

# Thermal Physics II

**1<sup>st</sup> short test – 26 February 2013**

given and surname :

university number :

course of study :

marks obtained :

total marks :

*comments* :

1. Order the following thermodynamic quantities into a group of extensive quantities on the left and a group of intensive quantities on the right: internal energy  $U$ , energy density  $u = U/V$ , volume  $V$  and entropy  $S$ .

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2. State the 1<sup>st</sup> law of thermodynamics for a gas of atoms.

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3. A small amount of heat,  $\Delta Q$ , is transferred to a system at temperature  $T$  via a quasi-static process. What is the resulting change in entropy?

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4. How does the heat capacity of a solid at constant magnetic field behave when the system is cooled close to  $T = 0$ ?

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5. Which of the following quantities has an exact differential in the variables stated:  $U = U(S, V)$ ,  $U = U(T, V)$ ,  $S = S(U, V)$ ,  $Q = Q(S, T)$ ?

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6. State the relation that defines the temperature for a isolated system.

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7. A system has 5 microstates with energies  $E_1 = 2$ ,  $E_2 = 3$ ,  $E_3 = 4$ ,  $E_4 = 5$  and  $E_5 = 1$ . Calculate the average energy and its fluctuation  $\sigma_E$ .

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8. At different times, the entropy of an isolated systems has been measured to be i)  $S = 3 \text{ J/K}$ , ii)  $S = 1.5 \text{ J/K}$ , iii)  $S = 3.5 \text{ J/K}$ , iv)  $S = 2.5 \text{ J/K}$ . Which of the states probed is closest to equilibrium?

9. A thermodynamic system is composed of two independent parts having entropies  $S_1$  and  $S_2$  and number of states  $\Omega_1$  and  $\Omega_2$ , respectively. What is the entropy and the number of states for the combined system?

10. Consider an idealised coin tossing experiment (same probabilities for heads and tails). What is the *probability* to get exactly 2 heads in 5 tries?

11. What is the number of states for a system with 20 entirely independent particles that can each occupy 5 states independent of each other?

12. Using the fact that  $dU = TdS - pdV + \mu dN$ , derive the Maxwell-relation  $(\partial T/\partial N)_{S,V} = (\partial \mu/\partial S)_{V,N}$ .

A+ A family has two children. You are told that one of them is a boy. What is the probability that the family has two boys?