



ANSWER BOOK

# Transformers

Magnetic fields · Year 13

AQA 3.7.5.6 · OCR A 6.3.3(f)(i)

18 questions · 48 marks

NAVY EDITION

## SECTION A · Warm-up

- A1** The alternating current in the primary produces a continually changing magnetic flux in the iron core, which links the secondary coil (1); by Faraday's law the changing flux linkage induces an alternating emf in the secondary, so energy is transferred without an electrical connection (1). [2]
- A2**  $V_s = V_p \times N_s/N_p = 230 \times 100/1000$  (1) [2]  
 $V_s = 23 \text{ V}$  (1)
- A3** Step-down: the secondary voltage is lower than the primary voltage (1). [1]
- A4** A steady current produces a constant flux in the core (1); with no change in the flux linkage of the secondary, no emf is induced (1). [2]
- A5** Any two of the following, one mark each (2): resistance of the windings heating the coils; eddy currents induced in the core; flux leakage, with some flux missing the secondary; energy used in repeatedly magnetising the core each cycle. [2]
- A6**  $N_p/N_s = V_p/V_s = 230/5.0$  (1) [2]  
 $N_p:N_s = 46:1$  (1)

## SECTION B · Standard

- B1**  $N_s = N_p \times V_s/V_p = 2000 \times 12/240$  (1) [2]  
 $N_s = 100 \text{ turns}$  (1)
- B2**  $P = V_p I_p = 230 \times 2.0 = 460 \text{ W}$  (1) [3]  
 Ideal, so  $V_s I_s = V_p I_p$  (1)  
 $I_s = 460/23 = 20 \text{ A}$  (1)
- B3** Efficiency = output power/input power =  $450/500$  (1) [2]  
 Efficiency = 0.90 (90%) (1)
- B4**  $I_p = V_s I_s / V_p = (1150 \times 0.40) / 230$  (1) [2]  
 $I_p = 2.0 \text{ A}$  (1)
- B5** Eddy currents are currents induced in the iron core itself by the changing flux (1); they dissipate energy by heating the core as they flow through its resistance (1); the core is made of thin laminations separated by insulation, which break the current loops into small ones and greatly reduce the loss (1). [3]

**B6** The core carries the same changing flux through every turn of both coils (1); by Faraday's law each turn therefore has the same rate of change of flux, so the same emf is induced in every turn (1); the total voltage across each coil is the emf per turn multiplied by its number of turns, so the voltages are in the ratio of the turns (1). [3]

**B7** Input power =  $230 \times 0.26 = 59.8 \text{ W}$  (1) [4]  
 Output power =  $11.5 \times 4.6 = 52.9 \text{ W}$  (1)  
 Efficiency =  $52.9/59.8 = 0.88$  (88%) (1)  
 Power dissipated =  $59.8 - 52.9 = 6.9 \text{ W}$  (1)

## SECTION C · Stretch

**C1** At 10 kV:  $I = P/V = 100000/10000 = 10 \text{ A}$  (1) [4]  
 Loss =  $I^2 R = 10^2 \times 5.0 = 500 \text{ W}$  (1)  
 At 100 kV:  $I = 1 \text{ A}$ , so loss =  $1^2 \times 5.0 = 5 \text{ W}$  (1)  
 Raising the voltage by a factor of 10 cuts the current by 10 and the loss by 100 (1).

**C2** Input power =  $230 \times 5.0 = 1150 \text{ W}$  (1) [3]  
 Output power =  $0.96 \times 1150 = 1104 \text{ W}$  (1)  
 $I_s = 1104/46 = 24 \text{ A}$  (1)

**C3** For a given power, a higher voltage means a smaller current, since  $P = VI$  (1); the power wasted heating the cables is  $I^2 R$  (1); reducing the current therefore greatly reduces the losses, making transmission more efficient (1). [3]

**C4**  $V_s = V_p \times N_s/N_p$  for each transformer (1) [4]  
 T1:  $V_s = 230 \times 52/1000 = 12.0 \text{ V}$  (1)  
 T2:  $V_s = 13.8 \text{ V}$  and T3:  $V_s = 9.2 \text{ V}$  (1)  
 Only T1 gives an output between 11.5 V and 12.5 V, so T1 is the suitable transformer (1)

**C5**  $V_s = 230/10 = 23 \text{ V}$  (1) [4]  
 $I_s = V_s/R = 23/4.6 = 5.0 \text{ A}$  (1)  
 Ideal, so  $I_p = V_s I_s / V_p$  (1)  
 $I_p = (23 \times 5.0)/230 = 0.50 \text{ A}$  (1)