Question 1
Controlling torque, $T_C = k\theta = 0.3 \times 10^{-6} \times \theta$ Nm
Deflecting torque, $T_d = 28.8 \times 10^{-6}$ Nm
In the final deflected position, $T_d = T_C$
$\therefore 0.3 \times 10^{-6} \times \theta = 28.8 \times 10^{-6}$

or $\theta = \dfrac{28.8\times10^{-6}}{0.3\times10^{-6}} = 96^\circ$

Question 2
Deflecting torque, $T_d \propto I^2$

(i) In spring-controlled instrument,

controlling torque $T_C \propto \theta$

In the final deflected position, $T_d = T_C$ so that $\theta \propto I^2$

For first case, $\theta_1 \propto 10^2$

For second case, $\theta_2 \propto 5^2$

$$\therefore \quad \frac{\theta_2}{\theta_1} = \frac{5^2}{10^2} \quad or \quad \theta_2 = \theta_1 \times \frac{5^2}{10^2} = 90^\circ \times \frac{25}{100} = 22.5^\circ$$

(ii) In gravity-controlled instrument,

controlling torque $T_C \propto \sin\theta$

In the final deflected position, $T_d = T_C$ so that $\sin\theta \propto I^2$

For first case, $\sin\theta_1 \propto 10^2$

For second case, $\sin\theta_2 \propto 5^2$

$$\therefore \quad \frac{\sin\theta_2}{\sin\theta_1} = \frac{5^2}{10^2} \quad or \quad \sin\theta_2 = \sin\theta_1 \times \frac{5^2}{10^2} = \sin 90^\circ \times \frac{25}{100} = 0.25$$

$$\therefore \quad \theta_2 = \sin^{-1} 0.25 = 14.5^\circ$$

Question 3
Full-scale deflection (F.S.D.), $\theta = 100°$; Voltage for F.S.D., V = 100 mV = 0.1 volt;
Resistance of voltmeter, $R_V = 200\ \Omega$

F.S.D. current, I_g

$$I_g = \frac{V}{R_V} = \frac{0.1}{200} = 0.0005 \text{ A}$$

F.S.D. deflecting torque, $T_d = BI_g N A$

Here, B = 0.2 Wb/m^2 ; I_g = 0.0005 A ; N = 100 turns ; A = 0.03 × 0.025 m^2

$T_d = 0.2 \times 0.0005 \times 100 \times 0.03 \times 0.025 = 7.5 \times 10^{-6}$ Nm

In the final deflected position, controlling torque, $T_C = T_d = 7.5 \times 10^{-6}$ Nm.

Now, $T_C = k\,\theta$

Control spring constant, k

$$k = \frac{T_C}{\theta} = \frac{7.5\times10^{-6}}{100} = \mathbf{7.5 \times 10^{-8}\ Nm/degree}$$

Length of coil, $l = 2(30 + 25) \times 10^{-3} \times 100 = 11$ m

Resistance of coil, R_C = 20% of R_V = 20/100× 200 = 40 Ω

Now, $R_C = \rho l/a$

X-sectional area of wire, a

$$a = \frac{\rho l}{R_C} = \frac{1.7\times10^{-8}\times11}{40} = 0.4675 \times 10^{-8}\ \text{m}^2$$

Now, $a = \pi d^2/4$

Diameter of wire, d

$$d = \sqrt{\frac{4a}{\pi}} = \sqrt{\frac{4\times0.4675\times10^{-8}}{\pi}} = 0.077 \times 10^{-3}\ \text{m}$$

$$d = 0.077\ \text{mm}$$

The small diameter of the instrument coil shows that it can carry very small current (a few mA) without being burnt due to excessive heat.

Question 4

$$\text{Multiplying power of shunt } = \frac{I}{I_m} = \frac{R_m + S}{S} = \frac{1.6+0.228}{0.228} = 8$$

$$\therefore \quad I_m = \frac{I}{8} = \frac{200}{8} = 25\ \text{mA}$$

Question 5

$$\text{Multiplying power of shunt } = \frac{I}{I_m} = \frac{10}{2.5\times10^{-3}} = 4000$$

$$\textit{Now,}\quad 4000 = \frac{R_m + S}{S} = \frac{R_m + 0.0025}{0.0025}$$

$$\therefore \quad R_m = 10\,\Omega$$

Question 6

The resistance RAB is negligible because ammeter has negligible resistance. This means that circuit resistance is equal to the resistance of the voltmeter (i.e., 2000 Ω).

∴ Circuit current, I = 2V / 2000 Ω = 1 mA

Hence, the reading of the ammeter will be 1 mA.

P.D. across voltmeter = I × Resistance of voltmeter = 1 mA × 2000 Ω = 2 V

Hence the voltmeter will read 2 V.

Question 7

The current through the meter and hence deflection of the pointer is inversely proportional to the total meter resistance (i.e., the sum of series resistance and the coil resistance).

Let the unknown voltage be *V* volts

$$V \propto \frac{1}{12000} \quad \text{and} \quad 242 \propto \frac{1}{12000+2500}$$

$$\therefore \quad \frac{V}{242} = \frac{12000+2500}{12000}$$

$$\text{or} \quad V = \frac{14500}{12000} \times 242 = 292.42 \text{ volts}$$