Q1

(a) $A = 0.00327$

(b) $k = 72.1$

$\boxed{\lambda = \frac{2\pi}{k}} = \frac{2\pi}{72.1}$

$w = 2.72$

$\boxed{f = \frac{w}{2\pi}} = \frac{2.72}{2\pi}$

$\boxed{T = \frac{1}{f}} = \frac{2\pi}{2.72}$

(c) $\boxed{v = \lambda f} = \frac{2\pi}{72.1} \cdot \frac{2.72}{2\pi}$

(d) $y(22.5, 18.9)$

$= 0.00327 \sin(72.1 \times 22.5 - 2.72 \times 18.9)$

$= 0.00327 \sin(-34.82)$

(e) $\boxed{u = \frac{dy}{dt}} = A w \cos(wt - kx)$

$= -0.00327 \times 2.72 \cos(-34.82)$

Q2. I $y(x,t) = y_1(x,t) + y_2(x,t)$

(a) $A = A_1 + A_2$.

(b) $A = |A_1 + A_2|$

(c) $A = \sqrt{A_1^2 + A_2^2 + 2A_1A_2\cos(\delta\varphi)}$

$A_{Max} = \sqrt{A_1^2 + A_2^2 + 2A_1A_2}$

$A_{min} = \sqrt{A_1^2 + A_2^2 - 2A_1A_2}$.

II
$\left\{\begin{array}{l}\text{Red}: \lambda \text{ increase} \\ \text{Blue}: \lambda \text{ decrease}.\end{array}\right\}$ light emitted by a star moving away from the observer

III
{ Heat: Energy transferred due to temperature difference

Temperature: Measure of average kinetic energy of particles

Q3. $L = 62$ dB $I_0 = 1 \times 10^{-12}$

(a) $\boxed{L = 10 \log \frac{I}{I_0}} \Rightarrow I = I_0 \times 10^{\frac{L}{10}}$

$\Rightarrow I = 1.585 \times 10^{-6}$

$\boxed{I = \frac{1}{2}\sqrt{\rho B w^6 A^6} = \frac{P_{max}^2}{2\rho v} = \frac{P_{max}^2}{2\sqrt{\rho B}}}$

$\Rightarrow P = \sqrt{2\rho v I}$

(b) $A = \sqrt{\frac{2I}{w^2\sqrt{\rho B}}} = \frac{P}{w\sqrt{\rho B}}$

(c) $\boxed{\frac{I_1}{I_2} = \frac{r_2^2}{r_1^2}}$.

$r_1 = 10$ m $I_1 = 1.585 \times 10^{-6}$

$I_2 = I_0 \times 10^{\frac{L_2}{10}}$

$\Rightarrow r_2 \approx 398.45$.

(d) { Transverse: Direction of vibration perpendicular to wave propagation

Longitudinal: - - - - parallel - - - -

{ Energy: transferred from one point to another through wave propagation.

Matter: Not move with the wave only oscillates locally

Q4. (a) $T = \frac{2\pi}{w} = \frac{2\pi}{5.4}$

$\lambda = \frac{2\pi}{k} = \frac{2\pi}{0.45}$

(b) $f = \frac{w}{2\pi} = \frac{1}{T} = \frac{5.4}{2\pi}$

(c) $v = \frac{\lambda}{T}$

$u = \frac{dy}{dt}$

$u_{max} = wA$

Q5. (a). (b)
$$\boxed{\begin{array}{l} T_F = \frac{9}{5}T_C + 32 \\ T_K = T_C + 273.15 \\ T_C = \frac{5}{9}(T_F - 32) \end{array}}$$

(c) $0°C$ / $100°C$

Q6.

(a). $T_1 = 25°C$ $m_1 = 0.25$ kg $C_1 = 4184$. J/kg°C

$T_2 = -20°C$ $m_2 = ?$ $C_2 = 2090$ J/kg°C

$T_{final} = 0°C$ Heat of fusion $= m_2 \cdot \boxed{L}$

$L = 334000$ J/kg

$Q = mc\Delta T$

Heat lost by cola = Heat gained by ice + Heat of fusion

$$m_1 C_1 (T_1 - T_{final}) = m_2 C_2 (T_{final} - T_2) + m_2 L$$

$\Rightarrow m_2 \approx 0.093$.

(b) $\boxed{e = \frac{W}{Q_H} = 1 + \frac{Q_C}{Q_H} = 1 - \left|\frac{Q_C}{Q_H}\right|}$

(c) $\boxed{\Delta S = \frac{Q}{T}} = \frac{mL}{T} = \frac{334000}{273.15}$.

Q7 $T_1 = 10°C$ $P_1 = 1.7 + P_0 = 2.72$ atm $V_1 = 0.025$ m^3

$T_2 = 50°C$ $P_2 = ?$ $V_2 = 0.0269$ m^3

(a) $\boxed{PV = nRT}$ (n, R constant)

$$\Rightarrow \frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

$$\Rightarrow P_2 = \frac{P_1 V_1}{T_1} \cdot \frac{T_2}{V_2} = 2.94 \text{ atm}$$

$P_{gauge} = P_2 - P_0 = 2.94 - 1.02 = 1.92$ atm

(b) $\boxed{E_{avg} = \frac{3}{2} kT} = \frac{3}{2} \times 1.38 \times 10^{-23} \times (27 + 273.15)$

$\approx 6.21 \times 10^{-21}$ J

(c) $\boxed{E_{Total} = 3NKT = 3nRT} = 3 \times 6.02 \times 10^{23} \times 1.38 \times 10^{-23} \times 300.15$

$= 3748.5$ J

Q8. $e = \frac{W}{Q_H} = 1 + \frac{Q_C}{Q_H} = 1 - \left|\frac{Q_C}{Q_H}\right|$

①→②: $\boxed{\Delta V = 0 \Rightarrow W = 0 \Rightarrow Q = nC_v \Delta T} = nC_v (T_2 - T_1)$

$PV = nRT$ (V constant) $\Rightarrow P_1 V = nRT_1$

$P_2 V = nRT_2$.

$\Rightarrow (P_2 - P_1) V = nR(T_2 - T_1)$ $(\Delta P V = nR\Delta T)$

$\Rightarrow n(T_2 - T_1) = \frac{(P_2 - P_1)V}{R}$ $\left(n\Delta T = \frac{\Delta P V}{R}\right)$

$\Rightarrow Q = \frac{C_v (P_2 - P_1) V}{R} = \frac{C_v P_0 V_0}{R}$ $(Q > 0)$

②→③ $\boxed{\Delta P = 0 \Rightarrow W = P\Delta V} = 2P_0 V_0$

$\boxed{\Rightarrow Q = nC_p \Delta T =} nC_p (T_2 - T_1)$

$PV = nRT$ (P constant) $\Rightarrow PV_1 = nRT_1$

$PV_2 = nRT_2$

-23
X10 X300.15

$\Rightarrow P(V_2 - V_1) = nR(T_2 - T_1)$ $(P\Delta V = nR\Delta T)$

$\Rightarrow Q = \frac{C_p P (V_2 - V_1)}{R} = \frac{2C_p P_0 V_0}{R}.$ $(Q > 0)$

③ → ④

$\Delta V = 0 \Rightarrow W = 0. \Rightarrow Q = nC_v \Delta T = \dfrac{C_v \Delta p V}{R}$

$= \dfrac{C_v (p_0 - 2p_0) \cdot 2V_0}{R}$

$= \dfrac{-2C_v p_0 V_0}{R}$

$(Q < 0)$

④ → ①

$\Delta p = 0 \Rightarrow W = p\Delta V = p(V_0 - 2V_0) = -p_0 V_0$

$Q = nC_p \Delta T = \dfrac{C_p \cdot p\Delta V}{R} = \dfrac{C_p \cdot p_0 (V_0 - 2V_0)}{R}$

$= -\dfrac{C_p p_0 V_0}{R}$

$(Q < 0)$

$\boxed{W_{Total} = W_{1\to2} + W_{2\to3} + W_{3\to4} + W_{4\to1}}$

$= 0 + 2p_0V_0 + 0 - p_0V_0 = p_0V_0$

$\boxed{Q_H = Q_{1\to2} + Q_{2\to3}}$

$= \dfrac{C_v p_0 V_0}{R} + \dfrac{2C_p p_0 V_0}{R} = (C_v + 2C_p)\dfrac{p_0V_0}{R}$

$C_p = C_v + R \Rightarrow Q_H = (3C_v + 2R)\dfrac{p_0V_0}{R}$

$\boxed{Q_C = Q_{3\to4} + Q_{4\to1}}$

$= -\dfrac{2C_v p_0 V_0}{R} - \dfrac{C_p p_0 V_0}{R} = (2C_v + C_p)\dfrac{p_0V_0}{R}$

$= (3C_v + R)\dfrac{p_0V_0}{R}$

$e = \dfrac{\dot{W}}{Q_H} = \dfrac{p_0V_0 \cdot R}{(3C_v + 2R)p_0V_0} = \dfrac{R}{3C_v + 2R} = \dfrac{R}{3(\frac{5R}{2}) + 2R}$

$= \dfrac{2}{19}$

$= 10.5\%$

Q9.

(a) $\boxed{\Delta L = \alpha L_0 \Delta T}$ $\alpha_s = 1.2 \times 10^{-5} \cdot (°C)^{-1}$

$\alpha_b = 1.9 \times 10^{-5} \ (°C)^{-1}$

$\Rightarrow \Delta T = \dfrac{\Delta L}{\alpha L_0} = \dfrac{0.002}{2.5 \times 1.2 \times 10^{-5}} \approx 66.7°C$

$T = T_0 + \Delta T = 20°C + 66.7°C = 86.7°C$

(b) $L = L_0 + \Delta L = L_0(1 + \alpha \Delta T)$

for steel and brass:

$L_{0s}(1 + \alpha_s \Delta T) = L_{0b}(1 + \alpha_b \Delta T)$

$\Rightarrow \Delta T = \dfrac{L_{0b} - L_{0s}}{L_{0s}\alpha_s - L_{0b}\alpha_b} = \dfrac{2.502 - 2.5}{(2.5 \times 1.2 \times 10^{-5}) - (2.502 \times 1.9 \times 10^{-5})}$

$\approx \dfrac{0.002}{\cancel{2.004} \times 10^{-5}}$ $\approx -\cancel{99.8}°C.$ $[-114°C)]$

(-1.7538)

$T = T_0 + \Delta T = 20 \cancel{99.8} \cancel{= 79.8}°C.$

$-114 = -96°C.$

(c) $L_0 = 1410$ m.

$\Delta T = 100°C - (-5°C) = 105°C$

$\Delta L = \alpha L_0 \Delta T = 1.2 \times 10^{-5} \times 1410 \times 105.$

$= 1.777$ m.