(1) We need $\mathbb{E}[M \mid N=2]$ and so $\mathbb{P}(M=m \mid N=2)$, $m \in \mathbb{N}$. To this end

$$\mathbb{P}(N=2) = \sum_{m=1}^{\infty} \mathbb{P}(M=m, N=2) = \sum_{m=1}^{\infty} \frac{3}{16} e^{-2}(1-e^{-2})^{m-1}$$

$$= \frac{3}{16} e^{-2} \sum_{m=0}^{\infty} (1-e^{-2})^{m} = \frac{3e^{-2}}{16} \frac{1}{e^{-2}} = \frac{3}{16}.$$

Then

$$\mathbb{P}(M=m \mid N=2) = \frac{\mathbb{P}(M=m, N=2)}{\mathbb{P}(N=2)} = \frac{16}{3} \cdot \frac{3}{16} e^{-2}(1-e^{-2})^{m-1}$$

$$= e^{-2}(1-e^{-2})^{m-1}, \quad m \in \mathbb{N}.$$

You can thus say that $M \mid N=2 \sim \mathrm{Geom}(e^{-2})$, so $\mathbb{E}[M \mid N=2] = e^{2}$.

Otherwise:

$$\mathbb{E}[M \mid N=2] = \sum_{m=1}^{\infty} m e^{-2}(1-e^{-2})^{m-1} = p \sum_{m=0}^{\infty} m (1-p)^{m-1}$$

$$= -p \sum_{m=0}^{\infty} \frac{d}{dp}(1-p)^{m} = -p \frac{d}{dp} \sum_{m=0}^{\infty} (1-p)^{m} = -p \frac{d}{dp} \frac{1}{p} = \frac{1}{p}.$$

(2) The density of the RV, T, is $f(t) = \frac{1}{3} e^{-\frac{1}{3}t}$, $t \in \mathbb{R}_+$.

Also:

$$T \vee 2 = \begin{cases} T, & T > 2 \\ 2, & T \le 2 \end{cases}$$

So

$$\mathbb{E}[T \vee 2] = \mathbb{E}[T \mathbb{I}\{T > 2\}] + 2\mathbb{E}[\mathbb{I}\{T \le 2\}]$$

$$= 2(1-e^{-\frac{2}{3}}) + e^{-\frac{2}{3}} \mathbb{E}[T \mid T>2]$$

$$= 2(1-e^{-\frac{2}{3}}) + e^{-\frac{2}{3}}(\mathbb{E}[T-2 \mid T>2] + 2)$$

$$= 2(1-e^{-\frac{2}{3}}) + e^{-\frac{2}{3}} \cdot (3+2)$$

$$= 2 + 3e^{-\frac{2}{3}}.$$