_1 \geq v_3 > v_2 \geq 0$ (4.1.1)

   $v_4 > v_1 \geq v_2 + v_3 \geq v_3 > v_2 \geq 0$ (4.1.5)

   $v_2 + v_3 > v_4 > v_1 \geq v_3 > v_2 \geq 0$ (4.2.2)

21. $v_4 > v_2 > v_1 \geq v_3 \geq 0$

   $v_4 \geq v_2 + v_3 \geq v_2 > v_1 \geq v_3 \geq 0$ (4.1.3)

   $v_2 + v_3 > v_4 > v_2 > v_1 \geq v_3 \geq 0$ (4.2.3)

22. $v_4 > v_2 \geq v_3 > v_1 \geq 0$

   $v_4 \geq v_1 + v_2 \geq v_2 \geq v_3 > v_1 \geq 0$ (3.1.2)

   $v_1 + v_2 > v_4 > v_2 \geq v_3 > v_1 \geq 0$ (3.2.2)

23. $v_4 > v_3 > v_1 \geq v_2 \geq 0$

   $v_4 \geq v_1 + v_2 \geq v_3 > v_1 \geq v_2 \geq 0$ (3.1.3)

   $v_4 > v_3 \geq v_1 + v_2 \geq v_1 \geq v_2 \geq 0$ (3.1.4)

   $v_1 + v_2 > v_4 > v_3 > v_1 \geq v_2 \geq 0$ (3.2.3)

24. $v_4 > v_3 > v_2 > v_1 \geq 0$

   $v_4 \geq v_1 + v_2 \geq v_3 > v_2 > v_1 \geq 0$ (3.1.1)

   $v_4 > v_3 \geq v_1 + v_2 \geq v_2 > v_1 \geq 0$ (3.1.5)

   $v_1 + v_2 > v_4 > v_3 > v_2 > v_1 \geq 0$ (3.2.1)