Nitesh Phyzics

DUET 2022

An Institute for IIT-JAM, GATE, JEST, TIFR & CUET Entrance in Physics & Physical Sciences
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NET-JRF, IIT-JAM, GATE, JEST, TIFR
CUET Entrance in Physics
Physical Sciences
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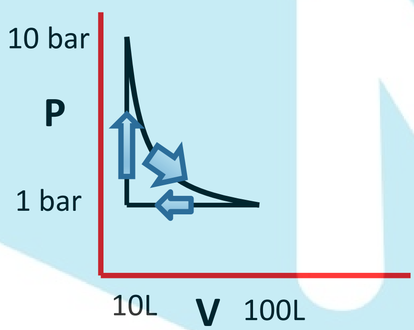
1. An ideal gas described by $T_1 = 300\ K$. $P_1 = 1\ bar$, $V_1 = 10\ L$ is heated at constant volume until $P = 10\ bar$. Then a reversible isothermal expansion takes place until the pressure reduces back to P = 1 bar. Finally, the original state of the ideal gas is restored by extracting heat at constant pressure. Which among the following is the correct $P - V$ diagram for the process?

1.



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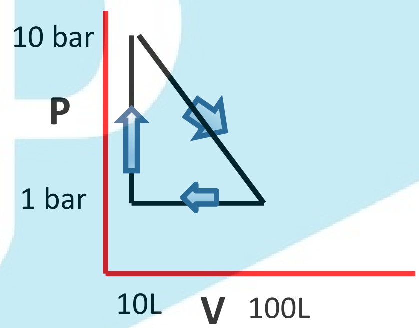

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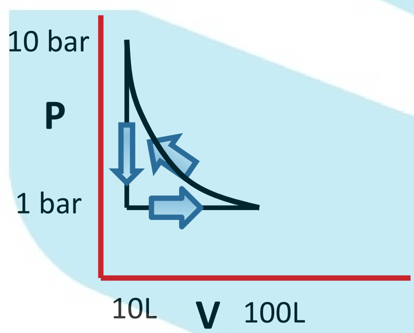

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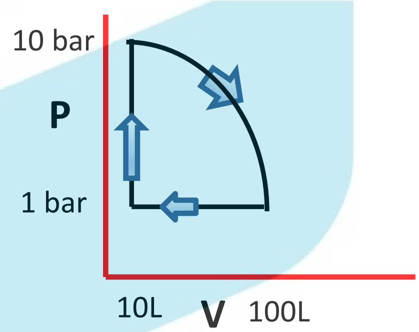

2. A bottle with a leak has a monoatomic ideal gas initially at a pressure of $1.2\ atm$ and a temperature of $30°C$. A balloon is attached to the leak and the entire setup is placed in the open atmosphere. At time $t = 0$, air from the bottle starts leaking into the balloon adiabatically, inflating it. Once the final equilibrium is attained, what is the temperature of the gas in the bottle?

1. 8.7° C

2. 28.4° C

3. 25° C

4. 12.5° C

3. 6 moles of a real gas obeying the Van der Waals equation are initially at a pressure of 25 KPa, occupying a volume of 36 cm³ with a temperature of 27° C. The gas is heated to 37° C while the volume is constricted to 27 cm³ and the final pressure is 64 KPa. What are the values of the real gas parameters, a, b: (Gas constant = 8.317 JK^{-1} mol^{-1})

1. a = 2.5 x 10^{-2} Pa m^6 mol^{-1}, b = 2.42 x 10^{-6} m³ mol^{-1}

2. a = 2.5 x 10^{-2} Pa m^6 mol^{-2}, b = 2.42 x 10^{-6} m³ mol^{-2}

3. a = 2.5 x 10^{-2} Pa m^4 mol^{-1}, b = 2.42 x 10^{-6} m^4 mol^{-1}

4. a = 2.5 x 10^{-2} Pa m^5 mol^{-1}, b = 2.42 x 10^{-6} m^2 mol^{-1}

4. An air conditioner removes 2Kcal/s heat from a large room by requiring a power of 2 KW. The amount of heat removed from the room by the air conditioner per unit work done on it, $\frac{Q}{W}$, for the air conditioner is a fifth of a Carnot refrigerator. If the temperature inside the room is $24°C$, what is the temperature outside? (1 kcal = 4184 J)

1. 38.2^0 C

2. 37.2^0 C

3. 39.8^0 C

4. 36.4^0 C

5. The magnetic moment of a paramagnet of mass 100 gms is given by M =$\frac{AH}{T}$ where A is a constant, T is the temperature and H is the external uniform magnetic field. The paramagnet is initially kept at a temperature of $27°C$ The paramagnet is then put in contact with a heat bath at a temperature of $57°C$ such that a total 10 KJ heat is transferred from the heat bath to the paramagnet. Assuming negligible change in the heat bath temperature and no work done on the paramagnet, what is the specific heat of the paramagnet?

1. $\frac{21\times10^6 - AH^2}{10500} JKg^{-1}K^{-1}$

2. $\frac{2.1\times10^6 - A^2H}{10500} JKg^{-1}K^{-1}$

3. $(2.1\times10^6 - AH^2)\, JKg^{-1}K^{-1}$

4. $21\times10^6\, JKg^{-1}K^{-1}$

6. The zero point energy of lattice vibration is

1. 0

2. (1/2) ħω

3. ħω

4. (n+1/2) ħω

7. A maximum frequency of 8 x 10^{12} Hz can propagate through a linear monoatomic lattice of constant 6 Å. Estimate the velocity of the wave in the solid.

1. 4.8×10^3 m/s

2. 9.6×10^3 m/s

3. 19.6×10^3 m/s

4. 5.6×10^3 m/s

8. Considering He^3 as a fermion with a nuclear spin of ½, its density of liquid is 0.08 g/cm^3 while approaching to absolute zero. Calculate its Fermi temperature. Mass of one Hydrogen atom is 1.67 x 10^{-24} g and K_B = 8.617 333 262 x 10^{-5} eV K^1.

1. 14.04 K

2. 9.36 K

3. 4.68 K

4. 1.56 K

9. In a system undergoing second order phase transformation, which parameter shows discontinuity?

1. Free energy

2. Entropy

3. Specific Heat

4. Enthalpy

10. In superconductors, the susceptibility and relative permeability values are

1. 0 and 1

2. -1 and 0

3. 0 and 0

4. 1 and 0

11. The 2's complement representation of -17 is

1. 101111

2. 101110

3. 110001

4. 111110

12. Most reduced (simplified) form of the Boolean expression: $\overline{AB}$+ AC+ A$\bar{B}$C(AB+C) is:

1. $\overline{A\bar{C}B}$

2. $\overline{ACB}$

3. $\bar{A}$C$\bar{B}$

4. $\overline{\bar{A}CB}$

13. The race around condition occurs in a J-K flip flop when

1. both inputs are 1

2. both inputs are 0

3. the inputs are complementary

4. it is power off

14. A universal register

1. accepts serial input

2. accepts parallel input

3. gives serial and parallel outputs

4. does not accept parallel input

15. In a microprocessor, the register which holds the address of the next instructions to be fetched is

1. Program Counter

2. Accumulator

3. Stack Pointer

4. Instruction Register

16. In the Young double slit experiment, if on introducing a slab of refractive index μ_1, and thickness t to one of slit, the 3rd order maxima comes to central maxima then wavelength of the light is

1. $\frac{t(\mu_1-1)}{3}$

2. $\frac{t(\mu_1-3)}{3}$

3. $3t(\mu-1)$

4. $\frac{t(2\mu_1-3)}{3}$

17. In newton's ring experiment, the diameter of 10th dark ring due to a wavelength of 575 nm in water (μ=1.25) is 5 mm. The radius of the curvature of the lens is

1.68 cm

2. 125 cm

3.136 cm

4.204 cm

18. A grating has slit each are 0.1 mm wide. The distance between centers of any two adjacent slits is 0.2mm. Which of the following orders of the spectra will be missing?

1. Only central maxima will be absent

2. First, third, fifth, seventh and so on

3. Second, fourth, sixth, eight and so on

4. No missing line will be there

19. Plane wave front of light of wavelength 4500 Å is incident on an opening and is received on the screen at 50cm away from the opening. What will be the radius of the 10^{th} half period zone?

1. 0.17 cm

2. 0.15 cm

3. 0.3 cm

4. 5 cm

20. If an unpolarised light is made to incident at Brewster's angle on the surface of some medium, which of the following statement is wrong?

1. Reflected and refracted light are perpendicular

2. Some part of the incident light is reflected and some is refracted.

3. The reflected light is completely polarised.

4. Parallel component of light is completely reflected.

21. The rates of stimulated absorption ($R_{A^{st}}$), stimulated emission ($R_{E^{st}}$) and spontaneous emission ($R_{E^{sp}}$),) for the 3p → 2s transition in hydrogen when it is inside a cavity at 1000 K are related as

1. ($R_{A^{st}}$) = ($R_{E^{st}}$) < ($R_{A^{sp}}$)

2. ($R_{A^{st}}$) < ($R_{E^{st}}$) < ($R_{A^{sp}}$)

3. ($R_{A^{st}}$) > ($R_{E^{st}}$) = ($R_{A^{sp}}$)

4. ($R_{A^{st}}$) > ($R_{E^{st}}$) > ($R_{A^{sp}}$)

22. The time rate of change of probability density associated with a normalized, square integrable wave function ψ(x,t) for a potential of the form "$V = V_0 - i\Gamma$" (V_0 and Γ are positive real constants) will be

1. (dP/dt) = -(4πΓ/h) P

2. (dP/dt) = 0

3. (dP/dt) = (2Γ/h) P

4. (dP/dt)= - (2Γ/h) P

23. X-rays of wavelength 10 pm are scattered from a target. The fractional change in wavelength of x-rays scattered through an angle of 60 degrees is

1. 12%

2. 24%

3. 36%

4. 48%

24. The spectral distribution of a radiating cavity is maximum at a wavelength of 27 μm. The temperature is changed such that the total power radiated becomes 16 times higher. The new spectral distribution will have its maximum at a wavelength of

1. 13.5 μm

2. 1.35 μm

3. 6.75 μm

4. 54.0 μm

25. The statement of the generalized uncertainty principle for two hermitian operators has the form

1. $\sigma_{A^2}\sigma_{B^2} \geq [(1/2i) < [A, B]>]^2$

2. $\sigma_X\sigma_P \geq (h/2\pi)$

3. $\sigma_A\sigma_B \geq [(1/2\pi) |< [A, B] >|$

4. $\sigma_t\sigma_E \geq (h/2\pi)$

26. If the magnetic field vector be expressed in the form $\vec{B} = \vec{\nabla}\phi \times \vec{\nabla}\xi$, where ϕ and ξ are scalar quantities, then a possible vector potential (form which $\vec{B}$ could be derived) is of the form

1. $\vec{A} = \phi\vec{\nabla}\xi$

2. $\vec{A} = -\xi\vec{\nabla}(\phi/\xi)$

3. $\vec{A} = -\phi\vec{\nabla}(\xi/\phi)$

4. $\vec{A} = [\vec{\nabla}(\phi\xi)]/\phi$

27. For a current of finite density $\vec{j}$ flowing through a perfect conductor, the magnetic field $\vec{B}$

1. is in general non-vanishing, but time-independent.

2. is in general non-vanishing and time-dependent, but irrotational

3. always decays exponentially with time

4. always vanishes.

28. Consider a spherical charge distribution of radius R with total charge Q. Let the volume charge density of the distribution be $\rho(\vec{r}) = \frac{k}{r}e^{-\beta r^2}$ where k and β are constants. In terms of β, Q and R the constant k is determined as

1. $\frac{\beta Q e^{\beta R^2}}{2\pi(1-e^{\beta R^2})}$

2. $\frac{\beta Q e^{-\beta R^2}}{4\pi(1-e^{-\beta R^2})}$

3. $\frac{\beta Q e^{-\beta R^2}}{2\pi(1-e^{2\beta R^2})}$

4. $\frac{\beta Q e^{\beta R^2}}{4\pi(1-e^{-2\beta R^2})}$

29. The magnetic field inside a long solenoid, of radius a, is given by $\vec{B} = B_0\,\hat{z}\cos\omega t$, where B_0, and ω are constants. If a circular loop of wire of radius a/2 and resistance R, be placed co-axially inside the solenoid, then the current induced in the loop would be

1. I = $\frac{\pi\omega a^2}{4R} B_0 \sin\omega t$

2. I = $\frac{\pi\omega a^4}{4R^2} B_0^2 \sin\omega t$

3. I = $\frac{4\pi\omega^2}{R^2 a^2} B_0^2 \sin\omega t$

4. I = $\frac{4\pi\omega}{Ra^2} B_0 \sin\omega t$

30. A plane electromagnetic wave, of frequency ω and wavelength λ & travels in a direction perpendicular to the positive x-axis, making an angle 60° with the positive z-axis. The corresponding electric field, of amplitude E_0, can be expressed as

1. $\vec{E} = E_0\,\hat{X}\exp\left[i\left(\omega t - \frac{\pi\sqrt{3}}{\lambda}y - \frac{\pi}{\lambda}z\right)\right]$

2. $\vec{E} = E_0\,(\hat{x} - \sqrt{3}\hat{z})\exp\left[i\left(\omega t - \frac{\pi\sqrt{3}}{\lambda}y\right)\right]$

3. $\vec{E} = E_0\,(\sqrt{3}\hat{x} - \hat{z})\exp\left[i\left(\omega t - \frac{\pi}{\lambda}y\right)\right]$

4. $\vec{E} = E_0\,\hat{X}\exp\left[i\left(\omega t - \frac{\pi}{\lambda}y - \frac{\pi\sqrt{3}}{\lambda}z\right)\right]$

31. The volume of an ideal gas undergoes an isobaric process starting from temperature 273 °C to 819 °C. The ratio of new volume of the gas to the old volume of gas is

1. 2

2. 1/2

3. 3

4. 1/3

32. Which of the following is a thermodynamics relation expressing Tds equation?

1. $TdS = C_p dT - T\left(\frac{\partial p}{\partial T}\right)_V dV$

2. $TdS = C_V dT + T\left(\frac{\partial p}{\partial T}\right)_V dV$

3. $TdS = C_V dT - T\left(\frac{\partial p}{\partial T}\right)_V dV$

4. $TdS = C_p dT + T\left(\frac{\partial p}{\partial T}\right)_V dV$

33. Two ends of a rod are kept at 327 $°C$ and 527 $°C$. The change in entropy when $3000\ cal$ of heat flows in rod is

1. 5 cal/K

2. 10 cal/K

3. 15 cal/K

4. 20 cal/K

34. In a certain process, $500J$ of heat is transferred to a system and the system simultaneously does $200J$ of work. The change in internal energy of the system is

1. $700\ J$

2. $300\ J$

3. $-300\ J$

4. $-700\, J$

35. The temperature of a black surface, 0.4 m² is area, is 540 $°C$. The wavelength of maximum monochromatic emissive power is

1. 1.57 x 10^{-6} m

2. 2.57 x 10^{-6} m

3. 3.57 x 10^{-6} m

4. 4.57 x 10^{-6} m

36. What will be the expectation value of the random variable x for which the probability density function $p(x)$ given below (N is the normalization constant)?

$$p(x) = Nx^2e^{-x}, \qquad x \geq 0.$$

$$= 0, otherwise$$

1. 2

2. 6

3. 3

4. 1/2

37. A certain detector gives, on an average, 2 counts per hour from the background (which is described by a Poisson distribution). What is the probability that the detector gives at least one count in a randomly chosen 10 minutes period?

1. 0.14

2. 0.28

3. 0.42

4. 0.71

38. What will be the correct Fourier series expansion for the following function?

$$f(x) = |x|, -\pi < x < \pi$$

1. f(x)= $\frac{\pi}{2} - \frac{4}{\pi}\sum_{k=1,2}^{\infty}\frac{\cos(2k-1)x}{(2k-1)^2}$

2. (x)= $\frac{\pi}{2} - \frac{2}{\pi}\sum_{k=1,2}^{\infty}\frac{\cos(2k-1)x}{(2k-1)}$

3. f(x)= $\frac{\pi}{2} - \frac{2}{\pi}\sum_{k=1,2}^{\infty}\frac{\cos(2k-1)x}{(2k-1)^2}$

4. f(x)= $\frac{\pi}{2} - \frac{4}{\pi}\sum_{k=1,2}^{\infty}\frac{\cos(2k-1)x}{(2k-1)}$

39. Which one of the following correctly represents the series form of the complex function f(z) = $\frac{1}{1+z}$ for $|z| > 1$

1. f(z)= $\frac{1}{z}\sum_{n=0}^{\infty}(-\frac{1}{z})^n$

2. f(z)= $\sum_{n=0}^{\infty}(-z)^n$

3. f(z)= $\frac{1}{z}\sum_{n=0}^{\infty}(-z)^n$

4. f(z)= $\sum_{n=0}^{\infty}(-\frac{1}{z})^n$

40. Find the value of Integral $I = \int_0^{2\pi}\cos(x)\,\delta(x^2-\pi^2)dx$

1. $I = -\frac{1}{2\pi}$

2. $I = -\frac{1}{\pi}$

3. $I = \frac{1}{\pi}$

4. $I = \frac{1}{2\pi}$

41. A quantum mechanical system in a harmonic oscillator potential has the initial wavefunction $\psi_0(X) + \psi_1(X)$ where $\psi_0(X)$ and $\psi_1(X)$ are the real wavefunction in the ground and first excited states of the harmonic Hamiltonian. For convenience we take m=ħ=ω=1 for oscillator. What is the probability density of finding the particle at x at time t = π

1. $(\psi_1(X) - \psi_0(X))^2$

2. $(\psi_1(X))^2 - (\psi_0(X))^2$

3. $(\psi_1(X) + \psi_0(X))^2$

4. $(\psi_1(X))^2 + (\psi_0(X))^2$

42. Which of the following describes the same physical state of a spin $\frac{1}{2}$ particle as $\frac{1}{\sqrt{2}}\binom{1}{i}$

1. $\frac{1}{\sqrt{2}}\binom{1}{1}$

2. $\frac{1}{\sqrt{2}}\binom{1}{0}$

3. $\frac{1}{\sqrt{2}}\binom{1}{-1}$

4. $\frac{1}{\sqrt{2}}\binom{i}{-1}$

43. Consider a spin $\frac{1}{2}$ in the presence of a homogeneous magnetic field of magnitude B along the z-axis which is prepared initially in a state $|\psi\rangle = \frac{1}{\sqrt{2}}(|\uparrow\rangle + |\downarrow\rangle)$ at time t=0. At what time will the particle be in the state $|\psi\rangle$ (μ_B is Bohr magneton)?

1. $t = \frac{\pi\hbar}{\mu_B B}$

2. $t = \frac{2\pi\hbar}{\mu_B B}$

3. $t = \frac{\pi\hbar}{2\mu_B B}$

4. Never

44. A particle of mass m in the potential $V(x, y) = \frac{1}{2} m\omega^2 (4x^2 + y^2)$, is in an eigenstate of energy $E = \frac{5}{2}\hbar\omega$. The corresponding un-normalized eigenfunction is

1. $y \exp\left[-\frac{m\omega}{2\hbar}(2x^2 + y^2)\right]$

2. x exp $\left[-\frac{m\omega}{2\hbar}(2x^2+y^2)\right]$

3. y exp $\left[-\frac{m\omega}{2\hbar}(x^2+y^2)\right]$

4. xy exp $\left[-\frac{m\omega}{2\hbar}(x^2+y^2)\right]$

45. Define $\sigma_x = (f^\dagger + f)$, $\sigma_y = -i(f^\dagger - f)$, where the σ's are Pauli spin matrices and f, $f^\dagger$ obey anticommutations relations {f, f} = 0, { f, $f^\dagger$ }= 1. Then σ_2 is given by

1. $f^\dagger f - 1$

2. $2 f^\dagger f - 1$

3. $2 f^\dagger f + 1$

4. $f^\dagger f$

46. An explosion releases energy E into the atmosphere having initial densityρ. The resulting shock wave propagates in a sphere of radius R. The approximate value of R at time t is given as $R = \frac{E^n t^{2n}}{\rho^n}$ The value of n is

1. 1/2

2. 1/3

3. 1/4

4. 1/5

47. A particle of mass m_1 is moving along the x-axis with velocity u_1 and another particle of m_2 is at rest at the origin. The two particles undergo elastic collision and start moving with velocities v_1 and v_2. If v_1 is one- fourth of v_2. , which of the following statements is true?

1. m_1 is half of m_2

2. m_1 is double of m_2

3. m_1 is one-fourth of m_2

4. m_1 is four times m_2

48. A particle of mass m is moving along a circle of radius r_0 in a horizontal plane with speed v_0 to as it is connected to the center of the circle through an inextensible string. The other end of the string is being pulled down through a vertical tube at a slow rate resulting in the gradual reduction in the radius of the circular orbit of the particle from its initial value r_0. The work done by the pulling force in reducing the radius from the initial value (r_0) to half of it is $(r_0/2)$ is

1. $\frac{3}{2}mv_0^2$

2. $\frac{1}{2}mv_0^2$

3. mv_0^2

4. $\frac{1}{4}mv_0^2$

49. A planet is rotating in a circular orbit of radius R around a mysterious star so that its potential energy at a distance r from the star is $\frac{1}{2}kr^2$ where k is a positive real constant. The time period of the planet is

1. $T = 2\pi\sqrt{\frac{m}{k}}$

2. $T = 2\pi\sqrt{\frac{m}{2k}}$

3. $T = 2\pi\sqrt{\frac{m}{3k}}$

4. $T = \pi\sqrt{\frac{m}{k}}$

50. A particle is acted upon by the following force $V(x) = \frac{1}{2}kx^2 - \frac{1}{4}\lambda x^4$ where k and λ are positive and real constants. The points where the particle is in stable equilibrium are

1. $x = 0, x = \pm\sqrt{k/\lambda}$

2. $x = \pm\sqrt{k/\lambda}$

3. $x = 0$

4. $x = 0, x = \pm\sqrt{2k/\lambda}$