Chemical Thermodynamics

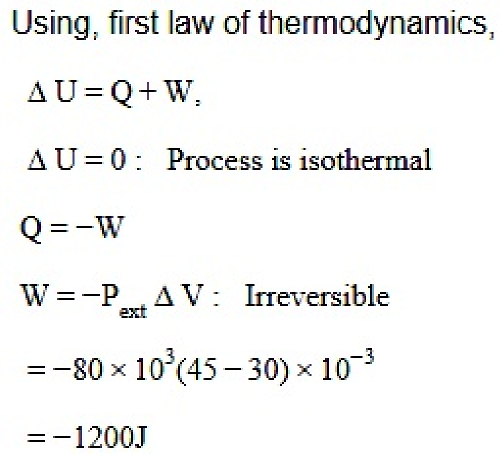
Question1

If three moles of an ideal gas at 300K expand isotherrnally from $30dm^3$ to $45dm^3$ against a constant opposing pressure of 80kPa, then the amount of heat transferred is ______J.

[27-Jan-2024 Shift 1]

Answer: 1200

Solution:



Using, first law of thermodynamics,

$\Delta U = Q + W,$

$\Delta U = 0$: Process is isothermal

$Q = -W$

$W = -P_{ext}\Delta V$: Irreversible

$= -80 \times 10^3 (45 - 30) \times 10^{-3}$

$= -1200J$

Question2

For a certain thermochemical reaction M → N at T = 400K, $\Delta H^\ominus = 77.2 kJmol^{-1}$, $\Delta S = 122 JK^{-1}$, log equilibrium constant (logK) is _____ × 10^{-1}.

[27-Jan-2024 Shift 2]

Answer: 37

Solution:

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

$$= 77.2 \times 10^3 - 400 \times 122 = 28400\text{J}$$

$$\Delta G^\circ = -2.303\,RT\log K$$

$$\Rightarrow 28400 = -2.303 \times 8.314 \times 400 \log K$$

$$\Rightarrow \log K = -3.708 = -37.08 \times 10^{-1}$$

Question3

Which of the following is not correct?

[29-Jan-2024 Shift 1]

Options:

A.

ΔG is negative for a spontaneous reaction

B.

ΔG is positive for a spontaneous reaction

C.

ΔG is zero for a reversible reaction

D.

ΔG is positive for a non-spontaneous reaction

Answer: B

Solution:

$(\Delta G)_{P,\,T}$ = (+)ve for non-spontaneous process

Question4

Standard enthalpy of vapourisation for CCl_4 is 30.5kJmol^{-1}. Heat required for vapourisation of 284g of CCl_4 at constant temperature is____ kJ. (Given molar mass in gmol^{-1} ; C = 12, Cl = 35.5)

[29-Jan-2024 Shift 2]

Answer: 56

Solution:

$\Delta H^\circ_{vap}\ CCl_4 = 30.5\ kJ/mol$

Mass of $CCl_4 = 284\ gm$

Molar mass of $CCl_4 = 154 g/mol$

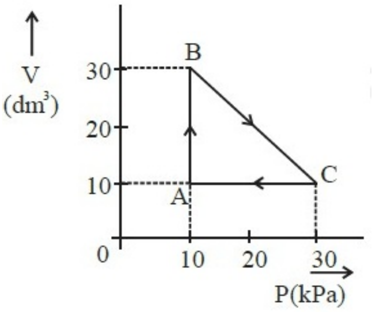
Moles of $CCl_4 = \frac{284}{154} = 1.844\ mol$

ΔH°_{vap} for 1 mole $= 30.5\ kJ/mol$

ΔH°_{vap} for $1.844\ mol = 30.5 \times 1.844$

$= 56.242\ kJ$

Question5



An ideal gas undergoes a cyclic transformation starting from the point A and coming back to the same point by tracing the path A → B → C → A as shown in the diagram. The total work done in the process is ______J.

[30-Jan-2024 Shift 1]

Answer: 200

Solution:

Work done is given by area enclosed in the P vs V cyclic graph or V vs P cyclic graph.

Sign of work is positive for clockwise cyclic process for V vs P graph.

$$W = \frac{1}{2} \times (30-10) \times (30-10) = 200\ kPa - dm^3$$

$$= 200 \times 1000\ Pa - L = 2L - bar = 200J$$

Question6

Two reactions are given below:

$2Fe_{(s)} + \frac{3}{2}O_{2(g)} \rightarrow Fe_2O_{3(s)}, \Delta H^o = -822\ kJ/mol$

$C_{(s)} + \frac{1}{2}O_{2(g)} \rightarrow CO_{(g)}, \Delta H^o = -110\ kJ/mol$

Then enthalpy change for following reaction

$3C_{(s)} + Fe_2O_{3(s)} \rightarrow 2Fe_{(s)} + 3CO_{(g)}$

[30-Jan-2024 Shift 2]

Answer: 492

Solution:

$2Fe_{(s)} + \frac{3}{2}O_{2(g)} \longrightarrow Fe_2O_{3(s)}, \Delta H^o = -822\ kJ/mol$ ....(1)

$C_{(s)} + \frac{1}{2}O_{2(g)} \longrightarrow CO_{(g)}, \Delta H^o = -110\ kJ/mol$ ....(2)

$3C_{(s)} + Fe_2O_{3(s)} \longrightarrow 2Fe_{(s)} + 3CO_{(g)}, \Delta H_3 = ?$

$(3) = 3 \times (2) - (1)$

$\Delta H_3 = 3 \times \Delta H_2 - \Delta H_1$

$= 3(-110) + 822$

$= 492\ kJ/mole$

Question7

Consider the following reaction at 298K.

$\frac{3}{2}O_{2(g)} \rightleftharpoons O_{3(g)} \cdot K_P = 2.47 \times 10^{-29}$.

$\Delta_r G^\Theta$ for the reaction is ______kJ. (Given R $= 8.314 JK^{-1} mol^{-1}$)

[31-Jan-2024 Shift 1]

Options:

Answer: 163

Solution:

$\frac{3}{2}O_{2(g)} \rightleftharpoons O_{3(g)} \cdot K_P = 2.47 \times 10^{-29}$.

$\Delta_r G^\Theta = -RT \ln K_P$

$= -8.314 \times 10^{-3} \times 298 \times \ln(2.47 \times 10^{-29})$

$= -8.314 \times 10^{-3} \times 298 \times (-65.87)$

$= 163.19\ kJ$

Question8

If 5 moles of an ideal gas expands from 10L to a volume of 100L at 300K under isothermal and reversible condition then work, w, is −xJ. The value of x is_____

(Given R = 8.314JK^{-1}mol^{-1})

[31-Jan-2024 Shift 2]

Answer: None

Solution:

It is isothermal reversible expansion, so work done negative

$$W = -2.303nRT\log\left(\frac{V_2}{V_1}\right)$$

$$= -2.303 \times 5 \times 8.314 \times 300 \log\left(\frac{100}{10}\right)$$

$$= -28720.713\text{J}$$

$$\equiv -28721\text{J}$$

Question9

Choose the correct option for free expansion of an ideal gas under adiabatic condition from the following :

[1-Feb-2024 Shift 1]

Options:

A.

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

B.

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

C.

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

D.

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

Answer: D

Solution:

During free expansion of an ideal gas under adiabatic condition $q = 0$, $\Delta T = 0$, $w = 0$.

Question10

For a certain reaction at 300K, $K = 10$, then ΔG° for the same reaction is______ $\times 10^{-1}$ $kJmol^{-1}$. (Given $R = 8.314 JK^{-1}mol^{-1}$)

[1-Feb-2024 Shift 2]

Answer: 57

Solution:

$\Delta G^\circ = -RT\ell nK$

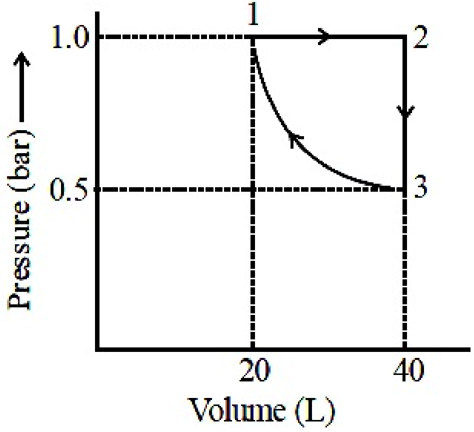
$= -8.314 \times 300 \ln(10)$

$= 5744.14 J/mole$

$= 57.44 \times 10^{-1} kJ/mole$

Question11

One mole of an ideal monoatomic gas is subjected to changes as shown in the graph. The magnitude of the work done (by the system or on the system) is J (nearest integer).



Given : $\log 2 = 0.3$, $\ln 10 = 2.3$
[24-Jan-2023 Shift 2]

Answer: 620

Solution:

$1 \rightarrow 2 \Rightarrow$ Isobaric process
$2 \rightarrow 3 \Rightarrow$ Isochoric process
$3 \rightarrow 1 \Rightarrow$ Isothermal process

$$W = W_{1\rightarrow 2} + W_{2\rightarrow 3} + W_{3\rightarrow 1}$$
$$= \left(-P(V_2 - V_1) + 0\left[-P_1V_1 \ln\left(\frac{V_2}{V_1}\right)\right]\right)$$
$$= \left[-1 \times (40 - 20) + 0 + \left[-1 \times 20 \ln\left(\frac{20}{40}\right)\right]\right]$$
$$= -20 + 20 \ln 2$$
$$= -20 + 20 \times 2.3 \times 0.3$$
$$= -6.2 \text{ bar L}$$
$$|W| = 6.2 \text{ bar } 1 = 620\text{J}$$

Question12

An athlete is given 100g of glucose ($C_6H_{12}O_6$) for energy. This is equivalent to 1800 kJ of energy. The 50% of this energy gained is utilized by the athlete for sports activities at the event. In order to avoid storage of energy, the weight of extra water he would need to perspire is _______ g (Nearest integer)

Assume that there is no other way of consuming stored energy.

Given : The enthalpy of evaporation of water is 45 kJ mol^{-1}

Molar mass of C, H&O are 12.1 and 16$gmol^{-1}$.

[25-Jan-2023 Shift 1]

Answer: 360

Solution:

Solution:

$C_6H_{12}O_6(s) + 6O_2 \rightarrow 6CO_2(g) + 6H_2O(l)$

Extra energy used to convert $H_2O(l)$ into $H_2O(l)$ into $H_2O(g)$

$$= \frac{1800}{2} = 900\,\text{kJ}$$
$$\Rightarrow \quad 900 = n_{H_2O} \times 45$$
$$n_{H_2O} = \frac{900}{45} = 20\,\text{mole}$$
$$W_{H_2O} = 20 \times 18 = 360\text{g}$$

Question13

28.0L of CO_2 is produced on complete combustion of 16.8L gaseous mixture of ethene and methane at 25°C and 1 atm. Heat evolved during the combustion process is ________ kJ.

Given : $\Delta H_C(CH_4) = -900\,kJ\,mol^{-1}$
$\Delta H_C(C_2H_4) = -1400\,kJ\,mol^{-1}$
[25-Jan-2023 Shift 2]

Answer: 847

Solution:

Solution:
Let, Volume of C_2H_4 is x litre
Total volume of $CO_2 = 2x + 16.8 - x$
$\Rightarrow\quad 28 = 16.8 + x$
$x = 11.2L$
$n_{CH_4} = \frac{PV}{RT} = \frac{1 \times 5.6}{0.082 \times 298} = 0.229$ mole
$n_{C_2H_2} = \frac{11.2}{0.082 \times 298} = 0.458$ mole
$\therefore$ Heat evolved $= 0.229 \times 900 + 0.458 \times 1400$
$= 206.1 + 641.2$
$= 847.3\,kJ$

Question14

Which of the following relations are correct?
(A) $\Delta U = q + p\,\Delta V$
(B) $\Delta G = \Delta H - T\,\Delta S$
(C) $\Delta S = \frac{q_{rev}}{T}$
(D) $\Delta H = \Delta U - \Delta\, nRT$
Choose the most appropriate answer from the options given below :
[29-Jan-2023 Shift 2]

Options:

A. C and D only

B. B and C only

C. A and B only

D. B and D only

Answer: B

Solution:

Solution:
Only (B) and (C) are correct.
(B) $G = H - TS$
At constant T
$\Delta G = \Delta H - T\,\Delta\,S$
(A) First law is given by

$\Delta U = Q + W$
If we apply constant P and reversible work.
$\Delta U = Q - P \Delta V$
(C)By definition of entropy change
$dS = \frac{dq\, q_{rev}}{T}$
At constant T
$\Delta S = \frac{q_{rev}}{T}$
(D) $H = U + PV$
For ideal gas
$H = U + nRT$
At constant T
$\Delta H = \Delta U + \Delta nRT$

Question15

When 2 litre of ideal gas expands isothermally into vacuum to a total volume of 6 litre, the change in internal energy is ______ J. (Nearest integer)
[30-Jan-2023 Shift 1]

Answer: 0

Solution:

Solution:
For ideal gas $U = f(T)$
and for isothermal process, $\Delta U = 0$

Question16

1 mole of ideal gas is allowed to expand reversibly and adiabatically from a temperature of $27^{\circ}C$. The work done is $3\,kJ\,mol^{-1}$. The final temperature of the gas is _______ K (Nearest integer). Given $C_v = 20 J mol^{-1} K^{-1}$.
[30-Jan-2023 Shift 2]

Answer: 150

Solution:

Solution:
$q = 0$
$\Delta U = W$
$1 \times 20 \times [T_2 - 300] = -3000$

$T_2 - 300 = -150$
$T_2 = 150K$

Question17

The enthalpy change for the conversion of $\frac{1}{2}Cl_2(g)$ to $Cl^-(aq)$ is $(-)$ ________ $kJ\,mol^{-1}$(Nearest$^-$. integer)
Given : $\Delta_{dis} H_{Cl_{2(g)}}{}^{\circ} = 240 kJmol^{-1}$
$\Delta_{eg} H_{Cl_{(g)}}{}^{\circ} = -350 kJmol^{-1}$
$\Delta_{hyd} H_{Cl_{(g)}}{}^{\circ} = -380 kJmol^{-1}$
[31-Jan-2023 Shift 1]

Answer: 610

Solution:

$\frac{1}{2}Cl_{2(g)} \rightarrow Cl_{(g)} \rightarrow Cl_{(g)}{}^{-} \rightarrow Cl_{(aq.)}{}^{-}$

$\Delta H^{\circ} = \frac{1}{2} \times 240 + (-350) + (-380)$
$= -610$ ans.

Question18

Enthalpies of formation of $CCl_4(g)$, $H_2O(g)$, $CO_2(g)$ and $HCl(g)$ are -105, -242, -394 and $-92\,kJ\,mol^{-1}$ respectively. The magnitude of enthalpy of the reaction given below is ________ $kJ\,mol^{-1}$
(nearest integer)
$CCl_4(g) + 2H_2O(g) \rightarrow CO_2(g) + 4\,HCl(g)$
[31-Jan-2023 Shift 2]

Answer: 173

Solution:

$\Delta_r H = \sum H_p - \sum H_R$
$= (-394 + 4\times -92) - (-105 + (2\times -242))$
$= -173\,\text{kJ / mol}$

Question19

0.3g of ethane undergoes combustion at 27°C in a bomb calorimeter. The temperature of calorimeter system (including the water) is found to rise by 0.5°C. The heat evolved during combustion of ethane at constant pressure is ______ kJ mol^{-1}.
(Nearest integer)
[Given: The heat capacity of the calorimeter system is $20\,\text{kJ K}^{-1}$, R = $8.3\text{JK}^{-1}\text{mol}^{-1}$.
Assume ideal gas behaviour.
Atomic mass of C and H are 12 and 1gmol^{-1} respectively]
[1-Feb-2023 Shift 2]

Answer: 1006

Solution:

Solution:
(Bomb calorimeter → const volume
Heat released
By combustion of 1 mole
$C_2H_6(\Delta U) = -\dfrac{20 \times 0.5}{0.3} \times 30 = -1000\,\text{kJ}$
$C_2H_6(g) + 7/2 O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l)$
$\Delta ng = 2 - (2 + 7/2) = -(7/2)$
$\Delta H = \Delta U + \Delta nRT$
$= -1000 - 7/2 \times 8.3 \times 300\,\text{kJ}$
$= -1000 - 6.225$
$= -1006\,\text{kJ}$
So heat released $= 1006\,\text{kJ mol}^{-1}$

Question20

The value of $\log K$ for the reaction A ⇋ B at 298K is___
(Nearest integer)
Given: $\Delta H^0 = -54.07\,\text{kJ mol}^{-1}$
$\Delta S^\circ = 10\text{JK}^{-1}\text{mol}^{-1}$
(Take $2.303 \times 8.314 \times 298 = 5705$)
[6-Apr-2023 shift 1]

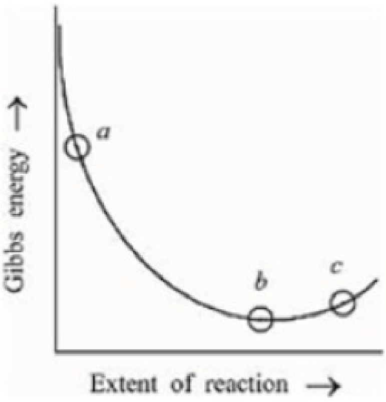
Answer: 10

Solution:

Solution:
$\Delta G^0 = \Delta H^0 - T \Delta S$
$\Rightarrow \Delta G^0 = (-54070 - 10 \times 298)$
Also, $\Delta G^0 = (-2.303 RT \log K)$
$\Rightarrow (-54070 - 10 \times 298)$
$= (-2.303 \times 8.134 \times 298 \log K)$
$\Rightarrow \log K = 10$ Ans: 10

Question21

Consider the graph of Gibbs free energy G vs Extent of reaction. The number of statement/s from the following which are true with respect to points (a), (b) and (c) is____



A. Reaction is spontaneous at (a) and (b)
B. Reaction is at equilibrium at point (b) and nonspontaneous at point (c)
C. Reaction is spontaneous at (a) and nonspontaneous at (c)
D. Reaction is non-spontaneous at (a) and (b)
[6-Apr-2023 shift 1]

Answer: 2

Solution:

Solution:
For, Spontaneous process $dG < 0$
For, Equilibrium $dG = 0$
For, Nonspontaneous process $dG > 0$
∴ A Wrong
B Correct
C Correct
D Wrong

Question22

Consider the following date
Heat of combustion of $H_2(g) = -241.8\,kJ\,mol^{-1}$
Heat of combustion of $C(s) = -393.5\,kJ\,mol^{-1}$
Heat of combustion of $C_2H_5OH(1) = -1234.7\,kJ\,mol^{-1}$.
The heat of formation of $C_2H_5OH(1)$ is (-)____ kJ mol^{-1} (Nearest integer)
[6-Apr-2023 shift 2]

Answer: 278

Solution:

$$2C_{(s)} + 3H_{2(g)} + \frac{1}{2}O_{2(g)} \rightarrow C_2H_5OH_{(l)}$$
$$(\Delta H_f)_{C_2H_5OH_{(1)}} = \Sigma(\Delta H_{comb})_{reactant} - \sum(\Delta H_{comb})_{product}$$
$$= 2 \times (-393.5) + 3(-241.8) - (-1234.7)$$
$$= -277.7\,kJ/mol$$

Question23

When a 60W electric heater is immersed in a gas for 100 s in a constant volume container with adiabatic walls, the temperature of the gas rises by 5°C. The heat capacity of the given gas is ______ JK^{-1} (Nearest integer)
[8-Apr-2023 shift 1]

Answer: 1200

Solution:

Solution:
Adiabatic wall \{no heat exchange between system and surrounding\}
$$C_v \times \Delta T = P \times t / \text{ sec}$$
$$C_v \times 5 = 60 \times 100$$
$$C_v = 1200$$

Question24

For complete combustion of ethane,
$C_2H_4(g) + 3O_2(g) \rightarrow 2CO_2(g) + 2H_2O(l)$
The amount of heat produced as measured in bomb calorimeter is $1406\,KJ\,mol^{-1}$ at 300K. The minimum value of $T\,\Delta\,S$ needed to reach equilibrium is _______ (−) KJ (Nearest integer)
Given : $R = 8.3JK^{-1}mol^{-1}$
[8-Apr-2023 shift 2]

Answer: 1411

Solution:

Solution:
$\Delta G = \Delta H - T\,\Delta\,S$ at equilibrium:-
$\Delta\,G = 0$
$T\,\Delta\,S = \Delta H = \Delta U + \Delta\,ngRT = -1406 + (-2) \times 8.3 \times 300 \times 10^{-3} = -1410.98 \approx 1411$

Question25

The number of incorrect statement from the following is _______
[8-Apr-2023 shift 2]

Options:

A. The electrical work that a reaction can perform at constant pressure and temperature is equal to the reaction Gibbs energy

B. $E_{cell}{}^{0}$ is dependent on the pressure

C. $\frac{dE_{cell}{}^{o}}{dT} = \frac{\Delta_r S^{\circ}}{nF}$

D. A cell is operating reversibly if the cell potential is exactly balanced by an opposing source of potential difference

Answer: A

Solution:

Solution:
$dG = vdp - sd\,T$
$dG = -\,sd\,T$
$\frac{dG}{dT} = -S \Rightarrow \frac{d\,\Delta\,G}{dT} = -\,\Delta\,S$
$\frac{dE^{\circ}}{dT} = \frac{-\,\Delta\,S}{-nF}$

Question26

The enthalpy change for the adsorption process and micelle formation respectively are
[10-Apr-2023 shift 1]

Options:

A. $\Delta H_{ads} < 0$ and $\Delta H_{mic} < 0$

B. $\Delta H_{ads} > 0$ and $\Delta H_{mic} < 0$

C. $\Delta H_{ads} < 0$ and $\Delta H_{mic} > 0$

D. $\Delta H_{ads} > 0$ and $\Delta H_{mic} > 0$

Answer: C

Solution:

Solution:
Adsorption → Exothermic ($\Delta H_{ads} = -ve$)
Micelle formation → Endothermic ($\Delta H_{mic} = +ve$)
$\Delta H_{ads} < O$ and $\Delta H_{mic} > O$

Question27

Given
(A) $\mathbf{2\,CO(g) + O_2(g) \rightarrow 2CO_2(g)\ \Delta H_1^o = -x\,kJ\,mol^{-1}}$

(B) $\mathbf{C\ (graphite) + O_2(g) \rightarrow CO_2(g)\quad \Delta H_2^{\circ} = -y\,KJ\,mol^{-1}}$
The $\mathbf{\Delta H^{\circ}}$ **for the reaction** $\mathbf{C(graphite) + \frac{1}{2}O_2(g) \rightarrow CO(g)}$ **is**
[10-Apr-2023 shift 1]

Options:

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

B. $\frac{x + 2y}{2}$

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

D. $2y - x$

Answer: A

Solution:

Solution:
$2\,CO(g) + O_2(g) \rightarrow 2CO_2(g)\quad \Delta H_1^{\circ} = y\,kJ\,/\,mol$ ....(2)
$C(\ graphite\ ) + O_2(g) \rightarrow CO_2(g)\quad \Delta H_2^{\circ} = -y\ kJ\,/\,mol$......... (2)

$C(\ \text{graphite}\ ) + {}^{1/2}O_2(g) \rightarrow CO(g) \quad \Delta H_3^\circ = ?$

$\Delta H_3^\circ = H_2^\circ - \frac{H_1^\circ}{2} = -y - \frac{-x}{2}$

$\Delta H_3^\circ = \frac{x}{2} - y = \frac{x - 2y}{2}$

Question28

$$\mathbf{FeO_4^{2-} \xrightarrow{+2.2V} Fe^{3+} \xrightarrow{+0.70V} Fe^{2+} \xrightarrow{-0.45V} Fe^{0}}$$

$E^\circ_{FeO_4^{2-}/Fe^{2+}}$ is $x \times 10^{-3}$V.

The value of x is ______

[10-Apr-2023 shift 1]

Answer: 1825

Solution:

Solution:

$$\begin{aligned}
&FeO_4^{2-} + 3e^\ominus \rightarrow Fe^{+3}\ \Delta G_1 \\
&\underline{\quad Fe^{+3} + e^\ominus \rightarrow Fe^{+2}\ \Delta G_2 \quad} \\
&FeO_4^{-2} + 4e^\ominus \rightarrow Fo^{+2}\ \Delta G_3
\end{aligned}$$

$\Delta G_3 = \Delta G_1 + \Delta G_2$

$(-)4E_3^\circ F = (-)3 \times 2.2 \times F + (-)1 \times 0.7 \times f$

$4E_3^\circ = 6.6 + 0.7 = 7.3$

$E_3^\circ = \frac{7.3}{4} = 1.825 = 1825 \times 10^{-3}$

Question29

The number of incorrect statement/s about the black body from the following is ______

(A) Emit or absorb energy in the form of electromagnetic radiation

(B) Frequency distribution of the emitted radiation depends on temperature

(C) At a given temperature, intensity vs frequency curve passes through a maximum value

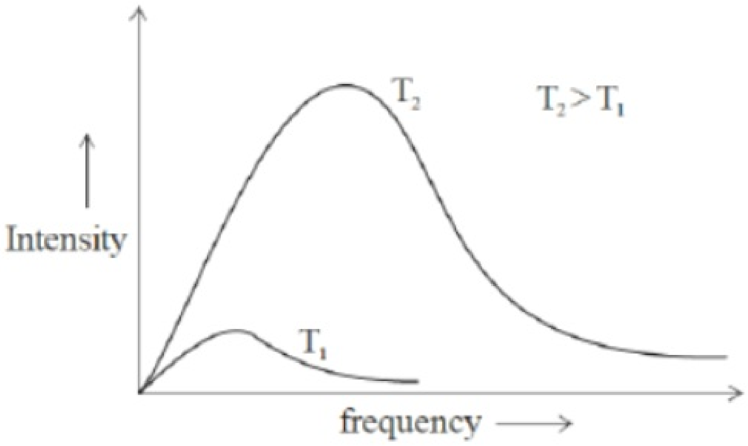
(D) The maximum of the intensity vs frequency curve is at a higher frequency at higher temperature compared to that at lower temperature

[10-Apr-2023 shift 1]

Answer: 0

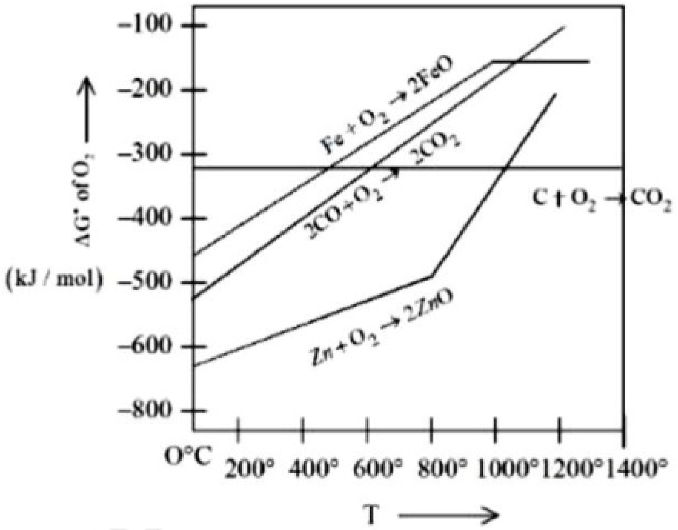
Solution:

Solution:



Question30

Gibbs energy vs T plot for the formation of oxides is given below.



For the given diagram, the correct statement is - [10-Apr-2023 shift 2]

Options:

A. At 600˚C, C can reduce ZnO

B. At 600˚C, C can reduce FeO

C. At 600˚C, CO cannot reduce FeO

D. At 600˚C, CO can reduce ZnO

Answer: B

Solution:

Solution:
$FeO + C \rightarrow Fe + CO_2$
At 600˚C Δ G of Reaction is −Ve

Question31

$A(g) \rightleftharpoons 2B(g) + C(g)$
For the given reaction, if the initial pressure is $450\,\text{mmHg}$ and the pressure at time t is $720\,\text{mmHg}$ at a constant temperature T and constant volume V. The fraction of A(g) decomposed under these conditions is $x \times 10^{-1}$. The value of x is ________ (nearest integer)
[10-Apr-2023 shift 2]

Answer: 3

Solution:

Solution:

$A(g) \rightleftharpoons 2B(g) + C(g)$
$t = 0 \;\; 450$
$\;\; \text{time} \;\; 450 - x \;\; 2x$
$P_T = P_A + P_B + P_C$
$720 = 450 - x + 2x + x$
$2x = 270$
$x = 135$

Fraction of A decomposed $= \dfrac{135}{450} = 0.3 = 3 \times 10^{-1}$

So, $x = 3$

Question32

The number of endothermic process/es from the following is
A. $I_2(g) \rightarrow 2I(g)$
B. $HCl(g) \rightarrow H(g) + Cl(g)$
C. $H_2O(l) \rightarrow H_2O(g)$
D. $C(s) + O_2(g) \rightarrow CO_2(g)$
E. Dissolution of ammonium chloride in water
[10-Apr-2023 shift 2]

Answer: 4

Solution:

Solution:
A→ Endothermic (Atomisation) B→ Endothermic (Atomisation)
C→ Endothermic (Vapourisation) D→ Exothermic (Combustion)
E→ Endothermic (Dissolution)

Question33

Solid fuel used in rocket is a mixture of Fe_2O_3 and Al (in ratio 1 : 2) the heat evolved (KJ) per gram of the mixture is ________ (Nearest integer)
Givne $\Delta H_f^{\ominus}(Al_2O_3) = -1700\,KJ\,mol^{-1}$
$\Delta H_f^{\ominus}(Fe_2O_3) = -840\,KJ\,mol^{-1}$
[11-Apr-2023 shift 1]

Answer: 4

Solution:

Solution:
$Fe_2O_3 + 2\,Al \rightarrow Al_2O_3 + 2\,Fe$
$\Delta H_r\ = (\Delta H_f)Al_2O_3 - \Delta\ H_f^{\circ}(Fe_2O_3)$
$= -1700 - (-840)$
$= -860\,kJ$
$Fe_2O_3 \& Al \rightarrow 1 : 2$
$Fe_2O_3 = 1\,mole\ = (2 \times 25 + 48)$
$= 112 + 48 = 160\,gm$
Al $= 2\,mole = 2 \times 27 = 54\,gm$
Total mass $= 160 + 54 = 214\,gm$
Heat evolved per gm $= \dfrac{-860}{214}\,kJ = -4.01 \approx 4\,kJ$

Question34

The total number of intensive properties from the following is ______ new line volume, Molar heat capacity, Molarity, E^{θ} cell, Gibbs free energy change, Molar mass, Mole
[11-Apr-2023 shift 2]

Answer: 4

Solution:

Solution:
Extensive ⇒ Mole, Volume, Gibbs free energy.
Intensive ⇒ Molar mass, Molar heat capacity, Molarity, E^{θ} cell.

Question35

One mole of an ideal gas at 350K is in a 2.0L vessel of thermally conducting walls, which are in contact with the surroundings. It undergoes isothermal reversible expansion from 2.0L to 3.0L against a constant pressure of 4 atm. The change in entropy of the surroundings (ΔS) is _______ JK^{-1} (Nearest integer)
Given: $R = 8.314 JK^{-1} mol^{-1}$
[12-Apr-2023 shift 1]

Answer: 3

Solution:

$$\Delta S_{\text{System}} = nR\ell\left(\frac{V_2}{V_1}\right) = 1 \times 8.314 \ln\left(\frac{3}{2}\right)$$

$$\Delta S_{\text{System}} = 3.37$$

$$\Delta S_{\text{Sur.}} = 3.37$$

Question36

$A_2 + B_2 \rightarrow 2AB \cdot \Delta H_f^0 = -200\,kJ\,mol^{-1}$ new line AB, A_2 and B_2 are diatomic molecules. If the bond enthalpies of A_2, B_2 and AB are in the ratio 1 : 0.5 : 1, then the bond enthalpy of A_2 is _______ $kJ\,mol^{-1}$.
(Nearest integer)
[13-Apr-2023 shift 1]

Answer: 800

Solution:

$A_2 + B_2 \rightarrow 2AB \quad \Delta H_f^{\circ} = -200\,kJ / mol$

Bond enthalpy of $A_2 = x$

Bond enthalpy of $B_2 = 0.5x$

Bond enthalpy of $AB = x$

$\Delta H_f^{\circ} = x + 0.5x - 2x = -2(200)$

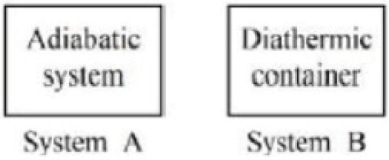
$-0.5x = -400$

$x = \dfrac{400}{0.5} = 800\,kJ / mol$

Bond enthalpy of $A_2 = x = 800\,kJ / mol$

Question37

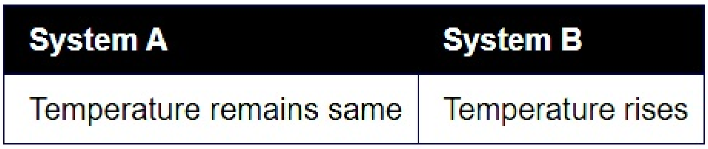
What happens when methane undergoes combustion in systems A and B respectively?



[13-Apr-2023 shift 2]

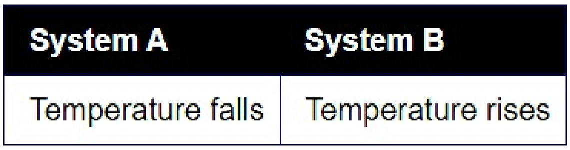
Options:

A.



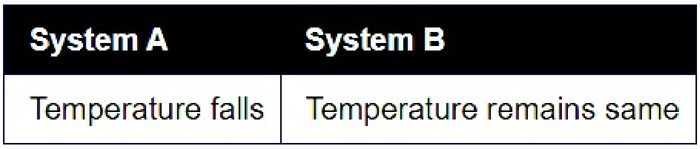
System A	System B
Temperature remains same	Temperature rises

B.



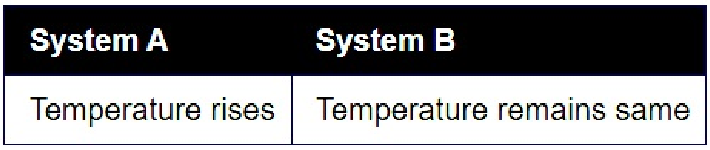
System A	System B
Temperature falls	Temperature rises

C.



System A	System B
Temperature falls	Temperature remains same

D.



System A	System B
Temperature rises	Temperature remains same

Answer: D

Solution:

Solution:
Adiabatic boundary does not allow heat exchange thus heat generated in container can't escape out thereby increasing the temperature. In case of Diathermic container, heat flow can occur to maintain the constant temperature.

Question38

30.4 kJ of heat is required to melt one mole of sodium chloride and the entropy change at the melting point is _______ 28.4 $JK^{-1}mol^{-1}$ at 1 atm. The melting point of sodium chloride is K. (Nearest Integer)
[15-Apr-2023 shift 1]

Answer: 1070

Solution:

Solution:

$$\Delta S = \frac{\Delta H}{T_{mp}}$$

$$28.4 = \frac{30.4 \times 1000}{T_{mp}}$$

$$T_{mp} = 1070.422K.$$

Question39

$2O_3(g) \rightleftharpoons 3O_2(g)$

At 300K, ozone is fifty percent dissociated. The standard free energy change at this temperature and 1 atm pressure is (−)______Jmol^{-1}.

(Nearest integer)

[Given : In 1.35 = 0.3 and .R = 8.3JK^{-1}mol^{-1}]

[24-Jun-2022-Shift-1]

Answer: 747

Solution:

Solution:

$$\underset{1-x}{2O_3(g)} \rightleftharpoons \underset{\frac{3x}{2}}{3O_2(g)}$$

Given, $x = 0.5$

$$\therefore k_p = \frac{[3(0.5)]^3 \times 1}{[2]^3 \times (0.5)^2 \times 1.25}$$

$$\therefore k_p = \frac{27}{8} \times \frac{0.5}{1.25} = 1.35$$

$$\Delta G^\circ = -2.303\,RT\log k_p$$

$$= -2.303 \times 8.3 \times 300\log 1.35$$

$$= -8.3 \times 300\ln(1.35)$$

$$= -747\text{Jmol}^{-1}$$

Question40

The standard entropy change for the reaction

$4\,Fe(s) + 3O_2(g) \rightarrow 2Fe_2O_3(s)$ is $-550JK^{-1}$ at 298K.

[Given : The standard enthalpy change for the reaction is $-165\,kJ\,mol^{-1}$].

The temperature in K at which the reaction attains equilibrium

is____(Nearest Integer)
[25-Jun-2022-Shift-1]

Answer: 300

Solution:

Solution:
$\Delta G = \Delta H - T\Delta S = 0$ at equilibrium
$\Rightarrow -165 \times 10^3 - T \times (-505) = 0$
$\Rightarrow T = 300K$

Question41

At 25°C and 1 atm pressure, the enthalpy of combustion of benzene (I) and acetylene (.g) are $-3268\,kJ\,mol^{-1}$ and $-1300\,kJ\,mol^{-1}$, respectively. The change in enthalpy for the reaction $3C_2H_2(g) \rightarrow C_6H_6(I)$, is
[25-Jun-2022-Shift-2]

Options:

A. $+324\,kJ\,mol^{-1}$

B. $+632\,kJ\,mol^{-1}$

C. $-632\,kJ\,mol^{-1}$

D. $-732\,kJ\,mol^{-1}$

Answer: C

Solution:

Solution:
$\Delta H = \Sigma\Delta H_{Combustion}$ (Reactant) $-\Sigma\Delta H_{Combustion}$ (Product)
$= 3 \times (-1300) - [-3268]$
$= -632\,kJ\,mol^{-1}$

Question42

For complete combustion of methanol
$CH_3OH(I) + \frac{3}{2}O_2(g) \rightarrow CO_2(g) + 2H_2O(I)$
the amount of heat produced as measured by bomb calorimeter is $726\,kJ\,mol^{-1}$ at 27°C. The enthalpy of combustion for the reaction is $-x\,kJ\,mol^{-1}$, where x is____ (Nearest integer)

(Given : R = $8.3 JK^{-1} mol^{-1}$)
[26-Jun-2022-Shift-1]

Answer: 727

Solution:

Solution:

$CH_3OH(l) + \frac{3}{2}O_2(g) \rightarrow CO_2(g) + 2H_2O(l)$

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

$= -726\,kJ + \left(\frac{-1}{2}\right) \times 8.3 \times 300$

$\simeq -727\,kJ\,mol^{-1}$

Question43

CNG is an important transportation fuel. When 100g CNG is mixed with 208g oxygen in vehicles, it leads to the formation of CO2 and H_2O and produces large quantity of heat during this combustion, then the amount of carbon dioxide, produced in grams is ____ [nearest integer] [Assume CNG to be methane]
[26-Jun-2022-Shift-2]

Answer: 143

Solution:

Solution:

$$\begin{array}{lcccc} & CH_4 & +\,2O_2 \longrightarrow & CO_2 & +\,2H_2O \\ \text{Initially:} & 6.25 & 6.5 & 0 & 0 \\ \text{finally:} & 6.25-\frac{6.5}{2} & 0 & \frac{6.5}{2} & 6.5 \end{array}$$

Initially,
Mass of $CNG(CH_4) = 100\,gm$
$\therefore$ Moles of $CH_4 = \frac{100}{16} = 6.25$ moles
Mass of $O_2 = 208\,gm$
$\therefore$ Moles of $O_2 = \frac{208}{32} = 6.5$ moles
From reaction you can see,
1 mole of CH_4 react with 2 mole of O_2
$\therefore$6.25 mole of CH_4 react with 6.25 × 2 = 12.5 moles of O_2
But here only 6.5 moles of O_2 present
So, O_2 will act as limiting reagent.
$\therefore$ Produced CO_2 will depends on moles of O_2.
From 2 moles of $O_2$1 mole of CO_2

∴ From 6.5 moles of O_2 $\frac{6.5}{2}$ moles of CO_2 produced.

∴ Weight of CO_2 = $\frac{6.5}{2} \times 44 = 143\,\mathrm{gm}$

Question44

A fish swimming in water body when taken out from the water body is covered with a film of water of weight 36g. When it is subjected to cooking at 100°C, then the internal energy for vaporization in $\mathrm{kJ\,mol^{-1}}$ is _____[nearest integer]
[Assume steam to be an ideal gas. Given $\Delta_{vap}H^{\Theta}$ for water at 373K and 1 bar is $41.1\,\mathrm{kJ\,mol^{-1}}$; $R = 8.31\mathrm{JK^{-1}mol^{-1}}$]
[26-Jun-2022-Shift-2]

Answer: 38

Solution:

Solution:

$H_2O(l) \rightarrow H_2O(g)$

$n = \frac{36}{18} = 2\,\mathrm{mol}$

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

$= 41.1 - \frac{1 \times 8.31 \times 373}{1000}\,\mathrm{kJ / mol}$

$= 38\,\mathrm{kJ / mol}$

Question45

40% of HI undergoes decomposition to H_2 and I_2 at 300K. $\Delta G^{\ominus}$ for this decomposition reaction at one atmosphere pressure is ____ $\mathrm{Jmol^{-1}}$.
[nearest integer]
(Use .$R = 8.31\mathrm{JK^{-1}mol^{-1}}$; $\log 2 = 0.3010$, $\ln 10 = 2.3$, $\log 3 = 0.477$)
[26-Jun-2022-Shift-2]

Answer: 2735

Solution:

$$\begin{array}{llll} & HI & \rightleftharpoons \frac{1}{2}H_2 & + \frac{1}{2}I_2 \\ \text{At } t = 0: & 1 & 0 & 0 \\ \text{At } t = t_{eq}: & 1-\alpha & \frac{\alpha}{2} & \frac{\alpha}{2} \end{array}$$

$$\therefore K = \frac{\left(\frac{\alpha}{2}\right)^{1/2} \times \left(\frac{\alpha}{2}\right)^{1/2}}{(1-\alpha)}$$

Given $\alpha = \frac{40}{100} = 0.4$

$$\therefore K = \frac{\left(\frac{0.4}{2}\right)^{1/2} \times \left(\frac{0.4}{2}\right)^{1/2}}{(1-0.4)}$$

$$= \frac{1}{3}$$

We know,

$\Delta G^{\circ} = -RT \ln K$

$= -RT \ln\left(\frac{1}{3}\right)$

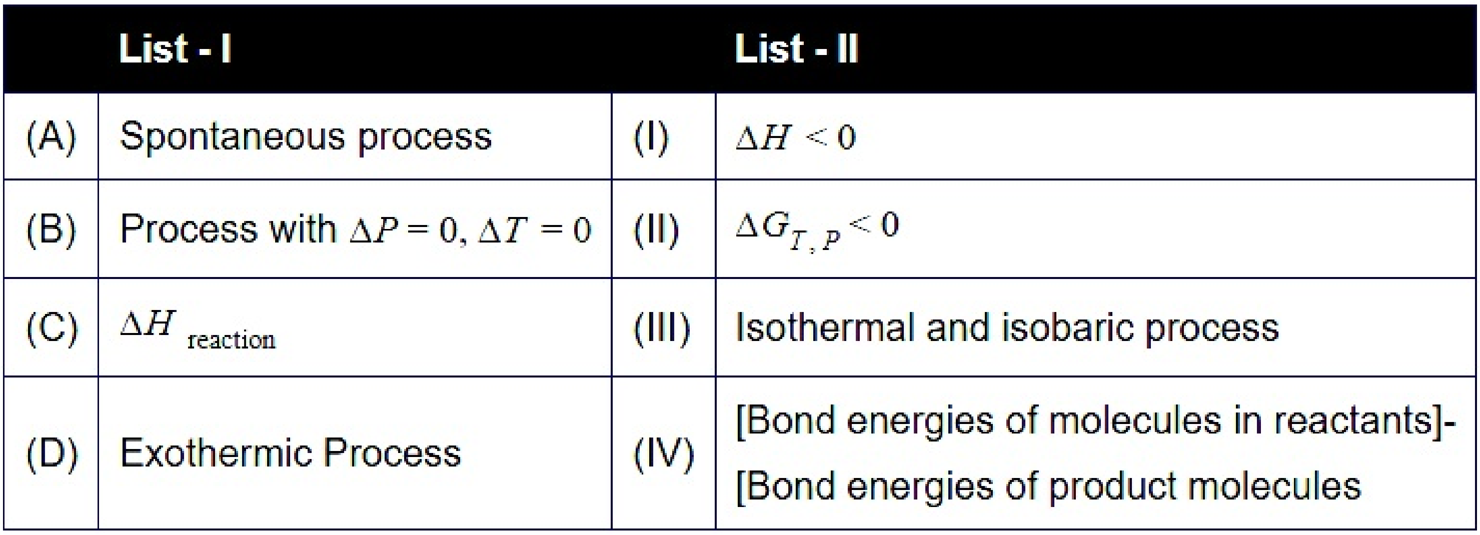
$= +RT \ln 3$

$= +8.314 \times 300 \times \ln 3$

$= 2735 J / mol$

Question46

Choose the correct answer from the options given below:



	List - I		List - II
(A)	Spontaneous process	(I)	$\Delta H < 0$
(B)	Process with $\Delta P = 0, \Delta T = 0$	(II)	$\Delta G_{T,P} < 0$
(C)	$\Delta H_{\text{reaction}}$	(III)	Isothermal and isobaric process
(D)	Exothermic Process	(IV)	[Bond energies of molecules in reactants]- [Bond energies of product molecules

[27-Jun-2022-Shift-1]

Options:

A. (A) - (III), (B) - (II), (C) - (IV), (D) - (I)

B. (A) - (II), (B) - (III), (C) - (IV), (D) - (I)

C. (A) - (II), (B) - (III), (C) - (I), (D) - (IV)

D. (A) - (II), (B) - (I), (C) - (III), (D) - (IV)

Answer: B

Solution:

Solution:

(A) For a spontaneous process $\Delta G_{T,P} < 0$

(B) $\Delta P = 0 \rightarrow$ Isobaric process, $\Delta T = 0 \rightarrow$ Isothermal process
(C) $\Delta H_{\text{reaction}} = (\Sigma$ Bond energies of reactants $) - (\Sigma$ bond energies of products $)$
(D) $\Delta H < 0$ is for exothermic reaction

Question47

When 5 moles of He gas expand isothermally and reversibly at 300K from 10 litre to 20 litre, the magnitude of the maximum work obtained is____ J. [nearest integer] (Given : $R = 8.3 JK^{-1} mol^{-1}$ and $\log 2 = 0.3010$)
[27-Jun-2022-Shift-2]

Answer: 8630

Solution:

Solution:

$$W_{rev} = -2.303\, nRT \log_{10}\left(\frac{V_2}{V_1}\right)$$
$$= -2.303 \times 5 \times 8.3 \times 300 \times \log_{10}\left(\frac{20}{10}\right)$$
$$\simeq -8630 J$$

Question48

4.0L of an ideal gas is allowed to expand isothermally into vacuum until the total volume is 2.0L. The amount of heat absorbed in this expansion is _____L atm.
[28-Jun-2022-Shift-1]

Answer: 0

Solution:

Solution:
Work done $= -P_{ext}\ \Delta v$
$\because P_{ext} = 0$ (vacuum)
$\therefore w = 0, \quad \Delta U = 0$ (as the process is isothermal)
So, $q = 0$

Question49

For combustion of one mole of magnesium in an open container at 300K and 1 bar pressure, $\Delta_C H^{\ominus} = -601.70\,\text{kJ mol}^{-1}$, the magnitude of change in internal energy for the reaction is _____ kJ. (Nearest integer)
(Given : $R = 8.3\,\text{JK}^{-1}\text{mol}^{-1}$)
[28-Jun-2022-Shift-2]

Answer: 600

Solution:

Solution:

$Mg(s) + \frac{1}{2}O_2(g) \longrightarrow MgO(s)$

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

$\Delta n_g = -\frac{1}{2}$

$-601.70 = \Delta U - \frac{1}{2}(8.3)(300) \times 10^{-3}$

$\Delta U = -601.70 + 1.245$

$\Delta U \simeq -600\,\text{kJ}$

The magnitude of change in internal energy is 600 kJ.

Question50

17.0g of NH_3 completely vapourises at $-33.42^{\circ}C$ and 1 bar pressure and the enthalpy change in the process is $23.4\,\text{kJ mol}^{-1}$. The enthalpy change for the vapourisation of 85g of NH_3 under the same conditions is ____kJ.
[29-Jun-2022-Shift-1]

Answer: 117

Solution:

Solution:

Given data is for 1 moles and asked for 5 moles so
value is 23.4 × 5 = 117 kJ

Question51

2.2g of nitrous oxide (N_2O) gas is cooled at a constant pressure of 1 atm from 310K to 270K causing the compression of the gas from 217.1 mL to 167.75 mL. The change in internal energy of the process, ΔU is ' $-x$' J .

The value of ' x ' is _____[nearest integer]
(Given : atomic mass of N = $14 g mol^{-1}$ and of O = $16 g mol^{-1}$. Molar heat capacity of N_2O is $100 J K^{-1} mol^{-1}$)
[29-Jun-2022-Shift-2]

Answer: 195

Solution:

Solution:
$\Delta T = -40K$
$\Delta U = q + w$
$= \frac{100 \times 2.2}{44}(-40) - (-49.39) \times 10^{-3} \times 101.325$
$= -200 + 5$
$= -195J$
$x = 195$

Question52

The enthalpy of combustion of propane, graphite and dihydrogen at 298K are $-2220.0 kJ mol^{-1}$, $-393.5 kJ mol^{-1}$ and $-285.8 kJ mol^{-1}$ respectively. The magnitude of enthalpy of formation of propane (C_3H_8) is kJ mol^{-1}. (Nearest integer)
[25-Jul-2022-Shift-1]

Answer: 104

Solution:

Solution:
Enthalpy of combustion of propane, graphite and H_2 at 298K are
$C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(I), \Delta H_1 = -2220 \, kJ \, mol^{-1}$
$C(\text{ graphite }) + O_2(g) \rightarrow CO_2(g), \quad \Delta H_2 = -393.5 \, kJ \, mol^{-1}$
$H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(I), \quad \Delta H_3 = -285.8 \, kJ \, mol^{-1}$
The desired reaction is
$3C \text{ (graphite) } + 4H_2(g) \rightarrow C_3H_8(g)$
$\Delta H_f = 3 \Delta H_2 + 4 \Delta H_3 - \Delta H_1$
$= 3(-393.5) + 4(-285.8) - (-2220)$
$= -103.7 \, kJ \, mol^{-1}$
$|\Delta H_f| \simeq 104 \, kJ \, mol^{-1}$

Question53

While performing a thermodynamics experiment, a student made the following observations.
$HCl + NaOH \rightarrow NaCl + H_2O\ \Delta H = -57.3 kJ\ mol^{-1}$
$CH_3COOH + NaOH \rightarrow CH_3COONa + H_2O\ \Delta H = -55.3 kJ\ mol^{-1}$
The enthalpy of ionization of CH_3COOH as calculated by the student is _____ $kJ\ mol^{-1}$. (nearest integer)
[25-Jul-2022-Shift-2]

Answer: 2

Solution:

Solution:
(I) $HCl + NaOH \rightarrow NaCl + H_2O$
$\Delta H_1 = -57.3 KJmol^{-1}$
(II) $CH_3COOH + NaOH \rightarrow CH_3COONa + H_2O$
$\Delta H_2 = -55.3 KJmol^{-1}$
Reaction (I) can be written as
(III) $NaCl + H_2O \rightarrow HCl + NaOH$
$\Delta H_3 = 57.3 KJmol^{-1}$
By adding (II) and (III)
$CH_3COOH + NaCl \rightarrow CH_3COONa + HCl \quad \Delta H_r$
$\Delta H_r = \Delta H_3 + \Delta H_2 \quad = 57.3 - 55.3$
$= 2 kJ\ mol^{-1}$

Question54

2.4g coal is burnt in a bomb calorimeter in excess of oxygen at 298K and 1 atm pressure. The temperature of the calorimeter rises from 298K to 300K. The enthalpy change during the combustion of coal is $-x\ kJ\ mol^{-1}$. The value of x is _______. (Nearest Integer)
(Given : Heat capacity of bomb calorimeter $20.0\ kJ\ K^{-1}$. Assume coal to be pure carbon)
[26-Jul-2022-Shift-1]

Answer: 200

Solution:

Solution:
$Q(\text{ Heat evolved }) = -\frac{C_{system}\Delta T}{n}$
$n_{coal} = \frac{2.4}{12}$

$Q = \frac{-20(300-298)}{0.2}$

$Q = -200\,\text{kJ / mol}$

$x = 200$

Question55

For the reaction

$H\ _2F_2(g) \rightarrow H_2(g) + F_2(g)$

$\Delta U\ = -59.6\,\text{kJ}\,\text{mol}^{-1}$ at $27^{\circ}C$

The enthalpy change for the above reaction is (−) ______ $\text{kJ}\,\text{mol}^{-1}$ [nearest integer]

Given: $R = 8.314 JK^{-1}mol^{-1}$

[26-Jul-2022-Shift-2]

Answer: 57

Solution:

Solution:

$H_2F_2(g) \longrightarrow H_2(g) + F_2(g)$

$\Delta U = -59.6\,\text{kJ}\,\text{mol}^{-1}$ at $27^{\circ}C$

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

$= -59.6 + \frac{1 \times 8.314 \times 300}{1000}$

$= -57.10\,\text{kJ}\,\text{mol}^{-1}$

Question56

The molar heat capacity for an ideal gas at constant pressure is $20.785 JK^{-1}mol^{-1}$. The change in internal energy is 5000J upon heating it from 300K to 500K. The number of moles of the gas at constant volume is ______. [[Nearest integer] (Given: $R = 8.314 JK^{-1}mol^{-1}$)

[27-Jul-2022-Shift-1]

Answer: 2

Solution:

Solution:

$C_p = 20.785 JK^{-1}mol^{-1}$

and $\Delta U = nCv\,\Delta\,T$

$\therefore\ nC_v = \frac{5000}{200} = 25$

and we know that

$C_p - C_v = R$

$20.785 - \frac{25}{n} = 8.314$

$n = \frac{25}{(20.785 - 8.314)} = 2$

Question57

A gas (Molar mass $= 280 gmol^{-1}$) was burnt in excess O_2 in a constant volume calorimeter and during combustion the temperature of calorimeter increased from 298.0K to 298.45K. If the heat capacity of calorimeter is $2.5\,kJ\,K^{-1}$ and enthalpy of combustion of gas is $9\,kJ\,mol^{-1}$ then amount of gas burnt is ________ g. (Nearest Integer) [27-Jul-2022-Shift-2]

Answer: 35

Solution:

Solution:

Let xg is burnt

$\text{moles} = \frac{x}{280}$

heat released by $\frac{x}{280}$ mole $= 2.5 \times 0.45\,kJ$

heat released by 1 mole $= \frac{2.5 \times 0.45 \times 280}{x} kJ$

$\Delta H = \Delta U + \Delta ngRT$

$\Delta H \simeq \Delta U$

$9 = \frac{2.5 \times 280 \times 0.45}{x}$

$x = 35g$

Question58

Which of the following relation is not correct? [28-Jul-2022-Shift-1]

Options:

A. $\Delta H = \Delta U - P\Delta V$

B. $\Delta U - q + W$

C. $\Delta S_{sys} + \Delta S_{surr} \ge sl\,ant0$

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

Answer: A

Solution:

Solution:
If U + Pv (By definition)
Δ14 = ΔU + Δ (Pr) at constant pressure
$\Delta H = \Delta U + P \Delta V$

Question59

Given below are two statements: One is labelled as Assertion AA and the other is labelled as Reason RR
Assertion A: The reduction of a metal oxide is easier if the metal formed is in liquid state than solid state.
Reason RR : The value of $\Delta G^{\ominus}$ Δ G becomes more on negative side as entropy is higher in liquid state than solid state.
In the light of the above statements, choose the most appropriate answer from the options given below
[28-Jul-2022-Shift-2]

Options:

A. Both A and R are correct and R is the correct explanation of A

B. Both A and R are correct but R is NOT the correct explanation of A

C. A is correct but R is not correct

D. A is not correct but R is correct

Answer: A

Solution:

Solution:
Reduction of a metal oxide is easier if the metal is formed in a liquid state at the temperature of reduction because the entropy is higher if the metal is in a liquid state.

Question60

Among the following the number of state variables is _______.
Internal energy (U)
Volume (V)
Heat (q)
Enthalpy (H)
[28-Jul-2022-Shift-2]

Answer: 3

Solution:

State variables are internal energy (U), Volume (V) and Enthalpy (H).

Question61

When 600 mL of 0.2MHNO_3 is mixed with 400 mL of 0.1M NaOH solution in a flask, the rise in temperature of the flask is _______ $\times 10^{-2}$°C (Enthalpy of neutralisation = 57 kJ mol^{-1} and Specific heat of water = 4.2$JK^{-1}g^{-1}$) (Neglect heat capacity of flask)
[29-Jul-2022-Shift-1]

Answer: 54

Solution:

Solution:
HNO_3
$600\text{ mL} \times 0.2\text{M} = 120\text{m mol}$
NaOH
$400\text{ mL} \times 0.1\text{M} = 40\text{m mol}$

$$\begin{array}{lllll} & HNO_3 + & NaOH \rightarrow & NaNO_3 + H_2O & \\ \text{Bef.} & 120 & 40 & & \\ \text{Aft.} & 80 & 0 & & 40\text{m mol} \end{array}$$

Heat liberated from reaction
$= 40 \times 10^{-3} \times 57 \times 10^3$JHeat gained by solution $= mC\,\Delta T$
m = mass of solution $= V \times d = 1000 \times 1$
$= 1000g$
Heat gained by solution $= 1000 \times 4.2 \times \Delta T$... (2)
From (1) and (2)
Heat liberated = Heat gained
$40 \times 10^{-3} \times 57 \times 10^3 = 1000 \times 4.2 \times \Delta T$
$\Delta T = 54 \times 10^{-2}$°C
(Rounded off to the nearest integer)

Question62

Five moles of an ideal gas at 293K is expanded isothermally from an initial pressure of 2.1M Pa to 1.3M Pa against at constant external pressure 4.3M Pa. The heat transferred in this process is .... kJ mol^{-1}. (Rounded off to the nearest integer) [R = 8.314J $mol^{-1}K^{-1}$]
[25 Feb 2021 Shift 2]

Answer: 15

Solution:

Solution:

The gas performs isothermal irreversible work (W).
where, $\Delta U = 0$ (change in internal energy)
From, 1st law of thermodynamics,
$\Rightarrow \Delta U = \Delta Q + W$
$\Rightarrow 0 = \Delta Q + W$
$\Rightarrow \Delta Q = -W$
$\text{Now,} \quad W = -p_{ext}(V_2 - V_1)$
$= -p_{ext}\left(\frac{nRT}{p_2} - \frac{nRT}{p_1}\right) = -p_{ext} \times nRT\left(\frac{1}{p_2} - \frac{1}{p_1}\right)$
Given, $p_{ext} = 4.3\text{M Pa}$, $p_1 = 2.1\text{M Pa}$, $p_2 = 1.3\text{M Pa}$,
$n = 5\text{mol}, T = 293\text{K}$ and $R = 8.314\text{J mol}^{-1}\text{K}^{-1}$
$= -4.3 \times 5 \times 8.314 \times 293\left(\frac{1}{1.3} - \frac{1}{2.1}\right)$
$= -15347.70\text{J mol}^{-1}$
$= -15.347\text{kJ mol}^{-1} \sim \text{eq} - 15\text{kJ mol}^{-1}$
$\Rightarrow \Delta Q = 15\text{kJ mol}^{-1}$

Question63

The ionisation enthalpy of Na^+formation from $Na(g)$ is 495.8kJ mol^{-1}, while the electron gain enthalpy of Br is -325.0kJ mol^{-1}. Given, the lattice enthalpy of $NaBr$ is -728.4kJ mol^{-1}. The energy for the formation of $NaBr$ ionic solid is (−)............ $\times 10^{-1}\text{kJ mol}^{-1}$.
[25 Feb 2021 Shift 1]

Answer: 5576

Solution:

Solution:

$Na(g) \xrightarrow{IE_1} Na^+(g)[IE_1 = 495.8\text{kJ mol}^{-1}]$

$Br(g) \xrightarrow[\text{gain enthalpy}]{\text{Electron}} (EG)Br^-(g)$[Gain enthalpy $= -325\text{kJ mol}^{-1}$]

$Na^+ + Br^- \xrightarrow[\text{energy}]{\text{Lattice}} (LE\ NaBr(s)$[Lattice energy $= -728.4\text{kJ mol}^{-1}$]

$\Delta H_{\text{Formation}} = IE_1 +$ Gain enthalpy + Lattice energy $\Delta H = 495.8 + (-325) + (-728.4)$
$= -557.6\text{kJ / mol}$
$= -5576 \times 10^{-1}\text{kJ}$

Question64

The average $S - F$ bond energy in kJ mol^{-1} of SF_6 is .... (Rounded off to the nearest integer) [Given, the values of standard enthalpy of

formation of $SF_6(g)$, $S(g)$ and $F(g)$ are -1100, 275 and $80 kJ\ mol^{-1}$ respectively.]
[26 Feb 2021 Shift 2]

Answer: 309

Solution:

Solution:
So, $\Delta_f H^\circ[S, g] + 6\times \Delta_f H^\circ[F, g] = \Delta_f H^\circ[SF_6, g] + 6\times E_{S-F}$
$[\therefore E_{S-F} =$ Average $S-F$ bond energy in $SF_6]$
$275 + 6\times 80 = -1100 + 6\times E_{S-F}$
$\Rightarrow E_{S-F} = \dfrac{275 + 6\times 80 + 1100}{6}$
$= 309.16 kJ\ mol^{-1} = 309 kJ\ mol^{-1}$

Question65

At 25°C, 50g of iron reacts with HCl to form $FeCl_2$. The evolved hydrogen gas expands against a constant pressure of 1 bar. The work done by the gas during this expansion is ......J. (Round off to the nearest integer) [Given, $R = 8.314 J\ mol^{-1} K^{-1}$. Assume, hydrogen is an ideal gas]
[Atomic mass off Fe is 55.85u]
[16 Mar 2021 Shift 2]

Answer: 2218

Solution:

Solution:
$\underset{50g}{Fe(s)} + HCl(aq) \longrightarrow FeCl_2(aq) + H_2(g)$
(Moles of Fe = Moles of H_2)
moles $= \dfrac{50}{55.85}$ $0.8952mol$ $0.8952mol$
$= 0.8952mol$
Work done can be given by
$W = -p_{ext}\ \Delta V$
$W = -\Delta n_g RT$
where, Δn_g = { gaseous moles on product side } - {gaseous mole on reactant side}
$= 0.8952 - 0$
$W = -0.8952 \times 8.314 \times 298$
$= -2217.92J$
Closest integer $= 2218$

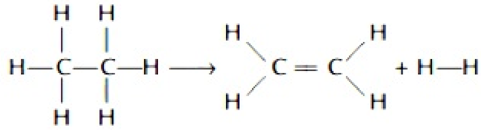
Question66

For the reaction,
$C_2H_6 \longrightarrow C_2H_4 + H_2$ (Round off to the nearest integer). [Given : Bond enthalpies in $kJ\ mol\ m^{-1}$:
$C-C = 347, C = C = 611; C-H = 414; H-H = 436$
[18 Mar 2021 Shift 1]

Answer: 128

Solution:

Solution:
The equation representing various substances involved in chemical reaction is



Given bond enthalpies of various bonds in $kJ\ mol^{-1}$ i.e.
$C-C = 347, C = C = 611, C-H = 414, H-H = 436$
This reaction involves the breaking of $2C-H$ bonds and formation, of $1C = C$ bond and $1H-H$ bond.
Δ_rH = [Sum of bond enthalpies of reactants] - [Sum of bond enthalpies of products]
$= [1\ \Delta_{C-C}H + 6\ \Delta_{C-H}H] - [1\Delta_C = CH + 4\ \Delta_{C-H}H + 1\ \Delta_{H-H}H]$
$= (357 + 6 \times 414) - [611 + 4 \times 414 + 436]$
$= 2831 - 2703$
$= 128 kJ/mol$

Question67

The standard enthalpies of formation of Al_2O_3 and CaO are $-1675 kJ\ mol^{-1}$ and $-625 kJ\ mol^{-1}$ respectively. For the reaction, $3CaO + 2Al \longrightarrow 3Ca + Al_2O_3$ the standard reaction enthalpy Δ_tH°........ kJ. (Round off to the nearest integer).
[17 Mar 2021 Shift 1]

Answer: 230

Solution:

Solution:
Given, $\Delta_fH_{Al_2O_3}^{o} = -1675 kJ/mol$
$\Delta_fH_{CaO}^{\circ} = -625 kJ/mol$
To find Δ_rH° for the reaction
$3CaO + 2Al \longrightarrow 3Ca + Al_2O_3; \Delta_rH^\circ = ?$

$\Delta_r H^\circ = \sum_{\Delta_f} H_{\text{product}}^\circ - \sum_{\Delta_f} H_{\text{Reactant}}^\circ$
$= \left\{\Delta_f H_{Al_2O_3}^\circ + 3\,\Delta_f H_{Ca}^\circ\right\} - \{3\,\Delta_f H_{CaO}^\circ + 2\,\Delta_f H_{Al}^\circ\}$
$= \Delta H_f^\circ(Al_2O_3) - 3\times \Delta H_f^a(CaO)$
We know, $\Delta_f H^\circ$ for elemental state $= 0$
$\Rightarrow \Delta_f H_{Ca}^o = 0, \Delta_f H_{Al}^o = 0$
Putting the value,
$\Delta_t H^\circ = \{-1675 + 0\} - \{3(-625) + 0\}$
$= -1675 + 1905$
$= 230 kJ$

Question68

During which of the following processes, does entropy decrease?
A. Freezing of water to ice at $0^\circ C$.
B. Freezing of water to ice at $-10^\circ C$.
C. $N_2(g) + 3H_2(g) \longrightarrow 2NH_3(g)$
D. Adsorption of CO(g) and lead surface.
E. Dissolution of NaCl in water.
[17 Mar 2021 Shift 2]

Options:

A. A, B, C and D

B. B and C

C. A and E

D. A, C and E

Answer: A

Solution:

Solution:
Entropy will decrease in A, B, C and D processes.
A, B→ Freezing of water will decrease entropy as particles will move closer and forces of attraction will increase. This leads to a decrease in randomness. So, entropy decreases.
(A) Water $\xrightarrow{0^\circ C}$ ice; $\Delta S = -$ ve
(B) Water $\xrightarrow{-10^\circ C}$ ice; $\Delta S = -$ ve
(C) $N_2(g) + 3H_2(g) \longrightarrow 2NH_3(g)$; $\Delta S = -$ ve
Number of moles are decreasing
$n = 2 - (3 + 1)$
$n = -2$
So, entropy decreases.
(D) Adsorption; $\Delta S = -$ ve
Adsorption will lead to a decrease in the randomness of gaseous particles.
So, entropy decreases.
(E) $NaCl(s) \longrightarrow Na^+(aq) + Cl^-(aq)$; $\Delta S > 0$
The number of species on product side is more than the number of species on reactant side. So, entropy increases on dissolution of NaCl in water.

Question69

When 400mL of 0.2M H_2SO_4 solution is mixed with 600mL of 0.1M NaOH solution, the increase in temperature of the final solution is $-10^{-2}K$. (Round off to the nearest integer).
[Use : $H^+(aq) + OH^-(aq) \rightarrow H_2O$:
$\Delta_{\gamma}H = -57.1 kJ\ mol^{-1}$]
Specific heat of $H_2O = 4.18 J\ K^{-1}g^{-1}$
density of $H_2O = 1.0 gcm^{-3}$
Assume no change in volume of solution on mixing.
[27 Jul 2021 Shift 2]

Answer: 82

Solution:

Solution:

$n_{H^+} = \frac{400 \times 0.2}{1000} \times 2 = 0.16$

$n_{OH^-} = \frac{600 \times 0.1}{1000} = 0.06 (L.R)$

Now, heat liberated from reaction = heat gained by solutions

or, $0.06 \times 57.1 \times 10^3$
$= (1000 \times 1.0) \times 4.18 \times \Delta T$
$\therefore \Delta T = 0.8196 K$
$= 81.96 \times 10^{-2} K \approx 82 \times 10^{-2} K$

Question70

For water at 100°C and 1 bar,
$\Delta_{vap}H - \Delta_{vap}U =$ ____ $\times 10^2 J\ mol^{-1}$.
(Round off to the Nearest Integer)
[Use : $R = 8.31 J\ mol^{-1}K^{-1}$]
[Assume volume of $H_2O(l)$ is much smaller than volume of $H_2O(g)$. Assume $H_2O(g)$ treated as an ideal gas]
[27 Jul 2021 Shift 1]

Answer: 31

Solution:

$H_2O_{(l)} \rightleftharpoons H_2O_{(v)}$
$\Delta H = \Delta U + \Delta n_g RT$
for 1 mole waters ;

$\Delta n_g = 1$
$\therefore \Delta n_g RT = 1\text{mol} \times 8.31\text{J} / \text{mol} - \text{k} \times 373\text{K}$
$= 3099.63\text{J} \cong 31 \times 10^2\text{J}$

Question71

A system does 200 J of work and at the same time absorbs 150 J of heat. The magnitude of the change in internal energy is _________ J. (Nearest integer)
[25 Jul 2021 Shift 2]

Answer: 50

Solution:

$w = -200\text{J}, q = +150 : \Delta U = q + w$
$\Delta U = 150 - 200 = -50\text{J}$: magnitude $= 50\text{J} = |\Delta U|$

Question72

At 298K, the enthalpy of fusion of a solid (X) is 2.8~kJ mol^{-1} and the enthalpy of vaporisation of the liquid (X) is 98.2kJ mol^{-1}. The enthalpy of sublimation of the substance (X) in kJ mol^{-1} is _______ . (in nearest integer)
[25 Jul 2021 Shift 1]

Answer: 101

Solution:

Solution:
$\Delta H_{\text{sub}} = \Delta H_{\text{fivs.}} + \Delta H_{\text{vap.}}$
$= 2.8 + 98.2$
$= 101\text{kJ} / \text{mol}$

Question73

At 298.2K the relationship between enthalpy of bond dissociation (in kJ mol^{-1}) for hydrogen (E_H) and its isotope, deuterium (E_D), is best

described by:
[25 Jul 2021 Shift 1]

Options:

A. $E_H = \frac{1}{2} E_D$

B. $E_H = E_D$

C. $E_H \simeq E_D - 7.5$

D. $E_H = 2E_D$

Answer: C

Solution:

Solution:
Enthalpy of bond dissociation (kJ/mole) at 298.2K
For , hydrogen = 435.88
For , Deuterium = 443.35
$\therefore E_H \simeq E_D - 7.5$

Question74

If the standard molar enthalpy change for combustion of graphite powder is $-2.48 \times 10^2 \mathrm{kJ\ mol}^{-1}$,the amount of heat generated on combustion of 1g. of graphite powder is _______ kJ . (Nearest integer)
[22 Jul 2021 Shift 2]

Answer: 21

Solution:

Solution:
$1\mathrm{mol}$ graphite $= 12\mathrm{gmC}$
Ans. $= \frac{248}{12} = 20.67\mathrm{kJ}$ / gm heat evolved

Question75

For a given chemical reaction $A \rightarrow B$ at $300\mathrm{K}$ the free energy change is $-49.4\mathrm{kJ\ mol}^{-1}$ and the enthalpy of reaction is $51.4\mathrm{kJ\ mol}^{-1}$. The entropy change of the reaction is $\mathrm{J\ K}^{-1}\mathrm{mol}^{-1}$.
[20 Jul 2021 Shift 2]

Answer: 336

Solution:

Solution:
Given chemical reaction:
$A \xrightarrow[T\ 300K]{} B[\Delta G]_{P,T} = -49.4$ kJ/mol
$\Delta H_{rxn} = 51.4$ kJ/mol
$\Delta S_{rxn} = ?$
⇒ From the relation $[\Delta G]_{P,T} = \Delta H - T\Delta S$
$\Rightarrow \Delta S_{rxn} = \frac{\Delta H_{rn} - [\Delta G]_{P,T}}{T}$
$= \frac{[51.4 - (-49.4)] \times 1000}{300} \frac{J}{mol\ K}$
$\Rightarrow \Delta S_{rxn} = 336 \frac{J}{mol\ K}$

Question76

For water $\Delta_{vap}H = 41\,kJ\,mol^{-1}$ at 373K and 1 bar pressure. Assuming that water vapour is an ideal gas that occupies a much larger volume than liquid water, the internal energy change during evaporation of water is .... $kJ\,mol^{-1}$.
[Use $R = 8.3 J mol^{-1} K^{-1}$]
[26 Aug 2021 Shift 2]

Answer: 38

Solution:

Solution:
$H_2O(l) \rightarrow H_2O(g)$
$\because \Delta H = \Delta U + \Delta n_g RT$
ΔH = enthalpy of vaporisation
ΔU = change in internal energy
Δn_g = number of moles of water vapour
$R = 8.3 J mol^{-1} K^{-1}$
$T = 373$ K
$\therefore 41\,kJ = \Delta U + RT$
$\Delta U = 41 - 8.3 \times 373 \times 10^{-3} = 41 - 3.095$
$= 37.90\,kJ\,mol^{-1} = 38\,kJ\,mol^{-1}$

Question77

200 mL of 0.2M HCl is mixed with 300 mL of 0.1M NaOH. The molar heat of neutralisation of this reaction is −57.1 kJ. The increase in

temperature in °C of the system on mixing is $x \times 10^{-2}$.
The value ofx is .... (Nearest integer)
[Given, specific heat of water $= 4.18 J g^{-1} K^{-1}$Density of water
$= 1.00 g cm^{-3}$]
(Assume no volume change on mixing)
[27 Aug 2021 Shift 1]

Answer: 82

Solution:

Solution:
Millimoles of HCl = 200 × 0.2 = 40
Millimoles of NaOH = 300 × 0.1 = 30
Heat released (q) = n× molar heat

$$= \frac{30}{1000} \times 57.1 \times 1000$$

= 1713 J
Mass of solution = × 500 × 1= 500 g
We know that,

$$\Delta T = \frac{q}{mc} = \frac{1713J}{500g \times 4.18J / g - K}$$

$$= 0.8196K = 81.96 \times 10^{-2}K$$

x ≈ 82

Question78

The Born-Haber cycle for KCl is evaluated with the following data :

$\Delta_f H°$ for KCl $= -436.7 \, kJ \, mol^{-1}$

$\Delta_{sub} H°$ for K $= 89.2 \, kJ \, mol^{-1}$,

$\Delta_{ionisation} H°$ for K $= 419.0 \, kJ \, mol^{-1}$;

$\Delta_{electron\,gain} H^{U}$ for Cl(g) $= -348.6 \, kJ \, mol^{-1}$,

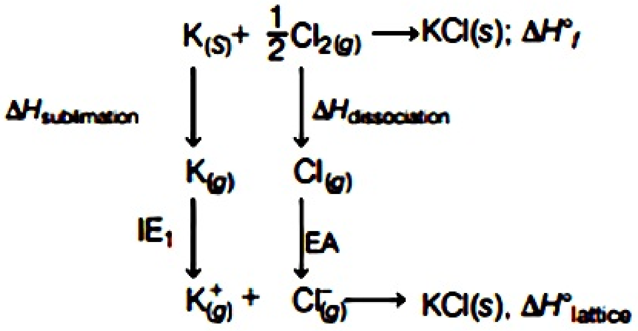
$\Delta_{bond} H°$ for $Cl_2 = 243.0 \, kJ \, mol^{-1}$

The magnitude of lattice enthalpy of KCl in kJ mol^{-1} is . (Nearest integer)
[26 Aug 2021 Shift 1]

Answer: 718

Solution:

Born-Haber cycle for KCl is as follows



$\therefore \Delta H_f^\circ = \Delta H_{sublimation} + \frac{1}{2}\Delta H_{dissociation} + IE_1 + EA + \Delta H_{lattice}$

$-436.7\,kJ/mol = 89.2\,kJ/mol + \frac{1}{2} \times (243\,kJ/mol) + 419\,kJ/mol + (-348.6\,kJ/mol) + \Delta H^\circ_{lattice}$

$\Rightarrow \Delta H^\circ_{lattice} = -717.8\,kJ/mol$

$\therefore$ Magnitude of lattice enthalpy of KCl in kJ / mol is 718 (nearest).

Question79

The incorrect expression among the following is [31 Aug 2021 Shift 2]

Options:

A. $\frac{\Delta G_{System}}{\Delta S_{Total}} = -T$ (at constant p)

B. $\ln k = \frac{\Delta H^\circ - T\Delta S^\circ}{RT}$

C. $k = e^{-\frac{\Delta G^\circ}{RT}}$

D. For isothermal process, $W_{reversible} = -nRT \ln \frac{V_f}{V_i}$

Answer: B

Solution:

Solution:
All the expression of thermodynamics are correct except
$\ln k = \frac{\Delta H^\circ - T\Delta S^\circ}{RT}$
As we know,
$\Delta G = \Delta H - T\Delta S^\circ$ ...(i)
Also $\Delta G = -RT\ln K$ ...(ii)
$\therefore$ From (i) and (ii)
$-RT\ln K = \Delta H - T\Delta S^\circ$
$\therefore \ln K = \frac{-\Delta H}{R} + \frac{\Delta S^\circ}{R}$
The corect expression is
$\ln K = \frac{-\Delta H^\circ}{RT} + \frac{\Delta S^\circ}{R} = \frac{\Delta H^\circ - T\Delta S^\circ}{RT}$

Question80

Data given for the following reaction is as follows.

$FeO(s) + C_{(graphite)} \rightarrow Fe(s) + CO(g)$

Substance	$\Delta H°(kJ\ mol^{-1})$	$\Delta S°(J\ mol^{-1}K^{-1})$
FeO(s)	-266.3	57.49
$C_{(graphite)}$	0	5.74
Fe(s)	0	27.28
CO(g)	-110.5	197.6

The minimum temperature in K at which the reaction becomes spontaneous is......... (Integer answer)
[27 Aug 2021 Shift 2]

Answer: 964

Solution:

$FeO(s) + C_{(graphite)} \rightarrow Fe(s) + CO(g)$
$\Delta H°_{reaction} = \Delta H°_{f(product)} - \Delta H°_{f(reactants)}$
$= [\Delta H°_{f(Fe)} + \Delta H°_{f(CO)}] - [\Delta H°_{f(FeO)} - \Delta H°_{f(C)}]$
$= [0 + (-110.5)] - [-266.3 - 0]$
$= 156kJ^{-1}mol^{-1}$
$\Delta S°_{reaction} = \Delta S°_{product} - \Delta S°_{reactant}$
$= [\Delta S°_{(Fe)} + \Delta S°_{(CO)}] - [\Delta S°_{(FeO)} - \Delta S°_{(O)}]$
$= [27.28 + 197.6] - [57.49 + 5.79]$
$= 161JK^{-1}mol^{-1}$
According to Gibb's equation,
$\Delta G° = \Delta H° - T\Delta S°$
The reaction becomes spontaneous when $\Delta G°$ is atleast zero or negative.
$0 = \Delta H° - T\Delta S°$
$T\Delta S° = \Delta H°$
$\Rightarrow T = \frac{\Delta H°}{\Delta S°} = \frac{156\, kJ\, mol^{-1}}{161JK^{-1}mol^{-1}}$
$= \frac{156000mol^{-1}}{161JK^{-1}mol^{-1}} = 964K$
The temperature at which reaction becomes spontaneous is 964 K.

Question81

For the reaction, $2NO_2(g) \rightleftharpoons N_2O_4(g)$, when $\Delta S = -176.0 \times JK^{-1}$ and $\Delta H = -57.8\, kJ\, mol^{-1}$, the magnitude of ΔG at 298K for the reaction is ....$kJ\, mol^{-1}$. (Nearest integer)
[1 Sep 2021 Shift 2]

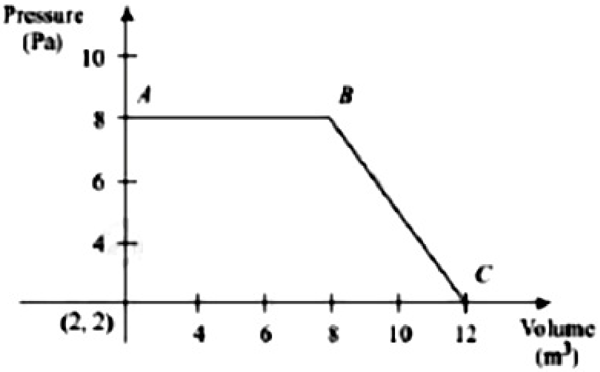
Answer: 5

Solution:

Given, $\Delta H = -57.8\,\text{kJ mol}^{-1}$
$\Delta S = -176 \text{JK}^{-1}\text{mol}^{-1}$
$T = 298\text{K}$
Using Gibb’s free energy relation
$\Delta G = \Delta H - T\Delta S$
where, ΔG = change in Gibb’s free energy
ΔH = change in enthalpy
T = temperature
ΔS = change in entropy
$\Delta G = 57.8\,\text{kJ / mol} - [\,298\text{K} \times (-176\text{Jk}^{-1}\ \text{mol}^{-1})\,]$
$= 57.8\,\text{kJ / mol} - \left(298 \times \frac{-176}{1000}\,\text{kJ}\right)$ [∴1kJ = 1000 J]
= − 5.352 kJ/mol
| ΔG | = 5.352
Hence, answer is 5.

Question82

The magnitude of work done by a gas that undergoes a reversible expansion along the path ABC shown in the figure is ________.



[NV, Jan. 08,2020(I)]

Answer: 48

Solution:

Solution:
Work done is given by the area under the trapezium.
$\therefore |\,w| = \frac{1}{2}(6 + 10) \times 6 = 48\text{J}$

Question83

At constant volume, 4 mol of an ideal gas when heated from 300K to 500K changes its internal energy by 5000J . The molar heat capacity at

constant volume is
[NV, Jan. 08, 2020 (II)]

Answer: 6.25

Solution:

Solution:
$\Delta U = nC_v \Delta T$
$5000 = 4 \times C_v(500 - 300)$
$C_v = 6.25 \mathrm{J\,K^{-1} mol^{-1}}$

Question84

If enthalpy of atomisation for $Br_2(\ell)$ is $x\,kJ/mol$ and bond enthalpy for Br_2 is $y\,kJ/mol$, the relation between them:
[Jan. 09,2020 (I)]

Options:

A. is $x = y$

B. does not exist

C. is $x > y$

D. is $x < y$

Answer: C

Solution:

Solution:
$\Delta H_{atomisation} = \Delta H_{vap} +$
Bond energy Hence $x > y$

Question85

For the reaction ;$A(l) \rightarrow 2B(g)$
$\Delta U = 2.1 kcal, \Delta S = 20 cal\,K^{-1}$ at 300K
Hence ΔG in kcal is.
[NV, Jan. 07, 2020 (I)]

Answer: -2.7

Solution:

Solution:

$\Delta U \quad = 2.1\text{kcal} \ = 2.1 \times 10^{3}\text{cal}$

$\Delta n_g = 2$

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

$\quad = 2.1 \times 10^{3} + 2 \times 2 \times 300$

$\quad = 2100 + 1200$

$\quad = 3300\text{cal}$

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

$\quad = 3300 - 300 \times 20$

$\quad = 3300 - 6000$

$\quad = -2700\text{cal s}$

$\quad = -2.7\text{kcal}$

Question86

The standard heat of formation ($\Delta_f H_{298}^{\circ}$) of ethane (in kJ / mol), if the heat of combustion of ethane, hydrogen and graphite are -1560, -393.5 and $-286\text{kJ} \ / \text{mol}$, respectively is ________.
[NV, Jan. 07,2020 (II)]

Answer: -192.5

Solution:

Solution:

$C(s) + O_2(g) \rightarrow CO_2(g)$

$\Delta_C H^{0}[\text{Cgraphite}] = -286.0\text{kJ} \ / \text{mol} \ \ . . . \text{(i)}$

$H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(g)$

$\Delta_C H^{0}[H_2(g)] = -393.5\text{kJ} \ / \text{mol} \ \ . . . \text{(ii)}$

$C_2H_6(g) + \frac{7}{2}O_2(g) \rightarrow 2CO_2(g) + 3H_2O(g)$

$\Delta_C H^{0}[C_2H_6(g)] = -1560\text{kJ} \ / \text{mol} \ \ . . . \text{(iii)}$

The reaction of formation of ethane is

$2C(s) + 3H_2(g) \rightarrow C_2H_6(g)$

$\therefore \Delta_f H^{0} \ \text{of} \ C_2H_6(g) =$

$2\times \Delta_C {}^{0}H\,[C_{\text{gaphite}}\ ] + 3\times \Delta_c\, H^{0}[H_2(g)] - \Delta_C\, H^{0}[C_2H_6(g)]$

$\quad = 2 \times (-286.0) + 3(-393.5) - (-1560)$

$\quad = -192.5\text{kJ} \ / \text{mol}$

Question87

The true statement amongst the following is :
[Jan. 09,2020 (II)]

Options:

A. Both ΔS and S are functions of temperature.

B. Both S and ΔS are not functions of temperature.

C. S is not a function of temperature but ΔS is a function of temperature.

D. S is a function of temperature but ΔS is not a function of temperature.

Answer: A

Solution:

Solution:
A system at higher temperature has greater entropy (randomness). S and Δ S are related with T as:
$S_T = \int_0^T \frac{nC \cdot dT}{T} \ \Delta S = \int \frac{dq}{T}$
Thus both S and ΔS are function of temperature.

Question88

Five moles of an ideal gas at 1 bar and 298K is expanded into vacuum to double the volume. The work done is:
[Sep. 04,2020 (II)]

Options:

A. $C_v(T_2 - T_1)$

B. $-RT(V_2 - V_1)$

C. $-RT \ \ln V_1 / V_1$

D. zero

Answer: D

Solution:

Solution:
In expansion against vacuum
$P_{ext} = 0$
$W = -P_{ext} \Delta V = 0$
$W = 0$

Question89

Lattice enthalpy and enthalpy of solution of $NaCl$ are $788 kJ mol^{-1}$ and $4 kJ mol^{-1}$, respectively. The hydration enthalpy of $NaCl$ is :
[Sep. 05, 2020(II)]

Options:

A. $-780 kJ mol^{-1}$

B. $780 \mathrm{kJ\,mol}^{-1}$

C. $-784 \mathrm{kJ\,mol}^{-1}$

D. $784 \mathrm{kJ\,mol}^{-1}$

Answer: C

Solution:

Solution:
$\Delta_{\text{sol.}} H^{\circ} = \Delta_{\text{lattice}} H^{\circ} + \Delta_{\text{Hyd.}} H^{\circ}$
$4 = 788 + \Delta_{\text{Hyd}} H^{\circ}$
$\Delta_{\text{Hyd.}} H^{\circ} = -784 \mathrm{kJ\,mol}^{-1}$

Question90

For one mole of an ideal gas, which of these statements must be true? (1) U and H each depends only on temperature (2) Compressibility factor z is not equal to 1 (3) $C_{P,m} - C_{V,m} = R$ (4) $dU = C_y dT$ for any process
[Sep. 04, 2020 (I)]

Options:

A. (1) and (3)

B. (2), (3) and (4)

C. (3) and (4)

D. (1), (3) and (4)

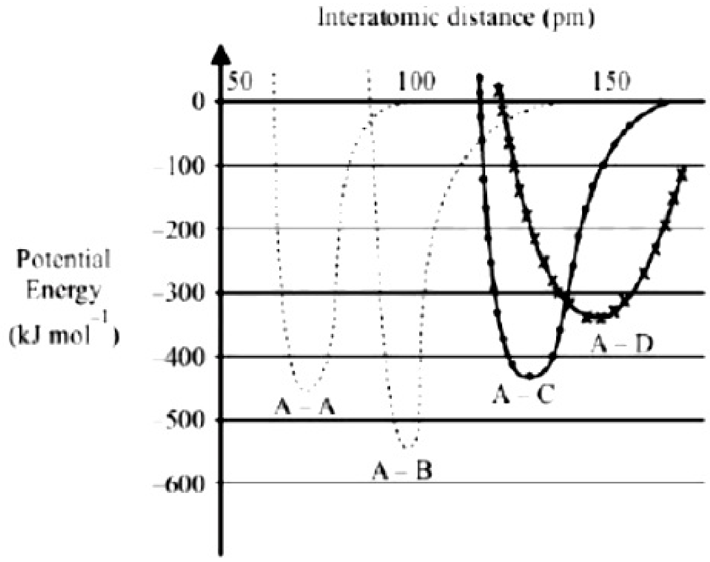
Answer: D

Solution:

Solution:
(1) For ideal gas U and H are function of temperature.
(2) Compressibility factor for an ideal gas is 1 .
(3) $C_P - C_V = R$
(4) ΔU = CvdT for all processes.

Question91

The intermolecular potential energy for the molecules A, B, C and D given below suggests that :



[Sep. 04,2020 (1)]

Options:

A. A-D has the shortest bond length

B. A-A has the largest bond enthalpy

C. D is more electronegative than other atoms

D. A-B has the stiffest bond

Answer: D

Solution:

Solution:
A-B bond has highest intermolecular potential energy among the given molecules. Hence, it is strongest bond and has maximum bond enthalpy.

Question92

The internal energy change (in J) when 90g of water undergoes complete evaporation at 100˚C is ______.
(Given : ΔH_{vap} for water at 373K = 41kJ / mol , R = 8.314J $K^{1}mol^{-1}$)
[NV, Sep. 02,2020(I)]

Answer: 189494

Solution:

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

$n = \frac{90}{18} = 5\text{mol}$

$H_2O(l) \rightleftharpoons H_2O(g)$

$\Delta n = 1$
$41000 = \Delta U + 1 \times 8.314 \times 373$
$\Rightarrow \Delta U = 37898.875J$
For 5 moles, $\Delta U = 37898.87 \times 5 = 189494J$

Question93

The heat of combustion of ethanol into carbon dioxids and water is -327 kcal at constant pressure. The heat evolved (in cal) at constant volume and $27^\circ C$ (if all gases behave ideally) is $(R = 2 \text{cal mol}^{-1} K^{-1})$______.
[NV, Sep. 02, 2020 (II)]

Answer: -326400

Solution:

Solution:
$C_2H_5OH(l) + O_2(g) \longrightarrow 2O_2(g) + 3H_2O(I)$
$\Delta H_C = -327K \text{ cal}$
$\Delta H = \Delta U + \Delta n_g RT$
$\Rightarrow -327 \times 10^3 = \Delta U + (-1) \times 2 \times 300$
$\Rightarrow \Delta U = -327 \times 10^3 + 600$
$\therefore \Delta U = -326400 \text{cal}$

Question94

For a dimerization reaction, $2A(g) \rightarrow A_2(g)$,
at $298K$, $\Delta U^\Theta = -20 \text{kJ mol}^{-1}$, $\Delta S^\Theta = -30 \text{J K}^{-1} \text{mol}^{-1}$,
then the ΔG^Θ will be ______ J.
[NV, Sep. 05,2020 (II)]

Answer: -13538

Solution:

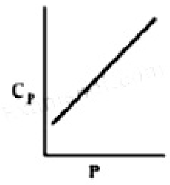
Solution:
From $\Delta H^\circ = \Delta U^\circ + \Delta n_g RT$
$\Delta H^\circ = -20 \times 1000 - 1 \times 8.314 J / mol . K \times 298K$
$= -22477.57J$
$\Delta G^\circ = \Delta H^\circ - T \Delta S^\circ = -22477.57 - (298 \times -30)$
$= -13538J$

Question95

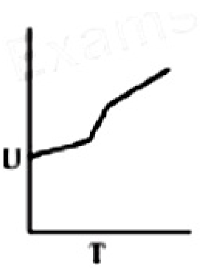
For a diatomic ideal gas in a closed system, which of the following plots does not correctly describe the relation between various thermodynamic quantities?
[Jan. 12, 2019 (I)]

Options:

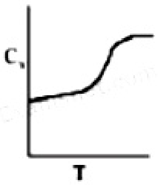
A.



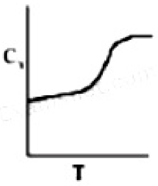
B.



C.



D.



Answer: A

Solution:

Solution:
For ideal gas, C_p and C_v are dependent on temperaturc only.

$C_p = \frac{7}{2}R\left(\text{ Independent of } P\right)$

$C_v = \frac{5}{2}R\left(\text{ Independent of } V\right)$

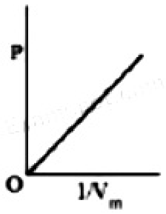
Thus, C_p will not change with pressure.

Question96

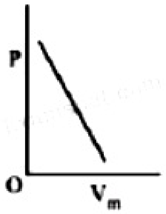
The combination of plots which does not represent isothermal expansion of an ideal gas is:
[Jan. 12, 2019 (II)]

Options:

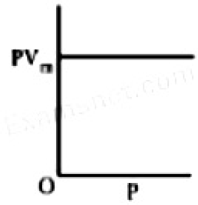
A.



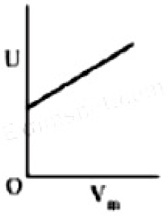
B.



C.



D.



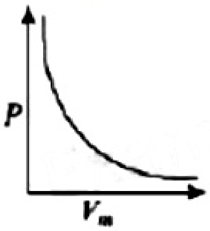
Answer: 0

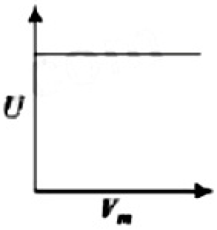
Solution:

Isothermal expansion

$PV_m = K$ (graph - C)

$P = \frac{K}{V_m}$(graph − A)





Therefore (B) and (D) are not correct representation.

Question97

An ideal gas undergoes isothermal compression from 5m^3 to 1m^3 against a constant external pressure of 4N m^{-2}. Heat released in this process is used to increase the temperature of 1 mole of Al . If molar heat capacity of Al is $24\text{J mol}^{-1}\text{K}^{-1}$, the temperature of Al increases by: [Jan. 10, 2019 (II)]

Options:

A. $\frac{3}{2}\text{K}$

B. 2K

C. $\frac{2}{3}\text{K}$

D. 1K

Answer: C

Solution:

Solution:
We know that,
$w = -P_{ext}(V_f - V_i)$
$w = -4\text{N m}^{-2}(1-5)\text{m}^3$
$w = 16\text{N m} \Rightarrow 16\text{J}$
For isothermal compression,
$\Delta U = q + w$
$\Rightarrow q = -w = -16\text{J}$ ($\because \Delta U = 0$ for isothermal process)
From calorimetry,
Heat given $= \text{nC}\,\Delta\,\text{T}$
So, $16 = \dfrac{1 \times 24\text{J} \times \Delta\,\text{T}}{\text{mol K}}$
$\therefore$ Change in temperature, $\Delta\text{T} = \frac{2}{3}\text{K}$

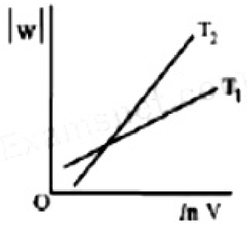
Question98

Consider the reversible isothermal expansion of an ideal gas in a closed system at two different temperatures, T_1 and $T_2 (T_1 < T_2)$. The correct graphical depiction of the dependence of work done (w) on the final volume (V) is:

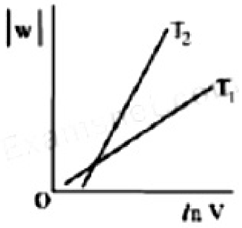
[Jan. 9, 2019 (I)]

Options:

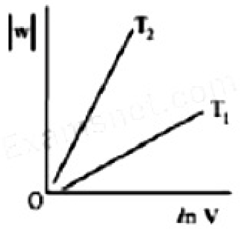
A.



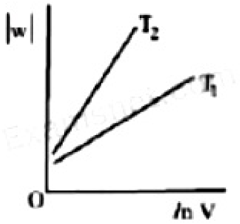
B.



C.



D.



Answer: B

Solution:

Solution:
For reversible isothermal expansion,

$w = -nRT\ \ln \frac{V_2}{V_1}$

$\Rightarrow |\ w \Big| = nRT\ \ln \frac{V_2}{V_1}$

$|w| = nRT\ (\ln V_2 - \ln V_1)$

$|w| = nRT\ \ln V_2 - nRT\ V_1$

$y = mx + c$

So, slope of curve 2 is more than curve 1 and intercept of curve 2 is more negative than curve 1 .

Question99

(i) C (graphite) $+ O_2(g) \rightarrow CO_2(g); \Delta_r H^0 = x kJ\ mol^{-1}$

(ii) C(graphite) + $\frac{1}{2} O_2(g) \rightarrow CO(g); \Delta_r H^0 = y kJ\ mol^{-1}$

(iii) $CO(g) + \frac{1}{2} O_2(g) \rightarrow CO_2(g); \Delta_r H^0 = z kJ\ mol^{-1}$

Based on the above thermochemical equations, find out which one of the following algebraic relationships is correct?
[Jan. 12, 2019 (II)]

Options:

A. $x = y + z$

B. $z = x + y$

C. $y = 2z - x$

D. $x = y - z$

Answer: A

Solution:

Equation (i) can be obtained by adding equations (ii) and equation (iii)

C(graphite) + $\frac{1}{2} O_2(g) \rightarrow CO(g); \Delta H_1^\circ = y kJ\ mol^{-1} \ldots$ (ii)

$CO(g) + \frac{1}{2} O_2(g) \rightarrow CO_2(g); \Delta H_2^\circ = z kJ\ mol^{-1} \ldots$ (iii)

C (graphite) $+ O_2(g) \rightarrow CO_2(g); \Delta H_3^\circ = x kJ\ mol^{-1} \ldots$ (i)

$\because\ \Delta H_3^\circ = \Delta H_1^\circ + \Delta H_2^\circ$

$x = y + z$

Question100

Two blocks of the same metal having same mass and at temperature T_1, and T_2, respectively, are brought in contact with each other and allowed to attain thermal equilibrium at constant pressure. The change in entropy, ΔS, for this process is :
[Jan. 11, 2019 (I)]

Options:

A. $C_P \ln \left[\frac{(T_1 + T_2)^2}{4T_1 T_2} \right]$

B. $2C_p \ln \left[\frac{(T_1 + T_2)^{\frac{1}{2}}}{T_1 T_2} \right]$

C. $2C_P \ln\left(\frac{T_1+T_2}{4T_1T_2}\right)$

D. $2C_P \ln\left[\frac{T_1+T_2}{2T_1T_2}\right]$

Answer: A

Solution:

Solution:

Final temperature $= \frac{T_1+T_2}{2}$, let $T_2 > T_1$

$\therefore dS = \frac{dq}{T} = \frac{C_p dT}{T}$

$\therefore \Delta S = C_p \ln\left(\frac{T_f}{T_i}\right)$

$\therefore \Delta S_{Total} = C_p \ln\left(\frac{T_1+T_2}{2T_1}\right) + C_p \ln\left(\frac{T_1+T_2}{2T_2}\right)$

$= C_p \ln\left[\frac{(T_1+T_2)^2}{4T_1T_2}\right]$

Question101

The process with negative entropy change is: [Jan. 10, 2019 (II)]

Options:

A. Dissociation of $CaSO_4(s)$ to $CaO(s)$ and $SO_3(g)$

B. Sublimation of dry ice

C. Dissolution of iodine in water

D. Synthesis of ammonia from N_2 and H_2

Answer: D

Solution:

Solution:
In the process of synthesis of ammonia from N_2 and H_2, number of moles decreases which implies that the change in entropy will be negative.
$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$

Question102

The entropy change associated with the conversion of 1 kg of ice at 273K to water vapours at 383K is: (Specific heat of water liquid and water vapour are $4.2 kJ\ K^{-1}kg^{-1}$ and

$2.0 \mathrm{kJ\ K^{-1} kg^{-1}}$; heat of liquid fusion and vapourisation of water are $334 \mathrm{kJ\ kg^{-1}}$ and $2491 \mathrm{kJ\ kg^{-1}}$, respectively).
($\log 273 = 2.436$, $\log 373 = 2.572$, $\log 383 = 2.583$)
[Jan. 9, 2019 (II)]

Options:

A. $7.90 \mathrm{kJ\ kg^{-1} K^{-1}}$

B. $2.64 \mathrm{kJ\ kg^{-1} K^{-1}}$

C. $8.49 \mathrm{kJ\ kg^{-1} K^{-1}}$

D. $9.26 \mathrm{kJ\ kg^{-1} K^{-1}}$

Answer: D

Solution:

∴ Total entropy change
$\Delta S = 1.28 + 6.68 + 1.31 + 0.05$
$= 9.26 \mathrm{kJ\ kg^{-1} K^{-1}}$

Question103

For the chemical reaction $X \rightleftharpoons Y$, the standard reaction Gibbs energy depends on temperature T (in K) as $\Delta_r G^\circ (\text{ in kJ mol}^{-1}) = 120 - \frac{3}{8} T$
The major component of the reaction mixture at T is :
[Jan. 11, 2019 (I)]

Options:

A. Y if $T = 300 \mathrm{K}$

B. Y if $T = 280 \mathrm{K}$

C. X if $T = 350 \mathrm{K}$

D. X if $T = 315 \mathrm{K}$

Answer: D

Solution:

At $315 \mathrm{K}$; $\Delta G^\circ = 120 - \frac{3}{8} T$
$\Delta G^\circ = 120 - 118.125 =$ positive
Since ΔG° is positive then $K_{eq} < 1$.
So $\frac{[Y]}{[X]} < 1$.
$\therefore [X] > [Y]$

Question104

The reaction $MgO(s) + C(s) \rightarrow Mg(s) + CO(g)$, for which $\Delta H^\circ = +491.1 kJ\,mol^{-1}$ and $\Delta S^\circ = 198.0 J\,K^{-1} mol^{-1}$ is not feasible at 298K. Temperature above which reaction will be feasible is
[Jan. 11, 2019 (II)]

Options:

A. 2040.5K

B. 1890.0K

C. 2480.3K

D. 2380.5K

Answer: C

Solution:

$MgO(s) + C(s) \rightarrow Mg(s) + CO(g)$
For a reaction to be spontaneous
$\Delta G < 0$
$\Delta H^\circ - T\,\Delta S^\circ < 0$
$\Rightarrow T > \dfrac{\Delta H^\circ}{\Delta S^\circ}$
$T > \dfrac{491.1 \times 1000}{198}$
$T > 2480.3K$

Question105

The standard reaction Gibbs energy for a chemical reaction at an absolute temperature T is given by $\Delta G^\circ = A - BT$ where A and B are non-zero constants. Which of the following is true about this reaction?
[Jan. 11, 2019 (II)]

Options:

A. Exothermic if $B < 0$

B. Endothermic if $A > 0$

C. Endothermic if $A < 0$ and $B > 0$

D. Exothermic if $A > 0$ and $B < 0$

Answer: B

Solution:

$\Delta G^\circ = A - BT$
A and B are non-zero constants
$\therefore \Delta G^\circ = \Delta H^\circ - T\Delta S^\circ = A - BT$
$\therefore$ Reaction will be endothermic if $\Delta G^0 > 0$.
Hence, $A > 0$ and $B < 0$.

Question106

A process has $\Delta H = 200\text{J mol}^{-1}$ and $\Delta S = 40\text{J K}^{-1}\text{mol}^{-1}$ Out of the values given below, choose the minimum temperature above which the process will be spontaneous:
[Jan. 10, 2019 (I)]

Options:

A. 20K

B. 12K

C. 5K

D. 4K

Answer: C

Solution:

$\Delta H = 200\text{J mol}^{-1}$
$\Delta S = 40\text{J K}^{-1}\text{mol}^{-1}$
For spontaneous reaction. $\Delta G < 0$
$\Delta H - T\Delta S < 0$; $\Delta H < T\Delta S$
$\frac{\Delta H}{\Delta S} < T$; $\frac{200}{40} < T$
$5 < T$
So, minimum temperature is 5K

Question107

An ideal gas is allowed to expand from 1L to 10L against a constant external pressure of 1 bar. The work done in kJ is:
[April 12, 2019(I)]

Options:

A. -9.0

B. $+10.0$

C. -0.9

D. -2.0

Answer: C

Solution:

$$
\begin{aligned}
W &= -P\Delta V\\
&= -(1\text{ bar})\times(9L)\\
&= -(10^5 Pa)\times(9\times10^{-3})m^3\\
&= -9\times10^2 N\cdot m\ [\because 1Pa = 1N/m^2]\\
&= -900J = -0.9kJ
\end{aligned}
$$

Question108

Among the following, the set of parameters that represents path functions, is:
(A) $q + w$
(B) q
(C) w
(D) $H - TS$
[April 9, 2019 (I)]

Options:

A. (B) and (C)

B. (B), (C) and (D)

C. (A) and (D)

D. (A), (B) and (C)

Answer: A

Solution:

Solution:
We know that heat and work are not state functions but $q + w = \Delta U$ is a state function. $H - TS$(i.e. G) is also a state function.

Question109

During compression of a spring the work done is 10kJ and 2kJ escaped to the surroundings as heat. The change in internal energy, "U (in kJ) is:
[April 9, 2019 (II)]

Options:

A. -12

B. -8

C. 8

D. 12

Answer: C

Solution:

$w = 10\text{kJ}$
$q = -2\text{kJ}$
$\Delta U = q + w = -2 + 10 = 8\text{kJ}$

Question110

Which one of the following equations does not correctly represent the first law of thermodynamics for the given processes involving an ideal gas ? (Assume non-expansion work is zero)
[April 8, 2019 (I)]

Options:

A. Cyclic process : $q = -w$

B. Adiabatic process : $\Delta U = -w$

C. Isochoric process: $\Delta U = q$

D. Isothermal process: $q = -w$

Answer: B

Solution:

Solution:
From first law of thermodynamics, $\Delta U = q + w$
For adiabatic process, $q = 0$
$\therefore \Delta U = w$
For isothermal process, $\Delta U = 0 \Rightarrow q = -w$
For cyclic process, $\Delta U = 0 \Rightarrow q = -w$
For isochoric process, $w = 0 \Rightarrow \Delta U = q$

Question111

5 moles of an ideal gas at 100K are allowed to undergo reversible compression till its temperature becomes 200 K. If $C_V = 28\text{J K}^{-1}\text{mol}^{-1}$, calculate ΔU and ΔpV for this process. ($R = 8.0\text{J K}^{-1}\text{mol}^{-1}$)
[April 8, 2019 (II)]

Options:

A. $\Delta U = 14\text{kJ}$; $\Delta(pV) = 18\text{kJ}$

B. $\Delta U = 14\text{kJ}$; $\Delta(pV) = 0.8\text{kJ}$

C. $\Delta U = 14\text{kJ}$; $\Delta(pV) = 4\text{kJ}$

D. $\Delta U = 14kJ$; $\Delta(pV) = 8.0kJ$

Answer: C

Solution:

Solution:
$\Delta U = nC_v \Delta T = 5 \times 28 \times 100 = 14kJ$
$\Delta(PV) = nR(T_2 - T_1) = 5 \times 8 \times 100 = 4kJ$

Question112

Enthalpy of sublimation of iodine is 24 cal g^{-1} at 200°C. If specific heat of I_2(s) and I_2 (vap) are 0.055 and 0.031 cal $g^{1}K^{-1}$ respectively, then enthalpy of sublimation of iodine at 250°C in cal g^{-1} is:
[April 12, 2019(I)]

Options:

A. 2.85

B. 5.7

C. 22.8

D. 11.4

Answer: C

Solution:

Solution:
$I_2(s) \longrightarrow I_2(g)$
Heat of reaction depend upon temperature i.e., it varies with temperature, as given by Kirchoff's equation,
$\Delta H_{T_2} = \Delta H_{T_1} + \int_{T_1}^{T_2} \Delta C_p d T$
where $\Delta C_p = C_p$ of product $- C_p$ of reactant
$\therefore \quad \Delta C_p = 0.031 - 0.055 = -0.024 cal / g$
Now, $\Delta H_{T_2} - \Delta H_{T_1} = \Delta C_p(T_2 - T_1)$
$\Delta H_{(250)} - \Delta H_{(200)} = -0.024(523 - 473)$
$\Delta H_{(250)} = 24 - 50 \times 0.024 = 22.8 cal / g$

Question113

The difference between ΔH and ΔU ($\Delta H - \Delta U$), when the combustion of one mole of heptane (l) is carried out at a temperature T, is equal to:
[April 10, 2019 (II)]

Options:

A. $-4RT$

B. $-3RT$

C. $4RT$

D. $3RT$

Answer: A

Solution:

Solution:
$C_7H_{16}(l) + 11O_2(g) \xrightarrow{\Delta} 7CO_2(g) + 8H_2O(I)$
$\Delta H - \Delta U = \Delta n_g RT$
$\Delta n_g =$ no. of moles of product in gaseous state - no. of moles of reactant in gaseous state.
$\because \Delta n_g = -4$
$\therefore \Delta H - \Delta U = -4RT$

Question114

For silver, $C_p(\mathrm{J\,K^{-1}mol^{-1}}) = 23 + 0.01T$. If the temperature (T) of 3 moles of silver is raised from 300K to 1000K at 1 atm pressure, the value of ΔH will be close to:
[April 8, 2019 (I)]

Answer: 62

Solution:

Solution:
Given: $n = 3$
$T_1 = 300; T_2 = 1000$
$C_p = 23 + 0.01T$
The relation between ΔH and mathcal C_p is
$\Delta H = \int_{T_1}^{T_2} nC_p dT$ . . . (i)
After putting all variable values in eq. (i), we get
$\Delta H = n \int_{300}^{1000} (23 + 0.01T)dT$
$= 3\left[23T + \frac{0.01T^2}{2} \right]_{300}^{1000}$
$= 3\Big[23\Big(1000 - 300 \Big[+ \frac{0.01}{2}(1000^2 - 300^2) \Big]$
$= 3[16100 + 4550]$
$= 3 \times 20650 = 61950J$
$= 61.95kJ$
$\approx 62kJ$

Question115

A process will be spontaneous at all temperatures if:
[April 10, 2019 (I)]

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 $\Delta S > 0$

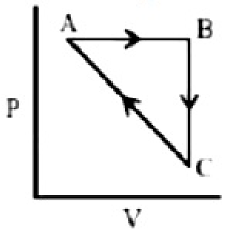
Answer: C

Solution:

Solution:
A reaction is spontaneous if ΔG_{sys} is negative.
$\Delta G_{sys} = \Delta H_{sys} - T \Delta S_{sys}$
A reaction will be spontaneous at all temperatures if
ΔH_{sys} is negative and ΔS_{sys} is positive.

Question116

An ideal gas undergoes a cyclic process as shown in Figure.



$$\Delta U_{BC} = -5\text{kJ mol}^{-1}, q_{48} = 2\text{kJ mol}^{-1}$$
$$W_{AB} = -5\text{kJ mol}^{-1}, W_{CA} = 3\text{kJ mol}^{-1}$$

Heat absorbed by the system during process CA is:
[Online April 15,2018 (I)]

Options:

A. -5kJ mol^{-1}

B. $+5\text{kJ mol}^{-1}$

C. 18kJ mol^{-1}

D. -18kJ mol^{-1}

Answer: B

Solution:

Solution:
$\Delta U_{AB} = q_{AB} + W_{AB} = 2 + (-5) = -3\text{kJ / mol}$
$\Delta U_{BC} = -5\text{kJ / mol}$

For cyclic process, $\Delta U = 0$
$\Delta U_{AB} + \Delta U_{BC} + \Delta U_{CA} = 0$
$\Delta U_{CA} = -\Delta U_{AB} - \Delta U_{BC}$
$\Delta U_{CA} = -(-3) - (-5) = 8 \text{kJ} / \text{mol}$
$\Delta U_{CA} = q_{CA} + W_{CA}$
$8 = q_{CA} + 3$
$q_{CA} = +5 \text{kJ} / \text{mol}$
Heat absorbed has positive sign.

Question117

The combustion of benzene (I) gives $CO_2(g)$ and $H_2O(l)$. Given that heat of combustion of benzene at constant volume is $-3263.9 \text{kJ mol}^{-1}$ at $25^\circ C$; heat of combustion (in kJ mol^{-1}) of benzene at constant pressure will be:
$(R = 8.314 \text{J K}^{-1} \text{mol}^{-1})$
[2018]

Options:

A. 4152.6

B. -452.46

C. 3260

D. -3267.6

Answer: D

Solution:

Solution:
$C_6H_6(l) + \frac{15}{2}O_2(g) \longrightarrow {}_6CO_2(g) + 3H_2O(l)$
$\Delta n_g = 6 - \frac{15}{2} = -\frac{3}{2}$ $\Delta H = \Delta U + \Delta n_g RT$
$= -3263.9 + \left(-\frac{3}{2}\right) \times 8.314 \times 10^{-3} \times 298$
$= -3263.9 + (-3.71) = -3267.6 \text{kJ mol}^{-1}$

Question118

For which of the following reactions, ΔH is equal to ΔU ?
[Online April 15, 2018 (I)]

Options:

A. $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$

B. $2HI(g) \rightarrow H_2(g) + I_2(g)$

C. $2SO_2(g) + O_2(g) \rightarrow 2SO_3(g)$

D. $2NO_2(g) \rightarrow N_2O_4(g)$

Answer: B

Solution:

Solution:
$\Delta H = \Delta U + \Delta n_g RT$
$2HI(g) \rightarrow H_2(g) + I_2(g); \Delta n_g = (1+1) - 2 = 0$
$\therefore \Delta H = \Delta U + 0$

Question119

For which of the following processes, ΔS is negative? [Online April 16, 2018]

Options:

A. C (diamond) →C (graphite)

B. N_2(g, latm) → N_2(g, 5atm)

C. N_2(g, 273K) → N_2(g, 300K)

D. $H_2(g) \rightarrow 2H(g)$

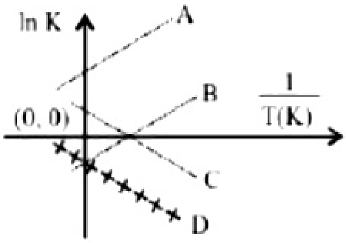
Answer: B

Solution:

Solution:
When diamond is converted into graphite (it is heated to 1500°C) entropy is increased, $\Delta S > 0$
(b) When pressure increases then molecules of gas will come closer and intermolecular distance decreases, so cntropy will also decrease, $\Delta S < 0$
(c) When we increase the temperature of a gas then randomness is increased as the kinetic energy gained by molecules. So, $\Delta S > 0$
(d) H_2 molecule is converted into atoms, the no. of particles increases. Thus entropy will increase, $\Delta S > 0$

Question120

Which of the following lines correctly show the temperature dependence of equilibrium constant, K , for an exothermic reaction?



[2018]

Options:

A. A and B

B. B and C

C. C and D

D. A and D

Answer: A

Solution:

Solution:
From thermodynamics relation.
$\Delta G^{\circ} = -RT\,\ell nK \;\; \Delta H^{\circ} - T\;\Delta S^{\circ} = RT\,\ell nK$
$-\frac{\Delta H^{\circ}}{RT} + \frac{T\;\Delta S^{\circ}}{RT} = \ln K$
or $\ln K = -\frac{\Delta H^{\circ}}{RT} + \frac{\Delta S^{\circ}}{R}$
For exothermic reaction, $\Delta H^{\circ} = -ve$
slope $= -\frac{\Delta H^{\circ}}{R} = +ve$
So from graph, lines should be A& B.

Question121

At $320K$, a gas A_2 is 20% dissociated to A(g). The standard free energy change at $320K$ and 1atm in $J\,mol^{-1}$ is approximately: ($R = 8.314J\,K^{-1}mol^{-1}$; $\ln 2 = 0.693$; $\ln 3 = 1.098$) [Online April 16, 2018]

Options:

A. 1844

B. 2068

C. 4281

D. 4763

Answer: D

Solution:

Solution:
$\Delta G_{rxn}{}^{o} = \Delta_f G^{\circ}(\text{vapour}) - \Delta_f\; G^{\circ}(\text{ liquid })$
$\Delta G_{rxn}{}^{o} = 103 - 100.7 = 2.3\text{kcal } / \text{mol } = 2300\text{cal } / \text{mol}$
$\Delta G_{rxn}{}^{0} = -RT\; \ln K_p (K_p = P_{vap})$
$2300\text{cal } / \text{mol } = -2\text{cal } / \text{mol } / K \times 500K \times \ln K_p$
$\ln K_p = -2.3\, \log_{10} K_p = -1$
$K_p =$ Antilog $-1 = 0.1\text{atm}$
∴ Vapour pressure of liquid ' S ' at $500K$ is approximately equal to 0.1atm.

Question122

$\Delta_f G^\circ$ at 500K for substance 'S' in liquid state and gaseous state are $+100.7 \text{kcal mol}^{-1}$ and $+103 \text{kcal mol}^{-1}$, respectively.
Vapour pressure of liquid 'S' at 500K is approximately equal to:
$(R = 2 \text{cal K}^{-1} \text{mol}^{-1})$.
[Online April 15, 2018(II)]

Options:

A. 100atm

B. 1atm

C. 10atm

D. 0.1atm

Answer: C

Solution:

Solution:
As we know that, at equilibrium,
$\Delta G^\circ = -2.303 \ \ RT \ \log K_{p..... \ (1)}$
$S_{(I)} \rightleftharpoons S_{(g)}$
From the above reaction,
$\Delta G^\circ = \Delta G_{f_{(product)}} - \Delta \ G_{(reactant)}^{\ \circ}$
$\Rightarrow \Delta \ G^\circ = 103 - 100.7 = 2.3 \text{kcal / mol} = 2.3 \times 10^3 \text{kcal / mol}$
Given:-
$T \ = 500K$
$R \ = 2 \text{cal / mol} - K$
From eq ^{n} (1), we have
$2.3 \times 10^3 = -2.303 \times 2 \times 500 \times \log K_p$
$\Rightarrow \log K_p = -1$
$\Rightarrow K_p = 10^{-1} \text{atm}$
Now, from the above reaction,
$K_p = \dfrac{1}{P_{S_1}}$
$\Rightarrow P_{S_1} = \dfrac{1}{10^{-1}} = 10 \text{atm}$
Hence the vapou pressure of liquid S is approximately equal to 10atm .

Question123

Given
(i) $2Fe_2O_3(s) \rightarrow 4Fe(s) + 3O_2(g)$;
$\Delta_r G^\circ = +1487.0 \text{kJ mol}^{-1}$
(ii) $2CO(g) + O_2(g) \rightarrow 2CO_2(g)$;
$\Delta_r G^\circ = -514.4 \text{kJ mol}^{-1}$
Free energy change, $\Delta_r G^\circ$ for the reaction
$2Fe_2O_3(s) + 6CO(g) \rightarrow 4Fe(s) + 6CO_2(g)$ will be:

[Online April 15, 2018 (II)]

Options:

A. $-112.4 \mathrm{kJ\ mol}^{-1}$

B. $-56.2 \mathrm{kJ\ mol}^{-1}$

C. $-208.0 \mathrm{kJ\ mol}^{-1}$

D. $-168.2 \mathrm{kJ\ mol}^{-1}$

Answer: B

Solution:

(i) $2Fe_2O_3(s) \rightarrow 4Fe(s) + 3O_2(g)$; $\Delta_r G^0 = +1487.0 \mathrm{\ kJ\ mol}^{-1}$
(ii) $2CO(g) + O_2(g) \rightarrow 2CO_2(g)$; $\Delta_r G^0 = -514.4 \mathrm{\ kJ\ mol}^{-1}$
Multiply above reaction with 3
(iii) $6CO(g) + 3O_2(g) \rightarrow 6CO_2(g)$; $\Delta_r G^0 = 3 \times -514.4 = -1543.2 \mathrm{\ kJ\ mol}^{-1}$
When we add reaction (i) and reaction (iii), we get reaction (iv)
(iv) $2Fe_2O_3(s) + 6CO(g) \rightarrow 4Fe(s) + 6CO_2(g)$
Free energy change, $\Delta_r G^0$ for the reaction will be, $1487.0 - 1543.2 = -56.2 \mathrm{\ kJ\ mol}^{-1}$

Question124

ΔU is equal to
[2017]

Options:

A. Isochoric work

B. Isobaric work

C. Adiabatic work

D. Isothermal work

Answer: C

Solution:

From 1 st law of thermodynamics
$\Delta U = q + w$
For adiabatic process : $q = 0$
$\therefore \Delta U = w$

Question125

A gas undergoes change from state A to state B. In this process, the heat absorbed and work done by the gas is 5 J and 8J, respectively. Now gas is brought back to A by another process during which 3J of heat is evolved. In this reverse process of B to A:
[Online April 9,2017]

Options:

A. 10J of the work will be done by the gas.

B. 6J of the work will be done by the gas.

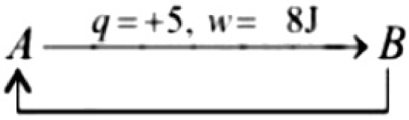
C. 10J of the work will be done by the surrounding on gas.

D. 6J of the work will be done by the surrounding on gas.

Answer: D

Solution:

Solution:



$\Delta U_{AB} = q + w = +5 + (-8) = -3$
$q = -3, \Delta U_{BA} = +3$
$\Delta U_{BA} = q + w$
$\Rightarrow 3 = -3 + w \Rightarrow w = +6$ (work done on the system).

Question126

Given
$C_{(\text{ graphite})} + O_2(g) \rightarrow CO_2(g); \Delta_r H^\circ = -393.5 \text{kJ mol}^{-1}$
$H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l); \Delta_r H^\circ = -285.8 \text{kJ mol}^{-1}$
$CO_2(g) + 2H_2O(l) \rightarrow CH_4(g) + 2O_2(g);$
$\Delta_r H^\circ = +890.3 \text{kJ mol}^{-1}$
Based on the above thermochemical equations, the value of $\Delta_r H^\circ$ at 298K for the reaction $C_{(\text{gaphite})} + 2H_2(g) \rightarrow CH_4(g)$ will be
[2017]

Options:

A. $+74.8 \text{kJ mol}^{-1}$

B. $+144.0 \text{kJ mol}^{-1}$

C. -74.8kJ mol^{-1}

D. $-144.0 \text{kJ mol}^{-1}$

Answer: C

Solution:

Solution:

$C_{(\text{ graphite})} + O_2(g) \longrightarrow CO_2(g);$
$\Delta H^\circ = -393.5 kJ\ / mol^{-1} \ldots\ (i)$
$H_2(g) + \frac{1}{2}O_2(g) \longrightarrow H_2O(I)$
$\Delta_r H^\circ = -285.8 kJ\ / mol^{-1} \ldots (ii)$
$CO_2(g) + 2H_2O(I) \longrightarrow CH_4(g) + 2O_2(g);$
$\Delta H_r^\circ = +890.3 kJ\ / mol^{-1} \ldots (iii)$
$C_{(\text{graphite})} + 2H_2(g) \longrightarrow CH_4(g)$
$\Delta H = ? \ldots (iv)$
$[\text{ Eq. } (i) + E q . (iii)] + [2 \times E q . (ii)] = E q(iv)$
$\therefore [\Delta H_1 + \Delta H_3] + [2 \times \Delta H_2] = \Delta H_4$
$[(-393.5) + (890.3)] + [2(-285.8)]$
$= -74.8 kJ\ / mol$

Question127

For a reaction, $A(g) \rightarrow A(l)$; $\Delta H = -3RT$. The correct statement for the reaction is:
[Online April 8,2017]

Options:

A. $\Delta H = \Delta U \neq O$

B. $\Delta H = \Delta U = O$

C. $|\Delta H| < |\Delta U|$

D. $|\Delta H| > |\Delta U|$

Answer: D

Solution:

$A(g) \longrightarrow A(I)$
$\Delta H = \Delta U + \Delta n_g RT$
Given, $\Delta H = -3RT$
Here
$\Delta n_g = n_p - n_r = 0 - 1 = -1$
$\Delta H = \Delta U + \Delta RT$
$\Rightarrow -3RT = \Delta U - RT$
$\Rightarrow -3RT + RT = \Delta U$
$\Rightarrow -2RT = \Delta U$
$|\Delta H| > |\Delta U|$

Question128

The enthalpy change on freezing of 1mol of water at 5°C to ice at -5°C is :
(Given $\Delta_{fis} H = 6 kJ\ mol^{-1}$ at 0°C,

$C_p(H_2O, l) = 75.3 J\ mol^{-1}K^{-1}$
$C_p(H_2O, s) = 36.8 J\ mol^{-1}K^{-1}$)
[Online April 8, 2017]

Options:

A. $5.44 kJ\ mol^{-1}$

B. $5.81 kJ\ mol^{-1}$

C. $6.56 kJ\ mol^{-1}$

D. $6.00 kJ\ mol^{-1}$

Answer: B

Solution:

Solution:
In order to calculate the enthalpy change for H_2O at $5^\circ C$ to ice at $-5^\circ C$, we need to calculate the enthalpy change of all the transformation involved in the process.
(a) Energy change of $1 mol$, $H_2O(l)$, at $5^\circ C$
$\rightarrow 1 mol$, $H_2O(I)$, $0^\circ C$
(b) Energy change of $1 mol$, $H_2O(l)$, at $0^\circ C$
$\rightarrow 1 mol$, $H_2O(s)(ice)$, $0^\circ C$
(c) Energy change of $1 mol$, ice (s), at $0^\circ C$
$\rightarrow 1 mol$, ice (s), $-5^\circ C$
Total ΔH
$= C_p[H_2O(l)]\ \Delta T + \Delta H_{freezing} + C_p[H_2O(s)]\ \Delta T$
$= (75.3 J\ mol^{-1}K^{-1})(0 - 5)K + (-6 \times 10^3 J\ mol^{-1})$
$+ (36.8 J\ mol^{-1}K^{-1})(-5 - 0)K$
$\Delta H = -6.56 kJ\ mol^{-1}$ (cxothermic process)
So, $\Delta H = 6.56 kJ\ mol^{-1}$.

Question129

An ideal gas undergoes isothermal expansion at constant pressure. During the process:
[Online April9, 2017]

Options:

A. enthalpy increases but entropy decreases.

B. enthalpy remains constant but entropy increases.

C. enthalpy decreases but entropy increases.

D. Both enthalpy and entropy remain constant.

Answer: B

Solution:

$\Delta H = nC_p \Delta T = 0$ means ΔH constant.

$\Delta S = nR\ln\left(\frac{V_f}{V_i}\right) \geq 0$ ΔS increases

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Question130

If 100 mole of H_2O_2 decomposes at 1 bar and 300K, the work done (kJ) by one mole of $O_2(g)$ as it expands against 1 bar pressure is :
$2H_2O_2(l) \rightleftharpoons H_2O(l) + O_2(g)$
$(R = 83J\,K^{-1}mol^{-1})$
[Online April 10, 2016]

Options:

A. 124.50

B. 249.00

C. 498.00

D. 62.25

Answer: A

Solution:

Solution:
$2H_2O_2(1) \rightleftharpoons 2H_2O(1) + O_2(g)$
$w = -P_{ext}(\Delta V) = -n_{O_2}RT$
$\because 100mol\,eH_2O_2$ on decomposition give $50mol\,eO_2$.
$\therefore W = -(50)(8.3)(300) = -124500J = -124.5kJ$.

Question131

The heats of combustion of carbon and carbon monoxide are -393.5 and $-283.5kJ\,mol^{-1}$, respectively. The heat of formation (in kJ) of carbon monoxide per mole is :
[2016]

Options:

A. -676.5

B. -110.5

C. 110.5

D. 676.5

Answer: B

Solution:

Given

$C(s) + O_2(g) \rightarrow CO_2(g); \Delta H = -393.5 \text{kJ mol}^{-1} \ldots (i)$

$CO(g) + \frac{1}{2}O_2(g) \rightarrow CO_2(g); \Delta H = -283.5 \text{kJ mol}^{-1} \ldots (ii)$

$\therefore$ Heat of formation of CO = $eq^n(i) - eq^n(ii)$

$= -393.5 - (-283.5)$

$= -110 \text{kJ}$

Question132

A reaction at 1 bar is non-spontaneous at low temperature but becomes spontaneous at high temperature. Identify the correct statement about the reaction among the following :

[Online April 9, 2016]

Options:

A. ΔH is negative while ΔS is positive

B. Both ΔH and ΔS are negative

C. ΔH is positive while ΔS is negative

D. Both ΔH and ΔS are positive.

Answer: D

Solution:

Solution:

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

At low temperature,

$T \Delta S < \Delta H$

$\Delta G > 0$ and the reaction is non spontaneous.

At high temperature,

$T \Delta S > \Delta H$

$\Delta G < 0$ and the reaction is spontaneous.

Question133

The heat of atomization of methane and ethane are 360kJ / mol and 620kJ / mol, respectively. The longest wavelength of light capable of breaking the C − C bond is (Avogadro number $= 6.02 \times 10^{23}$, $h = 6.62 \times 10^{-34}$ J s):

[Online April 10,2015]

Options:

A. 2.48×10^4 nm

B. 1.49×10^3 nm

C. 2.48×10^3 nm

D. 1.49×10^4nm

Answer: B

Solution:

Solution:
I nCH $_4$, $4 \times BE_{(C-H)} = 360kJ / mol$
$\therefore BE_{(C-H)} = 90kJ / mol$
In C_2H_6, $BE_{(C-C)} + 6 \times BE_{(C-H)} = 620kJ / mol$
$\therefore BE_{(C-C)} = 80kJ / mol$
$\therefore BE_{(C-C)} = \frac{80 \times 10^3}{6.023 \times 10^{23} J / mol}$
Now, $E = \frac{hc}{\lambda}$
$\therefore \lambda = \frac{6.626 \times 10^{-34} \times 3 \times 10^8 \times 6.023 \times 10^{23}}{80 \times 10^3}$
$\lambda = 1.49 \times 10^{-6}m$ $(\because 1nm = 10^{-9}m)$
$\therefore \lambda = 1.49 \times 10^3 nm$

Question134

For complete combustion of ethanol, $C_2H_5OH(l) + 3O_2(g) \longrightarrow 2CO_2(g) + 3H_2O(l)$, the amount of heat produced as measured in bomb calorimeter, is $1364.47kJ\,mol^{-1}$ at 25°C. Assuming ideality the enthalpy of combustion, $\Delta_c H$, for the reaction will be:
$(R = 8.314kJ\,mol^{-1})$
[2014]

Options:

A. $-1366.95kJ\,mol^{-1}$

B. $-1361.95kJ\,mol^{-1}$

C. $-1460.95kJ\,mol^{-1}$

D. $-1350.50kJ\,mol^{-1}$

Answer: A

Solution:

Solution:
$C_2H_5OH(l) + 3O_2(g) \longrightarrow 2CO_2(g) + 3H_2O(l)$
Bomb calorimeter gives ΔU of the reaction
Given, $\Delta U = -1364.47kJ\,mol^{-1}$
$\Delta n_g = -1$
$\Delta H = \Delta U + \Delta n_g RT$
$= -1364.47 - \frac{I \times 8.314 \times 298}{1000}$
$= -1366.95kJ\,mol^{-1}$

Question135

The standard enthalpy of formation of NH_3 is $-46.0 kJ / mol$. If the enthalpy of formation of H_2 from its atoms is $436 kJ\ / mol$ and that of N_2 is $-712 kJ\ / mol$, the average bond enthalpy of $N - H$ bond in NH_3 is:
[Online April 9, 2014]

Options:

A. $-1102 kJ\ / mol$

B. $-964 kJ\ / mol$

C. $+352 kJ\ / mol$

D. $+1056 kJ\ / mol$

Answer: C

Solution:

Given
$\frac{1}{2}N_2 + \frac{3}{2}H_2 \rightleftharpoons NH_3$
$\Delta_f H = -46.0 kJ\ / mol$
$H + H \rightleftharpoons H_2; \Delta_f H = -436 kJ\ / mol$
$N + N \rightleftharpoons N_2; \Delta_f H = -712 kJ\ / mol$
$\Delta_f H (NH_3) = \frac{1}{2} \Delta H_{N-N} + \frac{3}{2} \Delta H_{H-H} - 3 \Delta H_{N-H}$
$-46 = \frac{1}{2}(712) + \frac{3}{2}(436) - 3 \Delta H_{N-H}$
$-3 \Delta H_{N-H} = -1056$
$\Delta H_{N-H} = 352 kJ\ / mol$

Question136

The standard enthalpy of formation $(\Delta_f H_{298}^{\circ})$ for methane, CH_4 is $-74.9 kJ\, mol^{-1}$. In order to calculate the average energy given out in the formation of a $C - H$ bond from this it is necessary to know which one of the following?
[Online April 12, 2014]

Options:

A. The dissociation energy of the hydrogen molecule, H_2.

B. The first four ionisation energies of carbon.

C. The dissociation energy of H_2 and enthalpy of sublimation of carbon (graphite).

D. The first four ionisation energies of carbon and electron affinity of hydrogen.

Answer: C

Solution:

Solution:
To calculate average enthalpy of $C-H$ bond in methane following informations are needed
(i) dissociation energy of H_2 i.e.
$\frac{1}{2}H_2(g) \longrightarrow H(g); \Delta H = x(\text{ suppose })$
(ii) Sublimation energy of C(graphite) to C(g)
$C_{(\text{graphite})} \longrightarrow C(g); \Delta H = y(\text{ Suppose })$
Given
$C_{(\text{graphite})} + 2H_2(g) \longrightarrow CH_4(g)$
$\Delta H g = -74.9 kJ\ mol^{-1}$

Question137

The molar heat capacity (C_p) of CD_2O is 10 cals at 1000K. The change in entropy associated with cooling of 32g of CD_2O vapour from 1000K to 100K at constant pressure will be: (D = deuterium, atomic mass = 2u) [Online April 11, 2014]

Options:

A. 23.03 cal deg^{-1}

B. -23.03 cal deg^{-1}

C. 2.303 cal deg^{-1}

D. -2.303 cal deg^{-1}

Answer: B

Solution:

Solution:
(b) Given, $C_p = 10 cal$ at $1000K$
$T_1 = 1000K$. $T_2 = 100K$
$m = 32g$
$\Delta S = ?$
at constant pressure

$$\Delta S = C_p \ln \frac{T_2}{T_1}$$
$$= 2.303 \times C_p \log \frac{T_2}{T_1}$$
$$= 2.303 \times 10 \log \frac{100}{1000}$$
$$= -23.03 cal\ deg^{-1}$$

Question138

The (S°) of the following substances are:

$CH_4(g) 186.2 J\,K^{-1} mol^{-1}$ $O_2(g) 205.2 J\,K^{-1} mol^{-1}$
$CO_2(g) 213.6 J\,K^{-1} mol^{-1}$
$H_2O(l) 69.9 J\,K^{-1} mol^{-1}$
The entropy change (ΔS°) for the reaction
$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(l)$ is:
[Online April 12, 2014]

Options:

A. $-312.5 J\,K^{-1} mol^{-1}$

B. $-242.8 J\,K^{-1} mol^{-1}$

C. $-108.1 J\,K^{-1} mol^{-1}$

D. $-37.6 J\,K^{-1} mol^{-1}$

Answer: B

Solution:

Solution:
$\Delta S^{\circ} = S^{\circ}CO_2 + 2 \times S^{\circ}H_2O - \left(S^{\circ}CH_4 + 2 \times S_{O_2}{}^{\circ}\right)$
$= (213.6 + 2 \times 69.9) - (186.2 + 2 \times 205.2)$
$= -242.8 J\,K^{-1} mol^{-1}$

Question139

A piston filled with 0.04 mol of an ideal gas expands reversibly from 50.0 mL to 375 mL at a constant temperature of 37.0°C. As it does so, it absorbs 208 J of heat. The values of q and w for the process will be: $(R = 8.314 J / mol\,K)(\ln 7.5 = 2.01)$
[2013]

Options:

A. $q = +208 J, w = -208 J$

B. $q = -208 J, w = -208 J$

C. $q = -208 J, w = +208 J$

D. $q = +208 J, w = +208 J$

Answer: A

Solution:

Solution:
Process is isothermal reversible expansion, hence
$\Delta U = 0$, therefore $q = -w$
Since $q = +208 J$, $w = -208 J$

Question140

Which of the following statements\/relationships is not correct in thermodynamic changes?
[Online April 23,2013]

Options:

A. $\Delta U = 0$ (isothermal reversible expansion of a gas)

B. $w = -nRT \ln \frac{V_2}{V_1}$ (isothermal reversible expansion of an ideal gas)

C. $w = nRT \ln \frac{V_2}{V_1}$ (isothermal reversible expansion of an ideal gas)

D. For a system of constant volume heat involved directly changes to internal energy.

Answer: C

Solution:

Solution:
For isothermal reversible expansion.

$w = -nRT \ln \frac{V_2}{V_1}$

Question141

Given:
(I) $H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l)$
$\Delta H_{298K}^{\circ} = -285.9 \mathrm{kJ\,mol}^{-1}$
(II) $H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(g)$;
$\Delta H_{298K}^{\circ} = -241.8 \mathrm{kJ\,mol}^{-1}$
The molar enthalpy of vapourisation of water will be:
[Online April 9, 2013]

Options:

A. $241.8 \mathrm{kJ\,mol}^{-1}$

B. $22.0 \mathrm{kJ\,mol}^{-1}$

C. $44.1 \mathrm{kJ\,mol}^{-1}$

D. $527.7 \mathrm{kJ\,mol}^{-1}$

Answer: C

Solution:

Given

$H_2(g) + \frac{1}{2}O_2(g) \longrightarrow H_2O(l)$

$\Delta H^\circ = -285.9 \text{kJ mol}^{-1}$ . . . (i)

$H_2(g) + \frac{1}{2}O_2(g) \longrightarrow H_2O(g)$

$\Delta H^\circ = -241.8 \text{kJ mol}^{-1}$ . . . (ii)

We have to calculate

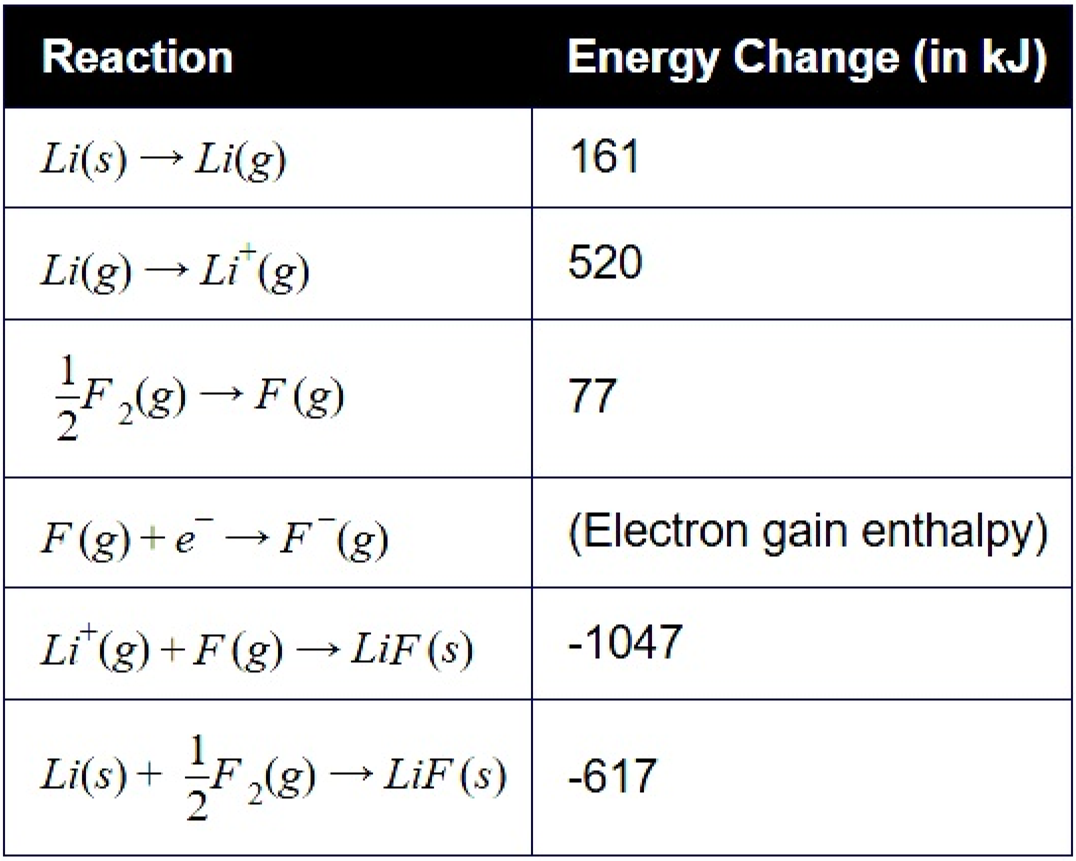
$H_2O(l) \longrightarrow H_2O(g); \Delta H^\circ = ?$

On substracting eqn. (ii) from eqn. (i) we get

$H_2O(l) \longrightarrow H_2O(g); \Delta H^\circ = -241.8 - (-285.9)$

$= 44.1 \text{kJ mol}^{-1}$

Question142



Reaction	Energy Change (in kJ)
$Li(s) \rightarrow Li(g)$	161
$Li(g) \rightarrow Li^+(g)$	520
$\frac{1}{2}F_2(g) \rightarrow F(g)$	77
$F(g) + e^- \rightarrow F^-(g)$	(Electron gain enthalpy)
$Li^+(g) + F(g) \rightarrow LiF(s)$	-1047
$Li(s) + \frac{1}{2}F_2(g) \rightarrow LiF(s)$	-617

Based on data provided, the value of electron gain enthalpy of fluorine would be :
[Online April 22,2013]

Options:

A. -300kJ mol^{-1}

B. -350kJ mol^{-1}

C. $-328 \mathrm{kJ\ mol}^{-1}$

D. $-228 \mathrm{kJ\ mol}^{-1}$

Answer: C

Solution:

Applying Hess's Law

$$\Delta_f H^\circ = \Delta_{sub} H + \frac{1}{2}\Delta_{d\,iss} H + I.E. + E.A. + \Delta_{lattice} H$$
$$-617 = 161 + 520 + 77 + E.A. + (-1047)$$
$$E.A. = -617 + 289 = -328 \mathrm{kJ\ mol}^{-1}$$
$\therefore$ electron affinity of fluorine $= -328 \mathrm{kJ\ mol}^{-1}$

Question143

In which of the following exothermic reactions, the heat liberated per mole is the highest?
[Online April 25, 2013]

Options:

A. $CaO + H_2O \rightarrow Ca(OH)_2$

B. $SrO + H_2O \rightarrow Sr(OH)_2$

C. $BaO + H_2O \rightarrow Ba(OH)_2$

D. $MgO + H_2O \rightarrow Mg(OH)_2$

Answer: A

Solution:

Solution:

Question144

Given that:
(i) $\Delta_f H^\circ$ of N_2O is $82 \mathrm{kJ\ mol}^{-1}$
(ii) Bond energies of $N = N$, $N = N$, $O = O$ and $N = O$ are 946, 418, 498 and $607 \mathrm{kJ\ mol}^{-1}$ respectively,
The resonance energy of N_2O is:
[Online April 25, 2013]

Options:

A. $-88 \mathrm{kJ}$

B. $-66 \mathrm{kJ}$

C. $-62 \mathrm{kJ}$

D. $-44 \mathrm{kJ}$

Answer: A

Solution:

$N_2(g) + \frac{1}{2}O_2 \rightarrow N_2O(g)$

$N \equiv N\,(g) + \frac{1}{2}(O = O) \rightarrow \overset{+}{N} = N = O(g)$

$\Delta_f H^o = [$

Energy required for breaking of bonds]

$-[$ Energy released for forming of bonds]

$= \left(\Delta H_{N \equiv N} + \frac{1}{2}\Delta H_{O = O} - (\Delta H_{N = N} + \Delta H_{N = O}\right)$

$= \left(946 + \frac{1}{2} \times 498\right) - (418 + 607) = 170 \mathrm{kJ\,mol}^{-1}$

Resonance energy = observed $\Delta_f H^\circ -$ calculated $\Delta_f H^\circ$

$82 - 170 = -88 \mathrm{kJ\,mol}^{-1}$

Question145

The difference between the reaction enthalpy change (ΔH) and reaction internal energy change ($\Delta_f U$) for the reaction:

$2C_6H_6(I) + 15O_2(g) \longrightarrow 12CO_2(g) + 6H_2O(I)$

at 300K is ($R = 8.314 \mathrm{J\,mol}^{-1}\mathrm{K}^{-1}$)

[Online May 12, 2012]

Options:

A. $0 \mathrm{J\,mol}^{-1}$

B. $2490 \mathrm{J\,mol}^{-1}$

C. $-2490 \mathrm{J\,mol}^{-1}$

D. $-7482 \mathrm{J\,mol}^{-1}$

Answer: D

Solution:

Solution:

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

For the reaction $\Delta n_g = 12 - 15 = -3$

$\Delta H - \Delta U = -3 \times 8.314 \times 300$

$= -7482.6 \mathrm{J\,mol}^{-1}$

Question146

The enthalpy of neutralisation of NH_4OH with HCl is $-51.46 kJ\ mol^{-1}$ and the enthalpy of neutralisation of $NaOH$ with HCl is $-55.90 kJ\ mol^{-1}$. The enthalpy of ionisation of NH_4OH is
[Online May 19, 2012]

Options:

A. $-107.36 kJ\ mol^{-1}$

B. $-4.44 kJ\ mol^{-1}$

C. $+107.36 kJ\ mol^{-1}$

D. $+4.44 kJ\ mol^{-1}$

Answer: D

Solution:

$\underset{\text{Strong acid}}{HCl} \longrightarrow \underset{\text{(Complete ionisation)}}{H^+ + Cl^-}$ ...(i)

$\underset{\text{Weak base}}{NH_4OH} \rightleftharpoons \underset{\Delta H = x kJ\ mol^{-1}}{NH_4^+ + OH^-}$ . . . (ii)

$H^+ + OH^- \longrightarrow H_2O$ . . . (iii)

$\Delta H = -55.90 kJ\ mol^{-1}$

(from neutralisation of strong acid and strong base)

From equation (i), (ii) and (iii)

$NH_4OH + HCl \longrightarrow NH_4^+ + Cl^- + H_2O$

$\Delta H = -51.46 kJ\ mol^{-1}$

$\therefore\ x + (-55.90) = -51.46$

$x = -51.46 + 55.90$

$= 4.44 kJ\ mol^{-1}$

∴ Enthalpy of ionisation of

$NH_4OH = 4.44 kJ\ mol^{-1}$

Question147

The entropy of a sample of a certain substance increases by $0.836 J\ K^{-1}$ on adding reversibly $0.3344 J$ of heat at constant temperature. The temperature of the sample is:
[Online May 7, 2012]

Options:

A. 2.5K

B. 0.3K

C. 0.016K

D. 0.4K

Answer: D

Solution:

Solution:

$\Delta S = \frac{\Delta H}{T}; T = \frac{\Delta H}{\Delta S} = \frac{0.3344}{0.836} = 0.4K$

Question148

One mole of an ideal gas is expanded isothermally and reversibly to half of its initial pressure. ΔS for the process in $J\,K^{-1}mol^{-1}$ is $[\ln 2 = 0.693$ and $R = 8.314, J\ /\ (mol\ K)]$
[Online May 26, 2012]

Options:

A. 6.76

B. 5.76

C. 10.76

D. 8.03

Answer: B

Solution:

Solution:
For isothermal process
$(\Delta T\ = 0)$

$\Delta S\ \ = R \ln \frac{P_1}{P_2} = 8.314 \ln 2$

$= 8.314 \times 0.693 = 5.76$

Question149

The incorrect expression among the following is:
[2012]

Options:

A. $\frac{\Delta G_{system}}{\Delta S_{total}} = -T$

B. In isothermal process, $w_{reversible} = -nRT \ln \frac{V_f}{V_i}$

C. $\ln K\ = \frac{\Delta H^{\circ} - T\ \Delta S^{\circ}}{RT}$

D. $K\ = e^{-\Delta G^{\prime}/RT}$

Answer: C

Solution:

Solution:

$\Delta G^{\circ} = \Delta H^{\circ} - T \Delta S^{\circ}$

$-RT \ln K = \Delta H^{\circ} - T \Delta S^{\circ}$

$\ln K = -\frac{\Delta H^{\circ} - T \Delta S^{\circ}}{RT}$

Question150

The value of enthalpy change (ΔH) for the reaction $C_2H_5OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l)$ at 27°C is $-1366.5 kJ\ mol^{-1}$. The value of internal energy change for the above reaction at this temperature will be :
[2011 RS]

Options:

A. $-1369.0 kJ$

B. $-1364.0 kJ$

C. $-1361.5 kJ$

D. $-1371.5 kJ$

Answer: B

Solution:

Solution:

$C_2H_5OH(l) + 3O_2(g) \longrightarrow 2CO_2(g) + 3H_2O(l)$

$\Delta n_g = 2 - 3 = -1$

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

$= -1366.5 - [(-1) \times 8.314 \times 300]$

$= -1366.5 + \left[(1) \times \frac{8.314}{10^3} \times 300\right]$

$= -1366.5 + 0.8314 \times 3 = -1364 kJ$

Question151

Consider the reaction:
$4NO_2(g) + O_2(g) \rightarrow 2N_2O_5(g)\ \Delta H = -111 kJ$ If $N_2O_5(s)$ is formed instead of $N_2O_5(g)$ in the above reaction, the $\Delta_r H$ value will be :
(given, ΔH of sublimation for N_2O_5 is $54 kJ\ mol^{-1}$)
[2011 RS]

Options:

A. $+54 kJ$

B. +219kJ

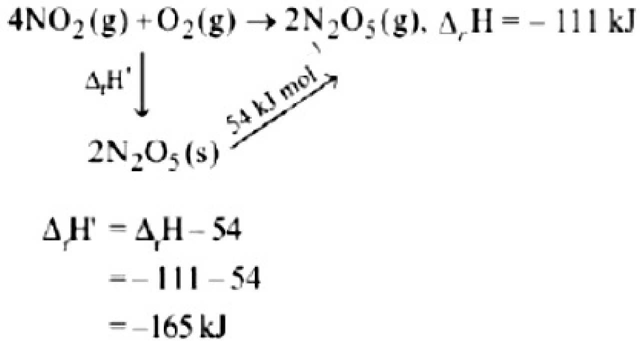
C. −219J

D. −165kJ

Answer: D

Solution:

Solution:



$$\begin{tikzcd}
4NO_2(g) + O_2(g) \arrow[r] \arrow[d, "\Delta_r H'"'] & 2N_2O_5(g),\ \Delta_r H = -111\ \text{kJ} \\
2N_2O_5(s) \arrow[ur, "54\ \text{kJ mol}^{-1}"] &
\end{tikzcd}$$

$\Delta_r H' = \Delta_r H - 54$

$= -111 - 54$

$= -165$ kJ

Question152

The standard enthalpy of formation of NH_3 is -46.0kJ mol^{-1}. If the enthalpy of formation of H_2 from its atoms is -436kJ mol^{-1} and that of N_2 is -712kJ mol^{-1}, the average bond enthalpy of $N - H$ bond in NH_3 is

[2010]

Options:

A. −964kJ mol^{-1}

B. +352kJ mol^{-1}

C. +1056kJ mol^{-1}

D. −1102kJ mol^{-1}

Answer: B

Solution:

Solution:

(b) $N_2 + 3H_2 \longrightarrow 2NH_3 \quad \Delta H = 2 \times -46.0\text{kJ mol}^{-1}$

Let x be the bond enthalpy of $N - H$ bond then [Note: Enthalpy of formation or bond formation enthalpy is given which is negative but the given reaction involves bond breaking hence values should be taken as positive.] $\Delta H = \Sigma$ Bond energies of reactants $-\Sigma$ Bond energies of products

$2 \times -46 = 712 + 3 \times (436) - 6x - 92 = 2020 - 6x$

$6x = 2020 + 92$

$6x = 2112$

$x = +352\text{kJ} / \text{mol}$

Question153

For a particular reversible reaction at temperature T, ΔH and ΔS were found to be both +ve. If T_e is the temperature at equilibrium, the reaction would be spontancous when
[2010]

Options:

A. $T_c > T$

B. $T > T_c$

C. T_e is 5 times T

D. $T = T_e$

Answer: B

Solution:

Solution:
At equilibrium $\Delta G = 0$
Hence, $\Delta G = \Delta H - T\Delta S = 0$
$\therefore \Delta H = T_e \Delta S$ or $T_e = \frac{\Delta H}{\Delta S}$
For a spontaneous reaction
ΔG must be negative which is possible only if $\Delta H < T\Delta S$
or $T > \frac{\Delta H}{\Delta S}$; $T_e < T$

Question154

On the basis of the following thermochemical data :
$(\Delta_f G^\circ H^{+}_{(aq)} = 0)$
$H_2O(l) \rightarrow H^+(aq) + OH^-(aq); \Delta H = 57.32 kJ$
$H_2(g) + \frac{1}{2}O_2(g) \longrightarrow H_2O(l); \Delta H = -286.20 kJ$
The value of enthalpy of formation of OH^- ion at 25°C is:
[2009]

Options:

A. $-228.88 kJ$

B. $+228.88 kJ$

C. $-343.52 kJ$

D. $-22.88 kJ$

Answer: A

Solution:

$H_2O(l) \longrightarrow H^+(aq.) + OH^-(aq.)$

$\Delta H = 57.32kJ \ . . . (i)$

$H_2(g) + \frac{1}{2}O_2(g) \longrightarrow H_2O(l)$

$\Delta H = -286.20kJ \ . . . (ii)$

By adding equation (i) & (ii) we get,

$H_2(g) + \frac{1}{2}(O_2) \longrightarrow H^+(aq) + OH^-(aq)$

$\Delta H = 57.32 - 286.2 = -228.88kJ$

Here $\Delta_f H^\circ$ of $H^+(aq.) = 0$

$\therefore \Delta_f H^\circ$ of $OH^- = -228.88kJ$

Question155

Oxidising power of chlorine in aqueous solution can be determined by the parameters indicated below:

$$\frac{1}{2}Cl_2(g) \xrightarrow{\frac{1}{2}\Delta_{diss}H^\circ} Cl(g) \xrightarrow{\Delta_{eg}H^\circ} Cl^-(g) \xrightarrow{\Delta_{hyd}H^\circ} Cl^-(aq)$$

The energy envolved in the conversion of

$\frac{1}{2}Cl_2(g)$ to $Cl^{-1}(aq)$

(using the data,

$\Delta_{diss} H_{Cl_2}^\circ = 240 kJ\,mol^{-1}$, $\Delta_{eg} H_{Cl}^o = -349 kJ\,mol^{-1}$

$\Delta_{hyd} H_{Cl}^\circ = -381 kJ\,mol^{-1}$), will be

[2008]

Options:

A. $+152 kJ\,mol^{-1}$

B. $-610 kJ\,mol^{-1}$

C. $-850 kJ\,mol^{-1}$

D. $+120 kJ\,mol^{-1}$

Answer: B

Solution:

Solution:

The energy involved in the conversion of

$\frac{1}{2}Cl_2(g)$ to $Cl^-(aq)$ is given by

$\Delta H = \frac{1}{2}\Delta_{diss} H_{Cl_2}^O + \Delta_{eg} H_{Cl}^\circ + \Delta_{hyd} H_{Cl}^\circ$

Substituting various values from given data, we get

$\Delta H = \left(\frac{1}{2} \times 240\right) + (-349) + (-381)$

$= (120 - 349 - 381) = -610 kJ\,mol^{-1}$

Question156

Standard entropy of X_2, Y_2 and XY_3 are 60,40 and 50J $K^{-1}mol^{-1}$, respectively. For the reaction,
$\frac{1}{2}X_2 + \frac{3}{2}Y_2 \rightarrow XY_3$, $\Delta H = -30kJ$, to be at equilibrium, the temperature will be
[2008]

Options:

A. 1250K

B. 500K

C. 750K

D. 1000K

Answer: C

Solution:

Solution:
For a reaction to be at equilibrium $\Delta G^{\circ} = 0$. Since $\Delta G^{\circ} = \Delta H^{\circ} - T\Delta S^{\circ}$ so at equilibrium $\Delta H^{\circ} - T\Delta S^{\circ} = 0$ or $\Delta H^{\circ} = T\Delta S^{\circ}$
For the reaction
$\frac{1}{2}X_2 + \frac{3}{2}Y_2 \longrightarrow XY_3; \Delta H^{\circ} = -30kJ$
Calculating ΔS° for the above reaction, we get
$\Delta S^{\circ} = 50 - \left[\frac{1}{2} \times 60 + \frac{3}{2} \times 40\right]$
$= 50 - (30 + 60) = -40J\,K^{-1}$
At equilibrium, $T\Delta S^{\circ} = \Delta H^{\circ}$ $[\because \Delta G^{\circ} = 0]$
$\therefore T \times (-40J\,K^{-1}) = -30 \times 1000J$ $[\because 1kJ = 1000J]$
or $T = \frac{-30 \times 1000}{-40} = 750K$

Question157

Assuming that water vapour is an ideal gas, the internal energy change (ΔU) when 1mol of water is vapourised at 1 bar pressure and 100°C, (given : molar enthalpy of vapourisation of water at 1 bar and 373K = 41kJ mol^{-1} and R = 8.3J $mol^{-1}K^{-1}$) will be
[2007]

Options:

A. 41.00kJ mol^{-1}

B. 4.100kJ mol^{-1}

C. 3.7904kJ mol^{-1}

D. 37.904kJ mol^{-1}

Answer: D

Solution:

Solution:
Given $\Delta H = 41 \text{kJ mol}^{-1} = 41000 \text{J mol}^{-1}$
$T = 100^{\circ}C = 273 + 100 = 373K$
$H_2O(I)\xrightarrow{\Delta}H_2O(g)$
$\Delta n_g = 1 - 0 = 1$
$\Delta U = \Delta H - \Delta nRT = 41000 - (1 \times 8.314 \times 373)$
$= 37898.88 \text{J mol}^{-1} \sim eq37.9 \text{kJ mol}^{-1}$

Question158

In conversion of lime-stone to lime, $CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$ the values of ΔH° and ΔS° are $+179.1 \text{kJ mol}^{-1}$ and $160.2 J/K$ respectively at $298K$ and 1 bar. Assuming that ΔH° and ΔS° do not change with temperature, temperature above which conversion of limestone to lime will be spontaneous is
[2007]

Options:

A. $1118K$

B. $1008K$

C. $1200K$

D. $845K$.

Answer: A

Solution:

Solution:
$\Delta G^{\circ} = \Delta H^{\circ} - T\Delta S^{\circ}$
For a spontaneous reaction $\Delta G^{\circ} < 0$

$$\text{or} \quad \Delta H^{\circ} - T\Delta S^{\circ} < 0 \Rightarrow T > \frac{\Delta H^{\circ}}{\Delta S^{\circ}}$$

$$\Rightarrow T > \frac{179.3 \times 10^3}{160.2}$$

$>1117.9K \approx 1118K$

Question159

Identify the correct statement regarding a spontaneous process:
[2007]

Options:

A. Lowering of energy in the process is the only criterion for spontaneity.

B. For a spontaneous process in an isolated system, the change in entropy is positive.

C. Endothermic processes are never spontaneous.

D. Exothermic processes are always spontaneous.

Answer: B

Solution:

Solution:
Spontaneity of reaction depends on tendency to acquire minimum energy state and maximum randomness. For a spontaneous process in an isolated system the change in entropy is positive.

Question160

An ideal gas is allowed to expand both reversibly and irreversibly in an isolated system. If T_i is the initial temperature and T_f is the final temperature, which of the following statements is correct?
[2006]

Options:

A. $(T_f)_{rev} = (T_f)_{irrev}$

B. $T_f = T_i$ for both reversible and irreversible processes

C. $(T_f)_{imcv} > (T_f)_{rev}$

D. $T_f > T_i$ for reversible process but $T_f = T_i$ for irreversible process

Answer: C

Solution:

Solution:
According to first law of thermodynamics $\Delta Q = \Delta U + \Delta W$
An isolated system is adiabatic. This means $\Delta Q = 0$. The first law in this case yields
$0 = \Delta U + \Delta W \Rightarrow \Delta W = -\Delta U$ . . . (i)
For expansion, ΔW is positive and hence ΔU is negative.
This means T_f is less than T_i in both the cases.
For the same expansion of volume, the work done in irreversible process is greater than that in reversible one because the system has to work against friction etc. Thus
$\Delta W_{\text{irreversible}} > \Delta W_{\text{reversible}}$
$\Rightarrow -\Delta U_{\text{irreversible}} > -\Delta U_{\text{reversible}}$ [from equation (i)]
$\Rightarrow \Delta U_{\text{irreversible}} < \Delta U_{\text{reversible}}$
$\Rightarrow \Delta T_{\text{irreversible}} < \Delta T_{\text{reversible}}$
$\Rightarrow T_{f\ \text{irreversible}} > T_{f\ \text{reversible}}$

Question161

The standard enthalpy of formation $(\Delta_f H^\circ)$ at 298K for methane, $CH_4(g)$ is $-74.8\,\text{kJ mol}^{-1}$. The additional information required to

determine the average energy for C − H bond formation would be [2006]

Options:

A. the first four ionization energies of carbon and electron gain enthalpy of hydrogen

B. the dissociation energy of hydrogen molecule, H_2

C. the dissociation energy of H_2 and enthalpy of sublimation of carbon

D. latent heat of vapourization of methane

Answer: C

Solution:

Solution:
The standard enthalpy of formation of CH_4 is given by the equation:
$C(s) + 2H_2(g) \longrightarrow CH_4(g)$
Hence, dissociation energy of hydrogen and enthalpy of sublimation of carbon is required.

Question162

The enthalpy changes for the following processes are listed below:
$Cl_2(g) = 2Cl(g),\ 242.3 kJ\ mol^{-1}$
$I_2(g) = 2I(g),\ 151.0 kJ\ mol^{-1}$
$ICl(g) = I(g) + Cl(g),\ 211.3 kJ\ mol^{-1}$
$I_2(s) = I_2(g),\ 62.76 kJ\ mol^{-1}$
Given that the standard states for iodine and chlorine are $I_2(s)$ and $Cl_2(g)$, the standard enthalpy of formation for $ICl(g)$ is :
[2006]

Options:

A. $+16.8 kJ\ mol^{-1}$

B. $+244.8 kJ\ mol^{-1}$

C. $-14.6 kJ\ mol^{-1}$

D. $-16.8 kJ\ mol^{-1}$

Answer: A

Solution:

Solution:
$I_2(s) + Cl_2(g) \longrightarrow 2ICl(g)$
$\Delta H = [\Delta H_{12(s)} \rightarrow_{12(g)} + \Delta H_{1-I} + \Delta H_{Cl-Cl}] - 2[\Delta H_{1-Cl}]$
$= 62.76 + 151.0 + 242.3 - 2 \times 211.3 = 33.46$

$\Delta H_f^{o}(I\,Cl) = \frac{33.46}{2} = 16.73 kJ\ / mol$

Question163

($\Delta H - \Delta U$) for the formation of carbon monoxide (CO) from its elements at 298K is ($R = 8.314 J\,K^{-1} mol^{-1}$)
[2006]

Options:

A. $-2477.57 J\,mol^{-1}$

B. $2477.57 J\,mol^{-1}$

C. $-1238.78 J\,mol^{-1}$

D. $1238.78 J\,mol^{-1}$

Answer: D

Solution:

Solution:
For the reaction,

$C(s) + \frac{1}{2}O_2(g) \longrightarrow CO(g)$

$\Delta H = \Delta U + \Delta n_g RT \quad or \quad \Delta H - \Delta U = \Delta n_g RT$

$\Delta n_g = 1 - \frac{1}{2} = \frac{1}{2};$

$\Delta H - \Delta U = \frac{1}{2} \times 8.314 \times 298$

$= 1238.78 J\,mol^{-1}$

Question164

Consider the reaction : $N_2 + 3H_2 \rightarrow 2NH_3$ carried out at constant temperature and pressure. If ΔH and ΔU are the enthalpy and internal energy changes for the reaction, which of the following expressions is true?
[2005]

Options:

A. $\Delta H > \Delta U$

B. $\Delta H < \Delta U$

C. $\Delta H = \Delta U$

D. $\Delta H = 0$

Answer: B

Solution:

Solution:
$\Delta H = \Delta U + \Delta n_g RT$ for
$N_2 + 3H_2 \longrightarrow 2NH_3$
$\Delta n_g = 2 - 4 = -2$
$\therefore \Delta H > \Delta U - 2RT$
or $\Delta U = \Delta H + 2RT \quad \therefore \Delta U > \Delta H$

Question165

If the bond dissociation energies of XY, X_2 and Y_2 (all diatomic molecules) are in the ratio of 1 : 1 : 0.5 and ΔH_f for the formation of XY is -200kJ mole^{-1}. The bond dissociation energy of X_2 will be [2005]

Options:

A. 400kJ mol^{-1}

B. 300kJ mol^{-1}

C. 200kJ mol^{-1}

D. 100kJ mol^{-1}

E. None of above

Answer: E

Solution:

Solution:
(N) $\frac{1}{2}X_2 + \frac{1}{2}Y_2 \longrightarrow XY, \Delta H = (-200)J$
Let x be the bond dissociation energy of X_2. Then
$\Delta H_f = -200 = \frac{1}{2}\Delta H_{x-x} + \frac{1}{2}\Delta H_{y-y} - \Delta H_{x-y}$
$-400 = x + 0.5x - 2x = -0.5x$
or $x = \frac{400}{0.5} = 800\text{kJ mol}^{-1}$
(In the question paper, this option was not mentioned. So the answer has been marked 'N')

Question166

An ideal gas expands in volume from 1×10^{-3} to $1 \times 10^{-2} m^3$ at 300K against a constant pressure of $1 \times 10^5 N m^{-2}$. The work done is [2004]

Options:

A. 270kJ

B. $-900 kJ$

C. $-900 J$

D. $900 kJ$

Answer: C

Solution:

Solution:
$w = -P\Delta V = -10^5[(1\times10^{-2})-(1\times10^{-3})]$
$= -900 J$

Question167

The enthalpies of combustion of carbon and carbon monoxide are -393.5 and $-283 kJ\ mol^{-1}$ respectively. The enthalpy of formation of carbon monoxide per mole is
[2004]

Options:

A. $-676.5 kJ$

B. $676.5 kJ$

C. $110.5 kJ$

D. $-110.5 kJ$

Answer: D

Solution:

Solution:
(i) $C + O_2 \rightleftharpoons CO_2,\ \Delta H = -393.5 kJ\ mol^{-1}$
(ii) $CO + \frac{1}{2}O_2 \rightleftharpoons CO_2,\ \Delta H = -283.0 kJ\ mol^{-1}$
Operating (i) - (ii), we have
$C + \frac{1}{2}O_2 \rightarrow CO\ \Delta H = -110.5 kJ\ mol^{-1}$

Question168

The internal energy change when a system goes from state A to B is 40kJ / mole. If the system goes from A to B by a reversible path and returns to state A by an irreversible path what would be the net change in internal energy?
[2003]

Options:

A. >40kJ

B. <40kJ

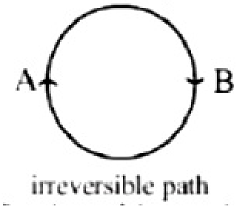
C. Zero

D. 40kJ

Answer: C

Solution:

Solution:
For a cyclic process, the net change in the internal energy is zero because the change in internal energy does not depend on the path.



Question169

If at 298K the bond energies of C − H , C − C, C = C and H − H bonds are respectively 414, 347, 615 and 435kJ mol $^{-1}$, the value of enthalpy change for the reaction $H_2C = CH_2(g) + H_2(g) \rightarrow H_3C - CH_3(g)$ at 298K will be
[2003]

Options:

A. −250kJ

B. +125kJ

C. −125kJ

D. +250kJ

Answer: C

Solution:

Solution:
$CH_2 = CH_2(g) + H_2(g) \rightarrow CH_3 - CH_3$
Enthalpy change = Bond energy of reactants − Bond energy of products.
$\Delta H = 1(C = C) + 4(C - H) + 1(H - H) - 1(C - C) - 6(C - H)$
$= 1(C = C) + 1(H - H) - 1(C - C) - 2(C - H)$
$= 615 + 435 - 347 - 2 \times 414 = 1050 - 1175$
$= -125 kJ$.

Question170

The enthalpy change for a reaction does not depend upon
[2003]

Options:

A. use of different reactants for the same product

B. the nature of intermediate reaction steps

C. the differences in initial or final temperatures of involved substances

D. the physical states of reactants and products

Answer: B

Solution:

Solution:
Enthalpy change for a reaction does not depend upon the nature of intermediate reaction steps.

Question171

In an irreversible process taking place at constant T and P and in which only pressure-volume work is being done, the change in Gibbs free energy (dG) and change in entropy (dS), satisfy the criteria
[2003]

Options:

A. $(dS)_{V,E} > 0, (dG)_{T,P} < 0$

B. $(dS)_{V,E} = 0, (dG)_{T,P} = 0$

C. $(dS)_{V,E} = 0, (dG)_{T,P} > 0$

D. $(dS)_{V,E} < 0, (dG)_{T,P}^{T} < 0$

Answer: A

Solution:

Solution:
For spontaneous reaction, $dS > 0$ and dG should be negative i.e. <0.

Question172

The correct relationship between free energy change in a reaction and the corresponding equilibrium constant K_c is
[2003]

Options:

A. $-\Delta G = RT / nK_c$

B. $\Delta G^{\circ} = RT / nK_c$

C. $-\Delta G^{\circ} = RT \ln K_c$

D. $\Delta G = RT \ln K_c$

Answer: C

Solution:

Solution:
$\Delta G^{\circ} = -RT \ln K_c$ or $-\Delta G^0 = RT \ln K_c$

Question173

A heat engine absorbs heat Q_1 at temperature T_1 and heat Q_2 at temperature T_2. Work done by the engine is $J(Q_1 + Q_2)$. This data [2002]

Options:

A. violates 1^{st} law of thermodynamics

B. violates 1^{st} law of themodynamics if Q_1 is $-$ve

C. violates 1^{st} law of thermodynamics of Q_2 is $-$ve

D. does not violate 1^{st} law of themodynamics.

Answer: A

Solution:

Solution:
According to first law of thermodynamics energy can neither be created nor destroyed although it can be converted from one form to another.
Note: Carnot cycle is based upon this principle but during the conversion of heat into work some mechanical energy is always converted to other form of energy hence this data violates 1 st law of thermodynamics.

Question174

The heat required to raise the temperature of body by 1K is called [2002]

Options:

A. specific heat

B. thermal capacity

C. water equivalent

D. none of these.

Answer: B

Solution:

Solution:
The heat required to raise the temperature of body by $1K$ is called thermal capacity or heat capacity.

Question175

For the reactions,
$2C + O_2 \rightarrow 2CO_2; \quad \Delta H = -393J$
$2Zn + O_2 \rightarrow 2ZnO; \quad \Delta H = -412J$
[2002]

Options:

A. carbon can oxidise Zn

B. oxidation of carbon is not feasible

C. oxidation of Zn is not feasible

D. Zn can oxidise carbon.

Answer: D

Solution:

Solution:
ΔH negative shows that the reaction is spontancous. Higher negative value for Zn shows that the reaction is more feasible.

Question176

If an endothermic reaction is non-spontaneous at freezing point of water and becomes feasible at its boiling point, then
[2002]

Options:

A. ΔH is $-$ve, ΔS is $+$ve

B. ΔH and ΔS both are $+$ve

C. ΔH and ΔS both are $-$ve

D. ΔH is $+$ve, ΔS is $-$ve

Answer: B

Solution:

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

For an endothermic reaction,

ΔH = + ve and at low temperature ΔS = + ve

Hence $\Delta G = (+) \Delta H - T (+) \Delta S$

and if $T \Delta S < \Delta H$ (at low temp)

$\Delta G = +\mathrm{ve}$ (non spontancous)

But at high temperature, reaction becomes spontaneous i.e. $\Delta G = -\mathrm{ve}$

because at higher temperature $T \Delta S > \Delta H$
