**Section 6, Exercise 1**

Assume $H = 0$, $J = 1$, and state 1 is the microstate where all spins are $s_i = +1$. In microstate 2, one spin has flipped. (Assume this flipped spin is not at an edge.) What is the difference in the energies of the two microstates, $E_1 - E_2$?

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With $H = 0$ and $J = -1$, we have

$$E = -\sum_{\text{pairs}} s_i s_j \tag{1}$$

Assume we have $N_{\text{pairs}}$ pairs. In Microstate 1, all spins are up, so

$$E_1 = -\sum_{i=0}^{N_{\text{pairs}}} (1)(1) = -N_{\text{pairs}} \tag{2}$$

In Microstate 2, all spins are up except for one. Of $N_{\text{pairs}}$ pairs, only 4 pairs are affected by this change, so

$$\begin{aligned} E_2 &= -\sum_{i=0}^{N_{\text{pairs}}-4} (1)(1) + -\sum_{i=0}^{4}(-1)(1) \\ &= -(N_{\text{pairs}} - 4) - 4(-1) \\ &= -N_{\text{pairs}} + 4 + 4 \\ &= 8 - N_{\text{pairs}} \end{aligned} \tag{3}$$

Therefore

$$E_1 - E_2 = -N_{\text{pairs}} - (8 - N_{\text{pairs}}) = -8 \tag{4}$$

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Magnetization is the sum of the spins on the lattice. In the given microstate, we know that at least 1 of $N$ spins must be up, so we have

$$M = 1 + \sum_{i=0}^{N-1} s_i \equiv 1 + M_{\text{other}} \tag{5}$$

where we've defined $M_{\text{other}}$ as the sum of spins other than the one we know is up. Then that one spin flips, so we have

$$M_{\text{new}} = -1 + \sum_{i=1}^{N-1} s_i = -1 + M_{\text{other}} = -1 + (M - 1) = M - 2 \tag{6}$$

**Section 6, Exercise 3**

1. On an $n \times n$ lattice with periodic boundary conditions, what is the maximum distance between two spins in the same row?

2. On an $n \times n$ lattice with periodic boundary conditions, how many other spins will a given spin be paired with to calculate the correlation function? Assume we are only considering pairs of spins in the same row or column.

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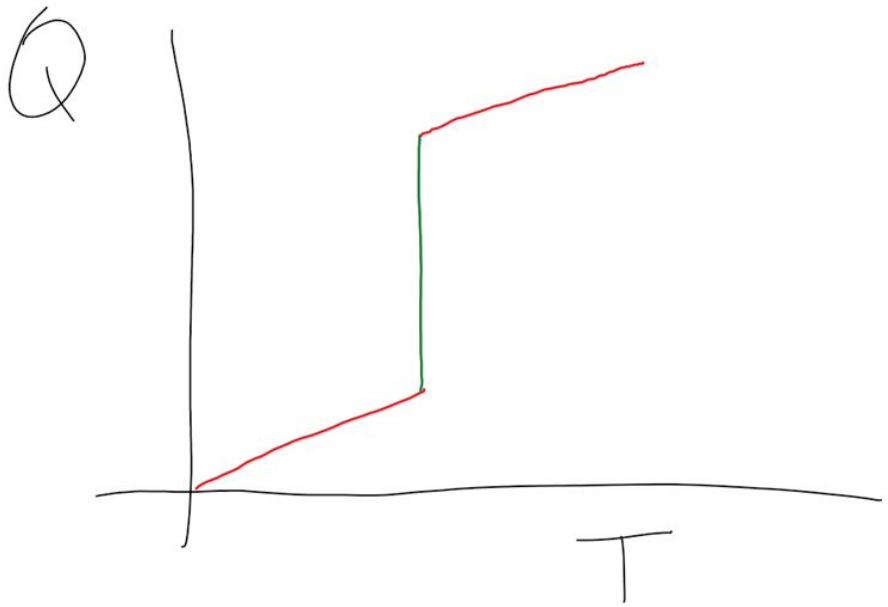
1. n/2 if n is even, or (n-1)/2 if n is odd
2. 2(n-1)

(See code)

**Section 6, Exercise 4**

The sketch shows the heat added ($Q$) vs the temperature of some substance at constant pressure. Explain what process is happening in the green portion of the curve.



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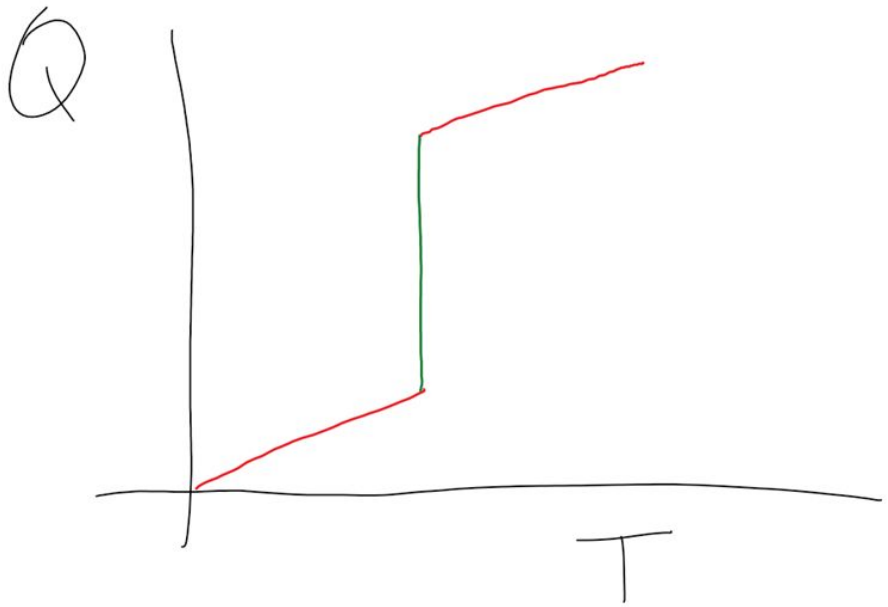


A phase change (i.e solid to liquid, liquid to gas). This is an example of a first-order phase transition.