1. Air flows through a nozzle of diameter 1.3 mm having a discharge coefficient of 0.95, from a pressure of 5 atm to a pressure of 1 atm at 25 ^oC. Density of air will be:
A) 5.930 g/cm^3
B) 59.30 kg/cm^3
C) 0.593 kg/m^3
D) None

Ans (A)

$$\rho = \frac{pM}{RT} = \frac{5x101325x29}{8314x298} = 5.93\ kg\ m^{-3}$$

2. For Q. 1 Maximum velocity will be:
A) 3.15 m/s
B) 2.95 m/s
C) 0.315 km/s
D) 3150 m/s

Answer (C)

Now, upstream pressure is 5 times greater than that of downstream pressure. Hence pressure ratio is at critical condition

$$v_0 = \sqrt{\frac{2\gamma p}{(\gamma-1)\rho}\left[1-\left(\frac{p_0}{p}\right)_{cr}^{\frac{\gamma-1}{\gamma}}\right]}$$

$$= \sqrt{\frac{2x1.4x5x101325}{(1.4-1)5.93}\left[1-(0.528)^{\frac{1.4-1}{1.4}}\right]}$$

$$= 315.83\ ms^{-1}$$

= 0.315 kms^{-1}

3. For Q. 1 Mass flow rate will be:
A) 669×10^{-6} kg/s
B) 24.09 Kg/h
C) Both A&B
D) None of these

Ans. (A)

$$Now,\ A_0 = \frac{\pi}{4}(0.0013)^2 = 1.327x10^{-6}\ m^2$$

$$\therefore W = C_D A_0 \sqrt{\frac{2\gamma p \rho}{(\gamma-1)}\left[\left(\frac{p_0}{P}\right)_{cr}^{\frac{2}{\gamma}} - \left(\frac{p_0}{p}\right)_{cr}^{\frac{\gamma+1}{\gamma}}\right]}$$

$$= 0.95x1.327x10^{-6}\ x \sqrt{\frac{2x1.4x101325x5.93}{(1.4-1)}\left[(0.528)^{\frac{2}{1.4}} - (0.528)^{\frac{1.4+1}{1.4}}\right]}$$

$$= 6.69x10^{-4}\ kg\ s^{-1},\quad or,\ 2.409\ kg\ h^{-1}$$

4. Methane is being pumped through a 50.0 cm ID pipeline for a distance of 1.0×10^5 m at a rate of 2.0 Kg Mole/s. Mass density of methane is

a) 40.746 $kg/m^2.s$

b) 162.984 $kg/m^2.s$

c) 1273.31 $kg/m^2.s$

d) 5093.25 $kg/m^2.s$

Ans. (b)

$$G = 2.0 \frac{\text{Kg Mole}}{\text{s}} \times 16 \frac{\text{Kg}}{\text{Kg Mole}} \times \frac{1}{\frac{\pi D^2}{4} m^2} = \frac{2\times16\times4}{3.1416\times.5^2} = 162.984\ kg/m^2.s$$

5. For adiabatic flow, $PV^{\gamma} = C$ where γ is

a) γ is the ratio of heat capacities at constant pressure and at constant volume respectively.

b) γ is the ratio of heat capacities at constant volume and at constant pressure respectively.

c) γ is always 1

d) None

Ans. (a)

$\gamma = C_p/C_v$

6. Discharge through nozzle is maximum when,

a) $P/P_o = 0.528$

b) $P_o /P = 0.528$

c) $P/P_o < 0.528$

d) All of the above

Ans. (b)

7. A nozzle of 1 mm dia with a coefficient of discharge of 0.92 is to deliver air from 4 atm pressure to 3 atm pressure at 35 ^{0}C. Density of air:

a) 4.59 kg/m^3

b) 3.44 kg/m^3

c) 4.59 g/m^3

d) 3.44 g/m^3

Ans. (a)

$$\rho = \frac{pM}{RT} = \frac{4 \times 101325 \times 28.97}{8314 \times 308} = 4.59\ \mathrm{kg/m^3}$$

8. In Q. 8 Velocity of air
   a) 260.15 m/s
   b) 220.85 m/s
   c) 220.85 cm/s
   d) None

   Ans. (b)

$$We\ know\ that, v_0 = \sqrt{\frac{2\gamma p}{(\gamma-1)\rho}\left[1-\left(\frac{p_0}{p}\right)^{\frac{\gamma-1}{\gamma}}\right]}$$

$$v_0 = \sqrt{\frac{2 \times 1.4 \times 4 \times 101325}{(1.4-1) \times 4.59}\left[1-\left(\frac{3}{4}\right)^{\frac{1.4-1}{1.4}}\right]}$$

=220.85 m/s

9. In Q. 8 Mass flow rate

a) 2.48 kg/h

b) 2.15 kg/h

c) 2.48 kg/s

d) 2.15 kg/s

Ans. (b)

$A_0 = \frac{\pi D^2}{4} = \frac{\pi \times .001^2}{4} = 7.85 \times 10^{-7}\ \mathrm{m^2}$

Now, we know that

$$W = C_D A_0 \sqrt{\frac{2\gamma p\rho}{(\gamma-1)}\left[\left(\frac{p_0}{P}\right)^{\frac{2}{\gamma}} - \left(\frac{p_0}{p}\right)^{\frac{\gamma+1}{\gamma}}\right]}$$

$$W = 0.92 \times 7.85 \times 10^{-7} \sqrt{\frac{2 \times 1.4 \times 4 \times 101325 \times 4.59}{(1.4-1)}\left[\left(\frac{3}{4}\right)^{2/1.4} - \left(\frac{3}{4}\right)^{\frac{1.4+1}{1.4}}\right]}$$

= 0.000597 Kg/s = 2.15 Kg/h

10. In Q. 8 Maximum velocity of air

a) 370.89 m/s

b) 321.20 m/s

c) 260.15 m/s

d) 220.85 m/s

Ans. (a)

At critical pressure ratio, i.e., $p_0/p = 0.528$, the velocity will be maximum

$$v_0 = \sqrt{\frac{2\gamma p}{(\gamma-1)\rho}\left[1 - \left(\frac{p_0}{p}\right)_{cr}^{\frac{\gamma-1}{\gamma}}\right]}$$

11. In Q. 8 Maximum mass flow rate is

a) 2.594 kg/h

b) 3 kg/h

c) 2.48 kg/h

d) None

Ans. (b)

At critical pressure ratio, i.e., $p_0/p = 0.528$, the discharge will be maximum

12. The unit of rate of mass discharge from the nozzle “W” will be

a) kg/hr

b) kg-hr
c) kg-m/s
d) None of the above

Ans. (a)

13. The expression for the Bernoulli's equation is

a) $\frac{p}{\rho} + \frac{v^2}{2} + gz = \text{constant}$
b) $\frac{p}{\rho} + \frac{v^2}{2g} + gz = \text{constant}$
c) $\frac{p}{\rho g} + \frac{v^2}{2g} + gz = \text{constant}$
d) $\frac{p}{\rho} + \frac{v^2}{2g} + z = \text{constant}$

Ans. (a)

14. For adiabatic flow

a) $pV^{\gamma} = C$
b) $pV = C$
c) $pV^{\gamma-1} = C$
d) None of the above

Ans. (a)