M-Step 1:

$$\theta_c' = \frac{\sum \text{weight}(c)}{\#\text{datapoints}} = \frac{\frac{1}{M \cdot |\text{val}(c)|}}{M \cdot |\text{val}(c)|} = \frac{1}{|\text{val}(c)|^2}$$

denote as $t_{ij}$

$$\theta_{x_i|c}' = \frac{\#\text{datapoints where } X_i = x_j \text{ and } C = c \cdot \text{weight}}{\#\text{datapoints where } C = c \cdot \text{weight}}$$

$$= \frac{t_{ij} \cdot \frac{1}{|\text{val}(c)|}}{M \cdot \frac{1}{|\text{val}(c)|}} = \frac{t_{ij}}{M}, \text{ where } t_{ij} \leq M$$

To show EM has converged, we will run one more E-step:

E-step 2: $w = \frac{1}{Z} \cdot \frac{1}{|\text{val}(c)|^2} \cdot \prod_{i=1}^{n} \frac{t_{ij}}{M} = \frac{1}{Z} \cdot \frac{1}{|\text{val}(c)|^2} \cdot \frac{1}{M^n} \cdot \prod_{i=1}^{n} t_{ij}$

$$Z = \sum_{h=1}^{|\text{val}(c)|} \frac{1}{|\text{val}(c)|^2} \cdot \frac{1}{M^n} \cdot \prod_{i=1}^{n} t_{ij} = \frac{1}{|\text{val}(c)|} \cdot \frac{1}{M^n} \cdot \prod_{i=1}^{n} t_{ij}$$

$$w = \frac{\frac{1}{|\text{val}(c)|^2} \cdot \frac{1}{M^n} \cdot \prod_{i=1}^{n} t_{ij}}{\frac{1}{|\text{val}(c)|} \cdot \frac{1}{M^n} \cdot \prod_{i=1}^{n} t_{ij}} = \frac{|\text{val}(c)|}{|\text{val}(c)|^2} = \frac{1}{|\text{val}(c)|}$$

Since the value for all weights is the same as the previous E-step, EM has converged.

The final parameter values are:

$$\theta_c = \frac{1}{|\text{val}(c)|^2}$$

$$\theta_{x_i|c} = \frac{t_{ij}}{M}$$