a) The given inputs

$x_1 = 0.3$

$x_2 = 0.6$

The given weights

$w_{3,1} = -0.1$, $w_{4,1} = 0.2$

$w_{3,2} = -0.2$, $w_{4,2} = 0.3$

$w_{3,0} = 0.1$, $w_{4,0} = 0.1$

$w_{5,3} = -0.1$, $w_{6,3} = 0.1$

$w_{5,4} = 0.2$, $w_{6,4} = -0.2$

$w_{5,0} = 0.1$ $w_{6,0} = 0.1$

For neuron 3

$$
\begin{aligned}
z_3 &= (x_1 \times w_{31}) + (x_2 \times w_{3,2}) + w_{3,0} \\
&= (0.3 \times -0.1) + (0.6 \times -0.2) + 0.1 \\
&= -0.03 - 0.12 + 0.1 \\
&= -0.05
\end{aligned}
$$

Since z_3 is negative the ReLU activation function will output zero.

$a_3 = \max(0, z_3) = 0.$

for neuron 4:

$z_4 = (x_1 \times w_{41}) + (x_2 \times w_{42}) + w_{410}$

$z_4 = (0.3 \times 0.2) + (0.6 \times 0.3) + 0.1$

$z_4 = 0.06 + 0.18 + 0.1$

$= 0.34$

$a_4 = \max(0, z_4) = 0.34$

for neuron 5:

$z_5 = (x_3 \times w_{53}) + (x_4 \times w_{54}) + w_{50}$

$= (0 \times -0.1) + (0.34 \times 0.2) + 0.1$

$= 0 + 0.068 + 0.1$

$= 0.168$

$a_5 = \max(0, z_5) = 0.168$

for neuron 6:

$z_6 = (x_3 + w_{6,3}) + (x_4 \times w_{6,4})$

$+ w_{6,0}$

$= (0 \times 0.1) + (0.34 \times -0.2) + 0.1$

$= 0 - 0.068 + 0.1$

$z_6 = 0.032$

$a_6 = \max(0, z_6) = 0.032$

The values for the out put Neurons

Neuron 5 $z_5 = 0.168$ f $a_5 = 0.168$

Neuron 6 : $z_6 = 0.032$ f $a_6 = 0.032$

b) The desired outputs are:

Neuron 5 : 0.7

Neuron 6 : 0.4.

The actual outputs are

Neuron 5 : 0.168

Neuron 6 : 0.032.

$$SSE = \frac{1}{2}\left((d5 - a5)^2 + (d6 - a6)^2\right)$$
$$= \frac{1}{2}\left((0.7 - 0.168)^2 + (0.4 - 0.032)^2\right)$$
$$= \frac{1}{2}\left((0.532)^2 + (0.368)^2\right)$$
$$= \frac{1}{2}(0.2830 + 0.1354)$$
$$= \frac{1}{2}(0.4184) = 0.2092$$

d5, d6 - desired outputs

a5, a6 - actual outputs

c) $\delta_5 = (d_5 - a_5) \times ReLU(a_5)$
$= (0.7 - 0.168) \times 1$
$= 0.532.$

The above is the error delta for neuron 5 (δ_5)

$\delta_6 = (d_6 - a_6) \times ReLU(a_6)$
$= (0.4 - 0.032) \times 1.$
$= 0.368$

For the Hidden neurons. (3 & 4)

For neuron 4.
$\delta_4 = (\delta_5 \times w_{5,4} + \delta_6 \times w_{6,4}) \times ReLU(a_4)$
$= (0.532 \times 0.2 + 0.368 \times -0.2) \times 1$
$= (0.1064 - 0.0736)$
$= 0.0328$

$\delta_5 = 0.532.$
$\delta_6 = 0.368$
$\delta_3 = 0$ (since neuron 3's output is 0 its contribution to the error is 0)
$\delta_4 = 0.0328$

d)1 $\frac{dE}{dw_{64}} = \delta_6 \cdot a_4 = 0.368 \times 0.34$

$\simeq 0.12512$

$\frac{dE}{dw_{63}} = \delta_6 \cdot a_3 = 0.368 \times 0$

$= 0.$

$\frac{dE}{dw_{6,0}} = \delta_6 = 0.368$

$\frac{dE}{dw_{5,4}} = \delta_5 \times a_4 = 0.532 \times 0.34$

$\simeq 0.18088$

$$\frac{dE}{dw_{5,3}} = \delta_5 \times a_3 = 0.532 \times 0$$

$$= 0.$$

$$\frac{dE}{dw_{5,0}} = \delta_5 = 0.532$$

$$\frac{dE}{dw_{4,2}} = \delta_4 \times a_2 = 0.0328 \times 0.6$$

$$\simeq 0.01968.$$

$$\frac{dE}{dw_{4,1}} = \delta_4 \times a_1 = 0.0328 \times 0.3$$

$$\simeq 0.00984$$

$$\frac{dE}{dw_{4,0}} = \delta_4 = 0.0328$$

$$\frac{dE}{dw_{3,2}} = \delta_3 \times a_2 = 0 \times 0.6. -$$

$$= 0$$

$$\frac{dE}{dw_{3,1}} = \delta_3 \times a_1 = 0 \times 0.3$$

$$= 0.$$

$$\frac{dE}{dw_{3,0}} = \delta_3 = 0.$$

e. Learning rate $\alpha = 0.1$

Weights.

$W_{new} = W_{old} - \alpha \times \frac{dE}{dw}$

bias.

$b_{new} = b_{old} - \alpha \times \delta.$

~~$W_{4,5}$ new~~

$W_{6,4}$ new $= W_{64} - \alpha \frac{dE}{dW_{6,4}}$

$\cancel{= 0.2 \times 0.12512}$

$= -0.2 - 0.1 \times 0.12512.$

$\simeq -0.212512.$

$W_{6,3}$ new $= \cancel{W_{6,3} \times d}$

$= W_{6,3} - \alpha \frac{dE}{dW_{6,3}}$

$= 0.1 - 0.1 \times 0 = 0.1$

e. Learning rate $\alpha = 0.1$

Weights.

$W_{new} = W_{old} - \alpha \times \frac{dE}{dw}$

bias.

$b_{new} = b_{old} - \alpha \times \delta.$

~~$W_{4,5}$ new~~

$W_{6,4}$ new $= W_{64} - \alpha \frac{dE}{dW_{6,4}}$

~~$= 0.2 \times 0.12512$~~

$= -0.2 - 0.1 \times 0.12512$

$\simeq -0.212512$

$W_{6,3}$ new $=$ ~~$W_{63} \times d$~~

$= W_{6,3} - \alpha \frac{dE}{dW_{6,3}}$

$= 0.1 - 0.1 \times 0 = 0.1$

$$w_{6,0} \text{ new} = w_{6,0} - \alpha \frac{dE}{dw_{6,0}}$$

$$= 0.1 - 0.1 \times (0.368)$$
$$= 0.1 - 0.0368$$
$$= 0.0632$$

$$w_{5,4} \text{ new} = w_{5,4} - \alpha \frac{dE}{dw_{5,4}}$$

$$= 0.2 - 0.1 \times (0.18088)$$
$$= 0.2 - 0.018088$$
$$= 0.181912$$

$$w_{5,3} \text{ new} = w_{5,3} - \alpha \frac{dE}{dw_{5,3}}$$

$$= -0.1 - 0.1 \times (0)$$

$$= -0.1$$

$$w_{5,0}\,new = w_{5,0} - \alpha \frac{de}{dw_{50}}$$

$$= 0.1 - 0.1 \times (0.532)$$
$$= 0.1 - 0.0532.$$
$$= 0.0468$$

$$w_{4,2}\,new = w_{4,2} - \alpha \frac{de}{dw_{42}}.$$

$$= 0.3 - 0.1 \times (0.01968)$$
$$= 0.3 - 0.001968$$
$$= 0.298032$$

$$w_{4,1}\,new = w_{41} - \alpha \frac{de}{dw_{4,1}}$$

$$= 0.2 - 0.1(0.00984)$$

$$= 0.2 - 0.000984.$$
$$= 0.199016.$$

$$w_{4,0}\,new = w_{4,0} - \alpha \frac{dE}{dw_{4,0}}$$

$$= 0.1 - 0.1(0.0328)$$

$$= 0.1 - 0.00328$$

$$= 0.09672$$

$$w_{3,2}\,new = w_{3,2} - \alpha \frac{dE}{dw_{3,2}}$$

$$= -0.2 - 0.1 \times (0)$$

$$= -0.2$$

$$w_{3,1}\,new = w_{3,1} - \alpha \frac{dE}{dw_{3,1}}$$

$$= -0.1 - 0.1 \times (0)$$

$$= -0.1$$

$$w_{3,0}\text{ new} = w_{3,0} - \alpha \frac{dE}{dw_{3,0}}$$

$$= 0.1 - 0.1 \times (0)$$

$$= 0.1$$

f. For Neuron 3.

Since there is no update in weights of w_{31} & w_{32}

$$z_3 = -0.05$$

$$a_3 = \max(0, -0.05) = 0$$

For neuron 4.

$$z_4 = (x_1 \times w_{41new}) + (x_2 \times w_{42new}) + w_{40}$$

$$z_4 = (0.3 \times 0.0199016) + (0.6 \times 0.298032) + 0.1$$

$$= 0.0597048 + 0.1788192 + 0.1$$

$$= 0.338524$$

$$a_4 = \max(0, 0.338524) =$$

$$= 0.338524$$

For neuron 5 :-

$z_5 = (x_3 \times w_{53}) + (x_4 \times w_{54}) + w_{510}$

$= (0 \times -0.1) + (0.338524 \times 0.181912) + 0.0468$

$z_5 = 0 + 0.061572 + 0.0468$
$\simeq 0.108372.$

$a_5 = \max(0, 0.108372)$
$= 0.108372$

For neuron 6.
Since $a_3 = 0$. it does not contribute to z_6

$z_6 = (0 \times 0.1) + (0.338524 \times -0.212512) + 0.0632.$

$z_6 = 0 - 0.071928 + 0.0632.$
$\simeq -0.008728$

$a_6 = \max(0, -0.008728) = 0$

g. The new SSE

$$SSE = \frac{1}{2}(d5 - a5)^2 + (d6 - a6)^2$$

$$= \frac{1}{2}(0.7 - 0.108372)^2 + (0.4 - 0)^2$$

$$= \frac{1}{2}\left[(0.59161)^2 + (0.4)^2\right]$$

$$= \frac{1}{2}\left[0.35001 + 0.16\right]$$

$$= \frac{1}{2}\left[0.51000\right]$$

$$= 0.255$$

h. Original SSE = 0.2092

New SSE = 0.255

Error = 0.255 - 0.2092
= - 0.0458

Therefore there is an increase in error of 0.0458