Physics 831 Practice Quiz #6 - Wednesday, Dec. 5

YOUR NAME:_____

1. Which of the following assumptions are necessary if one is to express the virial coefficient A_2 using only phase shifts from two-particle scattering along with information about particle's spin: (Circle all that apply)

   (a) No long-range interactions between the particles such as Coulomb

   (b) Phase space occupancies $<< 1$

   (c) Particles are spinless

2. Which of the following quantities must be equal between two phases if they are to coexist? (Circle all that apply)

   (a) Pressure

   (b) Density

   (c) Temperature

   (d) Energy Density

   (e) Chemical Potential

   (f) Helmholtz Free Energy Density

   (g) Gibb's Free Energy Density

3. In the low T limit, the specific heat from phonons in a three-dimensional crystal lattice behaves as T^n. What is n?

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4. Two metals, A and B, have the same BCC crystal structure, the same spin-spin coupling J between nearest neighbors, and the same critical temperature. In each metal, the spins can be either spin-up or spin-down. From the perspective of the Ising model, one concludes that the two metals also have the same: (Circle all that apply)

   (a) Number density

   (b) Mass density

   (c) Effective number of nearest neighbors

   (d) Magnetic permeability

5. A particle of mass m moves in a potential well

$$V(x) = Cx^8.$$

   Circle all that are true:

   (a) $\langle x \rangle = 0$

   (b) $\langle x \rangle \propto T$

   (c) $\langle x \rangle \propto T^{1/8}$

   (d) $\langle x \rangle \propto C^{-1}$

   (e) $\langle x \rangle \propto C^{-1/8}$

6. Circle the option(s) which have the least number of solutions for the average spin in the Ising model. (A solution means that the free energy is minimized for a given value of $\langle\sigma\rangle$)

   (a) No magnetic field, $T < T_c$

   (b) No magnetic field, $T > T_c$

   (c) Magnetic field, $T < T_c$

   (d) Magnetic field, $T > T_c$

7. In a non-relativistic degenerate Fermi gas at zero temperature in D dimensions, the density is proportional to what power of the chemical potential? i.e, $\rho \propto \mu^n$, what is n?

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8. In two dimensions: (Circle all the true statements)

   (a) Landau theory is valid near T_c.

   (b) A Bose gas of massless particles can undergo Bose condensation.

   (c) Long range order can ensue from short-range interactions

   (d) The density of single-particle states for non-relativistic particles is a constant

9. Consider a 3D Fermi gas of non-relativistic spin-half particles at temperatures much smaller than the Fermi energy, at fixed density. The entropy varies as T^n for small T. What is n?

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10. Let us assume that the free energy density obeys the form:

$$f = \frac{\kappa}{2}(\nabla\phi)^2 + \frac{A}{2}\phi^2 + \frac{B}{4}\phi^4 + \frac{C}{6}\phi^6,$$

    where B and C are both > 0, and near T_c, A behaves as at. Find the critical exponent beta in $\langle\phi\rangle \sim t^\beta$.

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11. For a Van der Waals equation of state,

$$P = \rho T \frac{1}{1-\rho v_0} - a\rho^2,$$

    the energy per particle depends on: (Circle all that apply)

    (a) the density ρ

    (b) the temperature T

    (c) the excluded volume v_0

    (d) a

12. Given the hydrogen atom at temperature T, state the ratio of the number of electrons in the $n = 1$ states to the number of electrons in the ground state. Express your answer in terms of the temperature T, the ground state binding energy $B = 13.6$ eV, the mass of the electron m, and fundamental constants such as $\hbar$. Ignore spin-orbit and spin-spin splitting.

13. The gradient term in the free-energy density from Landau theory,

$$f(x) = \frac{\kappa}{2} (\nabla\phi)^2 + \mathcal{V}(\phi)$$

originates from: (circle all that apply)

(a) Attractive short range interactions

(b) Repulsive short range interactions

(c) kinetic energy of constituents

(d) internal nuclear excitations

14. Imagine a box with volume V in which there is a dilute gas of N distinguishable particles in the canonical ensemble. The volume in the box is doubled and the number of distinguishable particles is also increased by a factor of 2. The entropy per particle S/N: (Circle one)

(a) decreases

(b) stays the same

(c) increases

15. If you read an article where the authors minimize the Gibbs's free energy to solve for an order parameter, which quantities can you assume were fixed in the calculation? (Circle all that apply)

(a) pressure

(b) volume

(c) temperature

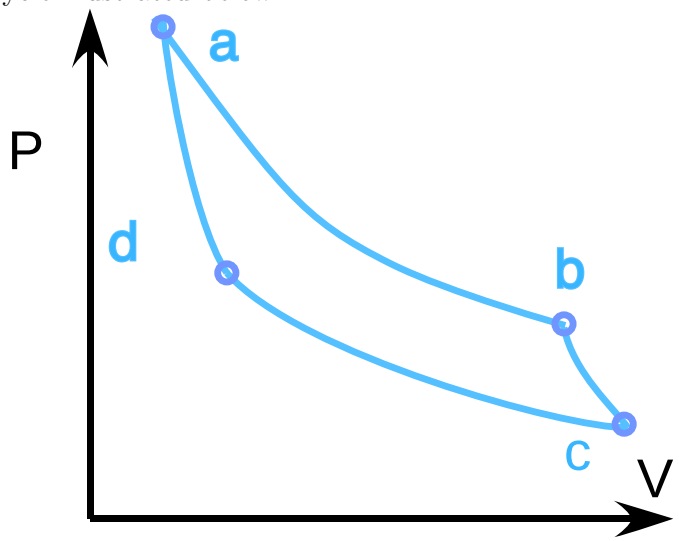
(d) particle number

(e) density

(f) chemical potential

(g) energy density

16. Consider the Carnot cycle illustrated below:



Circle all that are true:

(a) $T_a > T_b$
(b) $T_a = T_b$
(c) $T_a < T_b$
(d) $T_b > T_c$
(e) $T_b = T_c$
(f) $T_b < T_c$

17. A gas of particles expands without collisions. During the expansion, the entropy

(a) increases
(b) decreases
(c) stays the same

18. Consider a three-dimensional Bose gas at fixed density $\rho_{\rm tot}$ whose temperature is below that required for Bose condensation. For $T < T_c$ and $\rho > \rho_c$, the density of those particles not in the condensate is affected by: (Circle all that apply)

(a) the temperature T
(b) the total density $\rho_{\rm tot}$
(c) the mass of the particles m
(d) the chemical potential μ

19. If one were writing a computer model for a binary alloy made of species A and B on a cubic lattice, which parameters would one expect to enter into the model to calculate the entropy? (Circle all that apply)

(a) J_{AB}, the coupling constant describing the interaction between species A and B
(b) J_{AA}, the coupling constant describing the interaction between species A and A
(c) J_{BB}, the coupling constant describing the interaction between species B and B
(d) the temperature T
(e) the lattice spacing ℓ
(f) the fraction of sites of type A and of type B