Step-1

(a)

Consider the following matrices:

$$A = \begin{bmatrix} 0 & -1 \\ 1 & 0 \end{bmatrix}$$
$$B = \begin{bmatrix} 1 & 0 \\ 0 & -1 \end{bmatrix}$$

Here the matrix B is obtained from the matrix A by exchanging first and second row.

Eigen values of matrix A are $\pm i$.

Eigen values of B are -1 and 1.

Since similar matrices have same set of Eigen values and the matrices A and B have different Eigen values so, the matrix B is not similar to matrix A.

Therefore, the given statement is $\boxed{\text{false}}$.

Step-2

(b)

Consider the following matrices:

$$A = \begin{bmatrix} 1 & 2 \\ 0 & 2 \end{bmatrix}$$
$$B = \begin{bmatrix} 1 & 0 \\ 0 & 2 \end{bmatrix}$$

Characteristic polynomial of the matrix A is

$$(x-1)(x-2)=0$$

Eigen values of the matrix A are 1 and 2.

As Characteristic polynomial of the matrix A is product of linear factors and degree of the Characteristic polynomial is 2, is equal to order of the matrix A, so the matrix A is diagonalizable.

Hence, the matrix A is similar to a diagonal matrix; in fact the diagonal matrix is the matrix B.

Therefore, one can conclude that a triangular matrix A may be similar to a diagonal matrix B, but the triangular matrix may not itself a diagonal matrix.

Therefore, the given statement is $\boxed{\text{false}}$.

Step-3

(c)

Consider the following three statements about a matrix A.

A is Hermitian, A is unitary and $A^2 = I$.

Now one needs to check that any two of three conditions implies third one.

If A is Hermitian then

$A^H = A$ â€¦.. (1)

If A is unitary, then

$A^H A = I$ â€¦.. (2)

And

$A^2 = I$ â€¦.. (3)

First show that (1) and (2) implies (3).

To show this, substitute the value for A^H from (1) into (2).

$$\begin{aligned} A^H A &= I \\ A \cdot A &= I \\ A^2 &= I \end{aligned}$$

Therefore, the statements (1) and (2) imply the third statement.

Step-4

Next show that (1) and (3) implies (2).

To show this, consider (3).

$$\begin{aligned} A^2 &= I \\ A \cdot A &= I \\ A^H \cdot A &= I \qquad \text{from (1) } A = A^H \end{aligned}$$

Therefore, the statements (1) and (3) imply the second statement.

Step-5

Next show that (2) and (3) implies (1).

To show this, consider (2).

$$A^H \cdot A = I$$

Post multiply with A on both sides.

$$\begin{aligned} A^H \cdot A \cdot A &= I \cdot A \\ A^H \cdot A^2 &= A \\ A^H \cdot I &= A \quad \text{from (3) } A^2 = I \\ A^H &= A \end{aligned}$$

Therefore, the statements (2) and (3) imply the first statement.

Therefore, any two of three conditions implies third one.

Therefore, given statement is $\boxed{\text{true.}}$

Step-6

(d)

If matrix A and matrix B are diagonalizable, then matrix AB is also diagonalizable.

Therefore, the given statement is $\boxed{\text{true}}$.