Q1. A sinusoidal wave is traveling along a stretched string. The oscillator that generates the wave completes 40 vibrations in 30.0 s. A given peak of the wave travels 4.25 m along the string in 10.0 s. What is the wavelength of the wave?

A) 0.319 m
B) 0.425 m
C) 3.13 m
D) 0.667 m
E) 1.25 m

Q2. A sinusoidal wave of amplitude y_m and wavelength λ travels on a stretched string. The ratio of the maximum transverse speed of a particle on the string to the wave speed is:

A) $2\pi y_m/\lambda$
B) $2\pi\lambda/y_m$
C) $2\pi y_m\lambda$
D) $y_m/2\pi\lambda$
E) $\lambda/2\pi y_m$

Q3. Two sinusoidal waves have the same frequency, the same amplitude y_m, and travel in the same direction in the same medium. If the amplitude of the resultant wave is 1.8 y_m, the phase difference between the two waves is

A) 0.14 wavelengths
B) 52 wavelengths
C) 26 wavelengths
D) 6.9 wavelengths
E) 0.88 wavelengths

Q4. Vibrations with frequency 600 Hz are established on a string of length 1.33 m that is clamped at both ends. The speed of waves on the string is 400 m/s. How many antinodes are contained in the resulting standing wave pattern?

A) 4
B) 5
C) 2
D) 3
E) 8

Q5. The intensity of a certain sound wave is 6.0 $\mu W/cm^2$. If its sound level is raised by 10 decibels, the new intensity (in $\mu W/cm^2$) is:

A) 60
B) 6.6
C) 600
D) 12
E) 10

Q6. A pipe, with one end open and the other closed, is operating at one of its resonant frequencies. The open and closed ends are respectively:

A) pressure minimum, displacement minimum
B) pressure minimum, pressure minimum
C) displacement maximum, pressure minimum
D) displacement minimum, displacement minimum
E) pressure maximum, pressure maximum

Q7. A train moving at constant speed is passing a stationary observer. The whistle of the train emits sound with a frequency of 440 Hz. The observer hears the sound with a frequency of 415 Hz. The speed of sound in air is 343 m/s. Which of the following is correct? The train has a speed of

A) 20.7 m/s, and is moving away from the observer.
B) 20.7 m/s, and is moving toward the observer.
C) 19.5 m/s, and is moving away from the observer.
D) 19.5 m/s, and is moving toward the observer.
E) 324 m/s, and is moving away from the observer.

Q8. At a location that is 3.00 m from sound source A and 4.20 m from sound source B, constructive interference occurs. Source A and source B are in phase. What is the lowest frequency of the waves? The speed of sound in air is 343 m/s.

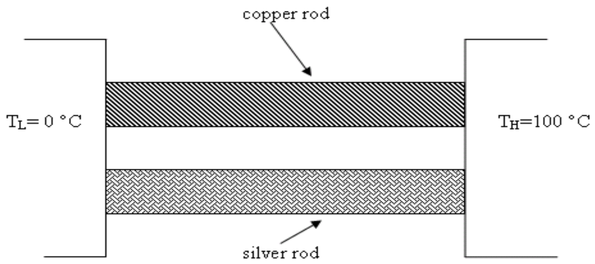
A) 286 Hz
B) 240 Hz
C) 360 Hz
D) 543 Hz
E) 356 Hz

Q9. Consider a steel ball of radius 10 cm at 20 ^{0}C. What is the magnitude of the change in its volume when the temperature is lowered to −20 ^{0}C? [The coefficient of linear expansion of steel = 11.7×10^{-6} /C^0].

A) 5.9×10^{-6} m^3
B) 1.6×10^{-6} m^3
C) 2.5×10^{-6} m^3
D) 3.2×10^{-6} m^3
E) 8.5×10^{-6} m^3

Q10. Two metal rods, one silver and the other copper, each are 5.00 cm long and have a square cross-section, 2.00 cm on a side. As shown in Figure 1 both rods are connected in parallel between a steam chamber at a temperature of 100°C, at one end, and an ice water bath, with a temperature of 0°C, at the other. How much heat flows through the two rods in 1.00 minute? [The thermal conductivity of silver is 417 W/(m·K), and that of copper is 395 W/(m·K)].

Fig#



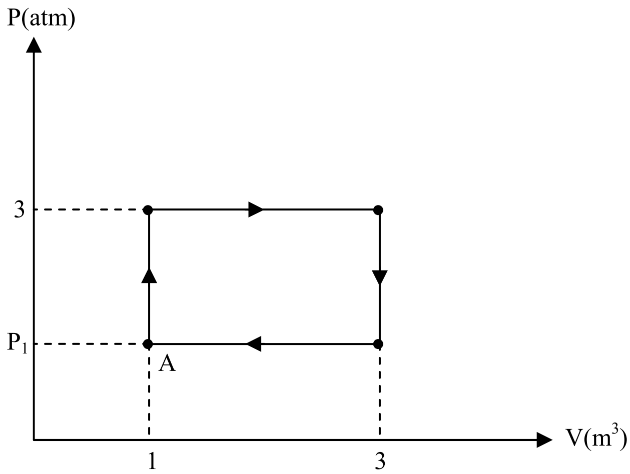
A) 39.0 kJ
B) 20.0 kJ
C) 47.0 kJ
D) 29.0 kJ
E) 11.0 kJ

Q11. A 200-g thermally insulated metal container has 100 g of water, both in thermal equilibrium at 22.0°C. A 21-g ice cube, at 0 °C, is dropped into the water, and when thermal equilibrium is reached the temperature is 15.0 °C. The specific heat for the metal is:

A) 3.86 kJ/kg·K
B) 5.45 kJ/kg·K
C) 2.73 kJ/kg·K
D) 4.95 kJ/kg·K
E) 4.45 kJ/kg·K

Q12. A 30.0 moles of an ideal gas starting at point A is carried around the cycle shown in Figure 2. In the process the gas does 3.00×10^5 J of work. Find the gas temperature at point A.

Fig#



A) 617 K
B) 301 K
C) 571 K
D) 743 K
E) 808 K

Q13. A sample of argon gas (molar mass 40 g) is at four times the absolute temperature of a sample of hydrogen gas (molar mass 2.0 g). The ratio of the rms speed of the argon molecules to that of the hydrogen molecules is

A) $1/\sqrt{5}$
B) 5
C) 1/5
D) 1
E) $\sqrt{5}$

Q14. When work is done on an ideal gas of *N* diatomic molecules in thermal insulation the temperature increases by (where W is the magnitude of the work)

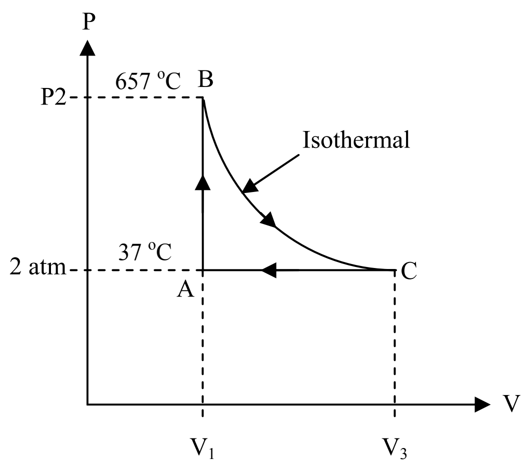
A) 2W/5Nk
B) W/3Nk
C) W/2Nk
D) W/Nk
E) 2W/3Nk

Q15. A 7.8 moles of an ideal gas is at an initial temperature of 24 ^{0}C and has an initial volume of 0.04 m^3. The gas expands adiabatically to a volume of 0.08 m^3. Calculate the work done by the gas during this expansion. ($\gamma = 1.67$)

A) 11 kJ
B) 31 kJ
C) 9.7 kJ
D) 16 kJ
E) 3.3 kJ

Q16. A 9.0 g of helium gas undergoes a cyclic process as shown Figure 3. Find the work done in the process from point B → C. (molar mass of helium is 4.0 g/mole)

Fig#



A) 19 kJ
B) 16 kJ

C) 32 kJ
D) 9.0 kJ
E) 5.4 kJ

Q17. The temperature of 5.0 mole of a monatomic ideal gas is raised reversibly from 200 K to 500 K, with its volume kept constant. The entropy change for the gas is:

A) 57 J/K
B) 32 J/K
C) 27 J/K
D) 15 J/K
E) 90 J/K

Q18. A Carnot heat engine operates between two reservoirs at temperatures of 500 K and 375 K. If the engine does 4.50×10^7 J of work per cycle, find the heat extracted per cycle.

A) 18.0×10^7 J
B) 24.0×10^7 J
C) 30.0×10^7 J
D) 10.0×10^7 J
E) 4.00×10^7 J

Q19. A freezer has a coefficient of performance of 3.80 and uses 200 W of power. How long would it take to freeze 600 g of water at 0 ^{o}C?

A) 4.4 minutes
B) 24 minutes
C) 30 seconds
D) 2.9 minutes
E) 1.2 minutes

Q20. One kilogram of water at 0 ^{o}C (system A) is added to one kilogram of water at 100 ^{o}C (system B) in an insulated container. Calculate the change in entropy of system B.

A) – 603 J/K
B) + 707 J/K
C) – 230 J/K
D) + 350 J/K
E) + 100 J/K

Physics 102 Major1
Formula sheet

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$PV = nRT = NkT$$

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

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

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

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

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

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

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

$$Q = mL$$

$$Q = mc\Delta T$$

$$Q = nc\Delta T$$

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

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

$$C_p - C_v = R$$

$$W = \int PdV$$

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

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

$$W = Q_H - Q_L$$

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

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

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

<u>Constants:</u>

1 Liter = 10^{-3} m^3

R = 8.31 J/mol K

N_A = 6.02 x 10^{23} molecules/mole

1 atm = 1.01 x 10^5 N/m^2

k = 1.38 x 10^{-23} J/K

1 calorie = 4.186 Joule

g = 9.8 m/s^2

for water:

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

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