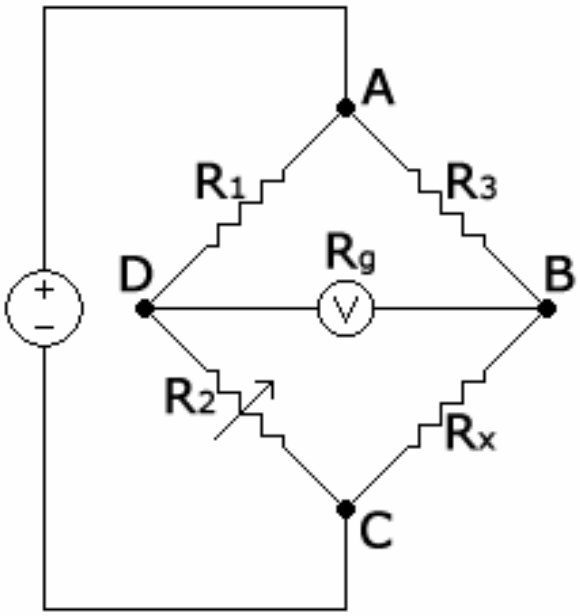
PENNSYLVANIA SCIENCE OLYMPIAD STATE FINALS 2006

CIRCUIT LAB C DIVISION

APRIL 28th, 2006

Juniata College



SCHOOL NAME_____ **SCHOOL CODE**_____

INSTRUCTIONS

1. Turn in all exam materials at the end of this event. *Missing exam materials will result in immediate disqualification of the team in question*. There is an exam packet and a blank answer sheet. There is also scrap paper for your calculations, should you need it; turn it in as well.

2. You may separate the exam pages. Re-staple them as you submit your materials to the supervisor. Keep the answer sheet and scrap paper separate.

3. *Only* the answers provided on the answer page will be considered. Do not write outside the designated spaces for each answer.

4. Include school name and school code in the appropriate locations on the answer sheet as well as on the title page. Indicate the names of the participants at the bottom of the answer sheet.

5. Point values for each question are in parentheses. Tiebreaker questions are identified with a number indicating the first, second, third, etc. They do not appear in numerical order. *Tiebreaker questions count toward the overall grade, and are only used as tiebreakers in the event of a tie.*

6. When the time is up, *the time is up*. Continuing to write after the time is up risks immediate disqualification.

7. There is a circuit on the title page. What is it? Put the answer in the "Bonus" box on the answer sheet.

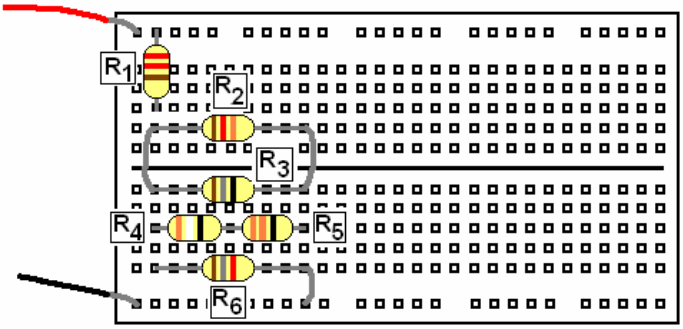
8. NON-PROGRAMMABLE CALCULATORS ONLY. DON'T ASK, THE ANSWER IS NO.

9. Use this table for the resistance of color-coded resistors.

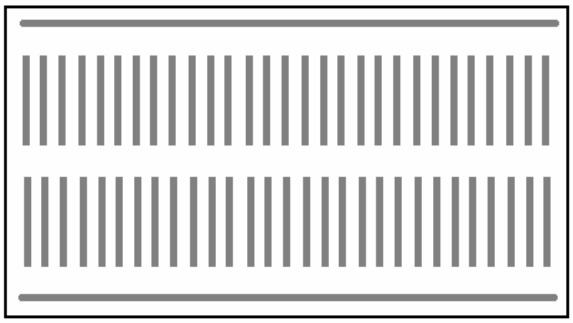
COLOR	1st stripe 1st digit	2nd stripe 2nd digit	3rd stripe multiplier
Black	0	0	X 1
Brown	1	1	X 10
Red	2	2	X 100
Orange	3	3	X 1000
Yellow	4	4	X 10000
Green	5	5	X 100000
Blue	6	6	X 1000000
Violet	7	7	
Grey	8	8	
White	9	9	

SECTION 1

The image below shows a circuit consisting of 6 resistors mounted on a standard breadboard. The red and black leads will be connected to a DC power supply set to 8.00 volts. Use this voltage value for the theoretical quantities. Point values for each question are in parentheses.



TOP



BOTTOM

(5) 1. Draw a schematic diagram of the circuit in the box provided. Use standard symbols.

(18) 2. (Tiebreaker 2) List the theoretical resistance, current, and voltage drop for each resistor in the circuit.

(3) 3. What is the equivalent resistance of the section of the circuit containing R_2, R_3, R_4, R_5, and R_6?

(3) 4. What is the equivalent resistance of the entire circuit?

(3) 5. What is the power dissipated by R_1?

The same circuit is wired and soldered onto a perfboard. *When your team is called*, use the digital multimeter provided to answer the following questions. Turn the power supply on, BUT DO NOT TOUCH THE DIALS. You are *NOT* to disassemble any parts of the circuit. *Only the leads from the power supply may be temporarily removed from the circuit.*

(2) 6. What is the actual resistance of R_1?

(3) 7. What is the current through resistor R_1?

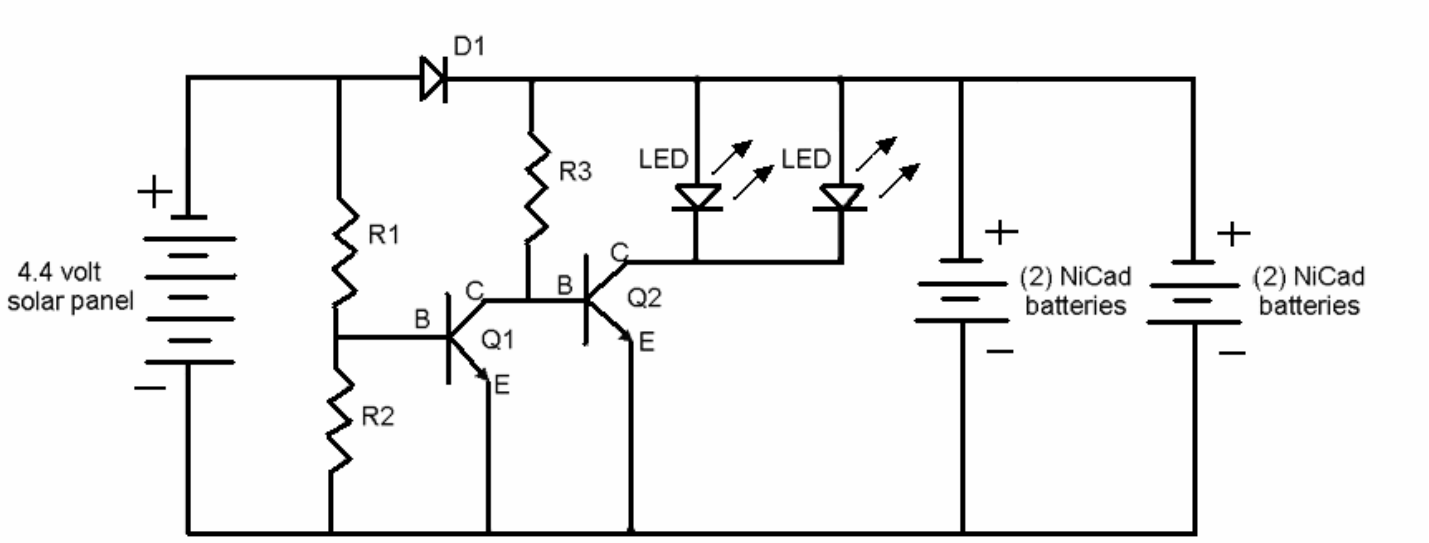
(3) 8. What is the voltage drop across resistor R_1?

(3) 9. What is the voltage drop across resistor R_2?

(3) 10. What is the voltage drop across resistor R_4?

SECTION 2

The image below shows a circuit schematic of a solar path light, courtesy of the Alternate Energy Zone. The components labeled Q1 and Q2 are transistors, which "turn on" and allow current to flow from the collector (C) to the emitter (E) *when there is a current into the base* (B). Point values for each question are in parentheses.



(6) 1. Trace the path(s) of electricity during the day when the sun is shining on the solar panel. Draw right on the image on the answer sheet, and indicate the direction of the current with arrows.

(8) 2. Trace the path(s) of electricity at night. Draw right on the image on the answer sheet, and indicate the direction of the current with arrows.

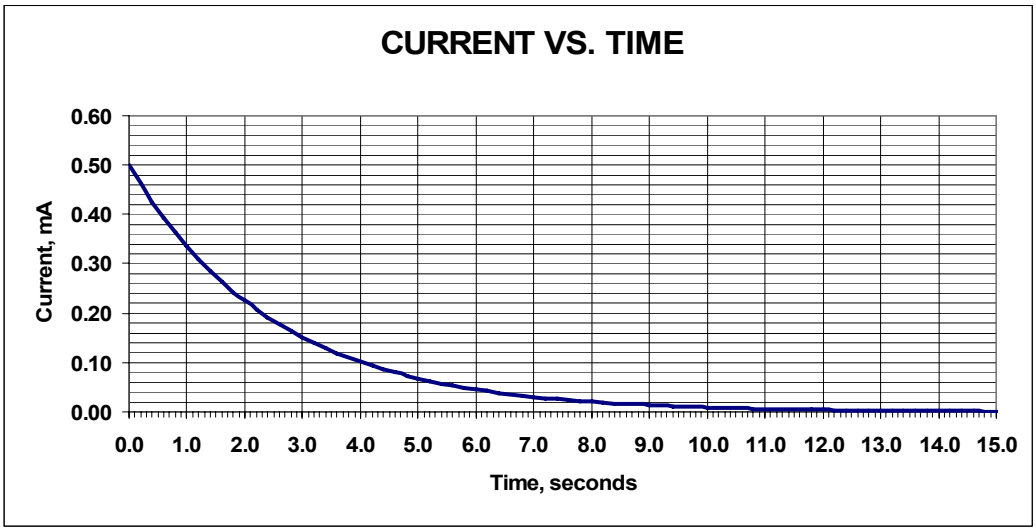
(3) 3. There are two layers of silicon in a solar cell; each is a different type. What are they called? What is the region called where the two layers meet?

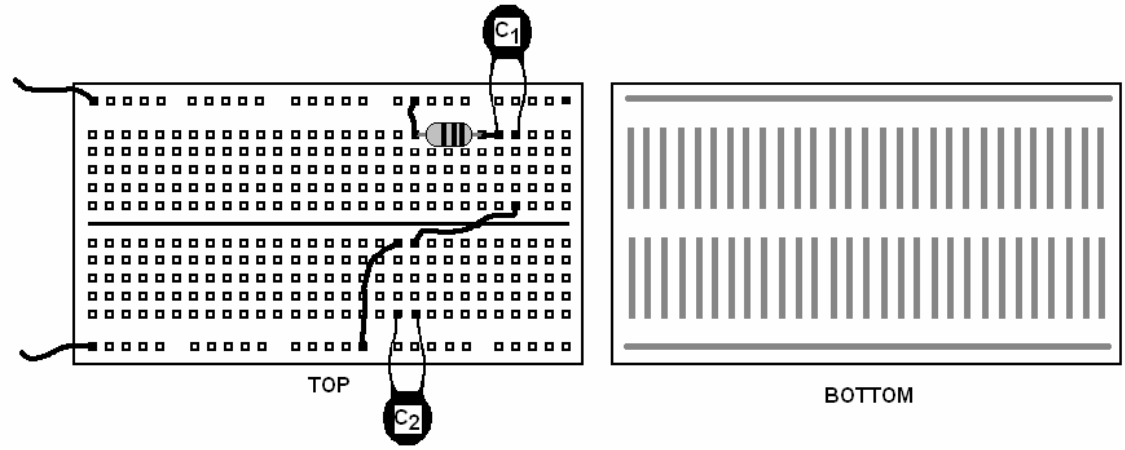
(4) 4. (Tiebreaker 3) What is the purpose of "doping" the silicon in a solar cell? What materials are they commonly doped with?

(2) 5. What is the name of the process by which electrons are liberated from the top layer of the solar cell?

SECTION 3

You are provided with a diagram of a circuit consisting of a resistor (R = 100 kΩ) and two capacitors mounted onto a solderless breadboard as shown. At time t = 0, the leads are connected to an ideal 50-volt DC power supply, and the resulting current in the circuit is shown as a function of time. Note the graph is measured in milliamps, and $C_2 = 2C_1$; that is, C_2 has twice the capacitance of C_1.





(2) 1. (Tiebreaker 4) What is the time constant for this circuit?

(2) 2. What is the equivalent capacitance of this circuit?

(4) 3. What is the capacitance of each capacitor in this circuit?

(2) 4. What is the charge on capacitor C_1 at t = ∞?

(2) 5. How much energy is stored in capacitor C_1 at t = ∞?

(2) 6. What is the current in the circuit at t = 0?

(2) 7. (Tiebreaker 5) What is the voltage drop across the resistor at t = 4.0 seconds?

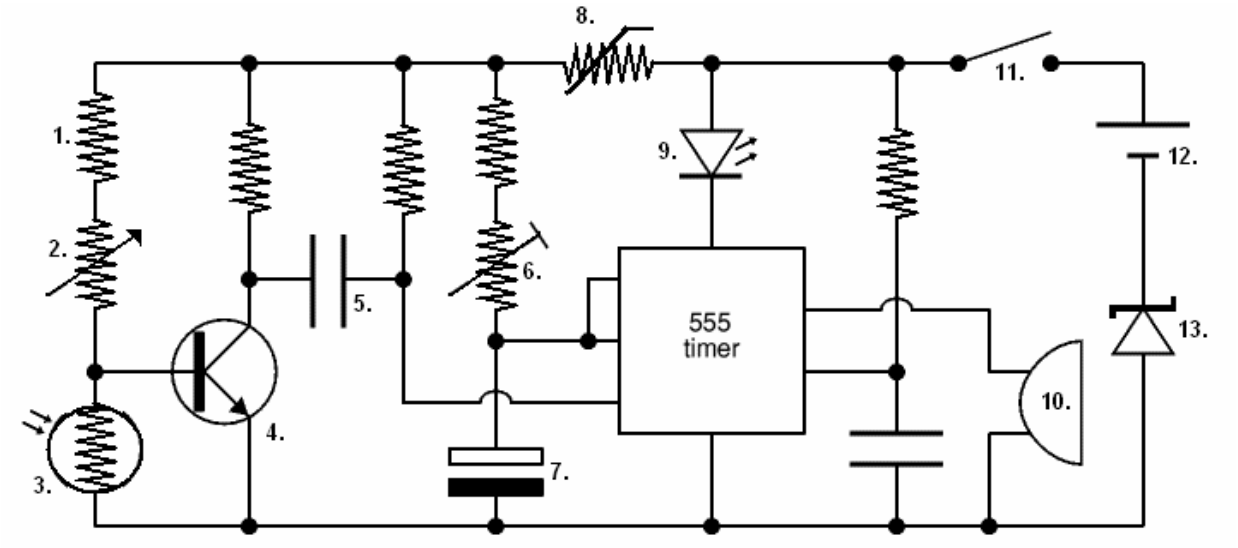
(2) 8. What is the voltage across the capacitor C_2 at t = ∞?

(2) 9. If there was a short circuit across C_2, would the time constant increase, decrease, or remain the same?

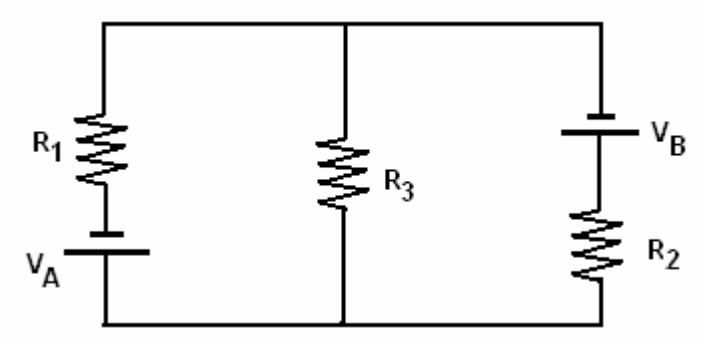
(4) 10. The leads are disconnected from the voltage source and then *connected to each other*. Briefly describe what happens.

SECTION 4

1-13: The image of the circuit below contains several different symbols for individual components. List what each numbered symbol represents. Each component is worth 2 points. (26)

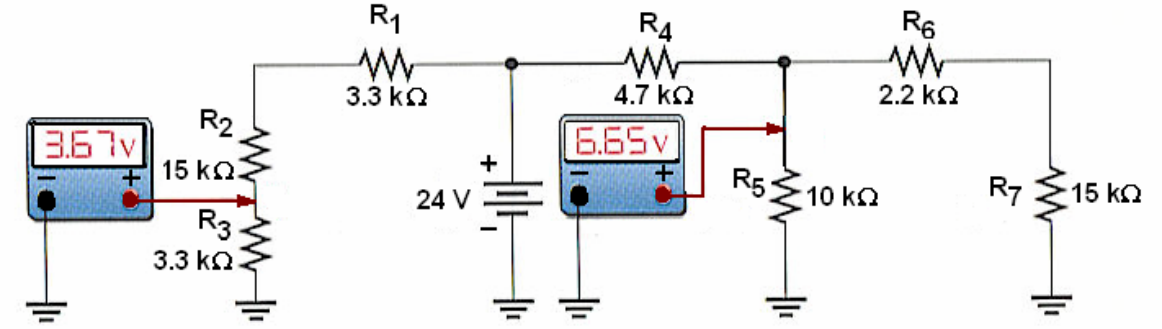


14-19: (Tiebreaker 1) The image below shows a circuit consisting of 3 resistors and 2 ideal batteries. Note the polarity of each battery. Use the data provided and solve for the current and voltage drop across each resistor. Each quantity is worth 3 points. (18)

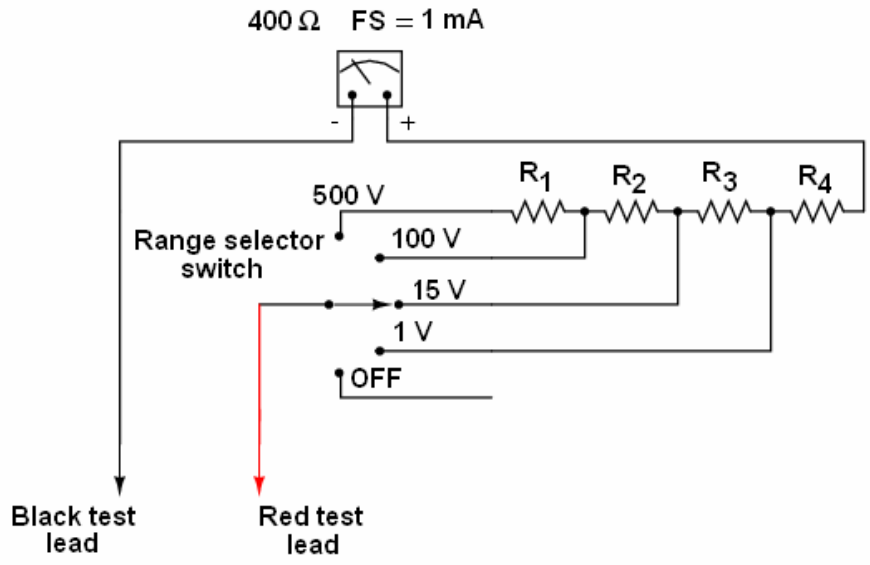


V_A	24.00	volts
V_B	12.00	volts
R_1	12.00	Ω
R_2	33.00	Ω
R_3	67.00	Ω

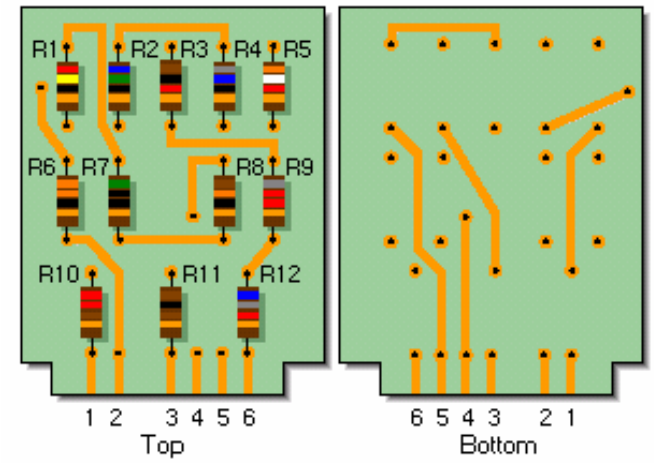
(4) 20. (Tiebreaker 6) What is the problem with this circuit?



21. - 24. A multi-range voltmeter is to be constructed such that the full-scale deflection on the galvanometer occurs with a current of 1.00 mA through the meter. The resistance of the galvanometer itself is 400 Ω. What are the values of the resistors R_1, R_2, R_3, and R_4 such that full-scale deflection of the meter occurs at 500 volts, 100 volts, 15 volts, and 1 volt? Each resistor is worth 2 points.



25 – 30. See the image of the front and back of a printed circuit board below. The "terminals" are numbered at the bottom.



(2) 25. The positive terminal of a 110 V DC voltage source is connected to terminal 1. Which of the other terminals (if any) will produce a current if the negative terminal of the source is connected to it?

(2) 26. How many separate circuits are on this board?

(3) 27. Which resistor(s), if any, are wired in series with R5?

(2) 28. Which resistor(s), if any, are wired in parallel with R7?

(2) 29. An ohmmeter (in the proper range) is connected across terminals 5 and 6. What does it read?

(2) 30. An ohmmeter (in the proper range) is connected across terminals 1 and 2. What does it read?