PH506 Statistical Mechanics (1st tierce exam)

Name:

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1. Thermodynamic of any medium or gas deal with the macroscopic quantities like temperature (T), entropy (S), internal energy (U), pressure (P), volume (V), chemical potential (μ) and total number of medium constituents or gas molecules (N). In terms of those quantities, Euler provide a thermodynamical relation:
(a) $\mu S = U + PV - NT$
(b) $TS = U + P\mu - VN$
(c) $TV = U + P\mu - SN$
(d) $TS = U + PV - \mu N$

2. The dimension of left hand side or right hand side of Euler thermodynamical relation will be the dimension of
(a) volume
(b) temperature
(c) energy
(d) pressure

3. Second law of thermodynamic relation (in terms of earlier mentioned macroscopic quantities) is
(a) $\mu dS = dU + PdV - NdT$
(b) $TdS = dU + PdV - \mu dN$
(c) $SdT = dU + VdP - Nd\mu$
(d) $dU + PdV - \mu dN = 0$

4. Using 2nd law of thermodynamics, pressure P can be defined as
(a) $P = 1/\left(\frac{\partial S}{\partial U}\right)_{V,N}$
(b) $P = T\left(\frac{\partial S}{\partial N}\right)_{U,V}$
(c) $P = T\left(\frac{\partial S}{\partial V}\right)_{U,N}$
(d) None of the above

5. Using the Carnot's entropy expression

$$S_C = NK\Big[\ln\Big(\frac{V}{N}\Big(\frac{3KT}{2}^{3/2}\Big)\Big) + \frac{5}{2}\Big] + C \tag{1}$$

one can derive pressure P by using correct relation (which is basically answer of earlier question) as
(a) $P = \frac{NKT}{V}$
(b) $P = 0$
(c) $P = \frac{2U}{3NK}$
(d) none of the above

6. Using 2nd law of thermodynamics, temperature T can be defined as
(a) $T = 1/\left(\frac{\partial S}{\partial U}\right)_{V,N}$
(b) $T = T\left(\frac{\partial S}{\partial N}\right)_{U,V}$
(c) $T = T\left(\frac{\partial S}{\partial V}\right)_{U,N}$
(d) None of the above

7. Using the Carnot's entropy expression, given in Eq. (1), one can derive temperature T by using correct relation (which is basically answer of earlier question)
(a) $T = \frac{NKT}{V}$
(b) $T = 0$

(c) $T = \frac{2U}{3NK}$
(d) none of the above

8. Drawing momentum p along y-axis and position x along x-axis for a harmonic oscillator with total energy $E = \frac{p^2}{2m} + \frac{kx^2}{2}$ (m = mass, k = spring constant), one can get its phase-space diagram, whose trajectory will be
(a) straight horizontal line
(b) straight vertical line
(c) ellipse
(d) parabola

9. Surface area of d dimension sphere (hyper sphere) can be expressed as

$$S_d = \frac{2\pi^{d/2}}{\Gamma(d/2)} \; r^{d-1} \tag{2}$$

where Γ-function follow the identity $\Gamma(n+1) = n\Gamma(n) = n!$, $\Gamma(1) = 1$ and $\Gamma(\frac{1}{2}) = \sqrt{\pi}$. For $d = 3$ and 2,
(a) $S_3 = \frac{4}{3}\pi r^3$, $S_2 = \pi r^2$
(b) $S_3 = 4\pi r^2$, $S_2 = 2\pi r$
(c) $S_3 = 2\pi r^2$, $S_2 = \pi r$
(d) $S_3 = 4\pi r$, $S_2 = 2\pi$

10. Imagine a hyper sphere of 3N number of momentum axes for a medium or gas having N particles. Radius of the sphere will be

$$\begin{aligned} p_{3N} &= [\sum_{i=1}^{N} (p_{xi}^2 + p_{yi}^2 + p_{zi}^2)]^{1/2} \\ &= [2m \sum_{i=1}^{N} \epsilon_i]^{1/2} \\ &= [2mU]^{1/2} \; , \end{aligned} \tag{3}$$

where energy of $i^{\rm th}$ particle is $\epsilon_i = \frac{1}{2m}(p_{xi}^2 + p_{yi}^2 + p_{zi}^2)$ and total kinetic energy of gas $U = \sum \epsilon_i$, which is also known as internal energy of the gas. What will be surface area of 3N dimension sphere in momentum space?
(a) $\frac{2\pi^{N/2}}{\Gamma(N/2)}(\sqrt{2mU})^{N-1}$
(b) $\frac{2\pi^{3N/2}}{\Gamma(3N/2)}(\sqrt{2mU})^{3N-1}$
(c) $\frac{2\pi^{3N}}{\Gamma(3N)}(\sqrt{2mU})^{3N-1}$
(d) $\frac{2\pi^{3N/2}}{\Gamma(3N/2)}(\sqrt{2mU})^{3N}$

11. A gas with constant T, μ, V can be described with ensemble, called
(a) Micro Canonical Ensemble (MCE)
(b) Canonical Ensemble (CE)
(c) Grand Canonical Ensemble (GCE)
(d) none of the above

12. A gas with constant T, N, V can be described with ensemble, called
(a) Micro Canonical Ensemble (MCE)
(b) Canonical Ensemble (CE)
(c) Grand Canonical Ensemble (GCE)
(d) none of the above

13. A gas with constant U, N, V can be described with ensemble, called
    (a) Micro Canonical Ensemble (MCE)
    (b) Canonical Ensemble (CE)
    (c) Grand Canonical Ensemble (GCE)
    (d) none of the above

14. Statistical mechanics is
    (a) the macroscopic description of thermodynamics
    (b) the microscopic description of thermodynamics
    (c) the macroscopic description of electromagnetic theory
    (d) none of the above.

15. Statistical mechanics make connection between microscopic and macroscopic world when total number of particle N will be quitely large, which is mathematically $N \to \infty$ but in real case the order of magnitude is roughly
    (a) hunderds
    (b) thousands
    (c) millions
    (d) none of the above.