Marking scheme

Any other solution that leads to correct results will be scored accordingly.

Theoretical Problem nr. 3 - Water world

A.	Part A. Falling droplets		Points
A.1.	$p_{up} + p_{hidro} = p_{down}$ $\sigma = \dfrac{\rho \cdot g \cdot h \cdot \left(h^2 - \delta^2\right)}{2\delta}$ $\quad \sigma \cong \dfrac{\rho \cdot g \cdot h^3}{2\delta}$	0.3p	**0.5p**
	$\sigma = 6.5 \times 10^{-2} N \cdot m^{-1}$	0.2p	
B.	Part B. Stalagmometer		Points
B.1.	$G = F_\sigma$ $\quad R = \sqrt[3]{\dfrac{3 \cdot d \cdot \sigma}{4 \cdot g \cdot \rho}}$	0.3p	**0.5p**
	$R = 7.9 \times 10^{-4} m$	0.2p	
B.2.	$G + F_H = F_\sigma$ $\quad \begin{cases} R_H = \sqrt[3]{\dfrac{3}{4}\left(\dfrac{d \cdot \sigma}{\rho \cdot g} - \dfrac{d^2 \cdot H}{4}\right)} \\ R_H = R \cdot \sqrt[3]{1 - \dfrac{d \cdot H \cdot \rho \cdot g}{4\sigma}} \end{cases}$	0.3p	**0.5p**
	$R_H = 7.4 \times 10^{-4} m$	0.2p	
C.	Part C. Electrically charged droplets		Points
C.1	The variation of the volume of the conductive drop, if its radius increases with the infinitely small amount ΔR $\Delta V = \dfrac{4\pi}{3} \cdot \left[\left(R + \Delta R\right)^3 - R^3\right] \cong 4\pi \cdot R^2 \cdot \Delta R$	0.3p	**2.0p**
	Variation of the capacitance of the spherical capacitor represented by the drop $\Delta C = 4\pi \cdot \varepsilon_0 \cdot \Delta R$	0.3p	
	The variation of the electrostatic energy, accumulated in the drop at the constant potential $\Delta W_\varepsilon = 2\pi \cdot \varepsilon_0 \cdot \phi^2 \cdot \Delta R$	0.4p	
	Mechanical work L_ε of electrostatic pressure p_ε, when increasing the volume with ΔV $\begin{cases} L_\varepsilon = p_\varepsilon \cdot \Delta V \\ L_\varepsilon = p_\varepsilon \cdot 4\pi \cdot R^2 \cdot \Delta R \end{cases}$	0.4p	
	$\Delta W_\varepsilon = L_\varepsilon$	0.3p	
	$p_\varepsilon = \dfrac{\varepsilon_0 \cdot \phi^2}{2R^2}$	0.3p	

C.2.	The expression of the pressure exerted towards the outside of the drop, just before the moment of its spraying $p_{\varepsilon}=\frac{\varepsilon_0\cdot\phi_{max}^2}{2R^2}$	0.2p	**1.0p**
	The expression of the pressure exerted towards the inside of the drop $p_{\sigma}=\frac{2\sigma}{R}$	0.2p	
	$p_{\sigma}=p_{\varepsilon}$	0.2p	
	$\phi_{max}=2\cdot\sqrt{\frac{\sigma\cdot R}{\varepsilon_0}}$	0.2p	
	$\phi_{max}=5.4\times10^3 V$	0.2p	
C.3.	The pressure due to the surface tension in each of the n small drops $p_{\sigma\pi}=\frac{2\sigma}{r}$ $p_{\sigma\pi}=\frac{2\sigma}{R}\cdot\sqrt[3]{n}$	0.2p	**1.0p**
	The electrostatic potential of each small drop $\frac{R}{n}\cdot\phi_{max}=r\cdot\phi_{\pi}$ $\phi_{\pi}=\frac{1}{\sqrt[3]{n^2}}\cdot2\cdot\sqrt{\frac{\sigma\cdot R}{\varepsilon_0}}$ $\phi_{\pi}=2\cdot\sigma^{1/2}\cdot\varepsilon_0^{-1/2}\cdot R^{1/2}\cdot n^{-2/3}$	0.2p	
	The outward pressure determined by the electric charges on each small drop $p_{\varepsilon\pi}=\frac{\varepsilon_0\cdot\phi_{\pi}^2}{2r^2}$ $p_{\varepsilon\pi}=\frac{2\sigma}{R}\cdot n^{-2/3}$	0.2p	
	Expression of the pressure leading to the spherical shape of the droplets resulting from the spray $p_{\pi}=\frac{2\sigma}{R}\cdot\left(n^{1/3}-n^{-2/3}\right)$	0.2p	
	$p_{\pi}=5.1\times10^2 N\cdot m^{-2}$	0.2p	
D.	***Part D. Water in magnetic field***		***Points***
D.1.	$\Delta w=w_w-w_0=\frac{B^2}{2\mu_0}\cdot\left(\frac{1}{\mu_r}-1\right)$	0.3p	**0.3p**
D.2.	$\Delta W=v\cdot\frac{B^2}{2\mu_0}\cdot\left(\frac{1}{\mu_r}-1\right)$	0.4p	**1.5p**
	$L=v\cdot(p_N-p_M)$	0.4p	
	$v\cdot(p_N-p_M)=v\cdot\frac{B^2}{2\mu_0}\cdot\left(\frac{1}{\mu_r}-1\right)$	0.5p	
	$p_N-p_M=\frac{B^2}{2\mu_0}\cdot\left(\frac{1}{\mu_r}-1\right)$	0.2p	
D.3.	$p_N=p_0+\rho\cdot g\cdot\frac{\mathbb{L}}{4}\cong p_0$	0.3p	**1.5p**
	$p_M=p_0-\frac{B^2}{2\mu_0}\cdot\left(\frac{1}{\mu_r}-1\right)$	0.4p	
	$p_M=p_s$ $p_s=p_s(70°C)$	0.3p	
	$I=\sqrt{-\frac{2\mu_0\cdot(1+\chi)\cdot(p_0-p_s)}{K^2\cdot\chi}}$	0.3p	
	$I=2.7\times10^3 A$	0.2p	

E.	Part E. Rising bubbles		Points
E.1.	$L_{bubble} = \pi \cdot R^2_{bubble} \cdot h_0 \cdot \rho \cdot \frac{v^2_{bubble}}{2}$	0.4p	**0.4p**
E.2.	$F_{asc} = \frac{4\pi}{3} \cdot R^3_{bubble} \cdot g \cdot \rho$ *Note: the weight of the vapor is negligible* $F_{dis} = \pi \cdot R^2_{bubble} \cdot \rho \cdot \frac{v^2_{bubble}}{2}$	0.2p	**0.8p**
	$\vec{F}_{asc} + \vec{F}_{dis} = 0$ $\qquad v_{bubble} = \sqrt{\frac{8g \cdot R_{bubble}}{3}}$	0.2p	
	$t_{up} = \frac{h_0}{\sqrt{\frac{8g \cdot R_{bubble}}{3}}}$	0.2p	
	$t_{up} = 6.2 \times 10^{-1} s$	0.2p	
	Total points		**10p**

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