a) the probability that the object is in A at time $n \geq 0$?

$$\begin{array}{ccc} A & B & C \end{array}$$

· Initial Probability: $P_0 = [1, 0, 0]$

$n \geq 0$ $\quad P_A = \underset{n=1}{P} \times \underset{n=2}{P} \times \underset{n=3}{P} \times \underset{n=4}{P} \ldots = p^n \Rightarrow \boxed{P(A) = p^n}$

b) The probability the object 1st reaches B at time $n >= 1$?

$P_B = (1-p) \times P_{(n-1)}$ → at $n = 0$ $P_B = \emptyset$ ✓

$\boxed{n = 1 \quad P_B = (1-p) \times P(A)_\emptyset = (1-p) \times 1 = \boxed{1-p}}$

$\cancel{n = 2} \quad \cancel{P_B} = P_{(n-1)} \times q = (1-p) \times q$

$n = 3 \quad P_B = P_{(n-1)} \times q = (1-p) \times q^2$

⋮

$\boxed{P_B = (1-p) \times q^n}$

c) The probability that the object is in B at time $n \geq 1$?

$n=1 \quad P_B = 1-p$

$n=2 \quad P_B = P_{(n-1)} \times q = (1-p) \times q$

$n=3 \quad P_B = P_{(n-1)} \times q = (1-p) \times q^2$

$\vdots$

$$\boxed{n=k \quad P_B = (1-p) \times q^{k-1}}$$

d.) The probability that the object first reaches C at time $n \geq 2$?

$n=0$ $P_0 = [1, 0, 0]$ $\rightarrow$ $n=1$ $P_B = (1-p) \times 1$

$n=2$ $P_C = (1-p) \times (1-q)$

$n=3$ $P_C = P(C) \times P_{(n-1)} = (1-p)(1-q) \times 1$

$\vdots$

$\boxed{n=k \quad P_C = (1-p)(1-q)}$