ICSE CLASS 10 · PHYSICS

Chapter 9 : HOUSEHOLD CIRCUITS

STEP-BY-STEP SOLUTIONS & MARKING SCHEME (40 MARKS)

Maximum Marks: 40 · Section A (20) compulsory · Section B: any two of three questions (2 × 10 = 20) · $P = VI$ · $R = V^2 \div P$ · fuse rating $\geq P \div V$

Marks for each step are shown in square brackets on the right. Parts added in the solution diagrams are drawn in red.

SECTION A (20 Marks)

Question 1 — Multiple choice [8 marks, 1 mark each]

No.	Answer	Reason
(i)	**(b)** reduce the loss of energy in the line wires	For a given power P = VI, a higher voltage gives a lower current, so the loss of energy I^2Rt as heat in the line wires is small.
(ii)	**(c)** lead and tin	The alloy of lead and tin has a low melting point and a high specific resistance, so it melts easily when the current is excessive.
(iii)	**(c)** live wire	The switch must be in the live wire so that, when it is off, the appliance is cut off from the high potential.
(iv)	**(b)** light blue	New code: live – brown, neutral – light blue, earth – green (or yellow-green).
(v)	**(c)** Both (A) and (R) are true, and (R) is the correct explanation for (A).	Both are true: the thicker, longer pin makes earth contact first and cannot enter the live or neutral hole; (R) explains (A).
(vi)	**(b)** 5 A	I = P ÷ V = 1000 ÷ 220 = 4.5 A, so a 5 A fuse is suitable.
(vii)	**(c)** 220 V, 50 Hz	The a.c. supply to domestic consumers is 220 V at 50 Hz.
(viii)	**(c)** both the live and the neutral wires	The main switch is a double pole switch: it breaks both live and neutral connections at the same time.

Question 2 [6 marks]

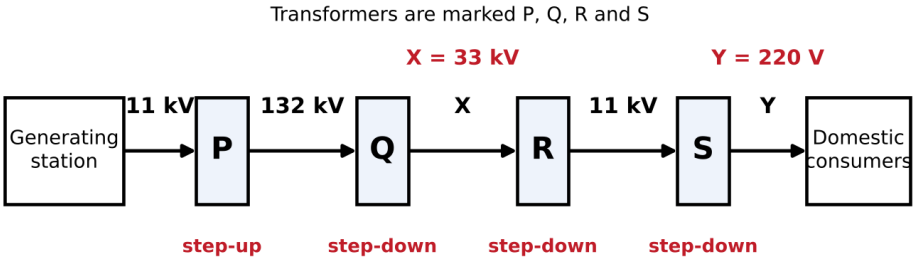
(a) A **fuse** is a short piece of thin wire of low melting point and high resistance, connected in series in the live wire; it is a safety device that limits the current in a circuit. [1] **[2]**

Principle: the heating effect of current. When the current exceeds the rating, the wire heats up, melts and breaks the circuit. [1]

(b) (i) P is a **step-up** transformer (11 kV to 132 kV); S is a **step-down** transformer (11 kV to 220 V). [1] **[3]**

(ii) Q steps down 132 kV to **X = 33 kV**; S steps down 11 kV to **Y = 220 V**. [1]

(iii) A high voltage means a low current for the same power (P = VI), so the loss of energy (I^2Rt) as heat in the line wires is small. [1]



Solution to Q2(b)

(c) **220 V** and **50 Hz**. [½ + ½] **[1]**

Question 3 [6 marks]

(a) Total power = 6 × 60 + 2 × 80 = 360 + 160 = 520 W. **[3]**

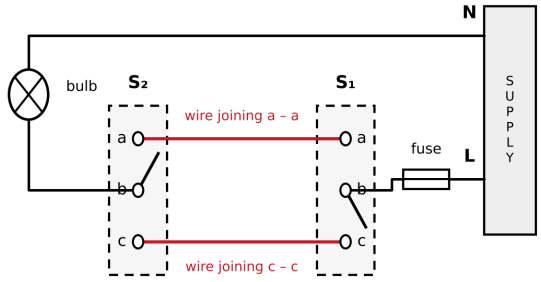
(i) I = P ÷ V = 520 ÷ 220 = **2.36 A**. [1]

(ii) Excess current = 10 − 2.36 = **7.64 A**. [1]

(iii) Current of each 100 W bulb = 100 ÷ 220 = 0.4545 A, so n = 7.64 ÷ 0.4545 = 16.8, i.e. **16 more bulbs** can be used. [1]

(b) (i) Join terminal **a of S_1 to a of S_2** and **c of S_1 to c of S_2** (red wires); the live wire (through the fuse) goes to b of S_1 and b of S_2 goes to the bulb. Changing either switch connects ba or bc and completes or breaks the circuit. [2] **[3]**

(ii) The fuse in the live wire cuts the appliance off from the high potential when the current exceeds the safe limit. If it were in the neutral wire, the appliance would remain connected to the live wire (dangerous). [1]



Solution to Q3(b)

SECTION B (20 Marks) — any two questions

Question 4 [10 marks]

(a) Given: P = 3 kW = 3000 W, V = 220 V. **[3]**

(i) I = P ÷ V = 3000 ÷ 220 = **13.6 A**. [1]

(ii) The fuse rating must be a little more than 13.6 A, so use the **15 A** fuse. [1]

(iii) If the fuse in the neutral wire blows, the appliance is still connected to the live wire (high potential) and touching it may give a shock. [1]

(b) (i) The alloy has a low melting point and higher specific resistance; copper has a high melting point and would not melt at the current limit. [1] **[3]**

(ii) Water forms a conducting layer between the hand and the live part, so current may pass through the body and give a fatal shock. [1]

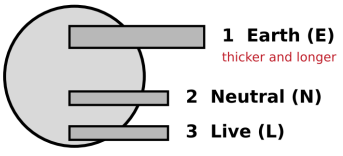
(iii) With the switch off in the neutral wire, the appliance stays connected to the live wire, so touching it is dangerous. [1]

(c) (i) Pin 1 = **earth (E)**; pin 2 = **neutral (N)**; pin 3 = **live (L)**. [1] **[4]**

(ii) The earth connection is made first, and it cannot be inserted into the live or neutral hole by mistake. [1]

(iii) Pin 3 (live): **brown**; pin 2 (neutral): **light blue**. [1]

(iv) The fuse is in the live wire, i.e. at **pin 3 (L)**; pin 1 connects the metal case of the appliance to the earth so that fault current flows to the earth. [1]



Solution to Q4(c)

Question 5 [10 marks]

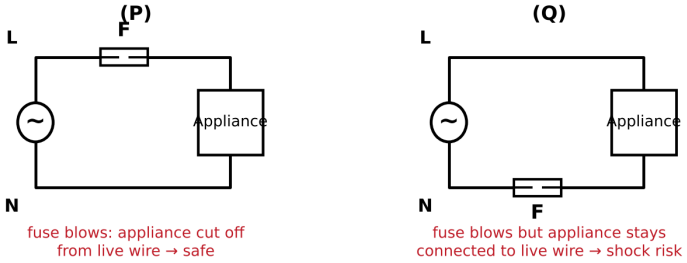
(a) Any three (1 mark each): **[3]**

- In series the voltage is divided among the appliances, so none gets its rated voltage.
- Adding one more appliance increases the total resistance, decreases the current, and each appliance gets less power.
- All appliances work together; one cannot be switched on or off independently.
- If one appliance fails (or is switched off), the whole circuit breaks and all stop working.

(b) (i) **Circuit P** (fuse in the live wire). [1] **[3]**

(ii) In Q the fuse is in the neutral wire: when it blows, the appliance is still connected to the live wire, so a person touching it gets a shock. [1]

(iii) An alloy of **lead and tin**. [1]

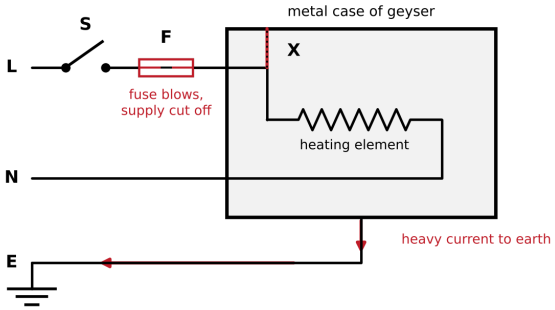


Solution to Q5(b)

(c) (i) The case is connected to the **earth wire**, which ends in a copper plate buried deep in the ground (local earthing). [1] **[4]**

(ii) When the live wire touches the case, a heavy current flows through the low-resistance earth wire to the ground; the fuse in the live wire blows and the supply is cut off. The case therefore does not remain at a high potential, so the person is safe. [2]

(iii) I = P ÷ V = 1500 ÷ 220 = 6.8 A, so the fuse should be of **8 A**. [1]



Solution to Q5(c)

Question 6 [10 marks]

(a) (i) **Live** – brown; **neutral** – light blue; **earth** – green (or green and yellow). [2] **[3]**

(ii) The **neutral and earth wires** are at the same potential (0 V), since they are connected together at the local sub-station. [1]

(b) A hole 2–3 m deep is dug near the kWh meter; a thick copper plate (about 50 cm × 50 cm) welded to a copper rod/wire is buried in it, surrounded by a mixture of charcoal and salt. [1] **[3]**

The upper end of the rod (inside an insulating pipe) is joined to the earth connection at the meter; water is poured in from time to time to keep the ground damp. [1]

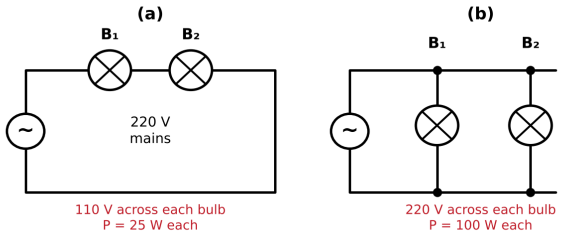
Advantage: excess current due to a short circuit flows to the earth, preventing overheating of wires and fire. [1]

(c) (i) $R = V^2 \div P = (220)^2 \div 100 =$ **484 Ω**. [1] **[4]**

(ii) Fig. 6(a): bulbs in series, so each gets 110 V; $P = V^2 \div R = (110)^2 \div 484 =$ **25 W** each. [1]

(iii) Fig. 6(b): bulbs in parallel, each gets 220 V and consumes 100 W; total = **200 W**. [1]

(iv) The **parallel** arrangement is used: each appliance gets its rated 220 V and works independently of the others. [1]



Solution to Q6(c)

Marks summary	
Section A: Q1 (8) + Q2 (2 + 3 + 1 = 6) + Q3 (3 + 3 = 6)	**20**
Section B: any two of Q4 – Q6 (10 marks each)	**20**
Total	**40**