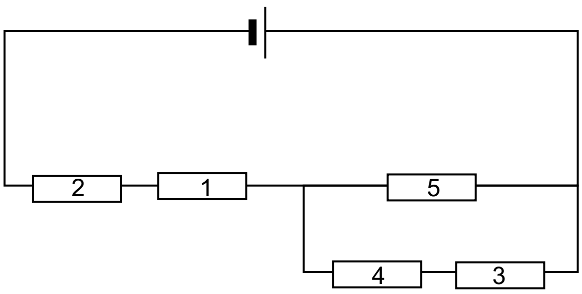
2020 Sec 4 Physics Chapter 15

D.C. Circuits - ANSWERS

Name: ______________________ ( ) **Class: 4 /** ___

15 D.C. Circuits
15.1 Series and Parallel Circuits

Example 1

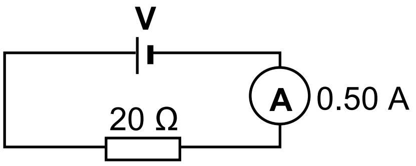


Exercises

1 (a) 5.0 Ω (b) 2.0 Ω (c) 0 Ω (d) 2.0 Ω (e) 2.2 Ω
(f) 1.3 Ω (g) 3.8 Ω (h) 1.0 Ω

2 Determine the unknown (**V** or **I**) in the following circuits.

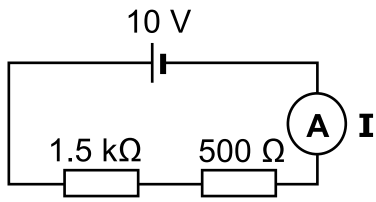
(a)



$V = IR = 0.50 \times 20 = 10$ V

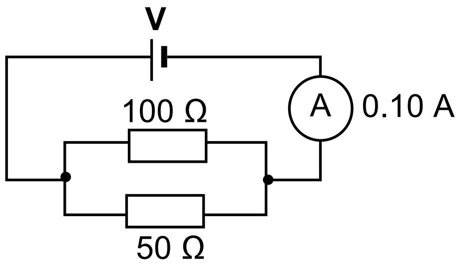
$V = 10$ V

(b)



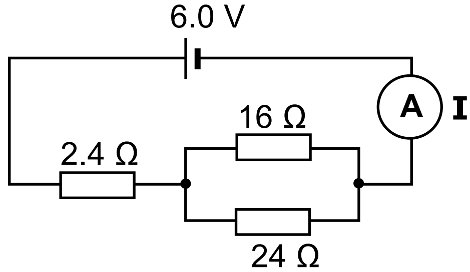
$I = V/R_T = 10/(1500 + 500)$
$= 10 / 2000$
$I = 0.005$ A

(c)



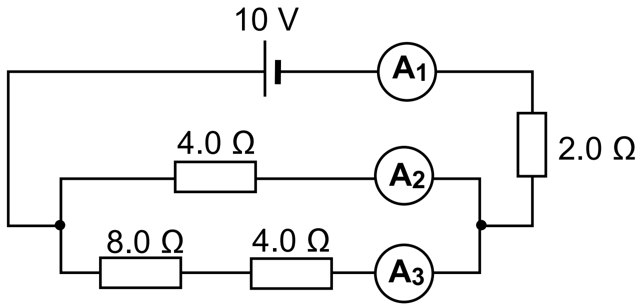
$R_T = 100/3\ \Omega$.
$V = IR = 0.10 \times (100/3)$
$V = 3.3$ V

(d)



$R_T = 2.4 + 9.6 = 12.0\ \Omega$
$I = V/R_T = 6.0 / 12.0$
$I = 0.5$ A

3 In the following circuit, determine:



(a) the total resistance in the circuit.

5.0 Ω

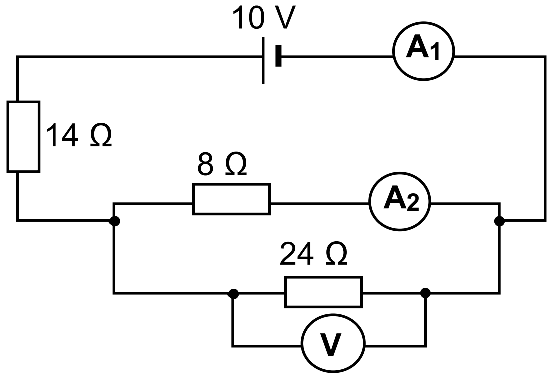
(b) the readings on ammeters

A_1, A_2 and **A_3**.

$A_1 = emf/R_T = 10/5.0 = 2.0$ A;

$A_2 = ¾ \times 2.0 = 1.5$ A; $A_3 = ¼ \times 2.0 = 0.5$ A

4 In the following circuit, determine:



(a) the total resistance of the circuit,

20 Ω

(b) the readings on ammeters **A_1** and **A_2**,

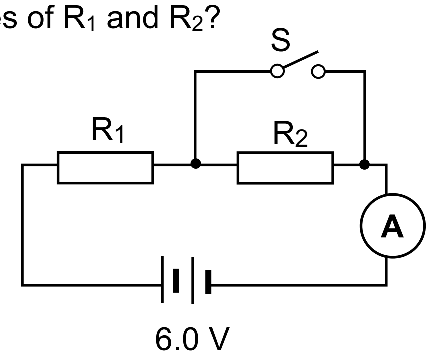
$A_1 = emf/R_T = 10/20 = 0.50$ A;

$A_2 = (24 / 32)\ 0.50 = 0.375 = 0.38$ A

(c) the reading on the voltmeter.

$V = IR = 0.375 \times 8 = 3.0$ V

5 In the following circuit, when switch S is closed, the ammeter reads 3.0 A. When S is opened, the ammeter reads 2.0 A. What are the values of R_1 and R_2?



$R_1 = V / I = 6.0 / 3.0 = 2.0\ \Omega$

$R_1 + R_2 = V / I = 6.0 / 2.0 = 3.0\ \Omega$.

Therefore $R_2 = 1.0\ \Omega$

15.2 Potential Divider Circuit

Example 1

As the resistance of the rheostat increases the p.d. across the rheostat also increases.

Example 2

(a)

S at A, voltmeter is zero.
As S moves from A towards B, the ratio of resistance of AS to SB increases.
Therefore, voltmeter increases.

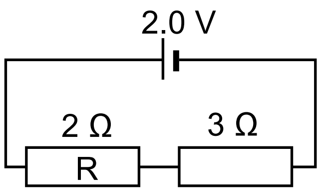
(b)

S at A, lamp will **not** light up as potential difference across the lamp is zero.
As S moves from A towards B, the ratio of resistance of AS to SB increases.
Therefore, the p.d. across the lamp increases. Lamp gets brighter.
S at B, lamp is at brightness as p.d. across the lamp is the greatest.

Exercises

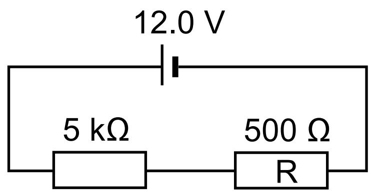
1 In each of the following circuit, find the potential difference across the resistor R using the potential divider concept.

(a)



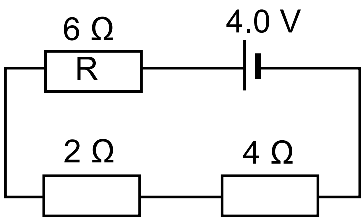
2/5 x 2.0 = 0.8 V

(b)



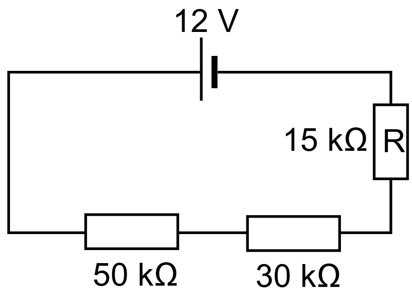
500/5500 x 12.0 = 1.09 V

(c)



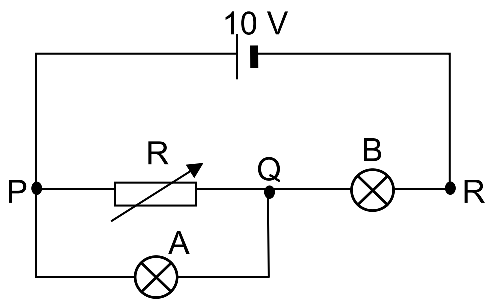
6/12 x 4.0 = 2.0 V

(d)



15/95 x 12 = 1.9 V

2. In the circuit shown, A and B are two identical lamps, each with a rating of 10 V. State and explain the changes to the brightness of the two lamps as the resistance of the variable resistor R is gradually increased.

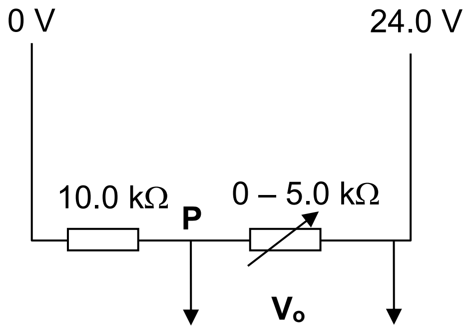


When the resistance of R is 0 Ω, A will not light up as R creates a short circuit (zero resistance) across A. **B will have normal brightness** as the p.d. across it is 10 V.As the resistance of R gradually increases, the effective resistance across PQ will increase such that the $0 < V_A <$ **5** V. Correspondingly, V_B = Emf – V_A decrease too. This will cause the brightness of **lamp A to increase** and **lamp B to decrease** but both will be dim.

3. In the circuit shown,

(a) use the potential divider concept to calculate the range of the output voltage, $\mathbf{V_o}$.

V_o = 0 – 8.0 V

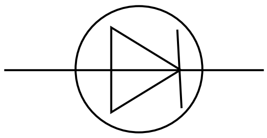


(b) determine the potential at point **P** of the circuit when the variable resistor is set at 2.0 kΩ.

Potential at P = 20 V

15.4 Diode

(may draw symbol without circle)



Exercises

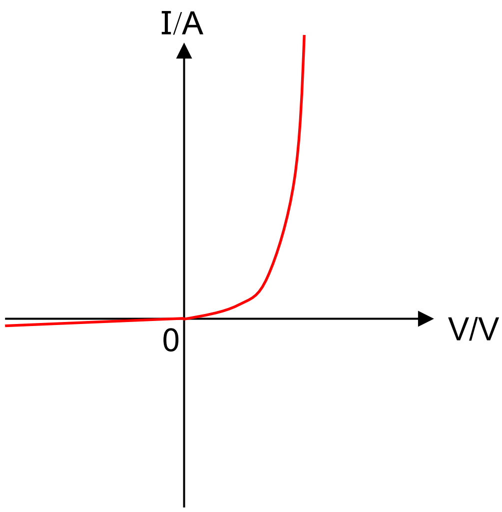
1 (A) C and D: Short-circuit across a.c. supply and cause electrical fire!

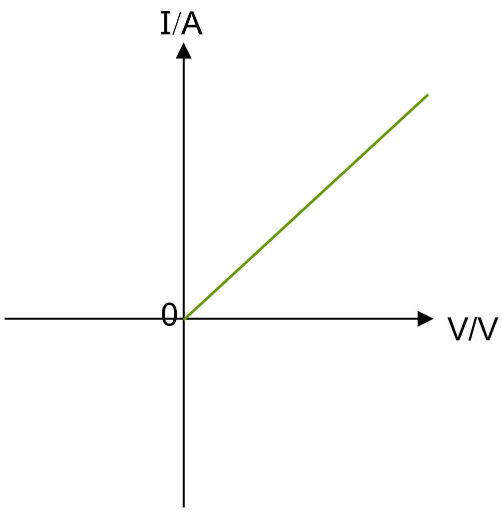
2

Sketch the graphs of current I against the p.d. V for the following.

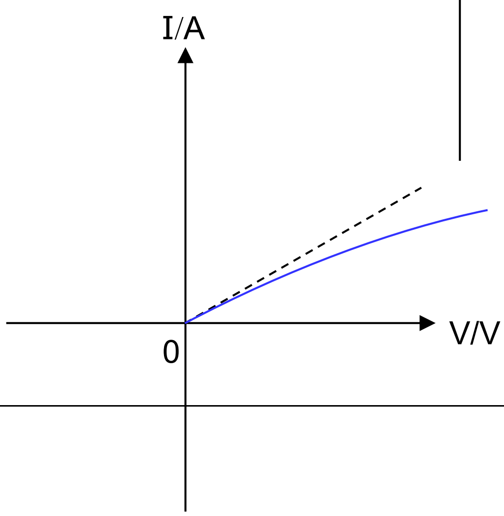
(i) a diode

(ii) a pure metal (temperature kept constant)





(iii) Filament lamp



3

(a)(i)

When V is negative, the current I is zero.

(a)(ii)

When V is positive, the current will remain at zero from V = 0 V to V = 0.6 V. For V > 0.6 V, the current will increase exponentially.

(b)

When V = 0.8 V, current I = 6 mA.

Applying Ohm's law, V = R x I,

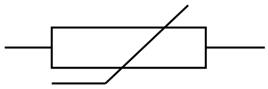
R = 0.8 V / (6 x 10^{-3} A) = 133 Ω

(c)

I do not agree with the student.

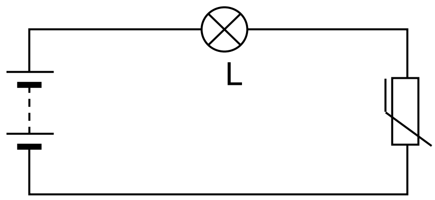
From R = V/ I , when I is zero, the value of R will be infinite.

15.5 Thermistor



Exercises

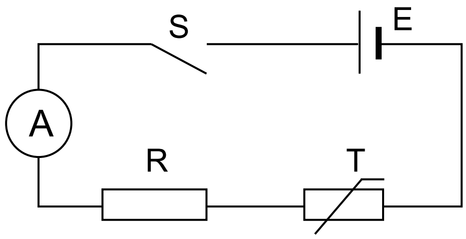
1 The circuit shows a lamp L and a thermistor connected in series.



Does the lamp L get brighter or dimmer if the thermistor is heated? Explain.

As the thermistor is heated, its resistance decreases. This will cause the effective resistance in the circuit to decrease. The current increases, hence, the lamp gets brighter.

2 In the circuit shown below, E is a battery of e.m.f. 3.00 V, R is a resistor of resistance 2.40 kΩ and T is a thermistor.



When the switch S is closed, the current in the circuit is 0.500 mA. Calculate

(a) the resistance of the whole circuit,

6000 Ω

(b) the resistance of the thermistor,

Resistor of thermistor = 6000 – 2400 = 3600 Ω

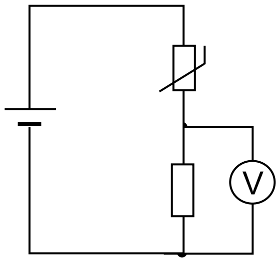
(c) the potential difference across the thermistor,

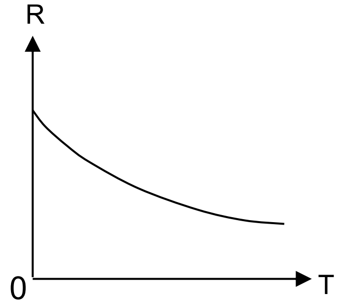
V = IR = 0.000500 x 3600 = 1.80 V

(d) the power developed in the thermistor. [P = IV]

P = IV = 0.000500 x 1.80 = 0.000900 W = 0.900 mW

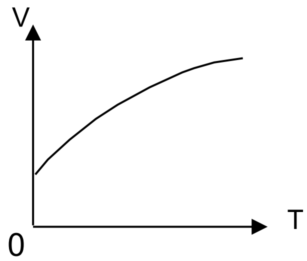
3 A thermistor is connected in the circuit shown. The graph below shows how its resistance R varies with temperature T.





(a) Sketch another graph to show how the potential difference V measured by the voltmeter varies with temperature T.

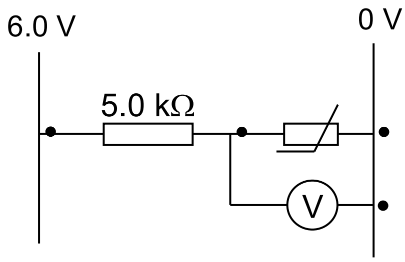
(b) Explain briefly how the graph is derived.



From the graph, the resistance of the thermistor **decreases decreasingly** with temperature. Hence, based on potential divider concept, the p.d. across the thermistor, $V_{thermistor}$ will **decrease decreasingly** with temperature too.
Since output V = emf – $V_{thermistor}$, the output V will **increase decreasingly** with temp.

4 In the circuit shown, a thermistor is connected in series with a 5.0 kΩ fixed resistor.

When the temperature is high, the resistance of the thermistor is 1.0 kΩ and when the temperature is low, the resistance of the thermistor increases to 8.0 kΩ.



(a) When the temperature is high, determine:

(i) the potential difference across the thermistor measured by the voltmeter,

V = (1.0 / 6.0) x 6 = 1.0 V

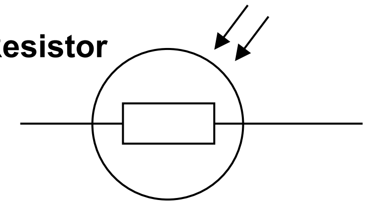
(ii) the power dissipated by the thermistor. [$P = V^2/R$]

$P = V^2/R = (1)^2 /1000 = 0.0010$ W = 1.0 mW

(b) Describe and explain the changes in the voltmeter reading when the temperature decreases.

Voltmeter reading increases to a maximum value of 8.0/(8.0+5.0)x6.0 = 3.7 V (2 sf). This is because as the temperature decreases the resistance of the thermistor increases; hence a greater potential difference is observed across the thermistor.

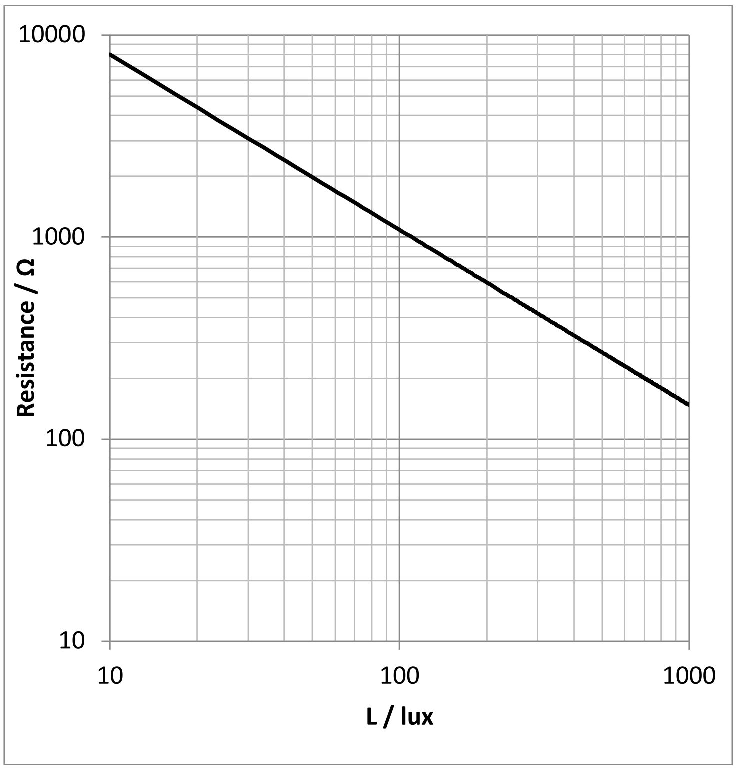
15.6 Light-Dependent Resistor



1 The graph shows how the resistance of a LDR varies with brightness, L that is measured in lux.

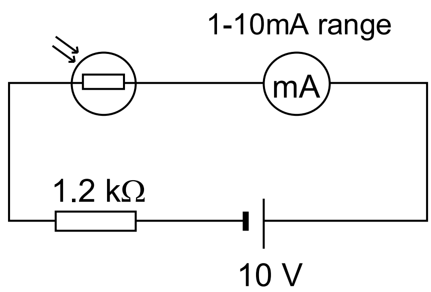
(a) Complete the table:

L / lux	R / Ω
700 (Bright Light)	200
200	600
10 (Poor Light)	8000



(b)

The LDR above is connected in series with a 1.2 kΩ resistor in the circuit shown.



(i) Using the values from the table above, determine the resistance of the above circuit under bright light.

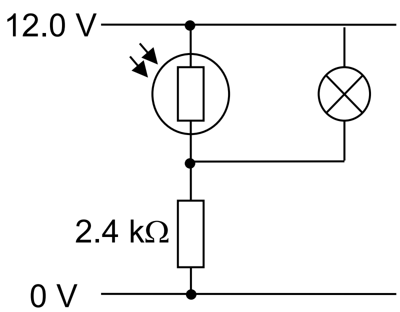
R = 1400 Ω

(ii) Hence, determine the reading on the milliammeter.

I = V / R = 10 / 1400 = 0.0071 A = 7.1 mA

2 The diagram shows how a LDR may be used in a circuit to automatically turn on a light bulb in the dark. The LDR has a resistance of 5.0 kΩ in the dark but a resistance of 25 Ω when exposed to light.

(Assume the lamp to have very high internal resistance)



(a) Calculate the potential difference across the light bulb when

(i) the LDR is in the dark.

In the dark, p.d. across bulb = 5000/(5000+2400)x12.0
= 8.108 = 8.1 V (2 s.f.)

(ii) The LDR is exposed to light.

When exposed to light, p.d. across blub = 25/(25+2400)x12.0
= 0.12 V (2s.f.)

(b) Hence, explain why the light bulb automatically lights up in the dark.

When it is dark, the resistance of the LDR is 5.0 kΩ. Hence, the p.d. of 8.1 V across the LDR (and also across the bulb as it is connected in parallel to the LDR). This is high enough for the bulb to light up.

(c) Sketch and explain how the circuit may be modified so that the light bulb lights up when the LDR is exposed to light.

Connect the bulb in parallel to the 2.4 kΩ resistor instead. Hence, p.d. across the bulb will be 11.9 V (12.0 V – 0.12 V) which is high enough for the bulb to light up.