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Class: XI
Subject: Physics
Topic: Thermodynamics
No. of Questions: 30

Q1. Equal masses of He and O_2 gases are given equal quantities of heat. Which will undergo a greater temperature rise?

a. He gas
b. O_2 gas
c. Same in both gases
d. None of these

Sol. a

He gas is a monatomic gas. So, the given heat to He will be totally used up in increasing the translational KE of its molecules whereas O_2 is a diatomic gas, so heat energy is used up in increasing KE of rotation and vibration.

Q2. An engine absorbs 1200 calories of heat from the sources and rejects 1000 calories of heat to the sink per cycle. What is the thermal efficiency?

a. 15%
b. 17%
c. 19%
d. 21%

Sol. b

$W = \theta_1 - \theta_2 = 1200 - 1000 = 200$ cal

$$\eta = \frac{W}{\theta_1} = \frac{200}{1200} \times 100 = 16.7\% \approx 17\%$$

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Q3. What does the area under P-V diagram represent?

a. The conduction of a system

b. Work done on or by the system

c. A thermodynamic process

d. All of the above

Sol. b

The area under P-V diagram represents work done on or by the system.

Q4. The first law of thermodynamics is a special case of _________

a. Newton's law

b. Law of conservation of energy

c. Charle's law

d. The law of heat exchange

Sol. b
The first law of thermodynamics is based on the principle of law of conservation of energy.

Q5. The energy emitted per second by a black body at 1227°C is B. If the temperature of the black body is increased to 2727°C. The energy emitted per second in terms of B is ______

a. 16 B

b. 10 B

c. 8 B

d. 5 B

Sol. a

$E_1 \propto T^4$

$\propto (1227 + 273)^4$

$E_1 = \sigma (1500)^4 = B$ (given)

$E_2 \propto (2727 + 273)^4$

$E_2 = \sigma (3000)^4 = \sigma (2 \times 1500)^4 = 16 B$

Q6. Which instrument is used to measure thermal radiation?

a. Thermocouple

b. Hygrometer

c. Bolometer

d. Galvanometer

Sol. c

Bolometer is used to measure thermal radiation.

Q7. A comfortable room temperature is 72°F. What is the temperature in degree Celsius?

a. 36°C

b. 144°C

c. 22°C

d. 11°C

Sol. c

$C = \frac{5}{9}[F - 32] = \frac{5}{9}[72 - 32] = 22°C$

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Q8. In a thermodynamic process, 500 J of heat is given to a gas and 200 J of work is also done on it. What is the change in internal energy of the gas?

a. 400 J

b. 500 J

c. 600 J

d. 700 J

Sol. D

According to first law of thermodynamics Q = U + dW is negative

∵ Work is done on the system

Q = U - dW

U = 500 + 200 = 700 J

Q9. An engine absorbs 2000 calories of heat from source and rejects 1800 calories of heat to the sink per cycle. What is its thermal efficiency?

a. 10%

b. 20%

c. 30%

d. 40%

Sol. A

W = $\theta_1 - \theta_2 = 2000 - 1800 = 200$ cal

$$\eta = \frac{w}{\theta_1} = \frac{200}{2000} \times 100 = 10\%$$

Q10. The pressure and density of a diatomic gas $\left(r = \frac{7}{5}\right)$ change adiabatically from (P, ρ) to (P', ρ). If $\left(\frac{\rho'}{\rho}\right)$ = 32, then (P'/ P) would be ______

a. $\frac{1}{28}$

b. 128

c. 32

d. $\frac{1}{64}$

Sol. b

$$P\left(\frac{m}{\rho}\right)^r = P'\left(\frac{m'}{\rho'}\right)^r$$

$$\left(\frac{\rho'}{\rho}\right)^r = \frac{P'}{P}$$

$$\Rightarrow \quad \left(\frac{\rho'}{\rho}\right)^y = (32)^{\frac{7}{5}} = (2^5)^{\frac{7}{5}} = 128$$

Q11. A ball of mass 2 kg falls from a height of 20 m on the ground and it rebounds to a height of 0.2 m. If the loss in P.E. is absorbed by the ball as heat, then what will be the temperature rise? (Specific heat of material = 0.09 cal $gm^{-1}°C^{-1}$)

a. $\frac{5}{3}$°C

b. $\frac{4}{11}$°C

c. $\frac{8}{2}$°C

d. $\frac{11}{21}$°C

Sol. d

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$W = W_1 - W_2 = mgh - mgh' = mg(h - h') = 2 \times 10 \times (20 - 0.2)$

$= 2 \times 10 \times 19.8$

$= 2 \times 198 = 396$ J

This energy is converted into heat when ball strikes the ground

Heat produced is $\theta = \frac{396}{4.2}$ cal

$$\Delta T = \frac{\theta}{mc} = \frac{396 \times 10}{42 \times 2000 \times 0.09} = \frac{396 \times 1000}{42 \times 9 \times 2000} = \frac{396}{42 \times 9 \times 2}$$

$$= \frac{396}{756} = \frac{11}{21}\,°C$$

Q12. In an isobaric process

a. pressure is constant

b. volume is constant

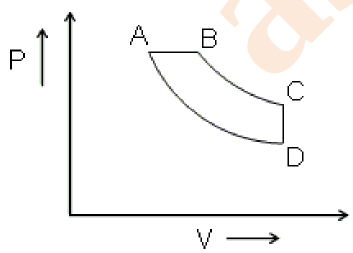
c. temperature is constant

d. internal energy is constant

Sol. A

In an isobaric process pressure is constant.

Q13. In the given P-V diagram, the isochoric and thermal parts are represented by ______



a. BC, CD

b. AD, CD

c. CD, DA

d. AB, AD

Sol. C

In the given P-V diagram, the isochloric and thermal parts are represented by CD, DA.

Q14. What is the coefficient of performance of a refrigerator between 10 °C and 42 °C?

a. 8.84

b. 7.87

c. 10.79

d. 6.74

Sol. A

$$K = \frac{273 + 10}{(273 + 4.2) - (273 + 10)} = \frac{283}{32} = 8.84$$

Q15. A car of mass 2000 kg is stopped by applying the brakes and the heat produced is 50 kCals. The speed of the car before applying the brakes was _______

a. 14.5 m/s

b. 29 m/s

c. 42 m/s

d. 33.7 m/s

Sol. A

$$\frac{1}{2}mv^2 = 50 \times 4.2 \times 10^3$$

$$V^2 = \frac{50 \times 4.2 \times 2}{2000} \times 10^3 \Rightarrow V = 14.5 \text{ m/s}$$

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Q16. Two kilocalories of heat are supplied to a system. The internal energy of the system rises by 5030 J and external work done is 3350 J. What is the value of J?

a. 2.21×10^3 J/Kcal

b. 3.12×10^3 J/Kcal

c. 4.19×10^3 J/Kcal

d. 5.21×10^3 J/Kcal

Sol. C

dQ = du + dW = 5030 + 3350 = 8280 J
Now, 8380 J = 2 kC
J = 4.19×10^3 J/kC

Q17. In a thermodynamic process, pressure of a fixed mass of gas is changed in such a manner that the gas releases 30 J of heat and 8 J of work is done on the gas. If the initial internal energy of the gas is 40 J, what will be the final internal energy?

a. 15 J

b. 18 J

c. 21 J

d. 24 J

Sol. B

dQ = du + dW = – 30 J, heat released by system
Work done on gas dW = – 8 J
dU = dQ - dW = – 30 – (– 8) = – 22 J
du = $u_f - u_i$
$\Rightarrow$ $u_f - u_i$ = du = 40 – 22 = 18 J

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Q18. A box with rigid insulating walls is divided into 2 parts by a partition. An ideal gas occupies half the box and the other half is completely evacuated. The partition is suddenly removed. What happens to the temperature of the gas?

a. Increases

b. Decreases

c. First increases then decreases

d. Remains the same

Sol. d

The temperature of gas will remain the same according to the first law of thermodynamics, $\Delta\theta = \Delta U + P\Delta V$; here $\Delta\theta = 0$ and P = 0, the gas expands in vacuum. Hence, $\Delta u = 0$. As the gas is ideal, there is no internal PE and hence, internal KE of the gas is constant.

Q19. Which of the following statements is/are true?

a. The internal energy of an ideal gas changes by heating or cooling.

b. When a piece of lead is hammered its internal energy decreases.

c. When a hot piece of iron is immersed in water, it decreases the internal energy of water.

d. All of the above

Sol. A

The internal energy of an ideal gas changes by heating or cooling the gas in a closed vessel.

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Q20. A substance absorbs an amount of heat θ_1 in going from one state to another and releases an amount of heat θ_2 in coming back from the second state to the first state. How much work is done by the substance?

a. $\frac{\theta_1}{\theta_2}$

b. $\theta_1 - \theta_2$

c. $\frac{\theta_2}{\theta_1}$

d. $\theta_1 + \theta_2$

Sol. B

W = $\theta_1 - \theta_2$

Applying the first law of thermodynamics,

$\Delta Q - \Delta W = \Delta u$

$Q_1 = W_{12} = u_2 - u_1$; .... (1)

$Q_{21} - W_{21} = u_1 = u_2$

Or $W_{21} - Q_{21} = u_2 - u_1$ .... (2)

Putting (2) in (1), we get

$Q_{12} - W_{12} = -Q_{21} + W_{21}$

Or $Q_{12} - Q_{21} = W_{12} + W_{21}$

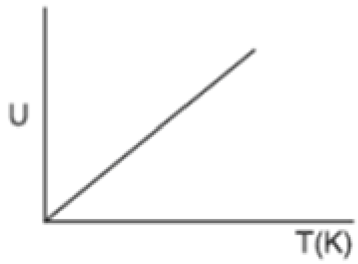
Or $Q_1 - Q_2 = W$

Q21. On what factors, does the efficiency of Carnot engine depend?

Sol. $\eta = 1 - T_2 / T_1$

Q22. Plot a graph between internal energy U and Temperature (T) of an ideal gas.

Sol.



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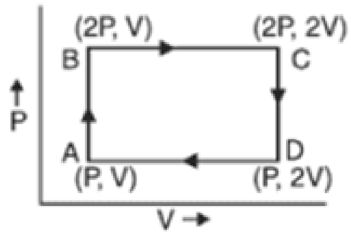
Q23. What is the specific heat of a gas in an adiabatic process.

Sol. Zero

Q24. Write two limitation of the first law of thermodynamics.

Sol. (i) It does not give the direction of flow of heat.
(ii) It does not explain why heat cannot be spontaneously converted into work.

Q25. An ideal monatomic gas is taken round the cycle ABCDA as shown.



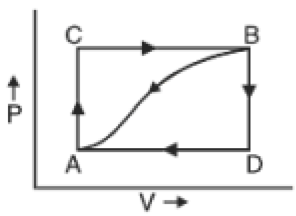
Sol. PV

Q26. Two bodies at different temperatures T_1 and T_2. If brought in thermal contact do not necessarily settle to the mean temperature $(T_1 + T_2) / 2$ Explain?

Sol. Heat flows from higher temperature to lower temperature until the temperature become equal only where the thermal capacities of two bodies are equal.

Q27. When a system is taken from state A to state B along the path ACB, 80 Kcal of heat flows into the system and 30 kcal of work done.

a. How much heat flows into the system along path ADB if the work done is 10 kcal?
b. When the system is returned from B to A along the curve path. The work done is 20 kcal. Does the system absorb or liberate heat.
c. If $U_A = 0$ and $U_D = 40$ kcal, find the heat absorbed in the process AD



Sol. (a) $dw_{ADB} = +10$ k cal

Internal energy is path independent

$du_{ADB} = du_{ACB} = 50$ k cal

$dQ_{ADB} = 50 + 10 = 60$ k cal.

(b) $dw_{BA} = -20$ k cal

$du_{BA} = -du_{ADB}$

$dQ_{BA} = du_{BA} + dW_{BA}$

$= -50 - 20 = -70$ k cal

(c) $U_A = 0$ $U_D = 40$ k cal

$du_{AD} = 40$ k cal

$dw_{ADB} = 10$ k cal

$dw_{DB} = 0$ since $dV = 0$

$dQ_{AD} = 40 + 10 = 50$ k cal

Q28. A perfect cannot engine utilizes an ideal gas the sources temperature is 500k and sink tempertature is 375k. If the engine takes 600k cal per cycle

(i) The efficiencty of engine

(ii) Work done per cycle

(iii) Heat rejected to sink per cycle.

Sol. (i) $T_1 = 500$ k $T_2 = 375$ k

Q_1 = Heat abosrbed = 600 k cal

$\eta = \frac{W}{Q_1}$

= 25 %

(ii) $\eta = \frac{W}{Q_1}$

$W = \eta Q_1 = 0.25 \times 60$ k cal = 150 k cal

= 450 k cal

(iii)$W = Q_1 - Q_2$ $Q_2 = Q_1 - W = 600 - 150$

= 450 k cal

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Q29. $\frac{1}{2}$ mole of helium is contained in a container at S.T.P. How much heat energy is needed to double the pressure of the gas, keeping the volume constant? Heat capacity of gas is $3\ Jg^{-1}k^{-1}$.

Sol.

$n = \frac{1}{2}$, $C_v = 3$ J/gK. M = 4

$C_v = MC_v = 12$ J/mole k M → Molecular mass

$$\frac{P_2}{P_1} = \frac{T_2}{T_1} = 2$$

$\Delta T = 2T_1 - T_1 = 273$ k

$\Delta Q = n\ c_v\ \Delta T = 1638$ J

Q30. The temperature T_1 and T_2 of the two heat reservoirs in an ideal cannot engine be 1500°C and 500°C respectively. Which of these increasing T_1 by 100°C or decreasing T_2 by 100°C would result in a greater important in the efficiency of the engine.

Sol.

$\eta = 1 - T_2/T_1$

(i) T_1 is increased from 1500°C to 1600°C

$T_1 = 1873$ K

T_2 remain constant $T_2 = 773$ k

$$\eta_1 = \frac{1873 - 773}{1873} = 58.73\%$$

(ii) T_1 remain constant 1500°C

$T_1 = 1500 + 273 = 1773$ k

T_2 is decreased by 100 i.e. 400°C

$T_2 = 400 + 273 = 673$ k

$$\eta_2 = \frac{1773 - 673}{1773} = \frac{1100}{1773} = 62.04\%$$

$\eta_2 > \eta_1$