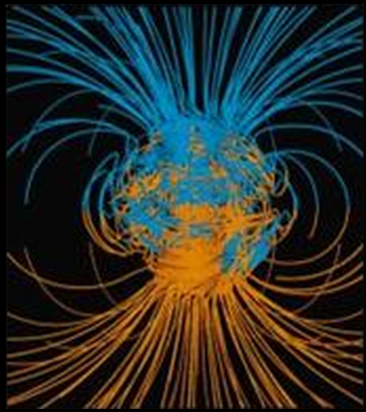


Phy2005
Applied Physics II
Spring 2018

Announcements:

January	29	M	**9**	1, 5, 8, 11, 13, 17	20.1 - 20.5	capacitor, field line in capacitor	
January	31	W	**10**	23, 25, 26, 30, 35	20.6 - 20.11	current, resistance, Ohm's law, R-network	Ohm's law, series/parallel ct.
February	2	F	**11**	37, 38, 39, 43, 47, 51	20.12 - 20.14	power, resistivity	copper-steel wire, electron drift

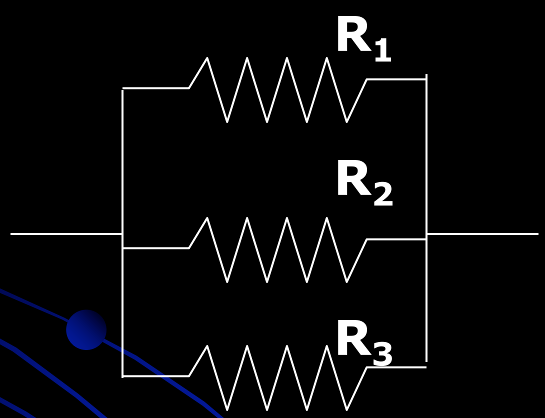
- Solutions to chapter 20 problems posted on HW page.
- Previous exams now available from the course web pages.
- Exam 1 Monday, Feb. 12 in class. 1 handwritten formula sheet ok.
- MUST, MUST, MUST bring laptop set not to time out for 1 hour.

Last time: Resistors

Ohm's law: $V=IR$

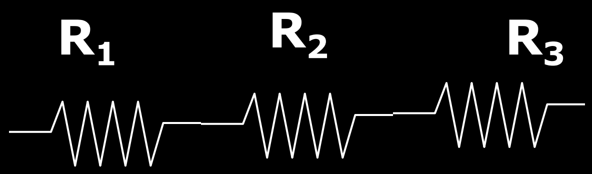
- V=Voltage across resistor
- I=current through resistor
- R=resistance of resistor

Parallel connection



$$1/R_{eq} = 1/R_1+1/R_2+1/R_3$$

Series connection



$$R_{eq} = R_1 + R_2 + R_3$$

Rules are "opposite" to those for capacitors!

Today: Resistance vs resistivity, power

Top Hat Quiz Time

ACADEMIC HONESTY

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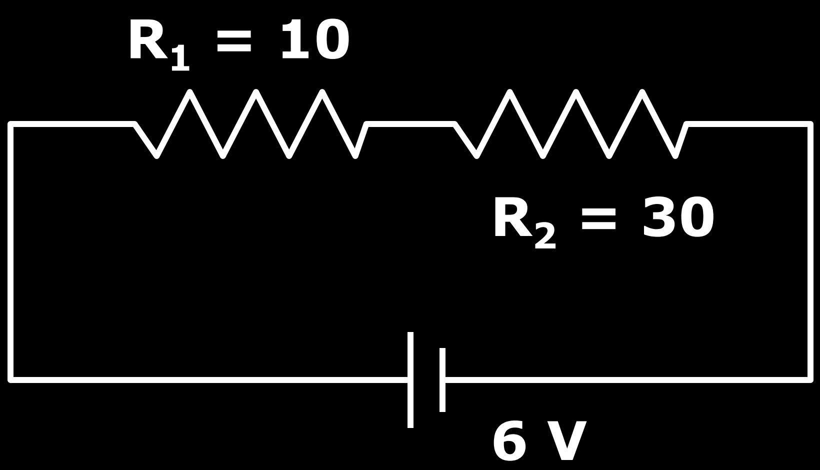
Have your phone ready!

Q1 (20-26) When a current of 3A flows through a 12-Ohm resistor, what is the potential difference between the ends of the resistor?

1. 36 V
2. 4 V
3. 0.25 V
4. 4 J
5. 0.25 J

Q2. What is the ratio of the current flowing through each resistor (I_1:I_2)?



1. 1:1
2. 3:1
3. 1:4
4. None of above

Resistance, Resistivity & Ohm's Law

We said some things conduct better than others. A measure of how well a given material conducts is its *resistivity*. Things with high resistivity conduct poorly. Things with low resistivity conduct well.

Table 25.1 Resistivities at Room Temperature (20°C)

	Substance	$\rho(\Omega \cdot m)$	Substance	$\rho(\Omega \cdot m)$
Conductors			*Semiconductors*	
Metals:	Silver	1.47×10^{-8}	Pure carbon (graphite)	3.5×10^{-5}
	Copper	1.72×10^{-8}	Pure germanium	0.60
	Gold	2.44×10^{-8}	Pure silicon	2300
	Aluminum	2.75×10^{-8}	*Insulators*	
	Tungsten	5.25×10^{-8}	Amber	5×10^{14}
	Steel	20×10^{-8}	Glass	10^{10}–10^{14}
	Lead	22×10^{-8}	Lucite	$>10^{13}$
	Mercury	95×10^{-8}	Mica	10^{11}–10^{15}
Alloys:	Manganin (Cu 84%, Mn 12%, Ni 4%)	44×10^{-8}	Quartz (fused)	75×10^{16}
	Constantan (Cu 60%, Ni 40%)	49×10^{-8}	Sulfur	10^{15}
	Nichrome	100×10^{-8}	Teflon	$>10^{13}$
			Wood	10^{8}–10^{11}

Resistance, Resistivity & Ohm's Law

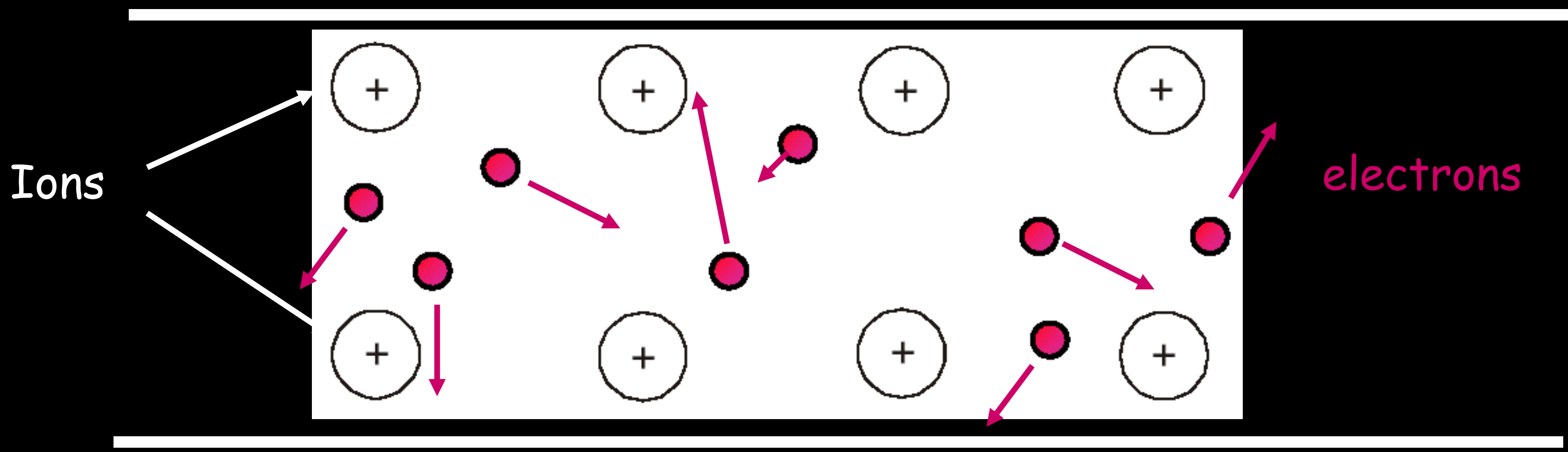
A given device, like a resistor has a value of resistance R that depends on the resistivity ρ of the material it's made out of, and its geometry. For a cylinder of cross-sectional area A and length L,

$$R = \rho \frac{L}{A}$$

[R] = Ω (Ohms)
[L] = m
[A] = m^2

So [ρ]= $\Omega * m$

Microscopic picture of conduction in wire

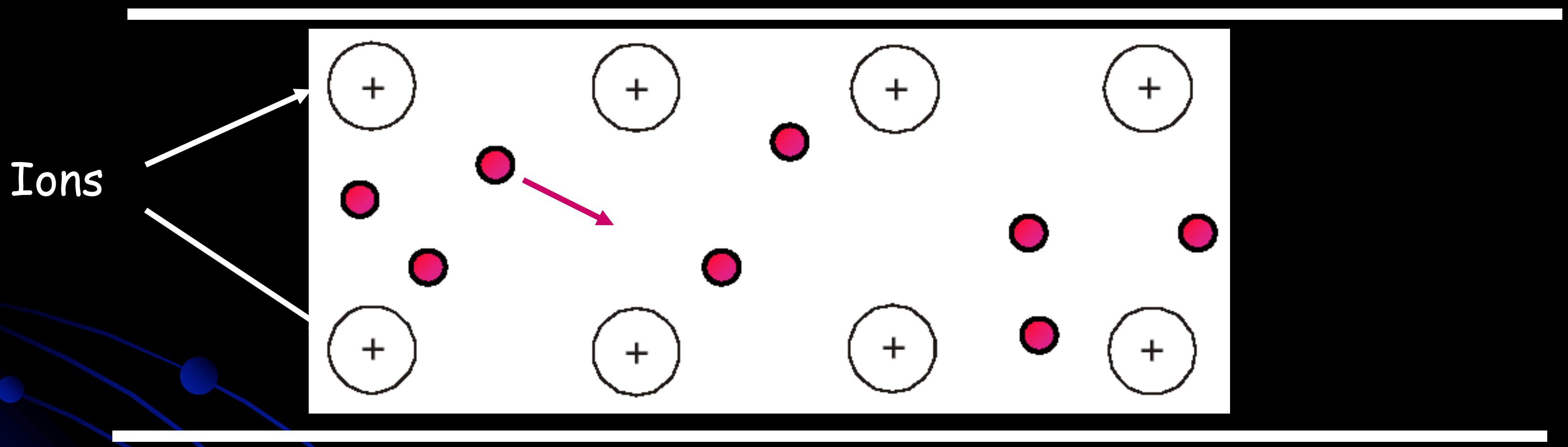


A metal wire consists of “gas” of electrons at some temperature T.

Even without net current, electrons move at typical speeds of 1/10 the speed of light. An electron moves at this high speed until it collides with something that changes its direction (ionic vibration, impurity, another electron). On the average, in the absence of an electric field, the velocity is zero.

Microscopic picture of conduction in wire

Here's what 1 electron does in a wire with no battery:



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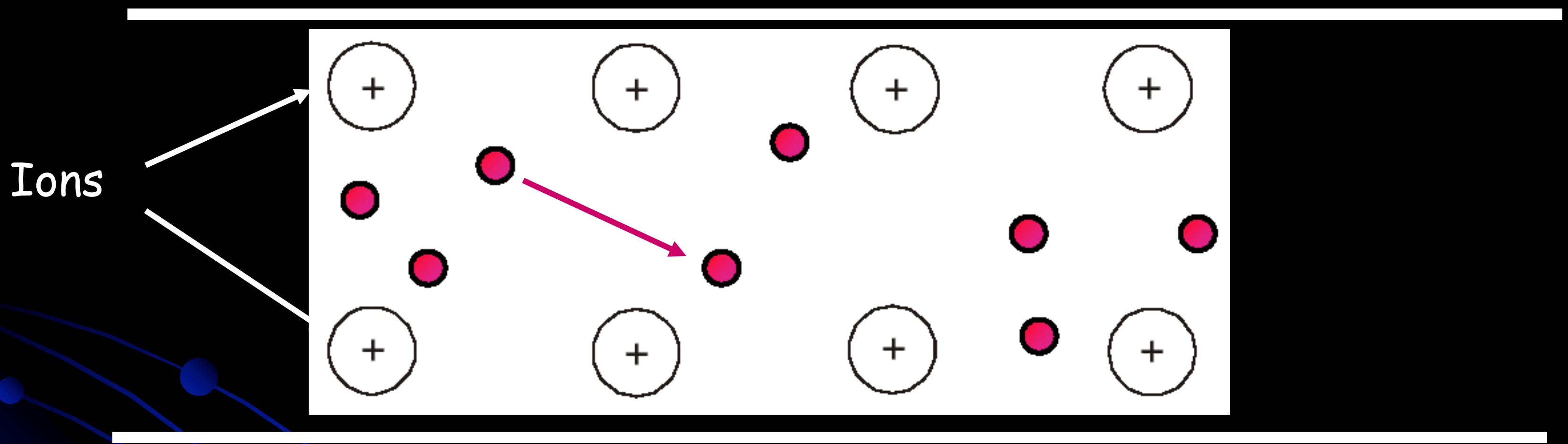

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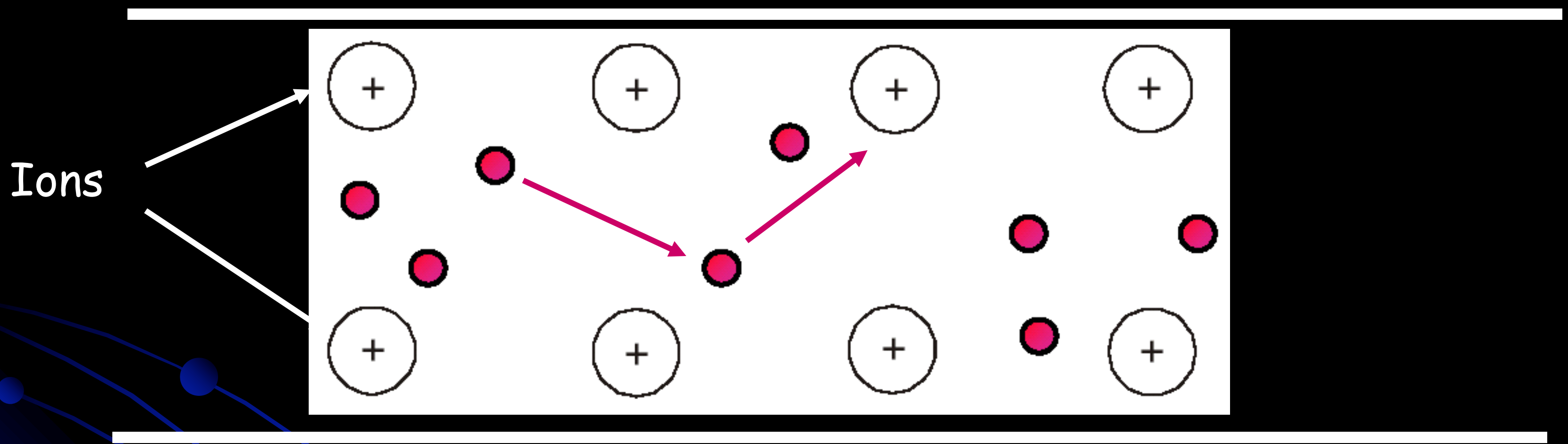

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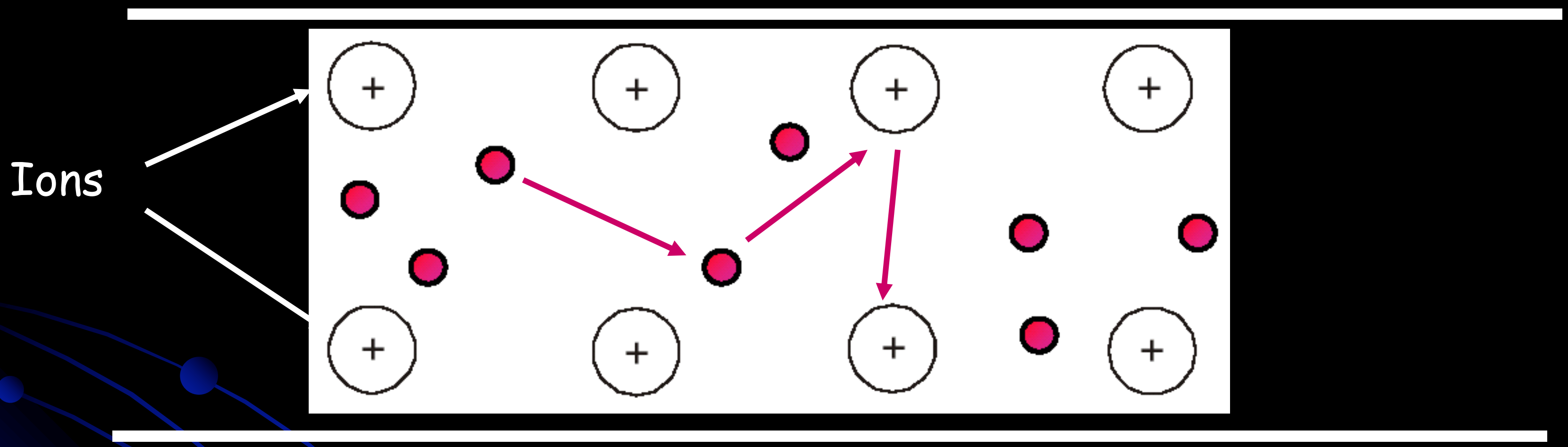

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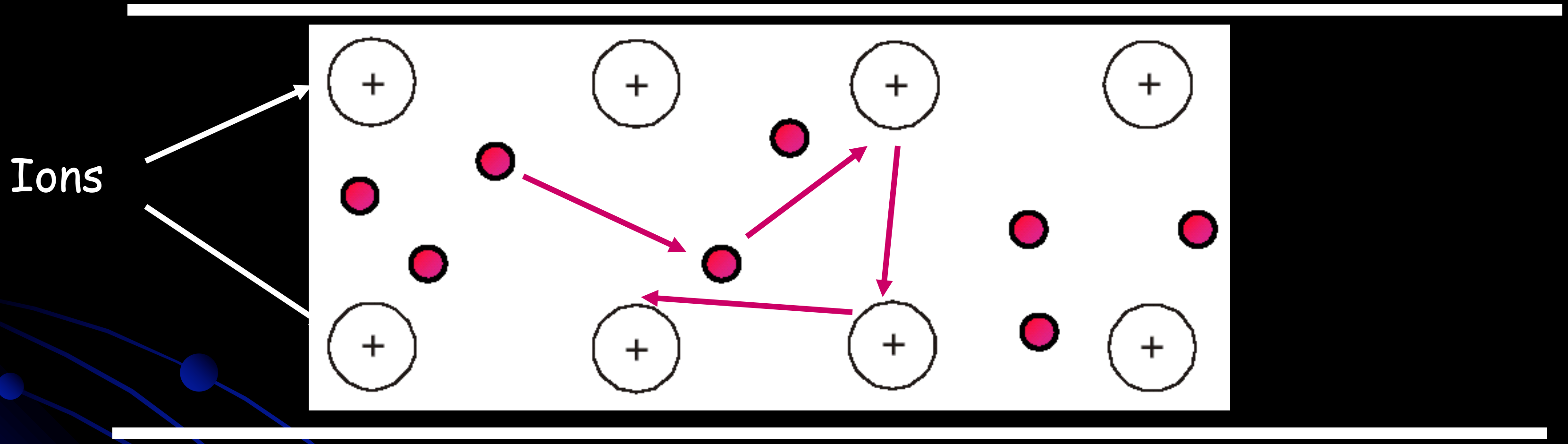

Microscopic picture of conduction in wire

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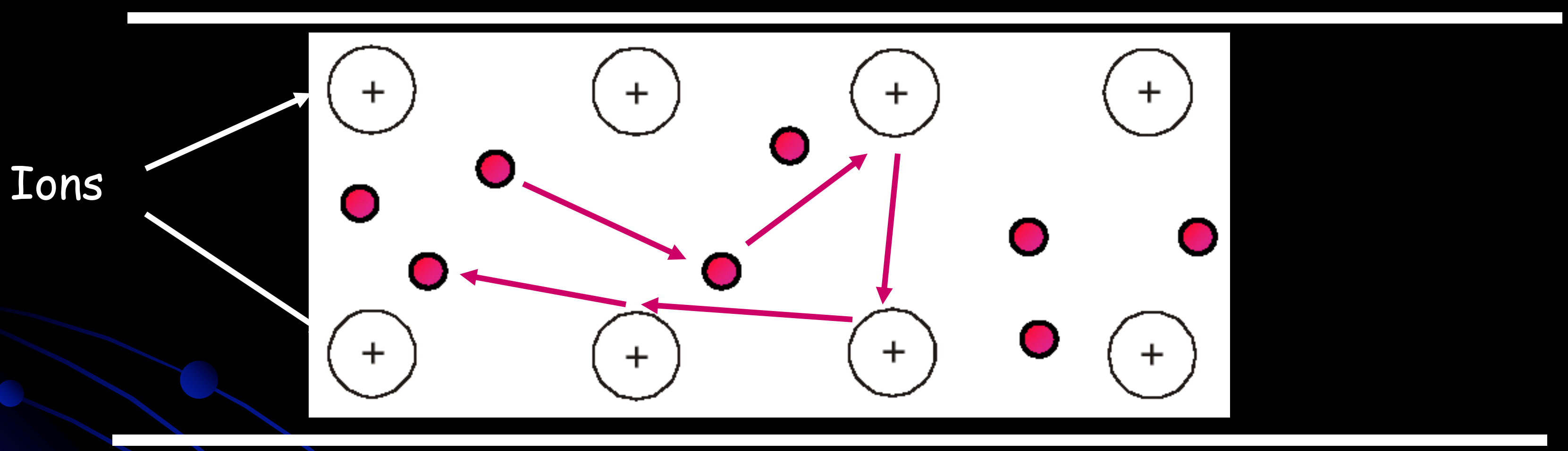

Microscopic picture of conduction in wire

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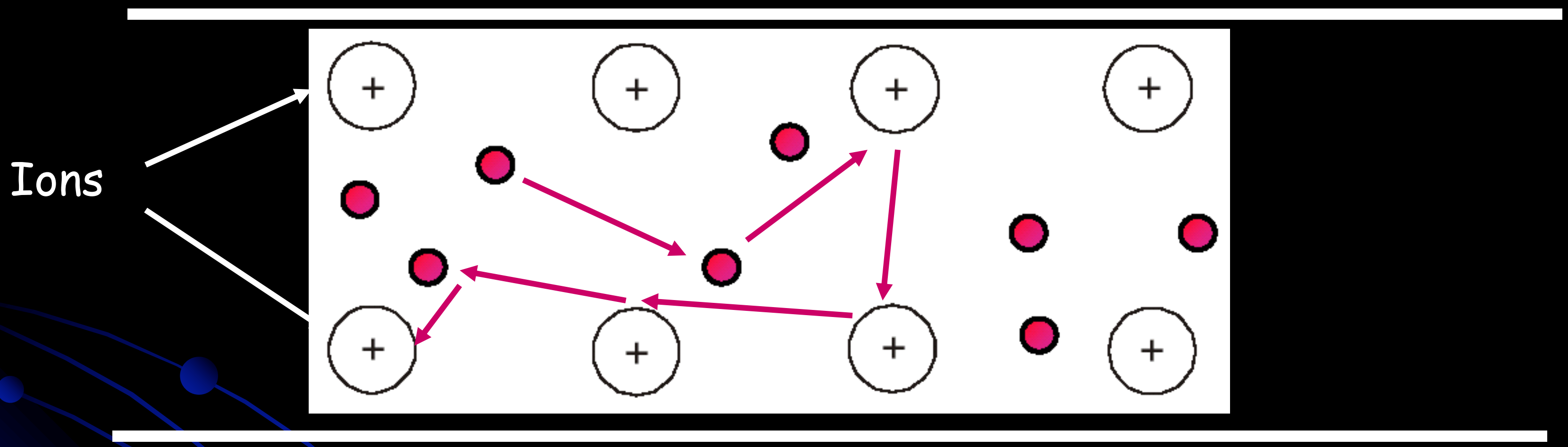
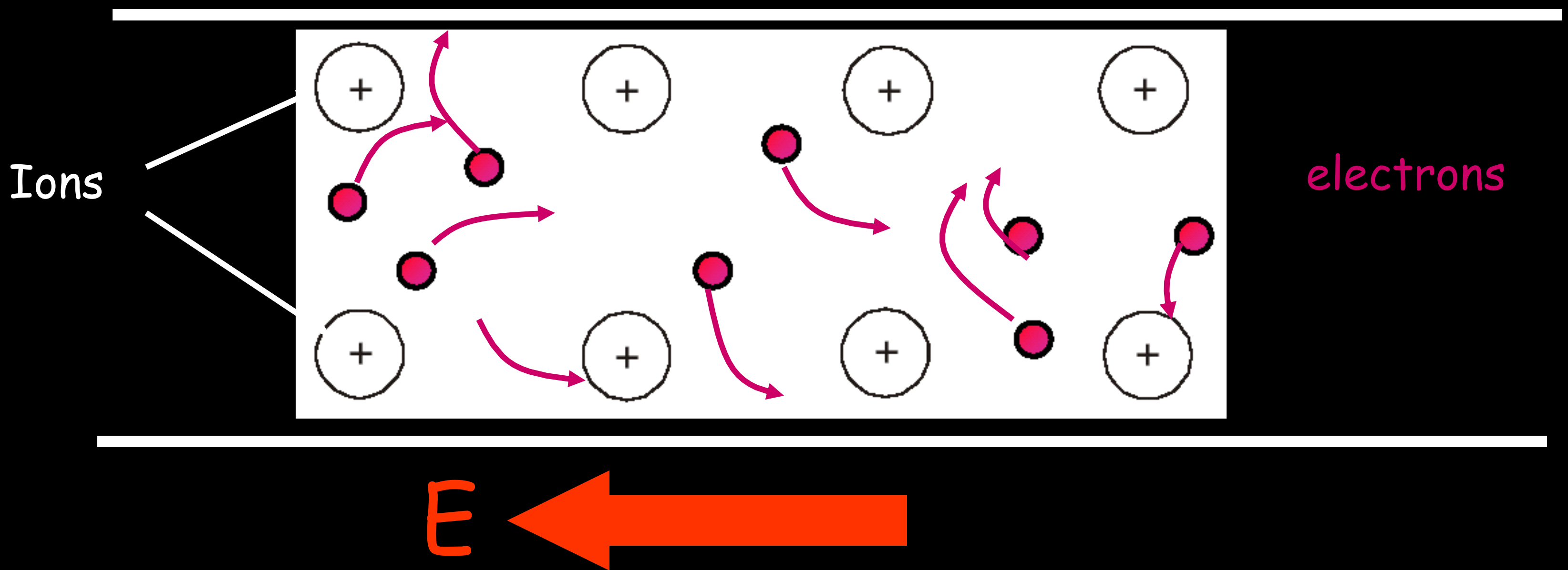


No net progress "downstream"!

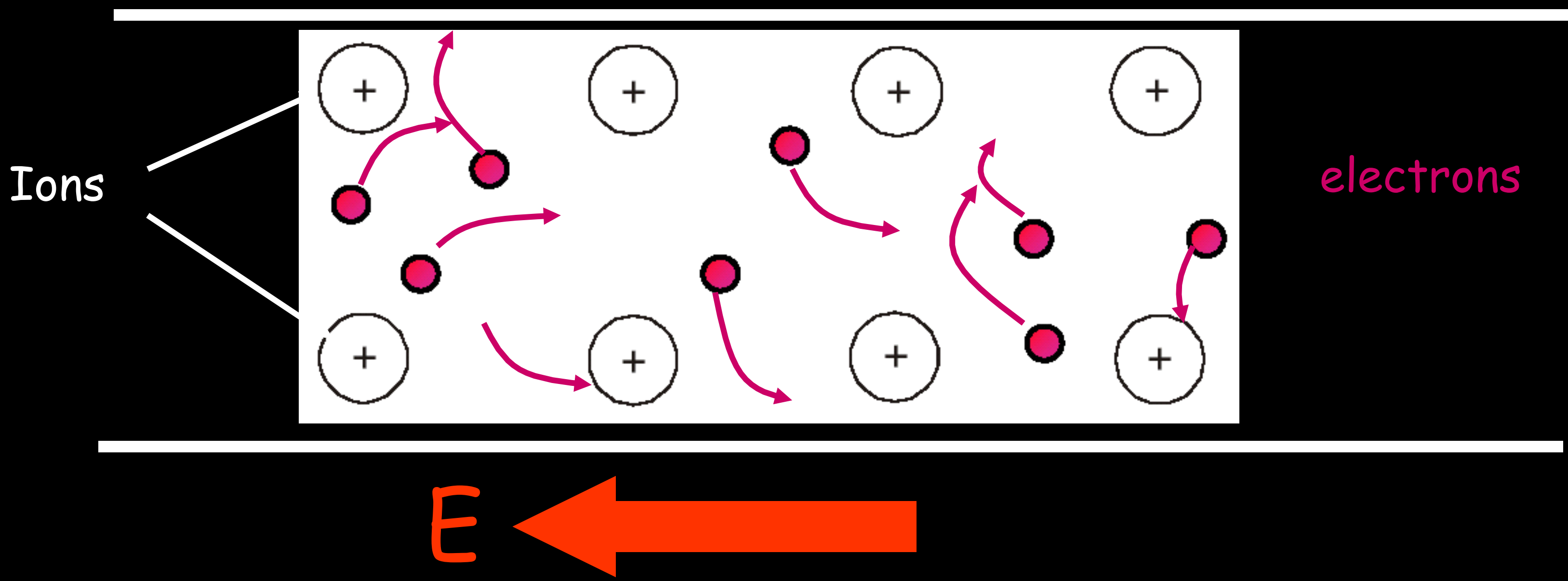
Microscopic picture of conduction in wire



If we apply an electric field, the electrons "drift downstream" *on the average*.

Q: Why don't they keep accelerating due to electric force?

Microscopic picture of conduction in wire



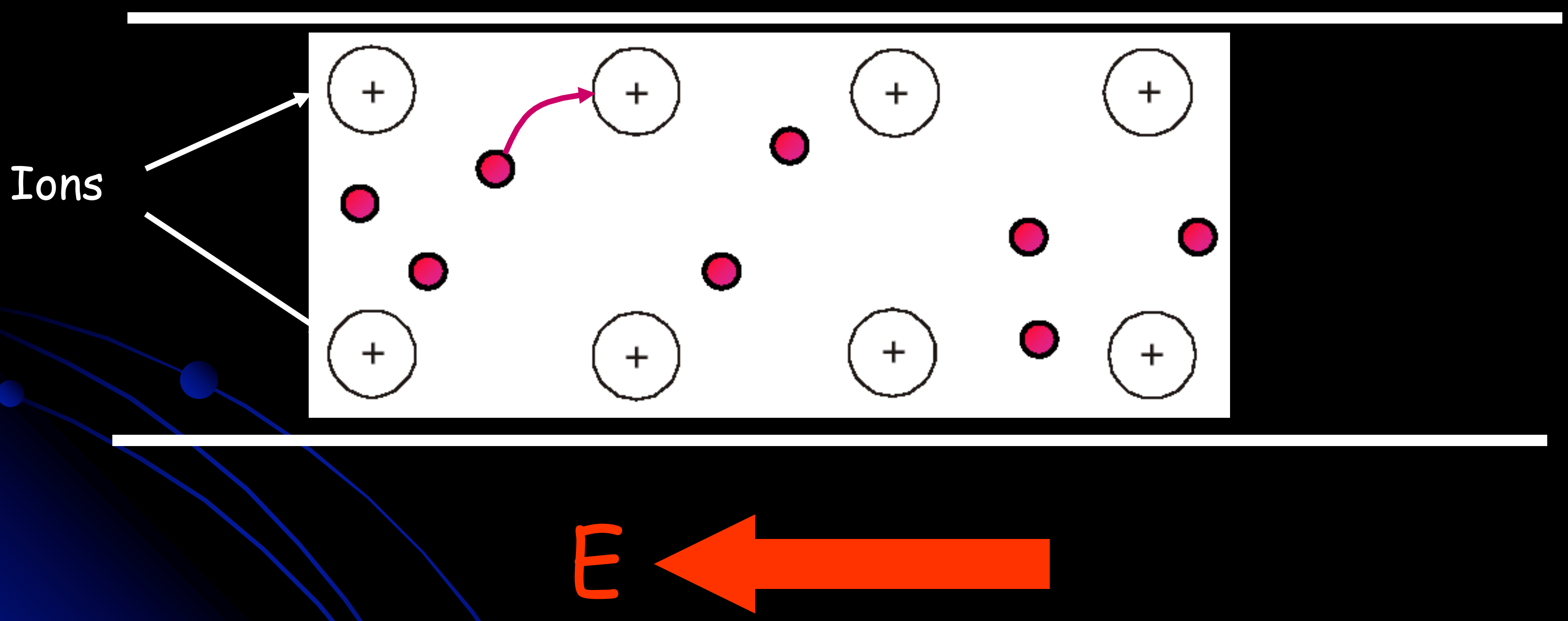
If we apply an electric field, the electrons "drift downstream" *on the average*.

Q: Why don't they keep accelerating due to electric force?

A: Collisions!

Microscopic picture of conduction in wire

Here's what 1 electron does
in a wire with a battery:



Microscopic picture of conduction in wire

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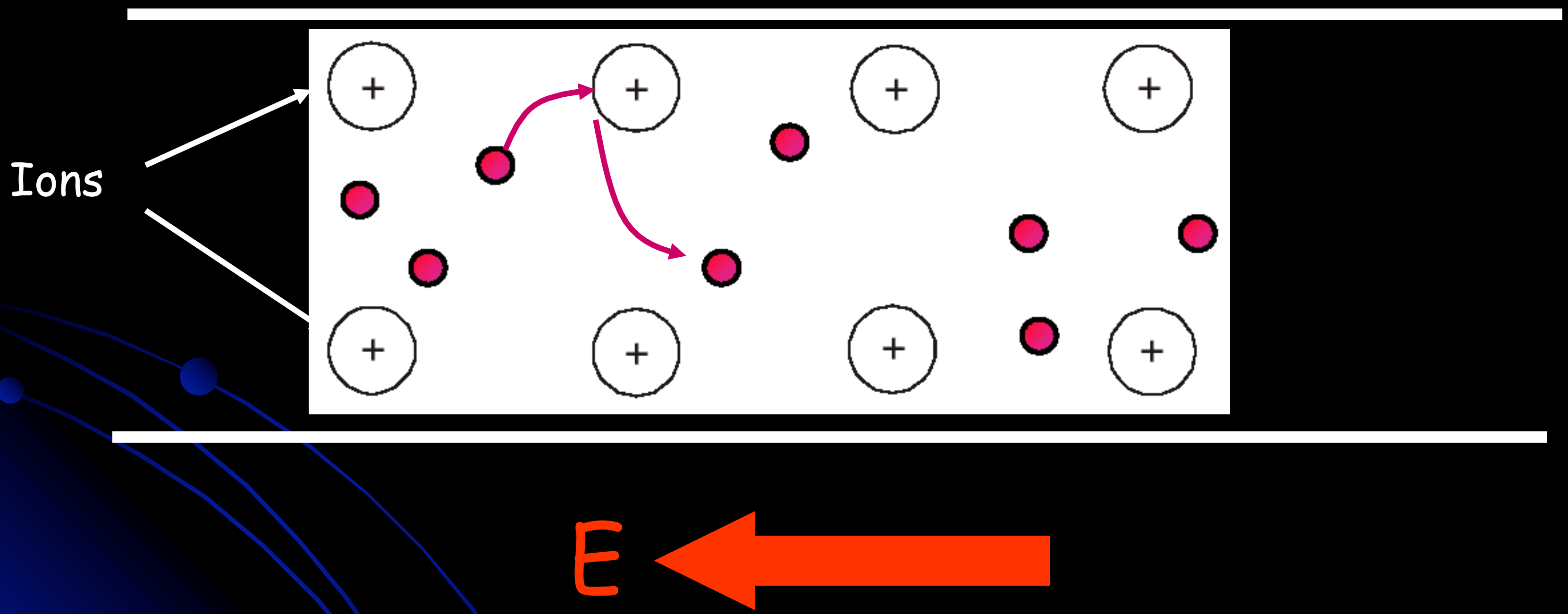

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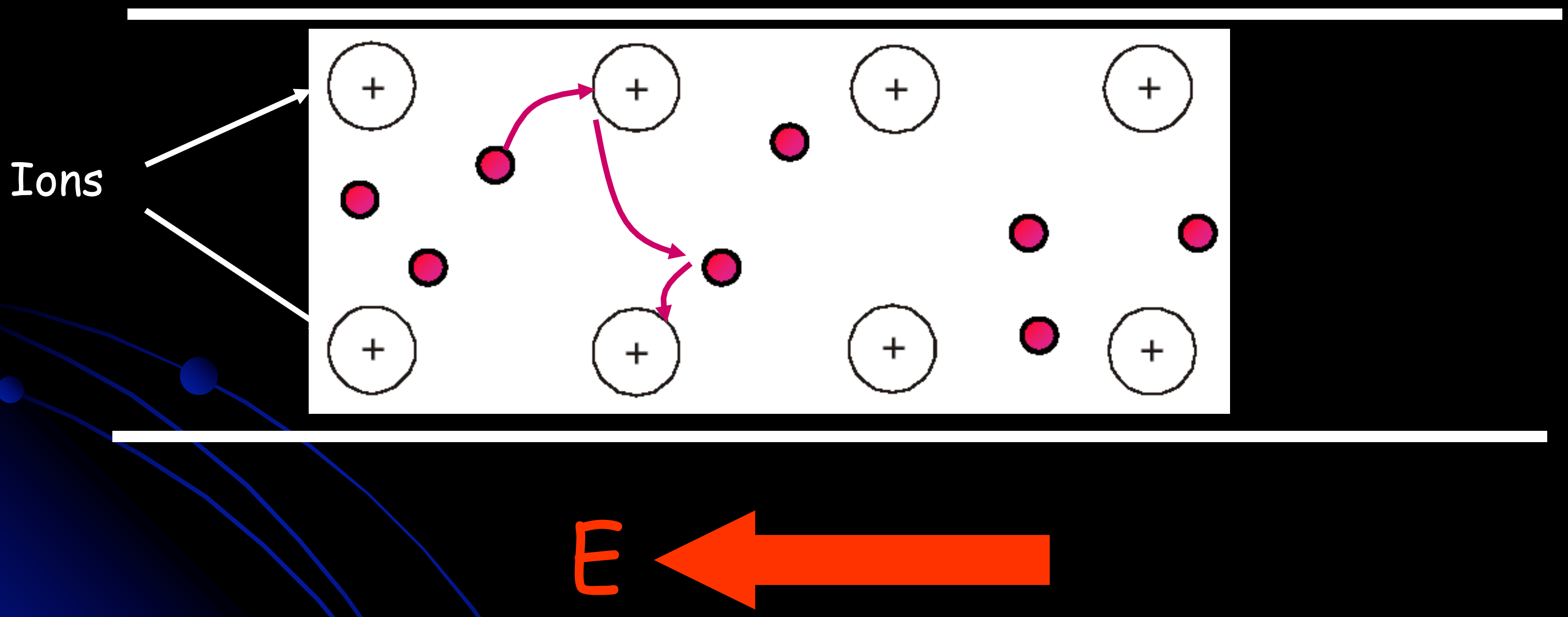

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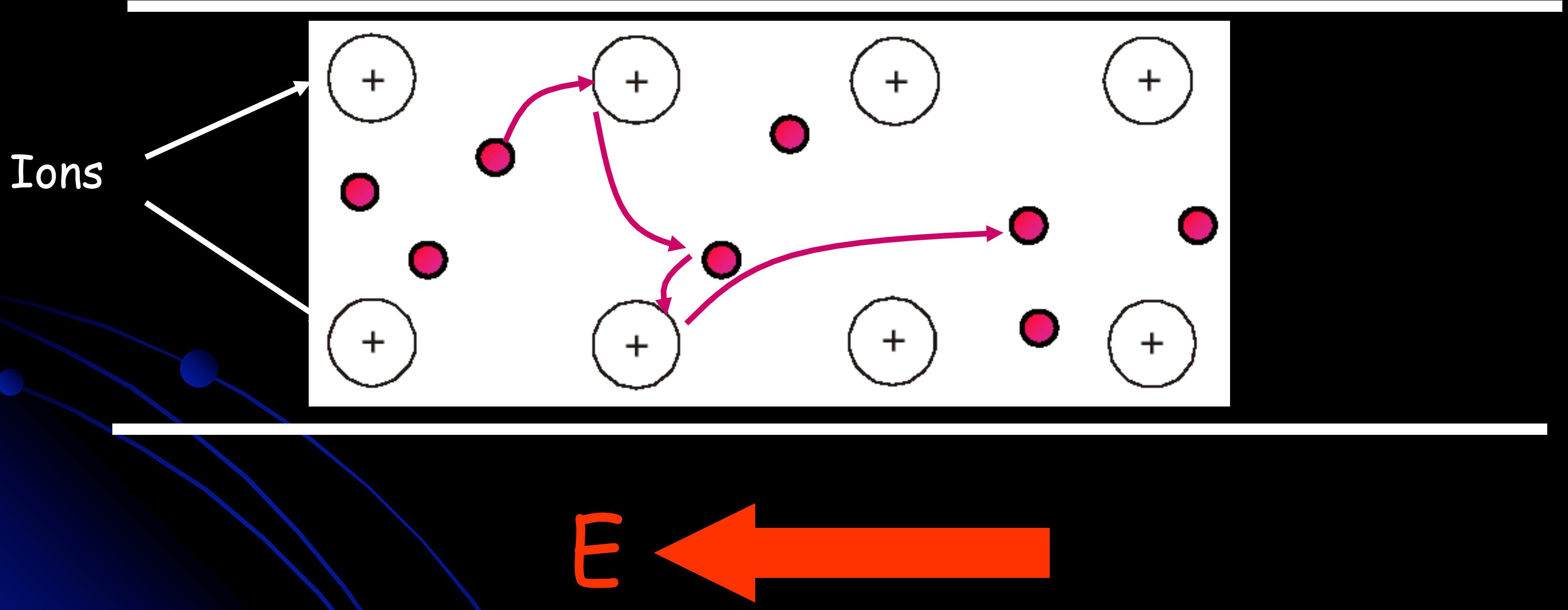

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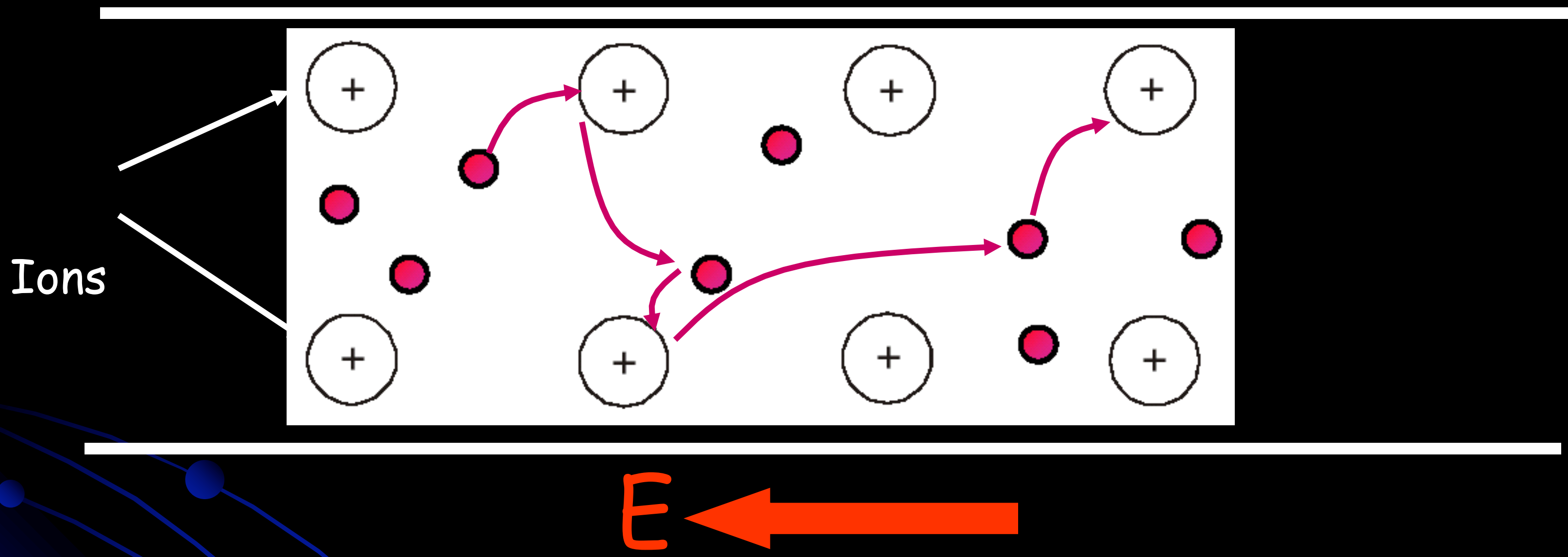


In presence of electric field, the electrons "drift downstream" *on the average*.

Net average velocity only 1cm/s or less!

Summary: three important speeds

1. *Average speed* of electrons in wire: about *c/10:*

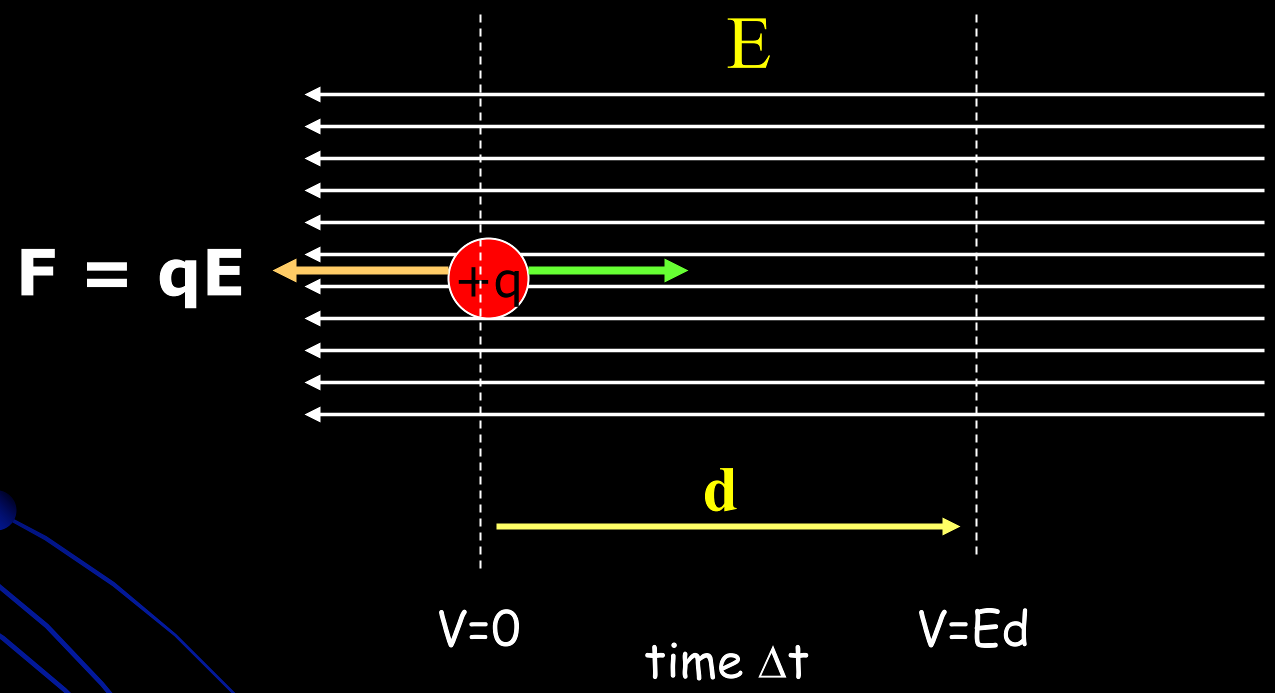
2. *Drift velocity* of electrons: very slow, less than 1 cm/sec. This velocity corresponds to the current we calculate.

3. *Velocity of information, energy flow*. Close to *c*.

where c = speed of light = 3×10^8 m/s

Power!

Power = work/time



Work done to move charge is qV in time Δt

So power supplied is qV/Δt = IV

P=IV

Q. A 40 W/120 V light bulb produces 40 W of power when connected to 120 V. How much power would be produced if the same bulb is connected to 60 V?

You can solve this problem by calculating R of the filament and use the formula for power, $P = IV = V^2/R$, and R is fixed.

P (for 120 V) = 40 (W),

p (for 60 V) = $40*(60/120)^2 = 10$ (W)

A certain 1400 W space heater is designed to operate on 120 V. How much current flows through it when it is operating? What is its resistance when operating?

Power = $IV = I^2R = V^2/R$

Since we know P and V, use $P = IV$ to calculate I.

$I = P/V = (1400\ W)/(120\ V) = 11.7\ A$

Now, we can use Ohm's law to calculate R.

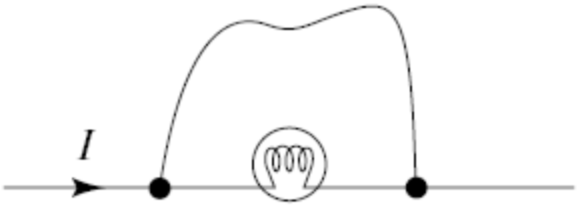
When it is operating on 120 V, 11.7 A current flows.

$R = V/I = (120\ V)/(11.7\ A) = 10.25\ \Omega$

Statement: $P = IV$ If I hook up this heater on 60 V, the power Produced by this heater would drop to ½.

No! No!

Charge flows through a light bulb. Suppose a wire is connected across the bulb as shown. When the wire is connected,



1. all the charge continues to flow through the bulb.
2. half the charge flows through the wire, the other half continues through the bulb.
3. all the charge flows through the wire.
4. none of the above

Top Hat Quiz Time

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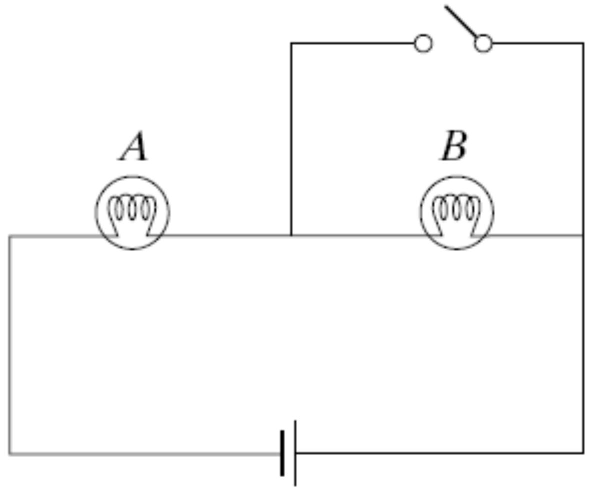
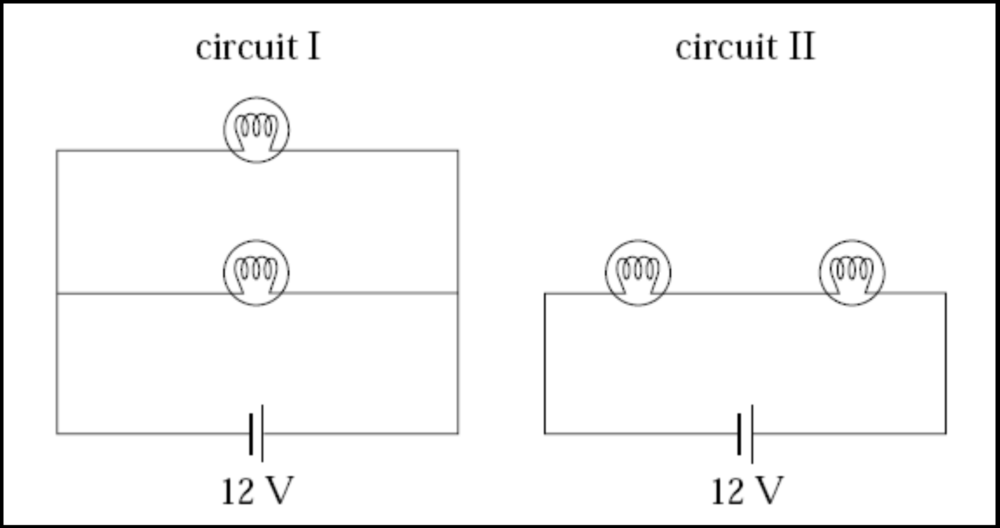
The circuit below consists of two identical light bulbs burning with equal brightness and a single 12 V battery. When the switch is closed, the brightness of bulb *A*

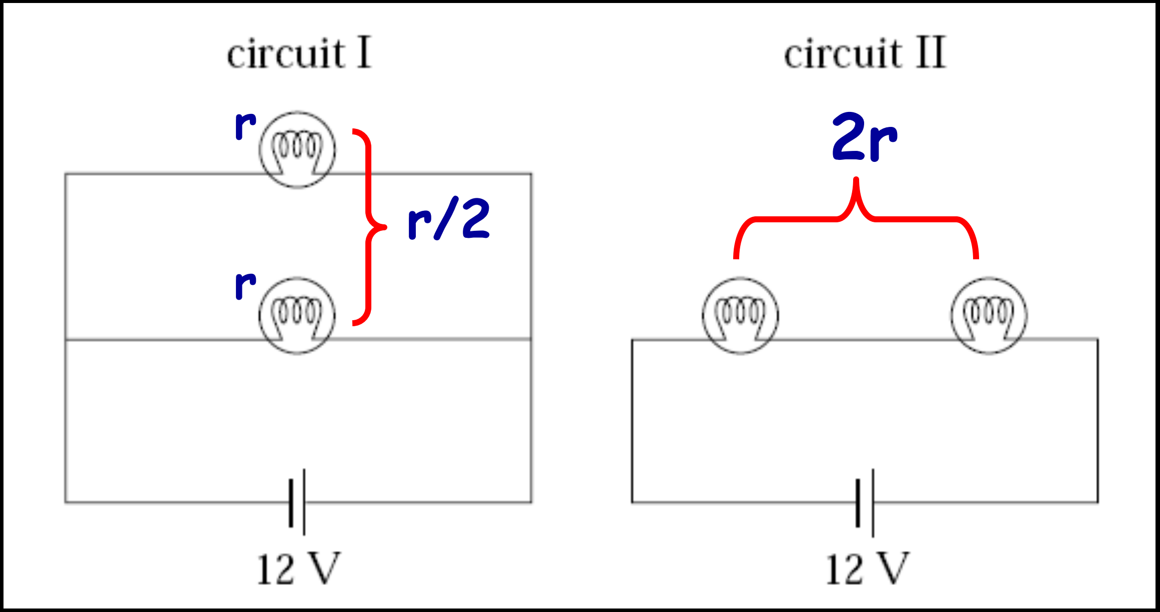


1. increases.
2. remains unchanged.
3. decreases.

If the four light bulbs in the figure are identical, which circuit puts out more light?



1. I
2. II
3. Same for both
4. Need to know R



$P = V^2/R$

$P_I = V^2/(r/2) = 2V^2/r$
$P_{II} = V^2/(2r) = V^2/(2r) = (1/4)P_I$