Q1(1):

Set the GPE as 0 at the ground.

Consider the conservation of energy: KE+GPE=KE+GPE, we have

$$\frac{1}{2}mv^2 + 0 = \frac{1}{2}mv_Q^2 + mgr$$

$$mv_Q^2 = mv^2 - 2mgr$$

Note the at the point Q, the centripetal force of the circular motion is entirely provided by the normal reaction. Therefore, we have $N = \frac{mv_Q^2}{r} = \boxed{\frac{mv^2}{r} - 2mg}$.

Q1(2):

The cycle of rotation of the Earth is 1 day.

By Kepler's third law, we have $T^2 \propto r^3$.

Therefore, we have the ratio$=(\frac{1}{27})^{\frac{2}{3}} = \boxed{\frac{1}{9}}$.

Q1(3):

The the charge is positive, negative charges of amount Q will be attracted towards the inner surface of the conductor. Correspondingly, positive charges of amount Q will be repulsed towards the outer surface of the conductor. Note that those charges will be distributed uniformly. Therefore, the answer is $\boxed{(g)}$.

Q1(4):

Let P be the pressure of gas inside the cylinder originally. Then the force due to the pressure difference=$(P-p)S$ N pointing upwards.

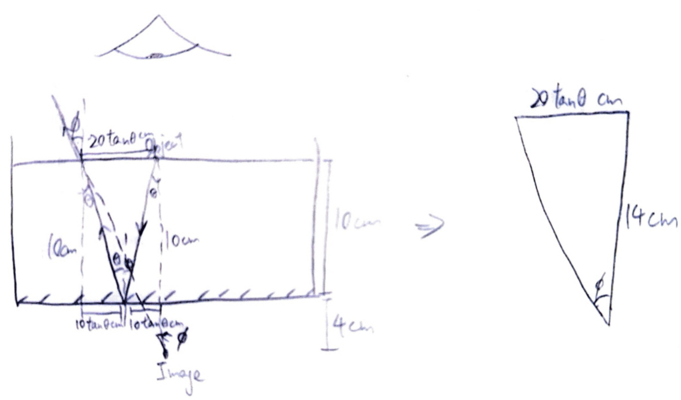
Considering the balance of forces, the above force balanced the weight of the piston. Therefore, we have $(P-p)S = Mg$.

On the other hand, when the cyliner is rotated by 180°, the volume becomes twice. As for constant temperature, the volume of gas is inversely proportional to the pressure of gas, we have the pressure becomes $\frac{1}{2}P$.

Then, the force due to the pressure difference between $(p - \frac{1}{2}P)S$ N pointing upwards and similarly we have $(p - \frac{1}{2}P)S = Mg$.

Adding the two equations together, we have $P = \frac{4Mg}{S}$ and hence $p = \boxed{\frac{3Mg}{S}}$.

Q1(5):



Referring to the sketch, we have $\tan\phi = \frac{20\tan\theta}{14}$, i.e. $\frac{\tan\phi}{\tan\theta} = \frac{20}{14}$.

By small angle approximation*, we have $n = \frac{\sin\phi}{\sin\theta} \approx \frac{\tan\phi}{\tan\theta} = \frac{20}{14} \approx \boxed{1.43}$.

*: As the image is observed by the eyes, which have a very small angular size when compared with the angle of reflection, all the angles involved must be very small.

Q2:

(1): By $F = Bqv$, the magnetic force is proportional to the speed.

Moreover, by Fleming's left hand rule, the direction of the force is always perpendicular to the magnetic field.

Therefore, the answer is $\boxed{(d)}$.

(2): For a positive ion, it is attracted to the negative pole of the capacitor, which is in the direction opposite to the electric field.

As to move in a straight line, a magnetic force opposite to this direction is required.

As the current created by the positive ion is in the same direction as its motion, by Fleming's left hand rule, the direction of the magnetic field is perpendicular to and out of the plane of the papaer $\boxed{(d)}$.

(3): As the magnetic force balanced the electric force, we have

$$qE = B_1qv$$

$$\boxed{v = \frac{E}{B_1}}$$

(4): Note the the magnetic force provided the entire centripetal force. Therefore, we have

$$\frac{mv^2}{r} = B_2 qv$$

$$\boxed{r = \frac{mv}{qB_2}}$$

(5): By (3), v is a constant. Therefore, by (4), we have $r \propto \frac{m}{q}$, the mass to charge ratio.

As the mass to charge ratio of an alpha particle is twice that of a proton, we have the ratio of their radii=$\boxed{2}$.

Q3:

(1): As the tension becomes 0 at B, the centripetal force is provided entirely by the weight of the mass. Therefore, we have

$$\frac{mv^2}{L} = mg\cos(\frac{\pi}{2} - \theta)$$

$$v = \boxed{\sqrt{gL\sin\theta}}$$

(2): Set the GPE as 0 at the height of A. Then, as the height of B with respect to A is $L + L\sin\theta$, the GPE at B is given by $mg(1 + \sin\theta)L$.

Therefore, consider the conservation of energy: KE+GPE=KE+GPE, we have

$$\frac{1}{2}mv_0^2 + 0 = \frac{1}{2}m(\sqrt{gL\sin\theta})^2 + mg(1 + \sin\theta)L$$

$$v_0 = \boxed{\sqrt{(2+3\sin\theta)gL}}$$

(3): Consider the vertical component of v, $v_y = v\sin(\frac{\pi}{2}-\theta) = v\cos\theta$.

Set the GPE as 0 at the height of B. Note that the vertical velocity drops to 0 when the object reaches the maximum height. Therefore, by the conservation of energy, we have

$$\frac{1}{2}m(v\cos\theta)^2 + 0 = 0 + mgh$$

$$h = \boxed{\frac{v^2}{2g}\cos^2\theta}$$

(4): The path of the projection is given by the parametric equation:

$$\begin{cases} x = v_x t = v\sin\theta t \\ y = v_y t - \frac{1}{2}gt^2 = v\cos\theta t - \frac{1}{2}gt^2 \end{cases}$$

As the height of C with respect to B is $L\sin(\pi-\phi) - L\sin\theta = L(\sin\phi - \sin\theta)$ and the distance between C and B=$L\cos(\pi-\phi) + L\cos\theta = L(\cos\theta - \cos\phi)$, if the object reaches C, we have the system of equation:

$$\begin{cases} L(\cos\theta - \cos\phi) = v\sin\theta t \\ L(\sin\phi - \sin\theta) = v\cos\theta t - \frac{1}{2}gt^2 \end{cases}$$

i.e. $L(\sin\phi - \sin\theta) = L\cot\theta(\cos\theta - \cos\phi) - \frac{1}{2}g(\frac{L(\cos\theta-\cos\phi)}{v\sin\theta})^2$.

Moreover, by (1), we have $v = \sqrt{gL\sin\theta}$ and the equation becomes

$\sin\phi - \sin\theta = \cot\theta(\cos\theta - \cos\phi) - \frac{(\cos\theta-\cos\phi)^2}{2\sin^3\theta}$.

Now, substitue $\theta = \frac{\pi}{3}$, we have

$$\sin\phi - \frac{\sqrt{3}}{2} = \frac{1}{\sqrt{3}}(\frac{1}{2} - \cos\phi) - \frac{(\frac{1}{2}-\cos\phi)^2}{2(\frac{\sqrt{3}}{2})^3}$$

$$\sqrt{3}\sin\phi - 9 = 1 + 2\cos\phi - 8\cos^2\phi$$

By substituting the four options into this equation, we have $\phi = \boxed{\pi}$.

(5): By the result of (4), we have the time duration $t = \frac{L(\frac{1}{2}+1)}{\frac{\sqrt{3}}{2}v} = \frac{\sqrt{3}L}{v}$.

Therefore, the vertical velocity becomes $v_y - gt = \frac{1}{2}v - \frac{\sqrt{3}gL}{v}$.

Hence, we have $\tan\omega = |\frac{v_y}{v_x}| = |\frac{\frac{1}{2}v - \frac{\sqrt{3}gL}{v}}{\frac{\sqrt{3}}{2}v}| = |\frac{1}{\sqrt{3}} - \frac{2gL}{v^2}| = \frac{3}{\sqrt{3}}$.

The corresponding value of ω will be $\boxed{\frac{\pi}{3}}$.

Q4:

(1): Recall that $c_p = c_v + R$, indepedent on the type of gas molecule. Therefore, we have $\frac{c_p - c_v}{R} = \boxed{1}$.

(2): As Ar is a monoatomic gas, the c_v value is $\frac{3}{2}R$. Therefore, $\frac{c_v}{R} = \boxed{\frac{3}{2}}$.

(3): For a diatomic gas, $c_v = \frac{5}{2}R$. Therefore, the value $\frac{c_v}{R}$ will be greater $\boxed{(c)}$.

(4): As same as (1), the value is constantly 1 $\boxed{(a)}$.

Q5:

(1): $\boxed{(a)}$.

Note: The speed of sound wave in air is 340 m/s = 1224 km/h. Generally, neither a car or wind can move in such a high speed.

(2)-(3): The general form of Doppler effect is given by $f' = \frac{V - v_{observer}}{V - v_{source}} f$.

Now that the wind is blowing at the same direction as that of the ambulance, the speed of the sound wave becomes $c + W$ when the ambulance is approaching the observer and $c - W$ when the ambulance is leaving the observer.

Therefore, we have $v_+ = \frac{c+W}{c+W-U} v$ and $v_- = \frac{c-W}{c-W+U} v$.

i.e. $\boxed{v_+ - v = v\dfrac{U}{c + w - U}}$ and $\boxed{v_- - v = v\dfrac{U}{c - W + U}}$.