ANSWER SHEET

1	A	13	B	25	A	37	C	49	B	61	B
2	C	14	D	26	B	38	28.57 Kj	50	B	62	50
3	B	15	A	27	D	39	C	51	C	63	599 – 601
4	20 bar	16	C	28	C	40	1975-1985	52	0.76 - 0.95	64	A
5	153.33 c	17	B	29	B	41	C	53	D	65	D
6	C	18	B	30	D	42	A	54	D		
7	2.33	19	A	31	B	43	C	55	C		
8	A	20	D	32	D	44	D	56	D		
9	D	21	A	33	A	45	B	57	C		
10	101.68 kpa	22	8.944	34	B	46	6	58	D		
11	A	23	B	35	A	47	B	59	A		
12	C	24	B	36	461.25KW	48	B	60	D		

SOLUTION

1. **(A)**
2. **(C)**
3. **(B)**
4. **(20 bar)**

Perfect gas

If temperature is constant

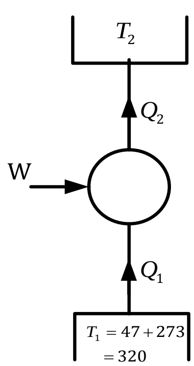
Ideal gas equation becomes $PV = C$

$P_1V_1 = P_2P_2$

$\Rightarrow \quad 5\times10 = P_2 \times 2.5$

$\Rightarrow \quad \boxed{P_2 = 20\,bar}$

5. **(153.33^0C)**



$\Rightarrow \quad (COP)_{HP} = \dfrac{Q_2}{W}$

$= \dfrac{Q_2}{Q_2 - Q_1}$

$(\therefore \quad W + Q_1 = Q_2)$

Since it is carnot cycle (assumed as reversible)

$(COP)_{HP} = \dfrac{T_2}{T_2 - T_1}$

$\Rightarrow \quad 4[T_2 - T_1] = T_2$

$\Rightarrow \quad 4T_2 - 4T_1 = T_2$

$\Rightarrow \quad 3T_2 = 4T_1$

$\Rightarrow \quad T_2 = \dfrac{4}{3}T_1$

$= 426.66\,K$

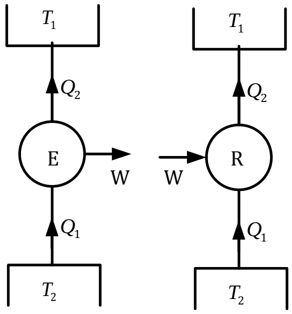
$T_1 = 426.66 - 273$

$= 153.66^0C$

6. **(C)**

Adiabatic but not reversible

7. **(2.33)**



$$¦ = \left(\frac{1-Q_2}{Q_1}\right) = 0.3$$

$$= \frac{Q_1 - Q_2}{Q_1} = 0.3$$

$$= \frac{Q_2}{Q_1} = 0.7$$

$$(COP)_R = \frac{Q_2}{Q_1 - Q_2}$$

$$or \quad \frac{\frac{Q_2}{Q_1}}{1-\frac{Q_2}{Q_1}} = \frac{0.7}{1-0.7}$$

$$(COP)_R = 2.33$$

8. (A)

$(0, \infty, 1)$

Isobaric $\rightarrow \quad n = 0$

Isochoric $\rightarrow \quad n = \infty$

Isothermal $\rightarrow \quad n = 1$

9. (D)

To locate state 2, two independent properties are required,

Here only volume is given Hence not possible to determine the temperature.

10. (101.68 KPa)

$P = ?$

$V = 350\,m^3$

$T = 37^0 C = 310\,K$

$m = 400\,kg$

$$\therefore \quad P = \frac{m \times R \times T}{v}$$

$$= \frac{400 \times 0.287 \times 310}{350}$$

$$= 101.68\,KPa$$

11. (A)

12. (C)

$W = -200\,kJ$

$dU = U_2 - U_1 = -100\,kJ$

$\therefore$ from first law

$dQ = dU + dW$

$= -300\,kJ$

$(-ve)$ sign indicates transfer of heat out of system.

13. (B)

14. (D)

15. (A)

16. (C)

17. (B)

18. (B)

19. (A)

20. (D)

21. (A)

Area of parallelograms $|\overline{OP} \times \overline{OR}|$

$\overline{OP} = ai + bj$

$\overline{OR} = ci + dj$

$= |\overline{OP} \times \overline{OR}| = |(ai + bj) \times (ci + dj)|$

$= ad\hat{k} - bc\hat{k}$

$= \left|(ad - bc)\hat{k}\right|$

$= (ad - bc)$

22. (8.944)

$\nabla f\,\big]_{(2,1,3)} = 8i + 6j + 6\overline{k}$

Directional derivative

$$= (8i + 6j + 6k)\frac{i + 2k}{\sqrt{5}} = 8.94427$$

23. (B)

Probability for a accident to one car in a week $= \frac{1}{7}$

SO Required probability that seven car accident happen in same day $= \frac{7}{7^7} = \frac{1}{7^6}$

24. (B)

Required probability for sharing same birth month is

$$= \frac{1}{12_{c_1}} = \frac{1}{12}$$

25. (A)

Required probability $= \mathrm{P}(x > 1)$

$$= \int_1^\infty f_x(x)\,dx = \int_1^\infty e^{-x}dx$$

$$= \left[-e^{-x}\right]_1^\infty = e^{-1} = \frac{1}{e} = 0.368$$

26. (B)

27. (D)

$$¦ = 1 - \frac{T_2}{T_1}$$

$$\left(\frac{d¦}{dT_1}\right)_{T_2} = \frac{T_2}{T_1^2}$$

$$\left(\frac{d¦}{dT_2}\right)_{T_1} = -\frac{1}{T_1}$$

since $T_1 > T_2$

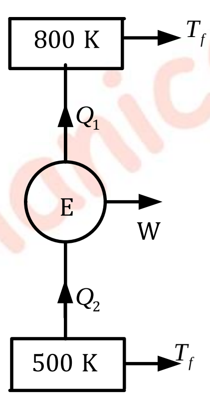
$$\left(\frac{d¦}{dT_2}\right)_{T_1} > \left(\frac{d¦}{dT_1}\right)_{T_2}$$

More effective way to inefficiency is to decrease T_2, by keeping T_1 constant.

28. (C)

$T_1 = 527 + 273 = 800\,K$

$T_2 = 227 + 273 = 500\,K$



For maximum work process should be reversible

$\therefore \quad (\Delta S)_{univ} = 0$

$$\Rightarrow \quad C\ln\left(\frac{T_f}{800}\right) + C\ln\left(\frac{T_f}{500}\right) = 0$$

$T_f^2 = 800 \times 500$

$T_f = 632.45\,K$

$\therefore \quad T_f = 632.45 - 273\,K = 359.45 \approx 360^0C$

29. (B)

$m = 10\,kg, c_V = 0.652\,kJ/kg-K$

$v = C$

$T_1 = 67^0C = 67 + 273 = 340\,K$

For constant volume process

$P = mRT$

$P \ {}^0C \ T$

$$\frac{P_2}{P_1} = \frac{T_2}{T_1}$$

$$\Rightarrow \quad 2 = \frac{T_2}{340\,K}$$

$\boxed{T_2 = 680\,K}$

For $v = C,\ dw = 0$

$dQ = mC_V\,dT$

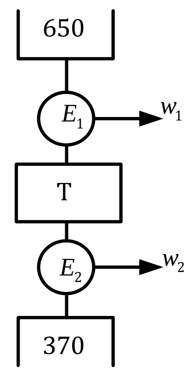
$= 10 \times 0.652 \times (680 - 340)$

$= 2216.8$

$\boxed{dQ = 2217\,kJ}$

30. (D)

31. (B)



For reversible engine

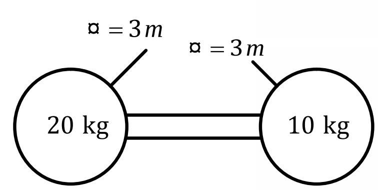
$$\frac{650}{T} = \frac{T}{370}$$

$\Rightarrow \quad T = \sqrt{650 \times 370}$

$= 490\,K$

$= 237^0C$

32. (D)



$T = 27^0C = 300\,K$

After mixing

$\Rightarrow \quad m = 20 + 10 = 30\,kg$

$v = 2 \times \frac{4}{3}® \times 1.5^3$

$T = 300\,K$

Ideal gas equation $pv = mRT$

$\therefore \quad P \times 2 \times \frac{4®}{3} \times 1.5^3 = 30 \times 0.287 \times 300$

$\Rightarrow \quad P = 91.3549\,KPa$

Or $\boxed{P = 0.91355\,bar}$

33. (A)

34. (B)

$dQ = 0 \quad [\text{for Adiabatic}]$

$pv^{¥} = C$

$$\Rightarrow \frac{v_2}{v_1} = \left(\frac{p_1}{p_2}\right)^{\frac{1}{¥}} = \left(\frac{1}{0.125}\right)^{\frac{1}{1.287}}$$

$\Rightarrow \quad v_2 = 0.1 \times 5.0315$

$= 0.503$

$$dw = \frac{p_1 v_1 - p_2 v_2}{¥ - 1}$$

$$= \frac{10^3 \times 0.1 - 125 \times 0.503}{0.287}$$

$= 129.35\,kJ$

35. (A)

$P_1 = 6\,MPa,\ P_2 = 200\,KPa$

$V_1 = 500 \times 10^{-6}\,m^3$

$T_1 = 1073\,K$

Since temperature is constant

$$w = P_1 V_1 \ln\left(\frac{P_1}{P_2}\right)$$

$$= 6 \times 10^3 \times 500 \times 10^{-3} \ln\left(\frac{6}{0.2}\right)$$

$= 10.2\,kJ$

$Tds = dh - vdp$

$$\Rightarrow \quad S_2 - S_1 = -R \ln\left(\frac{P_2}{P_1}\right)$$

$$= -0.287 \ln\left(\frac{0.2}{6}\right)$$

$= 0.976\,kJ/kg-K$

Or

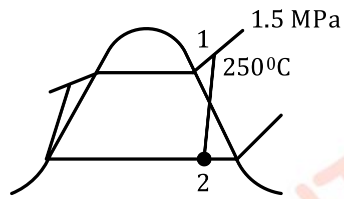
$\Delta S = m \times 0.976$

$= 9.5\,J/K$

$$m = \frac{6 \times 10^3 \times 500 \times 10^{-6}}{0.287 \times 1073}$$

$= 0.00974\,kg$

36. (461.25 kW)



Given,

$h_1 = 2920\,kJ/kg$

$h_2 = 185 + 0.8 \times 2650$

$= 2305$

$W = \dot{m}(h_1 - h_2)$

$$\Rightarrow \quad W = \frac{2700}{3600}[2920 - 2305]$$

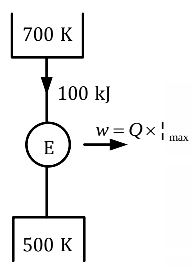
$\boxed{W = 461.25\,kW}$

37. (C)

$$\frac{P_2}{P_1} = \left(\frac{T_2}{T_1}\right)^{\frac{n}{n-1}} = (2)^{1.25/0.25} = 32$$

$$\frac{V_2}{V_1} = \left(\frac{T_1}{T_2}\right)^{\frac{1}{n-1}} = 0.5^{\frac{1}{0.25}} = \frac{1}{16}$$

38. (28.57 kJ)



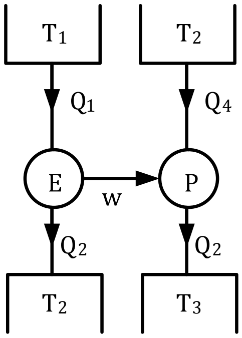
For a Reversible engine operating between 2 thermal Reservoir

$$¦_{max} = \left(1 - \frac{500}{700}\right) = 0.28571$$

$\therefore \quad W = 100 \times 0.2857$

$= 28.57\,kJ$

39. (C)



For Engine

$$W = Q_1\left(1-\frac{T_2}{T_1}\right) \qquad \text{...(i)}$$

For pump

$$Q_4 + W = Q_3$$

Also $\dfrac{Q_4}{Q_3} = \dfrac{T_4}{T_3}$

$$\Rightarrow \frac{Q_4}{Q_4+W} = \frac{T_4}{T_3}$$

$$\Rightarrow \frac{W+Q_4}{Q_4} = \frac{T_3}{T_4}$$

$$\Rightarrow 1+\frac{W}{Q_4} = \frac{T_3}{T_4}$$

$$W = Q_4\left(\frac{T_3}{T_4}-1\right) \qquad \text{...(ii)}$$

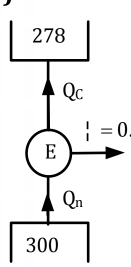
From equation (i) and (ii)

$$Q_1\left(1-\frac{T_2}{T_1}\right) = Q_4\left(\frac{T_3}{T_4}-1\right)$$

$$\Rightarrow \frac{Q_4}{Q_1} = \frac{\left(1-\frac{T_2}{T_1}\right)}{\left(\frac{T_3}{T_4}-1\right)}$$

$$\boxed{\frac{Q_4}{Q_1} = \frac{T_4}{T_1}\left(\frac{T_1-T_2}{T_3-T_4}\right)}$$

40. (1975-1985)



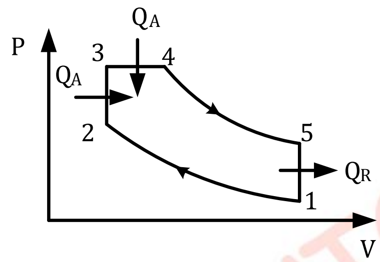
$$W = 0.8\left(1-\frac{278}{300}\right) = 0.0586$$

$$W = 0.0586\ Q_n = mC\Delta T$$

$$\Rightarrow \quad 0.0586\ Q_n = \frac{500\times 4.187\times[82.5-27]}{10^3}$$

$$\boxed{Q = 1982.95\,MJ}$$

41. (C)



Given,

$P_1 = 1\,bar,\ T_1 = 50^0C = 323\,K$

$$\therefore \quad v_1 = \frac{RT_1}{P_1} = \frac{0.287\times 323}{1\times 10^2} = 0.977\,m^3/kg$$

$$v_2 = \frac{0.927}{16} = 0.0579\,m^3/kg$$

Process 1-2

Given $r = 16$

$$\Rightarrow \quad T_2 = T_1 r^{r-1} = 323\times 16^{0.4}$$

$$\boxed{T_2 = 979\,K}$$

Process 2-3

$V_2 = V_3$

And $P_3V_3 = RT_3$

$$\Rightarrow \quad T_3 = \frac{70\times 10^2\times 0.0579}{0.287}$$

$$\boxed{T_3 = 1412.19\,K}$$

Given Heat added in const-pre. = Heat added in constant volume

$$\Rightarrow \quad C_V(T_3-T_2) = C_P(T_4-T_5)$$

$$\Rightarrow \quad T_3 - T_2 = 1.4T_4 - 1.4T_3$$

$$T_4 = \frac{2.4T_3 - T_2}{1.4}$$

$$\boxed{T_1 = 1721.6}$$

Process 4-5

$V_1 = V_5 = 0.927$

and $V_4 = \frac{0.287 \times 1721.61}{70 \times 10^2}$

$= 0.0705\, m^3$

$\therefore \quad \frac{T_5}{T_4} = \left(\frac{V_4}{V_5}\right)^{r-1}$

$\Rightarrow \quad T_5 = 1721.61 \times \left[\frac{0.0705}{0.927}\right]^{0.4}$

$\boxed{T_5 = 614.29\, K}$

$\therefore \quad ¦ = 1 - \frac{Q_R}{Q_A}$

$= 1 - \frac{C_V (T_5 - T_1)}{2C_V (T_3 - T_2)}$

$= \frac{1 - 0.5 \times (614.323)}{1412 - 979}$

$\boxed{¦ = 66.4.1}$

42. (A)

Isothermal process

$PV = C$

$\Rightarrow \quad PdV + VdP = O$

$\Rightarrow \quad \frac{dP}{dV} = \frac{-P}{V} = 2$

$PV^{¥} = C$

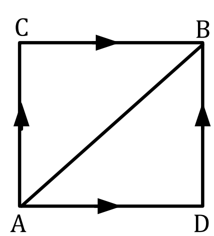
$P.¥V^{¥-1}dV + V^{¥}dP = 0$

$\Rightarrow \quad \frac{P}{V}¥ = -\frac{dP}{dV}$

$\Rightarrow \quad \frac{dP}{dV} = +¥\left(-\frac{P}{V}\right) = 1.3 \times 2$

$= 2.6$

43. (C)



Along ACB

$Q_{ACB} = (V_B - V_A) + W_{ACB}$

$\Rightarrow \quad +180 = (V_B - V_A) + 130\, kJ$

$\Rightarrow \quad V_B - V_A = 50\, kJ$

Along ADB

$Q_{ADB} = (V_B - V_A) + W_{ADB}$

$= 50 + 40$

$= 90\, kJ$

44. (D)

as we know that $\int_{-\infty}^{\infty} f_x(x) = 1$

SO $\int_0^2 K(5x - 2x^2)dx = 1$

$K\left[\frac{5x^2}{2} - 2\frac{x^3}{3}\right]_0^2 = 1$

$\Rightarrow K = \frac{3}{14}$

Now $P(X > 1) = \int_1^{\infty} f(x)dx$

$= \int_1^2 \frac{3}{14}(5x - 2x^2)dx$

$= \frac{3}{14}\left[\frac{5x^2}{2} - \frac{2x^3}{3}\right]_1^2 = \frac{17}{28}$

45. (B)

$\frac{N}{2}$ family has children = 3

& $\frac{3N}{10}$ family has children = 2

& $\frac{2N}{5}$ family has children = 1

So total children in N family

$= \frac{N}{2} \times 3 + 2 \times \frac{3N}{10} + \frac{2N}{5} \times 1$

$= \frac{3N}{2} + \frac{6N}{10} + \frac{2N}{5} = \frac{15N + 6N + 4N}{10} = \frac{25N}{10}$

Required probability $= \frac{3N/5}{\frac{25N}{10}} = \frac{3N}{5} \times \frac{10}{25N} = \frac{6}{25}$

46. (6)

Probability density function

$f_x(x) = \lambda(x-1)(2-x)$

Required probability $= \int_1^2 f_x(x) = 1$

$\Rightarrow \int_1^2 \lambda(x-1)(2-x)dx = 1$

$\Rightarrow \lambda\int_1^2 (2x - x^2 - 2 + x)dx = 1$

$$\Rightarrow a\left[\frac{2x^2}{2}-\frac{x^3}{3}-2x+\frac{x^2}{2}\right]=1$$

$$= a\left[\frac{27-26}{6}\right]=1$$

$$\Rightarrow \frac{a}{6}=1$$

$$\Rightarrow a=6$$

47. (B)

$$f(x)=\sqrt{x^2+y^2}$$

$$x=r\cos\theta,\ y=r\sin\theta$$

$f(x)=r\ i.e.$ r should be maximum.

$$Also,\ x^2+xy+y^2=1$$

$$r^2+r^2\cos\theta\sin\theta=1$$

$$r=\sqrt{\frac{1}{1+\frac{\sin 2\theta}{2}}}$$

For r to be maximum sin 2θ should be minimum sin 2θ = -1, so maximum value of $\sqrt{x^2+y^2}=\sqrt{2}$

48. (B)

$$\int_{-1}^{1}\frac{1}{x^2}e^{\frac{1}{x}}dx$$

$$Y=\frac{1}{x}dy=\frac{1}{x^2}dx$$

At $x=-1, y=-1, x=1, y=1$

$$\int_{-1}^{1}-e^{y}dy=\left[-e^{y}\right]_{-1}^{1}=e^{-1}-e=\frac{1-e^2}{e}$$

49. (B)

50. (B)

51. (C)

$$\lim_{x\to 0}\frac{x^2+\tan^{-1}x}{x+\sin^{-1}x+\sin^2 x}$$

Using L'Hospital's rule:

$$\lim_{x\to 0}\frac{2x+\frac{1}{1+x^2}}{1+\frac{1}{\sqrt{1-x^2}}+\sin^2 x}$$

$$=\frac{2\times 0+\frac{1}{1+0}}{1+\frac{1}{\sqrt{1}}+0}$$

$$=\frac{1}{1+1}$$

$$=\frac{1}{2}$$

52.

Solution:

0.84(0.76 - 0.95)

$$\text{Required probability} = \frac{\text{Favorable outcomes}}{\text{Total possible outcomes}}$$

Favorable outcomes = A false coin is chosen and flipped every time

Probability of selecting a false coin = $\frac{1}{4}$

Probability of getting a tail on every flip of false coin = 1.

∴ Favorable outcomes = $\frac{1}{4}\times 1=\frac{1}{4}$

Total possible outcomes = Favourable outcomes + Unfavourable outcomes

Unfourable outcomes = A fair coin is chosen and flipped everytime to get tail

Probability of selecting a fair coin = $\frac{3}{4}$

Probability of flipping a fair coin 4 times and getting

tails every time = $\left(\frac{1}{2}\right)^4=\frac{1}{16}$

∴ Unfavourable outcomes = $\frac{3}{4}\times\frac{1}{16}=\frac{3}{64}$

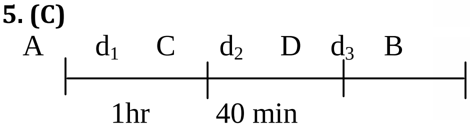
Total possible outcomes = $\frac{1}{4}+\frac{3}{64}=\frac{19}{64}$

∴ Required probability = $\frac{\frac{1}{4}}{\frac{19}{64}}=\frac{16}{19}\approx 0.84$

53. (D)

54. (D)

55. (C)



Time for cyclist to cover $d_1 + 2d_2 + 2d_3$ = 1 hour ....(1)
Time for cyclist to cover $d_2 + 2d_3$ = 40 minutes.

→ Time for cyclist to cover $d_1 + d_2$ = 20 minutes.
→ Time for pedestrian to cover $d_1 + d_2$ = 100 minutes.
→ Ratio of their speeds = 5 : 1.
Let 5x, x be speed of cycle and pedestrian respectively.

Speed of pedestrian $= = \frac{d_1}{60} = \frac{d_2}{40} \Rightarrow d_1 = \frac{3}{2} d_2$

Time for cyclist to cover $\left(\frac{3}{2} d_2 + d_2\right)$ = 20 minutes.

∴ Time for cyclist to cover d_1 = 12 minutes and to cover d 2 = 8 minutes.
∴ From (1) time for d_3 (cyclist) = 16 minutes. For pedestrian = 80 minutes.
∴ Total time for pedestrian = 1 hr + 40 min + 80 min = 3 hours.

56 . (D)

$$f(m_2) = \log[(m_2 - a_2)...(m_2 - m_2)...$$
$$(m_2 - z_2)] = \log 0$$

We know that logarithms are not defined for zero and negative numbers

57 . (C)

58. (D)

Venison is the meat of deer as beef is the meat of ox.

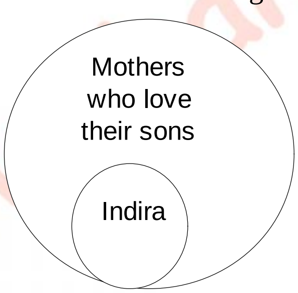
59. (A)

The context calls for words like cutting down in the first blank and restricting in the second blank .

60. (D)

61. (B)

Observe the following Venn diagram:



62. (50)

Quantity of milk k present in the
= 40% of 150 = 60

Quantity of water present in the solution = 60% of 150 = 90

Let us add x litres of water to make 30% milk solution (i.e. 70% water)

$$Hence, 90 + x = 70\% of (150 + x)$$
$$\Rightarrow \frac{90 + x}{150 + x} = \frac{7}{10}$$
$$\Rightarrow x = 50$$

63. (599- 601)

Let the total no. of passengers be x.

23 % of x by Bus

Remaining passengers = (100 – 23) % x = 77 % x

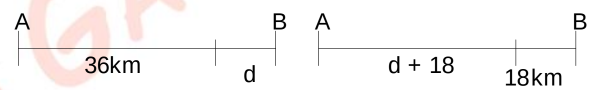
50 % of 77% of a by train = 38.5 %x by train (23 + 38.5)%x by Bus and train

Remaining i.e. [100 – (23 + 38.5)]% of x

$$38.5\% x = 231 \Rightarrow \frac{38.5}{100} \times x = 231$$

$$\therefore \quad x = 600$$

64. (A)



Let the distance traveled by N, when M covered 36Km, be d km

∴ The distance between A and B is (36 + d) km

M traveled 36 km of distance for first meeting, so he has to travel twice the distance for second meeting $\therefore 2(36) = d + 18 \Rightarrow d = 72 - 18 = 54$

∴ The time taken by M to travel 36km and the time taken by N to travel 54km are equal

∴ The ratio of speed of M and N = The ratio of the distances covered by them $= \frac{36}{54} = \frac{2}{3}$

65. (D)

Cash price = Rs. 27780, let each installment be Rs. X

First installment $= x = p_1\left(1 + \frac{15}{100}\right)^1 = p_1\left(\frac{23}{20}\right)$

Second installment $= x = p_2\left(1 + \frac{15}{100}\right)^2 = p_2\left(\frac{23}{20}\right)^2$

Third installment

$$= x = p_3\left(1+\frac{15}{100}\right)^3 = p_3\left(\frac{23}{20}\right)^3$$

$$\Rightarrow p_1 + p_2 + p_3 = x\left[\left(\frac{23}{20}\right)+\left(\frac{23}{20}\right)^2+\left(\frac{23}{20}\right)^3\right]$$

$$\Rightarrow 27780 = \frac{20X}{23}\left[1+\frac{20}{23}+\frac{400}{529}\right]$$

$$\Rightarrow x = 12167$$