① $g(x) = \dfrac{1}{1+e^{-x}}$

$$g'(x) = \frac{0 \cdot (1-e^{-x}) - 1(0-e^{-x})}{(1+e^{-x})^2} = \frac{e^{-x}}{1+2e^{-x}+e^{-2x}} =$$

$$= \boxed{\frac{e^{-x}}{(1+e^{-x})^2}}$$

$$(g(x))(1-g(x)) = \frac{1}{1+e^{-x}} \cdot \left(1 - \frac{1}{1+e^{-x}}\right) =$$

$$= \frac{1}{1+e^{-x}} \left(\frac{1+e^{-x}-1}{1+e^{-x}}\right) = \boxed{\frac{e^{-x}}{(1+e^{-x})^2}}$$

② $l(w) = \dfrac{1}{N} \displaystyle\sum_{t=1}^{N} \log\left(p(y_t | x_t)\right) =$

$$= \frac{1}{N} \sum_{t=1}^{N} \log\left(g(w^T x_t)^{y_t} (1-g(w^T x_t))^{1-y_t}\right)$$

$$\frac{\partial l(w)}{\partial w} = \frac{1}{N} \sum_{t=1}^{N} \frac{1}{g(w^T x_t)^{y_t}(1-g(w^T x_t))^{1-y_t}} \cdot \left(y_t g(w^T x_t)^{y_t-1} \cdot g(w^T x_t) \cdot (1-g(w^T x_t)) \right.$$

$$\cdot x_t \cdot (1-g(w^T x_t))^{1-y_t} + g(w^T x_t)^{y_t} \cdot (1-y_t) \cdot (1-g(w^T x_t))^{-y_t} \cdot$$

$$\cdot \left(-g(w^T x_t) \cdot (1-g(w^T x_t)) \cdot x_t\right)$$

$$= \frac{1}{N} \sum_{t=1}^{N} y_t \cdot (1-g(w^T x_t)) \cdot x_t + (1-y_t) \cdot (-g(w^T x_t)) \cdot x_t$$

$$= \frac{1}{N} \sum_{t=1}^{N} \left(y_t - y_t g(w^T x_t) - g(w^T x_t) + y_t g(w^T x_t)\right) x_t$$

$$= \frac{1}{N} \sum_{t=1}^{N} \left(y_t - g(w^T x_t)\right) x_t$$