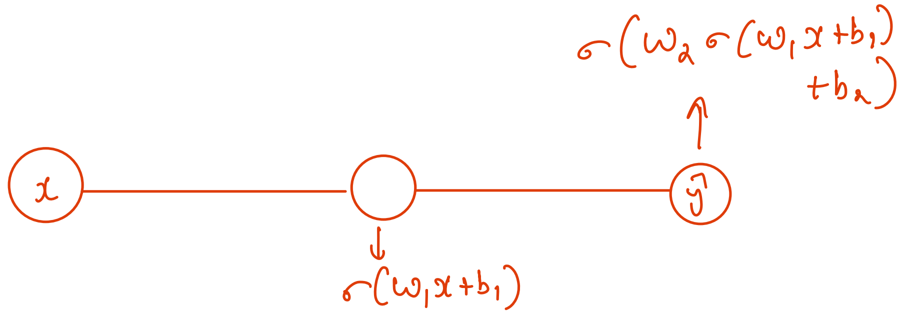
Ans#1 :-



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

$$L(\underset{\sim}{\theta}) = \frac{1}{2}\left(\sigma(w_2\sigma(w_1x+b_1)+b_2) - y\right)^2$$

$$\nabla_\theta L = \begin{bmatrix} \frac{\partial L}{\partial w_1} \\ \frac{\partial L}{\partial w_2} \\ \frac{\partial L}{\partial b_1} \\ \frac{\partial L}{\partial b_2} \end{bmatrix}$$

① Let $g(w_1, b_1) = \sigma(w_1 x + b_1)$

$f(w_2, g, b_2) = w_2\, \sigma(g(w_1, b_1)) + b_2$

$$L(\underset{\sim}{\theta}) = \frac{1}{2}\left(\sigma(f(w_2, g, b_2)) - y\right)^2$$

$$\frac{\partial L}{\partial w_1} = (\sigma(f) - y)\left(\frac{\partial \sigma}{\partial f}\frac{\partial f}{\partial g}\frac{\partial g}{\partial w_1}\right)$$

where :- $\dfrac{\partial \sigma}{\partial f} = \sigma(f)(1 - \sigma(f))$

$$\frac{\partial f}{\partial g} = w_2\left[\sigma(g)(1 - \sigma(g))\right]$$

$$\frac{\partial g}{\partial w_1} = x\left(\sigma(w_1 x + b_1)\right)\left[1 - \sigma(w_1 x + b_1)\right]$$

② $$\frac{\partial L}{\partial w_2} = (\sigma(f) - y)\left(\frac{\partial \sigma}{\partial f}\frac{\partial f}{\partial w_2}\right)$$

$$\frac{\partial \sigma}{\partial f} = \frac{\partial \sigma}{\partial f} = \sigma(f)(1 - \sigma(f))$$

$$\frac{\partial f}{\partial w_2} = \sigma(g)$$

③ $$\frac{\partial L}{\partial b_1} = (\sigma(f) - y)\left(\frac{\partial \sigma}{\partial f}\frac{\partial f}{\partial g}\frac{\partial g}{\partial b_1}\right)$$

$$\frac{\partial \sigma}{\partial f} = \sigma(f)(1-\sigma(f))$$

$$\frac{\partial f}{\partial g} = w_2\left[\sigma(g)(1-\sigma(g))\right]$$

$$\frac{\partial g}{\partial b_1} = (\sigma(w_1 x + b_1))\left[1 - \sigma(w_1 x + b_1)\right]$$

④ $$\frac{\partial L}{\partial b_2} = (\sigma(f) - y)\left(\frac{\partial \sigma}{\partial f}\frac{\partial f}{\partial b_2}\right)$$

where:-

$$\frac{\partial \sigma}{\partial f} = \sigma(f)(1-\sigma(f))$$

$$\frac{\partial f}{\partial b_2} = 1$$