Q1. A stretched string has a length of 2.00 m and mass of 1.56 g. A transverse sinusoidal wave is travelling on this string, and is given by: $y(x, t) = 0.100 \sin(3.00x - 144t)$ where x and y are in meters and t is in seconds. What is the magnitude of the tension in the string?

A) 1.80 N
B) 3.39 N
C) 3.74 N
D) 5.56 N
E) 2.95 N

Q2. Two identical waves moving in the same direction are sent along a string with a phase difference of 72^{o} between them. The amplitude of each wave is 3.0 mm. What is the amplitude of the resultant wave?

A) 4.9 mm
B) 6.0 mm
C) 2.0 mm
D) 5.8 mm
E) 1.2 mm

Q3. A stretched string that is fixed at both ends oscillates in a third-harmonic standing wave pattern. The distance between two adjacent nodes is 0.75 m. The tension is varied until the fourth-harmonic standing wave is generated on the same string. What is the distance between two adjacent nodes in this case?

A) 0.56 m
B) 1.0 m
C) 3.0 m
D) 0.38 m
E) 1.5 m

Q4. A transverse sinusoidal wave is travelling on a stretched string. The maximum transverse speed of a particle on the string is 24.0 m/s. The frequency of oscillations of a particle in the string is 120 Hz. What is the amplitude of the wave?

A) 31.8 mm
B) 25.1 mm
C) 12.0 mm
D) 43.3 mm
E) 53.2 mm

Q5. A tube open at both ends has a fundamental frequency of 76.0 Hz. What is the third harmonic frequency of this tube if one end is closed?

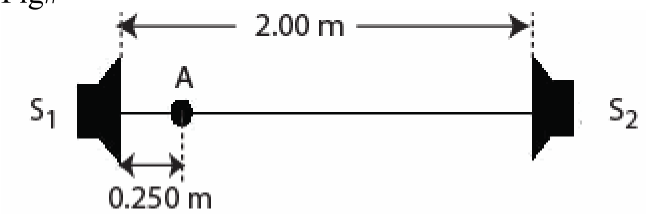
A) 114 Hz
B) 152 Hz
C) 76.0 Hz
D) 50.6 Hz
E) 57.0 Hz

Q6. A point sound source emits sound with an average power of 0.78 W. At what distance from the source is the sound level equal to 98 dB?

A) 3.1 m
B) 8.8 m
C) 9.6 m
D) 1.8 m
E) 2.2 m

Q7. Two sound sources, separated by a distance of 2.00 m, are in phase and both emit sound waveswith a frequency of 500 Hz. Point A is 0.250 m from S_1 (see Figure 1). What is the phase difference between the two sound waves at point A? (v_{sound} = 343 m/s)

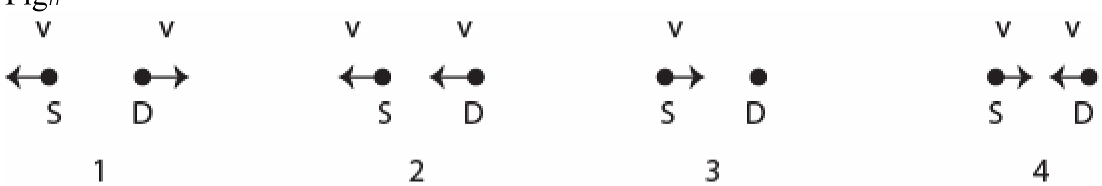
Fig#



A) 13.7 rad
B) 2.19 rad
C) 2.87 rad
D) 15.4 rad
E) 6.85 rad

Q8. Figure 2 shows four situations in which a moving source of sound S and a detector D either moving or stationary. The arrows indicate the directions of motion. The speeds v of the source and the detector are the same. Detector 3 is stationary. Rank the situations according to the frequency at the detector, highest to lowest.

Fig#



A) 4, 3, 2, 1
B) 1, 2, 3, 4
C) 1, 3, 2, 4
D) 4, 1, 2, 3
E) 4, 2, 3, 1

Q9. A student uses a metallic measuring rod that is exactly equal to 1.00 m long on a summer day having temperature of 45.0 ^{o}C. What is length of the rod on a winter day when the temperature is –5.00 ^{o}C. (the coefficient of linear expansion of the metal = 5.20×10^{-4} K^{-1}).

A) 0.974 m

B) 1.260 m
C) 0.210 m
D) 5.012 m
E) 0.952 m

Q10. 500 g of water at 100 ^{o}C is converted to steam at 100 ^{o}C by boiling it at a constant pressure of 1.01×10^5 Pa. The change in volume of the water-vapor system is 0.83 m^3. Calculate the change in internal energy of the water during this process.

A) 1.04×10^6 J
B) 2.28×10^5 J
C) 0.48×10^3 J
D) 6.78×10^7 J
E) 9.62×10^6 J

Q11. A copper block of mass 400 g at 80.0 ^{o}C is dropped into an insulated bucket containing ice at 0 ^{o}C. All the ice has melted and did not evaporate. Calculate the amount of melted ice. (Specific heat for copper is 386 J/kg.K). Neglect the heat gained by the bucket.

A) 37.1 g
B) 49.5 g
C) 64.8 g
D) 22.4 g
E) 400 g

Q12. Which of the following statements is **WRONG**?

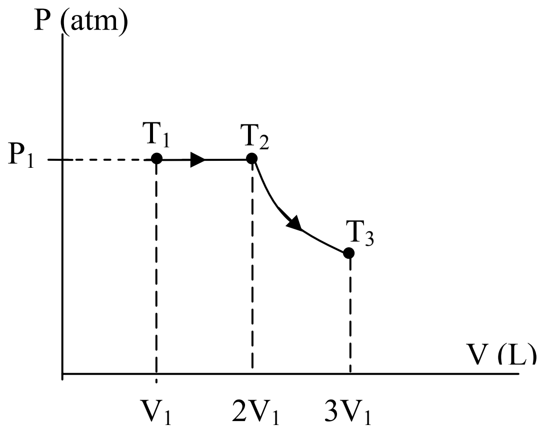
A) If work is done on a system, the internal energy of the system decreases in an adiabatic process.
B) In an adiabatic process, transfer of energy as heat is zero.
C) In a constant-volume process, the internal energy of the system increases if heat is added.
D) In a cyclic process, the change in internal energy of the system is zero.
E) Heat energy can be transferred only between bodies having different temperatures.

Q13. On a hot summer day, the amount of thermal energy transferred to a classroom from the outside through a 3.0 m^2 glass window is 3.0×10^5 J every minute. The thickness of the glass window is 1.5 cm. If the outside temperature is 45 ^{o}C, calculate the temperature inside the classroom. (k_{glass} = 1.2 W/m.K).

A) 24 ^{o}C
B) 30 ^{o}C
C) 21 ^{o}C
D) 45 ^{o}C
E) 16 ^{o}C

Q14. Three moles of a monatomic ideal gas at room temperature T_1 = 300K and pressure P_1 undergo an isobaric then an adiabatic expansion, as shown in Figure 3. Calculate the final temperature of the gas T_3. (γ= 1.67).

Fig#



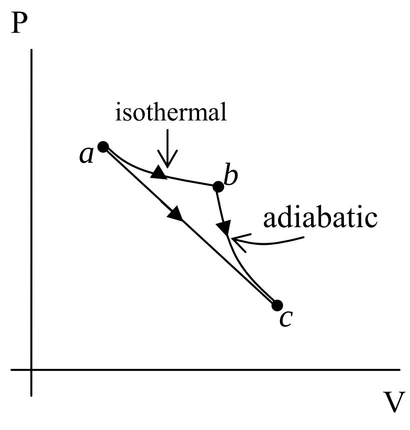
A) 457 K
B) 377 K
C) 543 K
D) 156 K
E) 600 K

Q15. A 0.050-m^3 container has 5.00 moles of argon gas at a pressure of 1.00 atm. What is the rms speed of the argon molecules? (M_{Ar} = 40.0 g/mole)

A) 275 m/s
B) 496 m/s
C) 398 m/s
D) 940 m/s
E) 870 m/s

Q16. In the PV diagram shown in Figure 4, the ideal gas does 10 J of work when taken along the isothermal process from *a* to *b* and 8.0 J of work when taken along the adiabatic process from *b* to *c*. What is the change in internal energy of the gas when it is taken along the straight path from *a* to *c*?

Fig#



A) − 8.0 J
B) 18 J

C) – 2.0 J
D) 2.0 J
E) 8.0 J

Q17. A heat engine operates between 200K and 100K. In each cycle it takes 100 J of heat from the hot reservoir, loses 25 J of heat to the cold reservoir, and does 75 J of work. This heat engine VIOLATES:

A) The second law but not the first law of thermodynamics
B) The first law but not the second law of thermodynamics
C) Both the first and second laws of thermodynamics
D) Neither the first law nor the second law of thermodynamics
E) Cannot answer without knowing the mechanical equivalent of heat.

Q18. An ideal (Carnot) refrigerator has a coefficient of performance equal to 5.0. If the temperature inside the refrigerator is –20 ^{o}C, what is the temperature at which heat is rejected?

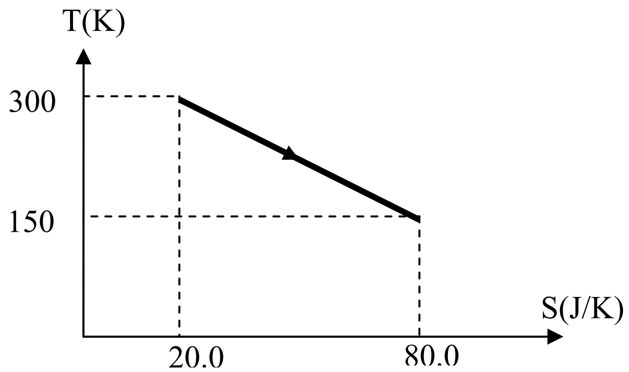
A) 31 ^{o}C
B) 20 ^{o}C
C) – 45 ^{o}C
D) 16 ^{o}C
E) –20 ^{o}C

Q19. Calculate the change in entropy when 10.0 g of ice at –10.0 ^{0}C is heated until it completely melts.

A) 13.0 J/K
B) 12.3 J/K
C) 10.5 J/K
D) 15.0 J/K
E) 20.1 J/K

Q20. 2.0 moles of an ideal monatomic gas undergo the reversible process shown in Figure 5. How much energy is absorbed as heat by the gas during this process?

Fig#



A) 13.5 kJ

B) 12.0 kJ
C) 10.6 kJ
D) 14.1 kJ
E) 21.5 kJ

$v = \lambda f = \frac{\omega}{k}$

$v = \sqrt{\frac{\tau}{\mu}}$ $v = \sqrt{\frac{B}{\rho}}$

$y = y_m \sin(kx \pm \omega t + \varphi)$

$P = \frac{1}{2}\mu\omega^2 y_m^2 v$

$S = S_m \cos(kx - \omega t)$

$\Delta P = \Delta P_m \sin(kx - \omega t);$ where $\Delta P_m = \rho v \omega S_m$

$I = \frac{1}{2}\rho(\omega S_m)^2 v$

$\beta = 10 \log\left(\frac{I}{I_o}\right),$ $I_o = 10^{-12}$ W/m^2

$I = \frac{\text{Power}}{\text{Area}}$

$f' = f\left(\frac{v \pm v_D}{v \pm v_S}\right)$

$y = \left(2y_m \cos\frac{\varphi}{2}\right)\sin\left(kx - \omega t + \frac{\varphi}{2}\right)$

$y = (2y_m \sin kx) \cos\omega t$

$f_n = \frac{nv}{2L},$ $n = 1,2,3,...$

$f_n = \frac{nv}{4L},$ $n = 1,3,5...$

$\Delta L = \alpha L \Delta T$ $\Delta V = \beta V \Delta T$

$PV = nRT = NkT$

$\Delta L = \frac{\lambda}{2\pi}\varphi$

$\Delta L = m\lambda$ $m = 0,1,2,\dots.$

$\Delta L = \left(m + \frac{1}{2}\right)\lambda,$ $m = 0,1,2,\dots..$

$PV^{\gamma} = \text{constant};$ $TV^{\gamma-1} = \text{constant}$

$C_V = \frac{3}{2}R$ for monatomic gases,

$= \frac{5}{2}R$ for diatomic gases.

$T_F = \frac{9}{5}T_C + 32$

$Q = mL$

$Q = mc\Delta T$

$Q = nc\Delta T$

$\Delta E_{int} = Q - W$

$\Delta E_{int} = nC_V\Delta T$

$C_p - C_v = R$

$W = \int PdV$

$P_{cond} = \frac{Q}{t} = kA\frac{T_H - T_C}{L}$

$\frac{m\overline{v^2}}{2} = (3/2)kT,$ $v_{rms} = \sqrt{\frac{3RT}{M}}$

$W = Q_H - Q_L$

$\varepsilon = \frac{W}{Q_H} = 1 - \frac{Q_L}{Q_H}$

$K = \frac{Q_L}{W}$

$\frac{Q_L}{Q_H} = \frac{T_L}{T_H}$, $\Delta S = \int\frac{dQ}{T}$

Constants:

1 Liter = 10^{-3} m^3
R = 8.31 J/mol K
$N_A = 6.02 \times 10^{23}$ molecules/mole
1 atm = 1.01×10^5 N/m^2
k = 1.38×10^{-23} J/K
1 calorie = 4.186 Joule
g = 9.8 m/s^2
for water:

$c_w = 4190\frac{J}{kg.K};$ $c_{ice} = 2220\frac{J}{kg.K}$

$L_F = 3.33\times10^5\frac{J}{kg},$ $L_V = 2.256\times10^6\frac{J}{kg}$