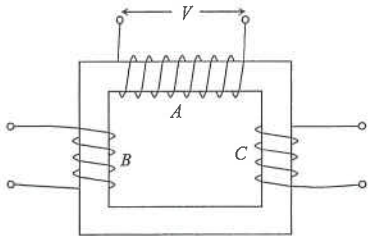
The following list of formulae may be found useful :

Power in a circuit $P = IV = I^2R$

Ratio of secondary voltage to primary voltage in a transformer $\frac{V_P}{V_S} \approx \frac{N_P}{N_S}$

Part A : HKCE examination questions

1. **< HKCE 1980 Paper II - 45 >**



Three coils A, B and C are wrapped around an iron core as shown. Coil A has N turns while coil B and C both have $\frac{1}{2}N$ turns. If an input voltage V is applied across A, what will be the voltage acting across coil C ?

A. $\frac{1}{4}V$

B. $\frac{1}{2}V$

C. $2V$

D. $4V$

2. **< HKCE 1980 Paper II - 34 >**

What is/are the advantage(s) of using high voltage in power transmission over long distances ?

(1) Current in the transmission cables can be reduced.
(2) Less energy is wasted as heat.
(3) Higher voltage can be used in household circuit.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

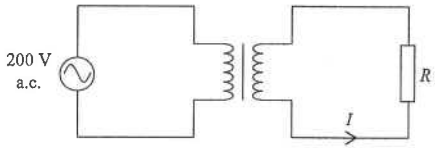
3. **< HKCE 1980 Paper II - 41 >**

Which of the following statements concerning direct current (d.c.) and alternating current (a.c.) is/are correct ?

(1) The magnitude of voltage in d.c. is constant while that in a.c. varies.
(2) The direction of current in d.c. does not change while that of a.c. reverses periodically.
(3) Both d.c. and a.c. can have heating effect on a resistor.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

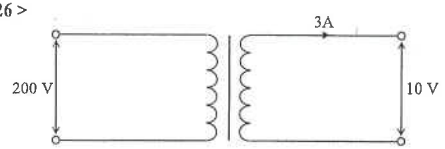
4. **< HKCE 1982 Paper II - 34 >**



In the transformer shown, the ratio of the number of turns on the primary coil to that on the secondary coil is 10 : 1. If the power input is 50 W, find the current in the secondary coil, assuming that the transformer has a 80% efficiency.

A. 1.0 A
B. 1.5 A
C. 2.0 A
D. 2.5 A

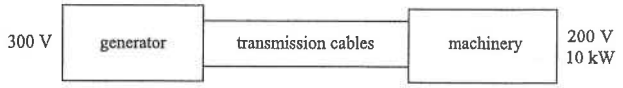
5. **< HKCE 1984 Paper II - 26 >**



As shown in the diagram, a 200 V mains supply is stepped down to 10 V by a transformer. If the output current is 3 A and the efficiency of the transformer is 75%, what is the current in the primary coil ?

A. 0.1 A
B. 0.2 A
C. 0.3 A
D. 0.4 A

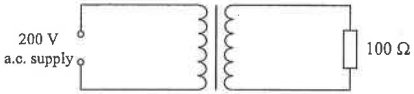
6. **< HKCE 1985 Paper II - 39 >**



The 300 V generator in the above diagram is supplying electrical power to operate a piece of machinery which has a rating of 10 kW at 200 V. The total resistance of the transmission cables is 2 Ω. What is the power loss in the transmission system ?

A. 2.5 kW
B. 5 kW
C. 10 kW
D. 20 kW

7. **< HKCE 1985 Paper II - 41 >**



The diagram shows a transformer with the primary coil connected to an a.c. voltage of 200 V while the secondary coil is connected to a resistor of 100 Ω. If there are 100 turns in the primary coil and 10 turns in the secondary coil, what is the current passing through the resistor ? (Assume that the efficiency of the transformer is 100%)

A. 0.05 A
B. 0.1 A
C. 0.2 A
D. 1 A

8. **< HKCE 1986 Paper II - 29 >**

A transformer can be used to
(1) step-up the voltage of a given a.c. supply.
(2) increase the power of a given a.c. supply.
(3) step-up the voltage of a given battery.

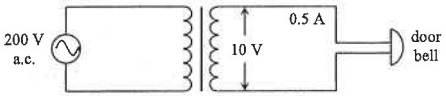
A. (1) only
B. (2) only
C. (1) & (2) only
D. (2) & (3) only

9. **< HKCE 1986 Paper II - 34 >**

The efficiency of a transformer is 50% and the input and output voltages are 200 V and 12 V respectively. If the power output is 30 W, the input current is

A. 0.15 A
B. 0.3 A
C. 1.5 A
D. 2.5 A

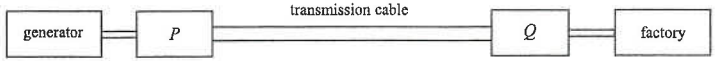
10. **< HKCE 1988 Paper II - 29 >**



In the circuit diagram shown, the transformer is 100% efficient. Which of the following statements is/are correct ?
(1) The current in the primary coil is 0.5 A.
(2) The resistance of the door-bell is 20 Ω.
(3) The ratio of the number of turns in the primary coil to that in the secondary coil is 20 : 1.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

11. **< HKCE 1989 Paper II - 36 >**



The figure above shows how electrical power can be transmitted to a distant factory. The transformers *P* and *Q* should be

	P	*Q*
A.	step up	step up
B.	step up	step down
C.	step down	step up
D.	step down	step down

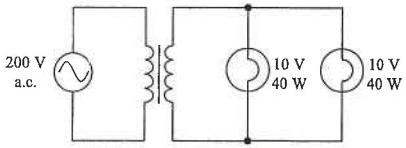
12. **< HKCE 1989 Paper II - 41 >**

Which of the following correctly shows the major change of energy in the devices ?

	Device	From	To
(1)	an electric motor	electrical	mechanical
(2)	a loudspeaker	sound	mechanical
(3)	a transformer	electrical	electrical

A. (1) only
B. (2) only
C. (1) & (3) only
D. (2) & (3) only

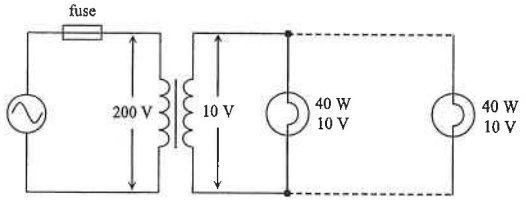
13. **< HKCE 1990 Paper II - 37 >**



In the circuit shown, the efficiency of the transformer is 80%. If the two lamps are to work at their rated values, what is the current in the primary coil and what kind of transformer is being used ?

	Current in primary coil	Transformer
A.	0.2 A	20 : 1 step down
B.	0.4 A	20 : 1 step down
C.	0.5 A	20 : 1 step down
D.	0.4 A	10 : 1 step down

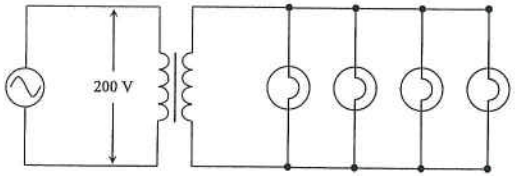
14. **< HKCE 1991 Paper II - 38 >**



In the above circuit diagram, the transformer is 100% efficient. What is the maximum number of identical light bulbs, each of rating '40 W, 10 V' that can be connected in parallel across the secondary coil without blowing the fuse ?
(Assume that the fuse will blow if the current flowing through it exceeds 15 A.)

A. 3
B. 20
C. 60
D. 75

15. **< HKCE 1992 Paper II - 34 >**



In the circuit shown, the rating of each light bulb is '20 W, 10 V'. The current in the primary coil is 0.5 A. If all the bulbs work at their rated values, find the turns ratio and the efficiency of the transformer.

	Turns ratio	Efficiency
A.	5 : 1 step down	80%
B.	20 : 1 step down	20%
C.	20 : 1 step down	40%
D.	20 : 1 step down	80%

16. **< HKCE 1992 Paper II - 35 >**

Which of the following can increase the efficiency of a transformer ?
(1) Increasing the number of turns of the secondary coil.
(2) Using a laminated iron core.
(3) Using a thicker copper wires to make the coils.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

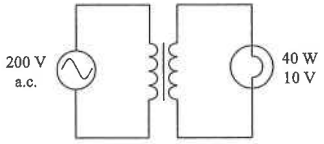
17. **< HKCE 1994 Paper II - 34 >**

An electrical power of 100 kW is transmitted at 20 kV through cables of total resistance of 4 Ω. Find the voltage drop and power loss in the cables.

	Voltage drop	Power loss
A.	20 V	20 W
B.	20 V	100 W
C.	100 V	20 W
D.	100 V	100 W

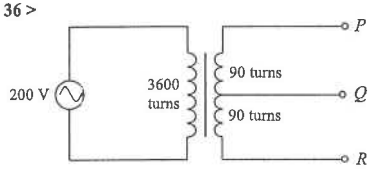
18. **< HKCE 1994 Paper II - 35 >**

In the circuit shown, the rating of the light bulb is '40 W, 10 V'. The efficiency of the transformer is 80%. If the bulb works at its rated value, find the current in the primary coil.



A. 0.16 A
B. 0.2 A
C. 0.25 A
D. 1.6 A

19. **< HKCE 1996 Paper II - 36 >**



The primary coil of a transformer has 3600 turns and is connected to 200 V a.c. supply. The secondary coil has 180 turns, which can be tapped at different points as shown above. A '40 W, 10 V' light bulb is connected to the transformer so that it works at its rated value. Which of the following statements is/are correct ?
(1) The bulb should be connected to points *P* and *Q*.
(2) The current through the bulb is 4 A.
(3) If the efficiency of the transformer is 80%, the current in the primary coil is 0.25 A.

A. (1) only
B. (2) only
C. (1) & (3) only
D. (2) & (3) only

20. **< HKCE 1997 Paper II - 32 >**

Which of the following devices converts mechanical energy into electrical energy when it works ?
A. a transformer
B. a dynamo
C. a motor
D. a microphone

21. **< HKCE 1998 Paper II - 35 >**

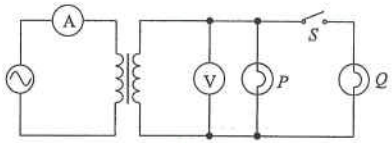
A 4 V a.c. supply is stepped up to 20 V by a transformer. If the current in the primary coil is 1 A and the power loss of the transformer is 0.8 W, find the current in the secondary coil.
A. 0.04 A
B. 0.16 A
C. 0.2 A
D. 0.24 A

22. **< HKCE 1999 Paper II - 34 >**

Which of the following is/are the advantage(s) of using high voltages for long distance transmission of electricity ?
(1) The transmission speed can be increased.
(2) Some heavy industries operate at high voltages.
(3) The energy loss in the transmission cable can be reduced.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

23. **< HKCE 1999 Paper II - 31 >**



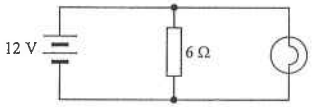
Two bulbs *P* and *Q* are connected to an ideal transformer as shown. Which of the following statements is/are true when switch *S* is closed ?
(1) The brightness of bulb *P* decreases.
(2) The reading of the ammeter increases.
(3) The reading of the voltmeter remains unchanged.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

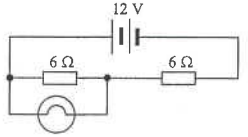
24. **< HKCE 1999 Paper II - 36 >**

A '6 V, 6 W' light bulb is to be operated at its rated value. Three circuits are set up as shown below.

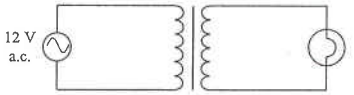
(1)



(2)



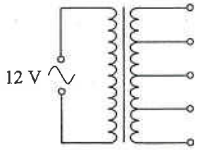
(3)



Number of turns
in primary coil = 200
in secondary coil = 100

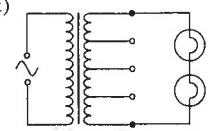
The power supplies all have negligible internal resistance. In which of the above circuits is the bulb working at its rated value ?
A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

25. **< HKCE 2001 Paper II - 34 >**

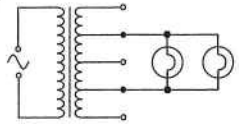


A 12 V a.c. supply is connected to a transformer with turns ratio 1 : 1. The secondary coil is tapped at equal intervals as shown above. Two '6 V, 0.5 W' light bulbs are connected to the secondary coil of the transformer. In which of the following cases will the two bulbs work at their rated values ?

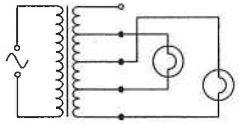
(1)



(2)



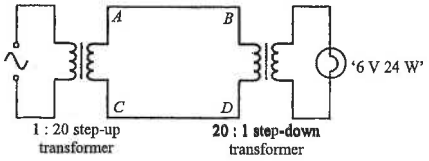
(3)



A. (3) only
B. (1) & (2) only
C. (2) & (3) only
D. (1), (2) & (3)

26. **< HKCE 2001 Paper II - 38 >**

The figure shows a model power line. An a.c. supply and two ideal transformers are used to operate a lamp of rating '6 V, 24 W'. The total resistance of the cables *AB* and *CD* is 10 Ω. If the lamp operates at its rated value, find the power loss in the cables.



A. 0.4 W
B. 3.6 W
C. 160 W
D. 1440 W

27. **< HKCE 2005 Paper II - 43 >**

Which of the following statements about long distance power transmission at high alternating voltages are correct ?

(1) Alternating voltages can be stepped up or down efficiently by transformers.
(2) For a given transmitted power, the current will be reduced if a high voltage is adopted.
(3) The power loss in the transmission cables will be reduced if a high voltage is adopted.

A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

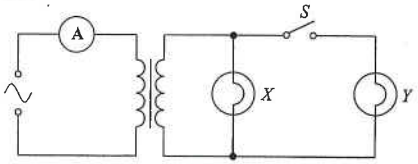
28. **< HKCE 2006 Paper II - 38 >**

The photograph shows an adaptor for charging up the battery inside a mobile phone. Which of the following statements about the adaptor are correct ?

(1) It is used to step down the voltage from the mains to a value for the mobile phone.
(2) It can convert the voltage from a.c. to d.c.
(3) It is black so that it can radiate heat more efficiently than those in other colours.

A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

29. **< HKCE 2006 Paper II - 37 >**



In the above circuit, the transformer is ideal (efficiency = 100%). At the beginning, the switch *S* is closed and the light bulbs *X* and *Y* are operated at their rated values. What would happen to the brightness of the bulb *X* and the ammeter reading if *S* is now opened ?

	Brightness of *X*	**Ammeter reading**
A.	increases	increases
B.	increases	decreases
C.	remains unchanged	decreases
D.	remains unchanged	remains unchanged

30. **< HKCE 2007 Paper II - 44 >**

Specification :

Voltage input	220 V
Voltage outputs	6 V & 12 V

The above figure shows a portable transformer. It outputs different voltage by varying the turns ratio between the primary and the secondary coils. Assume that there is no power loss in the transformer and the resistance of the load remains unchanged, when the output changes from 6 V to 12 V, which of the following statements describing the transformer is/are correct ?

(1) The number of turns of the primary coil should be doubled and the number of turns of the secondary coil remains unchanged.
(2) The input current should be doubled.
(3) The output power should be 4 times as before.

A. (2) only
B. (3) only
C. (2) & (3) only
D. (1), (2) & (3)

31. **< HKCE 2008 Paper II - 41 >**

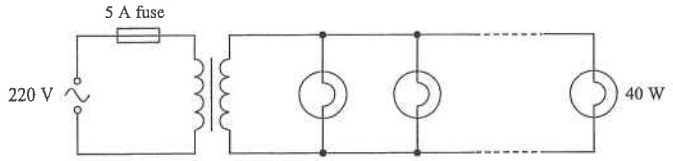
Specification :

Input	a.c. 220 V
Output	a.c. 12 V, 100 mA

The above figure shows a transformer. Assume the transformer is ideal, what is the current drawn from the mains supply if the transformer delivers currents at the rated value ?

A. 5.5 mA
B. 100 mA
C. 1200 mA
D. 1830 mA

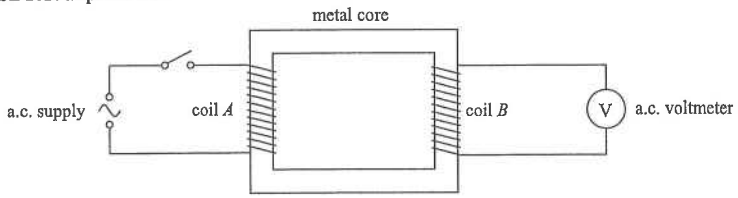
32. **< HKCE 2010 Paper II - 44 >**



In the circuit above, the primary coil of a transformer is connected to the 220 V mains supply with a 5 A fuse. The efficiency of the transformer is 90%. What is the maximum number of identical 40 W light bulbs, operating at their rated values, that can be connected in parallel to the secondary coil without blowing the fuse ?

A. 24
B. 25
C. 27
D. 28

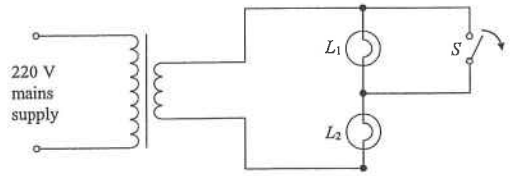
33. **< HKCE 2010 Paper II - 43 >**



The figure shows a metal core with two coils. When the switch is closed, the a.c. voltmeter shows a reading. Which of the following combinations will give the largest voltmeter reading ?

	material of the metal core	no. of turns of coil *A*	no. of turns of coil *B*
A.	copper	500	1000
B.	copper	1000	500
C.	iron	500	1000
D.	iron	1000	500

34. **< HKCE 2011 Paper II - 42 >**



The figure above shows an ideal transformer. The primary coil of the transformer is connected to the 220 V a.c. mains and two lamps L_1 and L_2 are connected in series to the secondary coil. Initially, S is closed. Which of the following statements is correct when S is opened ?

A. The current in the primary coil of the transformer decreases.
B. The voltage across the secondary coil of the transformer increases.
C. The brightness of L_1 decreases.
D. The brightness of L_2 increases.

35. **< HKCE 2011 Paper II - 43 >**

Electrical power is transmitted from a power station to local substations by an alternating current and high voltage. It is because

(1) the voltage of an alternating current can be stepped up or down using transformers easily.
(2) by using high voltages, electrical power can be transmitted faster along the cables.
(3) by using high voltages, there is less power loss in the transmission cables.

A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

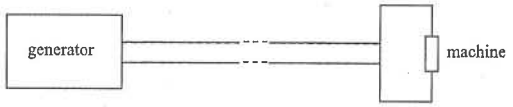
Part B : HKAL examination questions

36. **< HKAL 1984 Paper I - 26 >**

A power station supplied electrical power to a user. The power generated by the station is 1200 kW. After stepping up, the voltage transmitted to the cable is 132 kV. If the total resistance of the transmission cable is 550 Ω, find the electrical power available to the user.

A. 700 kW
B. 1155 kW
C. 1195 kW
D. 1200 kW

37. **< HKAL 1995 Paper IIA - 30 >**

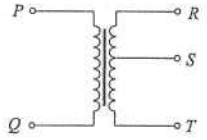


A large machine in a factory consumes 10 kW of electrical power at a voltage of 500 V. If the generator from the power station transmits electrical power to the factory through cables of total resistance 0.2 Ω, the voltage produced by the generator should be

A. 500 V
B. 501 V
C. 502 V
D. 504 V

38. **< HKAL 2008 Paper IIA - 19 >**

When 240 V a.c. is applied across PQ of an ideal transformer, the voltages measured across RS and ST are 4 V and 8 V respectively. If 6 V a.c. is now applied across ST, what will be the voltages measured across PQ and RS ?



	Voltage across *PQ*	Voltage across *RS*
A.	0 V	0 V
B.	180 V	0 V
C.	0 V	3 V
D.	180 V	3 V

39. **< HKAL 2013 Paper IIA - 34 >**

The electrical power dissipated by a heater when connected to a 10 V d.c. supply is two times of that when the heater is connected to a sinusoidal a.c. supply. What is the peak voltage of the sinusoidal a.c. supply ?

A. 5 V
B. $5\sqrt{2}$
C. 10 V
D. $10\sqrt{2}$

Part C : HKDSE examination questions

40. < HKDSE Sample Paper IA - 33 >

Power is transmitted over long distances at high alternating voltages. Which statements are correct ?

(1) Alternating voltages can be stepped up or down efficiently by transformers.

(2) For a given transmitted power, the current will be reduced if a high voltage is adopted.

(3) The power loss in the transmission cables will be reduced if a high voltage is adopted.

A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

41. < HKDSE 2014 Paper IA - 30 >

When a heater is connected to a d.c. voltage of 10 V, the power dissipated is P. If the heater is connected to a sinusoidal a.c., the power dissipated becomes $\frac{1}{2}P$. What is the r.m.s. voltage of this a.c. source ? Assume that the resistance of the heater is constant.

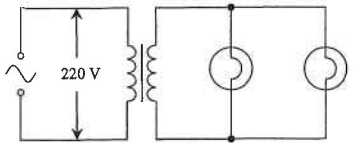
A. $\sqrt{5}$ V
B. $5\sqrt{2}$ V
C. 10 V
D. $10\sqrt{2}$ V

42. < HKDSE 2016 Paper IA - 30 >

A sinusoidal a.c. of a certain frequency delivers a r.m.s. voltage $V_{r.m.s.}$. If its frequency is doubled and its peak voltage is halved, what would be the r.m.s. voltage ?

A. $\frac{1}{2}V_{r.m.s.}$
B. $\frac{1}{\sqrt{2}}V_{r.m.s.}$
C. $\frac{1}{2\sqrt{2}}V_{r.m.s.}$
D. $V_{r.m.s.}$

43. < HKDSE 2016 Paper IA - 31 >



In the above circuit, each light bulb works at its rated value '22 W, 11 V'. The current in the primary coil is 0.25 A. Find the efficiency of the transformer.

A. 20%
B. 40%
C. 64%
D. 80%

44. < HKDSE 2017 Paper IA - 29 >

A heater of resistance 100 Ω is connected to the mains supply. The r.m.s. voltage of the mains supply is 110 V. Which of the following statements are correct ?

(1) The peak voltage across the heater is 156 V.

(2) The power dissipated by the heater is 121 W.

(3) The power dissipated by the heater will be doubled if the r.m.s. voltage of the mains supply doubles.

A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

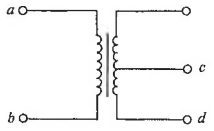
45. < HKDSE 2017 Paper IA - 30 >

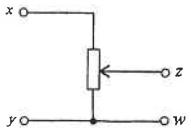
The input terminal of a transformer is connected to the 220 V mains supply. Ten identical light bulbs are connected in parallel to the output terminal of the transformer. All the light bulbs are working at their rated values of '3 V, 1.5 W'. If the efficiency of the transformer is 70%, what is the current drawn from the mains supply ?

A. 0.007 A
B. 0.048 A
C. 0.068 A
D. 0.097 A

46. < HKDSE 2018 Paper IA - 30 >

In the circuits below, if a 12 V sinusoidal a.c. is applied across *ab* and across *xy* respectively, the voltages across *cd* and *zw* are both 6 V. Now if a 6 V sinusoidal a.c. is applied across *cd* and across *zw* respectively, what would be the voltages across *ab* and *xy* respectively ?



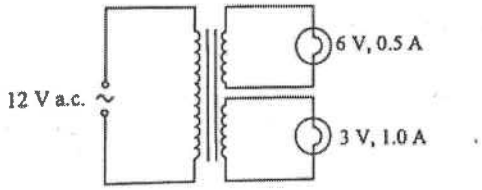


	voltage across *ab*	voltage across *xy*
A.	12 V	12 V
B.	12 V	6 V
C.	6 V	6 V
D.	12 V	0 V

47. <HKDSE 2019 Paper IA-29>

48. <HKDSE 2019 Paper IA-30>

49. <HKDSE 2020 Paper IA-29>



The figure shows an ideal transformer with two secondary coils connected to two light bulbs marked '6 V, 0.5 A' and '3 V, 1.0 A' respectively. When a 12 V a.c. supply is connected to the primary coil, the bulbs work at their respective rated values. Estimate the current in the primary coil.

A. 0.25 A
B. 0.50 A
C. 0.75 A
D. 1.0 A

M.C. Answers

1. B	11. B	21. B	31. A	41. B
2. C	12. C	22. B	32. A	42. A
3. D	13. C	23. D	33. C	43. D
4. C	14. D	24. B	34. A	44. A
5. B	15. D	25. D	35. B	45. D
6. B	16. D	26. A	36. B	46. B
7. C	17. B	27. D	37. D	47. C
8. A	18. C	28. D	38. D	48. B
9. B	19. D	29. C	39. C	49. B
10. D	20. B	30. B	40. D	

M.C. Solution

1. B

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

$\therefore \frac{(V_C)}{(V)} = \frac{(N/2)}{(N)} \quad \therefore V_C = \frac{V}{2}$

2. C

✓ (1) If high voltage is used, the current through the transmission cables would be small
by $P = VI \ \therefore V\uparrow \Rightarrow I\downarrow$

✓ (2) By $P = I^2R \ \therefore I\downarrow \Rightarrow P_{loss}\downarrow$
$\therefore$ less energy is wasted as heat during the transmission of power

× (3) Voltage in power transmission >> voltage in household circuit
$\therefore$ voltage need to be stepped down

3. D

× (1) The magnitude of voltage in d.c. may not be constant, such as that produced by d.c. generator.

✓ (2) Electron flows in the opposite direction of current.
In d.c., since the direction of current does not change, direction of electron flow does not change.

✓ (3) Current has heating effect on resistor, which does not depend on the direction of current.

4. C

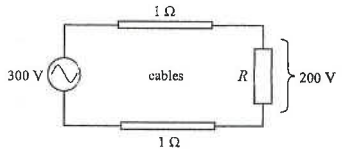
$\eta = \frac{P_{out}}{P_{in}} \quad \therefore 80\% = \frac{P_{out}}{(50)} \quad \therefore P_{out} = 40\,W$

$V_S = \frac{N_S}{N_P} \cdot V_P = \frac{1}{10} \times 200 = 20\,V \quad \therefore I = \frac{P_{out}}{V_S} = \frac{40}{20} = 2\,A$

5. B

$\eta = \frac{P_{out}}{P_{in}} = \frac{V_s I_s}{V_p I_p} \quad \therefore 75\% = \frac{(10)(3)}{(200) I_p} \quad \therefore I_p = 0.2\,A$

6. B



Let the resistance of the machinery be R.

Since the cables and machinery are in series, they have the same current I.

$R = \frac{V_t^2}{P_t} = \frac{(200)^2}{(10\times10^3)} = 4\,\Omega \quad \therefore I = \frac{300}{2+4} = 50\,A$

OR

By $P = VI \quad \therefore (10 \times 10^3) = (200) I \quad \therefore I = 50\,A$

Power loss in the cables : $P_{loss} = I^2 R = (50)^2 (2) = 5000\,W = 5\,kW$

7. C

By $\frac{V_S}{V_P} = \frac{N_S}{N_P} \quad \therefore \frac{V_S}{(200)} = \frac{10}{100} \quad \therefore V_S = 20\,V$

By $V_S = I_S R \quad \therefore (20) = I_s (100) \quad \therefore I_s = 0.2\,A$

8. A

✓ (1) Transformer can step-up the voltage of a.c.

× (2) Transformer cannot be used to increase the power.

× (3) Transformer cannot work on d.c., but battery gives d.c. steady voltage.

9. B

$\eta = \frac{P_{out}}{P_{in}} = \frac{P_{out}}{V_{in} I_{in}}$

$\therefore 50\% = \frac{(30)}{(200) I_{in}} \quad \therefore I_{in} = 0.3\,A$

10. D

× (1) For 100 % efficiency, $(200)I_P = (10)(0.5)$ $\therefore$ $I_P = 0.025$ A

✓ (2) $R = \frac{V}{I} = \frac{10}{0.5} = 20\,\Omega$

✓ (3) $\frac{N_P}{N_S} = \frac{V_P}{V_S} = \frac{200}{10} = 20$

11. B

High voltage is used in electricity transmission, thus P should be a step up transformer to step up the voltage in cable.
After transmission, the voltage has to be stepped down to be used in factory, thus Q is a step down transformer.

12. C

✓ (1) motor : electrical energy → mechanical energy

× (2) loudspeaker : electrical energy → sound

✓ (3) transformer : electrical energy → electrical energy

13. C

$\eta = \frac{P_{out}}{P_{in}} = \frac{P_{out}}{V_P I_P}$ $\therefore$ $80\,\% = \frac{(2\times 40)}{(200)\,I_P}$ $\therefore$ $I_P = 0.5$ A

Turns ratio in transformer : $\frac{N_P}{N_s} = \frac{V_P}{V_s} = \frac{200}{10} = 20$

It is a step down transformer since $N_P > N_S$.

14. D

$V_P I_P = P_{out}$ $\therefore$ $(200)(15) = n\,(40)$ $\therefore$ $n = 75$

15. D

Turns ratio : V_S = rated voltage = 10 V $\therefore$ $\frac{N_P}{N_S} = \frac{V_P}{V_S} = \frac{200}{10} = 20$

As the voltage changes from 200 V to 10 V, it is a step down transformer.

Efficiency : $\eta = \frac{(20\times 4)}{(200)(0.5)} = 80\,\%$

16. D

× (1) If number of turns of the secondary coil is increased, secondary voltage is increased,
however, power loss would not decrease, thus the efficiency remains unchanged.
(Although power output increases, but power input also increases to give the same efficiency.)

✓ (2) If laminated iron core is used, eddy current can be reduced, thus power loss is reduced.

✓ (3) If thicker copper wire is used, the resistance of the coils is reduced,
thus heating effect of current in the two coils is reduced, so power loss is reduced.

24. B

× (1) Voltage across bulb = 12 V ≠ 6 V, thus the bulb cannot work at its rated value.

× (2) Resistance of the light bulb : $R = \frac{V_r^2}{P_r} = \frac{(6)^2}{(6)} = 6\ \Omega$

Equivalent resistance of the bulb and the left resistor = $\frac{6}{2} = 3\ \Omega$

Thus, voltage across the light bulb is 4 V, the light bulb cannot work at its rated value.

✓ (3) Secondary voltage : $V_S = \frac{100}{200} \times 12 = 6\text{ V}$ ∴ the light bulb work at its rated value.

25. D

✓ (1) The output voltage is 12 V ∴ each light bulb shares 6 V ∴ work at rated values

✓ (2) Two intervals give an output voltage of 6 V ∴ work at rated values

✓ (3) Each light bulb is connected across two intervals ∴ each has an voltage of 6 V ∴ work at rated values

26. A

For the lamp to operate at its rated value, the current through the lamp should be $\frac{24}{6} = 4$ A

As it is a step down transformer, the current through the wire *ABCD* should be $\frac{4}{20} = 0.2$ A

Power loss in the cables = $I^2R = (0.2)^2(10) = 0.4$ W

27. D

✓ (1) Power transmission needs transformers for stepping up and down, and transformers work on a.c. only

✓ (2) For a give transmitted power, $P = VI$, thus current I is reduced if voltage V is increased.

✓ (3) By $P_{loss} = I^2R$, reduced current resulting from high voltage gives smaller power loss.

28. D

✓ (1) Since the voltage of a mobile phone is very low, about a few volts,
the adaptor must contain a step-down transformer for stepping down the voltage.

✓ (2) Since the battery of a mobile phone is d.c., the adaptor must convert the a.c. voltage of the mains to d.c.

✓ (3) Since transformer would give out heat when it operates,
black colour can increase the radiation of heat since black surface is a good emitter of heat.

29. C

(1) Since the secondary voltage of the transformer remains unchanged,
the power dissipated by bulb X is unchanged, thus the brightness of X remains unchanged.

(2) Since secondary current is decreased, by $\frac{I_S}{I_P} = \frac{N_P}{N_S}$ = constant, primary current should also decrease.

30. B

× (1) By $V_S : V_P = N_S : N_P$, if the number of turns of the primary coil is doubled,
the output voltage would change from 6 V to 3 V.

× (2) Since the output voltage is doubled, by $P_{out} = V_S^2 / R$, output power P_{out} becomes 4 times.
As there is no power loss, $P_{in} = P_{out}$, thus input power P_{in} also becomes 4 times.
By $P_{in} = V_P I_P$, as V_P is unchanged, I_P should be 4 times.

✓ (3) By $P = V_S^2 / R$, when V_S is doubled, the output power becomes 4 times.

31. A

Since the transformer is ideal, the efficiency is 100%, i.e. power input is equal to power output.

∴ $V_P I_P = V_S I_S$

∴ (220 V) I_P = (12 V) (100 mA) ∴ $I_P = 5.45\text{ mA} \approx 5.5\text{ mA}$

32. A

Assume the maximum number of light bulbs is n. The maximum primary current is 5 A which is limited by the fuse.

$\eta = \frac{P_{out}}{P_{in}} = \frac{P_{out}}{V_P I_P}$

∴ $(90\%) = \frac{40n}{(220)(5)}$ ∴ $n = 24.75$

The maximum number of light bulbs should be 24 so that the fuse would not blow.

33. C

The metal core should use iron so that there is good magnetic flux linkage between the two coils.

To give larger voltmeter reading, the transformer should be stepped up.

Thus, number of turns in coil A is 500 and number of turns in coil B is 1000 can give the largest voltmeter reading.

34. A

Before S is open, L_1 is shorted and thus only L_2 lights up. The resistance is R.

After S is open, both lamps light up and the equivalent resistance is $2R$, thus the secondary current decreases.

✓ A. Since $I_S : I_P = N_P : N_S$, with the same turns ratio, the decrease of I_S gives the decrease of I_P.

× B. The secondary voltage should remain unchanged as it depends on the turns ratio and V_P only.

× C. The brightness of L_1 should increase as it is not lit up initially.

× D. The brightness of L_2 should decrease as the current flowing through it is decreased.

35. B

✓ (1) Since transformers work on a.c., thus a.c. voltage can be changed easily.

× (2) Electrical power is transmitted with the speed of light, and is independent of the voltages.

✓ (3) By using high voltage, current in cables is reduced, thus less power is lost in the transmission cables.

36. B

$I = \frac{P}{V} = \frac{1200\times10^3}{132000} = 9.09\ \text{A}$

$P_{out} = P_{in} - P_{loss} = P_{in} - I^2 R$

$= (1200\times10^3) - (9.09)^2(550) = 1.155\times10^6\ \text{W} = 1155\ \text{kW}$

37. D

$I = \frac{P}{V} = \frac{(10\times10^3)}{(500)} = 20\ \text{A}$

Voltage across the cables $= (20)\times(0.2) = 4\ \text{V}$

E.m.f. produced by generator $= 500 + 4 = 504\ \text{V}$

38. D

Since the voltage is directly proportional to the number of turns,

$N_{PQ} : N_{RS} : N_{ST} = 240 : 4 : 8 = 60 : 1 : 2$

If $V_{ST} = 6\ \text{V}$, then $V_{PQ} : V_{RS} : 6 = 60 : 1 : 2$

$\therefore\ V_{PQ} = 180\ \text{V}$ and $V_{RS} = 3\ \text{V}$

39. C

For d.c. : $P_1 = \frac{V^2}{R} = \frac{(10)^2}{R}$

For a.c. : $P_2 = \frac{V_{rms}^{\ 2}}{R}$

$\frac{P_1}{P_2} = \frac{(10)^2}{V_{rms}^{\ 2}} = 2 \qquad \therefore\ V_{rms} = 7.07\ \text{V}$

Peak voltage : $V_o = \sqrt{2}\ V_{rms} = \sqrt{2}\times7.07 = 10\ \text{V}$

40. D

✓ (1) Transformers work on a.c. efficiently.

✓ (2) By $P = VI$, for the same P, higher V means that smaller transmission current I.

✓ (3) By $P_{loss} = I^2 R$, smaller I means that P_{loss} can be reduced.

41. B

For d.c. : $P = \frac{V^2}{R} \qquad \therefore\ (P) = \frac{(10)^2}{R}$

For a.c. : $P = \frac{V_{rms}^{\ 2}}{R} \qquad \therefore\ (\tfrac{1}{2}P) = \frac{V_{rms}^{\ 2}}{R}$

Combine the two equations : $\frac{1}{(\frac{1}{2})} = \frac{(10)^2}{(V_{rms})^2} \qquad \therefore\ V_{rms} = 5\sqrt{2}\ \text{V}$

42. A

By $V_{r.m.s.} = \frac{V_o}{\sqrt{2}}$

Thus, if the peak voltage is halved, the r.m.s. voltage is also halved.

43. D

$\eta = \frac{P_{out}}{P_{in}} = \frac{P_{out}}{V_P I_P} = \frac{(22\times2)}{(220)(0.25)} = 80\%$

44. A

✓ (1) Peak voltage : $V_o = \sqrt{2}\ V_{rms} = \sqrt{2}\times110 = 156\ \text{V}$

✓ (2) Power : $P = V_{rms}^{\ 2}/R = (110)^2/(100) = 121\ \text{W}$

× (3) Since $P \propto V^2$, if V doubles, power P should be 4 times.

45. D

By $\eta = \frac{P_{out}}{P_{in}} = \frac{P_{out}}{V_{in} I_{in}}$

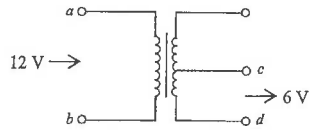
$\therefore\ 70\% = \frac{(1.5\times10)}{(220)\,I_P}$

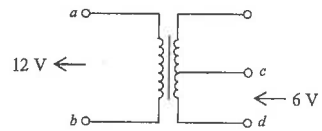
$\therefore\ I_P = 0.097\ \text{A}$

46. B

For the **transformer**, if the input voltage 12 V a.c. is applied across *ab*, the output voltage across *ab* is 6 V.

Thus, the turns ratio is 12 : 6 = 2 : 1 and it is a step-down transformer.

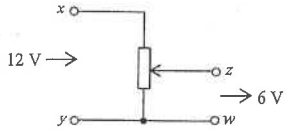


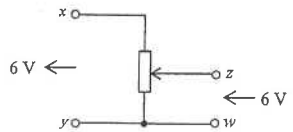


If the input voltage is 6 V a.c. across *cd*, since now the turns ratio is 1 : 2,

the output voltage across *ab* is 12 V and it becomes a step-up transformer.

For the **potential divider**, if the input voltage 12 V a.c. is applied across *xy*, the output voltage across *zw* is 6 V.





If the input voltage 6 V is applied across *zw*, since current only flows through the lower part of the resistor,

no current flows to the upper part of the resistor, the voltage across the upper part of the resistor is 0 V,

thus, the voltage across *xy* is still 6 V.

The following list of formulae may be found useful :

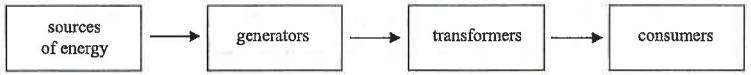
Power in a circuit $P = IV = I^2R$

Ratio of secondary voltage to primary voltage in a transformer $\frac{V_P}{V_S} \approx \frac{N_P}{N_S}$

Part A : HKCE examination questions

1. **< HKCE 1980 Paper I - 9 >**

The figure below is a block diagram showing how electric power is supplied to consumers.

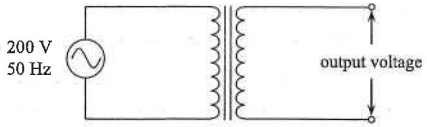


(a) One source of energy is from wind. State the conversion of energy in the generators and describe how the energy conversion is possible. (3 marks)

(b) Why is the efficiency of a transformer always less than 100% ? Mention one method of improving transformer efficiency. (4 marks)

(c) Explain why a 40 W fluorescent tube appears to be brighter than a 40 W filament lamp. (2 marks)

2. **< HKCE 1981 Paper I - 7 >**



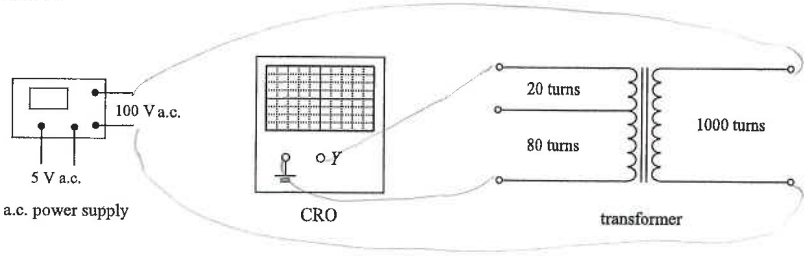
The primary coil of a transformer is connected to a 200 V, 50 Hz a.c. mains supply. Suppose the primary coil has 2000 turns and the secondary coil has 100 turns.

(a) Find the output voltage across the secondary coil. (3 marks)

2. (b) Find the frequency of the output voltage. (1 mark)

3. **< HKCE 1982 Paper I - 9 >**

The following pieces of apparatus (as shown in the below figure) are provided : an a.c. power supply, a C.R.O. and a transformer.



In the above diagram, show how you would connect the above pieces of apparatus to display a 10 V a.c. on the CRO. (6 marks)

4. **< HKCE 1983 Paper I - 7 >**

(a) 22000 W of electrical power are transmitted through a cable with a resistance of 0.5 Ω at 11000 V.

(i) Find the current passing through the cable. (2 marks)

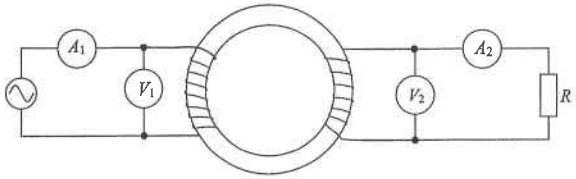
(ii) Find the power lost in the cable during transmission. (3 marks)

(iii) Why should a high voltage be used in power transmission ? (2 marks)

(b) Describe briefly how an alternating current of 11000 V can be stepped down to 200 V. (2 marks)

5. **< HKCE 1987 Paper I - 8 >**

The figure shows an arrangement to study the input and output characteristics of a transformer.



The readings of the ammeters and voltmeters are as follows:

Reading of A_1 = 2.5 A

Reading of A_2 = 1.8 A

Reading of V_1 = 12 V

Reading of V_2 = 2 V

(a) (i) Calculate the power input of the transformer. (1 mark)

(ii) Calculate the power output of the transformer. (1 mark)

(iii) Calculate the efficiency of the transformer. (1 mark)

(b) Suppose R is now replaced by another resistor of higher resistance.

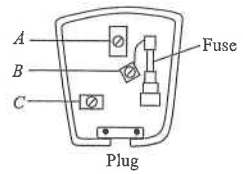
(i) How would the reading of the ammeter A_1 change ? (1 mark)

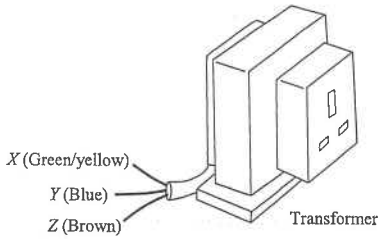
(ii) How would the reading of the ammeter A_2 change ? (1 mark)

(c) Suggest TWO changes in the transformer which will improve its efficiency. In each case, give ONE reason to support your suggestion. (4 marks)

6. **< HKCE 1990 Paper I - 7 >**

The below figure shows a 3-pin electrical plug and a transformer. The three wires X, Y, Z of the transformer are to be connected to the plug. The plug will be connected to a 200 V a.c. power supply. The output voltage of the transformer will be 110 V. Assume the transformer is 100% efficient.





(a) (i) To which of the terminals A, B, and C of the plug should each of the wires X, Y and Z be connected ? (2 marks)

(ii) Explain briefly why the fuse should be connected to the terminal B. (2 marks)

(iii) Suggest one reason why it is necessary to have the X-wire connection. (2 marks)

(iv) Find the turns ratio (primary coil to secondary coil) of the transformer. (2 marks)

(b) An iron of rated values "110 V, 1100 W" is connected to the output of the transformer and switched on for half an hour.

(i) Calculate the current drawn from the transformer by the iron. (2 marks)

(ii) Calculate the cost of electricity if one kilowatt-hour of electrical energy costs 80 cents. (2 marks)

(iii) If fuses marked 1 A, 3 A and 7 A are available, which one is most appropriate to be used in the plug in the figure ? Explain your choice. (3 marks)

7. **< HKCE 1995 Paper I - 5 >**

Two long wires *AB* and *CD* of total resistance 4 Ω are used to connect a d.c. power supply to a lamp. The lamp is working at its rated value '12 V, 24 W'.

(a) Find

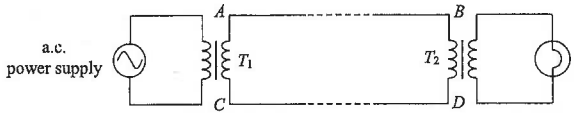
(i) the resistance of the lamp, (2 marks)

(ii) the current flowing through the lamp, (2 marks)

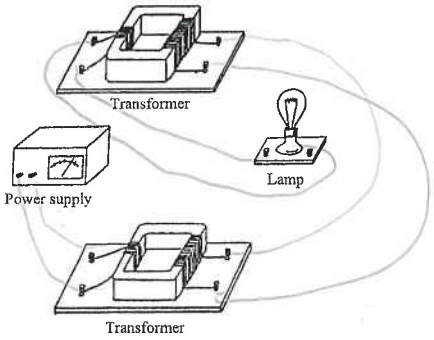
(iii) the power loss in the wires, (2 marks)

(iv) the efficiency of the circuit supplying power to the lamp. (2 marks)

(b) To reduce the power loss in the wires, an a.c. power supply and two transformers are used as shown in the figure below.



(i) In the figure below, draw wires to connect the terminals of the components according to the figure above. (3 marks)

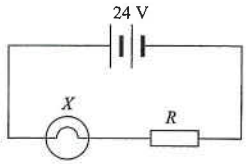


(ii) Explain how the arrangement can reduce the power loss in the wires. (3 marks)

8. **< HKCE 1997 Paper I - 7 >**

Two students suggest using a 24 V d.c. supply and a 24 V a.c. supply separately to operate a lamp *X* rated at '6 V, 12 W'.

(a)



A student connects *X* in series with a 24 V d.c. supply and a resistor *R* (see the Figure above). If *X* works at its rated value,

(i) find the current flowing through *X*, (2 marks)

(ii) find the voltage drop across *R*, (1 mark)

(iii) find the resistance of *R*, (2 marks)

(iv) what percentage of the electric power provided by the d.c. supply is dissipated in *R* ? (3 marks)

(b) The other student suggests that *X* can also be made to work by using a 24 V a.c. supply together with a transformer.

(i) Draw a circuit diagram to show how *X*, the a.c. supply and the transformer are connected. (2 marks)

(ii) What is the advantage of using this method over the one shown in the above Figure ? (1 mark)

(iii) Determine the turns ratio (primary to secondary) of the transformer for *X* to work at its rated value, and calculate the primary current if the transformer is 100% efficient. (4 marks)

9. **< HKCE 2000 Paper I - 10 >**

(a) A transformer is used to operate a '110 V, 1000 W' electric cooker at its rated value from the 220 V a.c. mains supply in Hong Kong. The primary coil of the transformer has 5000 turns and the efficiency of the transformer is 80%. Find

(i) the number of turns in the secondary coil of the transformer, (2 marks)

(ii) the operating resistance of the cooker, (2 marks)

(iii) the power input of the transformer, (2 marks)

(iv) the current flowing in the primary coil of the transformer. (2 marks)

(b) Figure 1 shows a travel cooker and the label attached on it. The cooker has a voltage selector switch shown in Figure 2.

Figure 1

Model No : EA 2000
a.c. 120 V / 240 V
360 W
~ 50-60 Hz

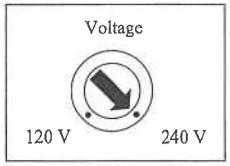


Figure 2

(i) A fuse is installed in the cooker. Explain the function of the fuse. (2 marks)

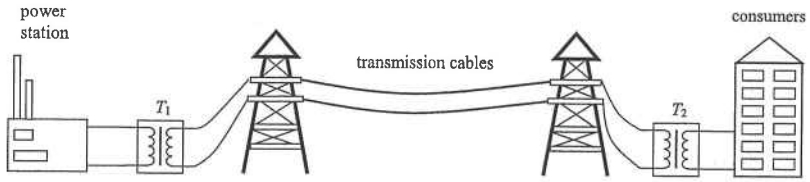
(ii) Two students make the following remarks about using the cooker in Hong Kong :

John : The voltage selector switch should be set to 120 V and the output of the cooker would be 360 W.

Peter : The voltage selector switch should be set to 240 V and the output of the cooker would be less than 360 W.

Explain whether each of the above remarks is correct. (4 marks)

10. **< HKCE 2001 Paper I - 5 >**

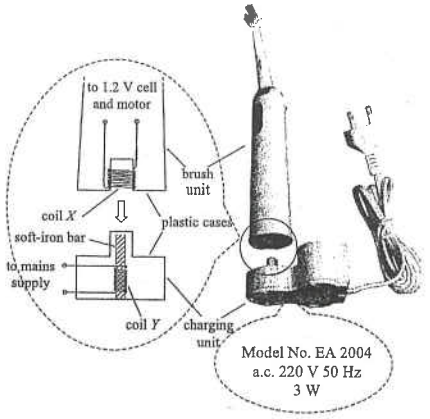


The above figure shows how electrical power generated in a power station is transmitted over long distances to consumers.

(a) State the function of the transformer T_1. (1 mark)

(b) Explain why a.c. and high voltages are used for long distance power transmission. (3 marks)

11. **< HKCE 2004 Paper I - 10 >**



The Figure above shows an electric toothbrush. It consists of a brush unit and a charging unit.

11. (a) Inside the brush unit, there is a 1.2 V rechargeable cell for driving a motor. When the toothbrush is in operation, the current flowing through the motor is 1.8 A. Calculate

(i) the power consumed by the motor, and

(ii) the energy consumed by the motor in 3 minutes. (4 marks)

(b) When the energy stored in the cell has been used up, the brush unit is placed on the charging unit to recharge the cell. The charging unit is connected to the mains supply and its label is also shown in the above Figure. It takes 16 hours to recharge the cell fully. Calculate the energy drawn by the charging unit from the mains supply in 16 hours. (2 marks)

(c) The cell inside the brush unit is connected to coil X located at the bottom of the unit. Another coil Y is located inside the charging unit with a soft-iron bar fixed inside it. When the brush unit is placed on the charging unit, the soft-iron bar lies inside coil X.

(i) The brush unit and the charging unit are completely covered by plastic cases and there is no metal contact between them. Explain how a current is produced in the brush unit to recharge the cell. (3 marks)

(ii) If coil Y has 11 000 turns, estimate the number of turns of coil X. Assume the output voltage of coil X is 3 V a.c. (2 marks)

(iii) State the function of the soft-iron bar. (1 mark)

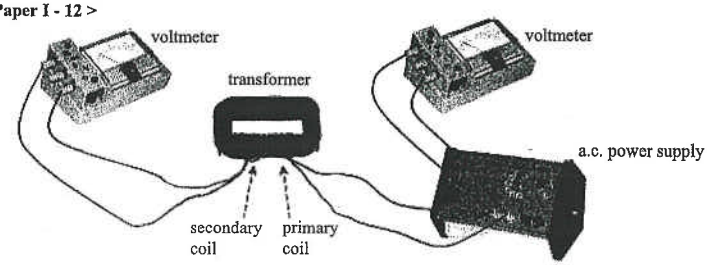
(d) The charging unit is fitted with a two-pin plug as shown in the above Figure.

(i) To which two wires of the mains supply should the pins of the plug be connected ? (1 mark)

(ii) Suggest one reason why it is safe for the charging unit to be fitted with a two-pin plug. (1 mark)

12. **< HKCE 2005 Paper I - 12 >**

Figure 1



Josephine conducts an investigation on transformers. She sets up a circuit as shown in Figure 1.

(a) Josephine varies the input voltage V_1 to the transformer and records the corresponding output voltage V_2. The results are shown in Table 1. In Figure 2, plot a graph of V_2 against V_1.

Hence draw a conclusion for this investigation.

V_1 / V	V_2 / V
1.0	1.7
2.0	3.3
3.0	5.1
4.0	6.9

Table 1

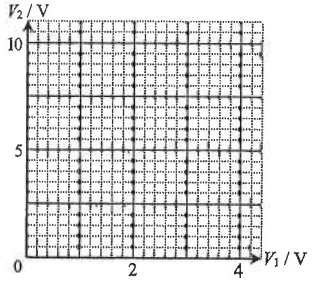


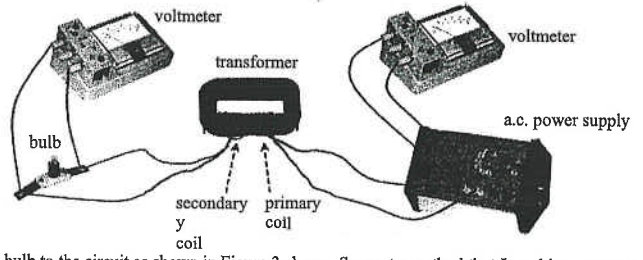
Figure 2

(2 marks)

(b) Josephine wants to study the relationship between the output voltage and the number of turns in the secondary coil of the transformer. Describe how she can conduct the experiment. (2 marks)

(c)

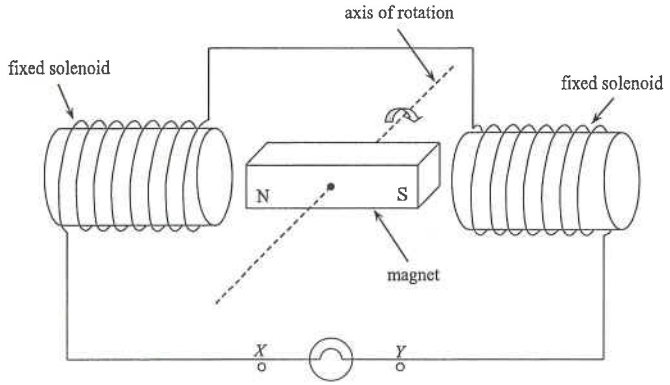
Figure 3



Josephine adds a bulb to the circuit as shown in Figure 3 above. Suggest a method that Josephine can use to estimate the efficiency of the transformer. Additional apparatus may be used if necessary. (3 marks)

13. **< HKCE 2007 Paper I - 12 >**

The Figure below shows a setup to generate electricity. A magnet is set into rotation between two fixed solenoids. The output terminals *X* and *Y* are connected to a light bulb.



(a) Explain how alternating current is generated in the above setup. (3 marks)

(b) The bulb is now removed from the setup. *X* and *Y* are then connected to the primary coil of a transformer. The secondary voltage output of the transformer is found to be 12 V. If the turns ratio of the primary coil to the secondary coil is 1 : 8, find the primary voltage. (2 marks)

(c) State the advantages of using

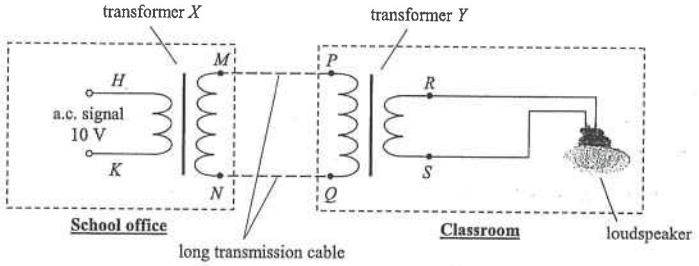
(i) a.c., and

(ii) high voltages

for long distance power transmission. (2 marks)

14. **< HKCE 2009 Paper I - 12 >**

The Figure below shows the power transmission of a bell system in a school. A signal generator in the school office produces a 10 V a.c. signal and is connected to *HK* as shown in the figure. The signal is then stepped up to 100 V and transmitted to a classroom through a long transmission cable. Assume all transformers are 100% efficient.



(a) The primary coil of transformer *X* has 500 turns. Find the number of turns in the secondary coil. (1 mark)

(b) Each wire of the transmission cable, *MP* and *NQ*, has a resistance of 80 Ω. Assume the current through the wires is 0.1 A.

(i) Find the voltage across *MP*. (2 marks)

(ii) Find the voltage across *PQ*. (1 mark)

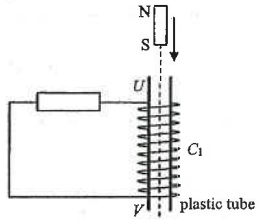
(iii) Find the power delivered to the loudspeaker. (2 marks)

(c) Suggest **TWO** methods to increase the power delivered to the loudspeaker with the same 10 V a.c. signal. (2 marks)

15. **< HKCE 2011 Paper I - 10 >**

(a) A magnet is dropped through a copper coil C_1 as shown in Figure (a). C_1 is connected to a resistor.

Figure (a)

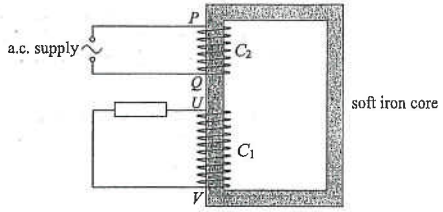


(i) What is the magnetic pole induced at end U of C_1 as the magnet approaches it ? (1 mark)

(ii) If the resistor is disconnected and the circuit becomes open, it is found that the magnet passes through C_1 in shorter time. Explain this phenomenon. (2 marks)

(b) Now, C_1 and another copper coil of smaller number of turns, C_2, are wound on a soft iron core as shown in Figure (b) to make a transformer. C_2 is connected to an a.c. supply.

Figure (b)

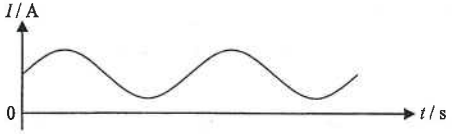


(i) What is the use of the transformer ? (1 mark)

(ii) Suggest **two** ways to improve the efficiency of the transformer. (2 marks)

(iii) Another power supply is connected to PQ to replace the a.c. supply. The variation of the current through C_2 with time is shown in Figure (c). A current flowing from P to Q through C_2 is taken as positive.

Figure (c)



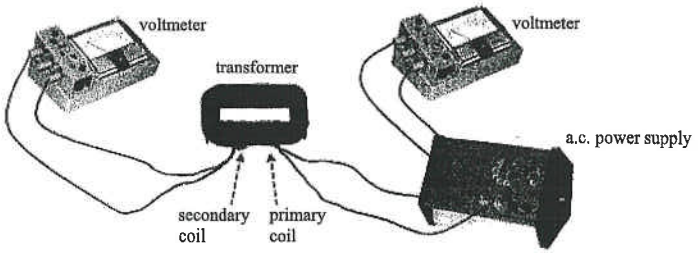
Tom claims that no induced current will be produced in C_1 as the current in C_2 has no change in direction. Comment on whether Tom's claim is correct or not. (3 marks)

Part B : HKDSE examination questions

16. **< HKDSE Sample Paper IB - 13 >**

Josephine conducts an investigation on transformers. Primary and secondary coils are wound on two soft-iron C-cores to form a transformer. She set up a circuit as shown in Figure 1.

Figure 1



(a) Josephine varies the input voltage V_1 to the transformer and records the corresponding output voltage V_2. The results are shown in Table 1. Figure 2 shows the graph of V_2 against V_1. Draw a conclusion for this investigation. (1 mark)

V_1 / V	V_2 / V
1.5	2.5
3.0	5.1
4.5	7.6
6.0	10.0

Table 1

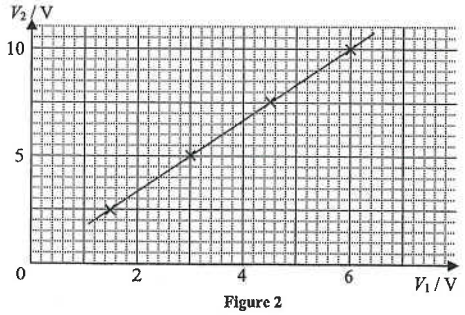


Figure 2

(b) Deduce the value of V_2 that will be produced when V_1 equals 8.0 V. (1 mark)

(c) Josephine wants to study the relationship between the output voltage and the number of turns in the secondary coil of the transformer. Describe how she can conduct the experiment. (2 marks)

16. (d)

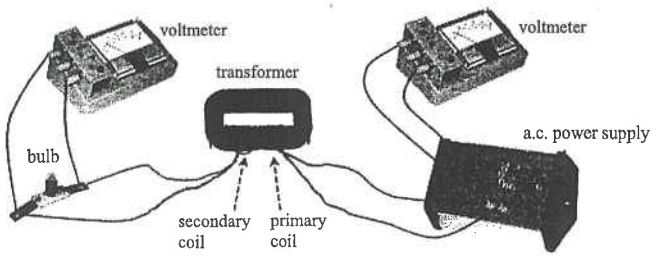


Figure 3

Josephine adds a bulb to the circuit as shown in Figure 3 above. Suggest how Josephine can estimate the efficiency of the transformer. State the measurement(s) she must take. Additional apparatus may be used if necessary. (3 marks)

17. **< HKDSE Practice Paper IB - 10 >**

Read the following passage about ignition coils and answer the questions that follow.

Ignition coil

An ignition coil is used to produce sparks from the battery of a car to ignite the fuel in the engine. It is used to produce high-voltage pulses from a low-voltage d.c. supply.

An ignition coil consists of two coils of insulated copper wire that are wound around a common iron core. One coil, called the primary coil, is made from relatively few (tens or hundreds) turns of thick copper wire. The other coil, called the secondary coil, typically consists of many (thousands) turns of thin copper wire.

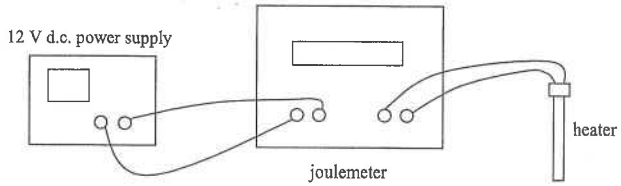
When an electric current is passes through the primary coil, a magnetic field is created. The iron core guides most of the primary coil's magnetic field to the secondary coil. When the current in the primary coil is suddenly interrupted, a high voltage pulse of many thousand volts is developed across the secondary coil. This voltage is then sufficient to cause an electrical discharge to produce a spark.

(a) Explain why a voltage is developed across the secondary coil when the current in primary coil is suddenly interrupted. (2 marks)

(b) Suggest **one** reason why the voltage developed across the secondary coil is very large. (1 mark)

(c) Assume input power to the primary coil equals to the output power of the secondary coil, explain why thick wire should be used to construct the primary coil. (2 marks)

18. **< HKDSE Practice Paper IB - 9 >**



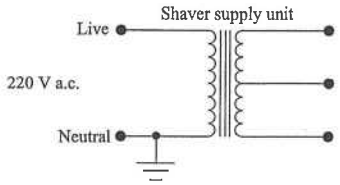
Suppose now the heater is connected to a sinusoidal a.c. power supply. The peak value of the voltage of the a.c. power supply is 15 V. How would the output power of the heater change ? (2 marks)

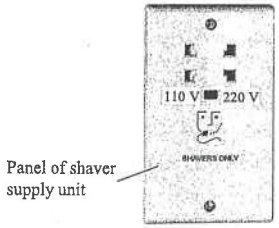
19. **< HKDSE 2012 Paper IB - 9 >**

Read the following description about the 'shaver supply unit' in bathrooms and answer the questions that follow.

The danger of electric shock is particularly high in bathrooms. Normal electric socket outlets should not be installed in bathrooms. As electric shavers and toothbrushes are becoming popular these days, a special unit, called 'shaver supply unit' is now common in bathrooms to provide electricity just for these low power consumption electric appliances (see the Figure).

The shaver supply unit consists of a transformer in which the secondary is not earthed and is completely isolated from the 220 V a.c. mains supply connecting to the primary. It can be used with 220 V or 110 V shavers.





(a) Explain why the chance of electric shock is high in bathrooms. (2 marks)

(b) Explain what would happen if the human body touches

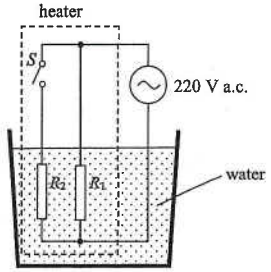
(i) the live wire of the mains supply in the primary circuit ; (2 marks)

19. (b) (ii) one of the conducting wires in the shaver circuit outlet. (2 marks)

(c) What is the turns ratio of the primary coil to the secondary coil of the transformer so as to provide 110 V ? (1 mark)

20. **< HKDSE 2012 Paper IB - 8 >**

In the circuit shown in the Figure, resistors R_1 and R_2 represent the heating elements in a heater using mains supply. Both resistors are immersed in water.



The heater can be operated in two modes, namely, heating and keeping warm, and it is controlled by the switch S. The power consumed by the heater in the heating mode is 550 W and in the mode of keeping warm is 88 W. The mains voltage is 220 V a.c.

(a) In which mode is the heater operating when switch S is open ? (1 mark)

(b) Find the resistance of R_1. (2 marks)

(c) When switch S is closed, calculate the current passing through resistor R_2. (3 marks)

(d) What is the *peak value* of the sinusoidal current flowing through the heater when switch S is closed ? (2 marks)

21. **< HKDSE 2015 Paper IB - 8 >**

Electricity generated from power plants are transmitted at a high voltage through overhead cables in suburban areas.

(a) Each overhead cable consists of 40 strands of identical transmission lines bundled together.

(i) One single strand of transmission line has a cross-sectional area of 1.3×10^{-5} m^2 and resistivity 2.6×10^{-8} Ω m. Find the resistance per km of a single strand of transmission line. (2 marks)

(ii) Explain why the resistance per km of an overhead cable is much smaller than that of a single strand of transmission line. Estimate the resistance per km of an overhead cable. (2 marks)

(iii) Hence, explain why a bird can stand with both feet on a high-voltage cable without getting an electric shock. (2 marks)

(b) Electrical power of 180 MW is transmitted at a voltage of 400 kV through an overhead cable.

(i) Calculate the current carried by the overhead cable. (2 marks)

(ii) Show that less than 0.1% of the electrical power is lost after transmitted through a total of 10 km of overhead cable. (2 marks)

(iii) As the voltage drop across this overhead cable is negligible, a voltage of 400 kV at the cable's end is stepped down by an ideal transformer with turns ratio 12 : 1.

(I) Find the secondary voltage from the transformer. (1 mark)

(II) State ONE factor leading to energy loss in a practical transformer and suggest the corresponding measure for improvement. (2 marks)

Question Solution

1. (a) Energy conversion in a generator is from kinetic energy to electrical energy. [2]

It is achieved by the wind driving the coil into rotation inside a magnetic field. [1]

(b) There is energy loss due to eddy current. [2]

Use laminated core. [2]

OR

There is energy loss due to dissipation of energy by the resistance of the coils. [2]

Use thicker wires. [2]

(c) In a fluorescent tube, less energy is wasted as heat. [2]

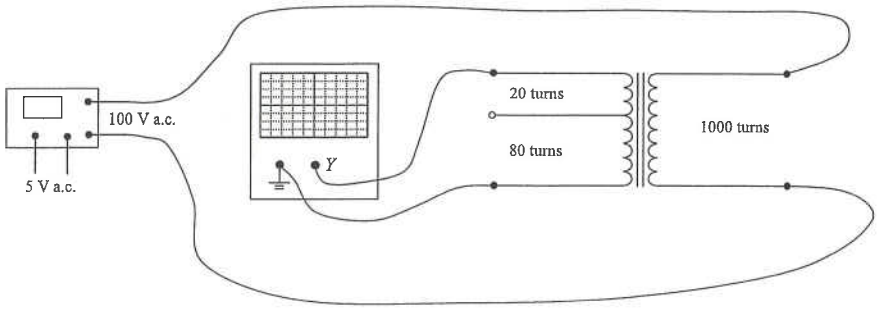
2. (a) $\frac{V_P}{V_S} = \frac{N_P}{N_S}$ [1]

$\therefore \frac{(200)}{V_S} = \frac{(2000)}{(100)}$ [1]

$\therefore V_S = 10\ V$ [1]

(b) $f = 50\ Hz$ [1]

3.



< Use 100 V a.c. > [1]

< Use 1000 turns as primary > [2]

< Use 100 turns as secondary > [2]

< Correct connection of the CRO > [1]

4. (a) (i) By $P = VI$ [1]

$(22000) = (11000)\,I \quad \therefore I = 2\ A$ [1]

(ii) Power loss $= I^2 R$ [1]

$= (2)^2 \times (0.5)$ [1]

$= 2\ W$ [1]

(iii) To reduce the current in the transmission cables [1]

and thus reduce energy loss (**OR** power loss) during power transmission. [1]

(b) Use a step-down transformer [1]

with turns ratio $= N_P : N_S = 11000 : 200 = 55 : 1$ [1]

5. (a) (i) Power input $= 12 \times 2.5 = 30\ W$ [1]

(ii) Power output $= 2 \times 1.8 = 3.6\ W$ [1]

(iii) Efficiency $= \frac{3.6}{30} \times 100\% = 12\%$ [1]

(b) (i) A_1 decreases [1]

(ii) A_2 decreases [1]

(c) ① Use laminated core [1]
to reduce the eddy current induced in the core. [1]

② Use thicker wires for the coils [1]
to reduce the resistance and heating loss in the coils. [1]

6. (a) (i) X connected to A Y connected to C Z connected to B

< any ONE correct > [1]

< the other TWO correct > [1]

(ii) Any **ONE** of the following : [2]

* The fuse will blow and break the circuit if a fault develops.
* Terminal B will be connected to the live wire.

(iii) To prevent electric shock if a fault develops. [2]

(iv) Turns ratio $= \frac{200}{110}$ [1]

$= 1.82$ [1]

6. (b) (i) $P = VI$ [1]

$(1100) = (110)\,I$

$\therefore\ I = 10$ A [1]

(ii) Energy $= 1.1$ kW $\times\ 0.5$ h $= 0.55$ kWh [1]

cost $= \$\,0.8 \times 0.55 = \$\,0.44$ [1]

(iii) $V_1 I_1 = V_2 I_2$ [1]

$(200)\,I_1 = (1100)$

$\therefore\ I_1 = 5.5$ A [1]

The fuse marked 7 A should be used. [1]

7. (a) (i) $R = \dfrac{V^2}{P} = \dfrac{(12)^2}{24} = 6\ \Omega$ [2]

(ii) $I = \dfrac{P}{V} = \dfrac{(24)}{(12)} = 2$ A [2]

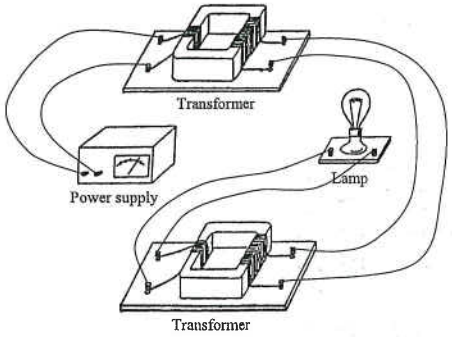
(iii) Power loss in the cables $= I^2 R = (2)^2 \times (4) = 16$ W [2]

(iv) Efficiency $= \dfrac{P_{out}}{P_{in}} \times 100\%$ [1]

$= \dfrac{24}{24 + 16} \times 100\%$

$= 60\%$ [1]

(b) (i) [3]



< Two wires connected from power supply to the left side of a transformer > [1]

< Two wires connected from the transformer to the right side of another transformer > [1]

< Two wires connected from the left side of the other transformer to the lamp > [1]

7. (b) (ii) Transformer T_1 steps up the voltage. [1]

The current through the cable is reduced. [1]

As power dissipated in the cables is equal to I^2R, so the power loss is reduced. [1]

8. (a) (i) Current through $X = \dfrac{P}{V} = \dfrac{12}{6}$ [1]

$= 2$ A [1]

(ii) Voltage drop across $R = 24 - 6 = 18$ V [1]

(iii) Resistance of $R = \dfrac{V}{I} = \dfrac{18}{2}$ [1]

$= 9\ \Omega$ [1]

(iv) Percentage $= \dfrac{2(18)}{2(24)} \times 100\%$ [2]

$= 75\%$ [1]

OR

Percentage $= \dfrac{2^2(9)}{2(24)} \times 100\%$ [2]

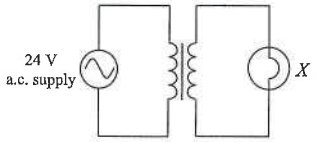
$= 75\%$ [1]

OR

Percentage $= \dfrac{2(18)}{2(18) + 12} \times 100\%$ [2]

$= 75\%$ [1]

(b) (i)



< Correct connection of circuit > [1]

< Correct symbols > [1]

(ii) This method can reduce the power loss in the circuit. [1]

(iii) Turns ratio $= \dfrac{V_P}{V_S} = \dfrac{24}{6}$ [1]

$= 4$ [1]

Primary current $= \dfrac{P}{V} = \dfrac{12}{24}$ [1]

$= 0.5$ A [1]

9. (a) (i) $\frac{V_P}{V_S} = \frac{N_P}{N_S}$

$\therefore \frac{220}{110} = \frac{5000}{N_S}$ [1]

$\therefore N_S = 2500$ [1]

(ii) $P = \frac{V^2}{R}$ [1]

$\therefore (1000) = \frac{(110)^2}{R}$

$\therefore R = 12.1\ \Omega$ [1]

(iii) Efficiency $= \frac{\text{Output power}}{\text{Input power}} \times 100\%$ [1]

$(80\%) = \frac{1000}{P_{in}} \times 100\%$

$\therefore P_{in} = 1250$ W [1]

(iv) $P = VI$ [1]

$(1250) = I(220)$

$\therefore I = 5.7$ A [1]

(b) (i) If an excessive large current flows through the cooker [1]

the fuse will melt (blow) and breaks the circuit. [1]

(ii) John is not correct.

The selector switch should not be set to 120 V, as the applied voltage in Hong Kong is 220 V,

that is much higher than the rated voltage. [1]

The fuse of the cooker will blow. [1]

Peter is correct.

The switch should be set to 240 V, as applied voltage in Hong Kong is 220 V. [1]

Since the applied voltage is slightly less than 240 V, the output power would be less than 360 W. [1]

10. (a) T_1 is used to step up the voltage. [1]

(b) An a.c. voltage is used because it can be stepped up or down by transformers efficiently. [1]

Stepping up the voltage can reduce the current passing through the cables. [1]

This can reduce the power loss in the cables. [1]

[**OR** This can increase the efficiency of power transmission.]

11. (a) (i) $P = VI = (1.2) \times (1.8)$ [1]

$= 2.16$ W [1]

(ii) $E = Pt = (2.16) \times (3 \times 60)$ [1]

$= 388.8$ J (OR 389 J) [1]

(b) $E = Pt$

$= (3) \times (16 \times 60 \times 60)$ [1]

$= 172\,800$ J (**OR** 173 000 J) (**OR** 173 kJ) [1]

(c) (i) When the charging unit is connected to the mains supply, an alternating current flows through coil Y. [1]

A changing magnetic field is set up in coil Y and hence in coil X. [1]

An induced voltage is set up in coil X to recharge the cell. [1]

(ii) By $\frac{V_P}{V_S} = \frac{N_P}{N_S}$

$\therefore \frac{220}{3} = \frac{11000}{N_S}$ [1]

$\therefore N_S = 150$

$\therefore$ Coil X has 150 turns. [1]

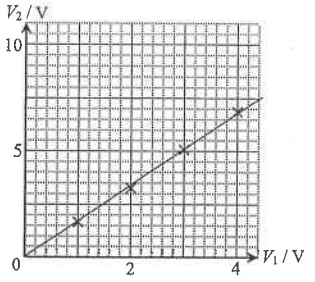
(iii) The soft iron bar can increase the strength of the magnetic field. [1]

(d) (i) The pins should be connected to the live and neutral wires. [1]

(ii) Any **ONE** of the following : [1]

* The charging unit has no metal case.
* The charging unit has a completely insulated plastic cover.
* The charging unit is double-insulated.

12. (a)



[1]

The output voltage V_2 is proportional to the input voltage V_1. [1]

12. (b) She should vary the number of turns of the secondary coil n_2, and measure the corresponding output voltage V_2. [1]
The input voltage V_1 and the number of turns of the primary coil n_1 should remain unchanged. [1]

(c) Josephine should use ammeters to measure the primary current I_1 and secondary current I_2, [1]
and calculate the input power $V_1 I_1$ and the output power $V_2 I_2$ [1]
The efficiency of the transformer can then be estimated by $\frac{V_2 I_2}{V_1 I_1} \times 100\%$ [1]

13. (a) The current is induced when the magnetic field between the two solenoids is changing. [1]
By Lenz's law, the induced current flows in a direction to oppose the change. [1]
When the magnet rotates towards a solenoid, the induced current flows in one direction,
and when the magnet rotates away from the solenoid, the induced current flows in the opposite direction. [1]

(b) $\frac{V_P}{V_S} = \frac{N_P}{N_S}$ [1]
$\frac{V_P}{(12)} = \frac{(1)}{(8)} \quad \therefore \ V_P = 1.5 \text{ V}$ [1]

(c) (i) Easy to step up during transmission. [1]
(ii) Reduce power loss. [1]

14. (a) $N_S = 500 \times \frac{100}{10} = 5000$ [1]

(b) (i) $V = IR$ [1]
$= (0.1)(80) = 8 \text{ V}$ [1]
(ii) $V_{PQ} = 100 - 8 - 8 = 84 \text{ V}$ [1]
(iii) $P = VI$ [1]
$= (84)(0.1) = 8.4 \text{ W}$ [1]
OR
$P = VI - I^2 R$ [1]
$= (100)(0.1) - (0.1)^2 (80 \times 2) = 8.4 \text{ W}$ [1]

(c) ① Deliver the power through the cable using a higher voltage.
(**OR** Increase the number of turns in the secondary coil of transformer X.) [1]
② Use thicker wires for the cable.
(**OR** Decrease the resistance of the cable.) [1]

15. (a) (i) South pole [1]
(ii) No induced current can flow in the open circuit. [1]
The magnet then passes through the solenoid without any resistive magnetic force. [1]

(b) (i) To step up the voltage. [1]
(ii) Use thicker wires in the coils. [1]
Use laminated core. [1]
(iii) As the magnitude of the current is varying, C_2 produces a varying magnetic field. [1]
C_1 will still experience changing magnetic field. [1]
Current will be induced in C_1 and hence, Tom's claim is wrong. [1]

16. (a) The output voltage V_2 is directly proportional to the input voltage V_1. <accept $V_2 \propto V_1$> [1]

(b) $V_2 = 8.0 \times \frac{10}{6} = 13.3 \text{ V}$ <accept 13.2 to 13.6 V> [1]

(c) The input voltage V_1 and the number of turns of the primary coil N_1 should remain unchanged. [1]
She should vary the number of turns of the secondary coil N_2 of the transformer,
and measure the corresponding output voltage V_2. [1]
The relationship can then be studied.

(d) Josephine may use ammeters to measure the primary current I_1 and secondary current I_2. [1]
She can then calculate the input power $V_1 I_2$ and the output power $V_2 I_2$. [1]
The efficiency can then be estimated by : efficiency $= \frac{\text{output power}}{\text{input power}} \times 100\%$. [1]

17. (a) When the primary current is suddenly interrupted, the magnetic field through the secondary coil changes. [1]
An e.m.f. is induced across the secondary coil. [1]

(b) The number of turns of the secondary coil is much larger than that of the primary coil. [1]
OR
The rate of change of magnetic flux is very large. [1]

(c) By $V_P I_P = V_S I_S$, as secondary voltage is higher, the primary current is larger. [1]
In order to minimize the heating effect of the primary current, thick wire of smaller resistance should be used. [1]

18. The r.m.s. voltage of the a.c. supply $= \frac{15}{\sqrt{2}} = 10.6 \text{ V}$ [1]
This value is smaller than 12 V, thus the power output of the heater decreases. [1]

19. (a) In bathroom, humid air and mist contain much water that is a conductor. [1]

The water provides a conducting path between the human body and the source of electricity. [1]

OR

The water lowers the resistance between the human body and the source of electricity. [1]

(b) (i) The human body would get electric shock [1]

because current flows through the body to the Earth and returns to the Neutral wire. [1]

(ii) The human body will not get electric shock [1]

because there is no return path for the current (**OR** there is no complete circuit) [1]

(c) Turns ratio = 2 : 1 <accept turns ratio = 2>

20. (a) keeping warm [1]

(b) $P = \dfrac{V^2}{R}$

$\therefore (88) = \dfrac{(220)^2}{R_1}$ [1]

$R_1 = 550\ \Omega$ [1]

(c) Power given out by the resistor $R_2 = 550 - 88 = 462$ W [1]

$P = VI$ [1]

$(462) = (220)\, I_2$

$\therefore I_2 = 2.1$ A [1]

OR

Total current $= \dfrac{P}{V} = \dfrac{(550)}{(220)} = 2.5$ A [1]

Current in $R_1 = \dfrac{(220)}{(550)} = 0.4$ A [1]

Current in $R_2 = 2.5 - 0.4 = 2.1$ A [1]

(d) Peak current $= \sqrt{2} \times 2.5$ [1]

$= 3.54$ A [1]

21. (a) (i) Consider a length of 1000 m

$R = \dfrac{\rho \ell}{A} = \dfrac{(2.6\times10^{-8})\times(1000)}{(1.3\times10^{-5})} = 2.0\ \Omega$ [1]

Resistance per km $= 2.0\ \Omega\ \text{km}^{-1}$ [1]

21. (a) (ii) The strands are connected in parallel. [1]

OR

The cross-sectional area of cable is greater than each of transmission line. [1]

Resistance of cable per km $= \dfrac{2.0}{40} = 0.05\ \Omega\ \text{km}^{-1}$ [1]

(iii) The resistance of the bird's body is much larger than that of the short segment of the overhead cable. [1]

OR

The potential difference across the feet is very small. [1]

Hence, negligible current flows through the bird's body. [1]

(b) (i) By $P = VI$ [1]

$\therefore (180 \times 10^6) = (400 \times 10^3)\, I$

$\therefore I = 450$ A [1]

(ii) $R = 0.05 \times 10 = 0.5\ \Omega$

$P_{\text{loss}} = I^2 R = (450)^2 \times (0.5) = 101\,250$ W [1]

Percentage of power loss $= \dfrac{101250}{180\times10^6} \times 100\% = 0.05625\ \% < 0.1\ \%$ [1]

(iii) $V_S = 400 \times \dfrac{1}{12} = 33.3$ kV [1]

(iv) Heating loss due to the heating effect of current in the resistance of coils. [1]

Use thicker wires for the coils. [1]

OR

Power loss due to eddy current induced in the soft iron core. [1]

Use laminated soft iron core. [1]