**Form No. T611**

**Philadelphia University**
**Faculty of Engineering**

**Student Name:**
**Student Number:**

## Dept. of Electrical Engineering
## Final Exam, Summer Semester: 2014/2015

| | |
|---|---|
| **Course Title: Instrumentation and Measurement** | **Date: 31/8/2015** |
| **Course No: (610332)** | **Time Allowed: 2 Hours** |
| **Lecturer: Dr. Mohammad Abu-Naser** | **No. of Pages: 4** |

Form A

***Question 1:*** ***(4Mark)***

**Objectives: This question is related to DC ammeters**

Ayrton shunt ammeter (Figure 1) has two resistors: $R_a = 0.005\ \Omega$, $R_b = 0.045\ \Omega$. The D'Arsonval movement has internal resistance $R_m = 1000\ \Omega$ and full scale deflection current $I_{fsd} = 50\ \mu A$. Calculate the two current ranges of the ammeter.

***Question 2:*** ***(4Mark)***

**Objectives: This question is related to rectifier-type AC voltmeter**

A full-wave rectifier voltmeter has an internal resistance of 50 Ω and full scale deflection current of 1 mA. Each diode has 50 Ω forward resistance and infinite reverse resistance. As shown in Figure 2 for 10 $V_{rms}$ AC range, calculate:

a) The multiplier resistance $R_s$.
b) Voltmeter sensitivity on the AC range.

***Question 3:*** ***(7Mark)***

**Objectives: This question is related to digital voltmeters**

a) Draw the block diagram of dual-slope digital voltmeter and name the main components.
b) If the integrator of the dual-slope digital voltmeter has a 100 kΩ resistor and 1 µF capacitor and the input voltage applied to the integrator is 1 V, what voltage will be present at the integrator output after $t_1 = 1$ second?
c) Now if a reference voltage is applied to the integrator in the previous part (b) at time $t_1 = 1$ second is 5 volts in amplitude, what is the time interval of $t_2$?

***Question 4:*** ***(6Mark)***

**Objectives: This question is related to Maxwell's bridge and error calculations**

A Maxwell's bridge is used to determine the self-inductance and the effective resistance of a coil. Under balance conditions the limiting values of various elements are:

$$R_1=1000\Omega\pm1\%,\ C_1=0.5\mu F\pm1\%,\ R_2=1000\Omega\pm1\%,\ R_3=1000\Omega\pm1\%$$

Calculate:

a) The value of the self-inductance ($L_4$) and effective resistance ($R_4$).
b) The limiting errors of both $L_4$ and $R_4$ in percent.
c) The limiting errors of both $L_4$ and $R_4$ in henry and ohm, respectively.

***Question 5:*** ***(6Mark)***

**Objectives: This question is related to temperature transducers**

At room temperature (25°C), the voltmeter in Figure 3 gives a reading of 6 V. The temperature of a material is sensed using platinum RTD and the voltmeter reading changed to 2.4 V. If the internal resistance of the voltmeter is 120 **Ω** and α=0.00392/°C, determine the temperature of the measured material.

***Question 6:*** ***(5Mark)***

**Objectives: This question is related to capacitive transducers**

A parallel plate capacitive transducer uses plates of area 250 $mm^2$ which are separated by a distance of 0.2 mm.

a) Calculate the value of capacitance when the dielectric is air having a permittivity of $8.85\times10^{-12}$ F/m.
b) Calculate the change in capacitance if a displacement reduces the distance between the plates to 0.18 mm.

***Question 7:*** ***(8Mark)***

**Objectives: This question is related to multiple choices**

1) In a permanent magnet moving coil ammeter the deflection of the pointer is proportional to the magnetic flux density produced by the permanent magnet. If the strength of the permanent magnet becomes 95% of the original, the meter gives erroneous reading. This error is classified as:
    a) Gross error.
    b) Systematic error.
    c) Random error.
    d) None of the above.

2) For the Lissajous in Figure 4, the phase angle is:
    a) 0°
    b) 30°
    c) 45°
    d) 60°

3) The voltage of a circuit is measured by a voltmeter having small impedance therefore causing error in measured voltage. This error is called
    a) Random error.
    b) Environmental error.
    c) Error caused by loading effect.
    d) None of the above.

4) Maxwell's bridge is used to measure inductance of:
    a) Low Q coil.
    b) Medium Q coil.
    c) High Q coil.
    d) Low and medium Q coils.

5) Frequency can be measured using:
   a) Anderson’s bridge.
   b) Wien’s bridge.
   c) Wheatstone bridge.
   d) Hay’s bridge.

6) The order in which the three types of temperature transducers exhibit sensitivity (highest to lowest) is:
   a) Thermistors, RTDs, thermocouples.
   b) Thermocouples, RTDs, thermistors.
   c) RTDs, thermistors, thermocouples.
   d) RTDs, thermocouples, thermistors.

7) The Lissajous pattern observed on screen of oscilloscope is a straight line inclined at 45° to x-axis. If ‘X’ plate input is 2sinωt, the 'Y' plate input is
   a) 2sin(ωt).
   b) 2sin(ωt + 45°).
   c) 2sin(ωt - 45°).
   d) 2√2sin(ωt + 45°).

8) Input to the 'Y' plate of oscilloscope is a signal defined by 10sin100t. Input to the 'X' plate is the signal 10cos100t. The gain for both X-channel and Y-channel is the same. The screen shows:
   a) A straight line.
   b) Sinisoidal.
   c) An ellipse.
   d) A circle.

Good luck

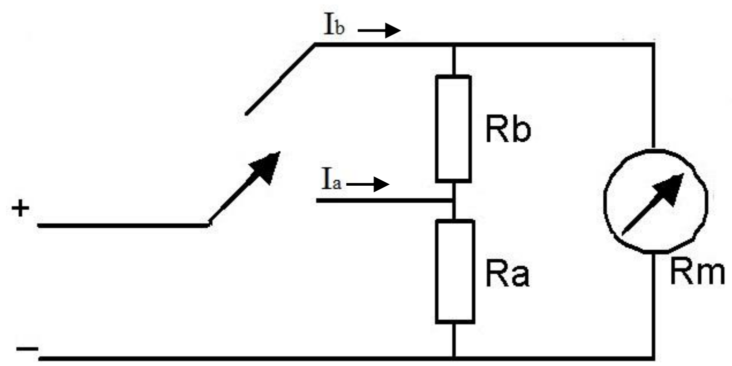



Figure 1

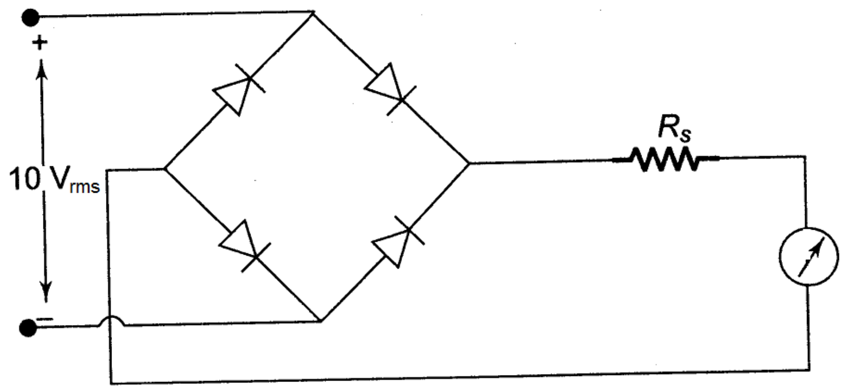



Figure 2

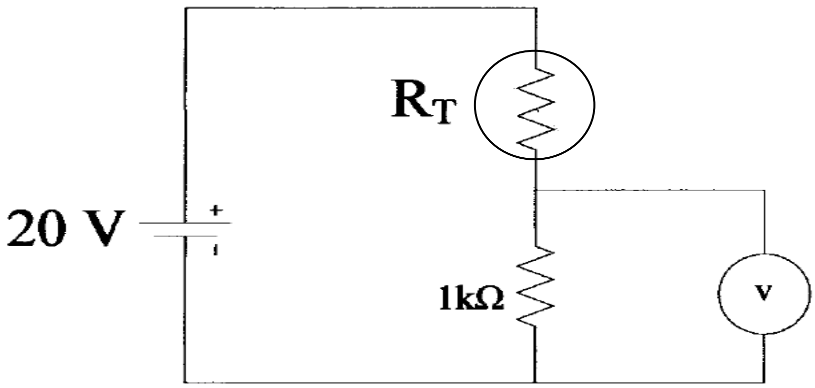



Figure 3

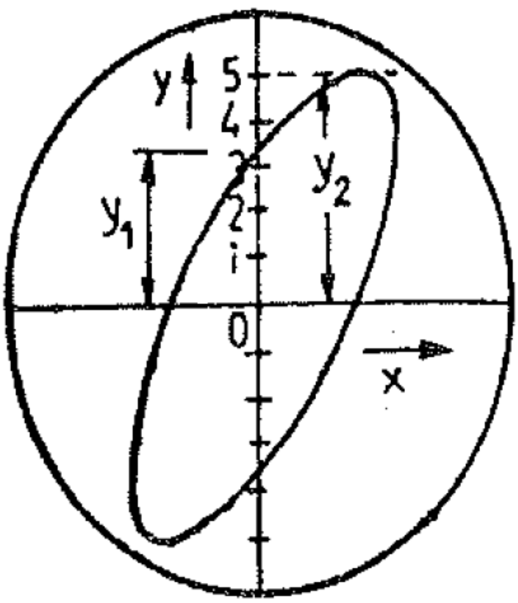



Figure 4

**Form No. T611**

**Philadelphia University**
**Faculty of Engineering**

**Student Name:**
**Student Number:**

## Dept. of Electrical Engineering
## Final Exam, Summer Semester: 2014/2015

| | |
|---|---|
| **Course Title: Instrumentation and Measurement** | **Date: 31/8/2015** |
| **Course No: (610332)** | **Time Allowed: 2 Hours** |
| **Lecturer: Dr. Mohammad Abu-Naser** | **No. of Pages: 4** |

Form B

***Question 1:*** ***(4Mark)***

**Objectives: This question is related to DC ammeters**

Ayrton shunt ammeter (Figure 1) has two resistors: $R_a$ = 0.005 Ω, $R_b$ = 0.045 Ω. The D'Arsonval movement has internal resistance $R_m$ = 1000 Ω and full scale deflection current $I_{fsd}$ = 50 µA. Calculate the two current ranges of the ammeter.

***Question 2:*** ***(4Mark)***

**Objectives: This question is related to rectifier-type AC voltmeter**

A full-wave rectifier voltmeter has an internal resistance of 50 Ω and full scale deflection current of 1 mA. Each diode has 50 Ω forward resistance and infinite reverse resistance. As shown in Figure 2 for 10 $V_{rms}$ AC range, calculate:

a) The multiplier resistance $R_s$.
b) Voltmeter sensitivity on the AC range.

***Question 3:*** ***(7Mark)***

**Objectives: This question is related to digital voltmeters**

a) Draw the block diagram of dual-slope digital voltmeter and name the main components.
b) If the integrator of the dual-slope digital voltmeter has a 100 kΩ resistor and 1 µF capacitor and the input voltage applied to the integrator is 1 V, what voltage will be present at the integrator output after $t_1$ = 1 second?
c) Now if a reference voltage is applied to the integrator in the previous part (b) at time $t_1$ = 1 second is 5 volts in amplitude, what is the time interval of $t_2$?

***Question 4:*** ***(6Mark)***

**Objectives: This question is related to Maxwell's bridge and error calculations**

A Maxwell's bridge is used to determine the self-inductance and the effective resistance of a coil. Under balance conditions the limiting values of various elements are:

$$R_1=1000\Omega\pm1\%,\ C_1=0.5\mu F\pm1\%,\ R_2=1000\Omega\pm1\%,\ R_3=1000\Omega\pm1\%$$

Calculate:

a) The value of the self-inductance ($L_4$) and effective resistance ($R_4$).
b) The limiting errors of both $L_4$ and $R_4$ in percent.
c) The limiting errors of both $L_4$ and $R_4$ in henry and ohm, respectively.

***Question 5:*** ***(6Mark)***

**Objectives: This question is related to temperature transducers**

At room temperature (25°C), the voltmeter in Figure 3 gives a reading of 6 V. The temperature of a material is sensed using platinum RTD and the voltmeter reading changed to 2.4 V. If the internal resistance of the voltmeter is 120 Ω and $\alpha$=0.00392/°C, determine the temperature of the measured material.

***Question 6:*** ***(5Mark)***

**Objectives: This question is related to capacitive transducers**

A parallel plate capacitive transducer uses plates of area 250 $mm^2$ which are separated by a distance of 0.2 mm.

a) Calculate the value of capacitance when the dielectric is air having a permittivity of $8.85\times10^{-12}$ F/m.
b) Calculate the change in capacitance if a displacement reduces the distance between the plates to 0.18 mm.

***Question 7:*** ***(8Mark)***

**Objectives: This question is related to multiple choices**

1) Capacitive transducers can be used for measurement of liquid level. The principle of operation used in this case is:
    a) Change of capacitance with change of distance between plates.
    b) Change of area of plates.
    c) Change of dielectric constant.
    d) None of the above.

2) For the Lissajous in Figure 4, the phase angle is:
    a) 0°
    b) 30°
    c) 45°
    d) 60°

3) Errors due to human mistakes are:
    a) Gross.
    b) Systematic.
    c) Instrumental.
    d) Random.

4) The advantage of Hay's bridge over Mawell's bridge:
    a) Its equations for balance do not contain any frequency terms.
    b) It can be used for measurement of inductance with low Q values.
    c) It can be used for measurement of inductance with high Q values.
    d) None of the above.

5) The resistance of a thermistor:
    a) Increases with increase in temperature.
    b) remains constant irrespective of the temperature.
    c) Decrease with increase in temperature in a linear manner.
    d) Decrease with increase in temperature in an exponential manner.

6) Platinum is commonly used in RTDs because:
   a) It has a constant value of resistance temperature coefficient of 0.00392 /°C for temperature ranges between 100°C to 650°C.
   b) It is very pure and accurate over large range of temperatures.
   c) It is very inert and can maintain stability for many years.
   d) All of the above.

7) The Lissajous pattern observed on screen of oscilloscope is a straight line inclined at 135° to x-axis. If 'X' plate input is $2\sin\omega t$, the 'Y' plate input is:
   a) $2\sin(\omega t)$.
   b) $-2\sin(\omega t)$.
   c) $2\sin(\omega t - 45°)$.
   d) $2\sqrt{2}\sin(\omega t + 45°)$.

8) Two in phase, 50 Hz sinusoidal waveforms of unit amplitude are fed into channel 1 and channel 2 respectively of an oscilloscope. Assuming that the voltage scale, time scale and other settings are exactly the same for both channels, what would be observed if the oscilloscope is operated in X-Y mode?
   a) A straight line inclined at 45° with respect to the X-axis
   b) A circle of unit radius.
   c) An ellipse.
   d) A parabola

Good luck

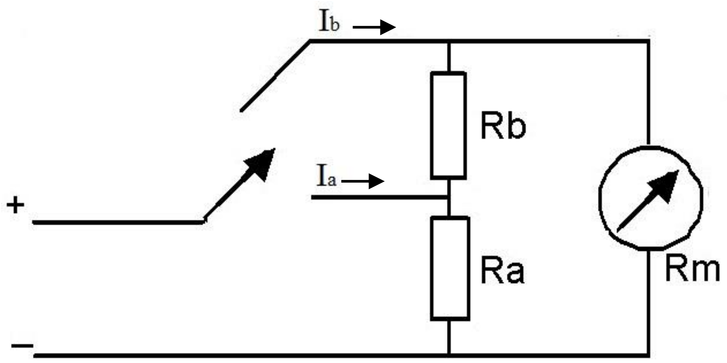



Figure 1

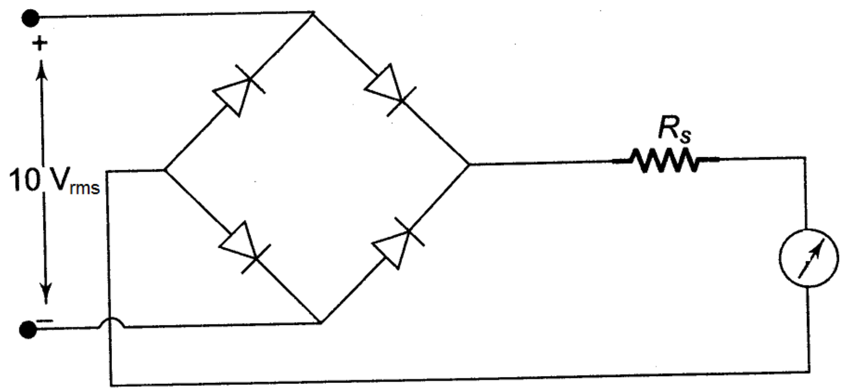


Figure 2

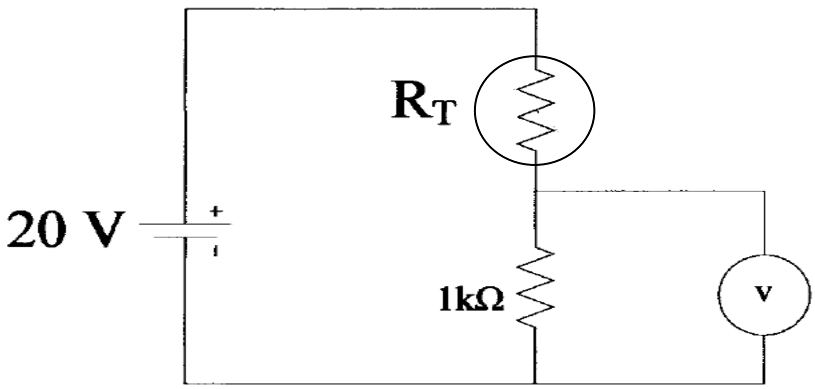


Figure 3

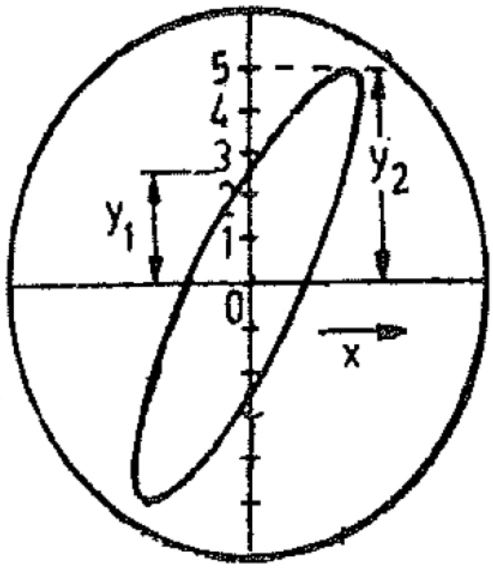


Figure 4

Instrumentation and Measurement
Final Exam
Summer Semester 2014/2015

**Q1**

Range $I_a$

$(R_a) \parallel (R_b + R_m)$

$I_m(R_b + R_m) = (I_a - I_m) R_a$

$50\times10^{-6}(.045 + 1000) = (I_a - 50\times10^{-6}).005$

$.05000225 = .005 I_a - 2.5\times10^{-7}$

$.005 I_a = .0500025$

$\Rightarrow I_a = 10\ A$

Range $I_b$

$(R_a + R_b) \parallel R_m$

$I_m R_m = (I_b - I_m)(R_a + R_b)$

$50\times10^{-6}\times1000 = (I_b - 50\times10^{-6})(.005 + .045)$

$.05 = .05 I_b - 2.5\times10^{-6}$

$.05 I_b = .0500025$

$\Rightarrow I_b = 1A.$

**Q2**

a) $V_{ave} = 0.9\times V_{rms}$

$= 0.9\times10 = 9V$

$R_{total} = \frac{9V}{1mA} = 9000\ \Omega$

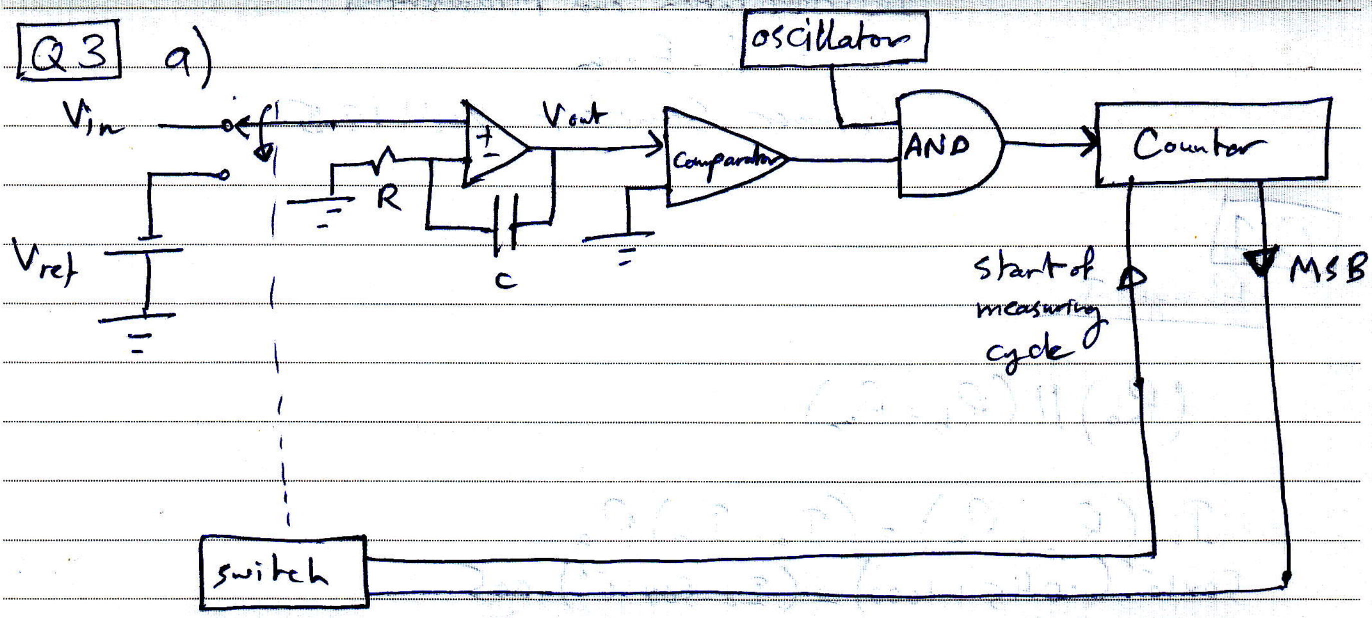
$R_s = R_{total} - R_m - 2R_D$

$= 9000 - 50 - 2\times50$

$= 8850\ \Omega$

b) $S_{AC} = \frac{R_{total}}{V_{rms}} = \frac{9000}{10} = 900\ \Omega/V.$

Q3 a)




b) $V_{out} = \dfrac{V_{in} t_1}{RC}$

$= \dfrac{1 * 1}{100 \times 10^3 * 1 * 10^{-6}} = 10\ V$

c) $\dfrac{t_2}{t_1} = \dfrac{V_{in}}{V_{ref}} \Rightarrow t_2 = \dfrac{V_{in}}{V_{ref}} * t_1 = \dfrac{1}{5} * 1 = 0.2$ seconds.

Q4

a) $R_4 = \dfrac{R_2 R_3}{R_1} = \dfrac{(1000 \pm 1\%)(1000 \pm 1\%)}{(1000 \pm 1\%)} = 1000 \pm 3\%$

$L_4 = R_2 R_3 C_1 = (1000 \pm 1\%)(1000 \pm 1\%)(0.5 * 10^{-6} \pm 1\%)$
$= 0.5 \pm 3\%$

$\therefore R_4 = 1000\ \Omega$
$L_4 = 0.5\ H$

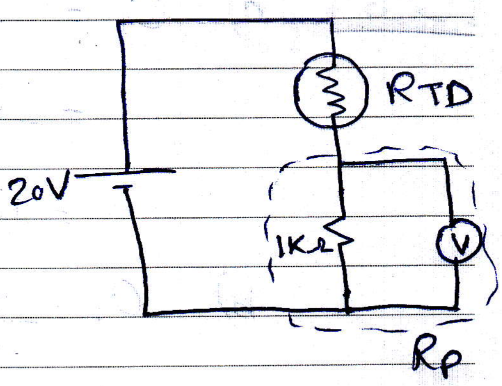
b) Limiting error of $R_4$ is 3%.
Limiting error of $L_4$ is 3%.

c) Limiting error of $R_4 = \dfrac{3}{100} \times 1000 = 30\ \Omega$

Limiting error of $L_4 = \dfrac{3}{1000} \times 0.5 = 0.015\ H$

**Q5**

$R_P = 1000 \parallel 120$
$= 107.14\ \Omega$




**At 25°C**

$$V_{measured} = V \times \frac{R_P}{R_{total}}$$

$$6 = 20 \times \frac{107.14}{R_{RTD} + 107.14}$$

$$6 R_{RTD} = 14 \times 107.14 = 1500\ \Omega$$

$$R_{RTD\ at\ 25^\circ C} = \frac{1500}{6} = 250\ \Omega$$

**At material temperature**

$$2.4 = 20 \times \frac{107.14}{R_{RTD} + 107.14}$$

$$2.4 R_{RTD} = 17.6 \times 107.14 = 1886\ \Omega$$

$$R_{RTD,\ material} = \frac{1886}{2.4} = 785.7\ \Omega$$

$$\therefore R_{material} = R_{25^\circ C}[1 + 0.00392\ \Delta T]$$

$$785.7 = 250[1 + 0.00392\ \Delta T]$$

$$\Rightarrow \Delta T = 546.6^\circ C$$

$$\Rightarrow T = 546.6 + 25 = 571.6^\circ C$$

**Q6**

a) $C_1 = \frac{\varepsilon A}{d_1}$

$= \frac{8.85 \times 10^{-12} \times 250 \times 10^{-6}}{0.2 \times 10^{-3}}$

$= 11.06 \ pF$

b) $C_2 = \frac{\varepsilon A}{d_2}$

$= \frac{8.85 \times 10^{-12} \times 250 \times 10^{-6}}{0.18 \times 10^{-3}}$

$= 12.29 \ pF$

$\Delta C = 12.29 - 11.06 = 1.23 \ pF.$

**Q7**

Form A: 1) b 2) c 3) c 4) b 5) b 6) a 7) a 8) d

Form B: 1) c 2) b 3) a 4) c 5) d 6) d 7) b 8) a