5)

a)

$$\text{percentage regulation} = \frac{I_F(R_e \times P_{fr} + X_e \times P_{fx})}{V_p}$$

I_F = full load current

R_e = Equivalent Resistance / winding Resistance

X_e = Equivalent Reactance / leakage Reactance

V_p = Supply Voltage

P_{fr} = Lagging power factor with reguards to resistance

P_{fx} = Lagging power factor with reguards to reactance

$I_f = \frac{200{,}000}{415} = 481.928$ to 3.dp

$R_e = 0.014$

$X_e = 0.057$

$P_{fr} = 0.8$

so $\cos^{-1}(0.8) = \theta$

$\theta = 36.87$ to 2.d.p

5a)

$\sin\theta = 0.6$

$Pfr = 0.6$

So

$$\text{percent regulation} = \frac{481.928(0.014 \times 0.8 + 0.057 \times 0.6)}{415}$$

$$= \frac{481.928(0.0112 + 0.0342)}{415}$$

$$= \frac{481.928 \times 0.0454}{415}$$

$$\frac{21.88}{415} \text{ to } 2.dp$$

$= 0.053$ to 3.dp

or 5.272% to 3.dp

5b)

Per unit regulation

$= I_1 \left(R_e \cos\phi_2 + X_e \sin\phi_2 \right)$

ϕ_2 = Phase angle of secondary Current

R_e = equivalent resistance reffered to primary

X_e = " reactance " " "

$$R_e = R_1 + R_2 \left(\frac{V_1}{V_2} \right)^2$$

$R_1 = 10\,m\Omega$ $\quad V_1$ 415 v $\quad V_2$ 11 kv

Regulation = 0.02 per unit

P.f = 1 $\quad \phi_2 = 0$

$$I_1 = \frac{200 \times 10^3}{11{,}000} = 18.18 \text{ Amps}$$

$$0.02 = \frac{18.18 (R_e \times 1 + X_e \times 0)}{415}$$

$$R_e = R_1 + R_2 \left(\frac{V_1}{V_2} \right)^2$$

5b)

$$0.02 = \frac{18.18 R_e}{415}$$

$415 \times 0.02 = 8.3$

$\frac{8.3}{18.18} = R_e$

$R_e = 0.457$ to 3.dp

$$R_e = 0.010 + R_z \left(\frac{415}{11000}\right)^2$$

$0.457 - 0.010$

$\frac{0.447}{1.423 \times 10^{-3}} = R_z$

$R_z = 314.125\,\Omega$ to 3. dp

Max $R_z = 314.125\,\Omega$ to 3.d.p.