

**WEEKLY TEST RANKER'S BATCH-02 TEST - 04 Balliwala**  
**SOLUTION Date 06-10-2019**

**[PHYSICS]**

1.  $\eta = 1 - \frac{T_L}{T_H}$

2.

3.  $C_v$  for hydrogen =  $\frac{5R}{2}$ ,  $C_0$  for helium =  $\frac{3R}{2}$

$$C_v \text{ for water vapour} = \frac{6R}{2}$$

$$\therefore [C_v]_{\text{mix}} = \frac{4 \times \frac{5R}{2} + 2 \times \frac{3R}{2} + 1 \times 3R}{4 + 2 + 1} = \frac{16R}{7}$$

$$\therefore C_p = C_v + R = \frac{16R}{7} + R = \frac{23R}{7}$$

4. As pressure is varying linearly with volume, work done  $dW = \text{area under PV curve}$

$$= P_1(V_F - V_1) + \frac{1}{2}(P_F - P_1)(V_F - V_1)$$

$$= \frac{1}{2}(P_F + P_1)(V_F - V_1)$$

$$dU = \mu C_v dT = \mu \frac{R}{\gamma - 1} dT = \frac{P_F V_F - P_1 V_1}{\gamma - 1}$$

$$\therefore dU = \frac{10^5(8 \times 0.5) - 4 \times 0.2}{(5/2) - 1} = 4.8 \times 10^5 \text{ J}$$

5.  $PV^\gamma = \text{constant}$

$$P^\gamma V^{\gamma-1} \gamma V + \Delta P V^\gamma = 0$$

$$\therefore \frac{\Delta P}{P} = -\gamma \frac{\Delta V}{V}$$

6.

7. In cylinder A, heat is supplied at constant pressure while in cylinder B heat is supplied at constant volume.

$$(\Delta Q)_A = n C_p (\Delta T)_A$$

$$\text{and } (\Delta Q)_B = n C_v (\Delta T)_B$$

**Given that :**

$$(\Delta Q)_A = (\Delta Q)_B$$

$$\therefore (\Delta T)_B = \frac{C_p}{C_v} (\Delta T)_A = (1.4)(30) = 42 \text{ K}$$



11. Since, P-V graph of the process is a straight line and two points  $(V_0, 2P_0)$  and  $(2V_0, P_0)$  are known, therefore its equation will be,

$$(P - P_0) = \frac{(2P_0 - P_0)}{(V_0 - 2V_0)}(V - 2V_0) = \frac{P_0}{V_0}(2V_0 - V)$$

$$\therefore P = 3P_0 - \frac{P_0 V}{V_0}$$

According to equation for ideal gas,

$$T = \frac{PV}{nR}$$

$$= \left( 3P_0 - \frac{P_0 V}{V_0} \right) \frac{V}{nR}$$

$$= \frac{3P_0 V_0 V - P_0 V^2}{nR V_0} \quad \dots\dots(i)$$

For T to be maximum,  $\frac{dT}{dV} = 0$

$$3P_0 V_0 - 2P_0 V = 0$$

$$\text{or } V = \frac{3V_0}{2} \quad \dots\dots(ii)$$

Putting this value in equation(i), we get,

$$T_{\max} = \frac{3P_0 V_0 \left( \frac{3V_0}{2} \right) - P_0 \left( \frac{9}{4} V_0^2 \right)}{nR V_0} = \frac{9P_0 V_0}{4nR}$$

12. In the curves 1-2 and 3-4, we find that the pressure is directly proportional to temperature. So, the volume remains unchanged, i.e., gas does not work.

The work done during the isobaric processes 2-3 and 1-4 are as follows

$$W_{2-3} = P_2(V_3 - V_2)$$

$$\text{Total work done} = P_2(V_3 - V_2) + P_1(V_1 - V_4)$$

$$W_T = P_2 V_3 - P_2 V_2 + P_1 V_1 - P_1 V_4$$

Three moles has been given, so

$$PV = nRT = 3RT$$

$$\therefore W_T = 3RT_3 - 3RT_2 + 3RT_1 - 3RT_4$$

$$= 3R[T_1 + T_3 - T_2 - T_4]$$

$$= 3R[400 + 2400 - 800 - 1200]$$

$$= 3R \times 800 = 20 \times 10^3 \text{ J} = 20 \text{ kJ}$$

13. According to first law of thermodynamics :

$$\Delta Q = \Delta U + \Delta W$$

$$\text{For the process abc, } 80 = \Delta U + 60$$

$$\text{or } \Delta U = 20 \text{ cal}$$

Since,  $\Delta U$  is independent of path the internal energy change is same for both the paths abc and adc.

$$\text{For the process adc, } \Delta Q = \Delta U + \Delta W$$

$$\therefore \Delta W = \Delta Q - \Delta U = 30 - 20 = 10 \text{ cal}$$

- 14.

15. In adiabatic expansion we know that  $dQ = 0$

$$dQ = dU + PdV \text{ or } 0 = dU + PdV$$

$$PdV = -dU$$

Thus, work done decrease internal energy which is function of temperature. Hence, temperature also decreases.



16. For mixture of gases, let specific heat be  $C_v$

$$C_v = \frac{n_1(C_v)_1 + n_2(C_v)_2}{n_1 + n_2}$$

$$\text{where } (C_v)_1 = \frac{5R}{2}, (C_v)_2 = \frac{3R}{2}$$

$$\therefore C_v = \frac{2 \times \frac{5R}{2} + 8 \times \frac{3R}{2}}{2 + 8} = \frac{17R}{10} = 1.7R$$

17. Two chambers are kept separate at  $(P, 5V)$  and  $(10P, V)$ . When the piston is allowed to move, the gases are kept separated but the pressure has to be equal

Let the equal new pressure on the both sides of piston in its equilibrium position be  $P'$ .

As the process is isothermal, hence

$$\text{for LHS portion: } P(5V) = P'(5V - x) \quad \dots(i)$$

$$\text{and for RHS portion: } 10P(V) = P'(V + x) \quad \dots(ii)$$

solving equations (i) and (ii) we get;

$$x = 3V$$

$$\therefore \text{New volume of LHS portion} = 2V \text{ and new volume of RHS portion} = 4V$$

18.  $PV^\gamma = \text{constant}$  for an adiabatic process

**Given:**  $P^3 \times V^4 = \text{constant}$

$$\text{or } PV^{4/3} = \text{constant} \quad \left( \text{as } P^3 \propto \frac{1}{V^4} \right)$$

$$\text{or } \gamma = \frac{4}{3} = 1.33$$

- 19.

20. From first law of thermodynamics,

$$Q = \Delta U + W$$

$$\text{For path iaf, } 50 = \Delta U + 20$$

$$\therefore \Delta U = U_f - U_i = 30 \text{ cal}$$

$$\text{For path ibf, } Q = \Delta U + W$$

$$\text{or } W = Q - \Delta U$$

$$= 36 - 30 = 6 \text{ cal}$$

21. In cyclic process, the amount of heat given to system is equal to the net work done by the system.

Hence, correct answer is (b)

22. Work done in complete cycle

$$= \text{Area under } P - V \text{ graph}$$

$$= P_0 V_0$$

Heat given to the gas in going from A to B

$$nC_v \Delta T = n \cdot \frac{3}{2} R \Delta T$$

Heat given to the gas in going from B to C

$$= nC_v \Delta T = n \left( \frac{5}{2} R \right) \Delta T$$

$$= \frac{5}{2} (2P_0) \Delta T = 5P_0 V_0$$

Heat is rejected in going from C to D and then D to A.

$$\text{Efficiency, } \eta = \frac{\text{Work done by the gas}}{\text{Heat given to the gas}} \times 100$$

$$= \frac{P_0 V_0 \times 100}{\frac{3}{2} P_0 V_0 + 5P_0 V_0} = \frac{2 \times 100}{13} = 15.4\%$$

$$23. \quad \frac{K_{Fe} A (100 - \theta)}{d} = \frac{K_{Ag} (\theta - 0)}{d}$$

$$\frac{K_{Fe}}{K_{Ag}} = \frac{\theta}{100 - \theta} \quad \text{or} \quad \frac{1}{11} = \frac{\theta}{100 - \theta}$$

$$\therefore \theta = \frac{100}{12} = 8.3^\circ\text{C}$$

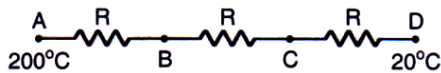
$$24. \quad \frac{dQ}{dt} = \frac{dQ_1}{dt} + \frac{dQ_2}{dt}$$

$$\frac{K(A_1 + A_2)(\theta_1 - \theta_2)}{d} = \frac{K_1 A_1 (\theta_1 - \theta_2)}{d} + \frac{K_2 A_2 (\theta_1 - \theta_2)}{d}$$

$$\therefore K = \frac{K_1 A_1 + K_2 A_2}{A_1 + A_2}$$

25.

26. Equivalent electrical circuit, will be as shown in figure.



Temperature difference between A and D is  $180^\circ\text{C}$ , which is equally distributed in all the rods. Therefore, temperature difference between A and B will be  $60^\circ\text{C}$ , or temperature of B should be  $140^\circ\text{C}$

27.

28. Rate of flow of heat  $\frac{dQ}{dt}$  or H is equal throughout the rod. Temperature difference is given by :

T.D. = (H) (Thermal Resistance)  
or R.D  $\propto$  Thermal Resistance R

$$\text{Where, } R = \frac{1}{KA} \quad \text{or} \quad R \propto \frac{1}{A}$$

Area across CD is less. Therefore, T.D. cross CD will be more.

29. Here,  $K_1 = K_2$ ,  $l_1 = l_2 = 1\text{m}$ ,

$$A_1 = 2A, A_2 = A$$

$$T_1 = 100^\circ\text{C}, \quad T_2 = 70^\circ\text{C}$$

$\therefore$  Temperature at C be T, then

$$\frac{\Delta Q}{\Delta t} = \frac{K_2 A (100 - T)}{1} = \frac{KA (T - 70)}{1}$$

$$\text{or } T = 90^\circ$$

30. We know that :  $\frac{dQ}{dt} = KA \frac{d\theta}{dx}$

In steady state flow of heat,

$$d\theta = \frac{dQ}{dt} \cdot \frac{1}{KA} dx$$

$$\text{or } \theta_H - \theta = K'x$$

$$\text{or } \theta = \theta_H - K'x$$

Equation,  $\theta = \theta_H - K'x$  represents a straight line.

31.

32.

33. For parallel combination of two rods of equal length and equal area of cross-section :

$$K = \frac{K_1 + K_2}{2} = \frac{K_1 + \frac{4K_1}{3}}{2} = \frac{7K_1}{6}$$

$$\text{Hence, } \frac{K}{K_1} = \frac{7}{6}$$

34. When a body cools by radiation, according to Stefan's law,

$$\frac{dT}{dt} \frac{eA\sigma}{mc} (T^4 - T_0^4)$$

Here, m, c, e, T and  $T_0$  are same for all bodies; so

$$\frac{dT}{dt} \propto \text{area } A$$

Now, as for a given mass, area of the sphere is minimum, hence it will have the lowest rate of cooling.

35.

Radius of small sphere = r and thickness = t

Radius of bigger sphere = 2r and thickness = t/4

$$\text{Mass of ice melted} = \frac{4}{3} \pi r^3 \rho$$

$$\text{For bigger sphere : } \frac{K_1 4\pi(2r^2) \times 100}{t/4} = \frac{\frac{4}{3} \pi (2r^2) \rho L}{25 \times 60}$$

$$\text{For smaller sphere : } \frac{K_2 4\pi r^2 \times 100}{t} = \frac{\frac{4}{3} \pi r^2 \rho L}{16 \times 60}$$

$$\frac{K_1}{K_2} = \frac{8}{25}$$

36.

According to Wein's law

$$\lambda_m T = \text{constant}$$

$$\text{or } (\lambda_{m1}) T_1 = (\lambda_{m2}) T_2$$

$$\text{or } 11 \times 10^{-5} \times T_1 = (5.5 \times 10^{-5}) \times T_2$$

$$\therefore T_1 = \frac{1}{2} T_2$$

37.

$$P \propto \frac{T^4}{d^2}$$

When T and d are doubled, then power received by the surface

$$P' \propto \frac{(2T)^4}{(2d)^2} \propto \frac{2^4 T^4}{2^2 d^2} \propto \frac{4T^4}{d^2}$$

$$\text{Hence, } P' = 4P$$

38.

39.

40.

41.

12.

According to Newton's law of cooling, rate of loss of heat  $\propto (T - T_0)$  where T is the average temperature in the given time interval. Hence,

$$43. \quad \frac{Q}{t} \propto K \quad \text{or} \quad Kt = \text{constant}$$

$$\therefore \frac{K_1}{K_2} = \frac{t_2}{t_1} = \frac{40}{20} = \frac{2}{1}$$

44. For slabs in series, we have,

$$R_{\text{eq.}} = R_1 + R_2$$

$$\text{i.e., } \frac{5x}{K_{\text{eq.}}A} = \frac{4x}{2KA} + \frac{x}{KA}$$

Now, is steady state, rate of heat transfer through the slab

$$\frac{K_{\text{eq.}}A(T_2 - T_1)}{5x} = \left( \frac{5(T_2 - T_1)K}{x} \right) f$$

Putting the value of  $K_{\text{eq.}}$ , we get;

$$f = \frac{1}{3}$$

$$45. \quad \frac{Q}{At} = \frac{K(\theta_1 - \theta_2)}{d} = \text{constant}$$

$$\therefore K_A \left( \frac{\theta_1 - \theta}{d} \right) = K_B \left( \frac{\theta - \theta_2}{d} \right)$$

$$\frac{K_A}{K_B} = \frac{\theta - \theta_2}{\theta_1 - \theta} \quad \text{or} \quad 3 = \frac{\theta - \theta_2}{\theta_1 - \theta}$$

$$\text{or } 3\theta_1 - \theta_2 = 4\theta \quad \dots (i)$$

$$\text{Given } \theta_1 - \theta_2 = 20^\circ\text{C} \quad \dots (ii)$$

Solving eqns. (i) & (ii), we have  $\theta - \theta_2 = 15^\circ\text{C}$

$$\begin{aligned} \therefore q - q &= \theta_1 - \theta_2 + \theta_2 - \theta \\ &= (\theta_1 - \theta_2) - (\theta - \theta_2) \\ &= 20^\circ\text{C} - 15^\circ\text{C} = 5^\circ\text{C} \end{aligned}$$