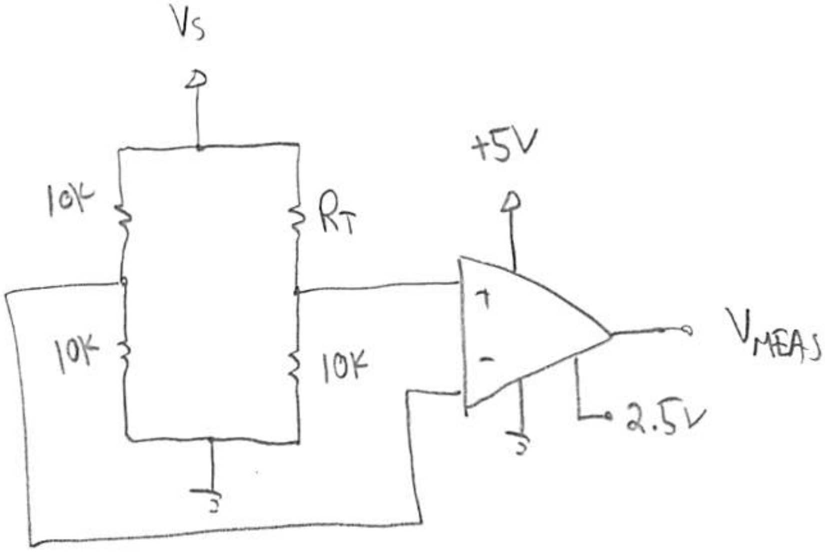
BME 386
Prelab 2 Solns

9 problems
30 pts

1) $\Delta V = V_s \frac{10K}{10K+R_T} - V_s \frac{10K}{10K+10K}$

$$\boxed{\Delta V = V_s\left(\frac{10K}{10K+R_T} - 0.5\right)}$$



2) According to data sheet:

$$\boxed{\begin{array}{l} R_T = 19.872K \text{ @ } 10^\circ C \\ \quad\;\; 6.535K \text{ @ } 35^\circ C \end{array}}$$

3) $\Delta V = 5\left(\frac{10K}{10K+19.872K} - 0.5\right) = \boxed{-0.826V}$ @ $T = 10^\circ C$

$\Delta V = 5\left(\frac{10K}{10K+6.535K} - 0.5\right) = \boxed{0.524V}$ @ $T = 35^\circ C$

4) $V_{MEAS} = 2.5 + A_d \Delta V$

Limited by amplifier!

At $T = 35^\circ C$: $V_{MEAS} < 4V$

$2.5 + A_d(0.524V) < 4V$

$A_d < \underline{\underline{2.86}}$

At $T = 10^\circ C$: $V_{MEAS} > 1V$ ← limited by amplifier!

$$2.5 + A_d(-.826) > 1V$$

$$1.5V > A_d(.826)$$

$$A_d < \underline{1.82}$$

$$\Rightarrow \text{Max allowable } \boxed{A_d = 1.82}$$

Satisfies both $A_d < 2.86$ AND $A_d < 1.82$

5) Closest available gain = $\underline{1.5}$

$$1.5 = 1 + \frac{49400}{R_g} \rightarrow R_g = 98.8K$$

$$\Rightarrow \text{Closest 5\% value} = \boxed{100K}$$

$$\text{Actual gain} = 1 + \frac{49400}{100000} = \boxed{1.494}$$

6)

$$V_{MEAS} = V_{REF} + A_d \Delta V = V_{REF} + A_d \times V_S\left(\frac{10K}{10K + R_T} - 0.5\right)$$

$$\frac{V_{MEAS} - V_{REF}}{A_d V_S} = \beta = \frac{10K}{10K + R_T} - 0.5$$

$$10K + R_T = \frac{10K}{\beta + .5}$$

$$R_T = 10K\left(\frac{1}{\beta + .5} - 1\right) = 10K\left(\frac{1}{\beta + .5} - \frac{\beta + .5}{\beta + .5}\right)$$

$$\boxed{R_T = 10K\left(\frac{0.5 - \beta}{0.5 + \beta}\right)} \leftarrow \beta = \frac{V_{MEAS} - V_{REF}}{A_d V_S}$$

7) $V_{MEAS} = 1.5V$

$$\rightarrow \beta = \frac{1.5 - 2.5}{(1.494)(5)} = -0.134$$

$$R_T = 10K\left(\frac{0.5 - (-.134)}{0.5 + (-.134)}\right) = 17.322K$$

$$T = \frac{1}{A + B\ln\left(\frac{17.322K}{10K}\right) + C\left[\ln\left(\frac{17.322K}{10K}\right)\right]^2 + D\left[\ln\left(\frac{17.322K}{10K}\right)\right]^3} - 273.15$$

$$= \boxed{12.95^\circ C}$$

8) $$\Delta V_{ADC} = \frac{5V}{2^{10}-1} = 4.9\,mV > \overbrace{2\,mV_{RMS}}^{\text{noise}}$$

Therefore, $$\Delta T_{MIN} = \frac{\Delta V_{ADC}}{\frac{\partial V_{MEAS}}{\partial T}}$$

$$V_{MEAS} = V_{REF} + A_d V_s\left(\frac{10K}{10K + R_T} - 0.5\right)$$

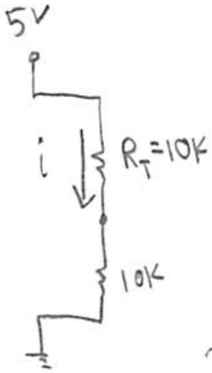
$$\frac{\partial V_{MEAS}}{\partial T} = -A_d V_s \frac{10K}{(10K + R_T)^2}\alpha R_T = -1.494 \times 5 \frac{10K}{(10K + 19.872K)^2} \times$$

$(-.0479\ 1/^\circ C)(19.872K)$

$= .080\ V/^\circ C$

$$\Rightarrow \Delta T_{MIN} = \frac{.0049V}{.080V/^\circ C} = \boxed{0.06^\circ C}$$

9) At $T = 25^\circ C$:



$$P = \left(\frac{5V}{20K}\right)^2 10K = 0.625\,mW \leftarrow$$

or can use

$$P = IV = \left(\frac{5V}{20K}\right) \times \left(\frac{5V}{20K} \cdot 10K\right) = .625\,mW$$

$$\Delta T_{SELF} = \frac{.625\,mW}{7\,mW/^\circ C} = 0.09\,^\circ C$$

$$\frac{\partial V_{MEAS}}{\partial T} = -1.494 \times 5 \times \frac{10K}{(10K + 10K)^2} (-.0438\,{}^{1}/_{^\circ C})(10K) = 0.082\,V/^\circ C$$

$$\Delta T_{MIN} = \frac{.0049V}{.082\,V/^\circ C} = \underline{\underline{.06^\circ C}}$$

← Basically the same as value at $10^\circ C$

$\boxed{\text{NO, we cannot}}$

but OK if desired ΔT_{MIN} is much bigger than actual ΔT_{MIN}.