Practical Electricity

Uses of Electricity

Dangers of Electricity

Safe Use of Electricity in the Home

HAMMAD HUSSIAN

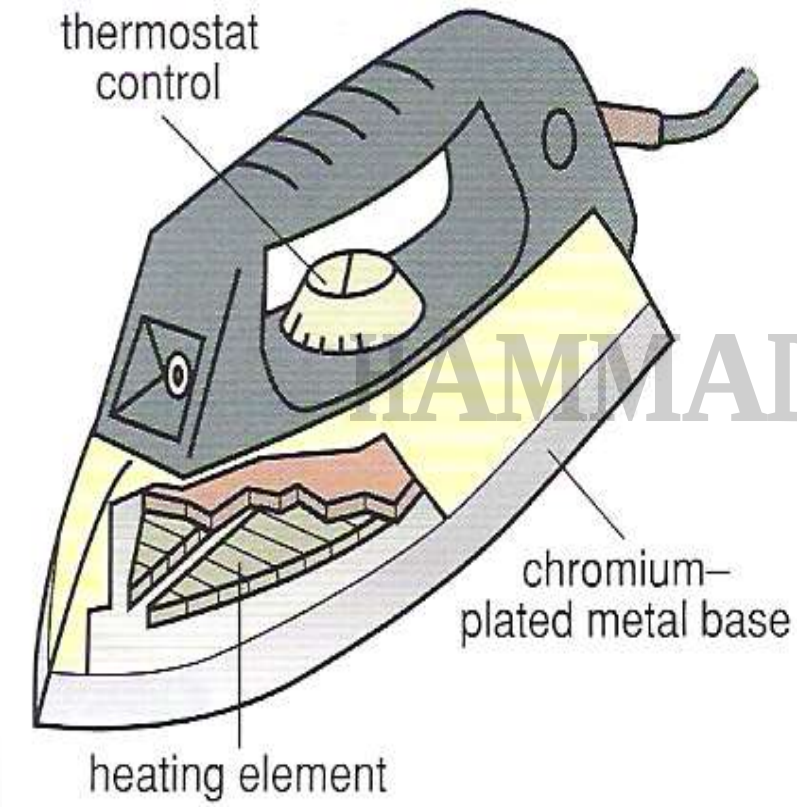
Describe the use of electricity in heating, lighting and motors.

USES OF ELECTRICITY

Uses of electricity

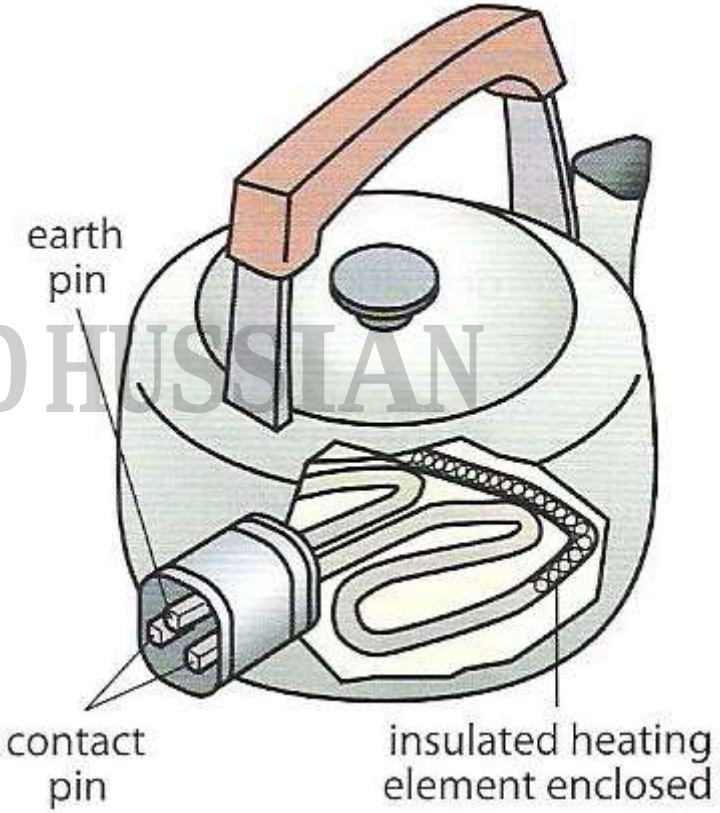
- Electrical energy, like all other forms of energy, obeys the laws of energy conversions.
- When an electric current flows through a circuit, it may give rise to heating effects (as in electric kettle), light effects (as in lamp) or motion effects (as in motor).

Heating

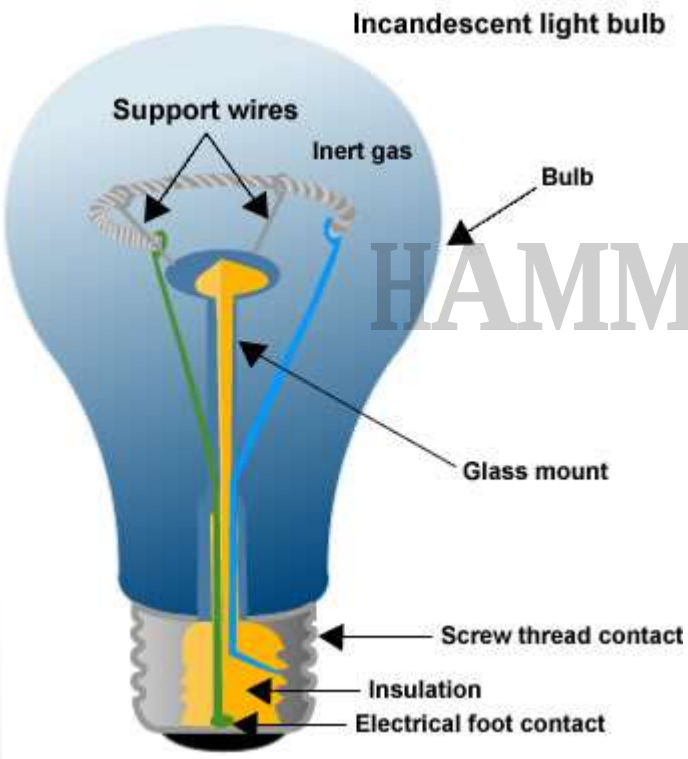


- The thermal energy produced by an electric iron is spread evenly over a large surface usually a metal base that conducts heat well.
- The heating element is wound round a flat sheet of mica and sandwiched between two thin insulating sheets.
- The metal base is chromium plated to make it smoother and withstand wear.
- It contains a thermostat which switches the current off when they get too hot.

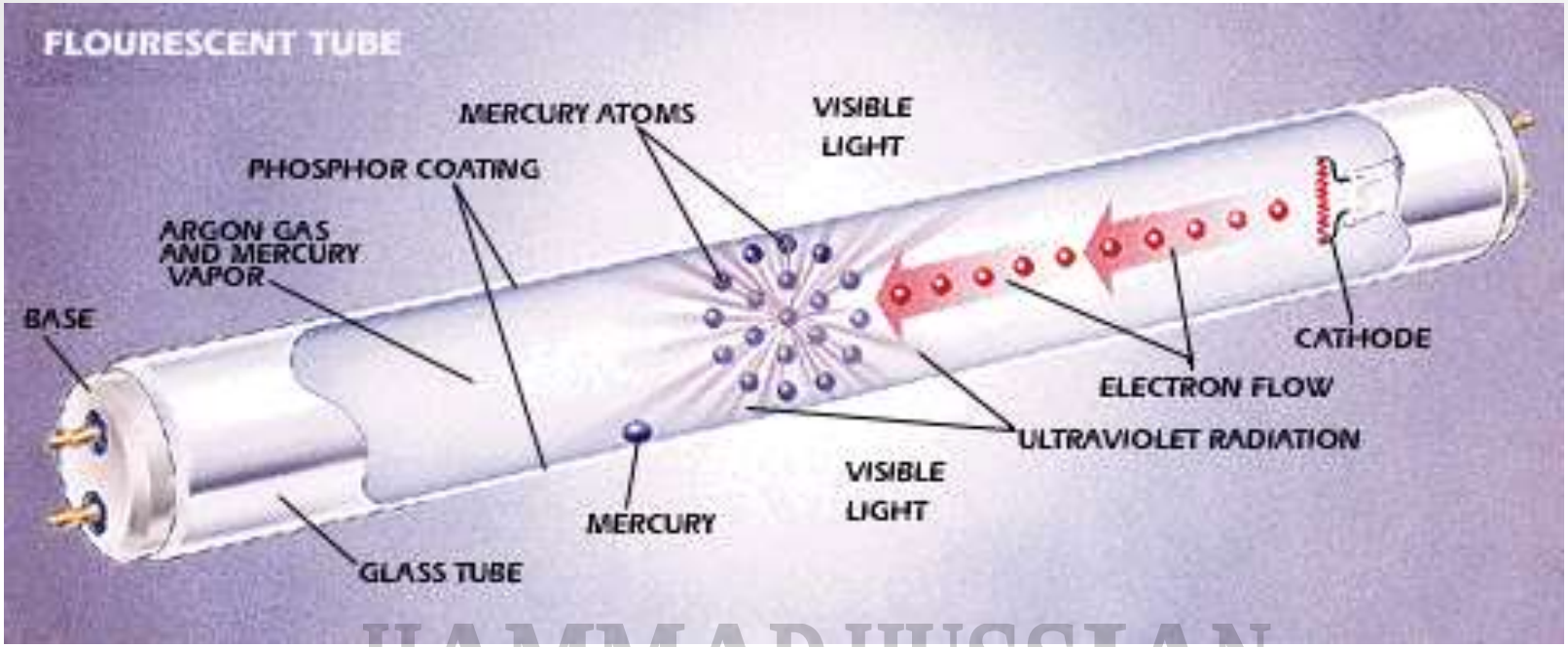
- The heating element is enclosed in a metal tube and electrically insulated from it.
- When a current flows through the heating element, the water around the element is heated first by conduction.
- Then the heat is spread through the water by convection.
- The heating element must be covered with water to avoid overheat



Lighting

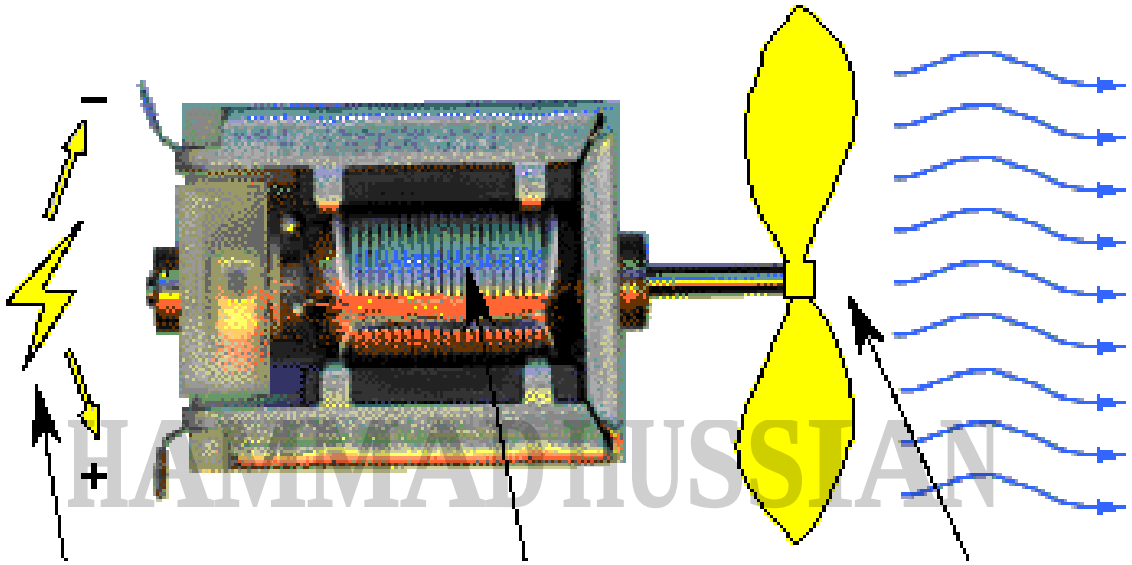


- The electricity flows through the filament, a tiny wire inside the light bulb.
- This element has a strong resistance, which in turn causes friction when electricity flows through it
- Therefor filament of the light bulb heating up and it starts to glow, converting electrical energy to light energy.

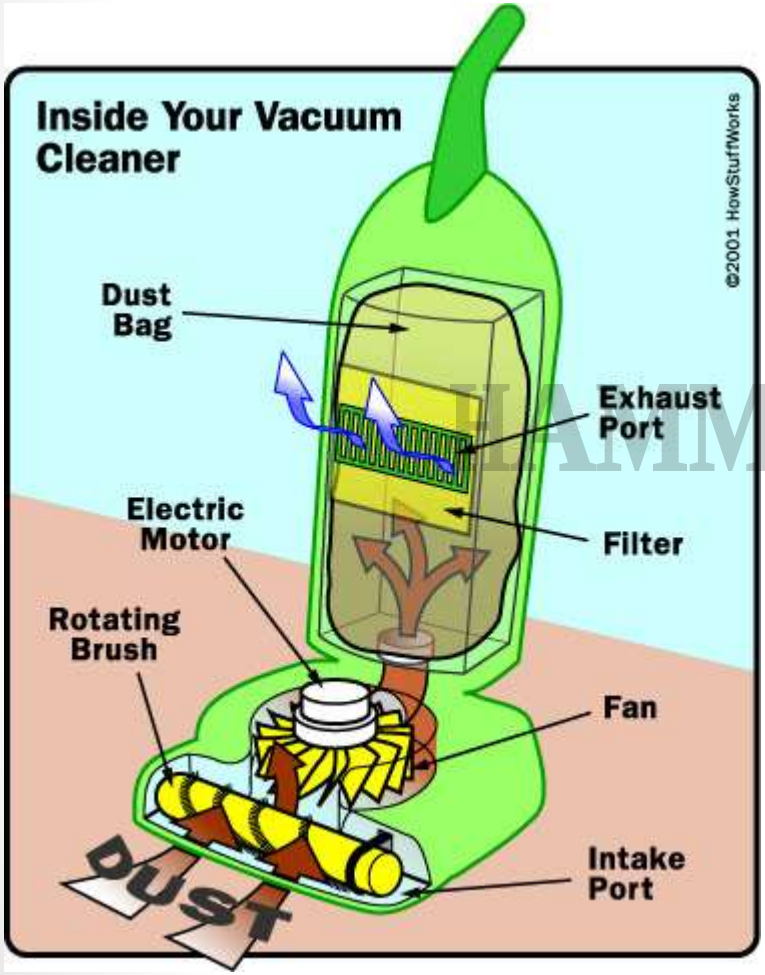


- The glass tube is filled with a noble gas at low pressure and a small quantity of mercury.
- The glass wall is coated with a fluorescent.
- Inside the housing, an electrical field develops between two electrodes and gas discharge occurs.
- The discharge process causes the mercury vapor to emit UV rays.
- Visible light is emitted as soon as the UV radiation makes contact with the fluorescent.

Motor



- As current passes through the wire, a magnetic field is caused that expends force in a clockwise motion that actually changes the electric energy into mechanical energy.
- This action causes the motor coils to spin and latter transferred to the fan blades.
- The slicing of the air caused by the fan blades is what pushes the air downward, causing the breeze created by the ceiling fan.



- The electric current operates the motor.
- The motor is attached to the fan, which has angled blades.
- As the fan blades turn, they force air forward, toward the exhaust port.
- When air particles are driven forward, the density of particles increases in front of the fan and decreases behind the fan.
- This pressure drop behind the fan creates suction, a partial vacuum, inside the vacuum cleaner.

Recall and use the equations *power* = *voltage* × *current*, and *energy* = *voltage* × *current* × *time*.

USES OF ELECTRICITY

Electrical Energy

- Potential difference is defined as one joule of energy released if one coulomb of electric charge flows through a potential difference of one volt.
- When Q coulombs of charge flows through a potential difference of V volts, the energy released, E joules, is given by

Energy = Charge x Potential difference

$$\boldsymbol{E = QV}$$

- But $Q = It$, where I is the current in amperes and t is the time measured in seconds, so

$$\boldsymbol{E = VIt}$$

Problem Solving

1. If a light bulb operates on 110 V, how much energy does it convert from electrical to other forms when 150 C of charge passes through it.
2. A light bulb operating on 110 V has 0.50 A of current passing through it. How much energy does the bulb convert in 5 minutes?
3. How much energy is transferred when a current of 3 A flows in a circuit with a voltage fo 12 V in 1 minute?
4. A heater which runs on 12 V transfers 4800 J of energy in 2 min. What is the current in the heater?
5. A bulb runs on a voltage of 110 V and has a current of 0.1 A in it. It transfers 2400 J of energy in a given time. What is this time?
6. A lamp transfers 24 J of energy and draws a current of 2 A for 1 s. What voltage is it operating at?

Electrical Power

- Power is defined as the rate of doing work.
- In an electric circuit, electric power is consider as the rate at which energy is released.

$$\text{Power} = \frac{\text{Energy Released}}{\text{Time Taken}}$$

$$P = \frac{E}{t}$$

- The formula can also be written as

$$\boldsymbol{P = \frac{E}{t} = \frac{VIt}{t} = VI}$$

- The SI unit of power ***watt***.

$$1\,\text{milliwatt (mW)} = \frac{1}{1000}\ \text{W}$$

$$1\,\text{kilowatt (kW)} = 1000\ \text{W}$$

$$1\,\text{megawatt(MW)} = 1\,000\,000\ \text{W}$$

Problem Solving

1. An electric iron is rated at 900 W on a 120 V circuit. How much current does the iron draw from the outlet.
2. An appliance has 2 A of current in it and operates at 110 V. What is its power rating?
3. If an electric heater takes a current of 4 A when connected to a 230 V supply, what is its power?
4. If a light bulb has a power of 36 W when connected to a 12 V supply, what is the current through it?
5. The current in a toy car is 7.0 A and the voltage of the battery is 3.0 V. Find the power delivered to the motor and energy dissipated in the motor in 6.5 minutes of operation.

6. A bulb takes a current of 3 A from a 12 V battery.
   a) What is the power of the bulb?
   b) How much energy is supplied in 10 minutes?
7. An electric fan runs from the 230 V mains. The current flowing through it is 0.4 A.
   a) At what rate is electrical energy transformed by the fan?
   b) How much energy is transformed in 1 minutes?
8. A wall outlet, operating on 120 V, delivers 4 A to an immersion heater for 10 minutes. If the heater is used to heat 2000 g of water, how much does the temperature of the water rise. (Specific heat capacity of water = 4200 J/kg°C)

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Define the kilowatt-hour (kW h) and calculate the cost of using electrical appliances where the energy unit is the kW h.

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USES OF ELECTRICITY

Electricity Consumption

- The difference between the current month's and the previous month's readings gives the amount of electricity used for the month.

25404 6

54250 4

- Electrical energy is sold in units of **kilowatt hour** (kWh). One kWh is the energy used by 1 kW electrical appliance in an hour.

$$\text{Energy released} = \text{Power x Time}$$

$$1\ \text{kWh} = 1\ \text{kW x}\ 1\ \text{hour}$$

$$= 1000\ \text{W x}\ 3600\ \text{s}$$

$$= 3600000\ \text{J}$$

$$= 3.6\ \text{MJ}$$

Problem Solving

1. If energy is 10 ¢ per unit, what is the cost of running 2 kW heater for 3 hours?
2. If energy costs 10 ¢ per unit, what is the cost of running 100 W lamp for 8 hours?
3. If 1 kWh of electricity costs 18 cents, how much would it cost to operate a 750 W electric iron for 4 hours?
4. If your television set draws a 4 A on a 120 V and electric energy costs you 10 cents/ kWh, how much does it cost to run the set for 8 hours?
5. A student uses two 150 W lamps for 6 hours. If the price per kilowatt-hour of electricity is 10 cents, what is the cost of this?

6. A 1.5 kW heater is switched on for 4 hours.
   a) How much energy does it transfer to the room, in kWh?
   b) What will the cost be if each kWh costs 15 cents?
7. A 4 kw appliance converts electrical energy into heat.
   a) How much energy does it convert in 10 minutes?
   b) If electricity is priced at $1.50 per kWh, how much does it cost to run the appliance for 10 minutes?
   c) If the p.d. across the appliance is 240 V, determine the current flowing through it.
8. An electric kettle with a power of 2kW is used for 10 minutes, three times a day. If the cost of electricity is 25 cent per unit, what is the cost of operating the kettle for 30 days?

State the hazards of damaged insulation, overheating of cables and damp conditions.

DANGERS OF ELECTRICITY

Dangers of Electricity

- Electrical energy is considered to be more efficient, cleaner and easier to use compare with other form of energy.
- However, if not handled properly, all forms of energy can be dangerous.

Hazard	Possible Consequences
Worn cables	Wiring can become exposed
Damaged plugs	
Water around sockets	Water conducts electricity, so can connect a person to a main supply
Pushing metal objects into sockets	This connects the holder to the mains supply
Overloading of sockets	Causes too high current, which might melt the insulation and cause fire
Long, coiled cable to an electric heater	Cable can heat up because of the coiling and start a fire

Damaged Insulation

- The insulation of a wire protects us from touching it.
- Exposure to damage insulation may lead to an electric shock.
- Damage insulation between the live and neutral wires may result in short circuit. This lead to sudden increase in current causing heat to start a fire.

Overheating of Cables

- Thin wire possesses a higher resistance than a thick wire.
- Although thin wire is cheap, their higher resistance will produce more heat when current flow.
- As it heats the wire faster, it will damage the wire insulations and can cause a fire.
- Thin wires are use for electrical appliances which need low power, e.g. lamps and radios, while thick wires are used for appliances which require high power, e.g. electric irons and kettles.

- If all electrical appliances were used at the same time on multi-way adaptor, the total current drawn by them through electric cable from the mains supply maybe so large that the cable become overloaded and overheated.
- This may result in fire.

Damp Conditions

- The severity of an electric shock depends on the size of the current passing through our body.

Current (approximate)	Effect
1 mA	Threshold – no pain below this point
5 mA	A frightening but harmless shock
10 – 20 mA	Uncontrolled muscular contractions Loss of muscle control – you cannot let go
50 mA	Pain and exhaustion; breathing affected
100 – 300 mA	Uncoordinated contraction of the heart leading to death

- The size of the current which flows depends on the voltage and the electrical resistance of our body.
- Most resistance of human body lies in the skin.
  - Dry skin has a resistance of 100 000 ohms or more.
  - Wet skin, especially with sweat or water of good conducting ability, the resistance falls drastically to a few hundred ohms.

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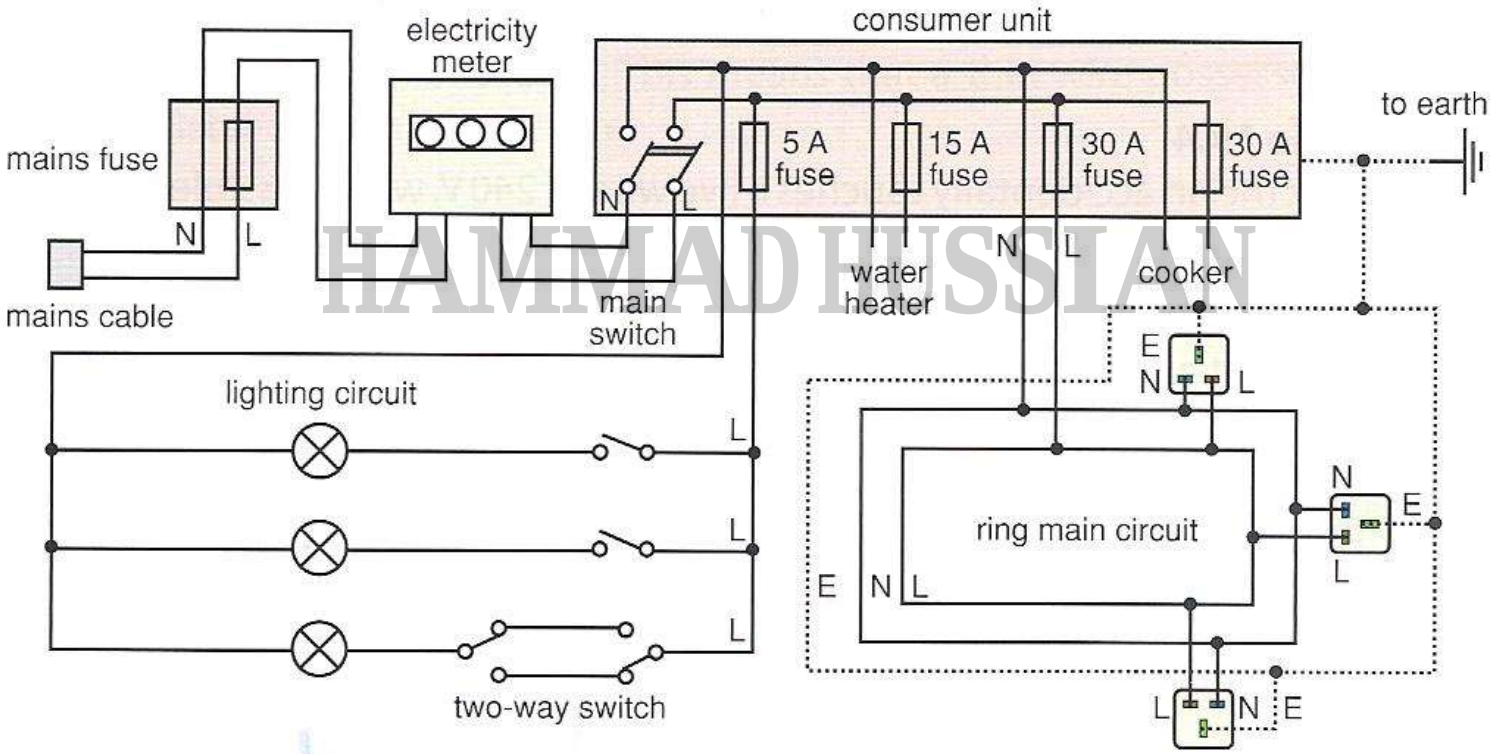
Explain the use of fuses and circuit breakers, and fuse ratings and circuit breaker settings.

SAFE USE OF ELECTRICITY IN THE HOME

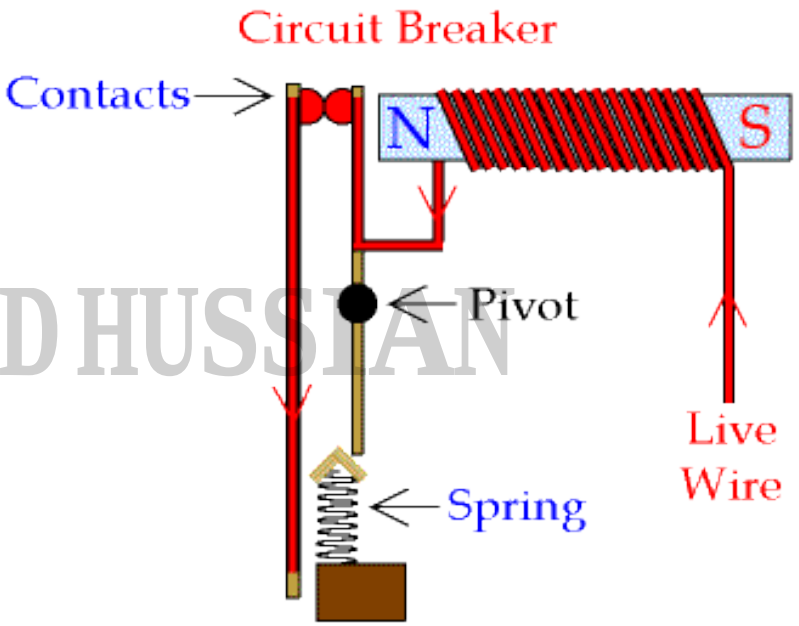
Safe Use of Electricity in the House



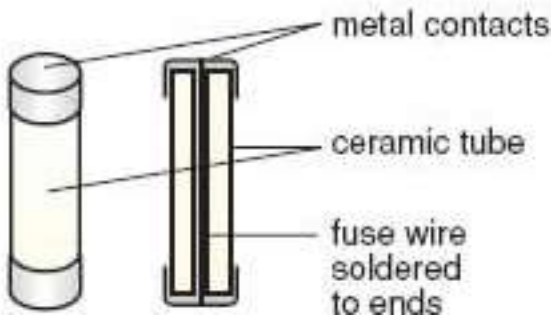
Earth Leakage Circuit Breakers

- Circuit breaker is an automatic switch which trips (turns off) when the current rises above the specific value.
- Circuit-breakers offer the following advantages compared to fuses.
  - they respond more rapidly to current surges than fuses do.
  - they are more reliable.
  - they are more sensitive.
  - unlike fuses which only operate once and need to be replaced a circuit-breaker can be reset at the flick of a switch.

- When the live wire carries the usual operating current, the electromagnet is not strong enough to separate the contacts.
- If something goes wrong with the appliance and a large current flows, the electromagnet will pull hard enough to separate the contacts and break the circuit.
- The spring then keeps the contacts apart.



Fuse



- A fuse is a safety device which is made up of a piece of a tin-coated copper wire.
- The thickness varies in different fuses depending on the amount of current which is permitted to flow through them.
- The fuse melts and breaks when the current exceeds its specified value.

Colour	Current (A)
purple	3
orange	5
brown	7.5
red	10
aqua	15
yellow	20
clear	25
green	30

- In practice, cartridge fuses are made in standard ratings. The most common are 3 A, 5 A and 13 A.
- Fuse is chosen that can take a current slightly larger than the maximum current that is allowed to pass through the electrical appliance before if overheats.
  - If the device operates normally at 3 A, use a 5 A fuse.
  - If the device operates normally at 10 A, use a 13 A fuse.

Problem Solving

Choose from 3A, 5A, 13 A and 20 A

1. Calculate the current taken by a 800 W vacuum cleaner connected to a 240 V supply. Suggest a suitable rating for a fuse to be used to prevent this vacuum cleaner from overheating.
2. Which fuses is the most suitable for a circuit in which an electric heater rated at 1.5 kW is to be connected to a 250 V supply?
3. A 3500 W electric kettle is to be connected to a 240 V mains supply socket using a flat-pin plug. Which fuse should be used?

4. Some countries use plugs with a fuse in. What is the fuse rating suitable for each appliance below when the supply voltage is 230 V?

appliance	power
vacuum cleaner	360 W
television	80 W
table lamp	100 W
kettle	2100 W
iron	900 W

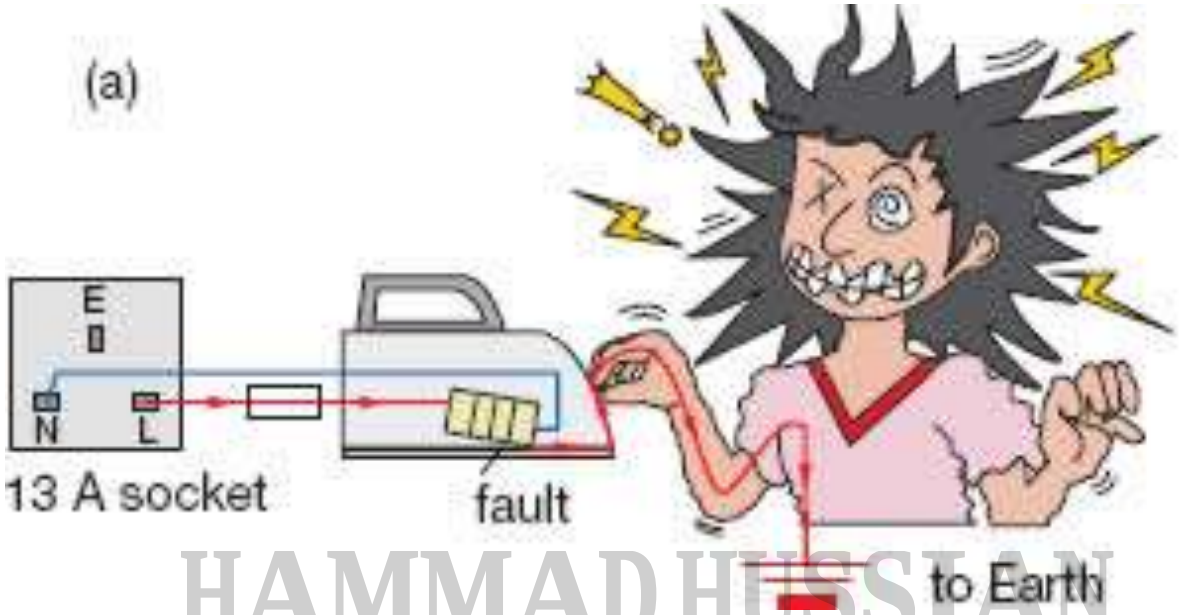
HAMMAD HUSSIAN

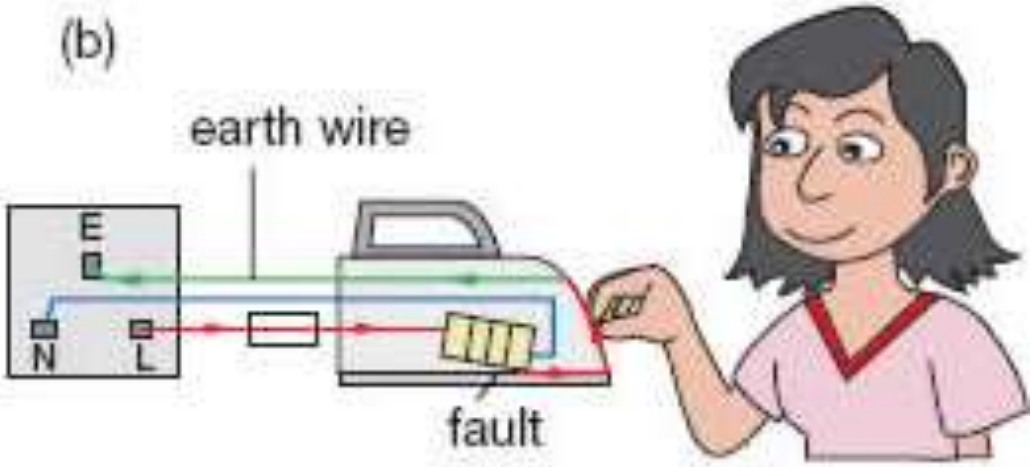
Explain the need for earthing metal cases and for double insulation.

SAFE USE OF ELECTRICITY IN THE HOME

Earthing

- Many electrical appliances have metal cases, including cookers, washing machines and refrigerators. The earth wire creates a safe route for the current to flow through if the live wire touches the casing.
  - When the appliance is working correctly, the live wire supplies the electricity which flows through all of the components. The neutral wire completes the circuit.
  - If something goes wrong inside the appliance and the live wire touches the metal case, then the earth wire allows the electricity to complete the circuit without flowing through the components.





Double Insulation

- Hair dryers, electric shavers and television sets are not connected to the earth of the power circuits.
- Here, the live electrical components are carefully shielded and isolated from the user by means of double insulation.
- They have been designed so that the live wire can not touch the casing. As a result, the casing cannot give an electric shock, even if the wires inside become loose.
- Double insulation means that the accessible metal parts cannot become live unless two independent layers of insulation fail.
  1. The electric cable is insulated from the internal components of the appliance.
  2. The internal metal parts, which could become live if a fault developed is also insulated from the external casing.

State the meaning of the terms *live*, *neutral* and *earth*.

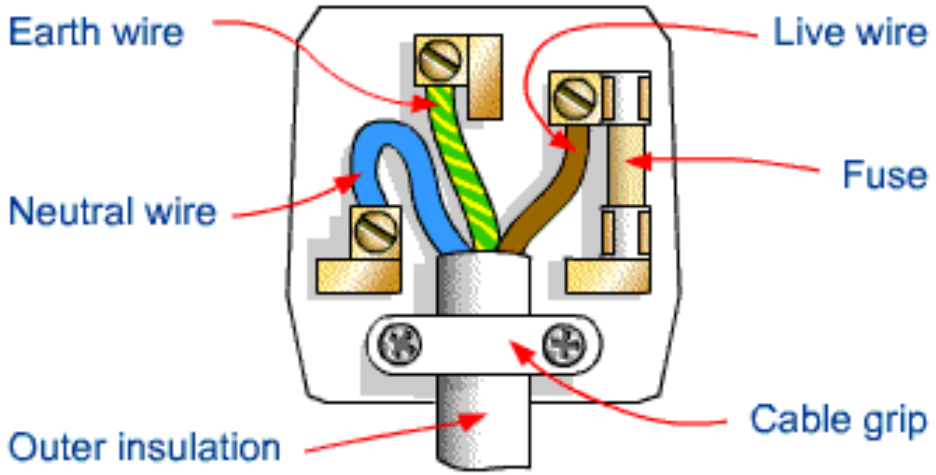
SAFE USE OF ELECTRICITY IN THE HOME

Describe how to wire a mains plug safely. Candidates will not be expected to show knowledge of the colours of the wires used in a mains supply.

SAFE USE OF ELECTRICITY IN THE HOME

Three-Pin Plug

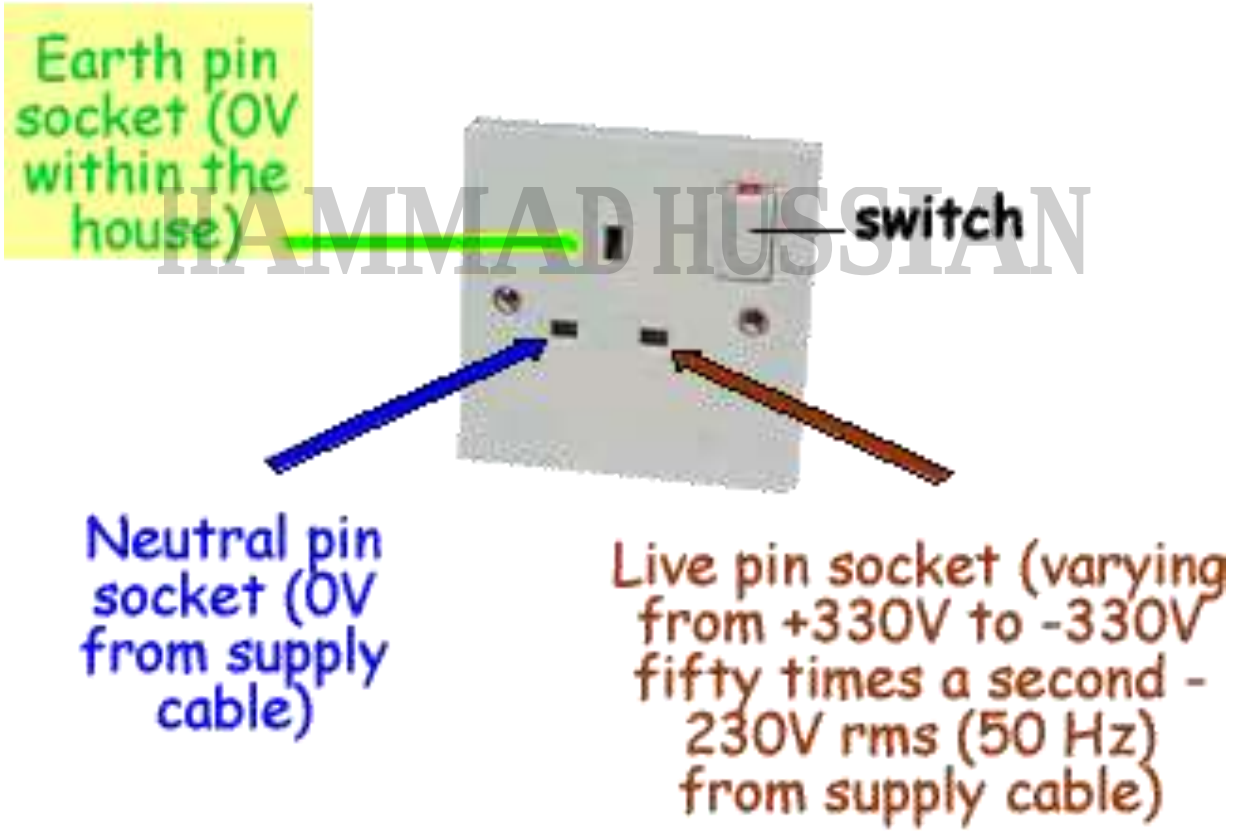
- Power plugs provide a relatively safe method for attaching appliances to power source.
- The plugs are designed to complete the circuit for the desired appliance, sending power into and taking unused power out from appliances.
- Some plugs are also designed to insulate the appliance user against accidental shock through a ground terminal.



- The features of a plug are:
  - The case is made from tough plastic or rubber, because these materials are good electrical insulators.
  - The three pins are made from brass, which is a good conductor of electricity.
  - There is a fuse between the live terminal and the live pin. It breaks the circuit if too much current flows.
  - The cable is secured in the plug by a cable grip. This should grip the cable itself, and not the individual wires inside it.

- The live wire is connected directly to the generators of the electricity supply company. It carries approximately 230 Volts
- The neutral wire returns the electricity to the generator after it has passed through the appliance. It is at approximately zero volts. If the wiring is faulty it may be carrying the same electricity as the Live wire.
- The earth wire usually carries no electricity. However, if something in the appliance goes wrong, or it is wired incorrectly, then the earth wire may also be carrying the same electricity as the live wire.

UK wall socket



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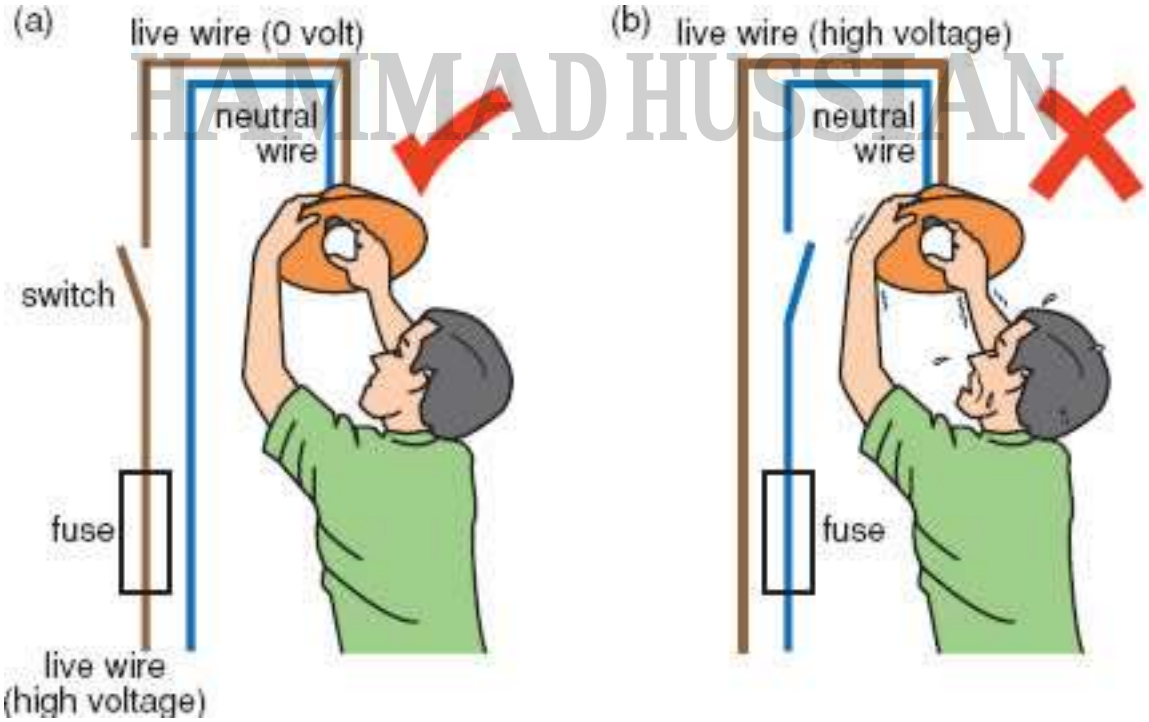
Explain why switches, fuses and circuit breakers are wired into the live conductor.

SAFE USE OF ELECTRICITY IN THE HOME

Switches, Fuses and Circuit Breakers

- Switches, fuses and circuit breakers must be fitted onto the live wire so that when the switch is off or when the fuse/circuit breaker is broken, they disconnect the high voltage from the appliances.



1. Energy is represented by the letter *E*, current by *I*, power by *P*, charge by *Q*, p.d. by *V* and time by *t*.

   Which pair of equations is correct?

   A. $E = It$ and $P = VIt$

   B. $E = VQ / t$ and $P = VI$

   C. $E = VIt$ and $P = VI$

   D. $E = VQ$ and $P = VI / t$

2. A small heater operates at 12V, 2A.

   How much energy will it use when it is run for 5 minutes?

   A. 30 J
   B. 120 J
   C. 1800 J
   D. 7200 J

3. An immersion heater is labelled 12 V, 60 W.

   What is the current in the heater when connected to a 12 V supply?

   A. 0.20 A
   B. 5.0 A
   C. 12 A
   D. 60 A

4. Which quantity is measured in kilowatt-hours?
   A. charge
   B. current
   C. energy
   D. power

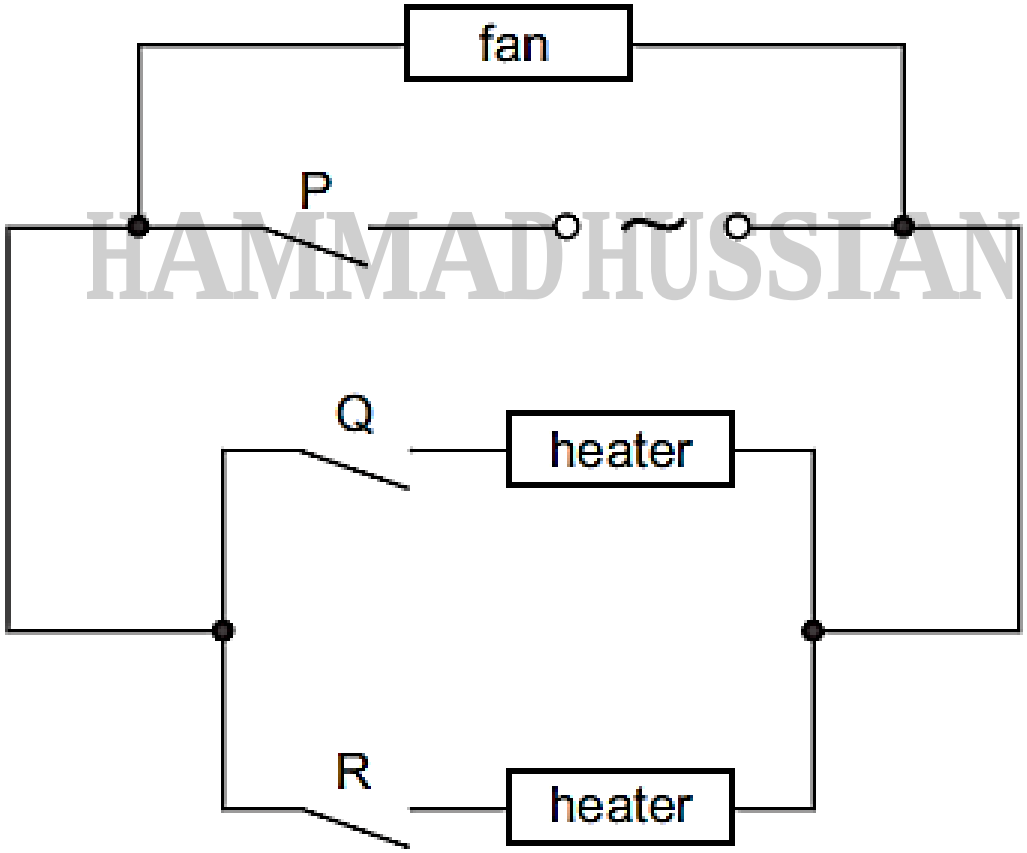
5. Which costs the most if operated from the same mains supply?
   A. a 5000 W electric cooker used for 1 minute
   B. a 1000 W electric fire used for 10 minutes
   C. a 500 W electric iron used for 1 hour
   D. a 100 W lamp used for 1 day

6. An electric heater is rated at 3 kW. Electrical energy costs 20 cents per kWh.

   What is the cost of using the heater for five hours?

   A. 12 cents
   B. 60 cents
   C. 100 cents
   D. 300 cents

7. The diagram shows the circuit for a hair-dryer.

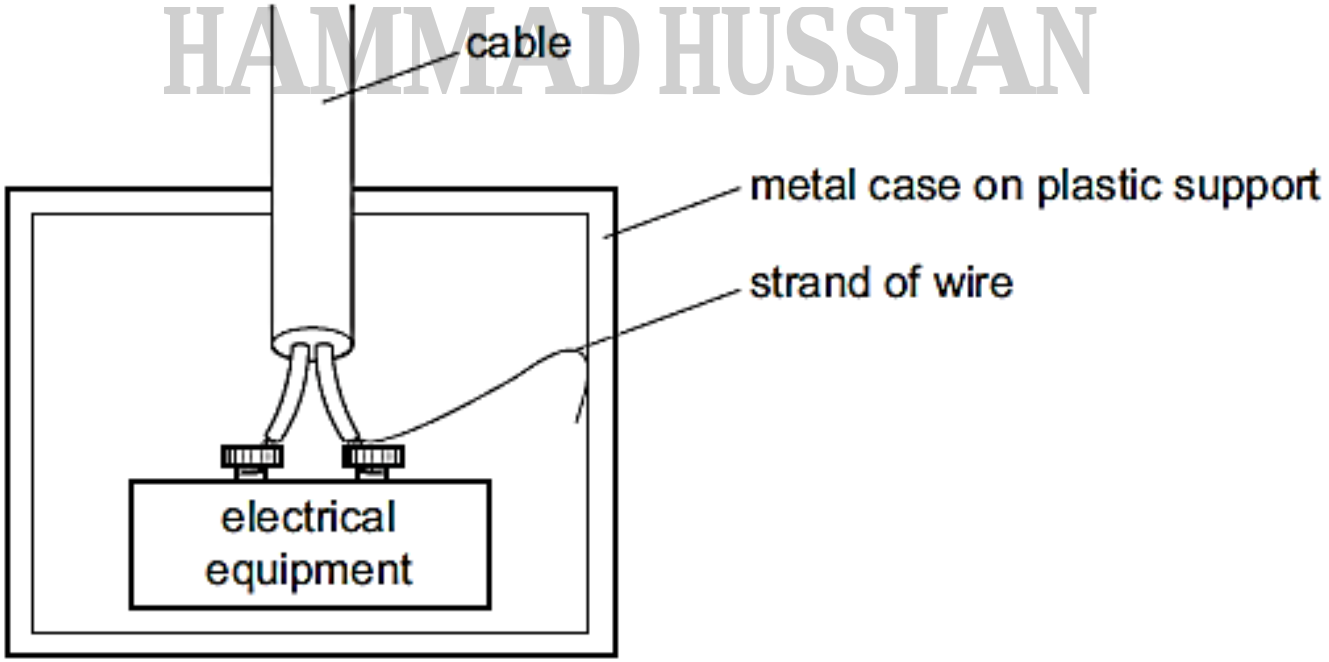


The fan has a power rating of 0.1 kW and the heaters each have a rating of 0.4 kW. The cost of electricity is 8 cents/kWh.

What is the cost of running the dryer for two hours with switches P and Q closed and switch R open?

A. 1.6 cents
B. 3.2 cents
C. 6.4 cents
D. 8.0 cents

8. Some electrical equipment is connected to a 230 V supply. It is kept inside a metal case which is not earthed. The case is fixed to a plastic support. A strand of wire has become loose and touches the metal case as shown.



Which statement about this situation is correct?

A. An electric current is passing through the metal case.
B. A fuse in the live wire will blow.
C. Someone touching the case would receive an electric shock.
D. The metal case is at 0 V.

9. After some building work in a house, a bare (uninsulated) live wire is left protruding from a wall.

   What is the greatest hazard?

   A. a fire
   B. a fuse will blow
   C. an electric shock
   D. no current will flow

10. On a building site, metal scaffolding is firmly embedded in the damp ground. A builder holds a mains-operated electric drill in one hand. With his other hand he holds on to the scaffolding.

    The power cable of the drill is damaged where it enters the metal casing of the drill.

    What danger does this present to the builder?

    A. A current could pass through the builder and electrocute him.
    B. A current in the scaffolding could heat it up and burn him.
    C. The large current could blow the fuse and damage the drill.
    D. The large current could make the motor spin too quickly.

11. A mains electrical circuit uses insulated copper cable and the cable overheats.

    To prevent the cable overheating, how should the cable be changed, and why?

    A. Use thicker copper cable which has less resistance.
    B. Use thicker insulation which stops the heat escaping.
    C. Use thinner copper cable which has more resistance.
    D. Use thinner insulation which allows less heat to escape.

12. What is the purpose of a circuit breaker in an electric circuit?

A. to change alternating current into direct current
B. to keep the current constant
C. to prevent the current from becoming too large
D. to reduce the current to a safe value

13. A fuse is a safety device for use in an electrical appliance.

    How does a fuse affect a circuit when the current in it becomes higher than the correct value for the appliance?

    A. It completely stops the current.
    B. It reduces the current to the correct value for the appliance.
    C. It sends the current to the outer case of the appliance.
    D. It sends the excess current to the earth wire.

14. An electric iron is marked 240 V, 2500 W.

    Four fuses are available with values of 5 A, 10 A, 13 A and 30 A.

    Which fuse should be used?

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

15. A certain electrical appliance is powered from a mains supply. The appliance normally uses a current of 3 A, but the current briefly rises to 4 A at the instant the appliance is switched on. The cable to the appliance is designed for currents up to 6 A.

    The fuses available to protect the cable are rated at 1 A, 3 A, 5 A and 13 A.

    Which fuse should be used?

    A. 1 A
    B. 3 A
    C. 5 A
    D. 13 A

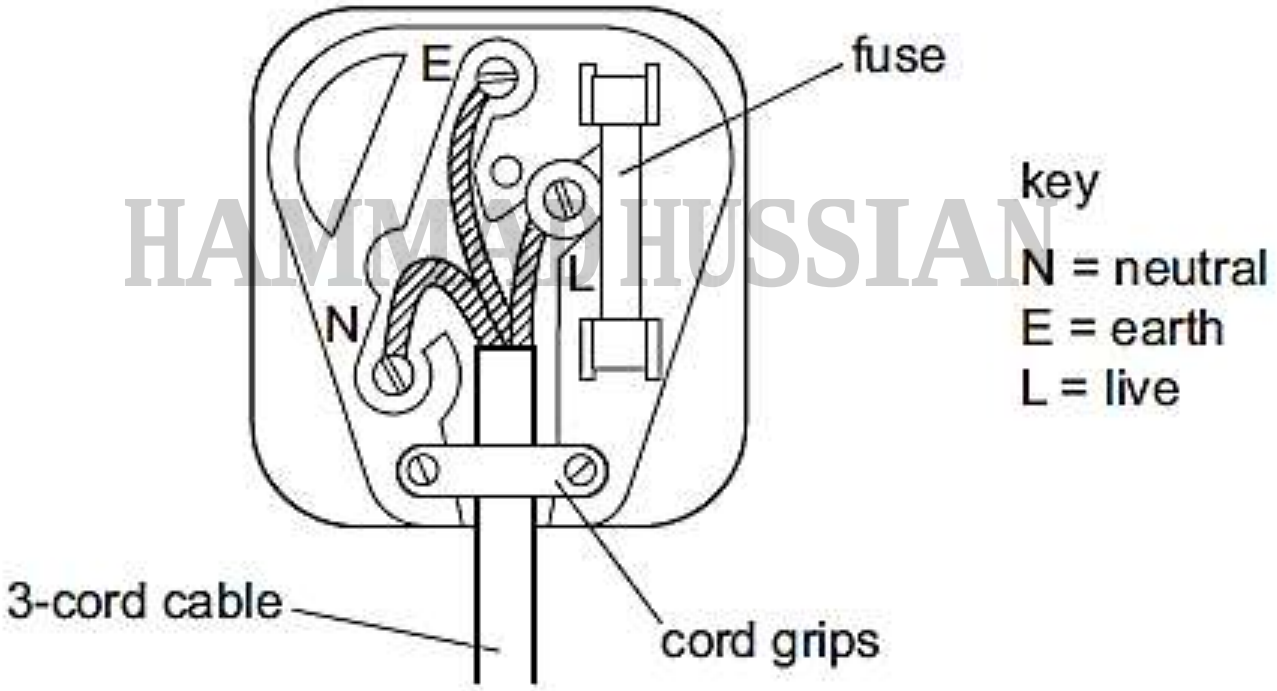
16. The metal case of an electric heater is earthed. The plug to the heater contains a 5 A fuse. There is a current of 4 A when the heater works normally.

    The cable to the heater becomes so worn that the live wire makes electrical contact with the case.

    What happens?

A. The current flows to earth and the fuse is not affected.
B. The fuse melts and switches off the circuit.
C. The metal case becomes live and dangerous.
D. The metal case becomes very hot.

17. The diagram shows a standard mains plug.



What are the correct colours for the wires?

	N	E	L
A	blue	brown	green and yellow
B	blue	green and yellow	brown
C	brown	green and yellow	blue
D	green and yellow	brown	blue

B

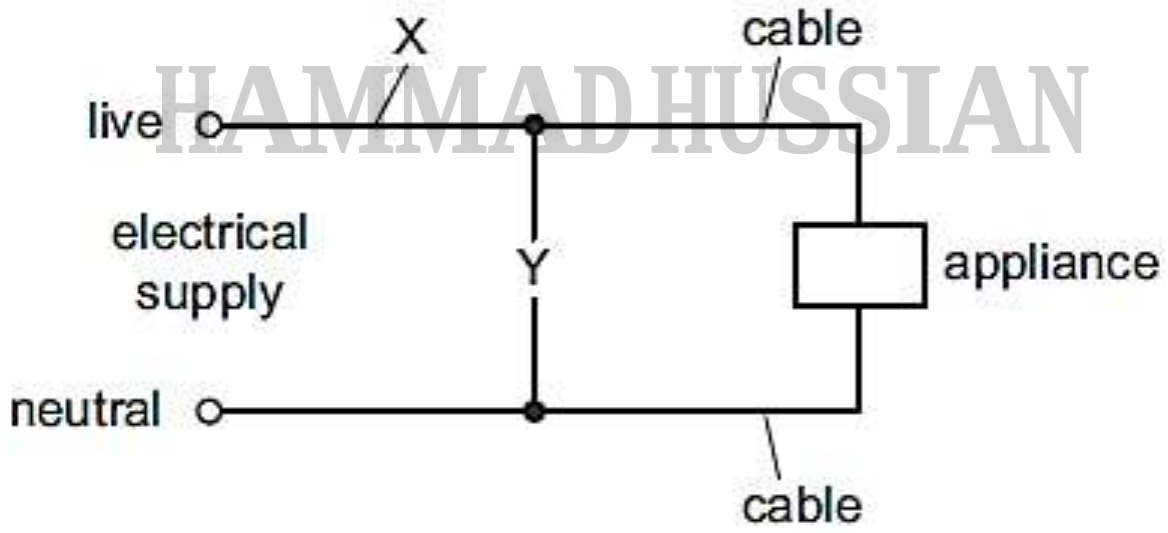
18. Many electrical appliances have metal cases.

    To prevent the case from becoming ‘live’, with the possibility of an electric shock, the earth wire of the electric cable is attached to the case.

    How does the earth wire prevent an electric shock?

A. It allows a current to flow to earth, so that the appliance continues working.
B. It allows a large current to flow to earth, blowing the fuse.
C. It prevents the fuse from blowing.
D. It reduces the current to a safe level.

19. Either a fuse or a circuit-breaker can be used to protect electrical cables from large currents that could cause overheating.



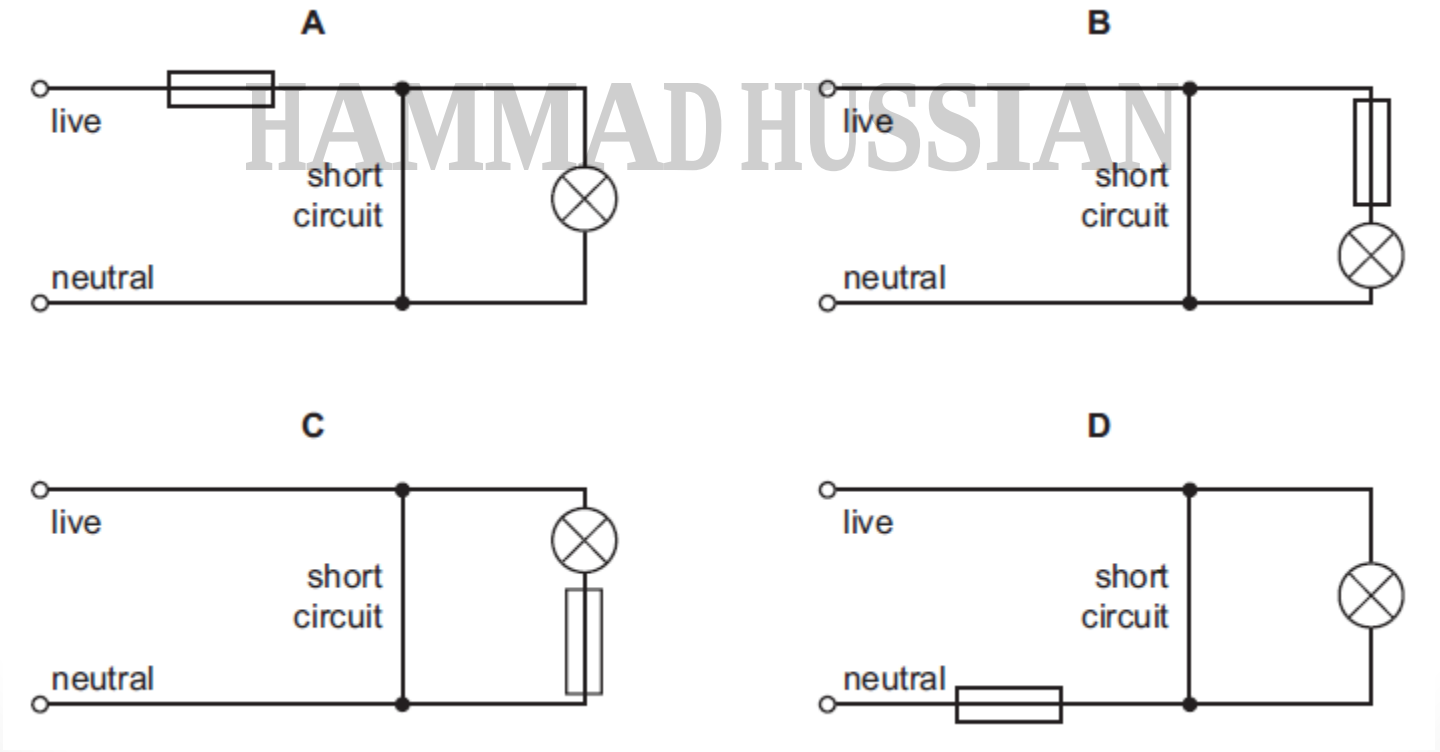
If a fuse is used, in which position in the circuit should it be connected, and if a circuit-breaker is used, in which position should it be connected?

	position of fuse	position of circuit-breaker
A	X	X
B	X	Y
C	Y	X
D	Y	Y

A

20. In each of the circuits below there is a short circuit.

In which circuit does the fuse blow and make the circuit safe to repair?



A