InkPhysics

ANSWER BOOK

Potential dividers

Electricity · Year 12

AQA 3.5.1.5 · CIE 9.3.7, 10.3.1, 10.3.2, 10.3.3, 10.3.4 · OCR A 4.2.3(d), 4.3.3(a), 4.3.3(b), 4.3.3(c)(i)

18 questions · 50 marks

NAVY EDITION

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SECTION A · Warm-up

A1 The same current flows through both, and the pd across each is IR (1). The larger the resistance, the larger its share of the pd, so the supply voltage is divided between them in the ratio of their resistances (1). [2]

A2 $V_{out} = V_{in} \times R_2/(R_1 + R_2)$ (1) [2]
$V_{out} = 12 \times 8.0/(4.0 + 8.0) = 8.0$ V (1)

A3 $V_{out} = V_{in} \times R_2/(R_1 + R_2)$, assuming the output draws negligible current, any load having a resistance far larger than the divider resistances (1). [1]

A4 (a) Zero (1). (b) The full supply pd, V_{in} (1). [2]

A5 $R_2/(R_1 + R_2) = 1/4$, so $R_1 + R_2 = 4R_2$ (1); $R_1 = 3R_2$, so the ratio is 3 : 1 (1). [2]

A6 The resistance falls as the light intensity rises (1). [1]

SECTION B · Standard

B1 $V_{out} = 10 \times 3.0/(2.0 + 3.0)$ (1) [2]
$V_{out} = 6.0$ V (1)

B2 $3.0 = 9.0 \times R_2/(4.0 + R_2)$ (1) [3]
$3.0(4.0 + R_2) = 9.0R_2$ (1)
$R_2 = 2.0$ kΩ (1)

B3 $V_{out} = 6.0 \times 4.0/(2.0 + 4.0)$ (1) [4]
$V_{out} = 4.0$ V (1)
As it cools the thermistor's resistance rises, taking a larger share of the pd (1)
The output across the fixed resistor therefore falls (1)

B4 A single resistive track is connected across the supply, and a sliding wiper taps off the output between one end and the wiper (1). Moving the wiper changes the proportion of the track, and so the resistance, in the output section (1), varying the output smoothly from zero up to the full supply voltage (1). [3]

B5 For a uniform track the resistance, and therefore the pd, is proportional to length (1); $V_{out} = 12 \times 15/20 = 9.0$ V (1). [2]

B6 pd across the thermistor = 12 - 8.0 = 4.0 V (1); current in the chain I = 8.0/2000 = 4.0 mA (1); R = 4.0/(4.0 × 10^{-3}) = 1.0 kΩ (1). [3]

B7 Total resistance = 68 + 12 = 80 kΩ (1); I = 20/80 kΩ = 0.25 mA (1); V_{out} = IR = 0.25 mA × 12 kΩ = 3.0 V (1). [3]

SECTION C · Stretch

C1 Dark: V_{out} = 6.0 × 2.0/(10 + 2.0) (1) [4]
V_{out} = 1.0 V (1)
Light: V_{out} = 6.0 × 2.0/(1.0 + 2.0) = 4.0 V (1)
The output rises as the light gets brighter (1)

C2 A potential divider can deliver any output from zero up to the full supply voltage (1), whereas a series rheostat can only reduce the voltage and never bring it down to zero (1). The divider therefore gives full, controllable range (1). [3]

C3 Darkness: V_{out} = 5.0 × 90/(90 + 5.0) = 4.7 V (1); bright light: V_{out} = 5.0 × 0.30/(0.30 + 5.0) = 0.28 V (1); 4.7 V is above 2.5 V, so the lamp is on in darkness, and 0.28 V is below 2.5 V, so it is off in daylight (1); the circuit therefore behaves as intended (1). [4]

C4 The lower section becomes 6.0 kΩ in parallel with 6.0 kΩ = 3.0 kΩ (1); V_{out} = 9.0 × 3.0/(6.0 + 3.0) (1) = 3.0 V (1). [3]

C5 Connect the thermistor in series with a fixed resistor across the supply (1). Take the output across the thermistor (1). As the greenhouse cools, the ntc thermistor's resistance rises (1). Its share of the supply pd therefore rises, so the output voltage rises, which is the required direction (1). The output feeds the switching circuit, which turns the heater on when the output exceeds its threshold (1). Using a variable resistor in place of the fixed resistor (or changing its value) alters the ratio, setting the temperature at which the switch-on threshold is reached (1). [6]