1. A 4-pole, 2.3 MW, 690 V, 50 Hz squirrel cage induction generator is used in a fixed-speed wind energy conversion system in Denmark (where the grid frequency is 50 Hz). Generator parameters are given below:

\[
\begin{align*}
R_1 &= 0.001102 \, \Omega \\
X'_2 &= 0.0204 \, \Omega \\
X_1 &= 0.0204 \, \Omega \\
R'_2 &= 0.001497 \, \Omega \\
R_C &= \infty \, \Omega \\
X_m &= 0.6706 \, \Omega
\end{align*}
\]

At a given wind speed, the machine operates at the rated speed of 1512 rpm. Neglecting windage and friction losses, determine the following:

a. The slip, and the rotor speed in mechanical rad/sec and in electrical rad/sec;
b. The stator and rotor currents;
c. The developed power and torque;
d. The stator and rotor winding losses;
e. The generator efficiency and power factor.