Detector Builder-C2020-Regional-Test Team #: Team Name:

score: /16 Member:

Member:

Points are based on the number of steps that must be shown to complete the problem, not the difficulty. For example, a one step problem is worth [1] point, a two step problem is worth [2] points, etc. There is a reference section at the end which includes useful formulas and tables.

1 Relationships between Resistance, Voltage, and Temperature

1.1 The relationship between a thermistor's temperature and its resistance is linear. [1]

(A) True
(B) False

1.2 The relationship between a thermistor's resistance and its voltage is [1]

(A) linear
(B) logarithmic
(C) exponential
(D) sinusoidal

1.3 When current passes through a thermistor, power is dissipated in the form of what? [1]

(A) Light
(B) Sound
(C) Gravity
(D) Heat

1.4 When a temperature difference exists across a thermocouple, a voltage is produced between the two ends of it. What is the name of this effect? [1]

(A) Hall Effect
(B) Peltier Effect
(C) Seebeck Effect
(D) Ettingshausen Effect

2 Theory of LEDs, Working Principles, and Applications

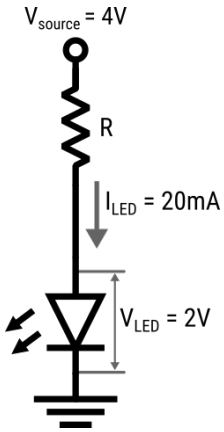
2.1 Given an LED with a forward voltage of 2.15V, theoretically, what color is the light released from the LED, based on table 1 in the reference section? [2]

- 1 point for using the equation that relates the LEDs forward voltage to its wavelength
- 1 point for writing the correct color

2.2 Explain why photons are released from an LED when it is powered. Use keywords such as *electrons* and *holes*, or, *conduction band* and *valence band*. [1]

2.3 We have an LED that we don't want to blow out. Our LED can safely handle a current of 20mA, I_{LED}, and has a forward voltage of 2V, V_{LED}. The circuit is supplied a voltage of 4V, V_{source}. Find the resistance, R. [3]

- 1 point for writing the current through the resistor
- 1 point for writing the voltage drop across the resistor
- 1 point for writing the resistance



3 The Process of Calibration

3.1 You are given a Negative Temperature Coefficient (NTC) thermistor. You take two resistance measurements across the thermistor at different temperatures (see table below). Find the material constant, β. *(Use the model given in the reference section)* [1]

Temperature	Resistance Measurement
$100°C$	950Ω
$20°C$	$12\text{k}\Omega$

3.2 Using the β value calculated above, estimate the temperature, given a resistance measurement of $R_{test} = 10\text{k}\Omega$. *(Answer in units of **Celsius**)* [1]

3.3 Which mathematical model **is the most accurate**, of the four choices below, for finding a precise temperature of a thermistor throughout the thermistor's entire working temperature range? [1]

(A) B-Parameter Equation
(B) Steinhart-Hart Equation
(C) Linear Equation
(D) Granger-Potter Equation

4 Operational Knowledge of Basic Device Components

4.1 What is the purpose of this component? *(It is not an axial inductor, though it looks like one)* [1]

(A) To store electrical charge.
(B) To resist the **change** in current.
(C) To limit current passing through it.
(D) To amplify a signal.

4.2 A **thermistor** acts similarly to which component? [1]

(A) Capacitor
(B) Transistor
(C) Resistor
(D) Inductor

4.3 What circuit component does a microcontroller use, internally, to convert an analog input voltage, connected to one of the microcontroller's GPIO pins, to a value that can be stored in memory? [1]

(A) Analog-to-Digital Converter
(B) Buck Converter
(C) Boost Converter
(D) AC-to-DC Converter

5 Reference

Table 1: Approximate Color with Respect to Wavelength

LED Color	Wavelength (nm)
Red	635-700
Orange	590-635
Yellow	560-590
Green	520-560
Cyan	490-520
Blue	450-490
Violet	400-450

Table 2: Constants and Equations

Symbol	Definition	Meaning
c	$3 \times 10^8 \text{m/s}$	Speed of Light
h	$4.136 \times 10^{-15} \text{eVs}$	Planck's Constant
f	c/λ	Frequency of Light
E	$h \cdot f$	Photon Energy

Temperature is in **Kelvin** for the below equations.

$$\beta = \frac{\ln \frac{R_{T1}}{R_{T2}}}{\frac{1}{T_1} - \frac{1}{T_2}} \qquad T = \frac{\beta}{\ln\left(\frac{R}{R_0 e^{-\beta/T_0}}\right)}$$