④ $\lambda = 18$ customers / hour

$c = 2$; $E(s) = \frac{1}{9}$ hour / customer

$\mu = \frac{1}{E(s)} = 9$ (each)

$N = 7$

ⓐ $P_0 = \left(1 + \left(\sum_{m=1}^{c} \frac{a^m}{m!}\right) + \left(\frac{a^c}{c!} \sum_{m=c+1}^{N} \rho^{m-c}\right)\right)^{-1}$

$\rho = \frac{\lambda}{c\mu} = \frac{18}{2 \times 9} = 1$; $a = \frac{\lambda}{\mu} = \frac{18}{9} = 2$

$P_0 = \left(1 + \left(\frac{a}{1!} + \frac{a^2}{2!}\right) + \frac{a^2}{2!}\left(\rho^1 + \rho^2 + \rho^3 + \rho^4 + \rho^5\right)\right)^{-1}$

$P_0 = \left(1 + (2+2) + \frac{4}{2}(1+1+1+1+1)\right)^{-1}$

$= \left(1 + 4 + (2(5))\right)^{-1}$

$= (15)^{-1} = 0.0667$

$L_Q = \frac{a^c P_0}{2c!}(N-c+1)(N-c)$, $\rho = 1$

$$= \frac{2^2\,(0.0667)}{4!}\,(7-2+1)(7-2)$$

$$= \frac{\cancel{4} \times 0.0667}{\cancel{4} \times 3 \cancel{\times 2}}\,(\cancel{6})(5)$$

$$= 0.3333$$

Long term average number of customers waiting in line are 0.3334.

(b) $W_Q = \dfrac{L_Q}{\lambda_e}$

$$\lambda_e = (1-P_N)\,\lambda$$

$$P_N = \frac{a^N P_0}{c!\,c^{N-C}} = \frac{2^7 \times 0.0667}{2!\;2^5}$$

$$= \frac{2^2 \times 0.0667}{2!}$$

$$= 0.1334$$

$$\lambda_e = (1-P_N)\,\lambda = (1-0.1334) \times 18$$

$$= 15.5988 \text{ cust./hr.}$$

$= 0.25998$ cust/min

$$W_Q = \frac{L_Q}{\lambda_e}$$

$$= \frac{0.3334}{0.25998}$$

$$= 1.2824$$

The long term average waiting time per customer is 1.2824 minutes.

(c) $$W = W_Q + \frac{1}{\mu}$$

$$= 1.2824 + \frac{1}{9}$$

$$= 1.3935$$

The long term average time a customer spends in the store is 1.3935 minutes.

(d) $$L = \lambda_e W$$

$$= \dots 1.3935$$

$= 0.25998 \times$

$= 0.3623$

The long term average number of customers in the store is 0.3623.