It's more convenient to start with 3. (b):

Originally we have the objective function

$$\|b - Ax\|_2^2 = (b - Ax)^*(b - Ax)$$

Which according to Theorem 11.1 is minimal if and only if

$$A^* A x = A^* b .$$

We now add the L_2 normalization term to get the new objective function:

$$\|b - Ax\|^2 + \alpha^2 \|x\|^2$$

$$= (b - Ax)^*(b - Ax) + \alpha^2 x^* x$$

$$= (\tilde{b} - \tilde{A} x)^*(\tilde{b} - \tilde{A} x)$$

with $\tilde{A} = \begin{pmatrix} A \\ \alpha I \end{pmatrix}$, $\tilde{b} = \begin{pmatrix} b \\ 0 \end{pmatrix}$

3. (a) Applying Theorem 11.1 to the new objective function immediately yields the new normal equations

$$\tilde{A}^* A x = \tilde{A}^* \tilde{b} = A^* b$$

$$\Leftrightarrow \quad (A^* A + \alpha^2 I) x = A^* b \quad \square$$