PHYSICS

BOOKS - CHHAYA PHYSICS (BENGALI ENGLISH)

FIRST AND SECOND LAW OF THERMODYNAMICS

Numerical Examples

1. 800 g lead balls are kept in a 1 m long, vertical tube which is a bad conductor and the tube is then closed at both ends. The tube is suddenly inverted so that the balls fall from one end to the other. The temperature of the lead balls increases by $3.89^\circ C$ after 50 such inversions. Find out the mechanical equivalent of heat assuming that the lead balls have retained the entire amount of heat produced.

2. Water drops from a height of 50 m in a waterfall. Find out the rise in temperature of water, if 75% of its energy is converted into heat and absorbed by water.

$\left(J = 4.2 \times 10^7 erg \cdot cal^{-1}, g = 9.8 m \cdot s^{-2}\right)$

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3. The velocity of a 42 kg celestial body reduces from $20 km \cdot \min^{-1}$ to $5 km \cdot \min^{-1}$ due to its passage through the earth's atmosphere. Find out the heat produced in calorie. $\left(J = 4.2 \times 10^7 erg \cdot cal^{-1}\right)$

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4. Find out the amount of work done to convert 100 g ice at $0^\circ C$ to water at $100^\circ C$. (Latent heat of fusion of ice = $80 cal \cdot g^{-1}$, mechanical equivalent of heat = $4.2 J \cdot cal^{-1}$).

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5. What will be the temperature difference between the top and the bottom of a 400 m high waterfall, assuming that 80% of the heat produced is retained by the water?

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6. Find out the minimum height from which a piece of ice at $0^{\circ} C$ should be dropped so that it melts completely due to its impact with the ground. Assume that half of the energy loss due to the fall is responsible for the fusion of ice. (Latent heat of fusion of ice = $80cal \cdot g^{-1}, g = 980cm \cdot s^{-2}, J = 4.2J \cdot cal^{-1}$)

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7. A piece of ice at $0^{\circ} C$ is dropped to the ground from some height. The piece of ice melts completely due to its impact with the ground. Find the height from which the piece was dropped considering that 60% of its energy is converted into heat. $\left(J = 4.2J \cdot cal^{-1}\right)$

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8. A stirrer rotates in 1l of water against a damping force of 0.1 N at 360 rpm in a circle of radius 5 cm. Calculate the rise in water temperature in 1 h, neglecting heat loss due to radiation . $\left(Jk = 4.2J \cdot cal^{-1}\right)$

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9. 10 l of water is dropped from a height of 250 m. How much heat (In calories) will be generated when the water reaches the bottom? Assuming that the entire heat will be retained by the mass of water, what will be the rise in temperature of the water? (Given $J = 4.18J \cdot cal^{-1}$)

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10. What will be the time required to heat a 15 l bucket full of water from $20^{\circ}C$ to $40^{\circ}C$ using a 1500 W immersion heater?

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11. The temperature of a piece of lead is $27^{\circ}C$. Find out the minimum velocity of its impact with a wall so that it melts completely. Suppose 58% of the heat generated is dissipated. Given, $J = 4.2 J \cdot cal^{-1}$, melting point, specific heat and latent heat of fusion of lead are $327^{\circ}C, 0.03 cal \cdot g^{-1} \cdot ^{\circ}C^{-1}$ and 5 cal cdot g^(-1)`, respectively.

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12. A body of mass 2 kg is pulled with a velocity $2m \cdot s^{-1}$ on horizontal surface. What will be the heat produced in 5s, if the coefficient of friction between the body and the surface is 0.2? Given, $J = 4.2 J \cdot cal^{-1}, g = 9.8 m \cdot s^{-2}$.

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13. Two pieces of ice, of equal mass and moving towards each other with the same velocity, collide head on and are vaporised due to this collision. Find out the minimum initial velocity of the pieces of ice. Given, initial temperature, specific heat and latent heat of fusion of ice are $-12^{\circ} C, 0.5 cal \cdot g^{-1} \cdot^{\circ} C^{-1}$ and $80 cal \cdot^{\circ} g^{-1}$ respectively, latent heat of steam is $540 cal \cdot g^{-1}$.

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14. The top of a waterfall is at a temperature $0.49^{\circ} C$ below that of the bottom. The work done by water due to its fall is converted entirely into heat. Find the height of the waterfall. Given, $g = 980 cm \cdot s^{-2}, J = 4.2 J \cdot cal^{-1}$.

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15. The volume of a gas changes from 20 l to 10 l under a pressure of $10^{60} dyn \cdot cm^{-2}$. What will be the heat evolved?

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16. Find out the amount of work done in the cyclic process of fig.

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17. An ideal monatomic gas goes through a cyclic process ABCDA, as shown in fig. Find out the work done and heat supplied in this cyclic process.

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18. The volume of 1 g of water $(1cm^3)$ becomes $1671cm^3$ on being converted to steam at standard atmosphere pressure. Find out the work done and rise in internal energy. Given, latent heat of vaporisation of water $=540cal \cdot g^{-1}$, the standard atmosphere pressure = $1.013 \times 10^5 N \cdot m^{-2}$.

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19. The specific heat of oxygen gas at constant volume is $0.155cal \cdot g^{-1} \cdot ^\circ C^{-1}$. What is its specific heat at constant pressure? Given, the molecular mass of oxygen = 32 and $R = 2cal \cdot mol^{-1} \cdot ^\circ C^{-1}$.

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20. For 1 mol of a triatomic ideal gas $C_v = 3R(R$ is universal gas constant). Fid $\delta(= C_p / C_v)$ for that gas.

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21. The temperature of 20 g of oxygen gas is raised from $10^\circ C$ to $90^\circ C$. Find out the heat supplied, the rise in internal energy and the work done by the gas, if the temperature rises at

(i) constant volume. (ii) constant pressure. Given the specific heats of oxygen are $0.155 cal \cdot g^{-1} \cdot^\circ C^{-1}$ at constant volume, and $0.218 cal \cdot g^{-1} \cdot^\circ C^{-1}$ at constant pressure.

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22. Find out the molar specific heats $C_p an C_v$ of an ideal gas having $\gamma = 1.67$. Given, $R = 2 cal \cdot mol^{-1} \cdot^\circ C^{-1}$.

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23. A gas of density $0.00125 g \cdot cm^3$, volume 8L at $0^\circ C$ temperature and 1 atm pressure is supplied with 30 cal of heat to raise its temperature to

$15^{\circ}C$ at constant pressure. Determine the specific heat of the gas at constant pressure and at constant volume. Given, $R = 2cal \cdot mol^{-1} \cdot^{\circ} C^{-1}$.

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24. The temperature of 20 g of oxygen gas is raised from $50^{\circ}C$ to $100^{\circ}C$. (i) At constant volume. Find out the amount of heat supplied and the rise in internal energy in case.

Given , $R = 2cal \cdot mol^{-1} \cdot K^{-1}$, for oxygen, $c_v = 0.155cal \cdot g^{-1} \cdot^{\circ} C^{-1}$.

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25. The temperature of 20 g of oxygen gas is raised from $50^{\circ}C$ to $100^{\circ}C$. (ii) At constant pressure. Find out the amount of heat supplied and the rise in internal energy in case.

Given , $R = 2cal \cdot mol^{-1} \cdot K^{-1}$, for oxygen, $c_v = 0.155cal \cdot g^{-1} \cdot^{\circ} C^{-1}$.

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26. 10 mol of an ideal gas is taken through an isothermal process in which the volume is compressed from 40 L to 30 L. If the temperature and the pressure of the gas are $0^{\circ} C$ and 1 atm respectively. Find the work done in the process.

Given: $R = 8.31 J \cdot mol^{-1} \cdot K^{-1}$.

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27. A gas has an initial volume of 1L at a pressure of 8 atm. An adiabatic expansion takes the gas to a pressure of 1 atm. What will be its final volume? Given , $gamm = 1.5$.

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28. Some amount of air, initially at STP, is adiabatically compressed to $\frac{1}{5}th$ its initial volume. Determine the rise in temperature. Given, $\gamma = 1.41$.

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29. Some amount of gas at $27^{\circ}C$ is suddenly compressed to 8 times its initial pressure. If $\gamma = 1.5$, find out the rise in temperature.

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30. Find out the work done to expand an ideal gas isothermally to twice its initial volume.

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31. Find out the work done in adiabatic compression of 1 mol of an ideal gas. The initial pressure and volume of the gas are $10^5 N \cdot m^{-2}$ and 6L, respectively, the final volume is 2L , the molar specific heat of the gas at constant volume is $\frac{3}{2}R$.

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32. The molar specific heat of an ideal gas at constant pressure is $C_p = \frac{5}{2}R$. Some amount of this gas in a closed container has a volume $0.0083 m^3$, a temperature 300 K and a pressure $1.6 \times 10^6 N \cdot m^{-2}$. If $2.49 \times 10^4 J$1 of heat is supplied at a constant volume of the gas, find out the final temperature and pressure. Given, $R = 8.3 J \cdot mol^{-1} \cdot K^{-1}$.

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33. 8g oxygen, 14 g nitrogen and 22 g carbon dioxide are mixed in a container of volume 4 l. Find out the pressure of the gas mixture at $27^\circ C$. Given $R = 8.315 J \cdot mol^{-1} \cdot K^{-1}$.

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34. A Carnot engine is being operated by taking heat from a source at temperature $527^\circ C$. If the surrounding temperature is $27^\circ C$, what is the efficiency of the engine? If the source supplies heat at the rate of $10^9 J$ per minute, how much usable work is obtained per minute?

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35. A Carnot engine takes up 200 cal of heat per cycle from a source at temperature 500 K and rejects 150 cal of heat to the sink. What is the temperature of the sink and the efficiency of the engine?

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36. The temperatures of the source and the sink of a Carnot engine are 500 K and 300 K respectively. If the temperature of the source diminished to 450 K, what will be the percentage change in efficiency?

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37. The temperature of the ice-box of a refrigerator is $-7^\circ C$ and the room temperature is $31^\circ C$. To maintain the temperature of the ice-box, the refrigerator approximates a Carnot refrigerator, what is its power consumption?

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38. An ideal gas is kept in a closed, rigid and heat insulating vessel. A coil of resistance 100 ohm, carrying a current of 1 ampere, is supplying heat to the gas for 5 minutes. What will be the change of internal energy of the gas?

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39. A Carnot engine takes 3000 kcal of heat from a reservoir at $627^{\circ} C$. The sink is at $27^{\circ} C$. What is the amount of work done by the engine?

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40. An ideal gas is taken through the cycle $A \rightarrow B \rightarrow C \rightarrow A$ as shown in fig. if the net heat supplied to the gas in the cycle is 5J, determine the work done by the gas in the process $C \rightarrow A$.

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41. If a system is taken from to f by the process $i \rightarrow a \rightarrow f$ (fig.), Q is 50 cal and W is 20 cal. If in the process $i \rightarrow b \rightarrow f$, Q is 36 cal , what is the value of W?

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42. A thermodynamic process is shown in fig. the pressures and volumes corresponding to some points in the figure are $p_A = 3 \times 10^4 Pa, p_B = 8 \times 10^4 Pa, V_A = 2 \times 10^{-3} m^3, V_D = 5 \times 10^{-3} m^3$. In process AB, 600 J of heat is added to the system and in process BC, 200 J of heat is added. What would be the change in internal energy of the system in the process AC?

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43. What is the amount of heat energy absorbed by a system going through a cyclic process shown in fig.

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44. A thermodynamic system is taken through the cycle PQRSP (fig.). What is net work done by the system?

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45. A sample of an ideal monatomic gas is taken around the cycle ABCA (fig.). Calculate the work done during the cycle.

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Section Related Questions

1. Why is heat called a type of energy?

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2. What is the relation between mechanical work done and heat produced?

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3. Define mechanical equivalent of heat. What is its value?

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4. The mechanical equivalent of heat is $4.2 \times 10^7 erg \cdot cal^{-1}$. What does it mean?

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5. What is an intensive variable? Give example.

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6. What are intensive variables of a system? Name two intensive variable for a gas in equilibrium kept in a container.

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7. What is an extensive variable? Give example.

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8. What do you mean by state function and path function?

Watch Video Solution

9. What do you mean by equilibrium state .

Watch Video Solution

10. What do you mean by process, in connection with a thermodynamic system?

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11. What are isobaric, isochoric, isothermal and adiabatic processes?

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12. A closed thermodynamic system has only two independent variables' - explain.

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13. The external work done in case of a closed gaseous system is $W = \int p dV$ - establish this relation.

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14. Find out the expressions of work done in (i) an isobaric process.

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15. Find out the expressions of work done in an isochoric process.

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16. The work done in a general process can be evaluated only if the pressure p of a system is expressible as a function of the volume V' - discuss.

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17. How is an equilibrium state. represented on a pV -diagram?

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18. How is a process represented on a pV -diagram?

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19. How is an amount of work in connection with a thermodynamic system, represented on a pV -diagram?

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20. What is a cyclic process? How can such a process and the corresponding value of work done be shown on the pV - diagram?

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21. The pV-diagram is a consequence of the fact that a thermodynamic system has only two independent properties' - explain.

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22. State and explain the first law of thermodynamics.

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23. Explain the significance of the first law of thermodynamics.

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24. What do you mean by the internal energy of a substance?

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25. What are the factor on which the internal energy of a gas depends?

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26. What do you mean by the internal energy of an ideal gas? How can you increase the internal energy of a gaseous system?

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27. Why do gases have two specific heats?

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28. Define specific heat of a gas at constant volume and that at constant pressure.

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29. What do you understand by the molar specific heat of a gas at constant volume and constant pressure?

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30. Prove that $C_p - C_v = R$, where C_p and C_v are the molar specific heats at constant pressure and constant volume respectively and R is the universal gas constant.

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31. Show that the specific heat of a gas at constant pressure is greater than that at constant volume.

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32. Explain the importance of the ratio of the two specific heats of a gas.

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33. Why are the specific heats of gases at constant pressure and at constant volume different? Determine the relation between these two specific heats of an ideal gas.

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34. What do you mean by isothermal and adiabatic processes?

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35. The volume of a certain amount of gas changes isothermally from $V_1 \text{to} V_2$. What will be the work done?

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36. Write down the equations relating pressure, volume and temperature for isothermal change and adiabatic change of an ideal gas.

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37. The temperature of a gas decreases in an adiabatic expansion. Explain.

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38. Adiabatic process is essentially a very fast process. Explain.

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39. Why do two isothermal curves not intersect each other?

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40. Prove that the adiabatic curves are steeper than the isothermal curves on a pV - diagram.

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41. Does the gas perform any work in adiabatic expansion? What is the source of that energy?

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42. What is meant by a reversible process? Give an example.

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43. What is meant by a irreversible process? Give an example.

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Watch Video Solution

44. Write down the conditions of reversibility of a process.

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45. Do reversible processes exist in nature? Justify your answer.

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46. What do you mean by entropy?

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47. State the entropy principle.

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48. Entropy manifests the flow of time - discuss.

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49. What is a heat reservoir? What is its heat capacity?

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50. What do you mean by source and sink of heat?

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Higher Order Thinking Skill Hots Questions

1. Water falls from the top to the bottom of a waterfall. Why does the temperature at the bottom become slightly higher?

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2. A bullet becomes hot on hitting a target. Why?

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3. Two balls of the same mass, one of iron and the other of copper, are dropped from the same height. Which one would become hotter?

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4. Show that the external work done by a gas in an isothermal expansion is equal to the heat supplied to the gas.

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5. An isothermal process is essentially a very slow process' .Explain.

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6. What is the source of the energy that does the work in an adiabatic expansion of a gas?

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7. A gas is compressed to half its volume in two different ways : (i) very rapidly. In which process will the work done on the gas be higher?

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8. A gas is compressed to half its volume in two different ways : (ii) very slowly. In which process will the work done on the gas be higher?

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9. A gas is compressed to half its volume (i) adiabatically, (ii) isothermally. In which process will the final temperature be higher?

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10. A gas expands from state 1 to another state 2 of higher pressure in tow different processes as shown in fig. Which process would require a greater supply of heat from the surroundings?

.

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11. A screen divides a container of volume $1m^3$ into two parts. One part is filled with an ideal gas at 300 K and the other part is empty. The system is isolated from the surroundings. Will there be any change in the temperature of the gas if the screen is suddenly removed?

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12. For an adiabatic process of an ideal monatomic gas the pressure and the temperature are related as $p \propto T^C$. Find out the value of C.

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13. Is the solar system n thermal equilibrium?

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14. The pressure and the temperature of an ideal gas in an adiabatic process are related as $p \propto T^3$. What is the value of the ratio C_p / C_v of the gas?

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15. At constant pressure, the temperature coefficient of volume expansion of an ideal gas is $\delta = \frac{1}{V}\frac{dV}{dT}$. What will be the nature of the graph relating δ with the temperature T?

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16. A rapid compression heats a gas, but a rapid expansion cools it - why?

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17. Why does a bicycle pump become hot when it pumps air in a bicycle tube?

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18. Adiabatic and isothermal processes of an ideal gas are represented on a pV diagram by two curves. A and B (fig.). Can we say that the curve A represents the isothermal process?

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19. In the V - T diagram (fig.), two different points show pressures p_1 and p_2. Which pressure would be higher- p_1 or p_2?

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20. The volume of a gas is doubled (i) very rapidly, and (ii) very slowly. In which one of the processes the work done by the gas is higher?

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21. How will the temperature of an ideal gas change in an adiabatic expansion?

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22. Three sample, A,B,C of a gas initially have the same volume. The volume of each sample is doubled by the following processes: (i) isothermal process on A, (ii) adiabatic process on B, and (iii) isobaric process on C. In which process will the work done be highest?

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23. An ideal gas of mass m is taken from state A to state B (fig) in three different processes 1,2 and 3. If the work done in the three processes are W_1, W_2 and W_3, arrange them in descending order.

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24. In a process on an ideal gas, $dW = 0$ and $dQ < 0$. Show that the temperature of the gas will fall.

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25. How will the temperature of an ideal gas change in an adiabatic compression?

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26. When the tyre of a bicycle or motor car bursts suddenly, cool air comes out from the tube. Explain why.

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27. The molar specific heats C_p and C_v of an ideal gas are expressed in the unit of $cal \cdot mol^{-1} \cdot ^\circ C^{-1}$. But R is expressed in $J \cdot mol^{-1} \cdot ^\circ C^{-1}$. Write down the relation between C_p and C_v.

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28. $C_p - C_v = a$ for hydrogen gas and $C_p - C_v = b$ for oxygen gas. What is the relation between a and b?

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29. An ideal gas undergoes four processes: isochoric, isobaric, isothermal and adiabatic. In which process is (i) the change in internal energy zero?

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30. An ideal gas undergoes four processes: isochoric, isobaric, isothermal and adiabatic. In which process is (ii) the work done zero?

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31. An ideal gas undergoes four processes: isochoric, isobaric, isothermal and adiabatic. In which process is (iii) the heat exchange zero?

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32. A system goes from state A to state B in two different processes I and II (fig.). What is the relation between the respective changes ΔU_I and ΔU_{II} of internal energy?

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33. One should not try to cool a kitchen by leaving the refrigerator door open. Explain why.

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34. The volume, pressure and temperature of some amount of a gas are V, p and T, respectively. A partition divides the gas into two equal parts. What will be the values of the quantities in each part?

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35. Show that the adiabatic bulk modulus of an ideal gas is equal to the product of the pressure of the gas and the ratio of its two specific heat (γ).

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Exercise Multiple Choice Questions Mark 1

1. When a bullet of 6g mass hits a target at a speed of $400m \cdot s^{-1}$, 70% of its energy is converted into heat. The value of heat generated is

A. 336 cal

B. 80 cal

C. $3.36 \times 10^5 cal$

D. 80000 cal

Answer: B

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2. Water drops from a height of 40 m in a waterfall. if 75% of its energy is converted into heat and absorbed by the water, the rise in temperature of the water will be

A. $0.035^{\circ} C$

B. $0.07^{\circ} C$

C. $0.35^{\circ} C$

D. $0.7^{\circ} C$

Answer: B

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3. The amount of work done to convert 1 g ice at $0^{\circ} C$ into steam at $100^{\circ} C$ is

A. 756 J

B. 2688 J

C. 3024 J

D. 171.4 J

Answer: C

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4. 169 J energy is required to transform $1g(1cm^3)$ of water into steam at 1 atm pressure. If the latent heat of vaporisation of water is $540cal \cdot g^{-1}$, the volume of that steam will be

A. $1560cm^3$

B. $1671cm^3$

C. $1571cm^3$

D. $1600cm^3$

Answer: B

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5. A man of mass 90 kg gains $10^5 cal$ of heat from his food intake. If his digestive ability is 28%, how much height can be climb up to?

A. 1333 m

B. 133.3 m

C. 13.33 m

D. 1.333 m

Answer: B

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6. Which of the following quantities does not indicate any thermodynamic state of a substance?

A. volume

B. temperature

C. pressure

D. work

Answer: D

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7. The internal energy of a substance actually means

A. the kinetic energy of the substance

B. the kinetic energy of the molecules of the substance

C. the sum of its kinetic and potential energies

D. the sum of kinetic and potential energies of the molecules of the substance

Answer: D

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8. If the average kinetic energy of the molecules of a certain mass of a gas decreases, then

A. the gas becomes hot

B. the gas becomes cold

C. the gas expands

D. the gas contracts

Answer: B

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9. If the volume of a gas of a certain mass changes from 1 L to 0.5 L at a constant pressure of $10^5 N \cdot m^{-2}$, work done by the gas will be

A. 50000 J

B. $-50000 J$

C. $50 J$

D. $-50 J$

Answer: D

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10. The internal energy of a system is U_1. In a process, work done by the system is W and heat accepted by the system is Q. At the end of the process, the internal energy of the system is

A. $U_1 + Q - W$

B. $U_1 - Q + W$

C. $U_1 + Q + W$

D. $U_1 - Q - W$

Answer: A

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11. The work done by an ideal gas at constant temperature is 10 J. the amount of heat gained in this process is

A. 10 cal

B. 2.38 cal

C. zero

D. data insufficient

Answer: B

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12. The work done by an ideal gas at constant pressure is 10 J. The amount of heat gained in this process is

A. 10 cal

B. 2.38 cal

C. zero

D. data insufficient

Answer: D

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13. If the internal energy U and the work W are expressed in unit of J and the heat is expressed in unit of cal, the first law of thermodynamics will be [here J = Joule's equivalent]

A. $dQ = dU + \frac{dW}{J}$

B. $dQ = dU + JdW$

C. $JdQ = dU + dW$

D. $\frac{dQ}{J} = dU + dW$

Answer: C

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14. $C_v = \frac{5}{2}R$, for 1 mol of any diatomic ideal gas. The value of the ratio of the two specific heats $\left[\frac{C_p}{C_v} = \gamma\right]$ of the gas is

A. $\frac{4}{3}$

B. $\frac{5}{3}$

C. $\frac{7}{3}$

D. $\frac{7}{5}$

Answer: D

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15. If $R = 2cal \cdot mol^{-1} \cdot^{\circ} C^{-1}$ and hydrogen is assumed to be an ideal gas, specific heat of that gas at constant pressure will be

A. $7cal \cdot g^{-1} \cdot^{\circ} C^{-1}$

B. $5cal \cdot g^{-1} \cdot^{\circ} C^{-1}$

C. $3.5cal \cdot g^{-1} \cdot^{\circ} C^{-1}$

D. $1.25cal \cdot g^{-1} \cdot^{\circ} C^{-1}$

Answer: C

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16. Work done becomes zero

A. at constant pressure

B. at constant volume

C. in isothermal process

D. in adiabatic process

Answer: B

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17. The change in internal energy of an ideal gas becomes zero

A. at constant pressure

B. at constant volume

C. in isothermal process

D. in adiabatic process

Answer: C

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18. The process in which changes in pressure, volume and temperature occur simultaneously is

A. isobaric

B. isochoric

C. isothermal

D. adiabatic

Answer: D

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19. It is observed by comparing the specific heat of all solid, liquid and gaseous substances that

A. specific heat of water is the highest

B. specific heats of hydrogen and helium are higher than that of water

C. all gases have specific heat higher than that of water

D. all liquid and gases have specific heats higher than that of water

Answer: B

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20. In an adiabatic expansion, the change in internal energy of 10 mol of a gas is 100 J. What is the amount of work done by the gas?

A. $-100J$

B. $100J$

C. $1000J$

D. $-1000J$

Answer: B

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21. Which of the following relations does an ideal gas follow in an adiabatic process?

A. $pV = RT$

B. $pV^{\gamma} = \text{constant}$

C. $\left(p + \frac{a}{V^2}\right)(V - b) = RT$

D. $pV^{\gamma - 1} = \text{constant}$

Answer: B

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22. The slope of an isothermal curve is always

A. same as that of an adiabatic curve

B. greater than that of an adiabatic curve

C. less than that of an adiabatic curve

D. not derivable

Answer: C

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23. Heat cannot transmit from a body at lower temperature to a body at higher temperature on its own' - which law is this statement derived from?

A. First law of thermodynamics

B. Second law of thermodynamics

C. Law of conservation of momentum

D. law of conservation of mass

Answer: B

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24. A system can go from state A to state B in two different processes 1 and 2. If the change in internal energy in two cases are ΔU_1 and ΔU_2, respectively, then

A. $\Delta U_1 < \Delta U_2$

B. $\Delta U_1 > \Delta U_2$

C. $\Delta U_1 = \Delta U_2$

D. the relation between ΔU_1 and ΔU_1 in uncertain

Answer: C

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25. In a given process of an ideal gas, $dW = 0$ and $dQ < 0$. Then for the gas

A. the temperature will decrease

B. the volume will increase

C. the pressure will remain constant

D. the temperature will increase

Answer: A

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26. 5.6 L of helium gas at STP is adiabatically compressed to 0.7 L. Taking the initial temperature to be T_1, the work done in the process is

A. $\frac{9}{8}RT_1$

B. $\frac{3}{2}RT_1$

C. $\frac{15}{8}RT_1$

D. $\frac{9}{2}RT_1$

Answer: A

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27. A Carnot engine, having an efficiency of $\eta = \frac{1}{10}$ as heat engine is used as a refrigerator. If the work done on the system is 10 J, the amount of energy absorbed from the reservoir at lower temperature is

A. 99 J

B. 90 J

C. 1 J

D. 100 J

Answer: B

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28. The efficiency of a Carnot heat engine working between temperatures $127^\circ C$ and $27^\circ C$ is

A. $\frac{27}{127}$

B. $\frac{100}{127}$

C. $\frac{300}{400}$

D. $\frac{100}{400}$

Answer: D

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29. The efficiency of an ideal heat engine is

A. 0

B. 0.5

C. 1

D. none

Answer: C

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30. Coefficient of performance of a machine is

A. $\frac{\text{output}}{\text{input}}$

B. $\frac{\text{input}}{\text{output}}$

C. $\frac{0}{\text{input}}$

D. none

Answer: A

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31. Even Carnot engine cannot give 100 % efficiency, because we cannot

A. prevent radiation

B. find ideal sources

C. reach absolute zero temperature

D. eliminate friction

Answer: C

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Exercise Very Short Answer Type Questions Mark 1

1. Which branch of physics deals with the study of relationship between heat and various form of energy?

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2. How is the work done related to the heat produced when work is completely converted into heat?

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3. If some amount of work is completely converted into heat, what is the name of the ratio of work done and amount of heat?

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4. What is the value of mechanical equivalent of heat in CGS system?

Watch Video Solution

5. What is the value of mechanical equivalent of heat in SI ?

Watch Video Solution

6. What would be the amount of heat generated if 4.2×10^7 erg of work is completely converted into heat?

Watch Video Solution

7. Give an example of intensive variable.

Watch Video Solution

8. Give an example of extensive variable.

Watch Video Solution

9. Which one of the four quantities does not indicate the thermodynamic state of a substance-volume, temperature, pressure and work?

Watch Video Solution

10. What is the change in temperature of water when it falls from the top to the bottom in a waterfall?

Watch Video Solution

11. Is pressure intensive or extensive variable?

Watch Video Solution

12. Is magnetic moment intensive or extensive variable?

Watch Video Solution

13. What would be the amount of heat required to increase the temperature of 1 g of water by $1^{\circ}C$?

Watch Video Solution

14. What is the change in internal energy of a substance when it is heated?

Watch Video Solution

15. On which factor does the internal energy of a certain amount of an ideal gas depend?

Watch Video Solution

16. Will there by any change in the internal energy of a certain amount of gas, if its pressure or volume changes at constant temperature?

Watch Video Solution

17. In case of expansion of a gas, would the work done by the gas be positive or negative?

Watch Video Solution

18. What is the SI unit of molar specific heat?

Watch Video Solution

19. First law of thermodynamics is the mathematical form of a universal law. Name it.

Watch Video Solution

20. How many types of specific heat of a gas are used in practice?

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21. How many types of molar specific heat of a gas are used in practice?

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22. Which is greater - specific heat at constant volume, C_v or specific heat at constant pressure, C_p?

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23. How is the heat supplied to a substance in an isothermal process used?

Watch Video Solution

24. In which process does the heat accepted or rejected become zero?

Watch Video Solution

25. Is reversible process slow or first?

Watch Video Solution

26. Which process does not suffer dissipative forces-reversible or irreversible?

Watch Video Solution

27. Is isothermal process slow or fast?

Watch Video Solution

28. Is adiabatic process slow or fast?

Watch Video Solution

29. Is rusting of iron reversible process?

Watch Video Solution

30. The sum of kinetic and potential energies of the molecular of a substance is equal to its _______. [Fill in the blank]

Watch Video Solution

31. In a process, if dU, dW and dQ are change in internal energy, work done and heat accepted respectively for a system, what is the relation between dU , dQ and dW?

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32. p and V are pressure and volume respectively of a gas of a particular mass. If volume changes to V + dV. What is the work done in the process?

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33. The molecular weight of a gas is M. If the specific heat and molar specific heat at constant volume of the gas is c_v and C_v respectively. Write down the relation between c_v. C_v and M.

Watch Video Solution

34. A bicycle pump becomes hot when air is pumped into the tube. Why?

Watch Video Solution

35. Air coming out form a burst bicycle or motorcar tube appears to be cold. Why?

Watch Video Solution

36. If γ of a gas is equal to 1.66 then what is the number of atoms in a molecule of the gas?

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37. Adiabatic curves are comparatively _______ then isothermal curves. [Fill in the blank]

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38. If the pressure and the temperature of a gas change at constant volume, what is the work done by the gas?

Watch Video Solution

39. What is the change in internal energy in an isothermal process?

Watch Video Solution

40. In which expansion the internal energy of a gas be decreases?

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41. If M is the molecular weight of a gas, what is the difference between the two specific heats of 1 g of an ideal gas?

Watch Video Solution

42. In case of 1 mol of an ideal gas, write down the value of $C_v - C_p$.

Watch Video Solution

43. An ideal gas rejects 10 cal of heat at constant volume. Find the work done.

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44. What is the relation between p and V in an adiabatic process?

Watch Video Solution

45. A process against frictional force cannot be ______. [Fill in the blank]

Watch Video Solution

46. Two balls of the same mass, one of iron and the other of copper, are dropped from the same height. Which one would become hotter?

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47. In an isothermal process, the gas containers should be made of highly______materials. [fill in the blank]

Watch Video Solution

Watch Video Solution

48. In an adiabatic process, the gas containers should be made of highly ______ materials. [Fill in the blank]

Watch Video Solution

49. Is joule's heating process reversible or irreversible?

Watch Video Solution

50. Write down the coefficient of performance of an ideal refrigerator.

Watch Video Solution

51. What is the value of the efficiency of an ideal heat engine?

Watch Video Solution

52. Heat engine is a mechanical device which converts heat into ______.

[Fill in the blank]

Watch Video Solution

53. When heat is gained or lost by heat reservoir, its temperature _______.[Fill in the blank]

Watch Video Solution

Exercise Short Answer Type Questions I Marks 2

1. After entering the earth's atmosphere, a meteorite burns completely. Explain why.

Watch Video Solution

2. When a liquid is stirred vigorously. It becomes hot. Is it a reversible or an irreversible process? Explain.

Watch Video Solution

3. A bullet becomes hot on hitting a target. Why?

Watch Video Solution

4. Air coming out form a burst bicycle or motorcar tube appears to be cold. Why?

Watch Video Solution

5. Why is the efficiency of Carnot's engine less than 100 % even if there is no wastage of energy?

Watch Video Solution

Exercise Short Answer Type Questions Ii Marks 3 Or 4

1. An oxygen-filled cylinder is kept on a running vehicle. What will be the change in internal energy of the gas molecules inside the cylinder?

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2. A gas is compressed to half its volume in two different ways: (i) very rapidly and (ii) very slowly. In which of the processes the work done on the gas would be higher?

Watch Video Solution

3. Is the function of a refrigerator against the second law of thermodynamics? Explain.

Watch Video Solution

Exercise Problem Set I Marks 2

1. A 150 cm long glass tube, closed at both ends, is filled with leads marbles up to a length of 30 cm. After how many inversions of the tube will the temperature of the lead marbles increase by $2^{\circ} C$? Specific heat of lead $= 0.03 cal \cdot g^{-1} \cdot^{\circ} C^{-1}$.

Watch Video Solution

2. If a lead bullet hits a wall, its temperature rises by $200^{\circ} C$. What is the speed of the bullet if the heat so produced remains completely in the bullet? Specific heat of lead = $0.03 cal \cdot g^{-1} \cdot^{\circ} C^{-1}$.

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3. What is the amount of work done to convert 40 g of ice at $-10^{\circ}C$ into steam at $100^{\circ}C$? Specific heat of ice $= 0.5 cal \cdot g^{-1} \cdot ^{\circ}C^{-1}$, latent heat of fusion of ice $= 80 cal \cdot g^{-1}$, latent heat of steam = $540 cal \cdot g^{-1}$, $J = 4.2 \times 10^{7} erg \cdot cal^{-1}$.

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4. Water is falling from a waterfall on a non-conducting surface. If the temperature of water rises by $0.25^{\circ}C$, what is the height of the water fall?

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5. The height of a waterfall is 200 m. What will be the difference in temperature of water between the top and the bottom? $g = 980 cm \cdot s^{-2}$, $J = 4.2 J \cdot cal^{-1}$.

Watch Video Solution

6. A piece of lead is dropped to the ground from a height of 200 m. What will be the increase in its temperature? Specific heat of lead = $0.03 cal \cdot g^{-1} \cdot ^{\circ} C^{-1}, J = 4.2 \times 10^{7} erg \cdot cal^{-1}$

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7. A body of mass 1 kg falls to the ground from a height of 1km. If the entire amount of energy is converted into heat , find out the amount of heat produced. $(J = 4 \cdot 1 \times 10^{7} erg \cdot cal^{-1})$.

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8. A lead bullet stopped on hitting an iron plate at a velocity of $300 m \cdot s^{-1}$. Find out the rise in temperature of the bullet, if the heat evolved is shared equally between the bullet and the plate. Given, $J = 4 \cdot 2 \times 10^{7} erg \cdot cal^{-1}$, specific heat of lead = $0.03 cal \cdot g^{-1} \cdot ^{\circ} C^{-1}$

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9. What will be the change in internal energy if 10 g of air is heated from $20^\circ C$ to $30^\circ C$ at constant volume? Given , for air, $c_v = 0.17 cal \cdot g^{-1} \cdot^\circ C^{-1}$.

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10. For an ideal gas, $\gamma = 1.4$. Find out the two molar specific heats of this gas. $\left[R = 2 cal \cdot mol^{-1} \cdot^\circ C^{-1}\right]$

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11. Consider a Carnot cycle operating between $T_1 = 500K$ and $T_2 = 300K$ producing 1 kJ of mechanical work per cycle. Find the heat transferred to the engine by the reservoirs.

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12. If coefficient of performance of a refrigerator is 5 and it operates at the room temperature $(27^{\circ} C)$, find the temperature inside the refrigerator.

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13. What amount of heat is to be supplied to 14 g of nitrogen in order to increase the temperature by $40^{\circ} C$ at constant pressure? Molecular weight of nitrogen $= 28$ and $R = 8.3 J \cdot mol^{-1} \cdot K^{-1}$.

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14. A geyser heats water flowing at the rate of 3.0 litres per minute from $27^{\circ} C$ to $77^{\circ} C$. If the geyser operates on a gas burner, what is the rate of consumption of the fuel if its heat of combination is $4.0 \times 10^{4} J \cdot g^{-1}$?

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15. What amount of heat must be supplied to $2.0 \times 10^{-2} kg$ of nitrogen (at room temperature) to raise its temperature by $45^{\circ} C$ at constant pressure? (Molecular mass of $N_2 = 28, R = 8.3 J \cdot mol^{-1} \cdot K^{-1}$)

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16. After detonation of an atom the ball of fire consisting of a spherical mass of gas was found to be 15.24 m radius at $3 \times 10^5 K$. Assuming adiabatic condition to exist, find the radius of the ball after 100 millisecond when its temperature is $3 \times 10^3 K \cdot \left(\gamma = \frac{5}{3}\right)$

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17. A sample of 100 gm of water is slowly heated from $27^{\circ} C$ to $87^{\circ} C$. Calculate the change in the entropy of water. Specific heat capacity of water = $4200 J \cdot kg^{-1} \cdot K^{-1}$

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18. Find the internal energy of air in a room of volume $40m^3$ at 1 standard atmospheric pressure. $\gamma_{\text{diatomic}} = 1.41$

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Exercise Problem Set Ii Marks 3 Or 4

1. The temperature of a hailstone is $0^\circ C$ and initially it is at rest. When it falls from a height, $\frac{1}{60} the$ part of it melts. Calculate the height, Ignore the air resistance and assume that the temperature of the surroundings is $0^\circ C$. When it hits the ground, only $\frac{1}{5} th$ of its stored energy is converted into heat.

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2. Find out the minimum height from which a piece of ice should be dropped to the ground so that it melts completely. Assume that 20% of energy is lost. $J = 4.2 \times 10^7 erg \cdot cal^{-1}$ and latent heat of fusion of ice $= 80 cal \cdot g^{-1}$.

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3. What will be the difference in temperature between the top and the bottom of a 400 m high waterfall if 80% of heat produced is retained by water?

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4. A lead bullet hits a target at a velocity of $300 m \cdot s^{-1}$. If it stops completely on hitting, determine the increase in temperature of the bullet. Assume that 50% of the heat produced is retained by the bullet. Specific heat of lead = $0.03 cal \cdot g^{-1} \cdot ^{\circ} C^{-1}$.

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5. Earth gains energy from the sun at a rate of $8.4 J \cdot cm^{-2} \cdot \min^{-1}$. A black coloured calorimeter, having water equivalent of 15g, contains 100 g water at $25^{\circ} C$. The calorimeter is kept at the focus of a convex lens facing the sun. If the aperture of the lens is $1000 cm^2$, how much time will the water take to reach its boiling point?

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6. The mean velocity of raindrops is $20 m \cdot s^{-1}$. When these drops fall on the ground, what will be the increase in temperature? Assume that 50% of the heat produced is absorbed by the water.

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7. A hole is made in a piece of iron of mass 200 g with the help of a 186.5 W drill. If half of the energy consumed is absorbed as heat by the piece

of iron, what will be the increase in its temperature in 1 min?

Specific heat of iron = $0.11 cal \cdot g^{-1} \cdot^{\circ} C^{-1}$.

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8. The speed of a 50 kg heavenly object reduces from $30 km \cdot \min^{-1}$ to $10 km \cdot \min^{-1}$ due to its passage through earth's atmosphere. Find out the heat generated in calorie, due to this change in speed. $J = 4.2 \times 10^7 erg$.

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9. Sea water is splattered horizontally from a jet at a speed of $10 m \cdot s^{-1}$. The water comes to rest after falling in a container, 20 m below the jet level. What will be the increase in the temperature of the water? Specific heat of sea water $= 0.94 cal \cdot g^{-1} \cdot^{\circ} C^{-1}, J = 4.2 \times 10^7 erg \cdot cal^{-1}$.

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10. Find out the minimum height from which a piece of ice at $0^{\circ} C$ should be dropped so that it melts completely. Assume that 50% of the energy lost due to its fall is responsible for the fusion of ice. $J = 4.2 \times 10^7 erg \cdot cal^{-1}$, latent heat of fusion of ice = $80 cal \cdot g^{-1}$.

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11. A lead bullet melts on hitting a fixed target. What will be the minimum speed of the bullet, if it is assumed that the heat produced is retained entirely by the bullet? Initial temperature of the bullet = $47.6^{\circ} C$, specific heat of lead = $0.03 cal \cdot g^{-1} \cdot {}^{\circ} C^{-1}$, melting point of lead = $327^{\circ} C$, latent heat of fusion of lead = $6 cal \cdot g^{-1}$, $J = 4.2 \times 10^7 erg \cdot cal^{-1}$.

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12. A certain volume of a gas expands at one standard atmosphere pressure when 400 cal of heat is supplied to it. If there is no change in the internal energy of the gas, calculate its volume expansion.

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13. The volume of 1 mol of a gas is doubled when it expands isothermally at $127^\circ C$. Find out the amount of work done and heat absorbed.

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14. 70 cal of heat is required to increase the temperature of 2 mol of an ideal diatomic gas at constant pressure from $40^\circ C$ to $45^\circ C$. How much heat will be required to increase the temperature of that gas by the same amount at constant volume? $R = 2cal \cdot mol^{-1} \cdot K^{-1}$.

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15. What will be the change in internal energy of 128 g of oxygen gas at constant volume when it is heated from $30^{\circ} C$ to $45^{\circ} C$? The molar specific heat of oxygen at constant pressure is $C_p = 7.03 cal \cdot mol^{-1} \cdot ^{\circ} C^{-1}$ and $R = 8.31 J \cdot mol^{-1} \cdot ^{\circ} C^{-1}$.

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16. What will be the increase in temperature if dry air at $27^{\circ} C$ is compressed adiabatically to $\frac{1}{3} rd$ its volume? (For air, $\gamma = 1.4$)

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17. The tyre of a motorcar bursts suddenly when air was being pumped in it. The internal pressure became 3 times the atmospheric pressure during pumping. If the initial temperature of the air inside the tyre is $27^{\circ} C$, what will be the decrease in temperature of air due to the bursting of tyre? for air, $\gamma = 1.4$.

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18. Calculate the amount of work done, if 20 g of hydrogen gas is compressed isothermally to $\frac{1}{4}th$ of its volume at $27^\circ C$.

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19. Some amount of gas at $27^\circ C$ is suddenly compressed to 27 times its initial pressure. If $\gamma = 1.5$, find out the rise in temperature.

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20. In an adiabatic process where pressure is increased by $\frac{2}{3}\%$, if $\frac{C_p}{C_v} = \frac{3}{2}$, find the percentage decrease in volume.

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21. The volume of air increases by 2% in its adiabatic expansion. Calculate the percentage change in pressure.

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22. Air at $27^{\circ} C$ and 128 atm pressure is filled in a container in research activity. If the container suddenly bursts, calculate the final temperature.

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23. Equal volume of mono atomic and diatomic gases of same initial temperature and mixed. Final the ratio of the specific heats of the mixture.

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24. A steam engine delivers $5.4 \times 10^8 J$ of work per minute and services $3.6 \times 10^9 J$ of heat per minute from its boiler. What is the efficiency of the engine? How much heat is wasted per minute?

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25. A reversible heat engine converts $\frac{1}{6}$ th of heat, which it extracts from source, into work. When the temperature of the sink is reduced by $40^\circ C$, its efficiency is doubled. Find the temperature of the source.

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26. What will be the specific heats of helium at constant volume and constant pressure? γ of helium = 1.667, $R = 8.318 \times 10^7 erg \cdot mol^{-1} \cdot ^\circ C^{-1}$, $J = 4.18 \times 10^7 erg \cdot cal^{-1}$ and molecular mass of helium = 4.

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27. The mass of 1 L of air at STP is 1.293 g. If $c_v = 0.169 cal \cdot g^{-1} \cdot ^{\circ} C^{-1}$ for air, what is the value of c_p? Given density of mercury at $0^{\circ} C = 13.6 g \cdot cm^{-3}$ and $J = 4.2 \times 10^7 erg \cdot cal^{-1}$.

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28. The initial volume of a gas is 1 L and the pressure is 16 atm. Due to adiabatic expansion, the final pressure of the gas becomes 2 atm. Find out the final volume of the gas $\left[\gamma = \frac{3}{2}\right]$.

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29. An ideal gas is compressed adiabatically to $\frac{1}{4} th$ of its initial volume at $10^{\circ} C$. Find out the final temperature of the gas $[\gamma = 1.4]$.

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30. A cylinder with a movable piston contains 3 moles of hydrogen at standard temperature and pressure. The walls of the cylinder are made of a heat insulator and the piston is insulated with a pile of sand kept on it. By what factor does the pressure of the gas increase if the gas is compressed to half its original volume?

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31. The relation between internal energy U, pressure p and volume V of a gas in an adiabatic process is :

$U = a + bpV$

where a and b are constants. If the ratio of c_p and c_v of the gas is γ, prove that, $\gamma = \frac{b+1}{b}$.

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32. The work of 146 kJ is performed in order to compress one k mole of a gas adiabatically and in this process the temperature of the gas increases by $7^\circ C$. Prove that the gas is diatomic. $R = 8.3J \cdot mol^{-1} \cdot K^{-1}$.

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33. An ideal gas is expanding such that pT^2 = constant. Calculate the coefficient of volume expansion of the gas.

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Exercise Hots Numerical Problems Marks 3 4 5

1. Two bodies, each having a mass of 3kg, collide with each other. One body was at rest and the other was moving with a $4m \cdot s^{-1}$ velocity. After collision they combine with each other. Find out the heat produced as a result of this collision. Mechanical equivalent of heat = $4.2J \cdot cal^{-1}$.

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2. If the temperature of a piece of aluminium increased by $1^\circ C$, what will be the increase in energy of one of its atom? 27 g of aluminium has 6×10^{23} atoms. Specific heat of aluminium = 0.22.

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3. 10^{18} electrons hit a target per second in a X-ray tube with a velocity of $2 \times 10^6 m \cdot s^{-1}$. The mass of the metallic piece of the target is 200 g, specific heat is $0.12 cal \cdot g^{-1} \cdot^\circ C^{-1}$ and mass of an electron is $9.1 \times 10^{-28} g$. If 98% of the energy is converted into heat, how much time will be required to increase the temperature of the metallic piece of the target by $50^\circ C$?

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4. 1 kg coal is burnt to produce 10000 cal of heat. A tank 10 m high is filled with 1000 L of water by an engine. If the engine uses 20% of the heat produced form coal, how much coal will be required?

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5. The rotational speed of a wheel of diameter 8.4 cm is 4 rps. When a steel object having mass 250 g is held tightly at the edge of the wheel, it applies a force of 0.5 kg along the tangent of the wheel. If 90% of the work done is converted into heat and absorbed by the object, then what will be the rise in temperature of the object in 1 min? Specific heat of steel = $0.12 cal \cdot g^{-1} \cdot ^{\circ} C^{-1}$ and $J = 4.2 J \cdot cal^{-1}$.

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6. The diameter of a hose pipe is 2 cm. $1 m^3$ of water discharged from the pipe in 20 s and it hits a wall. If the entire kinetic energy of water is converted into heat and this heat is absorbed by the water, what will be the increase in temperature of the water? $J = 4.2J \cdot cal^{-1}$.

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7. A block having mass of 2 kg is pulled over a horizontal surface at a constant velocity of $20km \cdot h^{-1}$. If the frictional coefficient is 0.5, calculate the amount of heat produced in 1 h. If 50% of the heat produced i absorbed by block, what will be the increase in its temperature? Specific heat of the body = $0.1cal \cdot g^{-1} \cdot ^{\circ} C^{-1}$.

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8. 1 kg oil is taken in a copper calorimeter having mass 100 g. This oil is stirred vigorously by applying a torque of $10^8 dyn \cdot cm$ with the help of a rotating paddle. The temperature of the oil rises by $5^{\circ} C$ after 220 rotations. Determine the mechanical equivalent of heat. Specific heat of copper = $0.09 cal \cdot g^{-1} \cdot {}^{\circ} C^{-1}$ and specific heat of oil = $0.64 cal \cdot g^{-1} \cdot {}^{\circ} C^{-1}$.

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9. The initial temperature of a lead bullet (specific heat $0.02 cal \cdot g^{-1} \cdot {}^{\circ} C^{-1}$) of mass 50 g is $30^{\circ} C$. It is projected upwards with a velocity of $840 m \cdot s^{-1}$. When the bullet falls down to the point of projection, it hits a block of ice. If the temperature of the ice will be transformed into water? Assume that the entire energy is consumed by the ice. The latent heat of fusion of ice = $80 cal \cdot g^{-1}$.

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10. A block of ice having mass 6 kg is pulled 50 m horizontally over a surface of ice. The temperature of both the ice is $0^{\circ} C$, coefficient of friction between the surfaces of ice is 0.03 and latent heat of fusion of ice is $80 cal \cdot g^{-1}$. Calculate the amount of ice that melts.

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11. What will be the change in internal energy of 5g of oxygen, if its temperature increases by $10^{\circ}C$ at constant volume and constant pressure? C_v and C_p of oxygen are $0.155 cal \cdot g^{-1} \cdot^{\circ} C^{-1}$ and $0.218 cal \cdot g^{-1} \cdot^{\circ} C^{-1}$, respectively.

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12. Two cylinders A and B of equal capacity are connected to each other via a stopcock. A contains a gas at standard temperature and pressure. B is completely evacuated. The entire system is thermally insulated. The stopcock is now opened. Answer the following

(a) What is the final pressure of the gas in A and B?

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13. Two cylinders A and B of equal capacity are connected to each other via a stopcock. A contains a gas at standard temperature and pressure. B is completely evacuated. The entire system is thermally insulated. The stopcock is now opened. Answer the following

(b) What is the change in internal energy of the gas?

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14. Two cylinders A and B of equal capacity are connected to each other via a stopcock. A contains a gas at standard temperature and pressure. B is completely evacuated. The entire system is thermally insulated. The stopcock is now opened. Answer the following

(c) What is the change in the temperature of the gas?

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15. Two cylinders A and B of equal capacity are connected to each other via a stopcock. A contains a gas at standard temperature and pressure. B is completely evacuated. The entire system is thermally insulated. The stopcock is now opened. Answer the following

(d) Do the intermediate states of the system (before settling to the final equilibrium state) lie on its p - V - T surface?

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16. The temperature of 10 g nitrogen gas is increased from $20^{\circ}C$ to $120^{\circ}C$

(i) at constant volume. Find out the amount of heat supplied, increase in internal energy and external work done in the case. For nitrogen

$c_v = 0.177 cal \cdot g^{-1} \cdot^{\circ} C^{-1}$ and

$c_p = 0.248 cal \cdot g^{-1} \cdot^{\circ} C^{-1}$.

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17. The temperature of 10 g nitrogen gas is increased from $20^{\circ} C$ to $120^{\circ} C$

(ii) at constant pressure. Find out the amount of heat supplied, increase in internal energy and external work done in the case. For nitrogen

$c_v = 0.177 cal \cdot g^{-1} \cdot ^{\circ} C^{-1}$ and

$c_p = 0.248 cal \cdot g^{-1} \cdot ^{\circ} C^{-1}$.

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18. Some amount of gas is compressed at STP in an (i) adiabatic process. What will be the final temperature and pressure of the gas in the case?

($\gamma = 1.4$ for the gas)

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19. Some amount of gas is compressed at STP in an (ii) isothermal process in such a way that the final volume of the gas becomes $\frac{1}{5}$ times the initial volume. What will be the final temperature and pressure of the gas in the case? ($\gamma = 1.4$ for the gas)

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20. The initial volume of a gas is $2m^3$. When the gas is compressed adiabatically at a pressure of $4 \times 10^5 N \cdot m^{-2}$, its volume become $0.5m^3$. What will be the final pressure of the gas? If it is compressed isothermally, what will be the final pressure? Calculate the work done on the gas in both cases ($\gamma = 1.4$).

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21. Some amount of gas is compressed adiabatically at $27^\circ C$ and standard atmospheric pressure. If the final volume of the gas becomes $\frac{1}{3}$ rd of its initial volume, what will be the final pressure and temperature of the gas? If the gas is compressed isothermally, what will be the final pressure? ($\gamma = 1.4$)

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22. Two lead bullets of equal mass top after head-on Collison and reach their melting point due to the heat generated. The temperature of the bullets before collision was $35^\circ C$. Find the relative velocity of the bullets before collision. Specific heat of lead $= 0.03 cal \cdot g^{-1} \cdot^\circ C^{-1}$, melting point of lead = $335^\circ C$, $J = 4.18 \times 10^7 erg \cdot cal^{-1}$.

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23. The specific heat of air at constant volume is $0.1684 cal \cdot g^{-1} \cdot^\circ C^{-1}$ and at constant pressure is $0.2375 cal \cdot g^{-1} \cdot^\circ C^{-1}$. Determine the value of J. Density of air at STP = $0.001293 g \cdot cm^{-3}$ and volume of 1 g air = $773.3 cm^3$.

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24. 1 mol oxygen is kept in an insulated closed vessel. The vessel is suddenly moved at constant velocity v_0 causing the temperature of the gas to rise by $1^\circ C$. Find out the value of v_0. For oxygen , $\gamma = 1.41$ and molar gas constant, $R = 8.31 J \cdot mol^{-1} \cdot K^{-1}$.

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25. If $C_p = 6.85 cal \cdot mol^{-1} \cdot^\circ C^{-1}$, $C_v = 4.87 cal \cdot mol^{-1} \cdot^\circ C^{-1}$ and $R = 8.31 \times 10^7 erg \cdot mol^{-1} \cdot^\circ C^{-1}$, then find out the value of J.

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26. Specific heat of argon at constant pressure and at constant volume are $0.12 cal \cdot g^{-1} \cdot^\circ C^{-1}$ and $0.08 cal \cdot g^{-1} \cdot^\circ C^{-1}$ respectively. Find out the density of argon at STP. $J = 4.2 \times 10^7 erg \cdot cal^{-1}$, standard pressure = $1.01 \times 10^6 dyn \cdot cm^{-2}$.

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27. Air is being pumped into the tyre of a car at a specific pressure. When the pressure of the tyre become double and the temperature of air is $15^\circ C$, the tyre bursts suddenly. Find out the change in temperature.

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28. A diatomic ideal gas is compressed adiabatically to $\frac{1}{32}$ of its initial volume. If the initial temperature of the gas is $T_i K$ and the final temperature is $\alpha T_f K$ then determine the value of α.

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Entrance Corner Assertion Reason Type

1. Statement I : In an isothermal process the whole heat energy supplied to the body is converted into internal energy.

Statement II : According to the first law of thermodynamics $\Delta Q = \Delta U + p\Delta V$.

A. Statement I is true, statement II is true, statement II is a correct explanation for statement I.

B. Statement I is true, statement II is true, statement II is not a correct explanation for statement I.

C. Statement I is true, statement II is false

D. Statement I is false, statement II is true.

Answer: D

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2. Statement I : The specific heat of a gas in an adiabatic process is zero but it is infinite in an isothermal process.

Statement II : Molar specific heat of a gas is directly proportional to heat exchanged with the system and inversely proportional to change in temperature.

A. Statement I is true, statement II is true, statement II is a correct explanation for statement I.

B. Statement I is true, statement II is true, statement II is not a correct explanation for statement I.

C. Statement I is true, statement II is false

D. Statement I is false, statement II is true.

Answer: A

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3. Statement I : In an adiabatic process, change in internal energy of a gas is equal to work done on or by the gas in the process.

Statement II : Temperature of gas remains constant in an adiabatic process.

A. Statement I is true, statement II is true, statement II is a correct explanation for statement I.

B. Statement I is true, statement II is true, statement II is not a correct explanation for statement I.

C. Statement I is true, statement II is false

D. Statement I is false, statement II is true.

Answer: C

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4. Statement I : Internal energy of an ideal gas does not depends on volume of the gas.

Statement II : This is because internal energy of an ideal gas depends on temperature of the gas.

A. Statement I is true, statement II is true, statement II is a correct explanation for statement I.

B. Statement I is true, statement II is true, statement II is not a correct explanation for statement I.

C. Statement I is true, statement II is false

D. Statement I is false, statement II is true.

Answer: B

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Entrance Corner Multiple Correct Answer Type

1. C_v and C_p denote the molar specific heat capacities of a gas at constant volume and constant volume and constant pressure, respectively. Then,

A. $(C_p - C_v)$ is larger for a diatomic ideal gas than for a monatomic ideal gas

B. $(C_p + C_v)$ is larger for a diatomic ideal gas than for a monatomic ideal gas

C. $\frac{C_p}{C_v}$ is larger for a diatomic ideal gas than for a monatomic ideal gas

D. $C_p \times C_v$ is larger for a diatomic ideal gas than for a monatomic ideal gas

Answer: B::D

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Entrance Corner Integer Answer Type

1. A diatomic ideal gas is compressed adiabatically to $\frac{1}{32}$ of its initial volume. If the initial temperature of the gas is T_1 (in kelvin) and the final temperature is aT_1.Find the value of a.

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2. During adiabatic expansion of 10 mol of a gas, internal energy decreases by 700 J.

Work done during the process is $x \times 10^2 J$. What is the value of x?

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3. Two Carnot engines A and B operate respectively between 500 K and 400 K and 300 K. What is the difference in their efficiencies (in percentage)?

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4. Calculate the pressure required to compress a gas adiabatically at atmospheric pressure to one third of its volume. Given $\gamma = 1.47$.

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5. A thermodynamic system is taken an initial state i with internal energy $U_i = 100J$ to the final state f along two different paths iaf and ibf, as shown in figure. The work done by the system along the paths af, ib and bf are $W_{af} = 200J$, $W_{ib} = 50J$ and $W_{bf} = 100J$ respectively. The heat supplied to the system along the path iaf, ib and bf and Q_{iaf}, Q_{ib} and Q_{bf} respectively. If the internal energy of the energy of the system in the state b is $U_b = 200J$ and $Q_{iaf} = 500J$ then find out the ratio of Q_{bf} / Q_{ib}.

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1. If an ideal gas expands adiabatically will its temperature increase or decrease? Use first law of thermodynamics to justify your answer.

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2. An ideal gas undergoes a cyclic process $(V, P) \rightarrow (3V, P) \rightarrow (V, 4P) \rightarrow (V, P)$ along straight lines on the P - V plane. Calculate the work done in the process.

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3. The temperature of a fixed mass of an ideal gas is changed from T_1K to $T_2K(T_2 > T_1)$. Calculate the work done if the change is brought about at (i) constant pressure (ii) constant volume. Hence find from the first law of thermodynamics, in which case heat absorbed will be greater.

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4. 1 mol of an ideal gas is compressed to half of its initial volume (i) isothermally and (ii) adiabatically. Draw the p-V diagram in each case and hence state with reason, in which case the work done in less.

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5. Write down the mathematical form of the first law of thermodynamics.

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6. The second law of thermodynamics.

A. gives the definition of temperature

B. determines the direction of flow of heat during exchange between bodies

C. is another form of the principle of conservation of heat and other forms of energy.

D. helps in computing the efficiency of the Carnot's engine.

Answer: A,B,D

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7. An ideal gas is compressed from state (P_1, V_1, T) to state (P_2, V_2, T) isothermally. What is the change in the internal energy of the gas? Answer with reason.

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8. Certain amount of an ideal gas $(\gamma = 1.4)$ performs 80J of work while undergoing isobaric expansion. Find the amount of heat absorbed by the gas in the process and the change in its internal energy.

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9. Show adiabatic and isothermal processes on a single p-V diagram. Of the two graphs, which one is steeper?

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10. Define reversible and irreversible process. Explain with an example of each process.

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11. Draw indicator diagram of Carnot's cycle.

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12. The efficiency of a Carnot engine is 50%. The temperature of the heat sink is $27^\circ C$. Find the temperature of the heat source.

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13. During adiabatic expansion of 2 mol of a gas, the internal energy of the gas is found to decrease by 2J. The work done by the gas during the process is

A. 1J

B. $-1J$

C. $2J$

D. $-2J$

Answer: C

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14. Why does ideal gas contain two specific heats?

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15. Determine the difference between two specific heats of one mole ideal gas.

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16. Adiabatic curves are much steeper than isothermal-Prove it.

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17. Give example of an intensive variable and an extensive variable.

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18. The slope of an isothermal curve is always

A. the same as that of an adiabatic curve

B. greater than that of an adiabatic curve

C. less than that of an adiabatic curve

D. none of these

Answer: C

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19. Define reversible and irreversible processes.

Watch Video Solution

20. Find out the expression for the work done by a gas in adiabatic expansion.

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21. Show that in an adiabatic process the relation between volume and temperature of a gas is $TV^{\gamma-1}$ = constant, where γ is the ratio of the two specific heat of the gas.

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22. When 110J of heat is supplied to a gaseous system, the internal energy of the system increase by 40J. The amount of external work done (in J) is

A. 150

B. 70

C. 110

D. 40

Answer: B

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23. Write down the mathematical form of the first law of thermodynamics. Mention the different terms.

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24. Show that for ideal gas $C_p - C_v = R$.

Watch Video Solution

25. A quantity of an ideal gas is compressed from state (p_1, V_1) to another state (p_2, V_2) (i) isothermally, (ii) adiabatically. In which process will the work done be greater?

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1. One mole of an ideal monatomic gas is heated at a constant pressure from $0^{\circ}C$ to $100^{\circ}C$. Then the change in the internal energy of the gas is (given $R = 8.32 J \cdot mol \cdot k^{-1}$)

A. $0.83 \times 10^{3} J$

B. $4.6 \times 10^{3} J$

C. $2.08 \times 10^{3} J$

D. $1.25 \times 10^{3} J$

Answer: D

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2. One mole of a van der Waal's gas obeying the equation $\left(p + \frac{a}{V^2}\right)(V - b) = RT$, undergoes the quasistatic cyclic process which is shown in the p-V diagram. The net heat absorbed by the gas in this process is

A. $\frac{1}{2}(p_1 - p_2)(V_1 - V_2)$

B. $\frac{1}{2}(p_1 + p_2)(V_1 - V_2)$

C. $\frac{1}{2}\left(p_1 + \frac{a}{V_1^2} - p_2 - \frac{a}{V_2^2}\right)(V_1 - V_2)$

D. $\frac{1}{2}\left(p_1 + \frac{a}{V_1^2} + p_2 + \frac{a}{V_2^2}\right)(V_1 - V_2)$

Answer: A

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3. A heating element of resistance r is fitted inside an adiabatic cylinder which carries a frictionless piston of mass m and cross section A as shown in diagram gas. The current flows through the element such that the temperature rises with time t as $\Delta T = \alpha + \frac{1}{2}\beta t^2 (\alpha \text{ and } \beta are cons\tan t)$, while pressure remains constant. the atmospheric pressure above the piston is P_0. Then

A. the rate of increase in internal energy is $\frac{5}{2}R(\alpha + \beta t)$

B. the current flowing in the element is $\sqrt{\frac{5}{2r}R(\alpha + \beta t)}$

C. the piston moves upwards with constant acceleration

D. the piston moves upwards with constant speed

Answer: A::C

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4. The pressure p, volume V and temperature T for a certain gas are related by $p = \frac{AT - BT^2}{V}$, where A and B are constants. The work done by the gas when the temperature changes from T_1 to T_2 while the pressure remains constant, is given by

A. $A(T_2 - T_1) + B(T_2^2 - T_1^2)$

B. $\dfrac{A(T_2 - T_1)}{V_2 - V_1} + \dfrac{B(T_2^2 - T_1^2)}{V_2 - V_1}$

C. $A(T_2 - T_1) - B(T_2^2 - T_1^2)$

D. $\dfrac{A(T_2 - T_2^2)}{V_2 - V_1}$

Answer: C

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5. 2 mol of an ideal monatomic gas is carried from a state (P_0, V_0) to a state $(2P_0, 2V_0)$ along a straight line path in a P - V diagram. The amount of heat absorbed by the gas in the process is given by

A. $3P_0V_0$

B. $\dfrac{9}{2}P_0V_0$

C. $6P_0V_0$

D. $\dfrac{3}{2}P_0V_0$

Answer: C

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6. One mole of a monatomic ideal gas undergoes a quasistatic process, which is depicted by a straight line joining points (V_0, T_0) and $(2V_0, 3T_0)$ in a V-T diagram. What is the value of the heat capacity of the gas at the point (V_0, T_0) ?

A. R

B. $\frac{3}{2}R$

C. $2R$

D. 0

Answer: C

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7. For an ideal gas with initial pressure and volume p_i and V_i respectively, a reversible isothermal expansion happens, when its volume becomes V_0. Then it is compressed to its original volume V_i by a reversible adiabatic process. If the final pressure is p_f, then which of the following statement is true?

A. $P_f = P_i$

B. $P_f > P_i$

C. $P_f < P_i$

D. $\frac{P_f}{V_0} = (P_i)(V_i)$

Answer: B

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8. Which of the following statement(s) is/are true?

"internal energy of an ideal gas ______"

A. decreases in an isothermal process

B. remains constant in an isothermal process

C. increases in an isobaric process

D. decreases in an isobaric process

Answer: B

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Examination Archive With Solution Jee Main

1. One mole of diatomic ideal gas undergoes a cyclic process ABC as shown in fig. The process BC is adiabatic. The temperature at A, B and C are 400 K, 800 K and 600 K, respectively. Choose the correct statement.

A. The change in internal energy in whole cyclic process is 250 R

B. The change in internal energy in the process CA is 700 R

C. The change in internal energy in the process AB is -350 R

D. The change in internal energy in the process BC is -500 R

Answer: D

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2. A solid body of constant heat capacity $1J/^{\circ}C$ is being heated by keeping it in contact with reservoirs in two ways:

(i) Sequentially keeping in contact with 2 reservoirs such that each reservoir supplies same amount of heat .

(ii) Sequentially keeping in contact with 8 reservoirs such that each reservoir supplies same amount of heat .

In both the cases body is brought from initial temperature $100^{\circ}C$ to final temperature $200^{\circ}C$. Entropy change of the body in the two cases respectively is

A. 1n 2, 4 1n 2

B. 1n 2, 1n 2

C. 1n 2, 21n 2

D. 21n 2, 81n 2

Answer: B

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3. An ideal gas undergoes a quasi-static, reversible process in which its molar heat capacity C remains constant. If during this process the relation of pressure p and volume V is given by pV^n = constant, then n is given by (Here C_p and C_v are molar specific heat at constant pressure and constant volume, respectively)

A. $n = \frac{C_p}{C_v}$

B. $n = \frac{C - C_p}{C - C_v}$

C. $n = \frac{C_p - C}{C - C_v}$

D. $n = \frac{C - C_v}{C - C_p}$

Answer: B

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4. n mol of an ideal gas undergoes a process $A \rightarrow B$ as shown in the figure. The maximum temperature of the gas during the process will be

A. $\frac{9p_0V_0}{4nR}$

B. $\frac{3p_0V_0}{2nR}$

C. $\frac{9p_0V_0}{2nR}$

D. $\frac{9p_0V_0}{nR}$

Answer: A

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5. C_p and C_v are specific heats at constant pressure and constant volume respectively. It is observed that

$C_p - C_v = a$ for hydrogen gas

$C_p - C_v = b$ for nitrogen gas

The correct relation between a and b is

A. $a = \frac{1}{14}b$

B. $a = b$

C. $a = 14b$

D. $a = 28b$

Answer: C

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6. Two moles of an ideal monatomic gas occupies a volume V at $27^\circ C$. The gas expands adiabatically to a volume 2V. Calculate (a) the final temperature of the gas and (b) change in its internal energy

A. (a) 189 K (b) -2.7 kJ

B. (a) 195 K (b) 2.7 kJ

C. (a) 189 K (b) 2.7 kJ

D. (a) 195 K (b) -2.7 kJ

Answer: A

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Examination Archive With Solution Aipmt

1. A monatomic gas at a pressure p having a volume V expands isothermally to a volume 2V and then adiabatically to a volume 16 V. The final pressure of the gas is (take $\gamma = 5/3$)

A. 64 p

B. 32 p

C. $p/64$

D. $16p$

Answer: C

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2. A thermodynamic system undergoes cyclic process ABCDA as shown in fig. The work done by the system in the cycle is

A. p_0V_0

B. $2p_0V_0$

C. $\frac{p_0V_0}{2}$

D. zero

Answer: D

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3. On observing light from three different stars P, Q and R, it was found that intensity of violet colour is maximum in the spectrum of P, the intensity of green colour is maximum in the spectrum of R and the intensity of red colour in maximum in the spectrum of Q. If T_p, T_Q and T_R are the respective absolute temperature of P, Q and R, then it can be concluded from the above observations that

A. $T_P > T_Q > T_R$

B. $T_P > T_R > T_Q$

C. $T_P < T_R < T_Q$

D. $T_P < T_Q < T_R$

Answer: B

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4. Figure below shows two paths that may be taken by a gas to go from a state A to state C.

In process AB, 400 J of heat is added to the system and in process BC, 100 J of heat is added to the system. The absorbed by the system in the process AC will be

A. 380 J

B. 500 J

C. 460 J

D. 300 J

Answer: C

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5. A Carnot engine, having an efficiency of $\eta = \frac{1}{10}$ as heat engine is used as a refrigerator. If the work done on the system is 10 J, the amount of energy absorbed from the reservoir at lower temperature is

A. 100 J

B. 99 J

C. 90 J

D. 1 J

Answer: C

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6. One mole of an ideal diatomic gas undergoes a transition from A to B along a path AB as shown in the figure.

The change in internal energy of the gas during the transition is

A. 20 KJ

B. $-20KJ$

C. 20 J

D. $-12KJ$

Answer: B

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Examination Archive With Solution Neet

1. A gas is compressed isothermally to half its initial volume. The same gas is compressed separately through an adiabatic process until its volume is again reduced to half. Then

A. compressing the gas through adiabatic process will require more work to be done

B. compressing the gas isothermally or adiabatically will require the same amount of work

C. which of the case (whether compression through isothermal or through adiabatic process) requires more work will depend upon the atomicity of the gas

D. compressing the gas isothermally will require more work to be done

Answer: A

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2. A refrigerator works between $4^\circ C$ and $30^\circ C$. It is required to remove 600 cal of heat every second in order to keep the temperature of the refrigerator space constant. The power required is (take 1 cal = 4.2 J)

A. 23.65 W

B. 236.5 W

C. 2365 W

D. 2.365 W

Answer: B

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3. The volume of 1 mol of an ideal gas with the adiabatic exponent γ is changed according to the relation $V = \frac{b}{T}$ where b = constant. The amount of heat absorbed by the gas in the process if the temperature is increased by ΔT will be

A. $\left(\frac{1-\gamma}{\gamma+1}\right)R\Delta T$

B. $\frac{R}{\gamma-1}\Delta T$

C. $\left(\frac{2-\gamma}{\gamma-1}\right)R\Delta T$

D. $\frac{R\Delta T}{\gamma-1}$

Answer: C

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4. One mole of a gas obeying the equation of state $P(V-b)=RT$ is made to expand from a state with coordinates (P_1, V_1) to a state with (P_2, V_2) along a process that is depicted by a straight line on a P - V diagram. Then, the work done is given by

A. $\frac{1}{2}(P_2-P_1)(V_2+V_1+2b)$

B. $\frac{1}{2}(P_1+P_2)(V_2-V_1)$

C. $\frac{1}{2}(P_1-P_2)(V_2-V_1)$

D. $\frac{1}{2}(P_2+P_1)(V_2-V_1+2b)$

Answer: B

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5. The volume V of a monatomic gas varies with its temperature T. as shown in the graph. The ratio of work done by the gas, to the heat

absorbed by it, when it undergoes a change from state A to state B, is

A. $\frac{1}{3}$

B. $\frac{2}{3}$

C. $\frac{2}{5}$

D. $\frac{2}{7}$

Answer: C

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6. The efficiency of an ideal heat engine working between the freezing point and boiling point of water, is

A. 6.25%

B. 20%

C. 26.8%

D. 12.5%

Answer: C

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7. A sample of 0.1 g of water at $100^{\circ}C$ and normal pressure $(1.013 \times 10^5 N \cdot m^{-2})$ requires 54 cal of heat energy to convert to steam at $100^{\circ}C$. If the volume of the steam produced is 167.1 cc, the change in internal energy of the sample is

A. 42.2 J

B. 208. 7 J

C. 104.3 J

D. 84.5 J

Answer: B

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Cbse Scanner

1. Write the second law of thermodynamics.

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2. Define 1st law of thermodynamics. By using this law, derive relationship between C_p and C_v.

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3. Give any one difference between a refrigerator and a heat engine.

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4. Write the expansion for coefficient of performance of a refrigerator in terms of heat released and heat absorbed.

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5. What type of thermodynamic process is associated with sudden bursting of an inflated balloon?

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6. Define isochoric process. What is the work done in such process?

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7. The molar specific heat capacity at constant volume of a mono atomic gas is $(3/2)$ R, where R is universal gas constant. Find the value of molar specific heat capacity of the gas at constant pressure.

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8. Prove $C_p - C_v = R$

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9. Give two points on comparison between isothermal and adiabatic processes.

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10. What are the limitations of first law of thermodynamics? How are these overcome in second law of thermodynamics? Explain briefly.

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11. A refrigerator is maintained (stabilizer kept inside) at $9^\circ C$. If room temperature is $36^\circ C$, calculate the coefficient of performance.

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12. Using first law of thermodynamics derive the relation between specific heat at constant pressure and constant volume.

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13. State the type thermodynamic process when (i) temperature is constant.

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14. State the type thermodynamic process when (ii) volume is constant.

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15. Define the coefficient of performance of a refrigerator.

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16. What is heat engine? Explain the principle and working of a heat engine. Define its efficiency.

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17. An ideal gas is compressed at a constant temperature, will its internal energy increase or decrease?

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18. Explain the two specific heats of a gas? Show that the difference between two specific heats is equal to the universal gas constant.

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