1. The diagram represents a perturbative calculation of the partition function.

Consider the connected diagram involving $p_a \rightarrow p_d$ which when used to calculate the pressure contributes at order $n$ in perturbation theory and to to order $m$ in powers of $e^{\beta \mu}$, i.e., the prefactor is $e^{m \beta \mu}$. Circle one of the below:

$$
\begin{array}{|c|c|c|}
\hline
n = 4, m = 4 & n = 4, m = 5 & n = 4, m = 12 \\
\hline
n = 5, m = 4 & n = 5, m = 5 & n = 5, m = 12 \\
\hline
n = 12, m = 4 & n = 12, m = 5 & n = 12, m = 12 \\
\hline
\text{none of the above} \\
\hline
\end{array}
$$

2. Consider a virial expansion for a non-relativistic two-dimensional gas of spin-zero bosons of mass $m$ at temperature $T$,

$$
\frac{P}{\rho T} = 1 + \sum_{m=2}^{\infty} A_m \left( \frac{\rho}{\rho_0} \right)^{m-1}, \quad \rho_0 \equiv \frac{mT}{2\pi\hbar^2}.
$$

Ignoring interactions between the particles, calculate $A_2$.

3. Consider two states:

$$
|\alpha\rangle = e^{\alpha a^\dagger}|0\rangle, \quad |\beta\rangle = e^{\beta a^\dagger}|0\rangle.
$$

Find the overlap, $\langle \alpha | \beta \rangle$. 