Step-1

We have $AA^{-1} = I$ hence

$\det\left(AA^{-1}\right) = \det I = 1$

$\Rightarrow \det A.\det A^{-1} = 1$

$\Rightarrow \det A^{-1} = \dfrac{1}{\det A}$

Given that $\det A^{-1}$ is an integer.

So, $\dfrac{1}{\det A}$ is an integer possible if and only if $\det A = -1$ or 1

Similarly, $\det A^{-1} = -1$ or 1.

Det A times $\det A^{-1}$ means $\det A.\det A^{-1}$

This is nothing but $\det I = 1$