CHAPTER NINE

ELECTRICAL POWER AND ENERGY

Electrical Energy

- When a potential difference is applied to the ends of a conductor, some of the electrons inside it are set in motion by the electrical forces. Work is therefore done and the electrons acquire energy. The moving electrons form an electric current.
- If a potential difference of 1 volt is applied to the ends of a conductor and 1 coulomb of electricity passes through it, the work done is 1 joule (J).
- Hence if the pd is in volts (V) and the quantity of electricity which passes is Q coulombs(C), then the
- Work done, W = QV

But $Q = It$, $W = VQ = VIt$ …… (1)

Also $V = IR$ or $I = \frac{V}{R}$

Thus $W = VIt = IR\ x\ It = I^2Rt$ …… (2)

Also $W = VIt = Vx\frac{V}{R}xt = \frac{V^2}{R}t$ …….. (3)

Electrical power

Power is the rate of doing work. If electrical work done in a time t seconds is W, then

$power = \frac{work}{time} = \frac{w}{t}$

But electrical work done is given by

$W = VIt$ or $W = I^2Rt$ or $W = \frac{V^2}{R}t$

Therefore Power is given by

$P = \frac{W}{t} = \frac{IVt}{t} = IV$ (1)

$P = \frac{I^2R}{t}t = I^2R$ (2)

$P = \frac{V^2t}{Rt} = \frac{V^2}{R}$ (3)

The unit of power is the watt.

It follows that a ***watt*** $= \frac{1\,joule(J)}{1\sec ond(s)}$

*A **watt** is defined as the rate of working of 1 joule per second.*

An appliance rated 240V, 75W gives out energy at a rate of 75J every second when connected to a 240V supply.

Commercial electrical energy

The commercial unit of energy is the kilowatt hour (kWh). The kWh is the energy supplied by a rate of working of 1000 watts for 1 hour, that is

1 kWh = 1000 watts for 1 hour

= 1000 x 60 x 60 joules

1 kWh = 3600000 joules = 3.6MJ

Unit consumed = Power(kW) x time(hour)

Example :1 Find the cost of running three 50W lamps and five 75W lamps for 6 hours if electrical energy costs shs 50 per unit.

Solution:

$Unit\ consumed = (3x\frac{50}{1000} + 5x\frac{75}{1000})x6 = 3.15 units$

If one unit costs shs 50, then 3.15 units will cost: $3.15x50 = 157.5$

Thus total cost will be shs 157.5

Example :2 Find the cost of running five 60W lamps and four 100W lamps for 8 hours if electric energy costs 40 shs per unit.

Solution:

$Unit\ consumed = (5x\frac{60}{1000} + 4x\frac{100}{1000})x8 = 5.6 units$

If one unit costs shs 40, then 5.6 units will cost: $5.6x40 = 224$

Thus total cost will be shs 224

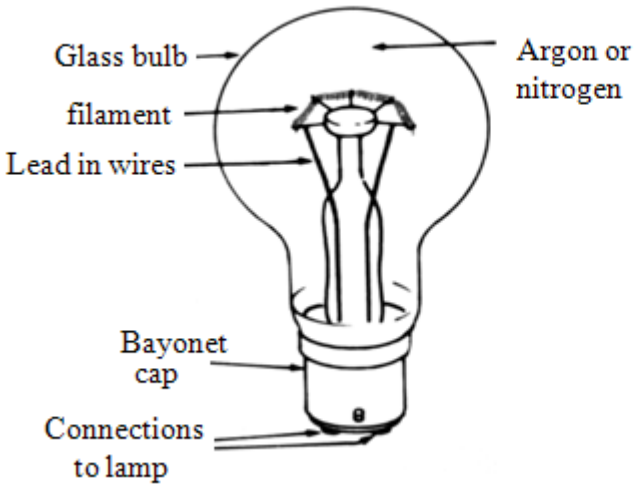
Electric lighting

a) Filament lamps:

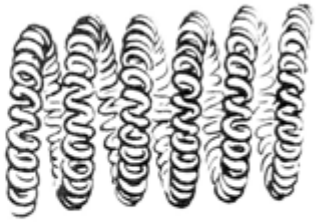
The filament is a small coiled coil of tungsten wire as in the figure below, which becomes white when current flows through it.

The higher the temperature of the filament, the greater is the proportion of electric energy changed to light and for this reason it is made of tungsten, a metal with a high melting point(3400 ^{0}C).

a)



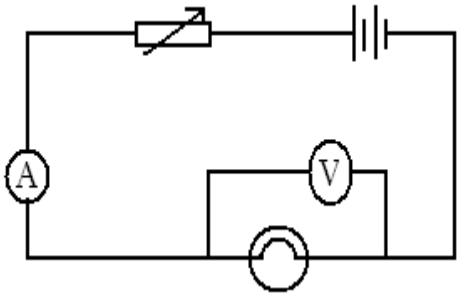
b)



Most lamps are gas filled and containing nitrogen or argon not air. This reduces evaporation of the tungsten which would otherwise condense on the bulb and blacken it.

The circuit figure below(a) and graph below (figure b) shows the variation of current through a tungsten filament with the p.d. across it.

a)



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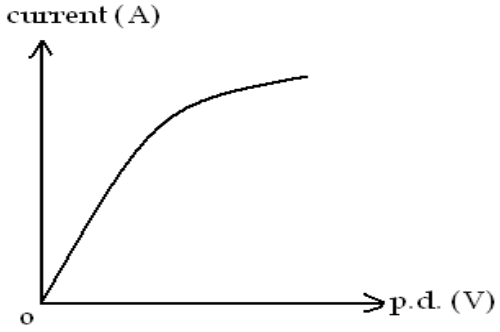
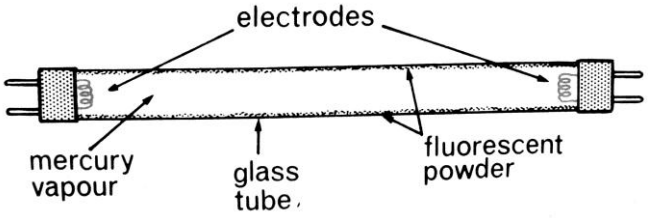


b) Fluorescent lamps

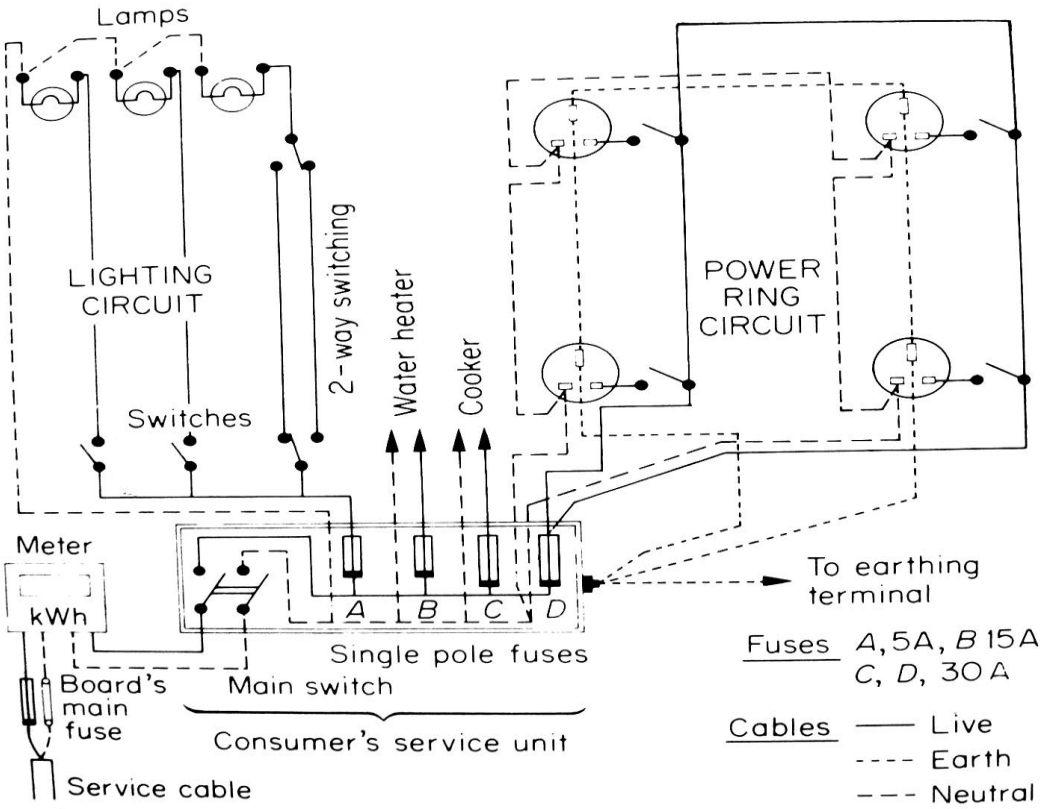


- A simplified diagram of a fluorescent lamp is shown in the figure above. When the lamp is switched on current passes until the tungsten filaments are hot enough to emit electrons. The electrons collide with the mercury atoms, causing the mercury vapour to emit ultra violet radiation (invisible) which makes the powder on the inside of the tube fluoresce (glow), i.e. light (visible) is emitted. Different powders give different colours.
- A filament lamp changes only 10% of the electrical energy supplied into light, the other 90% becomes heat.

Advantage of a fluorescent tube over a filament lamp

- Fluorescent lamps are more energy saving than normal bulbs.
- Fluorescent lamps don't give a lot of heat like filament lamps.
- Fluorescent lamps cost more to install but running costs are less than filament.

Domestic Electrical Installation



- The cable bringing the mains electricity supply into a house contains two wires, the live and the neutral. The neutral is earthed at the local sub-station and so is at zero potential. And live wire is alternatively positive and negative.
- Within a house, the supply cable which is carrying a.c. enters a sealed box where the live wire is joined to the Electricity Board's fuse.
- *A **fuse** is a device containing a short length of a thin wire which melts and breaks the circuit if the current exceeds a safe value.*
- From the box, the cables are passed to the consumers service unit in which there is a large main double pole switch combined with a single pole fuse for each of the lighting circuits, cookers, water heater circuit and ring circuit.
- Normally the lighting fuse is 5A, the water heater fuse is 15A, the cooker circuit fuse is 30A and other ring circuit fuse is 30A.
- In wiring the lighting circuit, two wires are used, these are the live and the neutral wire. In wiring the power ring circuit , heater circuit and cooker circuit, a third wire is introduced. This wire is called the **earth wire**. This is done so that one does not get a shock as sometimes the live wire may touch the metal frame of the appliance.
- In wiring an electric circuit, all the switches and fuses are placed on the live side of the supply.

TEST 9

SECTION A

1. A current of 10A flows through an electric heater for 1hour. If 7.2×10^6 J of electrical energy is converted to heat, find the p.d across the heater.

a. 2.0×10^2 V b. 2.0×10^3 V c. 1.2×10^4 V d. 7.2×10^5 V

2. If the cost of one unit of electrical energy is sh.150, find the cost of using two 75W lamps for 2 hours.

a. Sh. 0.30 b. Sh. 4.00 c. Sh. 22.50 d. Sh. 45.00

3. An electric lamp is marked 120 W, 240V. What does 120W mean?

A. Total energy consumed by the lamp.
B. Rate at which energy is consumed.
C. Total current flowing through the lamp.
D. Potentional difference across the lamp.

4. A transformer connected to 240V a.c mains is used to light a 12V 36W lamp. What current does the lamp draw?

a) 20.0 A b) 6.7 A c) 3.0 A d) 0.33A

5. Uganda electricity board charges sh.90 per Kilowatt-hour of electrical energy consumed. What is the total cost of operating 4 light bulbs rated at 100W for 5 hours.

a) sh.11.25 b) sh.45 c) sh.180 d) sh.180,000

6. What is the cost of running five 200 W lamps for 8 hours if electrical energy costs sh.140 per unit?

(a) Sh.1120 (b) sh. 700 (c) 224 (d) sh.28

7. The device which disconnects the mains when there is a sudden increase in voltage is

(a) fuse (b) switch
(c) earth wire (d) circuit breaker

8. An electric heater is connected to a 200 V supply. The heating element has a resistance of 10Ω. The cost of using the heater for 4 hours if each unit of energy costs Sh.35 is

(a) Sh.5600 (b) Sh.1400 (c) Sh.560 (d) sh.140

9. How many kilowatt hours are used to run

(i) 8 kW cooker for 1 hour
(ii) 3 kW immersion heater for 40 minutes
(iii) 960W hair dryer for 20 minutes

(a) 10.32kWh (b) 147.20kWh
(c) 768.00kWh (d) 971.00kWh

10. For safety in house, a fuse and a switch are connected to

	Fuse	Switch
A.	Live wire	Neutral wire
B.	Neutral wire	Earth wire
C.	Live wire	Live wire
D.	Earth wire	Neutral wire

11. An electric appliance having 4 heating elements, each rated at 0.75kW, is used on a 240 V mains. What is the power rating of the appliance?

A. 80 kW B. 60 kW C. 3 kW D. 3W

12. A car head lamp bulb is marked 12V, 48W. This means that when a

A. voltage of 12V is applied, a current of ¼ A flows.
B. power of 48W is developed, the resistance is 4Ω.
C. voltage of 12 V is applied, resistance is Ω.
D. voltage of 12 V is applied; energy used in every second is 48J.

13. Which of the following statements are true about electric wiring?

(i) The fuse is always connected into the live wire leading to circuit.
(ii) The fuse is connected into the neutral wire leading to a circuit.
(iii) When a fault develops in the circuit, it is the neutral wire which has to be disconnected.

A. (i) only. B. (iii) only.
C. (i) and (iii) only. D. (i), (ii) and (iii).

14. An electricity board charges shs 10 per kilowatt-hour of electrical energy supplied. What is the total cost in shs. Of operating 4 light bulbs, each rated at 100W for 5 hours?

A. Sh2. B. Sh.20. C. Sh 4,000 D. Sh 20,000

15. What is the most suitable fuse for an electric heater rated 2.5KW when connected to a voltage of 240V

A. 5A B. 10A C.13A D.30A

16. An electric heater is rated 240V, 400W. if the efficiency of the heater is 80% find the amount of energy wasted per second.

A. 48J. B. 80J. C. 192J. D. 320J.

17. An electric heater which operates from 240V mains draws 15A for 40 minutes. Calculate the cost of electricity, given that electricity costs 9.00 per kilowatt hour
a) Sh.1.44 b) sh.21.60 c) sh.960 d) sh.1296

18. A bulb of resistance 1.5Ω is connected to a cell of e.m.f. 2.0V. Find the energy dissipated in 45 seconds.
a) 60J b) 67.5J c) 90J d) 120J

19. Calculate the amount of current taken by an electric flat iron marked 250 V. 1000W.
(a) 0.25A (b) 0.40A (c) 2.50A (d) 4.00A

20.

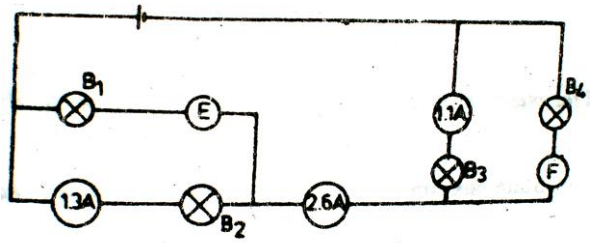


Fig 6

In the above circuit, *B1, B2, B3 and B4* are bulbs. The readings of ammeters E and F are respectively

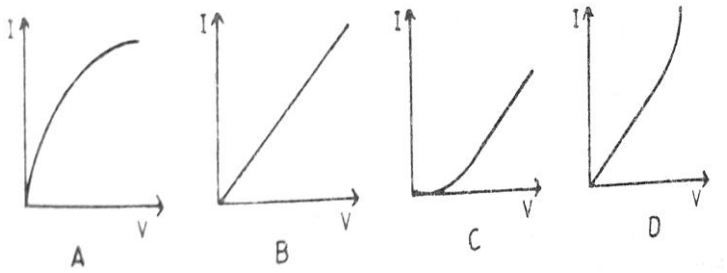
(a) 1.5A, 1.3A (b) 1.3A, 1.5A

(c) 1.3A, 1.1A (d) 1.3A, 2.6A

21. 4 bulbs each rated at 75 W operate for 120 hours. If the cost of electricity is sh.100 per unit, the total cost in shillings will be

(a) 150 (b) 900 (c) 3600 (d) 7500

22. Which one of the following graphs represents the current voltage variation for a tungsten filament wire lamp?



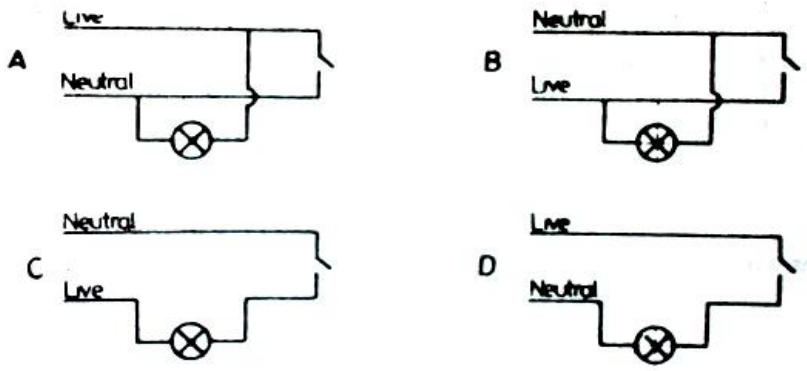
23. A house has four 75 W lamps and five 100 W lamps. What will be the cost of running the lamps for 10 hours if the cost per kWh is sh.50.

(a) sh.2500.00 (b) sh. 400.00 (c) sh. 500.00 (d) sh. 787.50

24. An electric heater is used to heat 0.2kg 0f water for 200 seconds. Find the p.d across the heater if the current through it is 0.5A and the temperature of the water rises by 25^0C

(a) 145V (b) 175V (c) 210V (d) 240V

25. Which of the following circuit diagrams shows the correct positions for a lamp and a switch in a lighting circuit?



26. A current of 2 A flows through a coil of resistance 3 ohms for one minute. How much energy is converted into heat?

a) 6J b) 12J c) 360J d) 720J

27. When a 240V supply is connected across an electric appliance, a current of 200mA flows in the circuit. What is the electric power supplied to the appliance

(a) 1.2W (b) 48.0W (c) 48000.0W (d) 120000.0W

SECTION B

1. A 240 V, 600W water heater is used to boil water for 5 min.

(a) By what means does heat spread through the water?

(b) Calculate:

(i) The current that flows in the heater.

(ii) The electrical energy converted into heat.

2. A bulb is rated 12.0volts, 36 watts when used on a 12.0 volts supply.

(a) How much current does it draw from the supply?

(b) What is its resistance?

3. (a) Describe the structure and action of a fluorescent tube.

(b) Give one advantage of a fluorescent tube over a filament lamp.

4. Find the cost of running two 75 W lamps for 10 hours if the cost of each unit is sh.50.

5. A bulb is rated 6V, 12W. Calculate;

(a) the current it takes.

(b) the energy it supplies in 30 seconds.

6. Describe the functions of:

(i) a fuse

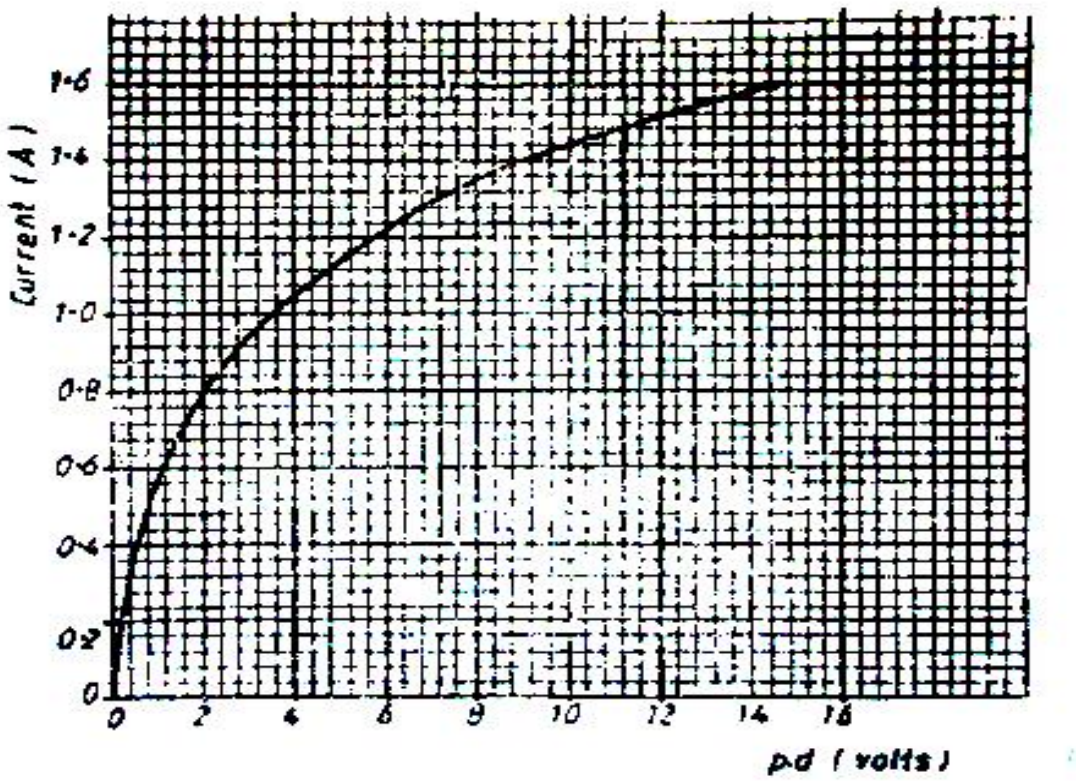
(ii) an earth wire.

7. An electric heater which operates from 240V mains draws 12A for 30 minutes. Calculate the cost of electricity, given that electricity costs 8.00 per kilowatt hour.

8. Find the cost of running two 60 W lamps for 20 hours if the cost of each unit is sh.40.

9. An electric heater of resistance 40Ω is connected to a 240 V mains. How long will it take to raise the temperature of 4kg of water from 40^0C to 100^0C?

10. The graph below shows the variations of current through a tungsten filament with the p.d across it.



(a) Draw a suitable circuit diagram to show how the results in the graph can be obtained.

(b) State what happens to the resistance of the filament as the current increases

(c) Using the graph, determine the resistance of the filament when the current is 0.7A.

TEST 9

1.A	2.D	3.B	4.C	5.C	6.A	7.A	8.C	9.A	10.C
11.C	12.D	13.A	14.B	15.C	16.B	17.B	18.D	19.D	20.B
21.C	22.A	23.B	24.C	25.D	26.D	27.B			