Q 02 The resistance of an electrical toaster has a temperature dependence given by $R(T) = R_0[1 + \alpha(T - T_0)]$ in its range of operation. At $T_0 = 300K$, $R = 100\,\Omega$ and at $T = 500$ K, $R = 120\,\Omega$. The toaster is connected to a voltage source at 200 V and its temperature is raised at a constant rate from 300 to 500 K in 30 s. The total work done in raising the temperature is : **[Online April 10, 2016]**

(a) $400 \ln \frac{5}{6} J$ (b) $200 \ln \frac{2}{3} J$

(c) 300 J (d) $400 \ln \frac{1.5}{1.3} J$

(None) Work done in 30s, $W = \int_0^{30} \frac{V^2}{R} dt$

or, $$W = \int_0^{30} \frac{(200)^2}{100(1+\alpha\frac{20t}{3})} dt = \frac{(200)^2}{100} \int_0^{30} \frac{dt}{1+\frac{20\alpha}{3}t}$$

$$= \frac{400 \times 3}{20\alpha} \ell n \left(\frac{\frac{1+20\alpha}{3} \times 30}{1} \right) = 60{,}000\, \ell n \left(\frac{6}{5}\right)$$

$\because\ 120 = 100[1 + \alpha(200)]$

$\therefore\ \alpha = \frac{1}{1000}$