Exploring the World of Science

University of Michigan Science Olympiad
2021 Invitational Tournament

Detector Building C

Test length: 50 Minutes

Team name: _____ **Team number:** _____

Student names: _____

Detector Building C - Detector Building Test - University of Michigan Div C - 02-20-2021

Instructions (shown before students start the test)

Welcome to the University of Michigan 2021 Invitational Detector Building test! Make sure you have a stable internet connection and are ready to compete!

For this test, you are allowed the following resources:

- A Google Meet/Zoom/Skype/Phone/Video call with your partner
- A 2 inch or smaller binder containing information in pdf form or printed
- Programmable/Non-programmable calculator
- Scratch paper

You MAY NOT take advantage of the following resources. Doing so will result in a disqualification plus 30 points added to your team's overall score.

- ANY internet resource
- Help from any person other than your partner
- A printed version of the test

Introduction (shown after students start the test)

This test consists of 40 questions and you will have 50 minutes to complete it.

The Tiebreakers for this test will be: Question 19, Question 25, and Question 7 in that order.

If you experience technical difficulties during the test:

Immediately contact the event supervisor through the classroom feature on Scilympiad, stating clearly what issue you are having.

If your work is not saving/submitting, take screenshots of your answers on Scilympiad and submit them to this google form (https://docs.google.com/forms/d/19cRQLafN7EARRS7tZH
8HOCt4B1F-4fYOSIiON1kro/viewform?edit_requested=true). Try to stay within your allotted 50 minutes.

This test contains various types of questions, make sure you read the entire question!

1. (1.00 pts) Which law is Gay Lussac known for?

- A) If a gas's **pressure decreases**, then so does its **temperature** if the mass and volume of the gas are held constant.
- B) If a gas's **temperature decreases**, then its **pressure increases** if the mass and volume of the gas are held constant.
- C) If a gas's **temperature increases**, then so does its **pressure** if the mass of the gas is held constant.
- D) If a gas's **temperature increases**, then so does its **pressure** if the size of the gas is held constant.

2. (1.00 pts) A famous physicist with the first name Daniel is known for his work developing a temperature scale. Which one is it?

- A) The Fahrenheit Scale
- B) The Kelvin Scale
- C) The Celsius Scale
- D) The Rankine Scale

3. (2.00 pts) What is 0 degrees Fahrenheit in Kelvin? (Nearest whole number, do not include units)

4. (1.00 pts) What is the coldest temperature possible?

- A) Total zero
- B) Absolute zero
- C) Absolute freezing
- D) Complete zero
- E) The critical point

5. (1.00 pts) What is an NTC thermistor?

- A) A thermally sensitive resistor whose resistance distinctively decreases (a precise and predictable change) as the temperature at the core increases.
- B) A thermally sensitive resistor whose resistance decreases (by subtle margins that require estimations) as the temperature at the core increases.
- C) A resistor that changes colors based on the temperature at its core.
- D) A thermistor that changes size significantly based on the temperature at its core.
- E) A thermally sensitive resistor whose resistance decreases (by subtle margins that require estimations) as the temperature at the core decreases.

6. (1.00 pts) What is not true about the Light Emitting Diode?

- A) When buying an LED bulb, you will notice they cost less than incandescent bulbs.
- B) They hold the title for producing the longest-lasting and most efficient lighting available today.
- C) They work great with solar powered systems since they consume low amounts of energy.
- D) They can be made very compact so they can fit anywhere.
- E) Display screens can be made out of them.

7. (1.00 pts) **Tie Breaker 3** How much more energy is wasted in an incandescent than an LED?

- A) 90% of power goes to heat in an incandescent and 20% goes to heat in an LED
- B) 40% of power goes to heat in an incandescent and 5% goes to heat in an LED
- C) 80% of power goes to heat in an incandescent and 0% goes to heat in an LED
- D) 30% of power goes to heat in an incandescent and 80% goes to heat in an LED

8. (1.00 pts)
What is the measurement of light based off of (where a gram – the measurement of mass – is "based off of" 1 cubic cm of water at 4 degrees Celcius)? This is the SI unit of luminous intensity.

- A) 1 Small LED
- B) 1 Florescent Lightbulb
- C) 1 Candle
- D) 1 Spark
- E) 1 Firework

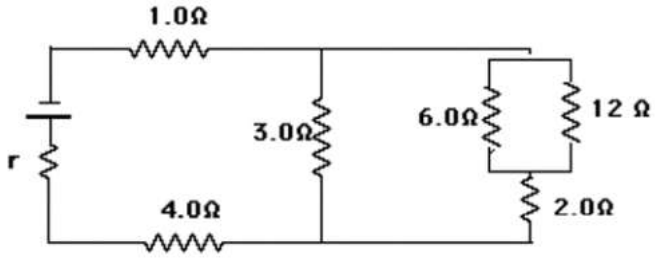
9. (1.00 pts) In a substance, temperature is the average _____ energy of the moving particles.

- A) Potential
- B) Frictional
- C) Thermal
- D) Nuclear
- E) Kinetic

10. (1.00 pts) Which of the following are ways to increase water's boiling point?

- A) Adding more water
- B) Removing some water
- C) Dissolving a solute in it
- D) Dissolving a solvent in it

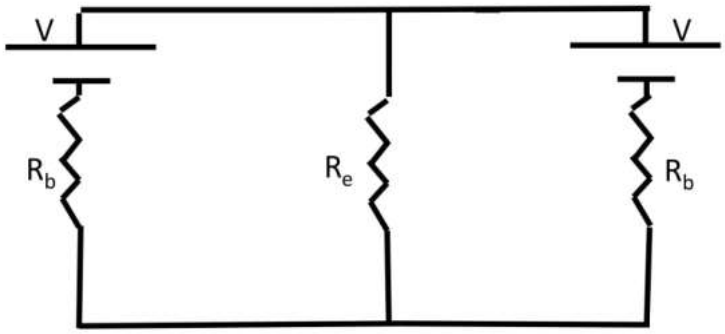
11. (2.00 pts) Calculate the Total Resistance of this circuit where r is 2 Ohms. Round to the nearest whole number and do not include units. (Free Response)



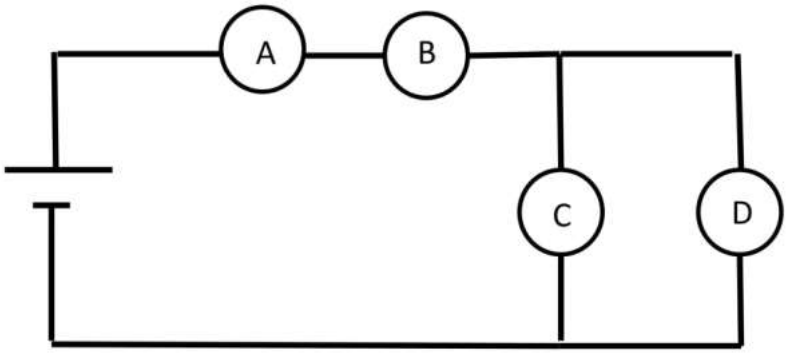
12. (1.00 pts)
Two cylindrical resistors are made from the same material and have equal diameters but the first resistor (resistor A) has length L and the second resistor (resistor B) has length 2L. I the current is the same through both, compare the voltages across them. (VA is voltage across resistor A and VB is voltage across resistor B)

- A) VA > VB
- B) VA = VB
- C) VA < VB

13. (3.00 pts)
In a circuit there are two identical batteries with voltage V = 9 Volts and each battery is in series with a resistor Rb = 7.87 Ohms. Another resistor, Re is rated at 9.06 Ohms. What is the magnitude of current through Re? Round to the nearest hundredth place and do not include units. (Free Response)

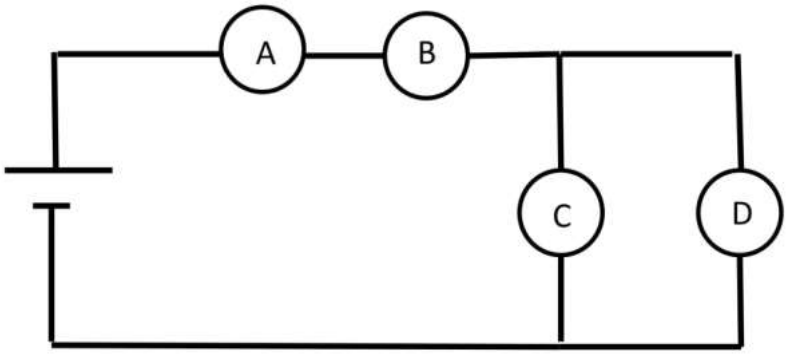


14. (2.00 pts) Four identical bulbs are placed in a circuit. If D burns out (no current flows through D), what will happen to the brightness of bulb C?



- A) C gets brighter
- B) C gets dimmer
- C) C stays the same

15. (2.00 pts) Four identical bulbs are placed in a circuit. If D burns out (no current flows through D), what will happen to the Voltage across C?



- A) V stays the same
- B) V decreases
- C) V increases

16. (1.00 pts) What is NOT a practical use for an LED?

- A) Can be used to measure speed
- B) Can be used in remotes to transmit information
- C) Can be used to check if code is working
- D) Can be used to store energy

17. (1.00 pts) What can an LED do? Select all that apply.

(Mark **ALL** correct answers)

- [ ] A) Cause a drop in current
- [ ] B) Cause a drop in voltage
- [ ] C) Cause current to only flow in one direction
- [ ] D) Store energy that can be used later by the circuit
- [ ] E) Store energy as light that can be used later by the circuit

18. (1.00 pts) In a DC circuit, what does adding resistors before an LED do?

- A) Makes the LED dimmer
- B) Makes the LED brighter
- C) LED brightness will remain the same

19. (2.00 pts) **Tie Breaker 1** What is the Steinhart-Hart equation?

- A) Converts a reading of resistance to a value measured in Kelvin
- B) Converts a reading of resistance to a value measured in Celsius
- C) Converts a reading of current to a value measured in Kelvin
- D) Converts a reading of voltage to a temperature value

20. (2.00 pts) What happens at 0 Kelvin?

- A) Water freezes
- B) Things start to melt
- C) Water boils
- D) All molecular motion stops

21. (1.00 pts)
There is a thermometer that consists of a bulb containing a liquid that expands into a capillary tube. The current liquid is replaced with another (same volume) that expands more for the same rise in temperature. The new thermometer will have

- A) More sensitivity and a larger range
- B) Less sensitivity and a larger range
- C) More sensitivity and less range

D) Less sensitivity and less range

22. (1.00 pts) In a liquid-in-glass thermometer, temperature shown increases. What is constant?

A) Mass of liquid
B) Density of liquid
C) Volume of liquid
D) The kinetic energy of the molecules

23. (1.00 pts) Which of the following is **not** a type of thermometer?

A) K-Type Thermometer
B) Resistance Thermometer
C) Thermocouple Thermometer
D) Solid Core Thermometer

24. (1.00 pts)
All thermometers must be calibrated to ensure they function properly. If you must do this without another thermometer, you may need a substance of a temperature known to you so you can compare it with the reading of the thermometer. What is needed:

A) A high fixed-point temperature
B) A low fixed-point temperature
C) A low and high fixed-point temperature
D) No fixed-point temperatures are required for calibration

25. (1.00 pts) **Tie Breaker 2** How does an Infrared Thermometer work?

A) Collects infrared light from molecules and converts it to heat.
B) The beam allows the sensor to feel the surface, kind of like it was an extension.
C) It measures the heat of the infrared beam shot from the thermometer.
D) It measures the heat in between the detector and object and makes a calculation based on distance.

26. (3.00 pts) Cold objects (above 0 K) will always _____.

A) Emit light
B) Cool other objects
C) Contract
D) Expand

27. (1.00 pts) What state of matter do modern thermometers rely on the expansion and contraction of to calculate the temperature?

A) Gas

B) Solid

C) Fluid

D) Some combination of them

28. (1.00 pts) What is not a type of resistance varying resistor (variable resistor)?

A) Humistor

B) Photoresistor

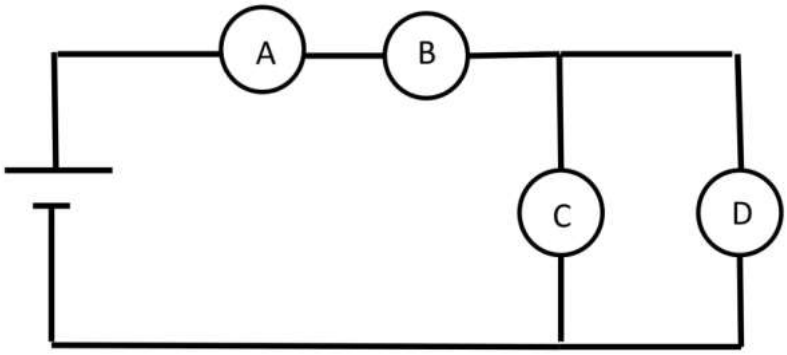
C) Potentiometer

D) Grid resistor

29. (1.00 pts) What color would you use to calibrate a color sensor? (Use all lower case letters)

30. (1.00 pts) What does LED stand for? (Use all lower case letters)

31. (2.00 pts) Four identical bulbs are placed in a circuit. If A burns out (no current flows through A), what will happen to the Voltage across C?



A) V stays the same

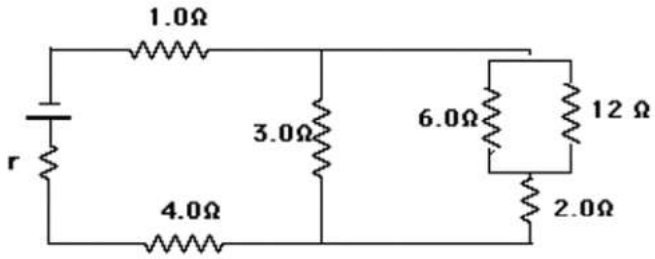
B) V decreases

C) V increases

32. (3.00 pts)
There is a battery, LED, and a resistor wired in series in a circuit. What is the needed resistance of the resistor to prevent the LED from burning out? The ideal current for the LED is 28mA, VLED is 2.2V, and VBattery is 9V. Round to the nearest whole number if needed and do not include units.

33. (1.00 pts)
You have many LEDs, all rated for 1.5V and 2.0mA, but you do not have any resistors. With a 9V battery, what is the minimum number of LEDs you would have to use to ensure you do not burn out your LEDs?

34. (2.00 pts) Calculate the voltage of the battery if the current through the battery is 3 Amps. r = 2 Ohms. Do not include units or decimals. (Free Response)



35. (1.00 pts) Enter the three generally accepted body temperatures considered healthy. No decimals.

36. (1.00 pts) Daniel Fahrenheit was responsible for inventing which thermometer?

- A) Alcohol-in-glass thermometer
- B) Mercury-in-glass thermometer
- C) Solid Core thermometer
- D) Digital thermometer

37. (2.00 pts) What was the earliest known thermometer called?

- A) Thermometer
- B) Thermoscope
- C) Temperature Detector
- D) Temperature Finder
- E) Detector

38. (1.00 pts) What was the first standard temperature scale?

- A) Celsius
- B) Kelvin
- C) Henry
- D) Fahrenheit

39. (6.00 pts)
In the next few questions, you will answer the following: If you were competing in person, how would you go about making the detector?

Part 1:

Describe the physical components of how you would build your detector. Include describing electrical components and how you would make your thermometer probe.

40. (8.00 pts)

Part 2:

Describe the process you would use to convert the information from the sensor to temperature (without using the Steinhart-Hart equation or program libraries). Be specific!

Congratulations on completing the University of Michigan 2021 Invitational Detector Building test!

If you have any questions or concerns pertaining to this event, please email tec.umichscioly@umich.edu, and we will try to get back to you as soon as we can.