Checkpoints Chapter 14 Transformers and transmission.

Question 556

This is a step down transformer, because the output voltage is less than the input voltage. This means that the number of turns in the secondary must be less than in the primary, but in the same ratio as the voltages.
Ratio = 240/19.8 = 12.1

$\therefore$ **E (ANS)**

Question 557

Power = V × I

$\therefore P_{in}$ = 240 × 1.2 = 288W.

$\therefore P_{out}$ = 19.8 × 12 =237.6

$\therefore$ Ratio of power out/power in

= 237.6/288

= 0.825

= 0.83 (correct to 2 sig. figs.) (ANS)

Question 558

You would **always** expect the actual value of the ratio power out/power in to be less than 1. It can never be greater than 1, because this would mean that you were getting more power out than you were putting in. So the transformer must have been gaining energy from somewhere. This is impossible.
So the actual ratio will always be less than 1, on the assumption that the transformer is losing (using) energy.
If you touch any transformer, you will immediately notice that it is warm. This heat energy is being generated because the transformer is not 100% efficient. Energy is being lost to heat. The heat is produced by stray currents in the iron core, that are not contributing 100% to the field being set up.

Question 559

You need to transform the voltage from 240 V down to 12 V. This requires a step-down transformer with a ratio of 240/12 which is 20/1 in the primary / secondary.

$\therefore$ **20:1 (ANS)**

Question 560

The transformer works on the principle that an AC current in the primary coil will induce a changing magnetic field in the iron of the transformer (because the field associated with a current carrying wire varies with the current in the wire). The changing magnetic flux in the iron core will induce an EMF in the secondary coil.
If the current in the primary coil is constant i.e. DC, then the field in the iron core is constant, so there is not an induced EMF (and current) in the secondary coil.

Question 561

The ratio of the number of turns is the same as the ratio of the input and output voltages.

$\frac{n_1}{n_2} = \frac{V_1}{V_2}$ which becomes

$\frac{n_2}{n_1} = \frac{V_2}{V_1}$ for this problem

$\therefore \frac{n_2}{n_1} = \frac{330kV}{15kV}$

= 22 (ANS)

You need to realise that this has to be a step-up transformer, so the secondary coil has to have more turns than the primary coil.

Question 562

If the transformer is ideal (100% efficient) then the power in = power out.

$\therefore VI_{in} = VI_{out}$.

This means that if the voltage steps down by a factor of 9 000 to 110, then the current must step up the same amount.

The voltage steps down by $\frac{9000}{110}$ = 81.82

So the output current will be 81.82 times the input current.

$\therefore$ 81.82 × 1.5 = 122.7

= 123 Amp (ANS)

Question 563

There is always a voltage drop across a resistor, (assuming that there is a current). For most situations the resistance of the wires in the circuit are so small in comparison to the resistance of the appliance that it is appropriate to assume that the voltage drop across the wires is zero.
When we have very long cables this assumption is not reasonable. There will be a noticeable potential drop along the cable. In this case the drop is 5 000V. It is given by V = iR. Where I is the current and R the resistance of the wires.

Question 564

The active and the neutral should always carry the same current, because all the current that flows into a device should flow out of it. There is no build up or loss of electrons in any part of the circuit.
If the currents are not equal, i.e. the current in the active is greater than the current in the neutral, then some of the current has found an alternative path to earth. This should not happen, it might be through the person using the device or through the casing of the device. This would make the casing 'live' to touch. This may also mean that the insulation protecting the user has broken down.

Question 565

With the wires around the core as shown the magnetic flux changes due to each should be equal and opposite, so they will cancel each other out. Magnetic fields are vectors.

Question 566

If the current in the active wire was greater than the current in the neutral wire, then the flux induced in the coil from the active wire would be greater than that produced from the neutral wire. Because the current is AC, then the flux through the coil will be changing

$\therefore$ **C (ANS)**

Question 567

There is always a voltage drop across a resistor, (assuming that there is a current). For most situations the resistance of the wires in the circuit are so small in comparison to the resistance of the appliance that it is appropriate to assume that the voltage drop across the wires is zero.
When we have very long cables this assumption is not reasonable. There will be a noticeable potential drop along the cable. It is given by V = iR. Where I is the current and R the resistance of the wires.
As more appliances are being used then the current being drawn increases. This means that the potential drop along the cable increases, so the voltage supplied to the house is decreased.

Question 568

If V = iR, then the voltage drop along the cable is given by $\Delta V = 240 - 225 = 15$ volt.
So if the current is 45 amp, then the resistance comes from V = iR

$\therefore R = V/i$
$= 15/45$
= 0.33 Ω (ANS)

Question 569

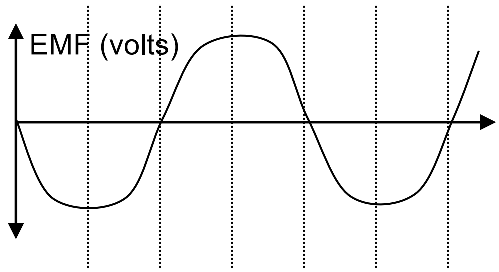
The ratio of the turns is the same as the ratio of the voltages.
The input voltage is 240 with an output of 6, so there must be (240/6) times as many turns on the primary side of the coil. $240 \div 6 = 40$.
So the number of turns on the output (secondary) side of the coil is $960 \div 40$

= 24 turns (ANS)

(Remember: The more turns the greater the voltage.)

Question 570

The supply is AC, (otherwise the transformers wouldn't work) So with an RMS current of 3.5 Amp, this means that the peak value of the current will be $3.5 \times \sqrt{2} = 4.95$ amp ~ 5 amp
The output voltage will look a little like this.



This means that the average value of this graph is the middle. $\therefore$ the average is zero.

$\therefore$ **C (ANS)**

Question 571

The voltage loss across the cables will now be

$\therefore \Delta V = I \times R$

where I = 3.5 amp and ΔV = 1.0 Volt

$\therefore R = \Delta V \div I$
$= 0.288$
$\therefore$ **R = 0.29Ω (ANS)**

Question 572

Power loss in cables

$= \Delta V \times I$
$= 1.0 \times 3.5$
$= 3.5$ Watt

This answer could also be found by using power loss in cables

$= i^2 \times R$
$= 3.5^2 \times 0.29$
= 3.5 W (ANS)

Question 573

Power $= V \times I = I^2 \times R$
$= V^2/R$
15 kW $= V^2/0.8$
(Don't forget the kW)
$15\,000 \times 0.8 = V^2$
$\therefore V^2 = 12\,000$
$\therefore V = 109.5$
$\therefore V = 110$ Volt
120 Volt is a better answer than 100V because the motor needs *at least* 15 kW.
∴ E, F (ANS)

Question 574

Power losses due to heating in transmission lines are given by $P = i^2R$.
To minimise this we need to minimise I. Since the power input is P = V × I, this means we need to increase V as much as possible.
We use a step-up transformer at 'A' so that the current in the lines is minimal. We then need to use a step-down transformer at the pump, to reduce the voltage to 240 V.

Question 575

The power being used by the pump is
P = V × I
= 240 × 20
= 4 800 W
So this must be the power being supplied to transformer B
So the V × I (in the wires) = 4 800
V = 4 800 / 0.8
= 6 000 V (ANS)

Question 576

Assume that the voltage V_{PQ} = 6 000 V. (On the exam, if you weren't able to calculate this, then you are to substitute in any number and explain it) The ratio of the number of turns in the primary coil : secondary coil is the same as the input voltage : output voltage. Remember always think about the 'voltages'.

$$\frac{V_P}{V_S} = \frac{N_P}{N_S}$$

$$\therefore \quad \frac{240}{6000} = \frac{100}{\text{'x'}}$$

$$\therefore x = \frac{6000 \times 100}{240}$$

∴ x = 2500 turns (ANS)

Question 577

If the Power loss is given by i^2R
$\therefore P = 0.8^2 \times 4$
= 2.56 W
= 2.6 W (ANS)
(correct to 2 sig. figs)

Question 578

If the Power loss is given by i^2R
$\therefore P = 10^2 \times 4$
= 400 W
= 4.0×10^2 W (ANS)
(correct to 2 sig. figs)

Question 579

If the transformer is ideal (100% efficient) then the power in = power out.
$\therefore VI_{in} = VI_{out}$. This means that if the voltage steps down by a factor of 20, then the current must step up the same amount. So the output current will be 20 times the input current.
∴ 10 × 20 = 200 Amp (ANS)

Question 580

Since V = IR, if you use a step-down transformer, you have lowered V to 12 volts. This makes it very difficult to get a large current in any circuit, because you need R to be small, to allow I to be large.

Question 581 (2010 Q14, 2m, 65%)

There was a resistance in the transmission lines, so there would be a voltage drop in the lines. Hence the voltage drop across the globe would be less than 2 V. Therefore the globe will not operate at normal brightness.

Question 582 (2010 Q15, 3m, 47%)

To get the globe to operate as designed, it needs 2 V across it and 2 Amp flowing through it. (From P =VI)
If a current of 2 A is flowing, then the voltage drop across each transmission line will be
V =iR ∴ 2 x 2 = 4 V
Considering both transmission lines
$\Delta V = 8$ V.

Therefore, the supply voltage needed to be 8 V for the transmission lines and 2 V for the globe

∴ **10 V** **(ANS)**

Question 583 **(2010 Q16, 2m, 50%)**

When the globe was operating properly at 4 W, the current would be 2 A.

Power loss in the transmission lines is given by

$P = i^2R$

∴ $P = 2^2 \times 4$ (total resistance of transmission lines)

= 16 W **(ANS)**

Question 584 **(2010 Q17, 2m, 40%)**

Power loss in cables is given by $P = I^2R$. Power delivered is given by P = VI.

To minimise power loss, I needs to be as small as possible, therefore we need to increase V.

Transformers are used to step up the voltage and step down the current. AC is used as it is possible to use a transformer to step down the AC current, but not a DC current.

For long-distance power transmission, AC is used.

Question 585 **(2010 Q18, 2m, 65%)**

The power supply was set to 20.8 $V_{RMS.}$

Therefore $V_P = 20.8 \times \sqrt{2}$

$= 29.4$ V,

∴ $V_{P\ to\ P} = 29.\ 4 \times 2$

$= 58.8$

∴ **D** **(ANS)**

Question 586 **(2010 Q19, 1m, 90%)**

This is a step down transformer, so the secondary coil will have less turns. The turn ratio is 10:1.Therefore the secondary coil has

146 turns **(ANS)**

Question 587 **(2010 Q20, 3m, 47%)**

The voltage required by the globe is 2 V, therefore the voltage on the primary side of the transformer is 20 V. (Using the 10:1 ratio)

The current out of the transformer is 2.0 amp, therefore the current into the transformer must be 0.2 A.

The power loss in the transmission cables is given by $P = i^2R$

∴ $P = 0.2^2 \times 4$

∴ **P = 0.16 W** **(ANS)**

Question 588 **(2011 Q13, 2m, 85%)**

Use Power = VI

= 50,000 x 15

= 750,000 W **(ANS)**

(We are finding the power, so we need to use the **RMS values** for the voltage and current.)

Question 589 **(2011 Q14, 3m, 57%)**

Using P = VI, if the same power is to be delivered, then the lower voltage means a higher current.

Power loss in the wires is $P = I^2R$

Therefore a greater current increases the power loss.

Question 590 **(2011 Q15, 2m, 85%)**

Use power loss = I^2R

$$\therefore R = \frac{9000}{15^2}$$

= 40 Ω **(ANS)**

(don't forget to square I)

Question 591 **(2011 Q16, 2m, 75%)**

Since the transformer is *ideal* (as are all transformers on VCE exams), we can use $VI_{in} = VI_{out}$

∴ $49\ 400 \times I_{primary} = 250 \times I_{secondary}$

$$\therefore \frac{49400}{250} = \frac{I_{secondary}}{I_{primary}}$$

$$\therefore \frac{I_{secondary}}{I_{primary}} = \mathbf{198} \quad \textbf{(ANS)}$$

(**Don't** leave your answer as a fraction).

Question 592 **(2012 Q3, 2m, 70%)**

The power is given by $P = \frac{V^2}{R}$

Need to use RMS value, not peak value, $\frac{150}{\sqrt{2}}$

AC $P = \frac{150^2}{(\sqrt{2})^2 \times 6} = 1875$ W

DC $P = \frac{120^2}{7} = 2057$ W

∴ **DC will provide more power** **(ANS)**

Question 593 **(2012 Q4a, 2m, 90%)**

Power = VI

= 900 x 50

= 45 kW **(ANS)**

Question 594 (2012 Q4b, 2m, 55%)

Use V = iR
Where V = 1000 V, and R is a total of 25 A
∴ 1000 = i x 25
∴ i = 40 A (ANS)

Question 595 (2012 Q4c, 3m, 50%)

There will be a voltage drop along the wires.
This is given by V = iR
∴ V = 40 x 7
∴ V_{drop} = 280 V

∴ $V_{\text{supplied to motor}}$ = 1000 – 280
= 720 V

The motor will not run properly, as it requires 900 V.
∴ the pump will not operate correctly.

Question 596 (2012 Q4d, 4m, 50%)

First change
Use step-up transformer to increase the voltage that the power is delivered along the lines, and then use a step-down transformer at the other end.
Since the power delivered is given by
P = VI, if V is increased then I will decrease to deliver the same power.
The energy losses in the wire are given by I^2R, so this will lower the energy losses due to heating in the wire.
Second change
Change the material that the wire is made from to one of lower resistance. This will lower the voltage drop across the transmission lines, which will lead to more power being available for the motor.

Question 597 (2012 Q6a, 1m, 90%)

Use $\frac{V_{out}}{V_{in}} = \frac{n_{secondary}}{n_{primary}}$

$\frac{V_{out}}{20} = \frac{150}{600}$

∴ V_{out} = 5 V (ANS)

Question 598 (2012 Q6b, 2m, 35%)

The constant voltage of the 20 V volt battery will supply a constant current. Therefore there will not be any change the flux. Therefore from Faraday's law there will not be an induced EMF.

Question 599 (2013 Q15a, 1m, 80%)

The ratio of the number of turns is 1:6
∴ the ratio of the voltages will be the same
∴ 3.0 : 18.0
∴ 18.0 V (ANS)

Question 600 (2013 Q15b, 1m, 80%)

Peak voltage = 18.0 x $\sqrt{2}$
∴ 25.5 V (ANS)

Question 601 (2013 Q15c, 2m, 65%)

Power is always calculated using RMS values.

∴ P = $\frac{V^2}{R}$

∴ P = $\frac{18^2}{1200}$

∴ P = 0.27 W (ANS)

Question 602 (2013 Q15d, 3m, 37%)

As the switch closes, the current changes from 0 to a maximum value.
This change in current creates a changing flux in the iron core of the transformer. This change in flux induces and EMF across the secondary coil. As the circuit is complete this will lead to a brief current through the resistor. This is an application of Faraday's law.
Once the switch is closed, there won't be any change in the current, therefore no change in the flux, therefore no induced current.

Question 603 (2013 Q18a, 2m, 65%)

Use V = iR
∴ 24 = 6 x R
∴ R = 4 Ω (ANS)

Question 604 (2013 Q18b, 2m, 70%)

Use P = VI
∴ 1200 = V x 6
∴ V = 200 V (ANS)

Question 605 (2013 Q18c, 3m, 63%)

$\frac{\text{power loss in the transmission lines}}{\text{power input to the transmission lines}}$

$= \frac{6 \times 24}{1200}$

$= \frac{6 \times 2}{100}$

= 12% (ANS)

Question 606 (2013 Q18d, 3m, 53%)

To find the current in the new transmission lines,
Use V = iR

∴ 10 = i x 2

∴ i = 5 A

Then use P = VI

∴ 1200 = V x 5

∴ **V = 240 V (ANS)**

Question 607 (2014 Q14a, 1m, 30%)

For a transformer to operate it requires a changing voltage as an input.
The DC voltage will be constant. Therefore the transformer will not operate.

∴ **0 V (ANS)**

Question 608 (2014 Q14a, 2m, 70%)

The turns ratio is 130:5200.
This is the equivalent of 1:40.
If the output voltage is 400, this is from a RMS input of 10 V.

∴ peak voltage = 10 × $\sqrt{2}$

14.1 V (ANS)

Question 609 (2014 Q15a, 1m, 80%)

The power supply is at 13 V, and 3 V is across the light globe.

∴ ΔV = 13 – 3

∴ **ΔV = 10 V (ANS)**

Question 610 (2014 Q15b, 1m, 70%)

For the light globe, use $P = \frac{V^2}{R}$

∴ $P = \frac{3^2}{1.5}$

∴ **P = 6 W (ANS)**

Question 611 (2014 Q15c, 1m, 60%)

For the connecting wires use V = iR.

∴ 10 = i × 5

∴ **i = 2 A (ANS)**

Check your answer using the light globe.

∴ V = iR

∴ 3 = i × 1.5

∴ i = 2 A

This is as required as the globe is in series with the long wires, therefore it must have the same current.

Question 612 (2014 Q15d, 3m, 47%)

If the voltage across the light globe is to be 6 V, then from V = iR,

6 = i × 1.5

∴ i = 4 A.

This means that the voltage drop across the transmission lines will be, V = iR,

∴ V = 4 × 5

∴ V = 20 V

This means that the supply voltage needs to be 20 + 6

∴ **26 V (ANS)**

Question 613 (2014 Q16, 4m, 43%)

To deliver a fixed amount of power, a step up transformer is used at the beginning. This transformer increases the voltage, and decreases the current whilst delivering the same power. Since the power, $VI_{in} = VI_{out}$ in an ideal transformer.

The definition of transmission losses is: the power losses in transmission lines, given by I^2R.

So a decrease in I, results in an I^2 reduction in the energy losses in the wires.

A step-down transformer is used at the other end of the transmission lines to bring the voltage down to a suitable level for appliances etc.
