TOPIC 19 Practical Electricity

Objectives

Candidates should be able to:

(a) describe the use of the heating effect of electricity in appliances such as electric kettles, ovens and heaters
(b) recall and apply the relationships $P = VI$ and $E = VI\,t$ to new situations or to solve related problems
(c) calculate the cost of using electrical appliances where the energy unit is the kW h
(d) compare the use of non-renewable and renewable energy sources such as fossil fuels, nuclear energy, solar energy, wind energy and hydroelectric generation to generate electricity in terms of energy conversion efficiency, cost per kW h produced and environmental impact
(e) state the hazards of using electricity in the following situations:
  (i) damaged insulation
  (ii) overheating of cables
  (iii) damp conditions
(f) explain the use of fuses and circuit breakers in electrical circuits and of fuse ratings
(g) explain the need for earthing metal cases and for double insulation
(h) state the meaning of the terms live, neutral and earth
(i) describe the wiring in a mains plug
(j) explain why switches, fuses, and circuit breakers are wired into the live conductor

NOTES

19.1 Application of Heating Effects of Electricity

1. Household appliances such as kettles, irons and rice-cookers make use of the heating effect of electric current.

2. Nichrome is chosen as a heating element due to the following advantages:
   (a) cheap
   (b) high resistance
   (c) high melting point
   (d) does not oxidise easily

19.2 Electrical Energy and Power

1. Recall: $W = QV$
   W is the work done by source (unit: J)
   Q is the charge (unit: C)
   V is the e.m.f. (unit: V)

2. Since $Q = It$, we have $W = (It)V = VIt$
   I is the current (unit: A)
   t is the time taken (unit: s)

3. The following table summarises the different forms of the electrical energy equation:

Equation 1	$W = VIt$	
Equation 2	$W = I^2Rt$	by substituting $V = IR$ into (1)
Equation 3	$W = \dfrac{V^2}{R}t$	by substituting $I = \dfrac{V}{R}$ into (1)

4. Power, $P = \dfrac{\text{Work time, } W}{\text{Time, } t}$
   Rearranging, we have $W = Pt$
   Compare with Equations 1, 2 and 3 in the above table:

Equation 1	$P = VI$
Equation 2	$P = I^2R$
Equation 3	$P = \dfrac{V^2}{R}$

5. SI unit for power: W or J/s

19.3 Calculating Cost of Using Electricity

1. The unit for measuring electrical consumption is the kilowatt-hour (kWh), which is the energy used by an electrical device at a rate of 1000 W in 1 hour.

   $$\begin{aligned} 1 \text{ kWh} &= 1000 \text{ W} \times 1 \text{ h} \\ &= 1000 \times 60 \times 60 \\ &= 3\ 600\ 000 \text{ J} \\ &= 3.6 \times 10^6 \text{ J} \end{aligned}$$

   Example 19.1

   Given that electrical energy costs \$0.25 per kWh, find the total cost of running eight 60 W lamps and a 3 kW electrical kettle continuously for 8 minutes.

   Solution

   Total power = (8 × 60) + (1 × 3000) = 3480 W = 3.48 kW

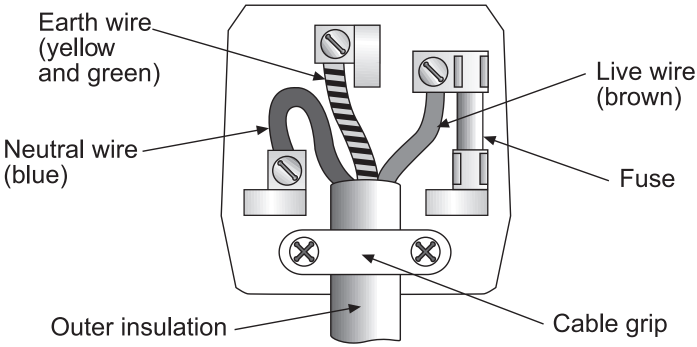
   No. of hours of operation $= \frac{8}{60} = \frac{2}{15}$ h

   Total cost $= 3.48 \times \frac{8}{60} \times 0.25 = \$0.116 = \$0.12$ (to 2 d.p.)

19.4 Hazards of Using Electricity

1. Electricity is dangerous and can harm people if it is not used properly.
2. Some of the common dangers involved are:
   (a) Handling electrical appliances with wet hands can lead to electric shock.
   (b) Overheated cables can lead to fire.
   e.g. Plugging many appliances to one power point using multiplugs.
   (c) Electrical cables with damaged insulation, especially the live wire, can lead to an electric shock.

19.5 Safe Use of Electricity in the House



1. There are three wires in the household electric cable: live (L), neutral (N) and earth (E).
   (a) All appliances need at least 2 wires (live and neutral) to form a complete circuit.
   (b) The live (L) wire (brown) delivers the current at high voltage from the supply to the appliance. It is the most dangerous, thus switches, fuses and circuit breakers are wired to it instead of the other wires.
   (c) The neutral (N) wire (blue) completes the circuit by forming a path for the current back to the supply. It is usually at 0 V.
   (d) The earth (E) wire (yellow and green) is a low-resistance wire, usually connected to the metal casing of the appliance.
   (e) Earthing (use of earth wire) protects the user from an electric shock if the metal casing should accidentally become live (contacted with bare live wire).
   (f) The large current that flows from the loose live wire through the metal casing and the earth wire will blow the circuit fuse and cut off the supply to the appliance.

2. Fuse
   (a) A fuse is a safety device that is connected to the live wire of an electrical circuit to protect the equipment and wiring against any excessive current flow.
   (b) Characteristics:
   Made of tin-lead alloy with a low melting point.
   Common fuse ratings: 1 A, 2 A, 5 A, 10 A and 13 A.

(c) How does a fuse work?

    1. Fuse rating for a fuse in a device must be slightly higher than the current through the device.
    2. When the current is too large, the fuse becomes hot and melts (blown fuse), thus cutting off the current flow from the live wire to the device.
    3. The blown fuse will have to be replaced by a new one for the device to work again.

3. Switches are used to close and open a circuit. Switching off disconnects the high voltage from an appliance.

4. Double insulation

    (a) Double insulation is a safety feature in an electrical appliance that can substitute for an earth wire.

    (b) It means that in addition to the first insulation covering the wires, there is a second insulation (**e.g.** plastic casing of a hair dryer).