Step-1

As per the definition, we can write $A \otimes B$ as follows:

$$A \otimes B = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ a_{n1} & a_{n2} & \cdots & a_{nn} \end{bmatrix} \otimes \begin{bmatrix} b_{11} & b_{12} & \cdots & b_{1m} \\ b_{21} & b_{22} & \cdots & b_{2m} \\ \vdots & \vdots & \vdots & \vdots \\ b_{m1} & b_{m2} & \cdots & b_{mm} \end{bmatrix}$$

$$= \begin{bmatrix} a_{11}B & a_{12}B & \cdots & a_{1n}B \\ a_{21}B & a_{22}B & \cdots & a_{2n}B \\ \vdots & \vdots & \vdots & \vdots \\ a_{n1}B & a_{n2}B & \cdots & a_{nn}B \end{bmatrix}$$

Step-2

Let A and B be invertible and let A^{-1} be as follows:

$$A^{-1} = \begin{bmatrix} a_{11}' & a_{12}' & \cdots & a_{1n}' \\ a_{21}' & a_{22}' & \cdots & a_{2n}' \\ \vdots & \vdots & \vdots & \vdots \\ a_{n1}' & a_{n2}' & \cdots & a_{nn}' \end{bmatrix}$$

Therefore, we have

$$A^{-1} \otimes B^{-1} = \begin{bmatrix} a_{11}' & a_{12}' & \cdots & a_{1n}' \\ a_{21}' & a_{22}' & \cdots & a_{2n}' \\ \vdots & \vdots & \vdots & \vdots \\ a_{n1}' & a_{n2}' & \cdots & a_{nn}' \end{bmatrix} \otimes B^{-1}$$

$$= \begin{bmatrix} a_{11}'B^{-1} & a_{12}'B^{-1} & \cdots & a_{1n}'B^{-1} \\ a_{21}'B^{-1} & a_{22}'B^{-1} & \cdots & a_{2n}'B^{-1} \\ \vdots & \vdots & \vdots & \vdots \\ a_{n1}'B^{-1} & a_{n2}'B^{-1} & \cdots & a_{nn}'B^{-1} \end{bmatrix}$$

Step-3

Now consider the following:

$$(A\otimes B)(A^{-1}\otimes B^{-1})=\begin{bmatrix} a_{11}B & a_{12}B & \cdots & a_{1n}B \\ a_{21}B & a_{22}B & \cdots & a_{2n}B \\ \vdots & \vdots & \vdots & \vdots \\ a_{n1}B & a_{n2}B & \cdots & a_{nn}B \end{bmatrix}\begin{bmatrix} a_{11}'B^{-1} & a_{12}'B^{-1} & \cdots & a_{1n}'B^{-1} \\ a_{21}'B^{-1} & a_{22}'B^{-1} & \cdots & a_{2n}'B^{-1} \\ \vdots & \vdots & \vdots & \vdots \\ a_{n1}'B^{-1} & a_{n2}'B^{-1} & \cdots & a_{nn}'B^{-1} \end{bmatrix}$$

Consider the ij^{th} entry of this matrix. The entry will be the sum of the product of the consecutive terms of the i^{th} row of $A\otimes B$ and the j^{th} column of $A^{-1}\otimes B^{-1}$.

Step-4

Thus, we have the ij^{th} entry as follows:

$$\begin{aligned}(A\otimes B)(A^{-1}\otimes B^{-1})_{ij} &= a_{i1}Ba_{1j}'B^{-1}+a_{i2}Ba_{2j}'B^{-1}+\ldots+a_{in}Ba_{nj}'B^{-1} \\ &= a_{i1}a_{1j}'BB^{-1}+a_{i2}a_{2j}'BB^{-1}+\ldots+a_{in}a_{nj}'BB^{-1} \\ &= a_{i1}a_{1j}'I+a_{i2}a_{2j}'I+\ldots+a_{in}a_{nj}'I \\ &= a_{i1}a_{1j}'+a_{i2}a_{2j}'+\ldots+a_{in}a_{nj}'\end{aligned}$$

From the property of the inverse of matrices, the following should be clear:

When $i=j$, $a_{i1}a_{1j}'+a_{i2}a_{2j}'+\ldots+a_{in}a_{nj}'=1$

When $i\neq j$, $a_{i1}a_{1j}'+a_{i2}a_{2j}'+\ldots+a_{in}a_{nj}'=0$.

This gives us the following:

$$(A\otimes B)(A^{-1}\otimes B^{-1})=\begin{bmatrix} I & 0 & \cdots & 0 \\ 0 & I & \cdots & 0 \\ \vdots & \vdots & \vdots & \vdots \\ 0 & 0 & \cdots & I \end{bmatrix}$$

In the above matrix, each identity matrix is of the order n. Thus, we can say that $(A\otimes B)(A^{-1}\otimes B^{-1})$ is itself an identity matrix of the order n^2.

Therefore, $\boxed{(A\otimes B)(A^{-1}\otimes B^{-1})=I_{2D}}$.