North Stradbroke Island is an island off the east coast of Australia with large sandy beaches. Moving small distances perpendicular to the waterline can greatly affect environmental variables such as moisture, salinity, and temperature. The primary research question is to see if distance from the waterline affects abundance of a certain genus of aquatic molluscs.

Researchers randomly selected twelve (12) different locations along the shore of the island. At each location, they put down two separate one-by-one meter square quadrats, one in each of two different tidal zones. One quadrat was placed in Zone 3 at the *mid-shore*, halfway between the lowest low tide and the highest high tide. A second quadrat was placed in Zone 2 *above the mid-shore*, partway between the mid-shore and the highest high tide mark.

In each quadrat, researchers counted the number of *Bembecium* individuals. (*Bembecium* are gastropods, a class of molluscs that usually have a shell consisting of a single piece.) The main statistical question is, "is there evidence that mean abundances of *Bembecium* differ in the two tidal zones?" Here is a data summary.

Location	1	2	3	4	5	6	7	8	9	10	11	12	mean	SD
Mid-shore	135	15	31	81	59	72	66	101	36	92	59	41	65.7	33.5
Above	81	20	25	62	41	28	43	50	48	31	39	24	41.0	17.7
Difference	54	−5	6	19	18	44	23	51	−12	61	20	17	24.7	23.3

(a) Use an appropriate t test to address the question. State hypotheses in words and symbols, compute a test statistic, find a p-value, and interpret the results in the context of the problem.

Solution: The hypotheses are as follows: $H_0: \mu_d = 0$, there is no difference in the mean abundances of *Bembecium* between the two tidal zones versus $H_A: \mu_d \neq 0$, there is a difference in the mean abundances of *Bembecium* between the two tidal zones.

This is a paired design, so the paired t test statistic is appropriate, $t = 24.7/(23.3/\sqrt{12}) = 3.67$. The p-value for this non-directional test is twice the area to the right of 3.67 under a t distribution with 11 degrees of freedom. From the Table, the p-value is between 0.001 and 0.01.

There is fairly strong evidence ($p < 0.01$, two-sided, paired t-test) that there is a difference in the abundances of *Bembicium* in the mid-shore and above mid-shore tidal zones of North Stradbroke Island.

(b) *Circle one choice in each box and fill in the blanks.*

In a sign test for this data with a non-directional alternative hypothesis, the p-value is [ONE | TWO]

times the probability of _____ [OR FEWER HEADS | HEADS EXACTLY | OR MORE HEADS] in

_____ independent coin tosses with head probability _____ .

Solution: There are two acceptable solutions: the p-value is *two times* the probability of either *2 or fewer heads* or *10 or more heads* in *12* independent coin tosses of a coin with head probability equal to *0.5*