CLASS TEST

S.No.: 01DLSK_ABCDEFGH_8726

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DC MACHINE + TRANSFORMER + INDUCTION

ELECTRICAL ENGINEERING

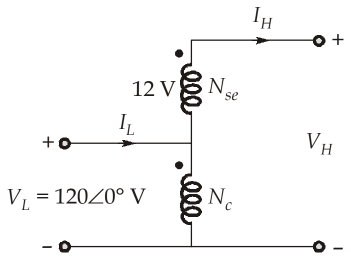
Date of Test : 08/07/2026

ANSWER KEY

1.	(d)	7.	(b)	13.	(b)	19.	(b)	25.	(a)
2.	(a)	8.	(d)	14.	(a)	20.	(d)	26.	(d)
3.	(a)	9.	(b)	15.	(b)	21.	(a)	27.	(a)
4.	(d)	10.	(d)	16.	(b)	22.	(c)	28.	(a)
5.	(c)	11.	(c)	17.	(c)	23.	(c)	29.	(d)
6.	(d)	12.	(d)	18.	(b)	24.	(b)	30.	(a)

DETAILED EXPLANATIONS

1. (d)



$$V_H = 132 \text{ V}$$

The maximum volt-ampere rating in either winding of this transformer is 100 VA.
The voltage on series winding is 12 V

$$I_{\text{series, max}} = \frac{S_{\max}}{V_{\text{series}}} = \frac{100}{12} = 8.33 \text{ A}$$

Since I_{series} is equal to I_H, so secondary apparent power is

$$S_{\text{out}} = V_S I_S = V_H I_H = 132 \times 8.33 = 1100 \text{ VA}$$

2. (a)

Maximum efficiency occurs at unity power factor and when copper loss is equal to the iron loss kVA rating at maximum efficiency

$$S_m = S_{fl}\sqrt{\frac{P_i}{P_{cu}}} = 300 \times \sqrt{\frac{1.5}{4.5}} = 173.205 \text{ kVA}$$

$$\therefore \quad \text{Maximum efficiency} = \frac{\text{Power output}}{\text{Power output + losses}}$$

$$\%\ \eta_{\max} = \frac{173.205}{173.205 + 1.5 + 1.5} \times 100 = 98.29\%$$

3. (a)

$$\text{Power output, } P_0 = 10 \text{ kW}$$
$$\text{Frequency, } f = 50 \text{ Hz}$$
$$\text{Poles, } P = 6$$
$$\text{Slip, } S = 0.04$$
$$\text{Friction and windage losses} = 0.4 \text{ kW}$$
$$\text{Mechanical power developed} = 10.4 \text{ kW}$$

$$\text{Air gap power, } P_g = \frac{\text{Mechanical power developed}}{1 - s} = \frac{10.4}{1 - 0.04} = 10.83 \text{ kW}$$

$$\text{Synchronous speed} = \frac{120 \times 50}{6} = 1000 \text{ rpm or } 104.72 \text{ rad/sec}$$

Full load electromagnetic torque,

$$T_e = \frac{P_g}{\omega_s} = \frac{10.83 \times 10^3}{104.72} = 103.42 \text{ N-m}$$

4. (d)

Hysteresis loss $P_h \propto fB^x \propto f\left(\frac{V}{f}\right)^x$

$$\frac{P_{h1}}{P_{h2}} = \frac{f_1}{f_2}\left(\frac{V_1}{V_2}\times\frac{f_2}{f_1}\right)^x$$

$$\frac{700}{P_{h2}} = \frac{50}{100}\left(\frac{1000}{2000}\times\frac{100}{50}\right)^x$$

$$P_{h2} = \frac{700\times 100}{50} = 1400 \text{ W}$$

Eddy current loss,

$$P_e \propto B^2 f^2 \propto f^2\left(\frac{V}{f}\right)^2$$

$$\frac{P_{e1}}{P_{e2}} = \left(\frac{f_1}{f_2}\right)^2\left(\frac{V_1}{V_2}\times\frac{f_2}{f_1}\right)^2$$

$$\frac{300}{P_{e2}} = \left(\frac{50}{100}\right)^2\left(\frac{1000\times 100}{2000\times 50}\right)^2$$

$$P_{e2} = 1200 \text{ W}$$

Total core loss, $P_c = P_{h2} + P_{e2} = 1400 + 1200 = 2600$ W

5. (c)

We know that,

Torque, $T \propto \phi I_a$

So, $$\frac{T_1}{T_2} = \frac{\phi_1 I_{a1}}{\phi_2 I_{a2}}$$

$$T_2 = \frac{\phi_2 I_{a2}}{\phi_1 I_{a1}}\times T_1$$

$$\phi_2 = 1.2\,\phi_1,\ I_{a1} = 40 \text{ A},\ I_{a2} = 60 \text{ A}$$

$$T_2 = 1.2\times\frac{60}{40}\times 20 = 36 \text{ N-m}$$

6. (d)

$$\frac{T_{st}}{T_{fl}} = \left(\frac{I_{st}}{I_{fl}}\right)^2 s_{fl}$$

For $T_{st} = T_{fl}$

$$\frac{I_{st}}{I_{fl}} = \sqrt{\frac{1}{s_{fl}}} = \frac{1}{\sqrt{0.01}} = 10$$

7. (b)

Rotation speed = 600 rpm

$$N = \frac{600}{60} = 10 \text{ rev/sec}$$

Peripheral velocity of commutator,

$$V_P = \pi DN = \pi\times 50\times 10 \text{ cm/sec}$$

As we know, $V_P \times t_c$ = Brush width

$\therefore$ Time of commutation, $t_c = \dfrac{2}{\pi \times 50 \times 10} = 1.273$ msec

8. (d)

We know that, emf generated,

$$E = \frac{P\phi NZ}{60A} = \phi \times 50 \times 18 \times \frac{9000}{60} \times \frac{4}{2}$$

$$357 = \phi \times 50 \times 18 \times \frac{9000}{60} \times \frac{4}{2}$$

Flux per pole, $\phi = 1.32$ mWb

9. (b)

Field current, $I_f = \dfrac{250}{125} = 2$ A

No load armature current, $I_{a0} = 16 - 2 = 14$ A;

Constant losses, $P_K = (250 \times 14 - (14)^2 \times 0.2) + 250 \times 2 = 3960.8$ W

$$I_a = 152 - 2 = 150 \text{ A}$$

$$P_L = I_a^2 R_a + P_K = (150)^2 \times 0.2 + 3960.8 = 8.461 \text{ kW}$$

$$P_{in} = 250 \times 152 = 38 \text{ kW}$$

$\therefore$ Efficiency, $\eta_n = \dfrac{38 - 8.461}{38} \times 100 = 77.73\%$

10. (d)

For dc series motor;

Given,

$$V_t = 220 \text{ V},$$
$$N_r = 1500 \text{ rpm}$$
$$I_a = 25 \text{ A},$$
$$R_a = 0.4\ \Omega,$$
$$R_{se} = 0.6\ \Omega$$

Torque; $T \propto I_a^2$

back emf at 1500 rpm,

$$E_{b1} = V_t - I_{a1}(R_a + R_{se}) = 220 - 25(0.4 + 0.6)$$

$$E_{b1} = 195 \text{ V}$$

We know that, $E_b \propto N$

Back emf at 1200 rpm;

$$\frac{E_{b2}}{195} = \frac{1200}{1500}$$

$$E_{b2} = \frac{12}{15} \times 195 = 156 \text{ V}$$

Let us assume R_{ext} to be connected in series:

$$E_{b2} = V_t - I_{a2}(R_a + R_{se} + R_{ext})$$

To obtain rated torque at 1200 rpm, armature current must be same;

i.e. $I_{a2} = 25$ A

Now, $156 = 220 - 25(0.4 + 0.6 + R_{ext})$

$$220 - 156 = 25(1 + R_{ext})$$

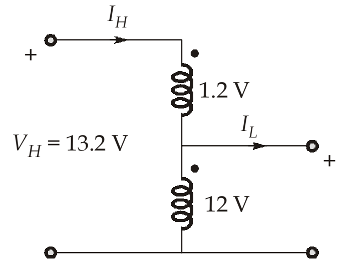
$$R_{ext} = 1.56\ \Omega$$

11. (c)

The apparent power rating will be

$$S_{auto} = \frac{N_{series} + N_{common}}{N_{series}} S_{TW}$$

$$= \frac{1.2 + 12}{1.2} \times 1000 = 11000 \text{ KVA}$$



The transformer impedance in p.u. system when connected in two winding manner is,

$$Z_{eq} = (0.01 + j0.08) \text{ p.u.}$$

The apparent power advantage of this auto transformer is 11, so the per unit impedance of the auto transformer is,

$$Z_{eq} = \frac{0.01 + j0.08}{11} = (0.00091 + j0.00727) \text{ p.u.}$$

12. (d)

$$I_A = I_L - I_F = 200 - \frac{250}{50} = 195 \text{ A}$$

$$E_A = V_T - I_A R_A = 250 - (195 \times 0.06) = 238.3 \text{ V}$$

At I_L = 200 A, the demagnetizing mmf is 840 A.T. So, effective shunt field current of the motor is

$$I_F^* = I_F - \frac{\text{mmf}}{N_F} = 5 - \frac{840}{1200} = 4.3 \text{ A}$$

From the given graph, if I_F^* = 4.3 A then $E_{\text{no load}}$ = 233 V

$$\frac{E_{1NL}}{E_2} = \frac{N_{1NL}}{N_2}$$

$$\frac{233}{238.3} = \frac{1200}{N_2}$$

Speed of the motor, $N = 1227.3$ rpm

13. (b)

Given, $I_{st} = 6 \times I_{fL}$

$$I_{fL} = \frac{\text{Power in kVA}}{\sqrt{3} \times V_L} = \frac{50 \times 10^3}{\sqrt{3} \times 440} = 65.608 \text{ A}$$

Current drawn by auto transformer from the mains at starting,

$$I_{st} = x^2 I_{st(motor)} = x^2 \times 6 \times I_{fl} = (0.5)^2 \times 6 \times 65.608 = 98.412 \text{ A}$$

Starting kVA drawn by the auto transformer

$$= \sqrt{3} V_L I_{st(auto)} = \sqrt{3} \times 440 \times 98.412 = 75 \text{ kVA}$$

14. (a)

We know that,

$$\text{Torque, } T = \frac{3}{\omega_{sm}} \times \frac{V^2}{R_2'} s \text{ (for low slip)}$$

Now, T = constant $\quad T \propto V^2 s$

(or) $\quad V_2^2 s_2 = V_1^2 s_1$

(or) $\quad s_2 = \left(\frac{V_1}{V_2}\right)^2 s_1$

(or) $\quad s_2 = 4s_1$,

hence slip increases 4 times,

Also, $\quad T = \frac{3I_2'^2}{\omega_{sm}} \times \frac{R_2'}{s} = \text{const.}$

(or) $\quad I_2'^2 \propto s$

$$\frac{I_2'}{I_1'} = \sqrt{\frac{s_2}{s_1}} = \sqrt{\frac{4}{1}} = 2$$

Hence, current increases by 2 times.

15. (b)

The motor and generator are identical

DC supply given to motor,

$$V = 1 \text{ p.u.}$$

Current in both motor and generator

$$I_{\text{am}} = I_{ag} = 1 \text{ p.u.}$$

$$R_{am} = R_{ag} = 0.02 \text{ p.u.}$$

Back emf in motor, $E_m = V - I_{am} R_{am}$

$$E_m = 1 - 1 \times 0.02 = 0.98 \text{ p.u.}$$

Also $\quad E_m I_{am} = E_g I_{ag}$

$\Rightarrow \quad E_m = E_g = 0.98$ p.u.

Terminal voltage of generator, $V_g = E_g - I_{ag} \cdot R_{ag} = 0.98 - 1 \times 0.02 = 0.96$ p.u.

$$\text{Load resistance} = \frac{V_g}{I_{ag}} = \frac{0.96}{1.0} = 0.96 \text{ p.u.}$$

16. (b)

$$\text{Synchronous speed, } N_s = \frac{120 \times 50}{6} = 1000 \text{ rpm}$$

Stalling speed = 900 rpm

$$\text{Slip at stalling torque, } s = \frac{1000 - 900}{1000} = 0.1$$

Slip at maximum torque; $\quad S_{mT} = \frac{R_2}{X_2} = \frac{0.01}{X_2}$

$\because \quad 0.1 = \frac{0.01}{X_2}$

$$X_2 = 0.1\ \Omega$$

To obtain maximum torque at starting,

Let rotor resistance = R_2'

At starting, slip, $s = 1$

$$S_{mT} = \frac{R_2'}{X_2}$$

$$\Rightarrow \quad 1 = \frac{R_2'}{0.1}$$

$$\Rightarrow \quad R_2' = 0.1\ \Omega/\text{phase}$$

The external resistance to be added,

$$R_{ext} = 0.1 - 0.01 = 0.09\ \Omega/\text{phase}$$

17. (c)

For maximum torque (T_{max})

$$s_{max,\,T} = \frac{R_2}{X_2}$$

$$s_{max,\,T} = \frac{1}{4}$$

$$\text{Synchronous speed, } N_s = \frac{120 \times 50}{6} = 1000 \text{ rpm}$$

Now at T_{max} speed of motor,

$$N_r = (1 - s)\, N_s = (1 - 0.25) \times 1000$$

$$N_r = 750 \text{ rpm}$$

18. (b)

Given that,

$$V_{OC} = 230 \text{ V},$$

$$I_{OC} = 1.3 \text{ A},$$

$$P_{OC} = 100 \text{ W}$$

$$R_C = \frac{V_{0C}^2}{P_{0C}} = \frac{230^2}{100} = 529\ \Omega$$

Power factor angle,

$$\phi_{OC} = \cos^{-1}\left(\frac{P_{OC}}{V_{OC} I_{OC}}\right) = \cos^{-1}\left(\frac{100}{230 \times 1.3}\right) = 70.46°$$

$$X_\phi = \frac{R_C}{\tan\phi_{OC}} = \frac{529}{\tan 70.46°} = 187.73\ \Omega$$

Referred to high voltage side,

$$R_C = 529 \times \left(\frac{400}{230}\right)^2 = 1600\ \Omega$$

$$X_\phi = 187.73 \times \left(\frac{400}{230}\right)^2 = 567.8\ \Omega$$

19. (b)

Load characteristic is

$$T_L \propto N^2$$

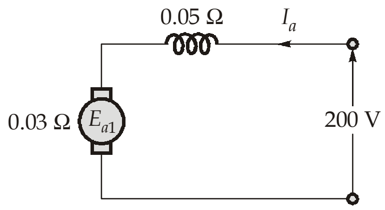
For dc series motor, torque-current relation is given by

$$T_d \propto I_a^2$$

$$\therefore \quad \frac{I_{a2}}{I_{a1}} = \frac{N_2}{N_1}$$

$$\frac{I_{a2}}{15} = \frac{750}{1500}$$
$$I_{a2} = 7.5 \text{ A}$$

Case-I:



$$E_{a1} = 200 - 15 \times (0.03 + 0.05)$$
$$E_{a1} = 198.8 \text{ V}$$

Case-II:

When additional resistance added in series with the armature circuit,

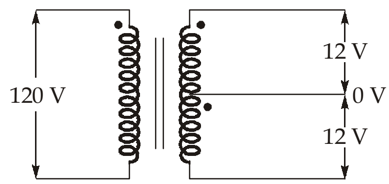
$$I_{a2} = 7.5 \text{ A},$$
$$N_2 = 750 \text{ rpm}$$

Now, $$E_a \propto \phi\omega_m$$

$$\frac{E_{a2}}{E_{a1}} = \frac{N_2}{N_1}\frac{I_{a2}}{I_{a1}} \qquad \text{(In dc series motor } \phi \propto I_a)$$

$$\frac{E_{a2}}{198.8} = \frac{750 \times 7.5}{1500 \times 15}$$
$$E_{a2} = 49.7 \text{ V}$$
$$E_{a2} = 200 - 7.5(0.08 + R_{ext}) = 49.7$$
$$0.08 + R_{ext} = \frac{200 - 49.7}{7.5}$$
$$R_{ext} = 20.04 - 0.08 = 19.96\ \Omega$$

20. (d)



EMF per turn is constant on either side of transformer. Total voltage rating of secondary side of transformer = 24 V. So, 24 turns will be required with center tap.

21. (a)

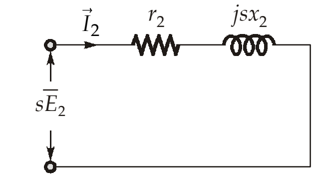
As we know, $$\frac{V_1}{V_2} = \frac{N_1}{N_2} \Rightarrow V_2 = \frac{1}{5} \times 230 = 46 \text{ V}$$

$$I_s = \frac{V_2}{R_2} = \frac{46}{4} = 11.5 \text{ A}$$

So, $$I_p = I_s\frac{N_2}{N_1} = \frac{11.5}{5} = 2.3 \text{ A}$$

22. (c)

Case-I



$$r_2 = 0.2\ \Omega,$$
$$X_2 = 2\ \Omega,$$
$$E_2 = 60\text{ V}$$

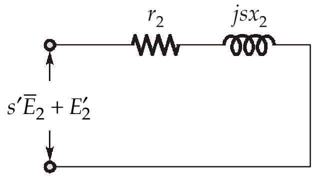
Impedance, $Z_2 = (0.2 + j0.04 \times 2) = 0.2154\angle 21.89°\ \Omega$

$$s = \frac{1500 - 1440}{1500} = 0.04$$

$\therefore$ $P_{ag} = |sE_2'||I_2'|\cos\theta_2$

$= (0.04 \times 60) \times 11.14 \times \cos(21.8)$ ...(i)

Case-II



$$s' = \frac{1500 - 1800}{1500} = -\frac{1}{5}$$

Impedance, $Z_2' = \left(0.2 - j2 \times \frac{1}{5}\right) = 0.447\angle -63.43°\ \Omega$

$P_{ag}' = (s \times 60 + E_2') \times I_2' \cos\theta_2'$ ...(ii)

$$I_2' = \frac{(s' \times 60 + E_2')}{\sqrt{r_2'^2 + (s'x_2)^2}} = \frac{\left(-\frac{1}{12} + E_2'\right)}{0.4472}$$

From equation (ii),

$\therefore$ $P_{ag}' = (-12 + E_2') \cdot \dfrac{(-12 + E_2')}{0.4472} \times 0.4472$

Since torque is same for both cases

$\therefore$ $P_{ag} = P_{ag}'$

$$(-12 + E_2')^2 = 24.84$$
$$E_2' = 16.98\text{ V}$$

23. (c)

Starting current drawn by motor rated voltage = I_{SC}

When supply voltage is reduced by factor 'x',

then starting current drawn by motor = $\dfrac{x \cdot V_{\text{rated}}}{Z_{sc}} = xI_{sc}$.

Since autotransformers transformation ratio is 1 : x

So starting current drawn from supply by transformer is = $x^2 I_{SC}$

it is also given that, $I_{SC} = 6\ I_{fL}$

$$I_{fL} = \frac{50000}{\sqrt{3} \times 440} = 62.60\text{ A}$$

Starting kVA drawn by auto transformer

$$(\text{kVA})_{\text{startor}} = \sqrt{3} V_L I_{L(\text{starting})} = \sqrt{3} V_L x^2 I_{SC} = \sqrt{3} V_L x^2 6 \times I_{fL}$$

$$= \sqrt{3} \times 440 \times \frac{1}{4} \times 6 \times 65.60 = 75\text{ kVA}$$

24. (b)

From the given condition,

$$I_{max}^2 r_2' = 18 I_{fL}^2 r_2'$$

$$\left(\frac{I_{fL}}{I_{max}}\right)^2 = \frac{1}{18}$$

As we know, $$\frac{T_{fL}}{T_{max}} = \frac{2 \cdot s_{mT} s_{fL}}{s_{m,T}^2 + s_{fL}^2} \quad \text{...(i)}$$

Also, $$\frac{T_{fL}}{T_{max}} = \left(\frac{I_{fL}}{I_{max}}\right)^2 \times \frac{s_{m,T}}{s_{fL}} \quad \text{...(ii)}$$

From equation (i) and (ii),

$$\left(\frac{I_{fL}}{I_{max}}\right)^2 = \frac{2 s_{fL}^2}{s_{m,T}^2 + s_{fL}^2}$$

$$\frac{1}{18} = \frac{2}{\left(\frac{s_{m,T}}{s_{fL}}\right)^2 + 1}$$

$\Rightarrow$ $$s_{m,\,T} = s_{fL}\sqrt{35} = 0.025 \times \sqrt{35} = 0.1479 \approx 0.15$$

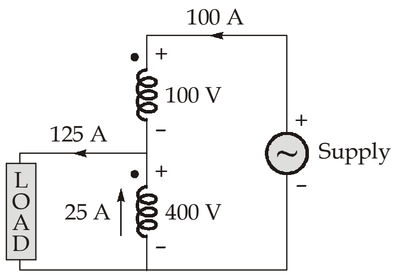
25. (a)

$$\eta_{2\text{-wdg}} = \frac{10 \times 0.85}{10 \times 0.85 + P_L} = 0.95$$

$$P_L = 0.4473 \text{ kW}$$

$$I_1 = \frac{10000}{400} = 25 \text{ A}$$

$$I_2 = \frac{10000}{100} = 100 \text{ A}$$



$$(\text{kVA})_{auto} = 500 \times 100 = 50 \text{ kVA}$$

$$\eta_{auto} = \frac{(\text{kVA})_{auto} * \cos\phi}{(\text{kVA})_{auto} * \cos\phi + P_L} = \frac{50 \times 0.95}{50 \times 0.95 + 0.4473} = 0.9906 = 99.06\%$$

26. (d)

Total armature resistance $= R_{am}$

$$R_{am} = (\text{armature winding + interpolar winding + brush) resistance}$$

$$R_{am} = 0.2 + 0.1 + 0.1 = 0.4\ \Omega$$

$$R_f = 100\ \Omega$$

$$I_{f1} = \frac{V}{R_f} = \frac{220}{100} = 2.2 \text{ A}$$

$$E_{a1} = V - (I_L - I_f)R_{am} = 220 - (200 - 2.2) \times 0.4$$

$$= 140.88 \text{ V}$$

As we know,

$$E_a \propto N\,\phi$$

$$\frac{E_{a2}}{E_{a1}} = \frac{N_2 I_{f2}}{N_1 I_{f1}} \qquad (\phi \propto I_f)$$

$$\frac{220 - 0.4(200 - I_{f2})}{140.88} = \frac{1600 I_{f2}}{1200 \times 2.2}$$

$$220 - 80 + 0.4 I_{f2} = 85.38\, I_{f2}$$

$$I_{f2} = \frac{140}{84.98} = 1.6474 \text{ A}$$

$$I_f = \frac{V}{100 + R_{ext}}$$

$$\Rightarrow \quad R_{ext} = \frac{220}{1.6474} - 100 = 33.54\ \Omega$$

27. (a)

As we know,
$$E_a = \frac{ZNP\phi}{60A} = \frac{ZN\phi}{60}\left(\frac{P}{A}\right)$$

$$= \frac{944 \times N \times 34.6 \times 10^{-3}}{60} \times 2 \qquad \text{for wave connected } A = 2,$$

$$E_a = 1.088\text{ N} \qquad ...(i)$$

and
$$E_a I_a = 4 \times 10^3 \qquad ...(ii)$$

$$I_a = \frac{V - E_a}{R_a} = \frac{500 - E_a}{3} \qquad ...(iii)$$

$$4000 = \frac{500 E_a - E_a^2}{3}$$

On putting equation (ii) in equation (iii),

$$4000 = \frac{500 E_a - E_a^2}{3}$$

$$E_a^2 - 500 E_a + 12000 = 0$$

On solving for E_a,

E_a = 474.72 V, 25.27 (neglected due to efficiency consideration)

So,
$$N = \frac{E_a}{1.088} = \frac{474.72}{1.088} = 436.32 \text{ rpm}$$

28. (a)

At no load;

Back emf, $E_{b0} = V_t - I_{a0}(R_a)$

$E_{b0} = 220 - 3(0.5)$

$E_{b0} = 218.5$ V

At full load;

Back emf, $E_{b\,fl} = V_t - I_{a\,fl}(R_a)$

$$= 220 - 45\,(0.5)$$

$$E_{b\,fl} = 197.5 \text{ V}$$

As flux is given constant;

then, we can write; $E_b \propto N$

or, $$\frac{E_{b\,fl}}{E_{b0}} = \frac{N_{fl}}{N_0}$$

$$N_{fl} = \left(\frac{197.5}{218.5}\right) \times 1500 = 1355.83 \approx 1356 \text{ rpm}$$

29. **(d)**

Given:

S.C. Test (H.V): 57.5 V, 8.34 A, 284 W

$$Z_{eq} = \frac{57.5}{8.34} = 6.894\ \Omega$$

$$R_{eq} = \frac{284}{(8.34)^2} = 4.083\ \Omega$$

$$X_{eq} = \sqrt{Z_{eq}^2 - R_{eq}^2} = 5.555\ \Omega$$

For voltage regulation to be zero;

$$\text{Power factor; } \cos\phi = \cos\tan^{-1}\left(\frac{R_{eq}}{X_{eq}}\right) = \cos\,(36.32°)$$

$$\cos\phi = 0.805 \text{ leading}$$

30. **(a)**

Primary is star connected and secondary is delta connected.

$$(V_L)_{primary} = 11000 \text{ V}$$

$$(V_{ph})_{primary} = \frac{11000}{\sqrt{3}} \text{ V}$$

$$\frac{(V_{ph})_{sec}}{(V_{ph})_{prim}} = \frac{1}{5}$$

$$\therefore \quad \text{Turns ratio} = \left(\frac{\text{High voltage}}{\text{Low voltage}}\right)_{phase}$$

$$\therefore \quad (V_{ph})_{sec} = \frac{11000}{5\sqrt{3}} \text{ V}$$

$$(V_{ph})_{\Delta} = (V_L)_{\Delta}$$

$$\text{Output kVA} = \sqrt{3}\,V_L I_L$$

$$= \sqrt{3} \times \frac{11000}{5\sqrt{3}} \times 423 = 930.6 \text{ kVA}$$

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