Q1: "Heat cannot by itself flow from a body at a lower temperature to a body at a higher temperature" is a statement or consequence of

(a) The second law of thermodynamics
(b) conservation of momentum
(c) conservation of mass
(d) The first law of thermodynamics

Answer: (a) Second law of thermodynamics.

Q2: Which of the following is incorrect regarding the first law of thermodynamics?

(a) It introduces the concept of internal energy
(b) It introduces the concept of entropy
(c) It is not applicable to any cyclic process
(d) It is a restatement of the principle of conservation of energy

Answer: Statements (b) and (c) are incorrect regarding the first law of thermodynamics.

Q3: Which of the following statements is correct for any thermodynamic system?

(a) The internal energy changes in all processes
(b) Internal energy and entropy are state functions
(c) The change in entropy can never be zero
(d) The work done in an adiabatic process is always zero

Answer: (b) Internal energy and entropy are state functions

Q4: Which of the following parameters does not characterize the thermodynamic state of matter?

(a) temperature
(b) pressure
(c) work
(d) volume

Answer: (c): The work does not characterize the thermodynamic state of matter

Q5: Even a 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): We cannot reach absolute zero temperature

Q6: Which statement is incorrect?
(a) All reversible cycles have the same efficiency
(b) The reversible cycle has more efficiency than an irreversible one
(c) Carnot cycle is a reversible one
(d) Carnot cycle has the maximum efficiency in all cycles

Answer: (a) All reversible cycles do not have the same efficiency.

Q7: A Carnot engine operating between temperatures T_1 and T_2 has efficiency 1/6 When T_2 is lowered by 62 K, its efficiency increases to ⅓. Then T_1 and T_2 are, respectively
(a) 372 K and 310 K
(b) 372 K and 330 K
(c) 330 K and 268 K
(d) 310 K and 248 K

Solution
The efficiency of Carnot engine,
$\eta = 1 - (T_2/T_1)$
$\eta = 1/6$
$T_2/T_1 = 5/6$
$T_1 = 6T_2/5$ --------------(1)
As per the question, when T_2 is lowered by 62 K, then its efficiency becomes 1/3
$1/3 = [1 - (T_2 - 62/T_1)]$

$[T_2 - 62/T_1] = 1 - (1/3)$ (Using equa (1))
$5(T_2 - 62)/6T_2 = 2/3$
$5T_2 - 310 = 4T_2 \Rightarrow T_2 = 310$ K
From equation (1) $T_1 = (6 \times 310)/5 = 372$ K
Answer: (a) 372 K and 310 K

Q8: 100 g of water is heated from 30 °C to 50 °C. Ignoring the slight expansion of the water, the change in its internal energy is (specific heat of water is 4184 J kg^{-1} K^{-1})
(a) 4.2 kJ
(b) 8.4 kJ
(c) 84 kJ
(d) 2.1 kJ

Solution
$\Delta Q = ms\Delta T$
Here m = 100 g = 100 $\times 10^{-3}$ Kg
S = 4184 J $kg^{-1}K^{-1}$ and $\Delta T = (50 - 30) = 20\ ^0C$
$\Delta Q = 100 \times 10^{-3} \times 4184 \times 20 = 8.4 \times 10^3$ J

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

Change in internal energy

$\Delta U = \Delta Q = 8.4 \times 10^3$ J = 8.4 kJ

Answer: (b) 8.4 kJ

Q9: 200 g water is heated from 40° C to 60 °C. Ignoring the slight expansion of water, the change in its internal energy is close to (Given specific heat of water = 4184 J/kg/K)

(a) 167.4 kJ

(b) 8.4 kJ

(c) 4.2 kJ

(d) 16.7 kJ

Solution

For isobaric process, $\Delta U = Q = ms\Delta T$

Here, m = 200 g = 0.2 Kg, s = 4184 J/Kg/K

$\Delta T = 60\ ^0C - 40\ ^0C = 20\ ^0C$

$\Delta U = (0.2)(4184)(20) = 16736$ J = 16.7 kJ

Answer: (d)16.7 kJ

Q10: The work of 146 kJ is performed in order to compress one-kilo mole of gas adiabatically and in this process the temperature of the gas increases by 7ºC. The gas is (R = 8.3 J mol^{-1} K^{-1})

(a) monoatomic

(b) diatomic

(c) triatomic

(d) a mixture of monoatomic and diatomic

Solution

According to the first law of thermodynamics

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

For an adiabatic process, $\Delta Q = 0$

$0 = \Delta U + \Delta W$

$\Delta U = -\Delta W$

$nC_v\Delta T = -\Delta W$

$C_v = -\Delta W/n\Delta T = -(-146) \times 103/[(1 \times 103) \times 7] = 20.8$ Jmol^{-1}K^{-1}

For diatomic gas, $C_v = (5/2)R = (5/2)\times 8.3 = 20.8$ Jmol^{-1}K^{-1}

Hence, the gas is diatomic

Answer: (b) diatomic

Q11: From the following statements, concerning ideal gas at any given temperature T, select the correct.

(a)The coefficient of volume expansion at constant pressure is the same for all ideal gases

(b)The average translational kinetic energy per molecule of oxygen gas is 3kT, k being Boltzmann constant

(c)The mean-free path of molecules increases with an increase in the pressure
(d)In a gaseous mixture, the average translational kinetic energy of the molecules of each component is different

Solution

$\gamma = dV/(V_0 \times dT)$ at a constant temperature
$\gamma = 1/V_0(dV/dT)_p$ since PV = RT
PdV = RdT or $(dV/dT) = R/P_0$
Therefore, $\gamma = (1/V_0)(R/P_0) = R/RT_0$
$\gamma = 1/T_0$
$\gamma = 1/273$
Answer: (a)The coefficient of volume expansion at constant pressure is the same for all ideal gases

Q12: Calorie is defined as the amount of heat required to raise the temperature of 1 g of water by 1 °C and it is defined under which of the following conditions?

(a) From 14.5 °C to 15.5 °C at 760 mm of Hg
(b) From 98.5 °C to 99.5 °C at 760 mm of Hg
(c) From 13.5 °C to 14.5 °C at 76 mm of Hg
(d) From 3.5 °C to 4.5 °C at 76 mm of Hg

Solution

1 calorie is the amount of heat required to raise the temperature of 1gm of water from 14.5 ^{0}C to 15.5 ^{0}C at 760 mm of Hg
Answer: (a) From 14.5 °C to 15.5 °C at 760 mm of Hg

Q13: The average translational kinetic energy of 02 (molar mass 32) molecules at a particular temperature is 0.048 eV. The translational kinetic energy of N2 (molar mass 28) molecules in eV at the same temperature is

(a) 0.0015
(b) 0.003
(c) 0.048
(d) 0.768

Solution

Average Kinetic Energy = (3/2)KT
It depends on temperature and does not depend on molar mass
For both the gases, average translational kinetic energy will be the same ie.,0.048 eV
Answer: (c) 0.048

Q14: One mole of a monoatomic gas is heated at a constant pressure of 1 atmosphere from 0 K to 100K. If the gas constant R=8.32 J/mol K, the change in internal energy of the gas is approximately [1998]

(a) 2.3 J
(b) 46 J
(c) 8.67×10^3J
(d) 1.25 x $l0^3$J

Solution

$\Delta U = C_v dT = (3R/2)\Delta T$

$\Delta U = (3/2) \times (8.3) \times (100) = 1.25 \times 10^3$ J

Answer: (d) 1.25 x $l0^3$J

Q15: An ideal gas heat engine is operating between 227 °C and 127 °C. It absorbs 104 J of heat at the higher temperature. The amount of heat converted into work is

(a) 2000 J
(b) 4000 J
(c) 8000 J
(d) 5600 J

Solution

$\eta = 1 - (T_2/T_1)$

$\eta = 1 - (127 + 273)/(227 + 273) = 1 - (400/500) = ⅕$

$W = \eta Q_1 = ⅕ \times 10^4 = 2000$ J

Answer: (a) 2000 J