Assignment 10

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14. To detect trace amounts of a gaseous species in a mixture of gases, the preferred probing tool is
    (A) Ionization spectroscopy with X-rays
    (B) NMR spectroscopy
    (C) ESR spectroscopy
    (D) Laser spectroscopy
15. A collection of N atoms is exposed to a strong resonant elctromagnetic radiation with N_g atoms in the ground state and N_e atoms in the excited state, such that $N_g + N_e = N$. This collection of two-level atoms will have the following population distribution:
    (A) $N_g << N_e$
    (B) $N_g >> N_e$
    (C) $N_g \approx N_e \approx \frac{N}{2}$
    (D) $N_g - N_e \approx \frac{N}{2}$
16. Two states of an atom ave definite parities. An electric dipole transition between these states is
    (A) Allowed if both the states have even parity
    (B) Allowed if both the states have odd parity
    (C) Allowed if both the states have oppsite parity
    (D) Not allowed unless a static electric field is applied
17. The spectrum of radiation emitted by a black body at a temperature 1000K peaks in the
    (A) Visible range of frequencies
    (B) Infrared range of frquencies
    (C) Ultraviolet range of frequencies
    (D) Microwave range of frequencies
18. An insulating sphere of radius a carries a charge density $\rho(\bar{r}) = \rho_0\left(a^2 - r^2\right)\cos\theta; r < a$. The leading order term for the electric field at a distance d, far away from the charge distribution is propotional to
    (A) d^{-1}
    (B) d^{-2}
    (C) d^{-3}
    (D) d^{-4}
19. The voltage resolution of 12-bit digital to analog converter(DAC), whose output varis from -10V to +10V is approximately
    (A) 1mV
    (B) 5mV
    (C) 20mV

(D) 100mV

20. In one of the following circuits, negative feedback does not operate for a negative input. Which one is it? The opamps are running from ±15V supplies.

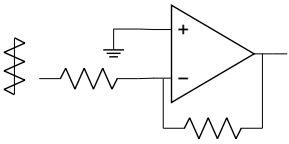

Fig. 0.1: option1

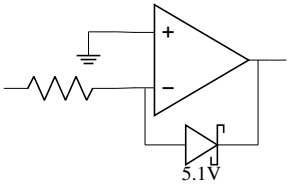

Fig. 0.2: option2

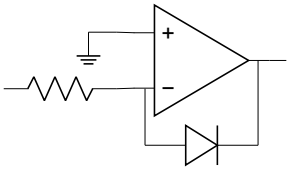

Fig. 0.3: option3

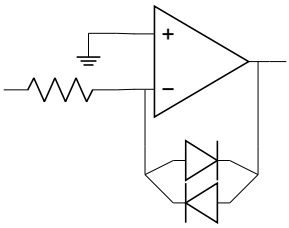

Fig. 0.4: option4

21. A system of N non-interacting classical point particles is constrained to move on the two-dimensional surface of a sphere. The internal energy of system is

(A) $\frac{3}{2}Nk_BT$
(B) $\frac{1}{2}Nk_BT$
(C) Nk_BT

(D) $\frac{5}{2}Nk_BT$

22. Which of the following atoms can't exhibit Bose-Einstein condensation, even in principle?
(A) ${}^{1}H_{1}$
(B) ${}^{4}He_{2}$
(C) ${}^{23}Na_{11}$
(D) ${}^{40}K_{19}$

23. For the set of all Lorentz transformations with velocities along the x-axis, consider the two statements given below:
P: If L is a Lorentz transformation then L^{-1} is also called Lorentz transformation
Q: If L_1andL_2 is a Lorentz transformations then L_1L_2 is also called Lorentz transformation.
Choose the correct otpion.
(A) P is true and Q is false
(B) Both P and Q are true
(C) Both P and Q are false
(D) Q is true and P is false

24. Which of the follwing is an allowed wavefunction for a particle in a bound state? N is a sonstant and $\alpha, \beta > 0$
(A) $\psi = N\frac{e^{-\alpha r}}{r^3}$
(B) $\psi = N(1 - e^{-\alpha r})$
(C) $\psi = Ne^{-\alpha x}e^{\beta\left(x^2+y^2+z^2\right)}$
(D) $\psi = \begin{cases} \text{non-zero constant} & if r < R \\ 0 & if r > R \end{cases}$

25. A particle is confined within a spherical region of radius one femtometer $\left(10^{-15}\right)$. Its momentum can be expected to be about
(A) $20\frac{keV}{c}$
(B) $200\frac{keV}{c}$
(C) $200\frac{MeV}{c}$
(D) $2\frac{GeV}{c}$

Q.26-Q.55 carry two marks each.

26. For the complex function, $f(z) = \frac{e^{\sqrt{z}} - e^{-\sqrt{z}}}{\sin\sqrt{z}}$, which of the following statements is correct?
(A) $z = 0$ is a branch point
(B) $z = 0$ is a pole of order one
(C) $z = 0$ is a removable singularity
(D) $z = 0$ is an essential singularity