Q1(1):

The distance travelled=The area under the $v - t$ graph

$=\frac{1}{2}v_1t_1 + \frac{(v_2+v_1)(t_2-t_1)}{2}$

$= \boxed{\dfrac{v_1t_2 - v_2t_1 + v_2t_2}{2}}$.

Q1(2):

The change in internal energy$=\frac{3}{2}P(V_2 - V_1)$.

The work done$=P(V_2 - V_1)$.

By the first law of thermodynamics, we have the heat required

$=\frac{3}{2}P(V_2 - V_1) + P(V_2 - V_1) = \boxed{\dfrac{5}{2}P(V_2 - V_1)}$.

Alternative The molar heat capacitor of monoatomic ideal gas under constant pressure is given by $\frac{5}{2}R$.

As $T \propto V$ under consant pressure, we have $\Delta T = T_0(\frac{V_2}{V_1} - 1)$.

Moreover, by $pV = nRT$, we have $T_0 = \frac{PV_1}{R}$.

Given the above, $Q = (\frac{5}{2}R)(\frac{PV_1}{R})(\frac{V_2}{V_1} - 1) = \boxed{\dfrac{5}{2}P(V_2 - V_1)}$.

Q1(3):

When $t = 0$, the acceleration of the block is maximum with the direction opposite to the stretch.

After the speed reaches the maximum $v = \omega d$, it starts to move in the positive direction and so on.

Therefore, the correct graph is $\boxed{(b)}$.

Q1(4):

Consider the balance of force: The compression of the spring=The electric force.

$$kd = \frac{1}{4\pi\epsilon_0}\frac{qQ}{(l+d)^2}$$

$$Q = \frac{4\pi\epsilon_0}{q}kd(l+d^2)$$

Q1(5):

The angle of infraction=$90° - \theta$. By considering the trigonometric ratio, we have $\sin(90° - \theta) = \frac{d}{\sqrt{h^2+d^2}}$.

Let ϕ be the angle of refractive, by considering the trigonometric ratio, we have $\sin\phi = \frac{d-x}{\sqrt{h^2+(d-x)^2}}$.

By Snells' law, we have $\frac{d}{\sqrt{h^2+d^2}} = n(\frac{d-x}{\sqrt{h^2+(d-x)^2}})$, i.e. $n = \boxed{\frac{d}{d-x}\sqrt{\frac{h^2+(d-x)^2}{h^2+d^2}}}$.

Q2:

(1): By the defination of capacitance, we have $Q = \boxed{CV}$.

(2): The electric field strength is given by $E = \boxed{\frac{V}{d}}$.

(3): We have $C = \frac{\epsilon_r S}{d}$. As $C = \frac{(1)S}{d}$, we have the surface area of the plate $S = Cd$.

Therefore, we have $C_1 = \frac{\epsilon(Cd)}{\frac{d}{2}} = \boxed{2\epsilon C}$.

(4): Similar to (3), the capacitance $C_2 = 2C$.

Therefore, the equivalent capacitance$=\frac{1}{\frac{1}{2\epsilon C}+\frac{1}{2C}} = \boxed{\dfrac{2\epsilon}{\epsilon+1}C}$.

(5): Similar to what we did above, we split the capacitor into two capacitors in parallel.

Then, the capacitances of the two capacitors are $\frac{\epsilon_1 \frac{S}{2}}{d} = \frac{1}{2}\epsilon_1 C$ and $\frac{\epsilon_2 \frac{S}{2}}{d} = \frac{1}{2}\epsilon_2 C$ respectively.

Then, the equivalent capacitance$=\frac{1}{2}\epsilon_1 C + \frac{1}{2}\epsilon_2 C = \boxed{\dfrac{\epsilon_1+\epsilon_2}{2}C}$.

Q3:

(1): Set the GPE as 0 at the height of point A.

The height at the position$=R\cos\theta$. Therefore, the GPE at the position $=-mgR(1-\cos\theta)$.

Consider the conservation of energy: KE+GPE=KE+GPE

$$0 + 0 = \frac{1}{2}mv^2 - mgR(1-\cos\theta)$$

$$v = \boxed{\sqrt{2gR(1-\cos\theta)}}$$

(2): The component of the weight in the direction perpendicular to the motion= $\boxed{mg\cos\theta}$.

As the ball is performing circular motion, we have the balance of force: Centripetal force=(The component)-(Normal force)

$$\frac{mv^2}{r} = mg\cos\theta - N$$

$$N = mg\cos\theta - \frac{m(\sqrt{2gR(1-\cos\theta)})^2}{R} = \cos\theta = \boxed{mg(3\cos\theta - 2)}$$

(3): The ball leaves the hemisphere when the normal force=0, i.e.

$$mg(3\cos\theta_B - 2) = 0$$

$$\cos\theta_B = \boxed{\frac{2}{3}}$$

(4): Consider the conservation of energy: KE+GPE=KE+GPE

$$0 + 0 = \frac{1}{2}mv^2 - mgR$$

$$v = \boxed{\sqrt{2gR}}$$

(5): By (1) and (3), the speed of the ball at the point B

$= \sqrt{2gR(1-\frac{2}{3})} = \sqrt{\frac{2}{3}gR}$.

The horizontal component= $\sqrt{\frac{2}{3}gR}\cos\theta_B = \sqrt{\frac{2}{3}gR}\frac{2}{3} = \sqrt{\frac{8}{27}gR}$.

After the ball left the hemi-sphere, it undergoes a projectile motion, where the horizontal acceleration is 0.

Therefore, the horizontal velocity at C=That at B= $\boxed{\sqrt{\frac{8}{27}gR}}$.

Q4:

(1): As T is directly proportional to pV under constant number of moles, we have $T_A = \boxed{\frac{1}{3}T_0}$.

(2): The change in internal energy in the process

$\Delta U = \frac{3}{2}(3p_0)(V_0) - \frac{3}{2}p_0V_0 = 3p_0V_0 = RT_0$.

As the volume remains constant, there is no work done by the gas.

Therefore, by the first law of thermodynamics, we have $Q = \Delta U + W_{gas} = \boxed{RT_0}$.

Alternative The molar heat capacity for fixed volume is given by $\frac{3}{2}R$. Therefore, the heat absorbed=$\frac{3}{2}R(T_0 - \frac{1}{3}T_0) = \boxed{RT_0}$.

(3): As the change in internal energy during the process=0, by the first law of thermodynamics, we have $W_{gas} = Q - \Delta U = \boxed{Q_0}$.

(4): The work done by the gas=The signed area under the $p - V$ graph

$=p_0(V_0 - 3V_0)$

$= -2p_0V_0$

$= \boxed{-\frac{2}{3}T_0}$.

(5): As the gas back to its initial state after the whole process, the net change in internal energy=0.

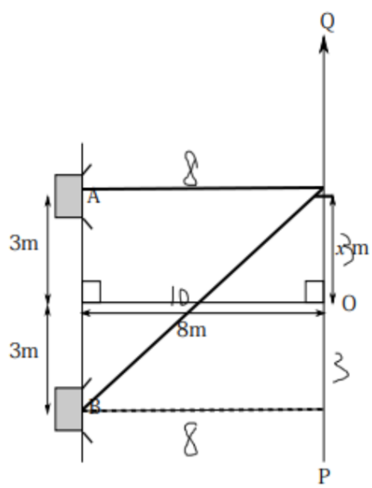
As the net work done by gas is given by the signed area bounded in the $p-V$ graph, where is greater than 0 in this process, we have $W > 0$.

Now, by the first law of thermodynamics, we have $Q = W > 0$.

Therefore, $\boxed{W > 0, Q > 0}$.

Q5:

(1): Refer to the graph:



A minimum sound is heard at 3 m, which implies a destructive interference occurs there.

Therefore, we have the path difference$=\frac{1}{2}\lambda$, i.e. $10-8=\frac{1}{2}\lambda$, i.e. $\lambda = \boxed{4\ m}$.

(2): By $v = f\lambda$, we have $f = \frac{v}{\lambda} = \frac{3.4\times10^2}{4} = \boxed{8.5\times10^1\ Hz}$.

(3): When f increases, λ decrease as the speed of wave is constant.

As the observer heard the minimum again, the second destructive interference occurse at $x = 3\ m$.

Therefore, we have $2 = \frac{3}{2}\lambda$, $\lambda = \frac{4}{3}\ m$, i.e. $f = \frac{3.4\times10^2}{\frac{4}{3}} \approx \boxed{2.6 \times 10^2\ Hz}$.

(4): As temperature increases, the density of the air increases. As sound waves spread via the vibration of air particles, the speed of the sound wave is hence increasd. Therefore, λ is also increased as f is fixed.

Then, the path difference required for destructive interference to occur will be increased and hence the value of x will also $\boxed{\text{increase}}$.