Theoretical Competition
25 April 2010

Student Code | | | | |

Question Number 3

2010 APhO
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Page No. | | Total No. | |

ANSWER SHEET

Theoretical Question 3

Electron and Gas Bubbles in Liquids

Do not write in any box marked with a solidus (oblique stroke, /).

Part A. An electron bubble in liquid helium

(a) Relation between P_{He}, P_e, and σ.

Expression of P_e =							
0.4 pt	/	/	/	/	/	/	/

Relation between E_k and P_e.

Expression:							
1.0 pt	/	/	/	/	/	/	/

(b) The smallest possible kinetic energy E_0 as a function of R.

Expression of E_0 =							
0.8 pt	/	/	/	/	/	/	/

(c) The bubble's equilibrium radius R_e when $E_k = E_0$ and $P_{He} = 0$.

Expression of R_e = Value of R_e =							
0.6 pt	/	/	/	/	/	/	/

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(d) Condition satisfied by R and P_{He} for locally stable equilibrium at radius R.

Expression:

0.6 pt	/	/	/	/	/	/	/

(e) The threshold pressure P_{th} below which no equilibrium is possible for the bubble.

Expression of $P_{\mathrm{th}} =$

0.6 pt	/	/	/	/	/	/	/

Part B. Single gas bubble in liquid — collapsing and radiation

(f) Work dW done on the liquid when the bubble's radius changes from R to $R + dR$.

Expression of $dW =$

0.4 pt	/	/	/	/	/	/	/

Values of the exponents m and n.

m =   n =

0.4 pt	/	/	/	/	/	/	/

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(g) Pressure $P \equiv P(R)$ and temperature $T \equiv T(R)$ as a function of R.

Expression of $P \equiv P(R) =$

Expression of $T \equiv T(R) =$

0.6 pt	/	/	/	/	/	/	/

(h) The coefficient μ in terms of R_i and P_0.

Expression of $\mu =$

0.6 pt	/	/	/	/	/	/	/

(i) Values of the constant C_m.

Value of $C_m =$

0.4 pt	/	/	/	/	/	/	/

The minimum radius R_m for $R_i = 7R_0$.

Value of $\mathrm{R_m} =$

0.3 pt	/	/	/	/	/	/	/

The temperature T_m of the gas at β_m.

Value of $T_m =$

0.3 pt	/	/	/	/	/	/	/

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(j) The radius β_u at which the radial speed $u \equiv |\dot{\beta}|$ reaches its maximum value.

Expression of $\beta_u =$

Value of $\beta_u =$

0.6 pt	/	/	/	/	/	/	/

The value of $\bar{u}$ of the dimensionless radial speed u at $\beta = \bar{\beta} \equiv \frac{1}{2}(\beta_{\mathrm{m}} + \beta_u)$.

Value of $\bar{u} =$

0.4 pt	/	/	/	/	/	/	/

The time duration Δt_{m} for β to diminish from β_u to the minimum value β_{m}.

Expression of $\Delta t_{\mathrm{m}} =$

Value of $\Delta t_{\mathrm{m}} =$

0.6 pt	/	/	/	/	/	/	/

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(k) The power $\dot{E}$ supplied to the bubble at β.

Expression of $\dot{E}$ =							
0.6 pt	/	/	/	/	/	/	/

The upper bound of the emissivity a.

Expression of a = Value of a =							
0.8 pt	/	/	/	/	/	/	/