TOPIC WISE MULTIPLE CHOICE QUESTIONS

11.1 KINETIC THEORY OF GASES

(1) Root mean square velocity is related to the absolute temperature of an ideal gas as: **LHR-2019 (G-I)**

(a) $V_{rms} \propto T$ (b) $V_{rms} \propto T^2$

(c) $V_{rms} \propto \sqrt{T}$ (d) $V_{rms} \propto \frac{1}{\sqrt{T}}$

(2) If p = pressure; V = volume of a gas $P\Delta V$ represents: **LHR-2019 (G-I)**

(a) work (b) density

(c) power (d) temperature

(3) At constant temperature, if pressure is halved then its volume is: **GRW-2019 (G-I)**

(a) constant (b) halved

(c) four times (d) doubled

(4) For an ideal gas, the potential energy associated with its molecules is **LHR-2018 (G-II)**

(a) maximum (b) zero

(c) $\frac{1}{2}kx_o^2$ (d) $\frac{1}{2}kx_o$

(5) At constant temperature and pressure, if volume of given mass of a gas is doubled, then density of the gas becomes: **LHR-2017 (G-I)**

(a) double (b) $\frac{1}{4}$ of original

(c) $\frac{1}{2}$ of original (d) unchanged

(6) The value of Boltzman constant is: **LHR 2016 (G-I, G-II)**

(a) $6.02 \times 10^{23}\ JK^{-1}$ (b) $1.38 \times 10^{23}\ JK^{-1}$

(c) $1.38 \times 10^{-23}\ JK^{-1}$ (d) $6.02 \times 10^{-23}\ JK^{-1}$

(7) Ideal gas law is: **(GRW 2015)**

(a) PT = NUK (b) P = NKT

(c) PV = nRT (d) P = nRT

(8) The SI unit of product of pressure and volume is: **RWP-2019 (G-I)**

(a) Watt (b) Joule

(c) Pascal (d) N.m

(9) Average translation K.E of a gas molecule is: **FSD 2019 (G-I)**

(a) $\frac{1}{2}kT$ **(b)** kT

(c) $\frac{2}{3}kT$ **(d)** $\frac{3}{2}kT$

(10) Pressure of a gas is given as **SGD-2016 (G-I)**

(a) $\frac{1}{3}\rho < v^2 >$ **(b)** $\frac{2}{3}\rho < v^2 >$

(c) $\frac{1}{3}N\rho < v^2 >$ **(d)** $\frac{4}{3}\rho < v^2 >$

(11) The Average Kinetic Energy of Gas is zero at: **BWP-2019 (G-II)**

(a) 0°C **(b)** –273°C

(c) 100°C **(d)** 100 K

(12) A diatomic gas molecule has: **BWP-2017 (G-II)**

(a) translational energy

(b) rotational energy only

(c) vibrational energy only

(d) all translational, rotational and vibrational energy

(13) Boltzman constant, universal gas constant and Avogadro number are related as: **BWP-2017 (G-II)**

(a) $k = \frac{R}{N_A}$ **(b)** $k = \frac{N_A}{R}$

(c) $R = \frac{k}{N_A}$ **(d)** $R = \frac{N_A}{k}$

(14) Fahrenheit and centigrade thermometers have same reading at

(a) –100° **(b)** 32°

(c) –40° **(d)** 273°

(15) Temperature of -273^{0}C on Kelvin scale is

(a) 100K **(b)** 373K

(c) 0 K **(d)** 273K

(16) Pressure of a gas can be written as

(a) $P = \frac{1}{3}\rho < v^2 >$ **(b)** $P = \frac{NkT}{V}$

(c) $P = \frac{2}{3}\frac{N}{V} < \frac{1}{2}mv^2 >$ **(d)** all of these

(17) The translational K.E per molecule of an ideal gas is given by

(a) $\frac{2}{3}kT$ **(b)** $\frac{3}{2}kT$

(c) $\frac{3}{2}kT^2$ **(d)** $\frac{3}{2kT}$

(18) The collisions among the gas molecules and with the walls of container are assumed to be
(a) perfectly elastic **(b)** elastic
(c) inelastic **(d)** none of them

(19) The application of kinetic theory can be studied in
(a) diffusion of gases **(b)** brownian motion
(c) both a & b **(d)** none of these

(20) Which of the following thermometers has only positive degrees of temperature?
(a) Celsius **(b)** Fahrenheit
(c) Kelvin **(d)** none

(21) Charle's law can be written mathematically as
(a) $V \propto T$ **(b)** $V \propto \frac{1}{T}$
(c) $P \propto T$ **(d)** $P \propto \frac{1}{T}$

(22) The temperature of a normal human body is 98.6^{0}F. This temperature on centigrade scale is
(a) 0°C **(b)** 37°C
(c) 73°C **(d)** 37.6°C

(23) Pressure of a gas is
(a) $1/3\ \rho\langle v\rangle$ **(b)** $2/3\ \rho\langle v^2\rangle$
(c) $1/3\ \rho\langle v^2\rangle$ **(d)** $3/2\ \rho\langle v^2\rangle$

(24) The direction of flow of heat between two bodies depends upon
(a) thermal conductivity **(b)** specific heat
(c) internal energies **(d)** temperature difference

(25) Pressure of gas depends upon
(a) molecular speed **(b)** number of molecules
(c) mass of molecules **(d)** all of them

(26) According to Boyle's law the volume is
(a) inversely proportional to temperature **(b)** directly proportional to pressure
(c) inversely proportional to pressure **(d)** directly proportional to temperature

(27) The unit of Boltzmann's constant is
(a) JK^{-1} **(b)** $J^{-1}\ K^{-1}$
(c) J K **(d)** $J^{-1}\ K$

(28) The unit of pressure
(a) Ns **(b)** Nm^{-1}
(c) Nm^{-2} **(d)** Nm^{-3}

(29) A mono-atomic gas contains
(a) translational K.E **(b)** vibrational K.E
(c) rotational K.E **(d)** all of these

(30) At constant pressure the graph between volume and absolute temperature
(a) parabola **(b)** straight line
(c) hyperbola **(d)** ellipse

(31) In Boyle's law, if the pressure is three times then the volume of a gas becomes
(a) one half **(b)** three times
(c) one third **(d)** double

(32) The relation between Celsius and Fahrenheit scale is given by

(a) $T_c = \frac{5}{9}(T_F + 32)$ **(b)** $T_c = \frac{9}{5}(T_F + 32)$

(c) $T_c = \frac{9}{5}(T_F - 32)$ **(d)** $T_c = \frac{5}{9}(T_F - 32)$

(33) On Kelvin scale the normal body temperature is given by

(a) 210K **(b)** 320K

(c) 310K **(d)** 373K

(34) The K.E of the molecules of an ideal gas at absolute zero will be

(a) zero **(b)** low

(c) high **(d)** remain same

(35) The relation PV = RT holds good for

(a) one kilogram of gas **(b)** one-meter cubic volume of gas

(c) one mole of gas **(d)** one gram of gas

(36) The relationship between heat and other forms of energy is called

(a) thermal equilibrium **(b)** thermodynamics

(c) thermal energy **(d)** none of these

11.2 INTERNAL ENERGY

(37) The SI unit of internal energy is

(a) joule **(b)** $J\ K^{-1}$

(c) erg (d) J K

(38) The internal energy of a body is maximum when its temperature is

(a) 0K **(b)** 273K

(c) –273K **(d)** $-273^{o}C$

(39) The sum of all molecular energies of a substance is called

(a) K.E **(b)** P.E

(c) internal energy **(d)** chemical energy

(40) The molecules of an ideal gas are mere mass points which exerts

(a) maximum force on one another **(b)** no force on one another

(c) equal force **(d)** none of these

(41) When we heat a substance, energy associated with its atoms or molecules

(a) increases **(b)** remains same

(c) decreases **(d)** none of these

(42) Internal energy depends upon

(a) final state **(b)** initial state

(c) both a & b **(d)** none of these

(43) The internal energy of an ideal gas depends upon only

(a) pressure **(b)** temperature

(c) volume **(d)** all of these

(44) By rubbing the objects together, their internal energy

(a) increases **(b)** decreases

(c) remains constant **(d)** becomes zero

(45) The internal energy is analogous to

(a) gravitational P.E **(b)** K.E

(c) Elastic P.E **(d)** none of these

(46) When some amount of heat energy enters a system
(a) it increases its internal energy **(b)** it decreases its internal energy
(c) the internal energy remains constant **(d)** none of these

(47) The sum of all forms of molecular energy present in a thermodynamic system is called its
(a) Environmental energy **(b)** Temperature
(c) Heat **(d)** internal energy

11.3 WORK AND HEAT

(48) Work done by the system on its environment is taken as
(a) positive **(b)** negative
(c) neutral **(d)** none of these

(49) The work done can also be calculated by the area of the curve under
(a) P-V graph **(b)** V-T graph
(c) P-T graph **(d)** P-1/V graph

(50) The relation for the work done by the system can be expressed as
(a) $W=A\Delta V$ **(b)** $W=P\Delta V$
(c) $W=A\Delta P$ **(d)** $W=P\Delta A$

(51) The dimension of work done on the system
(a) $[ML^{-1}T^{-2}]$ **(b)** $[ML^{2}T^{-2}]$
(c) $[MLT^{-2}]$ **(d)** $[ML^{-1}T^{-1}]$

11.4 FIRST LAW OF THERMODYNAMICS

(52) According to first law of thermodynamics the quantity which is conserved is: **GRW-2019 (G-II)**
(a) force **(b)** momentum
(c) power (d) energy

(53) What remains constant in adiabatic process? **GRW-2019 (G-II)**
(a) volume **(b)** pressure
(c) entropy (d) temperature

(54) The work done in isochoric process is: **LHR-2018 (G-I)**
(a) constant **(b)** variable
(c) zero (d) depend on condition

(55) The change in internal energy is defined as: **LHR-2017 (G-II)**
(a) Q – W **(b)** Q – T
(c) Q + P (d) Q – P

(56) Cloud formation in atmosphere is an example of **GRW-2016 (G-I)**
(a) isothermal process **(b)** isochoric process
(c) adiabatic process **(d)** isobaric process

(57) First law of thermodynamics for an adiabatic process is:
MTN-2018 (G-I), MTN-2019 (G-I), FSD-2017
(a) $Q = \Delta U$ **(b)** $Q = W$
(c) $W = Q + U$ (d) $W = -U$

(58) In thermodynamics system internal energy decreases by 100 J of work is done on the system then heat lost will be **SGD-2016 (G-I)**
(a) zero **(b)** 100 J
(c) 200 J (d) –200 J

(59) Human metabolism is the example of: **MTN-2019 (G-II)**

(a) first law of thermodynamics **(b)** entropy

(c) second law of thermodynamics **(d)** adiabatic process

(60) First law of Thermodynamics is the statement of law of conservation of

(a) mass **(b)** energy

(c) momentum **(d)** heat

(61) Examples of first law of thermodynamics

(a) working of bicycle pump **(b)** human metabolism

(c) brakes applied by an automobile **(d)** all of these

(62) The process in which no heat can enter or leave the system is called

(a) isothermal process **(b)** adiabatic process

(c) isobaric process **(d)** isochoric process

(63) The relation for the 1st law of thermodynamics can be expressed as

(a) $\Delta U = \Delta W - Q$ **(b)** $\Delta W = \Delta U - Q$

(c) $Q = \Delta U - \Delta W$ **(d)** $Q = \Delta U + W$

(64) The isothermal process obeys

(a) Charle's law **(b)** Boyle's law

(c) Stefen's law **(d)** Pascal's law

(65) The curve representing an isothermal process is called

(a) an isotherm **(b)** an adiabat

(c) an isobar **(d)** an isochoric

(66) An adiabatic compression causes the temperature of the gas

(a) to increase **(b)** to decrease

(c) to remain constant **(d)** to become zero

(67) The rapid expansion and compression of air through which a sound wave is passing, obeys

(a) isothermal process **(b)** isochoric process

(c) adiabatic process **(d)** isobaric process

(68) In relation $PV^{\gamma} = \text{constant}$ the γ is given by

(a) $\frac{C_v}{C_p}$ **(b)** $\frac{C_P}{C_v}$

(c) $C_p - C_v$ **(d)** $C_v - C_p$

(69) Compressed air coming out of punctured football becomes cooler because of

(a) isothermal expansion **(b)** adiabatic expansion

(c) energy dissipation **(d)** adiabatic compression

(70) For an isothermal process, first law of thermodynamics becomes

(a) Q = W **(b)** Q = ΔU + W

(c) W = –ΔU **(d)** W = 0

11.6 MOLAR SPECIFIC HEAT OF GAS

(71) Difference between C_p and C_v is equal to **LHR-2019 (G-II)**

(a) Avogadro's number **(b)** Planck's constant

(c) Universal gas constant **(d)** Boltzmann's constant

(72) If C_p for a gas is $\frac{7R}{2}$ then the value of C_v will be: **BWP-2019 (G-I)**

(a) $\frac{3R}{2}$ (b) $\frac{5R}{2}$

(c) $\frac{9R}{2}$ (d) R

(73) The difference between two molar heat capacities is equal to **DGK-2018 (G-I)**

(a) temperature **(b)** pressure

(c) **volume** (d) **universal gas constant**

(74) The amount of heat required to raise the temperature of one mole of substance through 1 Kelvin is called

(a) Specific heat **(b)** molar specific heat

(c) specific heat at constant volume **(d)** Heat capacity

(75) The amount of heat required to raise the temperature of one mole of substance through 1 kelvin at constant pressure is called

(a) Specific heat

(b) molar heat capacity at constant pressure

(c) molar specific heat capacity at constant pressure

(d) Heat capacity at constant pressure

(76) If 1 mole of an ideal gas is heated at constant pressure then

(a) $Q_P = C_V \Delta T$ **(b)** $Q_P = C_P \Delta T$

(c) $Q_V = C_V \Delta T$ **(d)** $Q_V = C_P \Delta T$

(77) The difference between the molar specific heat at constant pressure and at constant volume is called

(a) molar gas constant **(b)** universal gas constant

(c) pressure constant **(d)** Boltzman constant

(78) The amount of heat required to raise the temperature of one kg of substance through 1 °C is called

(a) Specific heat **(b)** molar heat capacity

(c) heat of fusion **(d)** latent heat of fusion

(79) The value of universal gas constant is

(a) 8.314 J mol^{-1} K^{-1} **(b)** 81.34 J mol^{-1} K^{-1}

(c) 0.8134 J mol^{-1} K^{-1} **(d)** 8134 J mol^{-1} K^{-1}

(80) The relation for the molar specific heat of a gas $C_P - C_V$ is

(a) $C_P - C_V = R$ **(b)** $C_V - C_P = R$

(c) $C_P = R - C_V$ **(d)** $C_V = R - C_P$

(81) For 1 mole of gas the relation $P\Delta V$ =

(a) $R\Delta T$ **(b)** $R\Delta V$

(c) $R\Delta P$ **(d)** $P\Delta T$

(82) Mathematically, the molar specific heat at constant pressure can be expressed as

(a) $C_p = \frac{Q_p}{\Delta T}$ **(b)** $C_p = \frac{\Delta T}{Q_p}$

(c) $C_p = \frac{T}{\Delta Q_p}$ **(d)** $C_p = \Delta Q_p \times T$

(83) Which of the following relation holds for $C_P - C_V = R$

(a) $C_V = C_P$ **(b)** $C_V < C_P$

(c) $C_V > C_P$ **(d)** $C_V + C_P$

11.6 REVERSIBLE AND IRREVERSIBLE PROCESSES

(84) Work done against friction is a

(a) reversible process **(b)** irreversible process

(c) adiabatic process **(d)** isobaric process

(85) All changes which occur suddenly or which involve friction or dissipation of energy are

(a) Reversible **(b)** adiabatic

(c) isothermal **(d)** irreversible

(86) The dissipation of energy through conduction, convection and radiation are

(a) reversible process **(b)** irreversible process

(c) isothermal process **(d)** isobaric process

(87) If a process cannot be traced in the backward direction by reversing the controlling factors, it is called

(a) irreversible process **(b)** reversible process

(c) adiabatic process **(d)** isothermal process

(88) A succession of events which brings the system back to its initial condition is called

(a) cycle **(b)** irreversible process

(c) isothermal process **(d)** adiabatic process

(89) Explosion is an example of

(a) highly reversible process **(b)** highly irreversible process

(c) slowly irreversible process **(d)** cyclic process

11.8 SECOND LAW OF THERMODYNAMICS

(90) It is impossible for heat engine to convert all heat into useful work, the law is called

(a) 1^{st} law of thermodynamics **(b)** 2^{nd} law of thermodynamics

(c) law of conservation of energy **(d)** law of conservation of mass

(91) The statement "it is impossible to devise a process which may convert heat, extracted from a single reservoir entirely into work" given by

(a) Lord Kelvin **(b)** Joule

(c) Newton **(d)** Pascal

(92) The statement "it is impossible for a self-acting machine, to transfer heat from a lower temperature to higher temperature" obeys

(a) 1^{st} law of thermodynamics **(b)** 2^{nd} law of thermodynamics

(c) law of conservation of momentum **(d)** law of conservation of energy

(93) The oceans and our atmosphere contain large amount of heat energy but it cannot be converted into useful

(a) chemical work **(b)** mechanical work

(c) electrical work **(d)** power

11.9 CARNOT ENGINE AND CARNOT THEOREM

(94) Carnot engine cycle consists of: **RWP-2019 (G-I)**

(a) two steps (b) three steps

(c) single step (d) four steps

(95) If temperature of sink is decreased, the efficiency of Carnot engine. **MTN-2019 (G-I)**

(a) decreases (b) increases
(c) remains same (d) first increases then decreases

(96) Efficiency of heat engine working between temperature 27°C and 327°C will be **DGK-2018 (G-II)**

(a) 50% (b) 90%
(c) 40% (d) 61%

(97) If the temperature of the sink is absolute zero, then efficiency of heat engine should be **DGK-2018 (G-I)**

(a) 100% (b) 50%
(c) zero (d) infinite

(98) A Carnot engine has an efficiency of 50%, when its sink temperature is at 27°C. The temperature of the source is: **BWP-2017 (G-I)**

(a) 273°C (b) 300°C
(c) 327°C (d) 373°C

(99) No heat engine can be more efficient than a Carnot engine operating between the same two

(a) pressure **(b)** Carnot cycle
(c) temperature **(d)** working substance

(100) The efficiency of heat engine is defined as

(a) $\eta = \frac{\text{Output}}{\text{Input}}$ **(b)** $\eta = \frac{\text{Input}}{\text{Output}}$

(c) $\eta = \text{Output} \times \text{Input}$ **(d)** $\eta = \frac{1}{\text{Input} \times \text{Output}}$

(101) Sadi Carnot mentioned an ideal engine in

(a) 1897 **(b)** 1840
(c) 1678 **(d)** 1856

(102) In Carnot engine internal energy in one cycle,

(a) becomes zero **(b)** remains constant
(c) increases **(d)** decreases

(103) A refrigerator transfers heat energy from

(a) low to high temperature **(b)** high to low temperature
(c) no transfer **(d)** maintain its internal energy

(104) Efficiency of carnot engine is 100% if T_2 low temperature is at

(a) 0°C **(b)** 0°F
(c) 0 K **(d)** all above

(105) Carnot engine worked on the basis of

(a) isothermal process **(b)** adiabatic process
(c) isobaric process **(d)** both a & b

(106) The Carnot cycle can be shown by

(a) V-T graph **(b)** P-V graph
(c) P-T graph **(d)** P-V-T graph

(107) The efficiency of Carnot engine is

(a) 100 % **(b)** less than 100%
(c) less than 10% **(d)** none of these

(108) The efficiency of Carnot engine in term of temperature can be expressed by

(a) $\eta = 1 - \frac{T_1}{T_2}$
(b) $\eta = \frac{T_1 - T_2}{T_1}$
(c) $\eta = \frac{T_2 - T_1}{T_1}$
(d) $\eta = \frac{T_1 + T_2}{T_2}$

(109) The unit of efficiency is

(a) Nm
(b) K^{-1}
(c) $J\ K^{-1}$
(d) no unit

(110) On which factor the efficiency of Carnot engine depends upon

(a) temperature of sink
(b) temperature of source
(c) both a & b
(d) working substance

(111) If the temperature of the sink is increased then the efficiency of the Carnot engine

(a) decreases
(b) increases
(c) remain same
(d) zero

(112) Carnot cycle is an example of

(a) isothermal process
(b) adiabatic process
(c) irreversible process
(d) reversible process

(113) All Carnot engines operating between the same two temperatures have

(a) same efficiency
(b) zero efficiency
(c) maximum efficiency
(d) depend upon the nature of working substances

(114) A turbine in steam power plant takes steam from a boiler at 700K and exhausts in a low temperature reservoir at 350 K. What is maximum possible efficiency

(a) 5%
(b) 100%
(c) 0.50%
(d) 50%

(115) If an air conditioner is left ON in the middle of a room. Then temperature of room

(a) increases
(b) decreases
(c) remains same
(d) may increase or decrease

(116) The highest efficiency of a heat engine whose lower temperature is 27^oC and the higher temperature of 227^oC is

(a) 20%
(b) 0.4%
(c) 40%
(d) 100%

(117) Which of the following is used as working substance in Carnot cycle?

(a) real gas
(b) ideal gas
(c) polar gas
(d) ammonia gas

ANSWER KEYS

(Topic Wise Multiple Choice Questions)

1	c	16	d	31	c	46	a	61	d	76	b	91	a	106	b
2	a	17	b	32	d	47	d	62	b	77	b	92	b	107	b
3	d	18	a	33	c	48	a	63	d	78	a	93	b	108	b
4	b	19	c	34	a	49	a	64	b	79	a	94	d	109	d
5	c	20	c	35	d	50	b	65	a	80	a	95	b	110	c
6	d	21	a	36	b	51	b	66	a	81	a	96	a	111	a
7	c	22	b	37	a	52	d	67	c	82	a	97	a	112	c
8	b	23	c	38	b	53	c	68	b	83	b	98	c	113	a
9	d	24	d	39	c	54	c	69	b	84	b	99	c	114	d
10	a	25	d	40	b	55	a	70	a	85	d	100	a	115	a
11	b	26	c	41	a	56	c	71	c	86	b	101	b	116	c
12	d	27	b	42	c	57	d	72	b	87	a	102	b	117	b
13	a	28	c	43	b	58	b	73	d	88	a	103	a		
14	c	29	a	44	a	59	a	74	b	89	b	104	c		
15	c	30	b	45	c	60	d	75	c	90	b	105	d		

SHORT QUESTIONS

(From Textbook Exercise)

11.1 Why is the average velocity of the molecules in a gas zero but the average of the square of velocities is not zero?

FSD-15(G-I), LHR-15(G-I)&(G-II) GRW-16 (G-I), DGK-16 (G-I) & (G-II), LHR-18 (G-II), GRW-19 (G-II)

Ans: The molecules in a gas are in a state of random motion. The number of molecules along positive x-axis is equal to the number of molecules along negative x-axis. This is also true for y-axis and z-axis.

$$< V_x >= \frac{V_x - V_x}{2} = 0$$

Similarly,

$$< V_y >= 0$$

And,

$$< V_z >= 0$$

But the average of square of velocities is not zero because square of a negative value is also positive:

$$\frac{(V_x)^2 + (-V_x)^2}{2} = \frac{2V_x^2}{2} = V_x^2$$

11.2 Why does the pressure of a gas in a car tyre increase when it is driven through some distance?

MTN-15 (G-II), RWP-15 (G-I), GRW-15(G-I), MIRPUR (AJK) 15, BWP-16 (G-I), MTN-16 (G-I), RWP-16 (G-I), FSD-17, LHR-17 (G-II), SWL-18, DGK-18 (G-I)&(G-II), GRW-19 (G-II), FSD-19 (G-I)

Ans: When the car is driven through some distance, then the work has to be done to overcome friction and a part of work done is converted into heat. As a result, temperature of a gas increases and hence kinetic energy of molecules increases,

As pressure $\propto$ K.E of gas molecules.

So, pressure of gas molecules increases.

11.5 Specific heat of a gas at constant pressure is greater than specific heat at constant volume. Why?

DGK-15(G-I), SGD-15 (G-II), FSD-15 (G-I), MTN-15(G-I), GRW-15(G-I), RWP-15(G-I), SGD-16 (G-I) & (G-II), MTN-16 (G-I),LHR-16 (G-II), BWP-17 (G-I), SWL-17, SGD-18 (G-I), FSD-18, DGK-18 (G-I), GRW-18, RWP-19 (G-I), SWL-19, MTN-19 (G-I), BWP-19 (G-II)

Ans: When a gas is heated at constant pressure, then part of heat is used in doing work and part of heat is used in increasing the internal energy or temperature of the gas.

When a gas is heated at constant volume, then whole of the heat supplied is used up in increasing the internal energy of the system. That's why specific heat at constant pressure is greater than specific heat at constant volume.

Since, $C_p - C_v = R$

$C_p > C_v$

11.6 Given an example of a process in which no heat is transferred to or from the system but the temperature of the system changes.

DGK-16 (G-I), SGD-16 (G-I) & (G-II)

Ans: The process in which no heat enters or leaves the system is called 'Adiabatic Process.'

When a gas expands adiabatically, work is done at the cost of internal energy.

$W = -\Delta U$

As a result, the temperature of the system falls.

11.7 Is it possible to convert internal energy into mechanical energy? Explain with an example.
BWP-15(G-I), MTN-15(G-I), SWL-16, GRW-16 (G-I), LHR-16 (G-I), FSD-18, DGK-18 (G-II), LHR-18 (G-II), FSD-19 (G-I), LHR-19 (G-II)

Ans: Yes, it is possible to convert internal energy into work in an "Adiabatic process", when a gas expands, work is done at the cost of internal energy.

$W = -\Delta U$

- In steam engine, the energy of molecules of the steam is used up in running the engine.

11.8 Is it possible to construct a heat engine that will not expel heat into the atmosphere?
SGD-15(G-I), MTN-15(G-II), LHR-15(G-I)&(G-II), SGD-16 (G-I), RWP-16 (G-I), LHR-16 (G-I), BWP-17 (G-I) & (G-II), LHR-19 (G-I), SWL-18, GRW-18, RWP-19 (G-I), BWP-19 (G-I)

Ans: No, it is not possible to construct a heat engine that will not expel heat into the atmosphere. According to second law of thermodynamics, in order to convert heat into work, a part of heat has to be rejected to the sink, (cold reservoir)

11.11 Can the mechanical energy be converted completely into heat energy? If so give an example. ***SGD-15(G-I), SWL-18, RWP-19 (G-I), BWP-19 (G-II)***

Ans: Yes, it is possible to convert mechanical energy completely into heat energy for example: When brakes are applied to stop a running car, then the car stops due to friction and mechanical energy supplied is completely converted into heat energy due to friction.

Also when a gas is compressed adiabatically, the work done is used to increase the internal energy which appears as heat energy.

$-W = \Delta U$

TOPIC WISE SHORT QUESTIONS

11.1 KINETIC THEORY OF GASES

(1) What is thermodynamics? **BWP-2019 (G-II)**

Ans: It deals with various phenomena of energy and related properties of matter, especially the transformation of heat into other forms of energy. An example of such transformation is the process converting heat into mechanical work.

Examples: Heat engine, refrigerator etc.

(2) Define pressure of a gas.

According to kinetic theory, the pressure exerted by a gas is merely the momentum transferred to the walls of the container per second per unit area due to the continuous collisions of the molecules of the gas.

(3) Write any three / four postulates of kinetic theory of gases?
LHR-2016 (G-II), SGD-2016 (G-I), MTN-2018 (G-I)

Ans: **Postulates of Kinetic theory of Gases**

(i) The size of the molecules is much smaller than the separation between molecules.

(ii) A finite volume of gas consists of very large number of molecules.

(iii) The gas molecules are in random motion and may change their direction of motion after every collision.

(iv) Collisions between gas molecules themselves and with walls of container are assumed to be perfectly elastic.

(4) What is the relation between absolute temperature and average K.E of the gas molecules?

Ans: We know that PV= nRT

If N_A is the Avogadro numbers then

$$PV=\frac{N}{N_A}RT$$

$$PV=NKT \qquad (i)$$

Where $K=\frac{R}{N_A}$ is the Boltzman's constant.

$$PV=\frac{2}{3}N<\frac{1}{2}mv^2> \qquad (ii)$$

Comparing eq (i) and (ii)

$$NK\,T=\frac{2}{3}N<\frac{1}{2}mv^2>$$

$$T=\frac{2}{3K}<\frac{1}{2}mv^2>$$

$$T=\text{Constant}<\frac{1}{2}mv^2>$$

$$T \propto <\frac{1}{2}mv^2>$$

This relation shows that absolute temperature of an Ideal gas is directly proportional to the average translational K.E of the gas molecules.

(5) A molecule of gas having mass 'm' moving with velocity v collides with wall of container and rebounds. What is the change in momentum?

Ans: Let initial momentum of the molecule before striking the wall = mv_{1x}.

Final momentum of the molecule after the collision = $-mv_{1x}$

Change in momentum = final momentum – Initial momentum

= $-mv_{1x} - mv_{1x}$

= $-2mv_{1x}$

Change in momentum = $-2mv_{1x}$

(6) Derive Boyle's Law from Kinetic theory of gases?

SWL-2019 (G-I), MTN-2016 (G-II)

OR

(7) Given $P=\frac{2}{3}N_o<\frac{1}{2}mv^2>$ where N_o is the number of molecules per unit volume prove Boyle's and Charles's Laws. **BWP-2013, SWL-2013, 2014**

Ans: From kinetic theory of gases.

$$PV=\frac{2}{3}N<\frac{1}{2}mv^2>$$

If we keep the temperature constant. Average K.E i.e. $<\frac{1}{2}mv^2>$ remains constant. So the right hand side of the equation is constant.

Hence, PV=Constant

$$P\propto\frac{1}{V}$$

Thus, pressure P is inversely proportional to volume V at constant temperature of the gas which is Boyles Law.

(8) Derive Charles's Law and Boyle's Law from Kinetic theory of gases?

LHR-2018 (G-I)&2019(G-I), RWP-13, SGD-2016 (G-II)

Ans: We know that $P = \frac{2}{3}\frac{N}{V} < \frac{1}{2}mv^2 >$

Charle's Law

$$V = \frac{2}{3}\frac{N}{P} < \frac{1}{2}mv^2 >$$ If pressure is kept constant.

$$V \propto < \frac{1}{2}mv^2 >$$

As $< \frac{1}{2}mv^2 > \propto T$

Hence $V \propto T$

Thus volume is directly proportional to absolute temperature of the gas provided pressure is kept constant. This is known as Charles Law

Boyle's law

The volume V of a given mass of a gas is inversely proportional to the pressure at constant temperature.

Mathematically:

$$P \propto \frac{1}{V}$$ Hence PV= Constant If T = Constant

(9) Show that the ratio of the root mean square speeds of molecules of two different gases at a certain temperature is equal to the square root of the inverse ratio of their masses. **MIRPUR (AJK) 2015**

Ans: We know that according to the kinetic theory of gas

$$P = \frac{1}{3}\rho < v^2 > = \frac{1}{3}\frac{mnN_A}{V} < v^2 > \quad \because \rho = \frac{mass}{volume}$$

$$PV = \frac{1}{3}mnN_A < v^2 > \quad \because PV = nRT$$

$$nRT = \frac{1}{3}mnN_A < v^2 >$$

$$\Rightarrow < v^2 > = \frac{3RT}{mN_A}$$

Taking square root by both sides

$$\sqrt{< v^2 >} = v_{avg} = \sqrt{\frac{3RT}{mN_A}} \Rightarrow \frac{(v_{avg})_1}{(v_{avg})_2} = \sqrt{\frac{m_2}{m_1}}$$

11.2 INTERNAL ENERGY

(10) Define the term internal energy. Discuss in what form it is in an ideal gas.

MTN-2016 (G-II), DGK-2016(G-I)

Ans: The sum of all forms of molecular energies (kinetic and potential) of a substance is termed as its internal energy.

In case of an ideal gas it is in the form of kinetic energy only.

(11) Why absolute value of internal energy cannot be measured? **BWP-2017 (G-I)**

In case of real gases at high pressure and low temperature inter-molecular (wander-walls) forces produce potential energy between the molecules. That is why absolute value of internal energy cannot be measured.

(12) What energies has a diatomic molecule of a gas?

Ans: A diatomic gas molecule has both translational and rotational energy. It also has vibrational energy associated with the spring like bond between its atoms.

(13) What is the similarities and differences between internal energy and gravitational P.E.?

Similarities:

Both are types of energies having same unit (S.I unite Joule).

Differences:

INTERNAL ENERGY	GRAVITATIONAL P.E
(i) I.E = K.E + P.E	(i) It is Potential Energy.
(ii) It depends upon the temperature of the gas.	(ii) It depends upon position from the center of earth.

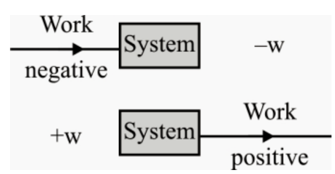
11.3 WORK AND HEAT

(14) What are sign conventions for work?

Ans: Work may be positive or negative

(a) When work is done by the system on surroundings then it is taken positive.

(b) When work is done on the system by the surrounding then it is taken negative.



(15) Differentiate between Heat and Temperature

Ans:

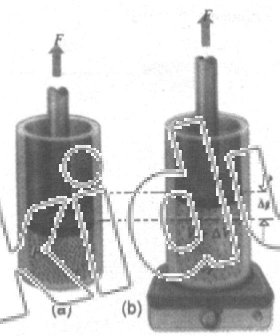
Heat	Temperature
(i) Heat is the sum of K.E of all molecules of a substance	(i) Temperature is the average K.E of molecules of a substance.
(ii) Heat is transfer of energy from higher temperature to lower temperature.	(ii) The degree of hotness or coldness of an object
(iii) S.I unit is Joule(J)	(iii) S.I unit is Kelvin (K)

(16) Justify "Work and heat are similar." **LHR-2019 (G-I)**

OR

Prove the relation $W = P\Delta V$ **BWP-2017 (G-II), DGK-2014**

We assume that the gas expands through ΔV very slowly, so that it remains in equilibrium.



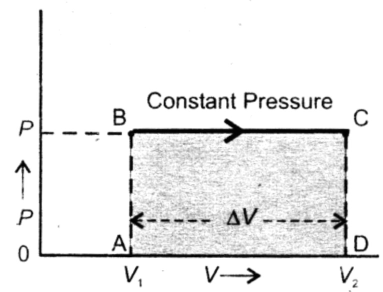
As the piston moves up through a small distance Δy, the work (W) done by the gas is

$$W = F\Delta y = PA\Delta y$$

Since (Change in volume) $A\Delta y = \Delta V$

Hence $W = P\Delta V$

The work done can also be calculated by area of the curve under P-V graph as shown in.



11.4 FIRST LAW OF THERMODYNAMICS

(17) State first law of thermodynamics. And give its mathematical form.

SWL-2019 (G-I), BWP-2015, DGK-2015

Ans: Statement:

In any thermodynamics process, when heat Q is added to a system, this energy appears as an increase in the internal energy ΔU stored in the system plus the work W done by the system on its surroundings.

Mathematically:

$$Q = \Delta U + W$$

(18) State First Law of thermodynamics. How it is applicable on human body?

OR

How process of Human metabolism can be explained, by the first Law of Thermodynamics? DGK -2016 (G-II)

Ans: Statement: (As above)

Energy transforming process that occurs within an organism are named as metabolism. We can apply the first law of thermodynamics, $\Delta U = Q - W$ to an organism of the human body. Work done will result in the decrease in internal energy of the body consequently, the internal energy is maintained by the food we eat.

(19) What will be heat lost if internal energy decreases by 300 J and work of 120 J is done by the system? BWP-2017 (G-I)

Ans: As internal energy is decreased and work is done by the system.

$Q = -\Delta U + W$

$Q = -300 + 120$

$Q = -180\,J$

(20) Define adiabatic process. Give its examples. **BWP-2016 (G-I) LHR-2016 (G-II)**

Ans: Adiabatic Process:

A process in which no heat enters or leaves the system is called adiabatic process.

Therefore Q = 0, and first law of thermodynamics gives

Q= ΔU+W

W=-ΔU

Examples

(i) The rapid escape of air from burst tyre

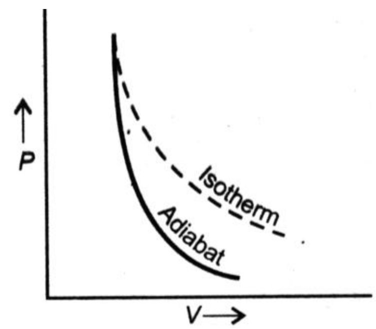
(ii) The rapid expansion and compression of air through which a sound wave is passing.

(iii) Cloud formation in the atmosphere.

(21) What is difference between adiabatic process and isothermal process? **SWL-2016 (G-I), RWP-2019 (G-I)**

Ans: Adiabatic process:

A process in which no heat enters or leaves the system is called an adiabatic process.



Since Q = 0; thus first law of thermodynamics becomes

$$Q = \Delta U + W$$

$$0 = \Delta U + W$$

or

$$\Delta U = -W$$

Isothermal process:

A process in which temperature of the system remains constant is called isothermal process

If the temperature of the ideal gas is constant, therefore $\Delta U = 0$.

Hence first law of thermodynamics reduces to

$$Q = \Delta U + W$$

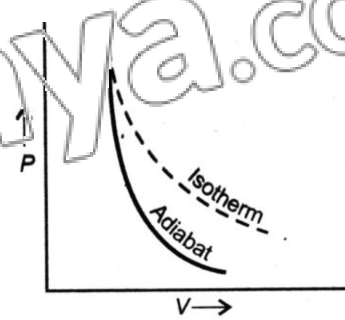
$$Q = W$$

(22) Why adiabatic is steeper than isotherm? **MTN-2018 (G-I)**

Ans: As adiabatic is quick and fast process there is no enough time to transfer the heat. By sudden change in pressure causes the rapid change in volume.

On the other hand, isothermal process is slow process. There is enough time to transfer heat. In this process the temperature of the system remains constant.

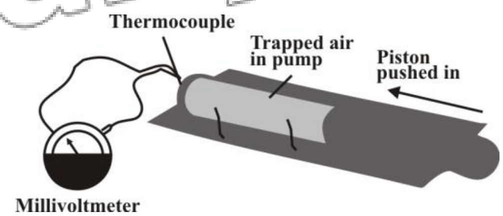
Both processes are shown in P-V diagram. It is clear that adiabatic is steeper than isothermal.



(23) Explain bicycle pump as an example of first law of thermodynamics. MTN-2018 (G-I)

Ans: Bicycle Pump

A bicycle pump provides a good example to explain the first law of thermodynamics. When we pump on the handle rapidly, it becomes hot due to mechanical work done on the gas, raising thereby its internal energy. One such simple arrangement is shown in fig. It consists of a bicycle pump with a blocked outlet a thermocouple connected through the blocked outlet allows the air temperature to be monitored. When piston is rapidly pushed, thermometer shows a temperature rise due to increase of internal energy of the air. The push force does work on the air, thereby, increasing its internal energy, which is shown, by the increase in temperature of the air.



(24) Explain with example that heat can be added to a system without heating.
BWP-2019 (G-II)

Ans: Adiabatic Compression:

A process in which no heat enters or leaves he system is called an adiabatic process.

Explanation:

This process can be achieved either by insulating the vessel or performing the process quickly. Consider some gas contained in an insulating vessel fitted with an airtight piston. On compressing the gas, work is done on it, which results in rise of temperature. Since Q = 0; thus first law of thermodynamics becomes

$$Q = \Delta U + W$$

$$0 = \Delta U + W$$

or

$$\Delta U = -W$$

Since work done on the system is negative, therefore ΔU is positive resulting rise in temperature.

Example:

The rapid expansion and compression of air through which a sound wave is passing.

11.5 MOLAR SPECIFIC HEATS OF A GAS

(25) Define molar specific heat of a gas at constant volume and at constant pressure?

Ans: Molar specific heat of a gas at constant volume:

It is defined as the amount of heat transfer required to raise the temperature of one mole of the gas through 1k at constant volume and is symbolized by Cv

Molar specific heat at constant pressure:

It is defined as the amount of heat transfer required to raise the temperature of one mole of the gas through 1k at constant pressure. It is represented by the symbol Cp.

11.6 REVERSIBLE AND IRREVESIBLE PROCESSES

(26) What do you mean by Reversible process? Give example LHR-2017(G-I)

Ans: A reversible process is one which can be retraced in exactly reverse order, without producing any change in the surrounding.

Example:

Although no actual change is completely reversible but the processes of liquefaction and evaporation of a substance, performed slowly, are practically reversible. Similarly, the slow compression of a gas in a cylinder is reversible process as the compression can be changed to expansion by slowly decreasing the pressure on the piston to reverse the operation.

Conditions:

(i) The change must take place at very slow rate.

(ii) There should be no loss of heat due to conduction, convection, friction etc.

(iii) The system must always be in thermal and mechanical equilibrium.

These conditions cannot be satisfied in practice so all real processes are irreversible process.

(27) Differentiate between reversible and irreversible process?

MTN-2015, SWL-2015, SGD-2015 (G-II)

Ans:

Reversible process	Irreversible process
• A reversible process is defined as that which can be retraced in exactly reverse order, without producing any change in the surroundings.	• An irreversible process is defined as that which cannot be retraced in the backward direction by reversing the controlling factors.
• In the reverse process, the working substance passes through the same stages as in the direct process but thermal and mechanical effects at each stage are exactly reversed.	• In the irreversible process the working substance does not pass through the same stages as in the direct process.
• Working substance restores to its original conditions.	• Working substance does not restore to its original condition.
• Although no actual change is reversible but following are few examples of reversible process. **(i)** Liquefaction **(ii)** Evaporation **(iii)** Slow compression of a gas **(iv)** Slow expansion of gas	• All changes which occur suddenly or which involve friction are irreversible process e.g. **(i)** Explosion **(ii)** Brust of tyre **(iii)** Rapid compression of gas **(iv)** Rapid expansion of gas

11.8 SECOND LAW OF THERMODYNAMICS

(28) What is Second Law of Thermodynamics? SGD-2015 (G-II)

Ans: It can be stated in a number of different ways.

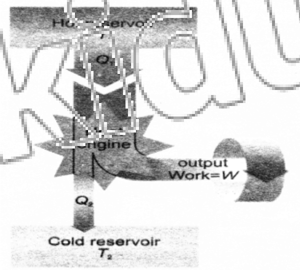
Lord Kelvin's Statement

It is impossible to devise a process which may convert heat, extracted from a single reservoir, entirely into work without leaving any change in the working substance.

This means that a single heat reservoir, no matter how much energy it contains, can not be made to perform any work.

(29) What are the defects in first law of Thermodynamics and how they can be removed in second law of Thermodynamics? **SWL-2014**

First law of thermodynamics tells us that heat energy can be completely converted into equivalent amount of work but it is silent about the conditions under which this conversion takes place.



The system represented absorbs heat Q_1 from heat source at temperature T_1. It does work W and expels heat Q_2 to low temperature reservoir T_2. The working substance goes through cyclic process means the change in internal energy is zero.

By Ist law of thermodynamics

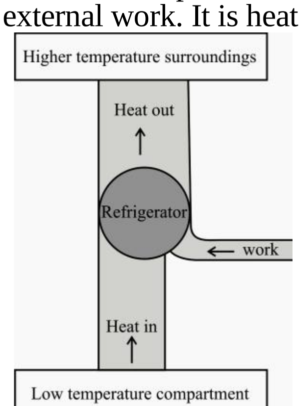
$$Q = \Delta U + W$$

$$W = Q \qquad \text{if } \Delta U = 0$$

In practice an engine extracts heat from the burning fuel and converts a fraction of this energy in to mechanical energy or work. It is observed petrol engine converts about 25% and diesel engine 34 to 40% available heat energy into work.

(30) What is Principle of Refrigerator? OR Give the schematic diagram of Refrigerator. **GRW-2018, FSD-2017**

Ans: A refrigerator transfers heat from a low temperature compartment to higher temperature i.e. surroundings with the help of external work. It is heat engine operating in reverse order.



11.9 CARNOT ENGINE AND CARNOT'S THEOREM

(31) State Carnot's theorem? **LHR 2013, FSD-2012, MTN-2013, SWL-2013**

Ans: All Carnot engines operating between the same two temperatures have the same efficiency, irrespective of the nature of working substance.

(32) Does the efficiency of Carnot engine depend on the nature of working substance?

Ans: The formula of the efficiency of a Carnot engine is

$$\eta = \left(1 - \frac{T_2}{T_1}\right) \times 100\%$$

This relation shows that, the efficiency of Carnot engine depends on the temperature of hot and cold reservoirs. It is independent of the nature of working substance.

The larger the temperature difference of two reservoirs, the greater is the efficiency. But it can never be one or 100% unless cold reservoir is at absolute zero temperature ($T_2 = 0$k)

(33) Under what circumstances the efficiency of a Carnot engine will be 100%? Is if possible? **BWP 2017 (G-II)**

Ans: The formula of the efficiency of a Carnot engine is

$$\eta = \left(1 - \frac{T_2}{T_1}\right) \times 100\%$$

This relation shows that, the efficiency of Carnot engine depends on the temperature of hot and cold reservoirs. If the temperature of the cold reservoir T_2 becomes zero Kelvin then the efficiency of the Carnot engine will be 100%. This is the lowest temperature ever to be reached. So 100 % efficient Carnot engine is not possible.

(34) Carnot cycle provides the basis to define a temperature scale that is independent of material properties. Explain. **BWP-2019 (G-I)**

Ans: The ratio of two temperatures T_2/T_1 can be found by operating a reversible Carnot cycle between these two temperatures and carefully measuring the heat transfers Q_2 and Q_1. The heat transfers are independent of the working substance of the Carnot cycle. The thermodynamic scale of temperature is defined by choosing 273.16 K as the absolute temperature of triple point of water as one fixed point and absolute zero as other point.