Chemical Thermodynamics

Question1

Choose the correct statement for the work done in the expansion and heat absorbed or released when 5 litres of an ideal gas at 10 atmospheric pressure isothermally expands into vacuum until volume is 15 litres :

[NEET 2024 Re]

Options:

A.

Both the heat and work done will be greater than zero

B.

Heat absorbed will be less than zero and work done will be positive

C.

Work done will be zero and heat will also be zero

D.

Work done will be greater than zero and heat will remain zero

Answer: C

Solution:

Since it is isothermal, $\Delta T = 0$

$\Delta U = nC_v \Delta T = 0$

Since expansion is taking place against vacuum

$P_{ext} = 0$

$W = -P_{ext} \Delta V = 0$

From first law of thermodynamics,

$\Delta U = q + W$

$0 = q + 0$

$q = 0$

Question2

For an endothermic reaction:

(A) q_p is negative.
(B) $\Delta_r H$ is positive.
(C) $\Delta_r H$ is negative.
(D) q_p is positive.

Choose the correct answer from the options given below:

[NEET 2024 Re]

Options:

A.

B and D

B.

C and D

C.

A and B

D.

A and C

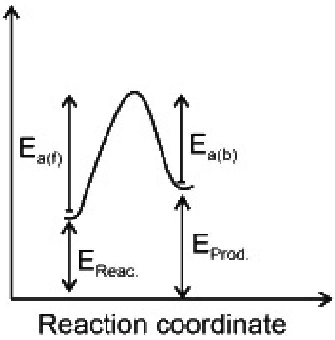
Answer: A

Solution:

For endothermic reactions,

$\Delta H_r =$ positive (Heat is absorbed)

$\Delta H = E_{a(f)} - E_{a(b)}$



$\boxed{q_p = +ve}$

Question3

For the following reaction at 300 K

$A_2(g) + 3B_2(g) \longrightarrow 2AB_3(g)$

the enthalpy change is +15 kJ , then the internal energy change is :

[NEET 2024 Re]

Options:

A.

19988.4 J

B.

200 J

C.

1999 J

D.

1.9988 kJ

Answer: A

Solution:

$A_2(g) + 3B_2(g) \longrightarrow 2A_3(g)$

$\Delta n_{(g)} = n_{(P)} - n_{(R)}$

$= 2 - 3 - 1 = -2$

$\Delta H = \Delta U + \Delta n_g RT$

$15 \times 1000 = \Delta U - 2 \times 8.314 \times 300$

$\Delta U = 15000 + 600 \times 8.314$

$= 15000 + 6 \times 831.4$

$= 15000 + 4988.4$

$\Delta U = 19988.4 J$

Question4

In which of the following processes entropy increases?

A. A liquid evaporates to vapour.
B. Temperature of a crystalline solid lowered from 130K to 0K .
C. $2NaHCO_{3(s)} \longrightarrow Na_2CO_{3(s)} + CO_{2(g)} + H_2O_{(g)}$
D. $Cl_{2(g)} \longrightarrow 2Cl_{(g)}$

Choose the correct answer from the options given below:

[NEET 2024]

Options:

A.

A and C

B.

A, B and D

C.

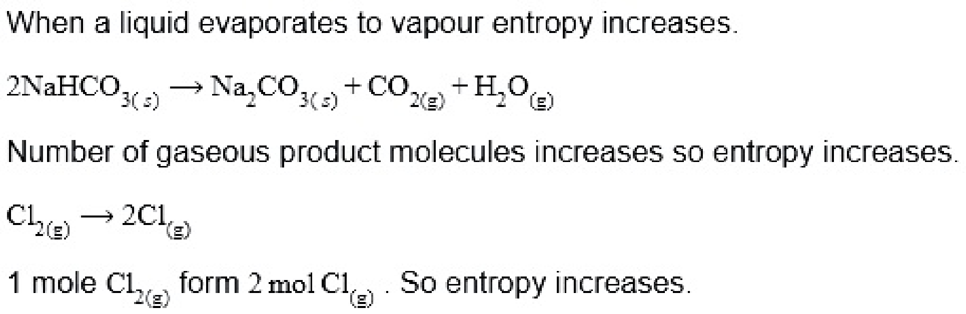
A,C and D

D.

C and D

Answer: C

Solution:



When a liquid evaporates to vapour entropy increases.

$2NaHCO_{3(s)} \longrightarrow Na_2CO_{3(s)} + CO_{2(g)} + H_2O_{(g)}$

Number of gaseous product molecules increases so entropy increases.

$Cl_{2(g)} \longrightarrow 2Cl_{(g)}$

1 mole $Cl_{2(g)}$ form 2 mol $Cl_{(g)}$. So entropy increases.

Question5

Match List I with List II.

	List-I (Process)		List-II (Conditions)
A.	Isothermal process	I.	No heat exchange
B.	Isochoric process	II.	Carried out at constant temperature
C.	Isobaric process	III.	Carried out at constant volume
D.	Adiabatic process	IV.	Carried out at constant pressure

Choose the correct answer from the options given below:

[NEET 2024]

Options:

A.

A-IV, B-III, C-II, D-I

B.

A-IV, B-II, C-III, D-I

C.

A-I, B-II, C-III, D-IV

D.

A-II, B-III, C-IV, D-I

Answer: D

Solution:

(A) Isothermal process ⇒ Temperature is constant throughout the process

(B) Isochoric process ⇒ Volume is constant throughout the process

(C) Isobaric process ⇒ Pressure is constant throughout the process

(D) Adiabatic process ⇒ No exchange of heat (q) between system and surrounding

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Question6

The work done during reversible isothermal expansion of one mole of hydrogen gas at 25°C from pressure of 20 atmosphere to10 atmosphere is

(Given R = 2.0 cal K^{-1} mol^{-1})

[NEET 2024]

Options:

A.

0 calorie

B.

-413.14 calories

C.

413.14 calories

D.

100 calories

Answer: B

Solution:

$$W_{\text{rev, iso}} = -2.303nRT \log \frac{P_1}{P_f}$$

$$= -2.303 \times 1 \times 2 \times 298 \times \log 2$$

$$= -2.303 \times 1 \times 2 \times 298 \times 0.3$$

$$= -413.14 \text{ calories}$$

Question7

Which amongst the following options is the correct relation between change in enthalpy and change in internal energy?

[NEET 2023]

Options:

A.

$\Delta H = \Delta U + \Delta n_g RT$

B.

$\Delta H - \Delta U = -\Delta nRT$

C.

$\Delta H + \Delta U = \Delta nR$

D.

$\Delta H = \Delta U - \Delta n_g RT$

Answer: A

Solution:

Solution:

Correct relation between change in enthalpy and change in internal energy is

$\Delta H = \Delta U + \Delta n_g RT$

Question8

Consider the following reaction :-

$2H_2(g) + O_2(g) \rightarrow 2H_2O(g)\ \Delta_r H^\circ = -483.64\ kJ$

What is the enthalpy change for decomposition of one mole of water? (Choose the right option).

[NEET 2023 mpr]

Options:

A.

120.9 kJ

B.

241.82 kJ

C.

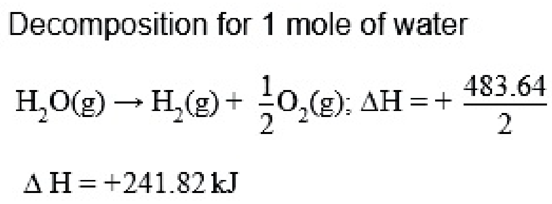
18 kJ

D.

100 kJ

Answer: B

Solution:



Decomposition for 1 mole of water

$$H_2O(g) \rightarrow H_2(g) + \frac{1}{2}O_2(g);\ \Delta H = +\frac{483.64}{2}$$

$$\Delta H = +241.82\ kJ$$

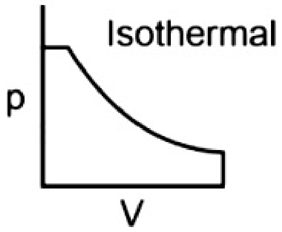
Question9

Which of the following p – V curve represents maximum work done? [NEET-2022]

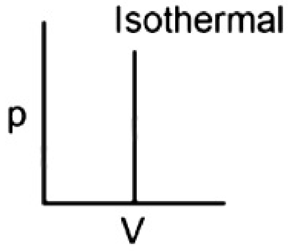
Options:

A.

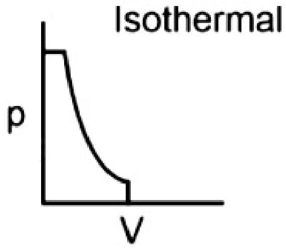
B.



C.



D.

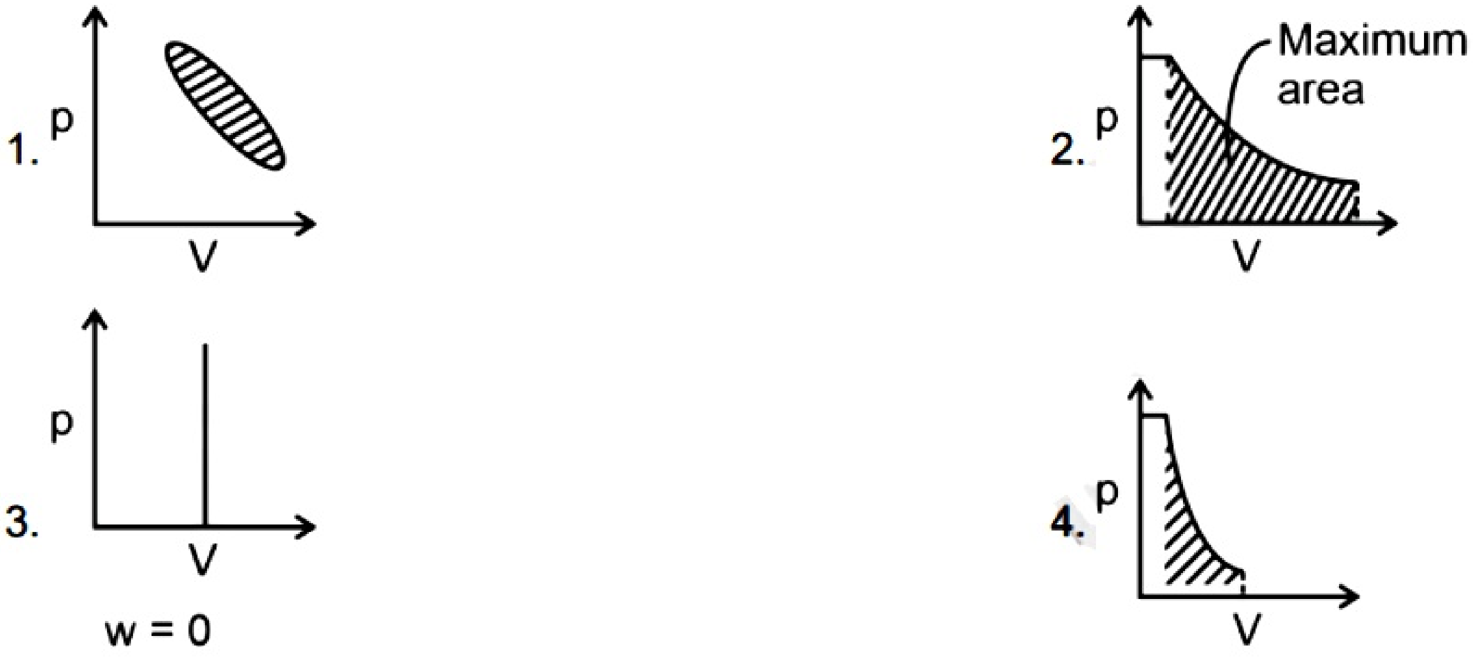


Answer: B

Solution:

Work done under any thermodynamic process can be determined by area under the 'p-V' graph.

As it can be observed maximum area is covered in option ' 2 '



Question10

One mole of an ideal gas at 300K is expanded isothermally from 1L to 10L volume. ΔU for this process is:
(Use $R = 8.314 JK^{-1} mol^{-1}$)
[NEET Re-2022]

Options:

A. 0J

B. 1260J

C. 2520J

D. 5040J

Answer: A

Solution:

In isothermal expansion/compression of ideal gas

$\Delta U = nC_V \, \Delta T, (\Delta T = 0)$

$\therefore \Delta U = 0$

Question11

What is the hybridization shown by C_1 and C_2 carbons, respectively in the given compound?

$OHC - CH = CH - CH_2COOCH_3$

[NEET Re-2022]

Options:

A. sp^3 and sp^3

B. sp^2 and sp^3

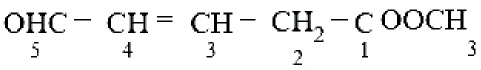
C. sp^2 and sp^2

D. sp^3 and sp^2

Answer: B

Solution:

Solution:



$\underset{5}{OHC} - \underset{4}{CH} = \underset{3}{CH} - \underset{2}{CH_2} - \underset{1}{C}\underset{3}{OOCH}$

Ester group has more priority than aldehyde. So numbering should be done from left to right. C_1 has double bond and is sp^2 hybridised.

Question12

Which one among the following is the correct option for right relationship between C_P and C_V for one mole of ideal gas?

[NEET 2021]

Options:

A. $C_P + C_V = R$

B. $C_P - C_V = R$

C. $C_P = RC_V$

D. $C_V = RC_P$

Answer: B

Solution:

At constant volume, $q_V = C_V \Delta T = \Delta U$
At constant pressure, $q_P = C_p \Delta T = \Delta H$
For a mole of an ideal gas,
$\Delta H = \Delta U + \Delta(PV)$
On putting the values of ΔH and ΔU, we have
$C_P \Delta T = C_V \Delta T + R\Delta T$
$C_P = C_V + R$
$C_P - C_V = R$

Question13

For irreversible expansion of an ideal gas under isothermal condition, the correct option is:
[NEET 2021]

Options:

A. $\Delta U = 0, \Delta S_{total} = 0$

B. $\Delta U \neq 0, \Delta S_{total} \neq 0$

C. $\Delta U = 0, \Delta S_{total} \neq 0$

D. $\Delta U \neq 0, \Delta S_{total} = 0$

Answer: C

Solution:

Solution:
● For a spontaneous process, $\Delta S_{total} > 0$ and since irreversible process is always spontaneous therefore $\Delta S_{total} > 0$.
● Since $\Delta U = nC_v \Delta T$ and $\Delta T = 0$ for isothermal process therefore $\Delta U = 0$.

Question14

The correct option for free expansion of an ideal gas under adiabatic condition is
[2020]

Options:

A. $q = 0, \Delta T < 0$ and $w > 0$

B. $q < 0, \Delta T = 0$ and $w = 0$

C. $q > 0, \Delta T > 0$ and $w > 0$

D. $q = 0, \Delta T = 0$ and $w = 0$

Answer: D

Solution:

(d) Free expansion of ideal gas $P_{ex} = 0$
$\therefore w = -P_{ex} \Delta V = 0$
$\because$ Adiabatic process $\Rightarrow q = 0$
$\Delta E = q + w$ (first law of thermodynamics)
$\therefore \Delta E = 0$
$\Delta E = nC_v dT \Rightarrow \Delta E = 0$
So, $q = 0, \Delta T = 0, w = 0$

Question15

For the reaction, $2\,Cl(g) \longrightarrow Cl_2(g)$, the correct option is :
(2020)

Options:

A. $\Delta_r H > 0$ and $\Delta_r S < 0$

B. $\Delta_r H < 0$ and $\Delta_r S > 0$

C. $\Delta_r H < 0$ and $\Delta_r S < 0$

D. $\Delta_r H > 0$ and $\Delta_r S > 0$

Answer: C

Solution:

Solution:
(c) We know that, $Cl_2(g) \longrightarrow 2Cl\,(g)$ is endothermic reaction because it required energy to break bond.

So reverse reaction, $2Cl(g) \longrightarrow Cl_2(g)$ will be exothermic, $\Delta_r H < 0$ Also, two gaseous atom combine together to form 1 gaseous molecule.

Question16

Under isothermal conditions, a gas at 300 K expands from 0.1 L to 0.25 L against a constant external pressure of 2 bar. The work done by the gas is [Given that 1L bar = 100J]
(NEET 2019)

Options:

A. 30J

B. -30J

C. 5kJ

D. 25J

Answer: B

Solution:

Solution:
Expansion of a gas against a constant external pressure is an irreversible process. The work done in an irreversible process

$= -P_{ext} \Delta V = -P_{ext}(V_2 - V_1) = -2(0.25 - 0.1)$

$= -2 \times 0.15$L bar $= -0.30 \times 100J = -30J$

Question17

In which case change in entropy is negative?
(NEET 2019)

Options:

A. $2H_{(g)} \rightarrow H_{2(g)}$

B. Evaporation of water

C. Expansion of a gas at constant temperature

D. Sublimation of solid to gas

Answer: A

Solution:

If $\Delta n_g < 0$ then $\Delta S < 0$

Question18

An ideal gas expands isothermally from $10^{-3}m^3$ to $10^{-2}m^3$ at 300K against a constant pressure of $10^5 N\,m^{-2}$. The work done on the gas is (Odisha NEET 2019)

Options:

A. +270kJ

B. −900J

C. +900 kJ

D. −900kJ

Answer: B

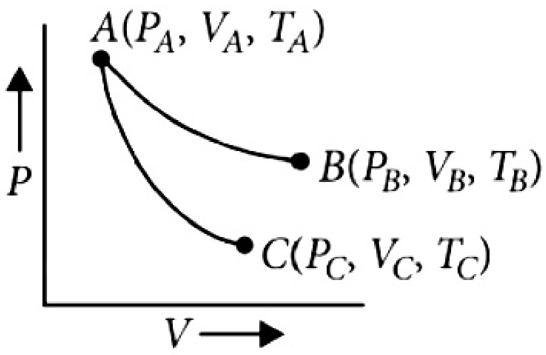
Solution:

Solution:

$$\begin{aligned} w &= -Pd\,V = -P(V_2 - V_1) \\ &= -10^5 N\,m^{-2}(10^{-2} - 10^{-3})m^3 \\ &= -10^5 N\,m^{-2}(9 \times 10^{-3})m^3 \\ &= -9 \times 10^2 N\,m = -900J \qquad (\because 1J = 1N\,m) \end{aligned}$$

Question19

Reversible expansion of an ideal gas under isothermal and adiabatic conditions are as shown in the figure.
AB→ Isothermal expansion AC→ Adiabatic expansion
Which of the following options is not correct?



(Odisha NEET 2019)

Options:

A. $\Delta S_{\text{isothermal}} > \Delta S_{\text{adiabatic}}$

B. $T_A = T_B$

C. $W_{\text{isothermal}} > W_{\text{adiabatic}}$

D. $T_c > T_A$

Answer: D

Solution:

Solution:
In adiabatic expansion cooling effect will take place, T_C will be less then T_A.
in adiabatic expansion $q = 0$
$\Delta U = w$
$W\, pv < 0$
$\Delta U < 0$
$nC_{vm}\, \Delta T < 0$
$\Delta T < 0$
$T_C - T_A < 0$

Question20

The bond dissociation energies of X_2, Y_2 and XY are in the ratio of $1 : 0.5 : 1$. ΔH for the formation of XY is -200kJ mol^{-1}. The bond dissociation energy of X_2 will be
(NEET 2018)

Options:

A. 200kJ mol^{-1}

B. 100kJ mol^{-1}

C. 800kJ mol^{-1}

D. 400kJ mol^{-1}

Answer: C

Solution:

Solution:
Let B.E. of X_2, Y_2 and XY are x kJ mol^{-1}, $0.5x$ kJ mol^{-1} and x kJ mol^{-1} respectively.
$\frac{1}{2}X_2 + \frac{1}{2}Y_2 \rightarrow XY\,;\ \Delta H = -200\text{kJ mol}^{-1}$
$\Delta H = \Sigma(\text{ B.E. })_{\text{Reactant}} - \Sigma(\text{ B.E. })_{\text{Product}}$
$\therefore -200 = \left[\frac{1}{2} \times (x) + \frac{1}{2} \times (0.5x)\right] - [1 \times (x)]$
B.E. of $X_2 = x = 800\text{kJ mol}^{-1}$

Question21

For a given reaction, $\Delta H = 35.5\ \text{kJ mol}^{-1}$ and $\Delta S = 83.6\text{J K}^{-1}\text{mol}^{-1}$. The reaction is spontaneous at (Assume that ΔH and ΔS do not vary with temperature.)
(NEET 2017)

Options:

A. $T > 425K$

B. all temperatures

C. $T > 298K$

D. $T < 425K$

Answer: A

Solution:

Solution:
For a spontaneous reaction,
$\Delta G < 0$ i.e., $\Delta H - T\ \Delta S < 0$

$$T > \frac{\Delta H}{\Delta S}$$

$$T > \left(\frac{35.5 \times 1000}{83.6} = 424.6 \approx 425K\right)$$

$\therefore\ T > 425K$

Question22

A gas is allowed to expand in a well insulated container against a constant external pressure of 2.5 atm from an initial volume of 2.50L to a final volume of 4.50L.
The change in internal energy ΔU of the gas in joules will be
(NEET 2017)

Options:

A. $-500J$

B. $-505J$

C. $+505J$

D. $1136.25J$

Answer: B

Solution:

$w = -P_{ext}\Delta V = -2.5(4.50 - 2.50)$
$= -5\text{L atm} = -5 \times 101.325\text{J} = -506.625\text{J}$
$\Delta U = q + w$
As, the container is insulated, thus $q = 0$
Hence, $\Delta U = w = -506.625\text{J}$

Question23

For a sample of perfect gas when its pressure is changed isothermally from p_i to p_f, the entropy change is given by (NEET-II 2016)

Options:

A. $\Delta S = nR\ln\left(\frac{p_f}{p_i}\right)$

B. $\Delta S = nR\ln\left(\frac{p_i}{p_f}\right)$

C. $\Delta S = nRT\ln\left(\frac{p_f}{p_i}\right)$

D. $\Delta S = RT\ln\left(\frac{p_i}{p_f}\right)$

Answer: B

Solution:

Solution:
For an ideal gas undergoing reversible expansion, when temperature changes from T_i to T_f and pressure changes from p_i to p_f,

$\Delta S = nC_p\ln\frac{T_f}{T_i} + nR\ln\frac{p_i}{p_f}$

For an isothermal process, $T_i = T_f$ so, $\ln 1 = 0$

$\therefore \Delta S = nR\ln\frac{p_i}{p_f}$

Question24

The correct thermodynamic conditions for the spontaneous reaction at all temperatures is (NEET- I 2016)

Options:

A. $\Delta H < 0$ and $\Delta S > 0$

B. $\Delta H < 0$ and $\Delta S < 0$

C. $\Delta H < 0$ and $\Delta S = 0$

D. $\Delta H > 0$ and $\Delta S < 0$

Answer: C

Solution:

Solution:
$\Delta G = \Delta H - T\,\Delta S$
If $\Delta H < 0$ and $\Delta S > 0$
$\Delta G = (-\mathrm{ve}) - T(+\mathrm{ve})$
then at all temperatures, $\Delta G = -$ ve, spontaneous reaction
If $\Delta H < 0$ and $\Delta S = 0$
$\Delta G = (-\mathrm{ve}) - T(0) = -\mathrm{ve}$ at all temperatures.

Question25

Consider the following liquid-vapour equilibrium. Liquid ⇌ Vapour Which of the following relations is correct? (NEET- I 2016)

Options:

A. $\frac{d\ln P}{dT^2} = \frac{-\Delta H_v}{T^2}$

B. $\frac{d\ln P}{dT} = \frac{\Delta H_v}{RT^2}$

C. $\frac{d\ln G}{dT^2} = \frac{\Delta H_v}{RT^2}$

D. $\frac{d\ln P}{dT} = \frac{-\Delta H_v}{RT}$

Answer: B

Solution:

Solution:
This is Clausius-Clapeyron equation.

Question26

The heat of combustion of carbon to CO_2 is -393.5kJ/mol.The heat released upon formation of 35.2 g of CO_2 from carbon and oxygen gas is (2015)

Options:

A. $+315\text{kJ}$

B. -630kJ

C. -3.15kJ

D. -315kJ

Answer: D

Solution:

Given :
$C_{(s)} + O_{2(g)} \rightarrow CO_{2(g)} \Delta = -393.5$ kJ/mol
Amount of heat released on formation of 44 g $CO_2 = -393.5\text{kJ}$
∴ Amount of heat released on formation of 35.2 g CO_2
$= -\frac{393.5}{44} \times 35.2$
$= -314.8 \approx -315\text{kJ}$

Question27

For the reaction $X_2O_4(l) \rightarrow 2XO_2(g)$
$\Delta U = 2.1\text{kcal}, \Delta S = 20\text{cal K}^{-1}$ at 300K
Hence, ΔG is
(2014)

Options:

A. 2.7 kcal

B. - 2.7 kcal

C. 9.3 kcal

D. -9.3 kcal

Answer: B

Solution:

$\Delta H = \Delta U + \Delta n_g RT$
Given,$\Delta U = 2.1\text{kcal}, \Delta n_g = 2$
$R = 2 \times 10^{-3}\text{kcal}, T = 300\text{K}$
$\therefore \Delta H = 2.1 + 2 \times 2 \times 10^{-3} \times 300 = 3.3\text{kcal}$
Again $\Delta G = \Delta H - T\Delta S$
Given, $\Delta S = 20 \times 10^{-3}\text{kcal K}^{-1}$
On putting the value of ΔH in the equation, we get
$\Delta G = 3.3 - 300 \times 20 \times 10^{-3}$
$= 3.3 - 6 \times 10^{3} \times 10^{-3} = -2.7\text{kcal}$

Question28

Which of the following statements is correct for the spontaneous adsorption of a gas?
(2014)

Options:

A. ΔS is negative and, therefore ΔH should be highly positive.

B. ΔS is negative and therefore, ΔHshould be highly negative.

C. ΔS is positive and therefore, ΔH should be negative.

D. ΔS is positive and therefore, ΔH should also be highly positive.

Answer: B

Solution:

Solution:
Using Gibb's -Helmholtz equation,
ΔG = ΔH - TΔS
During adsorption of a gas, entropy decreases i.e. ΔS < 0
For spontaneous adsorption, ΔG should be negative, which possible when Δh is highly negative.

Question29

A reaction having equal energies of activation for forward and reverse reactions has
(2013 NEET)

Options:

A. ΔH = 0

B. ΔH = ΔG = ΔS = 0

C. ΔS = 0

D. ΔG = 0

Answer: A

Solution:

Solution:
$\Delta H = (E_a)_f - (E_a)_b = 0$

Question30

When 5 litres of a gas mixture of methane and propane is perfectly combusted at 0˚C and 1 atmosphere, 16 litres of oxygen at the same temperature and pressure is consumed. The amount of heat released from this combustion in
kJ ($\Delta H_{comb.}(CH_4) = 890 kJ\,mol^{-1}$, $\Delta H_{comb.}(C_3H_8) = 2220 kJ\,mol^{-1}$)
is
(Karnataka NEET 2013)

Options:

A. 38

B. 317

C. 477

D. 32

Answer: B

Solution:

Solution:
$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$
$C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$
$CH_4 + C_3H_8 = \frac{5}{22.4} = 0.22$ moles
$O_2 = \frac{16}{22.4} = 0.71$ moles
$2x + (0.22 - x)5 = 0.71$
$x = 0.13$
Heat liberated
$= 0.13 \times 890 + 0.09 \times 2220 = 316 kJ$

Question31

Three thermochemical equations are given below
(i) $C_{(graphite)} + O_{2(g)} \rightarrow CO_{2(g)}$; $\Delta_r H^\circ = x kJ\,mol^{-1}$
(ii) $C_{(graphite)} + \frac{1}{2}O_{2(g)} \rightarrow CO_{(g)}$; $\Delta_r H^\circ = y kJ\,mol^{-1}$
(iii) $CO_{(g)} + \frac{1}{2}O_{2(g)} \rightarrow CO_{2(g)}$; $\Delta_r H^\circ = z kJ\,mol^{-1}$
Based on the above equations, find out which of the relationship given below is correct.
(Karnataka NEET 2013)

Options:

A. $z = x + y$

B. $x = y + z$

C. $y = 2z - x$

D. $x = y - z$

Answer: B

Solution:

Solution:
According to Hess's law, equation (i) is equal to equations (ii) + (iii).

Question32

The Gibb's energy for the decomposition of Al_2O_3 at 500°C is as follows
$\frac{2}{3}Al_2O_3 \rightarrow \frac{4}{3}Al + O_2$
$\Delta_r G = +960 kJ\ mol^{-1}$
The potential difference needed for the electrolytic reduction of aluminium oxide (Al_2O_3) at 500°C is at least
(2012 Mains)

Options:

A. 4.5 V

B. 3.0 V

C. 2.5 V

D. 5.0 V

Answer: C

Solution:

$\Delta G° = -nF E°$
$F = 96500,\ \Delta G° = +960 \times 10^3 \frac{J}{mol}$
$\frac{2}{3}Al_2O_3 \rightarrow \frac{4}{3}Al + O_2$
Total number of Al atoms in $Al_2O_3 = \frac{2}{3} \times 2 = \frac{4}{3}$
$Al^{3+} + 3e^- \rightarrow Al$
As $3e^-$ change occur for each A1 atom
$\therefore$ Total $n = \frac{4}{3} \times 3 = 4$
$E° = \frac{\Delta G°}{nF} = \frac{960 \times 1000}{4 \times 96500}$
$\Rightarrow E° = -2.48 = -2.5V$

Question33

Equal volumes of two monatomic gases, A and B at same temperature and pressure arc mixed. The ratio of specific heats (C_p/C_y) of the mixture will be
(2012 Mains)

Options:

A. 0.83

B. 1.50

C. 3.3

D. 1.67

Answer: D

Solution:

Solution:

C_p for monoatomic gas mixture of same volume $= \frac{5}{2}R$

$C_V = \frac{3}{2}R$

$$\therefore \frac{C_p}{C_V} = \frac{\frac{5}{2}R}{\frac{3}{2}R} = \frac{5}{3} = 1.67$$

Question34

Standard enthalpy of vaporization $\Delta_{vap}H°$ for water at 100°C is $40.66\,kJ\,mol^{-1}$. The internal energy of vaporisation of water at 100°C (in $kJ\,mol^{-1}$) is
(Assume water vapour to behave like an ideal gas)
(2012)

Options:

A. + 37.56

B. - 43.76

C. + 43.76

D. + 40.66

Answer: A

Solution:

$\Delta_{vap}H^\circ = 40.66 kJ\ mol^{-1}$
$T = 100 + 273 = 373K$, $\Delta E = ?$
$\Delta H = \Delta E = \Delta n_g RT \Rightarrow \Delta E = \Delta H - \Delta n_g RT$
$\Delta n_g =$ No. of gaseous mole of products - No. of gaseous moles of reactants
$H_2O(l) \rightleftharpoons H_2O(g)$
$\Delta n_g = 1 - 0 = 1$
$\Delta E = \Delta H - RT$
$\Delta E = (40.66 \times 10^3) - (8.314 \times 373)$
= 37559 J/mol or 37.56 kJ/mol

Question35

The enthalpy of fusion of water is 1.435 kcal/mol. The molar entropy change for the melting of ice at 0°C is (2012)

Options:

A. 10.52 cal/(mol K)

B. 21.04 cal/(mol K)

C. 5.260 cal/(mol K)

D. 0.526 cal/(mol K)

Answer: C

Solution:

Solution:
$\Delta H_f = 1.435$kcal/mol
$\Delta S = \frac{\Delta H_f}{T_f} = \frac{1.435 \times 10^3}{273} =$ 5.26 cal/mol K

Question36

In which of the following reactions, standard reaction entropy change (ΔS°)is positive and standard Gibb's energy change (ΔG°) decreases sharply with increasing temperature? (2012)

Options:

A. $C_{(graphite)} + \frac{1}{2}O_{2(g)} \rightarrow CO_{(g)}$

B. $CO_{(g)} + \frac{1}{2}O_{2(g)} \rightarrow CO_{2(g)}$

C. $Mg_{(s)} + \frac{1}{2}O_{2(g)} \rightarrow MgO_{(s)}$

D. $\frac{1}{2}C_{(graphite)} + \frac{1}{2}O_{2(g)} \rightarrow \frac{1}{2}CO_{2(g)}$

Answer: A

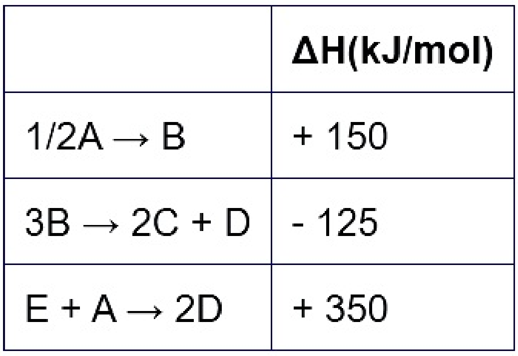
Solution:

Solution:
$C_{(graphite)} + \frac{1}{2}O_2(g) \rightarrow CO(g)$
$\Delta n_g = 1 - \frac{1}{2} = \frac{1}{2}$
As amount of gaseous substance is increasing in product, thus
Δ S is positive for this reaction.
And we know that $\Delta G = \Delta H - T\Delta S$
As ΔS is positive, thus increase in temperature will make $T\Delta S$ more negative and ΔG will decrease

---

Question37

Consider the following processes:



	ΔH(kJ/mol)
$1/2A \rightarrow B$	+ 150
$3B \rightarrow 2C + D$	- 125
$E + A \rightarrow 2D$	+ 350

(2011 Mains)

Options:

A. 525 kJ/mol

B. - 175 kJ/mol

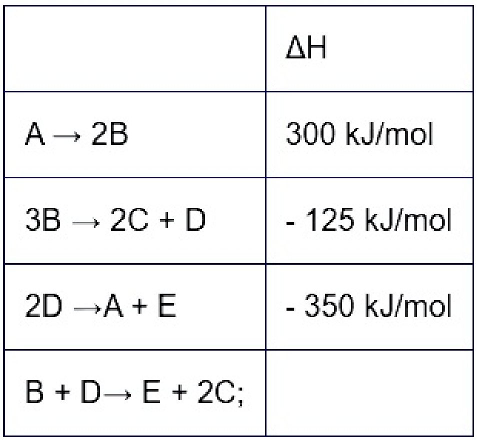
C. -325 kJ/mol

D. 325 kJ/mol

Answer: B

Solution:

Solution:
Adding all the equations :



	ΔH
$A \rightarrow 2B$	300 kJ/mol
$3B \rightarrow 2C + D$	- 125 kJ/mol
$2D \rightarrow A + E$	- 350 kJ/mol
$B + D \rightarrow E + 2C$;	

$\Delta H = (300 - 125 - 350) = -175 kJ/mol$

Question38

Which of the following is correct option for free expansion of an ideal gas under adiabatic condition?
(2011)

Options:

A. $q = 0, \Delta T \neq 0, w = 0$

B. $q \neq 0, \Delta T = 0, w = 0$

C. $q = 0, \Delta T = 0, w = 0$

D. $q = 0, \Delta T < 0, w \neq 0$

Answer: C

Solution:

Solution:
For free expansion of an ideal gas under adiabatic condition $q = 0$, $\Delta T = 0, w = 0$

Question39

Enthalpy change for the reaction,
$4H_{(g)} \rightarrow 2H_{2(g)}$ is $-869.6 kJ$
The dissociation energy of H - H bond is
(2011)

Options:

A. - 434.8 kJ

B. - 896.6 kJ

C. + 434.8 kJ

D. + 217.4 kJ

Answer: C

Solution:

Solution:

The dissociation energy of H - H bond is $\frac{869.6}{2} = 434.8\text{kJ}$

Question40

If the enthalpy change for the transition of liquid water to steam is 30kJ mol^{-1} at 27°C,the entropy change for the process would be (2011)

Options:

A. $10\text{J mol}^{-1}\text{K}^{-1}$

B. $1.0\text{J mol}^{-1}\text{K}^{-1}$

C. $0.1\text{J mol}^{-1}\text{K}^{-1}$

D. $100\text{J mol}^{-1}\text{K}^{-1}$

Answer: D

Solution:

Solution:

We know that ΔG = ΔH - TΔS
0 = ΔH - TΔS [∵ΔG=0]

$\Delta S = \frac{\Delta H}{T} = \frac{30 \times 10^3}{300} = 100\text{J mol}^{-1}\text{K}^{-1}$

Question41

The following two reactions are known
$Fe_2O_{3(s)} + 3CO_{(g)} \rightarrow 2Fe_{(s)} + 3CO_{2(g)}; \Delta H = -26.8\text{kJ}$
$FeO_{(s)} + CO_{(g)} \rightarrow Fe_{(s)} + CO_{2(g)}; \Delta H = -16.5\text{kJ}$
The value of ΔH for the following reaction
$Fe_2O_{3(s)} + CO_{(g)} \rightarrow 2FeO_{(s)} + CO_{2(g)}$
is
(2010 Mains)

Options:

A. +10.3 kJ

B. -43.3 kJ

C. -10.3 Kj

D. +6.2 Kj

Answer: D

Solution:

$Fe_2O_3(s) + 3CO(g) \rightarrow 2Fe(s) + 3CO_2(g);\ \Delta H = -26.8kJ$ ......(i)
$FeO(s) + CO(g) \rightarrow Fe(s) + CO_2(g);\ \Delta H = -16.5kJ$ ......(ii)
$Fe_2O_3(s) + CO(g) \rightarrow 2FeO(s) + CO_2(g)\Delta H = = ?$....(iii)
Eq (iii) can be obtained as (i) - 2(ii)
$\Delta H = -26.8 - 2(-16.5) = -26.8 + 33.0 = +6.2kJ$

Question42

For vaporization of water at 1 atmospheric pressure, the values of ΔH and ΔS are $40.63KJ\,mol^{-1}$ and $108.8J\,K^{-1}mol^{-1}$ respectively. The temperature when Gibb's energy change (ΔG) for this transformation will be zero, is
(2010 Mains)

Options:

A. 273.4 K

B. 393.4 K

C. 373.4 K

D. 293.4 K

Answer: C

Solution:

Solution:
According to Gibb's equation, ΔG = ΔH - TΔS
When ΔG=0,ΔH = TΔS
Given,
$\Delta H = 40.63kJ\,mol^{-1} = 40.63 \times 10^3 jmol^{-1}$
$\Delta S = 108.8J\,K^{-1}mol^{-1}$
$\therefore T = \frac{\Delta H}{\Delta S} = \frac{40.63 \times 10^3}{108.8} = 373.43K$

Question43

Three moles of an ideal gas expanded spontaneously into vacuum. The work done will be
(2010 Mains)

Options:

A. Infinite

B. 3 Joules

C. 9 Joules

D. Zero

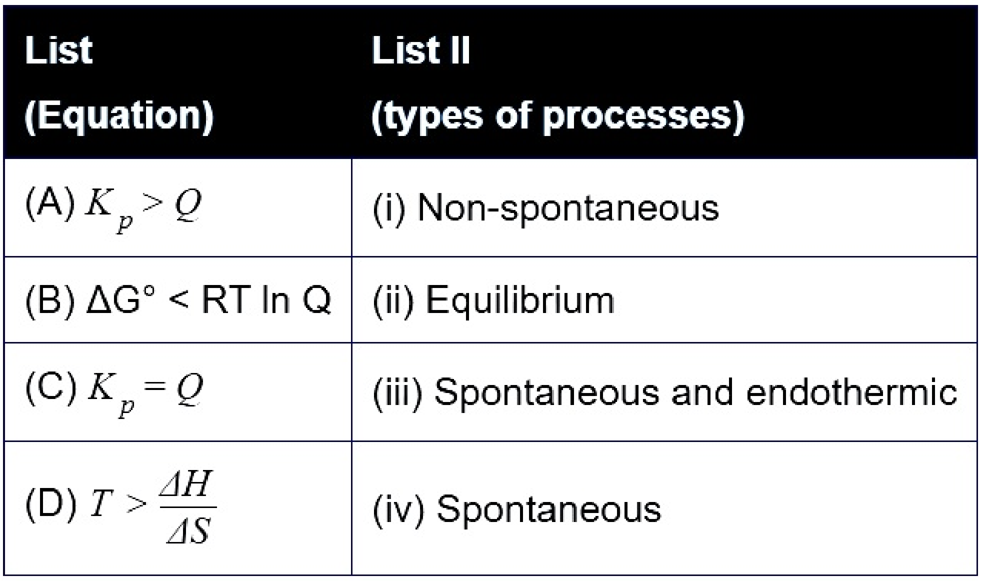
Answer: D

Solution:

Solution:
Since the ideal gas expands spontaneously into vacuum,
P_{ext} = 0,hence work done is also zero.

Question44

Match List I (Equations) with List II (Type of processes) and select the correct option.



List (Equation)	List II (types of processes)
(A) $K_p > Q$	(i) Non-spontaneous
(B) ΔG° < RT In Q	(ii) Equilibrium
(C) $K_p = Q$	(iii) Spontaneous and endothermic
(D) $T > \frac{\Delta H}{\Delta S}$	(iv) Spontaneous

(2010 Mains)

Options:

A. A - (i), B - (ii), C - (iii), D - (iv)

B. A - (iii), B - (iv), C - (ii), D - (i)

C. A - (iv), B - (i), C - (ii), D - (iii)

D. A - (ii), B - (i), C - (iv), D - (iii)

Answer: C

Solution:

Solution:
When $K_p > Q$,rate of forward reaction > rate of backward reaction.
∴ Reaction is spontaneous
When $\Delta G° < RT \ln Q$, $\Delta G°$ is positive, reverse reaction is feasible, thus reaction is non-spontaneous
When $K_P = Q$ rate of forward reaction = rate of backward reaction.
∴ Reaction is equilibrium
When $T \Delta S > \Delta H$, ΔG will be negative only when $\Delta H = +ve$
∴ Reaction is spontaneous and endothermic.

Question45

Standard entropies of X_2, Y_2 and XY_3 are 60,40 and 50 $J K^{-1} mol^{-1}$ respectively.For the reaction $\frac{1}{2}X_2 + \frac{3}{2}Y_2 \rightleftharpoons XY_3$, $\Delta H = -30 kJ$,to be at equilibrium the temperature should be
(2010)

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Options:

A. 750 K

B. 1000 K

C. 1250 K

D. 500 K

Answer: A

Solution:

Given reaction is :
$\frac{1}{2}X_2 + \frac{3}{2}Y_2 \rightleftharpoons XY_3$
We know ,$\Delta S° = \sum S°_{products} - \sum S°_{reactants}$
$= 50 - (30 + 60) = -40 J K^{-1} mol^{-1}$

At equilibrium $\Delta G° = 0$
$\Delta H° = T\Delta S°$
$$\therefore T = \frac{\Delta H°}{\Delta S°} = \frac{-30 \times 10^3 J\, mol^{-1}}{-40 J\, K^{-1} mol^{-1}} = 750K$$

Question46

For an endothermic reaction, energy of activation is E_a and enthalpy of

reactions is ΔH (both of these in kJ/mol).Minimum value of E_a will be (2010)

Options:

A. less than ΔH

B. equal to ΔH

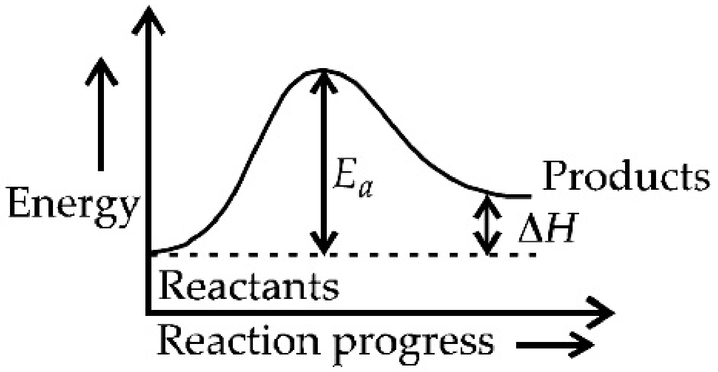
C. more than ΔH

D. equal to zero

Answer: C

Solution:

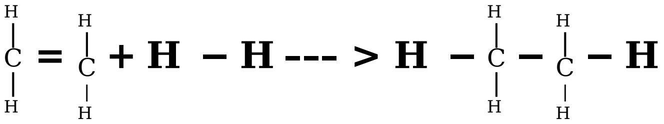
Solution:



We find that the least E_a will be more than ΔH for an endothermic reaction since $E_{products} > E_{reactoins}$

Question47

From the following bond energies:
H - H bond energy : 431.37kJ mol^{-1}
C = C bond energy : 606.10kJ mol^{-1}
C -C bond energy : 336.9kJ mol^{-1}
C-H bond energy : 410.50kJ mol^{-1}
Enthalpy for the reactions,



$$\underset{H}{\overset{H}{C}} = \underset{H}{\overset{H}{C}} + H - H \text{---} > H - \underset{H}{\overset{H}{C}} - \underset{H}{\overset{H}{C}} - H$$

will be
(2009)

Options:

A. $-243.6 \text{kJ mol}^{-1}$

B. $-120.0 \text{kJ mol}^{-1}$

C. 553.0kJ mol^{-1}

D. $1523.6 \mathrm{kJ\ mol}^{-1}$

Answer: B

Solution:

For the given reaction, enthalpy of reaction can be calculated as
= B.E.(reactant) − B.E.(product)
$= [B.E._{(C=C)} + B.E._{(H-H)} + 4 \times B.E._{(C-H)}] - [B.E._{(C-C)} + 6 \times B.E._{(C-H)}]$
$= [606.10 + 431.37 + 4 \times 410.50] - [336.49 + 6 \times 410.50]$
$= 2679.47 - 2799.49 = -120.02 \mathrm{kJ\ mol}^{-1}$

Question48

The values of ΔH and ΔS for the reaction, $C_{(graphite)} + CO_{2(g)} \rightarrow 2CO_{(g)}$ are 170 kJ and $170 \mathrm{J\ K}^{-1}$,respectively. This reaction will be spontaneous at
(2009)

Options:

A. 910 K

B. 1110 K

C. 510 K

D. 710 K

Answer: B

Solution:

Solution:
For the reaction to be spontaneous,
$\Delta G = -ve$
Given, $\Delta H = 170 \mathrm{kJ} = 170 \times 10^3 \mathrm{J}$
$\Delta S = 170 \mathrm{J\ K}^{-1}$
Applying, $\Delta G = \Delta H - T\Delta S$, the value of $\Delta G = -ve$ only when $T\Delta S > \Delta H$, which is possible only when $T = 1110 \mathrm{K}$.
$\therefore \Delta G = 170 \times 10^3 - (1110 \times 170) = -18700 \mathrm{J}$
Thus, reaction is spontaneous at $T = 1110 \mathrm{K}$

Question49

Which of the following are not state functions?
(I) q + w
(II) q
(III) w
(IV) H - Ts

(2008)

Options:

A. (I) (II) and (III)

B. (II) and (III)

C. (I) and (Iv)

D. (II) (III) and (Iv)

Answer: B

Solution:

Solution:
State functions or state variables are those which depend only on the state of the system and not on how the state was reached.

$$\left.\begin{array}{r} q + w = \Delta E \text{ (internal energy)} \\ H - TS = G \text{ (free energy)} \end{array}\right\} \text{State functions}$$

Path function depends on the path followed during a process as well as the end states. Work and heat are the path functions.

Question50

For the gas phase reaction
$PCl_{5(g)} \rightleftharpoons PCl_{3(g)} + Cl_{2(g)}$
Which of the following conditions are correct
(2008)

Options:

A. $\Delta H < 0$ and $\Delta S < 0$

B. $\Delta H > 0$ and $\Delta S < 0$

C. $\Delta H = 0$ and $\Delta S < 0$

D. $\Delta H > 0$ and $\Delta S > 0$

Answer: D

Solution:

Gas phase reaction
$PCl_{5(g)} \rightleftharpoons PCl_{3(g)} + Cl_{2(g)}$
$\Delta H = \Delta E + \Delta n_g RT$
$\Delta n_g =$ Change in number of moles of product and reactant species.
Since $\Delta n_g = +ve$, hence $\Delta H = +ve$
also one mole of PCl_5 is dissociated into two moles of PCl_3 and Cl_2 in the same phase.
Therefore, $\Delta S = S_{product} - S_{reactant}$

$\Delta S = +$ ve.

Question51

Bond dissociation enthalpy of H_2, Cl_2 and HCl are 434,242 and 431kJ mol^{-1} respectively.Enthalpy of formation of HCl is (2008)

Options:

A. $-93 kJ\ mol^{-1}$

B. $245 kJ\ mol^{-1}$

C. $93 kJ\ mol^{-1}$

D. $-245 kJ\ mol^{-1}$

Answer: A

Solution:

Solution:
$H_2 + Cl_2 \rightarrow 2HCl$
$\Delta H_{reaction} = \Sigma(\ B.E\ )_{reactant} - \Sigma(\ B.E\ )_{product}$
$= [(B \cdot E\ )_{H-H} + (B \cdot E\ )_{Cl-Cl}] - [2B \cdot E_{(H-Cl)}]$
$= 434 + 242 - (431) \times 2$
$\Delta H_{reaction} = -186 kJ$
Heat of formation is the amount of heat absorbed or evolved when one mole of substance is directly obtained from its constituent element.
Hence, enthalpy of formation of $HCl = \frac{-186}{2} kJ$
$= -93 kJ\ mol^{-1}$

Question52

Given that bond energies of H - H and Cl - Cl are 430kJ mol^{-1} and 240kJ mol^{-1} respectively and ΔH_f for HCl is $-90 kJ\ mol^{-1}$ bond enthalpy of HCl is (2007)

Options:

A. $380 kJ\ mol^{-1}$

B. $425 kJ\ mol^{-1}$

C. $245 kJ\ mol^{-1}$

D. $290 \mathrm{kJ\ mol}^{-1}$

Answer: B

Solution:

$$\mathrm{HCl} \rightarrow \frac{1}{2}\mathrm{H}_2 + \frac{1}{2}\mathrm{Cl}_2$$
$$\Delta H = \Sigma B.E._{\text{(products)}} - \Sigma B.E._{\text{(reactants)}}$$
$$= \frac{1}{2}[B.E._{(H_2)} + B.E._{(Cl_2)}] - B.E._{(HCl)}$$
$$= \frac{1}{2}(430 + 240) - (-90) = \frac{1}{2} \times 670 + 90$$
$$= 335 + 90 = 425 \mathrm{kJ\ mol}^{-1}$$

Question53

Consider the following reactions:
(i) $\mathrm{H}^+_{(aq)} + \mathrm{OH}^-_{(aq)} \rightarrow \mathrm{H_2O}_{(l)}, \Delta H = -X_1 \mathrm{kJ\ mol}^{-1}$
(ii) $\mathrm{H}_{2(g)} + \frac{1}{2}\mathrm{O}_{2(g)} \rightarrow \mathrm{H_2O}_{(l)}, \Delta H = -X_2 \mathrm{kJ\ mol}^{-1}$
(iii) $\mathrm{CO}_{2(g)} + \mathrm{H}_{2(g)} \rightarrow \mathrm{CO}_{(g)} + \mathrm{H_2O}_{(l)}, \Delta H = X_3 \mathrm{kJ\ mol}^{-1}$
(iv) $\mathrm{C_2H}_{2(g)} + \frac{5}{2}\mathrm{O}_{2(g)} \rightarrow 2\mathrm{CO}_{2(g)} + \mathrm{H_2O}_{(l)}, \Delta H = +X_4 \mathrm{kJ\ mol}^{-1}$
Enthalpy of formation of $\mathrm{H_2O}_{(l)}$ is
(2007)

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Options:

A. $+X_3 \mathrm{kJ\ mol}^{-1}$

B. $-X_4 \mathrm{kJ\ mol}^{-1}$

C. $+X_1 \mathrm{kJ\ mol}^{-1}$

D. $-X_2 \mathrm{kJ\ mol}^{-1}$

Answer: D

Solution:

Solution:
The amount of heat absorbed or released when 1 mole of a substance is directly obtained from its constituent elements is called the heat of formation or enthalpy of formation. Equation (i) represents neutralisation reaction, (iii) represents hydrogenation reaction and (iv) represents combustion reaction.

Question54

The enthalpy of hydrogenation of cyclohexene is $-119.5 \mathrm{kJ\ mol}^{-1}$,If resonance energy of benzene is $-150.4 \mathrm{kJ\ mol}^{-1}$,its enthalpy of hydrogenation would be
(2006)

Options:

A. $-358.5 \mathrm{kJ\ mol}^{-1}$

B. $-508 \mathrm{kJ\ mol}^{-1}$

C. $-208.1 \mathrm{kJ\ mol}^{-1}$

D. $-269.9 \mathrm{kJ\ mol}^{-1}$

Answer: C

Solution:

Solution:
$\Delta H = -119.5 \mathrm{kJ\ mol}^{-1}$
Enthalpy of hydrogenation of benzene
$= 3 \times \Delta H -$resonance energy
$= 3 \times (-119.5) - (-150.4) = -358.5 + 150.4$
$= -208.1 \mathrm{kJ\ mol}^{-1}$

Question55

The enthalpy and entropy change for the reaction:
$Br_{2(l)} + Cl_{2(g)} \rightarrow 2BrCl_{(g)}$
are 30 kJ mol^{-1} and 105J $\mathrm{K}^{-1}\mathrm{mol}^{-1}$ respectively. The temperature at which the reaction will be in equilibrium is
(2006)

Options:

A. 300K

B. 285.7 K

C. 273 K

D. 450 K

Answer: B

Solution:

Solution:
$Br_{2(l)} + Cl_{2(g)} \rightarrow 2BrCl_{(g)}$

$\Delta H = 30 kJ\ mol^{-1}, \Delta S = 105 J\ K^{-1} mol^{-1}$

$\Delta S = \frac{\Delta H}{T}$ i.e. $105 = \frac{30}{T} \times 1000$

$\therefore T = \frac{30 \times 1000}{105} = 285.7K$

Question56

Assume each reaction is carried out in an open container. For which reaction will $\Delta H = \Delta E$?
(2006)

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Options:

A. $2CO_{(g)} + O_{2(g)} \rightarrow 2CO_{2(g)}$

B. $H_{2(g)} + Br_{2(g)} \rightarrow 2HBr_{(g)}$

C.

$C_{(s)} + 2H_2O_{(g)} \rightarrow 2H_{2(g)} + CO_{2(g)}$

D. $PCl_{5(g)} \rightarrow PCl_{3(g)} + Cl_{2(g)}$

Answer: B

Solution:

Solution:

$\Delta H = \Delta E + \Delta n_g RT$

For $H_{2(g)} + Br_{2(g)} \rightarrow 2HBr_{(g)}$

$\Delta n_g = 2 - (1 + 1) = 0$. i.e. $\Delta H = \Delta E$

Question57

Identify the correct statement for change of Gibbs energy for a system (ΔG_{system}) at constant temperature and pressure.
(2006)

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Options:

A. If $\Delta G_{system} < 0$, the process is not spontaneous.

B. If $\Delta G_{system} > 0$, the process is spontaneous.

C. If $\Delta G_{system} = 0$, the system has attained equilibrium.

D. If $\Delta G_{system} = 0$, the system is still moving in a particular direction.

Answer: C

Solution:

Solution:
The criteria for spontaneity of a process in terms of ΔG is as follows:
→ If ΔG is negative, the process is spontaneous.
→ If ΔG is positive, the process does not occur in the forward direction. It may occur in the backward direction.
→ If ΔG is zero, the system is in equilibrium.

Question58

Which of the following pairs of a chemical reaction is certain to result in a spontaneous reaction?
(2005)

Options:

A. Exothermic and increasing disorder

B. Exothermic and decreasing disorder

C. Endothermic and increasing disorder

D. Endothermic and decreasing disorder

Answer: A

Solution:

Solution:
For spontaneous reaction $\Delta H = -$ ve, $\Delta S = +$ve
Spontaneity depends upon both critical minimum energy and maximum randomness / disorder.

Question59

A reaction occurs spontaneously if
(2005)

Options:

A. $T\Delta S < \Delta H$ and both ΔH and ΔS are + ve

B. $T\Delta S > \Delta H$ and ΔH is +ve and ΔS is -ve

C. $T\Delta S > \Delta H$ and both ΔH and ΔS are + ve

D. $T\Delta S = \Delta H$ and both ΔH and ΔS are + ve

Answer: C

Solution:

$\Delta G = \Delta H - T\Delta S$
$\Delta G = -$ ve for spontaneous reaction
When $\Delta S = +\mathrm{ve}$, $\Delta H = +\mathrm{ve}$
and $T\Delta S > \Delta H \Rightarrow \Delta G = -\mathrm{ve}$

Question60

The absolute enthalpy of neutralisation of the reaction :
$MgO_{(s)} + 2HCl_{(aq)} \rightarrow MgCl_{2(aq)} + H_2O_l$
will be
(2005)

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Options:

A. $-57.33\mathrm{kJ\ mol}^{-1}$

B. greater than $-57.33\mathrm{kJ\ mol}^{-1}$

C. less than $-57.33\mathrm{kJ\ mol}^{-1}$

D. $57.33\mathrm{kJ\ mol}^{-1}$ If

Answer: B

Solution:

Solution:
The enthalpy of hydration of Mg^{2+} ion is very high. Due to this, the absolute enthalpy of neutralization of the reaction is greater than $-57.33\mathrm{KJ\ mol}^{-1}$. The $\triangle H$ for the above reaction is found to be $-146\mathrm{KJ}$ which states that the enthalpy of neutralization of $H^+$is $-73\mathrm{KJ}/\mathrm{mol}$ which is greater than the enthalpy of neutralization i.e. $57.33\mathrm{KJ}/\mathrm{mol}$.

Question61

If the bond energies of $H-H$, $Br-Br$ and $H-Br$ are 433,192 and $364\mathrm{kJ\ mol}^{-1}$ respectively, the ΔH° for the reaction $H_2 + Br_{2(g)} \rightarrow 2HBr_{(g)}$ is
(2004)

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Options:

A. $-261\mathrm{kJ}$

B. $+103\mathrm{kJ}$

C. $+261\mathrm{kJ}$

D. $-103 \mathrm{kJ}$

Answer: D

Solution:

$\mathrm{H-H} + \mathrm{Br-Br} \rightarrow 2\mathrm{H-Br}$
$433 + 192$ $\qquad$ 2×364
$= 625$ $\qquad$ $= 728$
Energy absorbed $\qquad$ Energy released
Net energy released $= 728 - 625 = 103 \mathrm{kJ}$
i.e. $\Delta \mathrm{H} = -103 \mathrm{kJ}$

Question62

Standard enthalpy and standard entropy changes for the oxidation of ammonia at 298 K are -382.64 and $-145.6 \mathrm{kJ\ mol}^{-1}$, respectively. Standard Gibbs' energy change for the same reaction at 298 K is (2004)

Options:

A. $-221.1 \mathrm{kJ\ mol}^{-1}$

B. $-339.3 \mathrm{kJ\ mol}^{-1}$

C. $-439.3 \mathrm{kJ\ mol}^{-1}$

D. $-523.2 \mathrm{kJ\ mol}^{-1}$

Answer: B

Solution:

Solution:

$\Delta G = \Delta H - T \Delta S$

$= -382.64 - 298\left(\frac{-145.6}{1000}\right)$

$= -382.64 + 43.38 = -339.3 \mathrm{kJ\ mol}^{-1}$

Question63

Considering entropy (S) as a thermodynamic parameter, the criterion for the spontaneity of any process is
(2004)

Options:

A.

$\Delta S_{\text{system}} + \Delta S_{\text{surroundings}} > 0$

B.

$\Delta S_{\text{system}} - \Delta S_{\text{surroundings}} > 0$

C. $\Delta S_{\text{system}} > 0$ only

D. $\Delta S_{\text{surroundings}} > 0$ only.

Answer: A

Solution:

Solution:
$\Delta S = R \ln V_2/V_1$
Here the volume of gas increases from V_1 to V_2 at constant temperature T.
since $V_2 > V_1$, it is obvious that the spontaneous (irreversible) isothermal expansion of a gas is accompanied by an increase in the entropy of the system and its surroundings considered together.
$\Delta S_{sys} + \Delta S_{surr} > 0$

Question64

The work done during the expansion of a gas from a volume of $4 dm^3$ to $6 dm^3$ against a constant external pressure of 3atm is (1Latm = 101.32J) (2004)

Options:

A. $-6J$

B. $-608J$

C. $+304J$

D. $-304J$

Answer: B

Solution:

Solution:
Work $= -P_{ext} \times$ volume change
$= -3 \times 101.32 \times (6-4) = 6 \times 101.32$
$= -607.92J \approx -608J$

Question65

For the reaction,
$C_3H_8 + 5O_{2(g)} \rightarrow 3CO_{2(g)} + 4H_2O_{(l)}$
at constant temperature, $\Delta H - \Delta E$ is
(2003)

Options:

A. $+RT$

B. $-3RT$

C. $+3RT$

D. $-RT$

Answer: B

Solution:

Solution:
$C_3H_{8(g)} + 5O_{2(g)} \rightarrow 3CO_{2(g)} + 4H_2O_{(l)}$
$\Delta n_g = 3 - 6 = -3$
$\Delta H = \Delta E + P\Delta V$ or $\Delta H - \Delta E = P\Delta V$
$\Delta H - \Delta E = \Delta n_g RT = -3RT$

Question66

The densities of graphite and diamond at 298K are 2.25 and 3.31gcm^{-3}, respectively. If the standard free energy difference (ΔG°) is equal to 1895J mol^{-1}, the pressure at which graphite will be transformed into diamond at 298K is
(2003)

Options:

A. 9.92×10^8Pa

B. 9.92×10^7Pa

C. 9.92×10^6Pa

D. 9.92×10^5Pa

E. None of the above

Answer: E

Solution:

$\Delta G = -P\,\Delta V = \text{Work done}$

$\Delta V = \left(\frac{12}{3.31} - \frac{12}{2.25}\right) \times 10^{-3}\mathrm{L} = -1.71 \times 10^{-3}\mathrm{L}$

$\Delta G = \text{Work done} = -(-1.71 \times 10^{-3}) \times P \times 101.3\mathrm{J}$

$P = \dfrac{1895}{1.71 \times 10^{-3} \times 101.3} = 10.93 \times 10^{3}\mathrm{atm}$

$= 11.07 \times 10^{8}\mathrm{Pa}$

Question67

What is the entropy change (in $\mathrm{J\,K^{-1}mol^{-1}}$) when one mole of ice is converted into water at $0^\circ\mathrm{C}$? (The enthalpy change for the conversion of ice to liquid water is $6.0\mathrm{kJ\ mol^{-1}}$ at $0^\circ\mathrm{C}$.)
(2003)

Options:

A. 20.13

B. 2.013

C. 2.198

D. 21.98

Answer: D

Solution:

Solution:

$S = \frac{q_{rev}}{T} = \frac{6000}{273} = 21.978\mathrm{J\,K^{-1}mol^{-1}}$

Question68

Formation of a solution from two components can be considered as
(i) Pure solvent → separated solvent molecules, ΔH_1
(ii) Pure solute → separated solute molecules, ΔH_2
(iii) Separated solvent and solute molecules → solution, ΔH_3
Solution so formed will be ideal if
(2003)

Options:

A.

$\Delta H_{\mathrm{sol\,n}} = \Delta H_1 + \Delta H_2 + \Delta H_3$

B.

$\Delta H_{soln} = \Delta H_1 + \Delta H_2 - \Delta H_3$

C.

$\Delta H_{soln} = \Delta H_1 - \Delta H_2 - \Delta H_3$

D.

$\Delta H_{soln} = \Delta H_3 - \Delta H_1 - \Delta H_2$

Answer: A

Solution:

Solution:
Heat of solution is defined as the amount of heat evolved or absorbed when one mole of the substance is dissolved in excess of the solvent. For hydrated salt and for salts which do not form hydrates, ΔH is positive and for anhydrous salts, it is negative.

Question69

For which one of the following equations is $\Delta H_{reaction}{}^{\circ}$ equal to $\Delta H_j{}^{\circ}$ for the product?
(2003)

Options:

A. $N_{2(g)} + O_{3(g)} \rightarrow N_2O_{3(g)}$

B.

$CH_{4(g)} + 2Cl_{2(g)} \rightarrow CH_2Cl_{2(l)} + 2HCl_{(g)}$

C. $Xe_{(g)} + 2F_{2(g)} \rightarrow XeF_{4(g)}$

D. $2CO_{(g)} + O_{2(g)} \rightarrow 2CO_{2(g)}$

Answer: C

Solution:

Solution:
For (c) $\Delta H^{\circ}_{reaction}$
$= \Delta H_f{}^{\circ}(XeF_4) - [\Delta H_f{}^{\circ}(Xe) + 2\Delta H_f{}^{\circ}(F_2)]$
Enthalpies of formation of elementary substances Xe and F_2, are taken as zero.
Thus, $\Delta H^{\circ}_{reaction} = \Delta H^{\circ}_f(XeF_4)$

Question70

The molar heat capacity of water at constant pressure, C, is $75\mathrm{J\,K}^{-1}\mathrm{mol}^{-1}$. When 1.0kJ of heat is supplied to 100g of water which is free to expand, the increase in temperature of water is
(2003)

Options:

A. 1.2K

B. 2.4K

C. 4.8K

D. 6.6K

Answer: B

Solution:

Solution:
Molar heat capacity $= 75\mathrm{J\,K}^{-1}\mathrm{mol}^{-1}$
18g of water $= 1\mathrm{mol\,e} = 75\mathrm{J\,K}^{-1}\mathrm{mol}^{-1}$
1g of water $= \frac{75}{18}\mathrm{J\,K}^{-1}$
$\mathrm{Q} = \mathrm{m} \cdot \mathrm{C} \cdot \Delta \mathrm{t}$ or $1000 = 100 \times \frac{75}{18} \times \Delta \mathrm{t}$
$\Rightarrow \Delta \mathrm{t} = \frac{10 \times 18}{75} = 2.4\mathrm{K}$

Question71

Unit of entropy is
(2002)

Options:

A. $\mathrm{J\,K}^{-1}\mathrm{mol}^{-1}$

B. $\mathrm{J\,mol}^{-1}$

C. $\mathrm{J}^{-1}\mathrm{K}^{-1}\mathrm{mol}^{-1}$

D. $\mathrm{J\,K\,mol}^{-1}$

Answer: A

Solution:

Entropy change (ΔS) is given by $\Delta S = q_{rev}/T$
$\therefore$ Unit of entropy $= J/K$ mol (entropy per unit mole $= J K^{-1} mol^{-1}$

Question72

In a closed insulated container a liquid is stirred with a paddle to increase the temperature which of the following is true?
(2002)

Options:

A. $\Delta E = W \neq 0, q = 0$

B. $\Delta E = W = q \neq 0$

C. $\Delta E = 0, W = q \neq 0$

D. $W = 0, \Delta E = q \neq 0$

Answer: A

Solution:

Solution:
The mathematical form of first law of thermodynamics: $q = \Delta E + W$
since the system is closed and insulated, $q = 0$
Paddle work is done on system. $\therefore W \neq 0$.
Temperature and hence internal energy of the system increases. $\therefore \Delta E \neq 0$

Question73

Heat of combustion ΔH for $C_{(s)}$, $H_{2(g)}$ and $CH_{4(g)}$ are -94, -68 and -213 kcla/mol then $C_{(s)} + 2H_{2(g)} \rightarrow CH_{4(g)}$ is
(2002)

Options:

A. -17kcal

B. -111kcal

C. -170kcal

D. -85 kcal

Answer: A

Solution:

(i) $C_{(s)} + O_{2(g)} \rightarrow CO_{2(g)}$ $\Delta H_{i} = -94\text{kcal/mole}$
(ii) $2H_{2(g)} + O_{2(g)} \rightarrow 2H_{2}O_{(l)}$ $\Delta H_{ii} = -68 \times 2\text{kcal/mole}$
(iii) $CH_{4(g)} + 2O_{2(g)} \rightarrow CO_{2(g)} + 2H_{2}O_{(n)}$ $\Delta H_{iii} = -213\text{kcal/mole}$
(iv) $C_{(s)} + 2H_{2(g)} \rightarrow CH_{4(g)}$; $\Delta H_{iv} = ?$
By applying Hess's law we can compute ΔH_{iv}
$\therefore\ \Delta H_{iv} = \Delta H_{i} + \Delta H_{ii} - \Delta H_{iii}$
$= (-94 - 68 \times 2 + 213)\text{kcal} = -17\text{kcal}$

Question74

2 mole of ideal gas at 27°C temperature is expanded reversibly from 2 lit. to 20 lit. Find entropy change. ($R = 2\text{cal}/\text{mol K}$)
(2002)

Options:

A. 92.1

B. 0

C. 4

D. 9.2

Answer: D

Solution:

The change of entropy $dS = \frac{q_{rev}}{T}$
From the first law of thermodynamics,
$dq = dU + PdV = C_V dT + PdV$
$\Rightarrow \frac{dq}{T} = C_V \frac{dT}{T} + \frac{P}{T} dV$
$\Rightarrow \frac{dq}{T} = C_V \frac{dT}{T} + \frac{RdV}{V}$ $\left[\frac{P}{T} = \frac{R}{V}\right]$
$\therefore\ dS = C_V \frac{dT}{T} + R\frac{dV}{V}$
$\Rightarrow \Delta S = C_V \ln\frac{T_2}{T_1} + R\ln\frac{V_2}{V_1}$ [for one mole of ideal gas]
Here
$T_2 = T_1 = 27^\circ C = 300K \therefore \ln\frac{T_2}{T_1} = 0$
$\therefore\ \Delta S = R\ln\frac{V_2}{V_1} = 2\ln\frac{20}{2} = 2\ln 10 = 4.605$
$\therefore\ \Delta S = 4.605\text{cal/mol K}$
Entropy change for 2 moles of gas
$= 2 \times 4.605\text{cal/K} = 9.2\text{cal/K}$

Question75

Change in enthalpy for reaction, $2H_2O_{2(l)} \rightarrow 2H_2O_{(l)} + O_2$ if heat of

formation of $H_2O_{2(l)}$ and $H_2O_{(l)}$ are -188 and $-286 kJ/mol$ respectively, is
(2001)

Options:

A. $-196 kJ/mol$

B. $+196 kJ/mol$

C. $+948 kJ/mol$

D. $-948 kJ/mol$ e

Answer: A

Solution:

$\Delta H_f^\circ = \Sigma H_{f(\text{ product })}^\circ - \Sigma H_{f\ (\text{reactant})}^\circ$
For the given reaction,
$2H_2O_{2(l)} \rightarrow 2H_2O_{(l)} + O_{2(g)}$
$\Delta H_f^\circ = 2 \times \Delta H_{f(H_2O)}^\circ - 2 \times \Sigma H_{f(H_2O_2)}^\circ$
$= 2 \times -286 kJ\ mol^{-1} - 2 \times (-188) kJ\ mol^{-1}$
$= -196 kJ\ mol^{-1}$

Question76

When 1mol of gas is heated at constant volume temperature is raised from 298 to 308 K. Heat supplied to the gas is 500J Then which statement is correct?
(2001)

Options:

A. $q = w = 500J, \Delta E = 0$

B. $q = \Delta E = 500J, w = 0$

C. $q = w = 500J, \Delta E = 0$

D. $\Delta E = 0, q = w = -500J$

Answer: B

Solution:

Solution:
$\Delta H = \Delta E + P \Delta V$
When $\Delta V = 0$; $w = 0$
$\Delta H = \Delta E + 0$ or $\Delta H = \Delta E$
As $\Delta E = q + w$, $\Delta E = q$

In the present problem, $\Delta H = 500J$,
$\Delta H = \Delta E = 500J$, $q = 500J$, $w = 0$

Question77

Enthalpy of $CH_4 + 1/2O_2 \rightarrow CH_3OH$ is negative. If enthalpy of combustion of CH_4 and CH_3OH are x and y respectively. Then which relation is correct?
(2001)

Options:

A. $x > y$

B. $x < y$

C. $x = y$

D. $x \geq y$

Answer: A

Solution:

Solution:
$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O, \Delta H_1 = -xkJ$ ...(i)
$CH_3OH + \frac{3}{2}O_2 \rightarrow CO_2 + 2H_2O, \Delta H_2 = -ykJ$ .....(ii)
Subtracting (ii) from (i), we get
$CH_4 + \frac{1}{2}O_2 \rightarrow CH_3OH , \Delta H_3 = -ve$
i. e., $-x-(-y) = -ve$
$y - x = -$ ve
Hence, $x > y$

Question78

$PbO_2 \rightarrow PbO; \Delta G_{298} < 0$
$SnO_2 \rightarrow SnO; \Delta G_{298} > 0$
Most probable oxidation state of Pb and Sn will be
(2001)

Options:

A. Pb^{4+}, Sn^{4+}

B. Pb^{4+}, Sn^{2+}

C. Pb^{2+}, Sn^{2+}

D. Pb^{2+}, Sn^{4+}

Answer: D

Solution:

Solution:
The sign and magnitude of Gibbs free energy is a criterion of spontaneity for a process. When $\Delta G > 0$ or +ve, it means
$G_{\text{product}} > G_{\text{reactant}}$
the reaction will not take place spontaneously,i.e. the reaction should be spontaneous in reverse direction.
$SnO_2 \rightarrow SnO; \quad \Delta G > 0$
$+4 \qquad +2$
(more favourable)
$\Delta G < 0$ or -ve, the reaction or change occurs spontaneously.
$PbO_2 \rightarrow PbO; \rightarrow \Delta G < 0$
$+4 \qquad +2$
(more favourable)

Question79

Cell reaction is spontaneous when (2000)

Options:

A. ΔG° is negative

B. ΔG° is positive

C. $\Delta E_{\text{red}}^{\circ}$ is positive

D. $\Delta E_{\text{red}}^{\circ}$ is negative.

Answer: A

Solution:

Solution:
For a cell reaction to be spontaneous ΔG° should be negative. As $\Delta G^{\circ} = -nFE_{\text{cell}}^{\circ}$ so the value will be -ve only when E_{cell}° is +ve.

Question80

$2Zn + O_2 \rightarrow 2ZnO; \Delta G^{\circ} = -616J$
$2Zn + S_2 \rightarrow 2ZnS; \Delta G^{\circ} = -293J$
$S_2 + 2O_2 \rightarrow 2SO_2; \Delta G^{\circ} = -408J$
ΔG° for the following reaction
$2ZnS + 3O_2 \rightarrow 2ZnO + 2SO_2$ is

(2000)

Options:

A. -731 J

B. -1317 J

C. -501 J

D. +731 J

Answer: A

Solution:

For the reactions,
$2ZnS \rightarrow 2Zn + S_2; \Delta G^\circ = +293J$ ....(1)
$2Zn + O_2 \rightarrow 2ZnO; \Delta G^\circ = -616J$ ....(2)
$S_2 + 2O_2 \rightarrow 2SO_2; \Delta G^\circ = -408J$ ...(3)
The ΔG° for the reaction,
$2ZnS + 3O_2 \rightarrow 2ZnO + 2SO_2$ can be obtained by adding eq. (1),(2) and (3)
So, $\Delta G^\circ = 293 - 616 - 408 = -731$ J

Question81

At 27°C latent heat of fusion of a compound is 2930J /mol . Entropy change is
(2000)

Options:

A. 9.77J /mol K

B. 10.77J /mol K

C. 9.07J /mol K

D. 0.977J /mol K

Answer: A

Solution:

Solution:
$\Delta S = \frac{Q}{T} = \frac{2930}{300} = 9 \cdot 77J\ / \text{mol K}$

Question82

For the reaction,
$C_2H_5OH_{(l)} + 3O_2 \rightarrow 2CO_{2(g)} + 3H_2O_{(l)}$
which one is true?
(2000)

Options:

A. $\Delta H = \Delta E - RT$

B. $\Delta H = \Delta E + RT$

C. $\Delta H = \Delta E + 2RT$

D. $\Delta H = \Delta E - 2RT$

Answer: A

Solution:

Solution:
$\Delta H = \Delta E + P\Delta V$
also $PV = nRT$ (ideal gas equation)
or $P\Delta V = \Delta n_g RT$
$\Delta n_g =$ change in number of gaseous moles
$\therefore \Delta H = \Delta E + \Delta n_g RT \Rightarrow \Delta n_g = 2 - 3 = -1$
$\Rightarrow \Delta H = \Delta E - RT$

Question83

In an endothermic reaction, the value of ΔH is
(1999)

Options:

A. negative

B. positive

C. zero

D. constant.

Answer: B

Solution:

Solution:
In endothermic reactions, energy of reactants is less than energy of products. Thus, $E_R < E_p$
$\Delta H = E_P - E_R = +ve$

Question84

In the reaction: $S + \frac{3}{2}O_2 \rightarrow SO_3 + 2x\text{kcal}$ and $SO_2 + \frac{1}{2}O_2 \rightarrow SO_3 + y\text{kcal}$, the heat of formation of SO_2 is
(1999)

Options:

A. $(2x + y)$

B. $(x - y)$

C. $(x + y)$

D. $(2x - y)$

Answer: D

Solution:

Solution:

$S + \frac{3}{2}O_2 \rightarrow SO_3 + 2x$ kcal ....(i)

$SO_2 + \frac{1}{2}O_2 \rightarrow SO_3 + y$ kcal ....(ii)

By subtracting equation (ii) from (i) we get,
The heat of formation of SO_2 is $(2x - y)$ kcal/mole.

Question85

Identify the correct statement regarding entropy.
(1998)

Options:

A. At absolute zero of temperature, the entropy of all crystalline substances is taken to be zero.

B. At absolute zero of temperature, the entropy of a perfectly crystalline substance is +ve.

C. At absolute zero of temperature, entropy of a perfectly crystalline substance is taken to be zero.

D. At 0°C, the entropy of a perfectly crystalline substance is taken to be zero.

Answer: C

Solution:

The entropy of a substance increases with increase in temperature . However at absolute zero the entropy of a perfectly crystalline substance is taken as zero. which is also called as third law of thermodynamics

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Question86

One mole of an ideal gas at 300K is expanded isothermally from an initial volume of 1 litre to 10 litres. The ΔE for this process is ($R = 2$ cal $mol^{-1} K^{-1}$)

(1998)

Options:

A. 1381.1cal

B. zero

C. 163.7cal

D. 9L atm

Answer: B

Solution:

Change in internal energy depends upon temperature. At constant temperature, the internal energy of the gas remains constant, so $\Delta E = 0$

Question87

Given that $C + O_2 \rightarrow CO_2, \Delta H^\circ = -x kJ$ $2CO + O_2 \rightarrow 2CO_2, \Delta H^\circ = -y kJ$ The enthalpy of formation of carbon monoxide will be

(1997)

Options:

A. $\frac{y - 2x}{2}$

B. $2x - y$

C. $y - 2x$

D. $\frac{2x - y}{2}$

Answer: A

Solution:

$C_{(s)} + O_{2(g)} \rightarrow CO_{2(g)}$; $\Delta H = -x kJ$ .....(i)

$CO_{(g)} + \frac{1}{2}O_{2(g)} \rightarrow CO_{2(g)}$; $\Delta H = \frac{-y}{2} kJ$ .....(ii)

By subtracting equation (ii) from (i) we get,

$C_{(s)} + \frac{1}{2}O_{2(g)} \rightarrow CO_{(g)}$

$\Delta H = -x - \left(-\frac{y}{2}\right) = \frac{y-2x}{2} kJ$

Question88

Which of the following is the correct equation? (1996)

Options:

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

B. $\Delta U = \Delta Q - W$

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

D. None of these

Answer: B

Solution:

Solution:
This is the mathematical relation of first law of thermodyamics. Here ΔU = change in internal energy; ΔQ = heat absorbed by the system and W = work done by the system.

Question89

It enthalpies of formation for C_2H_4, $CO_{2(g)}$ and $H_2O_{(l)}$ at 25°C and 1 atm pressure are 52, −394 and −286kJ /mol respectively, then enthalpy of combustion of $C_2H_{4(g)}$ will be (1995)

Options:

A. $+141.2 kJ/mol$

B. $+1412 kJ/mol$

C. $-141.2 kJ/mol$

D. $-1412 kJ/mol$

Answer: D

Solution:

$C_2H_4 + 3O_2 \rightarrow 2CO_2 + 2H_2O$
$\Delta H = \Delta H_{products} - \Delta H_{reactants}$
$= 2 \times (-394) + 2 \times (-286) - (52 + 0) = -1412 kJ/mol$

Question90

For a reaction to occur spontaneously (1995)

Options:

A. ΔH must be negative

B. ΔS must be negative

C. $(\Delta H - T\Delta S)$ must be negative

D. $(\Delta H + T\Delta S)$ must be negative.

Answer: C

Solution:

Solution:
For a reaction to be spontaneous, ΔG (Gibbs' free energy change) must be negative.
$\Delta G = \Delta H - T\Delta S$
ΔH = change in enthalpy, ΔS = change in entropy.

Question91

During isothermal expansion of an ideal gas, its (1994,1991)

Options:

A. internal energy increases

B. enthalpy decreases

C. enthalpy remains unaffected

D. enthalpy reduces to zero.

Answer: C

Solution:

An isothermal process is a change of a system, in which the temperature remains constant. For an ideal gas during an isothermal expansion the enthalpy, as well as internal energy, remains constant.
During isothermal expansion of an ideal gas, $\Delta E = 0, \Delta T = 0$
From the definition of enthalpy, $H = E + PV$
or $\Delta H = \Delta E + \Delta (PV)$
or $\Delta H = \Delta E + \Delta (nRT)$ \{ Since, $PV = nRT$ for an ideal gas\}
or $\Delta H = \Delta E + nR \Delta T$
or $\Delta H = 0$

Question92

Following reaction occurring in an automobile
$2C_8H_{18} + 25O_{2(g)} \rightarrow 16CO_{2(g)} + 18H_2O_{(g)}$
The sign of ΔH, ΔS and ΔG would be
(1994)

Options:

A. $-, +, +$

B. $+, +, -$

C. $+, -, +$

D. $-, +, -$

Answer: D

Solution:

Solution:
The given reaction is a combustion reaction, therefore ΔH is less than 0. Hence, ΔH is negative.
(ii) Since there is increase in the number of moles, therefore ΔS is positive
(iii) Since reaction is spontaneous, therefore ΔG is negative.

Question93

For the reaction $N_2 + 3H_2 \rightleftharpoons 2NH_3$, $\Delta H = ?$
(1991)

Options:

A. $\Delta E + 2RT$

B. $\Delta E - 2RT$

C. $\Delta H = RT$

D. $\Delta E - RT$

Answer: B

Solution:

Solution:
$\Delta n_g = 2 - 4 = -2, \Delta H = \Delta E - 2RT$

Question94

If ΔH is the change in enthalpy and ΔE, the change in internal energy accompanying a gaseous reaction, then
(1990)

Options:

A. ΔH is always greater than ΔE

B. $\Delta H < \Delta E$ only if the number of moles of the products is greater than the number of moles of the reactants

C. ΔH is always less than ΔE

D. $\Delta H < \Delta E$ only if the number of moles of products is less than the number of moles of the reactants.

Answer: D

Solution:

If $n_p < n_r$; $\Delta n_g = n_p - n_r = -$ ve.
Hence $\Delta H < \Delta E$.
