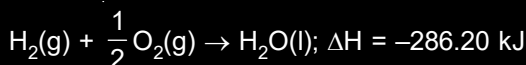


Thermodynamics

On the basis of the following thermochemical data

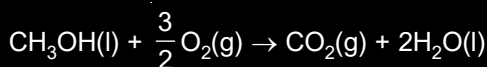
$$: (\Delta_f G^\circ H_{(aq)}^+ = 0)$$



The value of enthalpy of formation of OH^- ion at $25^\circ C$ is **[AIEEE-2009]**

- (1) -228.88 kJ (2) $+228.88 \text{ kJ}$
(3) -343.52 kJ (4) -22.88 kJ

In a fuel cell methanol is used as fuel and oxygen gas is used as an oxidizer. The reaction is



At 298 K standard Gibb's energies of formation for $CH_3OH(l)$, $H_2O(l)$ and $CO_2(g)$ are -166.2 , -237.2 and $-394.4 \text{ kJ mol}^{-1}$ respectively. If standard enthalpy of combustion of methanol is -726 kJ mol^{-1} , efficiency of the fuel cell will be **[AIEEE-2009]**

- (1) 87% (2) 90%
(3) 97% (4) 80%

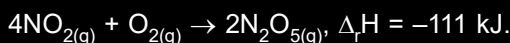
For a particular reversible reaction at temperature T , ΔH and ΔS were found to be both +ve. If T_e is the temperature at equilibrium, the reaction would be spontaneous when **[AIEEE-2010]**

- (1) $T = T_e$ (2) $T_e > T$
(3) $T > T_e$ (4) T_e is 5 times T

The standard enthalpy of formation of NH_3 is $-46.0 \text{ kJ mol}^{-1}$. If the enthalpy of formation of H_2 from its atoms is -436 kJ mol^{-1} and that of N_2 is -712 kJ mol^{-1} , the average bond enthalpy of $N-H$ bond is NH_3 is **[AIEEE-2010]**

- (1) $-1102 \text{ kJ mol}^{-1}$
(2) -964 kJ mol^{-1}
(3) $+352 \text{ kJ mol}^{-1}$
(4) $+1056 \text{ kJ mol}^{-1}$

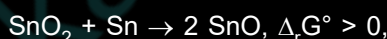
5. Consider the reaction :



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}) **[AIEEE-2011]**

- (1) -219 kJ (2) -165 kJ
(3) $+54 \text{ kJ}$ (4) $+219 \text{ kJ}$

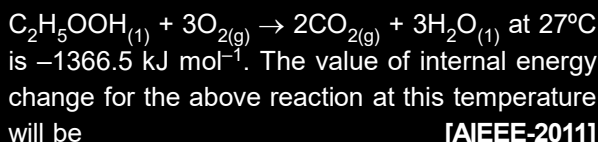
6. In view of the signs of $\Delta_r G^\circ$ for the following reactions



which oxidation states are more characteristic for lead and tin? **[AIEEE-2011]**

- (1) For lead +2, for tin +4
(2) For lead +4, for tin +2
(3) For lead +2, for tin +2
(4) For lead +4, for tin +4

7. The value of enthalpy change (ΔH) for the reaction



- (1) -1361.5 kJ (2) -1371.5 kJ
(3) -1369.0 kJ (4) -1364.0 kJ

8. The incorrect expression among the following is **[AIEEE-2012]**

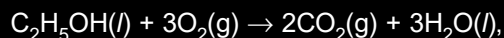
- (1) In isothermal process, $W_{\text{reversible}} = -nRT \ln \frac{V_t}{V_i}$
(2) $\ln K = \frac{\Delta H^\circ - T\Delta S^\circ}{RT}$
(3) $K = e^{-\Delta G^\circ/RT}$
(4) $\frac{\Delta G_{\text{system}}}{\Delta S_{\text{Total}}} = -T$

absorbs 208 J of heat. The values of q and w for the process will be **[JEE (Main)-2013]**

$$(R = 8.314 \text{ J/mol K}) (\ln 7.5 = 2.01)$$

- (1) $q = +208 \text{ J}$, $w = -208 \text{ J}$
- (2) $q = -208 \text{ J}$, $w = -208 \text{ J}$
- (3) $q = -208 \text{ J}$, $w = +208 \text{ J}$
- (4) $q = +208 \text{ J}$, $w = +208 \text{ J}$

0. For complete combustion of ethanol,

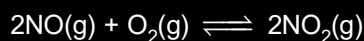


the amount of heat produced as measured in bomb calorimeter, is $1364.47 \text{ kJ mol}^{-1}$ at 25°C . Assuming ideality the enthalpy of combustion, $\Delta_c H$, for the reaction will be ($R = 8.314 \text{ kJ mol}^{-1}$)

[JEE (Main)-2014]

- (1) $-1366.95 \text{ kJ mol}^{-1}$
- (2) $-1361.95 \text{ kJ mol}^{-1}$
- (3) $-1460.50 \text{ kJ mol}^{-1}$
- (4) $-1350.50 \text{ kJ mol}^{-1}$

1. The following reaction is performed at 298 K .



The standard free energy of formation of $\text{NO}(g)$ is 86.6 kJ/mol at 298 K . What is the standard free energy of formation of $\text{NO}_2(g)$ at 298 K ?

$$(K_p = 1.6 \times 10^{12})$$

[JEE (Main)-2015]

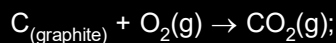
- (1) $R(298) \ln(1.6 \times 10^{12}) - 86600$
- (2) $86600 + R(298) \ln(1.6 \times 10^{12})$
- (3) $86600 - \frac{\ln(1.6 \times 10^{12})}{R(298)}$

$$(4) 0.5 [2 \times 86,600 - R(298) \ln 1.6 \times 10^{12}]$$

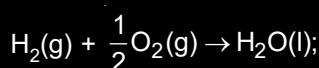
2. The heats of combustion of carbon and carbon monoxide are -393.5 and $-283.5 \text{ kJ mol}^{-1}$, respectively. The heat of formation (in kJ) of carbon monoxide per mole is **[JEE (Main)-2016]**

- (1) 676.5
- (2) -676.5
- (3) -110.5
- (4) 110.5

3. Given

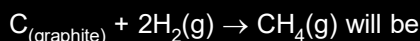


$$\Delta_f H^\circ = -393.5 \text{ kJ mol}^{-1}$$



$$\Delta_f H^\circ = +890.3 \text{ kJ mol}^{-1}$$

Based on the above thermochemical equations, the value of $\Delta_r H^\circ$ at 298 K for the reaction



[JEE (Main)-2017]

- (1) $-74.8 \text{ kJ mol}^{-1}$
- (2) $-144.0 \text{ kJ mol}^{-1}$
- (3) $+74.8 \text{ kJ mol}^{-1}$
- (4) $+144.0 \text{ kJ mol}^{-1}$

14. ΔU is equal to

[JEE (Main)-2017]

- (1) Adiabatic work
- (2) Isothermal work
- (3) Isochoric work
- (4) Isobaric work

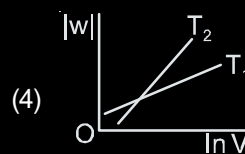
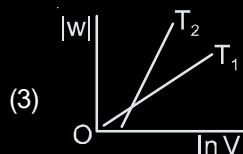
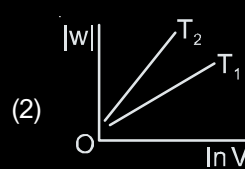
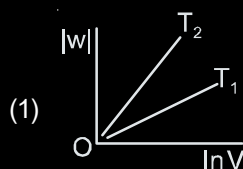
15. The combustion of benzene (l) gives $\text{CO}_2(g)$ and $\text{H}_2\text{O}(l)$. Given that heat of combustion of benzene at constant volume is $-3263.9 \text{ kJ mol}^{-1}$ at 25°C ; heat of combustion (in kJ mol^{-1}) of benzene at constant pressure will be ($R = 8.314 \text{ JK}^{-1} \text{ mol}^{-1}$)

[JEE (Main)-2018]

- (1) 4152.6
- (2) -452.46
- (3) 3260
- (4) -3267.6

16. 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

[JEE (Main)-2019]



17. The entropy change associated with the conversion of 1 kg of ice at 273 K to water vapours at 383 K is

(Specific heat of water liquid and water vapour are $4.2 \text{ kJ K}^{-1} \text{ kg}^{-1}$ and $2.0 \text{ kJ K}^{-1} \text{ kg}^{-1}$; heat of liquid fusion and vapourisation of water are 334 kJ kg^{-1} and 2491 kJ kg^{-1} , respectively). ($\log 273 = 2.436$, $\log 373 = 2.572$, $\log 383 = 2.583$)

[JEE (Main)-2019]

- (1) $8.49 \text{ kJ kg}^{-1} \text{ K}^{-1}$
- (2) $7.90 \text{ kJ kg}^{-1} \text{ K}^{-1}$
- (3) $9.26 \text{ kJ kg}^{-1} \text{ K}^{-1}$
- (4) $2.64 \text{ kJ kg}^{-1} \text{ K}^{-1}$

process will be spontaneous. [JEE (Main)-2019]

- (1) 4 K (2) 12 K
(3) 5 K (4) 20 K

9. An ideal gas undergoes isothermal compression from 5 m^3 to 1 m^3 against a constant external pressure of 4 Nm^{-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 [JEE (Main)-2019]

- (1) $\frac{3}{2} \text{ K}$ (2) 1 K
(3) 2 K (4) $\frac{2}{3} \text{ K}$

10. 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

[JEE (Main)-2019]

- (1) Y if $T = 280 \text{ K}$ (2) X if $T = 315 \text{ K}$
(3) Y if $T = 300 \text{ K}$ (4) X if $T = 350 \text{ K}$

11. 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

[JEE (Main)-2019]

- (1) $2C_p \ln \left[\frac{T_1 + T_2}{4T_1 T_2} \right]$ (2) $C_p \ln \left[\frac{(T_1 + T_2)^2}{4T_1 T_2} \right]$
(3) $2C_p \ln \left[\frac{T_1 + T_2}{2T_1 T_2} \right]$ (4) $2C_p \ln \left[\frac{(T_1 + T_2)^{\frac{1}{2}}}{T_1 T_2} \right]$

12. The reaction

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

- (1) 2040.5 K (2) 1890.0 K
(3) 2480.3 K (4) 2380.5 K

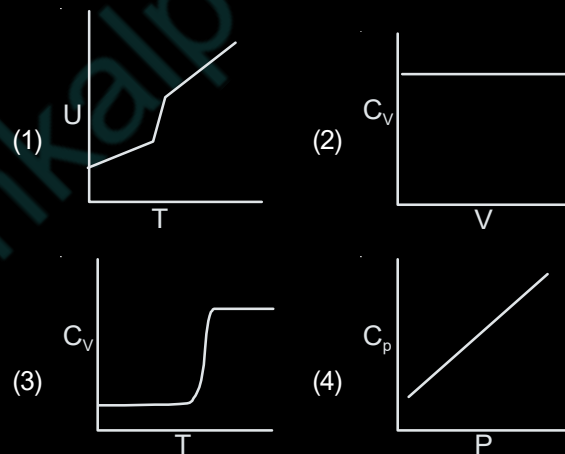
$$\Delta_r G^\circ = A - B/T$$

Where A and B are non-zero constants. Which of the following is true about this reaction?

[JEE (Main)-2019]

- (1) Exothermic if $B < 0$
(2) Endothermic if $A > 0$
(3) Endothermic if $A < 0$ and $B > 0$
(4) Exothermic if $A > 0$ and $B < 0$

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

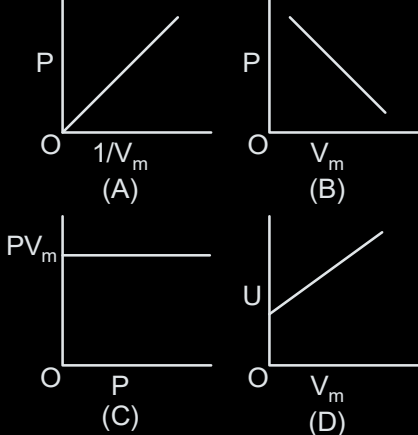


25. Given

- (i) $\text{C (graphite)} + \text{O}_2(\text{g}) \rightarrow \text{CO}_2(\text{g}); \Delta_r H^\circ = x \text{ kJ mol}^{-1}$
(ii) $\text{C (graphite)} + \frac{1}{2} \text{O}_2(\text{g}) \rightarrow \text{CO}_2(\text{g}); \Delta_r H^\circ = y \text{ kJ mol}^{-1}$
(iii) $\text{CO(g)} + \frac{1}{2} \text{O}_2(\text{g}) \rightarrow \text{CO}_2(\text{g}); \Delta_r H^\circ = z \text{ kJ mol}^{-1}$

Based on the above thermochemical equations, find out which one of the following algebraic relationships is correct? [JEE (Main)-2019]

- (1) $x = y - z$
(2) $x = y + z$
(3) $y = 2z - x$
(4) $z = x + y$



[JEE (Main)-2019]

- (1) (A) and (C) (2) (A) and (D)
 (3) (B) and (C) (4) (B) and (D)
7. 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)

[JEE (Main)-2019]

- (1) Isothermal process : $q = -w$
 (2) Cyclic process : $q = -w$
 (3) Isochoric process : $\Delta U = q$
 (4) Adiabatic process : $\Delta U = -w$
8. For silver, $C_p(\text{JK}^{-1} \text{mol}^{-1}) = 23 + 0.01T$. If the temperature (T) of 3 moles of silver is raised from 300 K to 1000 K at 1 atm pressure, the value of ΔH will be close to

[JEE (Main)-2019]

- (1) 21 kJ
 (2) 13 kJ
 (3) 62 kJ
 (4) 16 kJ
9. 5 moles of an ideal gas at 100 K 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. ($R = 8.0 \text{ J K}^{-1} \text{mol}^{-1}$)

[JEE (Main)-2019]

- (1) $\Delta U = 14 \text{ kJ}$; $\Delta(pV) = 18 \text{ kJ}$
 (2) $\Delta U = 2.8 \text{ kJ}$; $\Delta(pV) = 0.8 \text{ kJ}$
 (3) $\Delta U = 14 \text{ J}$; $\Delta(pV) = 0.8 \text{ J}$
 (4) $\Delta U = 14 \text{ kJ}$; $\Delta(pV) = 4 \text{ kJ}$

- (C) w (D) $H - TS$

- (1) (A), (B) and (C)
 (2) (B) and (C)
 (3) (B), (C) and (D)
 (4) (A) and (D)

31. During compression of a spring the work done is 10 kJ and 2 kJ escaped to the surroundings as heat. The change in internal energy, ΔU (in kJ) is

[JEE (Main)-2019]

- (1) 12 (2) -12
 (3) 8 (4) -8

32. A process will be spontaneous at all temperatures if :

[JEE (Main)-2019]

- (1) $\Delta H < 0$ and $\Delta S > 0$
 (2) $\Delta H > 0$ and $\Delta S < 0$
 (3) $\Delta H > 0$ and $\Delta S > 0$
 (4) $\Delta H < 0$ and $\Delta S < 0$

33. 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

[JEE (Main)-2019]

- (1) $-3RT$ (2) $4RT$
 (3) $3RT$ (4) $-4RT$

34. An ideal gas is allowed to expand from 1 L to 10 L against a constant external pressure of 1 bar. The work done in kJ is

[JEE (Main)-2019]

- (1) -9.0 (2) -0.9
 (3) -2.0 (4) +10.0

35. Enthalpy of sublimation of iodine is 24 cal g^{-1} at 200°C . If specific heat of $\text{I}_2(\text{s})$ and $\text{I}_2(\text{vap})$ are 0.055 and $0.031 \text{ cal g}^{-1}\text{K}^{-1}$ respectively, then enthalpy of sublimation of iodine at 250°C in cal g^{-1} is

[JEE (Main)-2019]

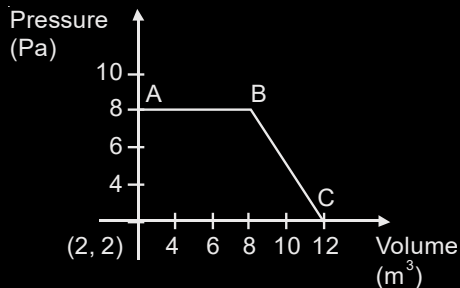
- (1) 11.4 (2) 2.85
 (3) 5.7 (4) 22.8

36. The process with negative entropy change is

[JEE (Main)-2019]

- (1) Sublimation of dry ice
 (2) Dissociation of $\text{CaSO}_4(\text{s})$ to $\text{CaO}(\text{s})$ and $\text{SO}_3(\text{g})$
 (3) Synthesis of ammonia from N_2 and H_2
 (4) Dissolution of iodine in water

- (1) is $x > y$ (2) does not exist
(3) is $x = y$ (4) is $x < y$
8. The true statement amongst the following is
[JEE (Main)-2020]
- (1) S is not a function of temperature but ΔS is a function of temperature
(2) S is a function of temperature but ΔS is not a function of temperature
(3) Both ΔS and S are functions of temperature
(4) Both S and ΔS are not functions of temperature
9. The first and second ionisation enthalpies of a metal are 496 and 4560 kJ mol⁻¹, respectively. How many moles of HCl and H₂SO₄, respectively, will be needed to react completely with 1 mole of the metal hydroxide?
[JEE (Main)-2020]
- (1) 2 and 0.5 (2) 1 and 2
(3) 1 and 0.5 (4) 1 and 1
10. For one mole of an ideal gas, which of these statements must be true?
(a) U and H each depends only on temperature
(b) Compressibility factor z is not equal to 1
(c) $C_{P,m} - C_{V,m} = R$
(d) $dU = C_V dT$ for any process [JEE (Main)-2020]
- (1) (a) and (c) (2) (a), (c) and (d)
(3) (b), (c) and (d) (4) (c) and (d)
11. Five moles of an ideal gas at 1 bar and 298 K is expanded into vacuum to double the volume. The work done is
[JEE (Main)-2020]
- (1) Zero
(2) $-RT \ln V_2/V_1$
(3) $C_V (T_2 - T_1)$
(4) $-RT (V_2 - V_1)$
12. The standard heat of formation ($\Delta_f H_{298}^0$) of ethane (in kJ/mol), if the heat of combustion of ethane, hydrogen and graphite are -1560, -393.5 and -286 kJ/mol, respectively is _____.
[JEE (Main)-2020]



[JEE (Main)-2020]

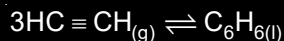
44. At constant volume, 4 mol of an ideal gas when heated from 300 K to 500 K changes its internal energy by 5000 J. The molar heat capacity at constant volume is _____. [JEE (Main)-2020]
45. The internal energy change (in J) when 90 g of water undergoes complete evaporation at 100°C is _____. [JEE (Main)-2020]
- (Given : ΔH_{vap} for water at 373 K = 41 kJ/mol, $R = 8.314 \text{ JK}^{-1} \text{ mol}^{-1}$) [JEE (Main)-2020]
46. The heat of combustion of ethanol into carbon dioxide and water is - 327 kcal at constant pressure. The heat evolved (in cal) at constant volume and 27°C (if all gases behave ideally) is ($R = 2 \text{ cal mol}^{-1} \text{ K}^{-1}$) _____. [JEE (Main)-2020]
47. For a dimerization reaction,
 $2A(g) \rightarrow A_2(g)$,
at 298 K, $\Delta U^\circ = -20 \text{ kJ mol}^{-1}$, $\Delta S^\circ = -30 \text{ JK}^{-1} \text{ mol}^{-1}$, then the ΔG° will be _____ J.
[JEE (Main)-2020]
48. For the reaction
 $A(l) \rightarrow 2B(g)$
 $\Delta U = 2.1 \text{ kcal}$, $\Delta S = 20 \text{ cal K}^{-1}$ at 300 K.
Hence ΔG in kcal is _____.
[JEE (Main)-2020]
49. 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 [JEE (Main)-2020]
- (1) 784 kJ mol⁻¹ (2) -780 kJ mol⁻¹
(3) 780 kJ mol⁻¹ (4) -784 kJ mol⁻¹

to 100.0 The value of $\Delta_r G$ for the reaction at 300 K and 1 atm in J mol^{-1} is $-xR$, where x is _____ (Rounded off to the nearest integer)

[$R = 8.31 \text{ J mol}^{-1}\text{K}^{-1}$ and $\ln 10 = 2.3$]

[JEE (Main)-2021]

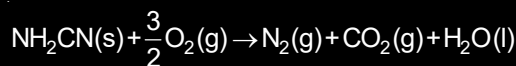
51. Assuming ideal behaviour, the magnitude of $\log K$ for the following reaction at 25°C is $x \times 10^{-1}$. The value of x is _____ (Integer answer)



[Given : $\Delta_f G^\circ(\text{HC} \equiv \text{CH}) = -2.04 \times 10^5 \text{ J mol}^{-1}$; $\Delta_f G^\circ(\text{C}_6\text{H}_6) = -1.24 \times 10^5 \text{ J mol}^{-1}$; $R = 8.314 \text{ J K}^{-1} \text{ mol}^{-1}$]

[JEE (Main)-2021]

52. The reaction of cyanamide, $\text{NH}_2\text{CN}_{(\text{s})}$ with oxygen was run in a bomb calorimeter and ΔU was found to be $-742.24 \text{ kJ mol}^{-1}$. The magnitude of ΔH_{298} for the reaction



is _____ kJ. (Rounded off to the nearest integer)

[Assume ideal gases and $R=8.314 \text{ J mol}^{-1} \text{ K}^{-1}$]

[JEE (Main)-2021]

53. The ionization enthalpy of Na^+ formation from $\text{Na}_{(\text{g})}$ is $495.8 \text{ kJ mol}^{-1}$, while the electron gain enthalpy of Br is $-325.0 \text{ kJ mol}^{-1}$. Given the lattice enthalpy of NaBr is $-728.4 \text{ kJ mol}^{-1}$. The energy for the formation of NaBr ionic solid from $\text{Na}(\text{g})$ and $\text{Br}(\text{g})$ is $(-)$ _____ $\times 10^{-1} \text{ kJ mol}^{-1}$.

[JEE (Main)-2021]

54. For a chemical reaction $\text{A} + \text{B} \rightleftharpoons \text{C} + \text{D}$ ($\Delta_r H^\circ = 80 \text{ kJ mol}^{-1}$) the entropy change $\Delta_r S^\circ$ depends on the temperature T (in K) as $\Delta_r S^\circ = 2T \text{ (J K}^{-1} \text{ mol}^{-1})$.

Minimum temperature at which it will become spontaneous is _____ K. (Integer)

[JEE (Main)-2021]

55. 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 $\text{SF}_{6(\text{g})}$, $\text{S}_{(\text{g})}$ and $\text{F}_{(\text{g})}$ are -1100 , 275 and 80 kJ mol^{-1} respectively.]

[JEE (Main)-2021]

constant pressure of 1 bar. The work done by the gas during this expansion is _____ J.

(Round off to the Nearest Integer).

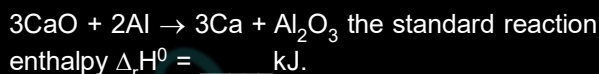
[Given : $R = 8.314 \text{ J mol}^{-1} \text{ K}^{-1}$. Assume, hydrogen is an ideal gas]

[Atomic mass of Fe is 55.85 u]

[JEE (Main)-2021]

57. The standard enthalpies of formation of Al_2O_3 and CaO are $-1675 \text{ kJ mol}^{-1}$ and -635 kJ mol^{-1} respectively.

For the reaction



(Round off to the Nearest Integer).

[JEE (Main)-2021]

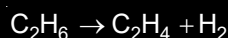
58. During which of the following processes, does entropy decrease?

- (A) Freezing of water to ice at 0°C
 (B) Freezing of water to ice at -10°C
 (C) $\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightarrow 2\text{NH}_3(\text{g})$
 (D) Adsorption of $\text{CO}(\text{g})$ on lead surface
 (E) Dissolution of NaCl in water

Choose the **correct** answer from the options given below.

[JEE (Main)-2021]

- (1) (A) and (E) only
 (2) (A), (C) and (E) only
 (3) (A), (B), (C) and (D) only
 (4) (B) and (C) only
59. For the reaction



the reaction enthalpy $\Delta_r H =$ _____ kJ mol^{-1} .

(Round off to the Nearest Integer).

[Given : Bond enthalpies in kJ mol^{-1} :

$\text{C} - \text{C} : 347$, $\text{C} = \text{C} : 611$;

$\text{C} - \text{H} : 414$, $\text{H} - \text{H} : 436$]

[JEE (Main)-2021]

at 400 K has $\Delta G^\circ = +25.2 \text{ kJ mol}^{-1}$

The equilibrium constant K_c for this reaction is _____ $\times 10^{-2}$. (Round off to the Nearest Integer).

[Use : $R = 8.3 \text{ J mol}^{-1} \text{ K}^{-1}$, $\ln 10 = 2.3 \log_{10}$
 $2 = 0.30$, $1 \text{ atm} = 1 \text{ bar}$]

[antilog $(-0.3) = 0.501$] **[JEE (Main)-2021]**

1. An average person needs about 10000 kJ energy per day. The amount of glucose (molar mass = 180.0 g mol^{-1}) needed to meet this energy requirement is _____ g. (Nearest integer)

(Use: $\Delta_c H(\text{glucose}) = -2700 \text{ kJ mol}^{-1}$)

[JEE (Main)-2021]

2. For a given chemical reaction $A \rightarrow B$ at 300 K the free energy change is $-49.4 \text{ kJ mol}^{-1}$ and the enthalpy of reaction is 51.4 kJ mol^{-1} . The entropy change of the reaction is _____ $\text{J K}^{-1} \text{ mol}^{-1}$.

[JEE (Main)-2021]

3. If the standard molar enthalpy change for combustion of graphite powder is $-2.48 \times 10^2 \text{ kJ mol}^{-1}$, the amount of heat generated on combustion of 1 g of graphite powder is _____ kJ. (Nearest integer) **[JEE (Main)-2021]**

4. At 298 K, the enthalpy of fusion of a solid (X) is 2.8 kJ mol^{-1} and the enthalpy of vaporisation of the liquid (X) is 98.2 kJ mol^{-1} . The enthalpy of sublimation of the substance (X) in kJ mol^{-1} is _____. (in nearest integer) **[JEE (Main)-2021]**

5. 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) **[JEE (Main)-2021]**

6. For water at 100°C and 1 bar,

$\Delta_{\text{vap}} H - \Delta_{\text{vap}} U = \text{_____} \times 10^2 \text{ J mol}^{-1}$. (Round off to the Nearest Integer)

[Use : $R = 8.31 \text{ J mol}^{-1} \text{ K}^{-1}$]

[Assume volume of $\text{H}_2\text{O}(\text{l})$ is much smaller than volume of $\text{H}_2\text{O}(\text{g})$. Assume $\text{H}_2\text{O}(\text{g})$ can be treated as an ideal gas] **[JEE (Main)-2021]**

7. When 400 mL of 0.2 M H_2SO_4 solution is mixed with 600 mL of 0.1 M NaOH solution, the increase in temperature of the final solution is _____ $\times 10^{-2} \text{ K}$. (Round off to the Nearest Integer).

Specific heat of $\text{H}_2\text{O} = 4.18 \text{ J K}^{-1} \text{ g}^{-1}$

Density of $\text{H}_2\text{O} = 1.0 \text{ g cm}^{-3}$

Assume no change in volume of solution on mixing.] **[JEE (Main)-2021]**

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

$\Delta_f H^\circ$ for KCl = $-436.7 \text{ kJ mol}^{-1}$; $\Delta_{\text{sub}} H^\circ$ for K = 89.2 kJ mol^{-1} ;

$\Delta_{\text{ionization}} H^\circ$ for K = $419.0 \text{ kJ mol}^{-1}$; $\Delta_{\text{electron gain}} H^\circ$ for

$\text{Cl}_{(\text{g})} = -348.6 \text{ kJ mol}^{-1}$;

$\Delta_{\text{bond}} H^\circ$ for $\text{Cl}_2 = 243.0 \text{ kJ mol}^{-1}$

The magnitude of lattice enthalpy of KCl in kJ mol^{-1} is _____. (Nearest integer) **[JEE (Main)-2021]**

69. For water $\Delta_{\text{vap}} H = 41 \text{ kJ mol}^{-1}$ at 373 K 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 : $R = 8.3 \text{ J mol}^{-1} \text{ K}^{-1}$] **[JEE (Main)-2021]**

70. 200 mL of 0.2 M HCl is mixed with 300 mL of 0.1 M NaOH. The molar heat of neutralization of this reaction is -57.1 kJ . The increase in temperature in $^\circ\text{C}$ of the system on mixing is $x \times 10^{-2}$. The value of x is _____. (Nearest integer)

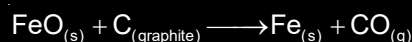
[Given : Specific heat of water = $4.18 \text{ J g}^{-1} \text{ K}^{-1}$

Density of water = 1.00 g cm^{-3}]

(Assume no volume change on mixing)

[JEE (Main)-2021]

71. Data given for the following reaction is as follows:



Substance	$\Delta_f H^\circ$ (kJ mol^{-1})	ΔS° ($\text{J mol}^{-1} \text{ K}^{-1}$)
$\text{FeO}_{(\text{s})}$	-266.3	57.49
$\text{C}_{(\text{graphite})}$	0	5.74
$\text{Fe}_{(\text{s})}$	0	27.28
$\text{CO}_{(\text{g})}$	-110.5	197.6

The minimum temperature in K at which the reaction becomes spontaneous is _____. (Integer answer) **[JEE (Main)-2021]**

- (1) For isothermal process $w_{\text{reversible}}$

$$= -nRT \ln \frac{V_f}{V_i}$$
- (2) $\frac{\Delta G_{\text{system}}}{\Delta S_{\text{Total}}} = -T$ (at constant P)
- (3) $\ln K = \frac{\Delta H^\circ - T\Delta S^\circ}{RT}$
- (4) $K = e^{-\Delta G^\circ/RT}$
3. For the reaction $2\text{NO}_2(\text{g}) \rightleftharpoons \text{N}_2\text{O}_4(\text{g})$, when $\Delta S = -176.0 \text{ J K}^{-1}$ and $\Delta H = -57.8 \text{ kJ mol}^{-1}$, the magnitude of ΔG at 298 K for the reaction is _____ kJ mol^{-1} . (Nearest integer)
[JEE (Main)-2021]
4. $2\text{O}_3(\text{g}) \rightleftharpoons 3\text{O}_2(\text{g})$
 At 300 K, ozone is fifty percent dissociated. The standard free energy change at this temperature and 1 atm pressure is (–) _____ J mol^{-1} . (Nearest integer)
 [Given: $\ln 1.35 = 0.3$ and $R = 8.3 \text{ J K}^{-1} \text{ mol}^{-1}$]
[JEE (Main)-2022]
5. At 25°C and 1 atm pressure, the enthalpies of combustion are as given below :
- | Substance | H_2 | $\text{C}(\text{graphite})$ | $\text{C}_2\text{H}_6(\text{g})$ |
|---|--------------|-----------------------------|----------------------------------|
| $\frac{\Delta_c H^\circ}{\text{kJ mol}^{-1}}$ | –286.0 | –394.0 | –1560.0 |
- The enthalpy of formation of ethane is
[JEE (Main)-2022]
- (1) +54.0 kJ mol^{-1} (2) –68.0 kJ mol^{-1}
 (3) –86.0 kJ mol^{-1} (4) +97.0 kJ mol^{-1}
6. The standard entropy change for the reaction $4\text{Fe}(\text{s}) + 3\text{O}_2(\text{g}) \rightarrow 2\text{Fe}_2\text{O}_3(\text{s})$ is -550 J K^{-1} at 298 K.
 [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)
[JEE (Main)-2022]
- pressure is $-x \text{ J mol}^{-1}$. The value of x is _____.
 (Nearest Integer)
 [Given : $R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$, $\log 1.33 = 0.1239$ $\ln 10 = 2.3$]
[JEE (Main)-2022]
78. At 25°C and 1 atm pressure, the enthalpy of combustion of benzene (l) and acetylene (g) are $-3268 \text{ kJ mol}^{-1}$ and $-1300 \text{ kJ mol}^{-1}$, respectively. The change in enthalpy for the reaction $3\text{C}_2\text{H}_2(\text{g}) \rightarrow \text{C}_6\text{H}_6(\text{l})$, is
[JEE (Main)-2022]
- (1) +324 kJ mol^{-1} (2) +632 kJ mol^{-1}
 (3) –632 kJ mol^{-1} (4) –732 kJ mol^{-1}
79. For complete combustion of methanol
- $$\text{CH}_3\text{OH}(\text{l}) + \frac{3}{2}\text{O}_2(\text{g}) \rightarrow \text{CO}_2(\text{g}) + 2\text{H}_2\text{O}(\text{l})$$
- 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 $-x \text{ kJ mol}^{-1}$, where x is _____. (Nearest integer)
 (Given : $R = 8.3 \text{ J K}^{-1} \text{ mol}^{-1}$)
[JEE (Main)-2022]
80. A fish swimming in water body when taken out from the water body is covered with a film of water of weight 36 g. When it is subjected to cooking at 100 °C, then the internal energy for vaporization in kJ mol^{-1} is _____. [nearest integer]
 [Assume steam to be an ideal gas. Given $\Delta_{\text{vap}} H^\circ$ for water at 373 K and 1 bar is 41.1 kJ mol^{-1} ; $R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$]
[JEE (Main)-2022]
81. 40% of HI undergoes decomposition to H_2 and I_2 at 300 K. ΔG° for this decomposition reaction at one atmosphere pressure is _____ J mol^{-1} . [nearest integer]
 (Use $R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$; $\log 2 = 0.3010$, $\ln 10 = 2.3$, $\log 3 = 0.477$)
[JEE (Main)-2022]
82. Match **List-I** with **List-II**
- List-I**
- (A) Spontaneous process
 (B) Process with $\Delta P = 0$, $\Delta T = 0$
 (C) $\Delta H_{\text{reaction}}$
 (D) Exothermic Process

(II) $\Delta G_{T,P} < 0$

(III) Isothermal and isobaric process

(IV) [Bond energies of molecules in reactants] –
[Bond energies of product molecules]

Choose the **correct** answer from the options given below : **[JEE (Main)-2022]**

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

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

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

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

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

4. 4.0 L of an ideal gas is allowed to expand isothermally into vacuum until the total volume is 20 L. The amount of heat absorbed in this expansion is _____ L atm. **[JEE (Main)-2022]**

5. For combustion of one mole of magnesium in an open container at 300 K 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 : $R = 8.3 \text{ J K}^{-1} \text{ mol}^{-1}$) **[JEE (Main)-2022]**

6. 17.0 g of NH_3 completely vapourises at -33.42°C and 1 bar pressure and the enthalpy change in the process is 23.4 kJ mol^{-1} . The enthalpy change for the vapourisation of 85 g of NH_3 under the same conditions is _____ kJ. **[JEE (Main)-2022]**

7. 2.2 g of nitrous oxide (N_2O) gas is cooled at a constant pressure of 1 atm from 310 K to 270 K 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})

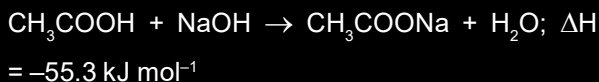
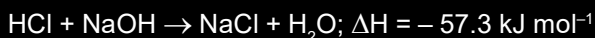
Molar heat capacity of N_2O is $100 \text{ J K}^{-1} \text{ mol}^{-1}$

[JEE (Main)-2022]

$-393.5 \text{ kJ mol}^{-1}$ and $-285.8 \text{ kJ mol}^{-1}$ respectively. The magnitude of enthalpy of formation of propane (C_3H_8) is _____ kJ mol^{-1} . (Nearest integer)

[JEE (Main)-2022]

89. While performing a thermodynamics experiment, a student made the following observations.



The enthalpy of ionization of CH_3COOH as calculated by the student is _____ kJ mol^{-1} . [nearest integer]

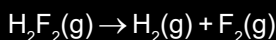
[JEE (Main)-2022]

90. 2.4 g coal is burnt in a bomb calorimeter in excess of oxygen at 298 K and 1 atm pressure. The temperature of the calorimeter rises from 298 K to 300 K. The enthalpy change during the combustion of coal is $-x \text{ kJ mol}^{-1}$. The value of x is _____. (Nearest integer)

(Given : Heat capacity of bomb calorimeter is 20.0 kJ K^{-1} . Assume coal to be pure carbon)

[JEE (Main)-2022]

91. For the reaction



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

The enthalpy change for the above reaction is $(-)$ _____ kJ mol^{-1} [nearest integer]

Given : $R = 8.314 \text{ J K}^{-1} \text{ mol}^{-1}$.

[JEE (Main)-2022]

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

[JEE (Main)-2022]

during combustion the temperature of calorimeter increased from 298.0 K to 298.45 K. 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)

[JEE (Main)-2022]

4. Which of the following relation is not correct?

[JEE (Main)-2022]

- (1) $\Delta H = \Delta U - P\Delta V$ (2) $\Delta U = q + W$
 (3) $\Delta S_{\text{sys}} + \Delta S_{\text{surr}} \geq 0$ (4) $\Delta G = \Delta H - T\Delta S$

5. Among the following the number of state variables is ____.

[JEE (Main)-2022]

Internal energy (U)

Volume (V)

Heat (q)

Enthalpy (H)

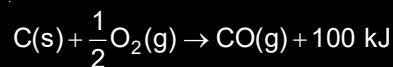
temperature of the flask is _____ $\times 10^{-3} \text{ }^{\circ}\text{C}$.

(Enthalpy of neutralisation = 57 kJ mol^{-1} and Specific heat of water = $4.2 \text{ JK}^{-1} \text{ g}^{-1}$)

(Neglect heat capacity of flask)

[JEE (Main)-2022]

97. $\text{C(s)} + \text{O}_2(\text{g}) \rightarrow \text{CO}_2(\text{g}) + 400 \text{ kJ}$



When coal of purity 60% is allowed to burn in presence of insufficient oxygen, 60% of carbon is converted into 'CO' and the remaining is converted into 'CO₂'. The heat generated when 0.6 kg of coal is burnt is _____.

[JEE (Main)-2022]

(1) 1600 kJ

(2) 3200 kJ

(3) 4400 kJ

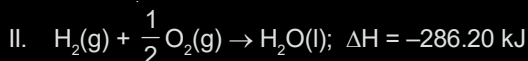
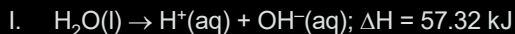
(4) 6600 kJ



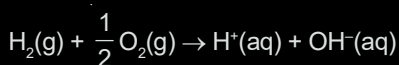
Chapter 6

Thermodynamics

1. Answer (1)

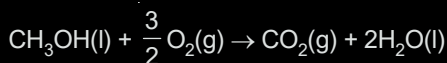


Adding I & II we get,



$$\begin{aligned}\Delta\text{H} &= 57.32 - 286.2 \\ &= -228.88 \text{ kJ}\end{aligned}$$

2. Answer (3)



$$\begin{aligned}\Delta G_{\text{reaction}} &= \Delta G_{\text{products}} - \Delta G_{\text{reactant}} \\ &= [-394.4 - 2 \times 237.2] - [-166.2] \\ &= -702.6 \text{ kJ}\end{aligned}$$

We know, efficiency of a fuel cell,

$$\begin{aligned}\eta &= \frac{\Delta G}{\Delta H} \times 100 \\ &= \frac{-702.6}{-726} \times 100 \\ &\approx 97\%\end{aligned}$$

3. Answer (3)

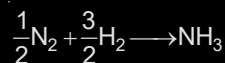
$$\Delta G = \Delta H - T\Delta S$$

For equilibrium $\Delta G = 0$

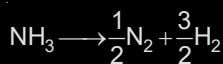
For spontaneous reaction, $\Delta G < 0$

$$\therefore T > T_e$$

4. Answer (3)



$$\Delta H_{\text{NH}_3} = -46 \text{ kJ}$$



$$46 = 3\Delta H_{\text{N-H}} - \frac{1}{2} \times (712) - \frac{3}{2} \times 436$$

$$\Delta H_{\text{N-H}} = 352 \text{ kJ/mol}$$

5. Answer (1)

$$\begin{aligned}\Delta_r H &= -111 - (2 \times 54) \\ &= -219 \text{ kJ}\end{aligned}$$

6. Answer (1)

From the data, it is clear that Pb^{+2} is more stable than Pb^{+4} and Sn^{+2} is less stable than Sn^{+4} .

7. Answer (4)

$$\begin{aligned}\Delta H &= \Delta E + \Delta n_g RT \\ -1366.5 &= \Delta E + (-1 \times 8.314 \times 300 \times 10^{-3}) \\ \Delta E &= -1364 \text{ kJ}\end{aligned}$$

8. Answer (2)

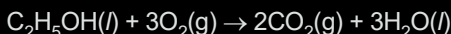
9. Answer (1)

For isothermal reversible expansion of an ideal gas, the work done is given by

$$\begin{aligned}W_{\text{rev}} &= -0.04 \times 8.314 \times 310 \ln \frac{375}{50} \\ &= -207.22 \approx -208 \text{ J}\end{aligned}$$

$$q = -W_{\text{rev}} = +208 \text{ J}$$

10. Answer (1)



Bomb calorimeter gives ΔU of the reaction

So, as per question

$$\Delta U = -1364.47 \text{ kJ mol}^{-1}$$

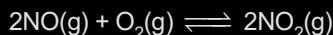
$$\Delta n_g = -1$$

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

$$= -1364.47 - \frac{1 \times 8.314 \times 298}{1000}$$

$$= -1366.93 \text{ kJ mol}^{-1}$$

11. Answer (4)



$$(\Delta G^\circ)_{\text{reaction}} = \left[(\Delta G^\circ)_{\text{formation}} \right]_{\text{product}} - \left[(\Delta G^\circ)_{\text{formation}} \right]_{\text{reactant}}$$

$$\Rightarrow -RT \ln K_P = 2 \times (\Delta G^\circ)_{\text{NO}_2} - 2(\Delta G^\circ)_{\text{NO}}$$

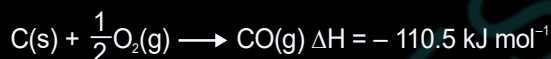
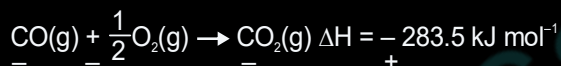
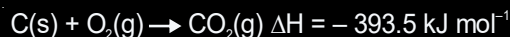
$$\Rightarrow (\Delta G^\circ)_{\text{NO}_2} = 2(\Delta G^\circ)_{\text{NO}} - RT \ln K_P$$

$$\Rightarrow (\Delta G^\circ)_{\text{NO}_2} = \frac{2 \times 86600 - R(298) \ln K_P}{2}$$

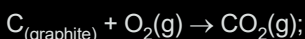
$$= \frac{2 \times 86600 - R(298) \ln 1.6 \times 10^{12}}{2}$$

$$= 0.5 [2 \times 86,600 - R(298) \ln 1.6 \times 10^{12}]$$

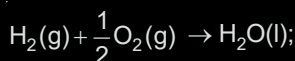
12. Answer (3)



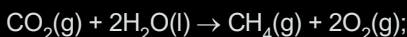
13. Answer (1)



$$\Delta_r H^\circ = -393.5 \text{ kJ mol}^{-1} \quad \dots(\text{i})$$



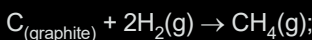
$$\Delta_r H^\circ = -285.8 \text{ kJ mol}^{-1} \quad \dots(\text{ii})$$



$$\Delta_r H^\circ = 890.3 \text{ kJ mol}^{-1} \quad \dots(\text{iii})$$

By applying the operation

(i) + 2 × (ii) + (iii), we get



$$\Delta_r H^\circ = -393.5 - 285.8 \times 2 + 890.3$$

$$= -74.8 \text{ kJ mol}^{-1}$$

14. Answer (1)

For adiabatic process, q = 0

∴ As per 1st law of thermodynamics,

$$\Delta U = W$$

15. Answer (4)



$$\Delta n_g = 6 - \frac{15}{2} = -\frac{3}{2}$$

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

$$= -3263.9 + \left(-\frac{3}{2}\right) \times 8.314 \times 298 \times 10^{-3}$$

$$= -3263.9 + (-3.71)$$

$$= -3267.6 \text{ kJ mol}^{-1}$$

16. Answer (3)

Work done in an isothermal reversible expansion is given by

$$W = -2.303 nRT \log \frac{V_f}{V_i}$$

$$|W| = nRT \ln \frac{V_f}{V_i}$$

$$\therefore T_2 > T_1$$

$$\text{So, } (V_i)_{T_2} > (V_i)_{T_1}$$

Hence, slope at T_2 will be greater but intercept at T_2 will be lesser.

17. Answer (3)

$$\Delta S_{\text{fus}} = \frac{\Delta H_{\text{fus}}}{273} = \frac{334}{273} = 1.22$$

$$\Delta S_{\text{vap}} = \frac{\Delta H_{\text{vap}}}{373} = \frac{2491}{373} = 6.67$$

$$\Delta S_{\text{water}} = \frac{mC_d T}{T} = mC_d \ln \left(\frac{T_2}{T_1} \right)$$

$$= 4.2 \times \ln \left(\frac{373}{273} \right) = 1.31$$

$$\Delta S_{\text{vap}} = mC_d \ln \left(\frac{T_2}{T_1} \right)$$

$$= 2 \times \ln \left(\frac{383}{373} \right) = 0.05$$

Total entropy change

$$\Delta S = 9.26 \text{ kJ kg}^{-1} \text{ K}^{-1}$$

18. Answer (3)

$$\Delta H = 200 \text{ J mol}^{-1}$$

$$\Delta S = 40 \text{ JK}^{-1} \text{ mol}^{-1}$$

For spontaneous reaction,

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

$$T \geq \frac{200}{40} \geq 5 \text{ K}$$

So, minimum temperature is 5 K

19. Answer (4)

$$w = -P_{\text{ext}}(V_f - V_i)$$

$$= -4 \text{ Nm}^{-2} (1 - 5) \text{ m}^3$$

$$= 16 \text{ Nm} \Rightarrow 16 \text{ J}$$

For isothermal process

$$\Delta U = q + w \Rightarrow q = -w = -16 \text{ J}$$

($\therefore \Delta U = 0$ for isothermal process)

From calorimetry

Heat given = $nC\Delta T$

$$16 = \frac{1 \times 24 \text{ J} \times \Delta T}{\text{mol K}}$$

$$\Delta T = \frac{2}{3} \text{ K}$$

20. Answer (2)

If ΔG° is positive then $K_{\text{eq}} < 1$.

$$\text{so, } \frac{[Y]}{[X]} < 1$$

If ΔG° is negative then $K_{\text{eq}} > 1$

$$\text{so, } \frac{[Y]}{[X]} > 1$$

$$\Delta G^\circ = 120 - \frac{3}{8} T$$

At 315 K, $\Delta G^\circ = 120 - 118.125 = \text{positive}$

so, $[X] > [Y]$.

21. Answer (2)

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

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

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

$$\therefore \Delta S_{\text{total}} = C_P \ln \left(\frac{T_1 + T_2}{2T_1} \right) + C_P \ln \left(\frac{T_1 + T_2}{2T_2} \right)$$

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

22. Answer (3)



For reaction to be spontaneous

$$\Delta_r H^\circ - T \Delta_r S^\circ < 0$$

$$\Rightarrow T > \frac{\Delta_r H^\circ}{\Delta_r S^\circ}$$

$$T > \frac{491.1 \times 1000}{198}$$

$$T > 2480.3 \text{ K}$$

23. Answer (2)

$$\Delta_r G^\circ = A - BT$$

A and B are non-zero constants

$$\therefore \Delta G^\circ = \Delta H^\circ - T \Delta S^\circ = A - BT$$

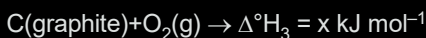
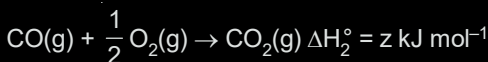
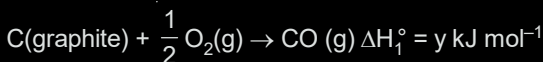
\therefore Reaction will be endothermic if $A > 0$.

24. Answer (4)

C_p and C_v for ideal gases are dependant on temperature only. So, C_p will not change with pressure.

25. Answer (2)

According to Hess's law, the enthalpy change of a reaction does not depend on the number of steps involved in the reaction.



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

$$x = y + z$$

** in reaction ii, Product should be CO (gas) instead of CO₂ (gas).

26. Answer (4)

(B) and (D) are not correct representation for isothermal expansion of ideal gas.

27. Answer (4)

$$\Delta U = q + W$$

Adiabatic process $q = 0$

$$\Delta U = W$$

For isothermal, $\Delta U = 0$

For cyclic, $\Delta U = 0$

For isochoric, $W = 0$

28. Answer (3)

$$n = 3$$

$$T_1 = 300$$

$$T_2 = 1000$$

$$C_p = 23 + 0.01T$$

$$\Delta H = \int_{T_1}^{T_2} nC_p dT$$

$$= n \int_{300}^{1000} (23 + 0.01T) dT$$

$$= 3 \left[23T + \frac{0.01T^2}{2} \right]_{300}^{1000}$$

$$= 3[16100 + 4550]$$

$$= 3 \times 20650 = 61950 \text{ J}$$

$$= 61.95 \text{ kJ}$$

$$\approx 62$$

29. Answer (4)

$$\Delta U = n c_{vm} \Delta T = 5 \times 28 \times 100 = 14 \text{ kJ}$$

$$\Delta(PV) = nR(T_2 - T_1)$$

$$= 5 \times 8 \times 100 = 4 \text{ kJ}$$

30. Answer (2)

(A) $q + w = \Delta U$, state function

(B) q , path function

(C) w , path function

(D) $H - TS = G$, state function

31. Answer (3)

$$w = 10 \text{ kJ}$$

$$q = -2 \text{ kJ}$$

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

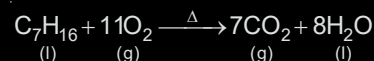
32. Answer (1)

A reaction is spontaneous if ΔG_{sys} is negative.

$$\Delta G_{\text{sys}} = \Delta H_{\text{sys}} - T\Delta S_{\text{sys}}$$

A reaction will be spontaneous at all temperatures if ΔH_{sys} is negative and $\Delta S_{\text{sys}} = +ve$

33. Answer (4)



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

$$\therefore \Delta n_g = -4$$

$$\therefore \Delta H - \Delta U = -4RT$$

34. Answer (2)

$$w = -P\Delta V$$

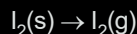
$$= -(1 \text{ bar}) \times (9 \text{ L})$$

$$= -(10^5 \text{ Pa}) \times (9 \times 10^{-3} \text{ m}^3)$$

$$= -9 \times 10^2 \text{ N-m}$$

$$= -900 \text{ J} = -0.9 \text{ kJ}$$

35. Answer (4)

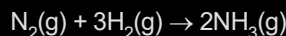


$$(\Delta H)_{T_2} - (\Delta H)_{T_1} = (\Delta C_p)(T_2 - T_1)$$

$$\therefore (\Delta H)_{250} = (\Delta H)_{200} + (0.031 - 0.055) 50$$

$$= 24 - 50 \times 0.024 = 22.8$$

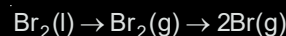
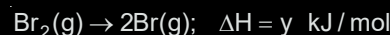
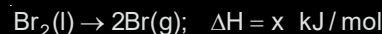
36. Answer (3)



\therefore Number of gaseous moles are decreasing

\therefore Change in entropy will be negative.

37. Answer (1)



$$\therefore \boxed{x > y}$$

38. Answer (3)

Both entropy and change in entropy are function of temperature.

39. Answer (3)

From the given ionisation enthalpy data it can be concluded that valency of the given metal is one.

∴ Its hydroxide is MOH



40. Answer (2)

For 1 mole of ideal gas.

- Both internal energy (U) and Enthalpy (H) depends on temperature
- Compressibility factor $Z = 1$
- $C_{P,m} - C_{V,m} = R$
and $dU = C_V dT$

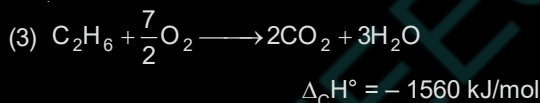
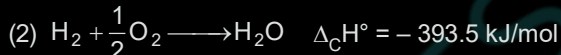
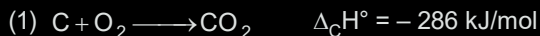
41. Answer (1)

$$P_{\text{ext}} = 0$$

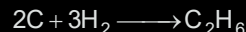
$$w = -P_{\text{ext}} \Delta V$$

$$= 0$$

42. Answer (−192.5)



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

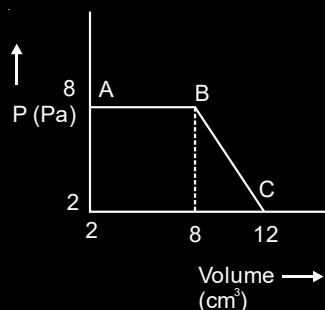


$$\Delta H_f^\circ (\text{C}_2\text{H}_6) = 2(-286) + 3(-393.5) + 1560$$

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

43. Answer (48.00)

Work done by a gas that undergoes a reversible expansion along the path ABC is given by



$$W = (6 \times 6) + \left(\frac{1}{2} \times 4 \times 6 \right) = 48.00 \text{ J}$$

44. Answer (6.25)

$$\Delta U = nC_V \Delta T$$

$$5000 = 4 \times C_V (500 - 300)$$

$$C_V = 6.25 \text{ JK}^{-1} \text{mol}^{-1}$$

45. Answer (189494)



$$\Delta H_{\text{vap}} = \Delta U + \Delta n_g RT$$

$$\Delta U = \Delta H_{\text{vap}} - RT$$

$$= 41,000 - 8.314 \times 373 \text{ J mol}^{-1}$$

$$= 37898.878$$

$$\text{For 5 moles, } \Delta U = 37898.878 \times 5 \text{ J}$$

$$= 189494 \text{ J}$$

46. Answer (−326400)



$$\Delta H = -327 \text{ kcal}; \Delta n_g = -1$$

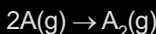
$$\Delta H = \Delta U + \Delta n_g RT$$

$$\Delta U = -327 + 2 \times 10^{-3} \times 300$$

$$= -326.4 \text{ kcal}$$

$$= -326400 \text{ cal}$$

47. Answer (−13537.57)



$$\Delta U^\circ = -20 \text{ kJ/mol and } \Delta S^\circ = -30 \text{ J/K mol}$$

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

$$= -20000 - 1 \times 8.314 \times 298$$

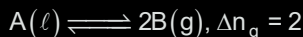
$$= -22477.57$$

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

$$= -22477.57 + 298 \times 30$$

$$= -13537.57$$

48. Answer (−02.70)



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

$$= (2.1 + 2 \times 2 \times 300 \times 10^{-3}) \text{ kcal}$$

$$= 3.3 \text{ kcal}$$

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

$$= 3.3 - 300 \times 20 \times 10^{-3}$$

$$= 3.3 - 6$$

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

49. Answer (4)

$$\begin{aligned}\Delta_{\text{Sol}}H^\circ &= \Delta_{\text{lattice}}H^\circ + \Delta_{\text{Hyd}}H^\circ \\ 4 &= 788 + \Delta_{\text{Hyd}}H^\circ \\ \Delta_{\text{Hyd}}H^\circ &= -784 \text{ kJ/mol}\end{aligned}$$

50. Answer (1380)



$$K_{\text{eq}} = 100$$

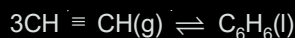
$$\begin{aligned}\Delta_r G^\circ &= -RT \ln K_{\text{eq}} \\ &= -R \times 300 \times \ln 100 \\ &= -R \times 300 \times 2 \times 2.3 \\ &= -1380 R\end{aligned}$$

$\Delta_r G$ of reaction at equilibrium will be zero.

$$\Delta_r G^\circ = -1380 R$$

Note : In this question, we have reported the value of $\Delta_r G^\circ$ which matches with the answer given by NTA.

51. Answer (855)



$$\begin{aligned}\Delta G^\circ &= \Delta G_f^\circ(\text{C}_6\text{H}_6) - 3\Delta G_f^\circ(\text{CH} \equiv \text{CH}) \\ &= -1.24 \times 10^5 - 3(-2.04 \times 10^5) \\ &= 4.88 \times 10^5 \text{ J mol}^{-1}\end{aligned}$$

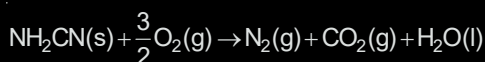
$$\begin{aligned}\Delta_r G^\circ &= -RT \ln K \\ &= -2.303 RT \log K\end{aligned}$$

$$|\log K| = \frac{4.88 \times 10^5}{2.303 \times 8.314 \times 298}$$

$$x \times 10^{-1} = 85.5$$

$$x = 855$$

52. Answer (741)



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

$$\Delta n_g = 2 - \frac{3}{2} = 0.5$$

Assuming that the ΔU is given at the same temperature.

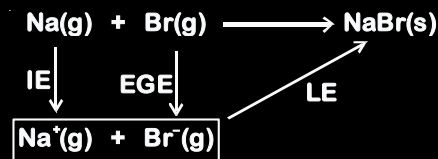
$$\Delta H_{298} = -742.24 + \frac{0.5 \times 8.314 \times 298}{1000}$$

$$= -742.24 + 1.24$$

$$= -741 \text{ kJ}$$

53. Answer (5576)

From the data given :



$$\Delta_r H = 495.8 - 325 - 728.4$$

$$= -557.6 \text{ kJ/mol}$$

$$= -5576 \times 10^{-1} \text{ kJ/mol}$$

Note : We have solved the question on the basis of information/data given. The final value obtained will not be the enthalpy of formation of NaBr(s). As for calculation of enthalpy of formation of NaBr(s), sublimation energy of Na(s), enthalpy of vapourisation of Br₂(l), and bond energy of Br₂(g) is also required.

54. Answer (200)



For a reaction to be spontaneous

$$\Delta_r G < 0$$

$$\text{or } \Delta_r G^\circ < 0 \text{ (For the given case)}$$

$$\Rightarrow \Delta_r H^\circ - T\Delta_r S^\circ < 0$$

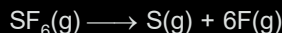
$$\Rightarrow 80 \times 1000 - T \times 2T < 0$$

$$\Rightarrow T^2 > 40000$$

$$T > 200$$

$$\therefore T_{\text{min}} = 200 \text{ K}$$

55. Answer (309)



$$\Delta_r H^\circ = \Delta_r H_f^\circ(\text{S}) + 6\Delta_r H_f^\circ(\text{F}) - \Delta_r H_f^\circ(\text{SF}_6)$$

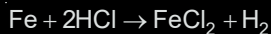
$$= 275 + 6 \times 80 - (-1100)$$

$$= 1855 \text{ kJ mol}^{-1}$$

$$\text{Also, } \Delta_r H^\circ = 6\Delta H_{\text{S-F}}$$

$$\therefore \Delta H_{\text{S-F}} = \frac{1855}{6} = 309.17 \approx 309 \text{ kJ mol}^{-1}$$

56. Answer (2218)



$$\frac{50}{55.85} \text{ moles}$$

$$\text{No. of H}_2 \text{ produced} = \frac{50}{55.85} \text{ moles}$$

$$\text{Work done} = -P_{\text{ext}} \cdot \Delta V$$

$$= -\Delta n_g RT$$

$$= \frac{50}{55.85} \times 8.314 \times 298$$

$$\approx 2218 \text{ J}$$

57. Answer (230)

$$\Delta H_f^\circ(\text{Al}_2\text{O}_3) = -1675 \text{ kJ mol}^{-1}$$

$$\Delta H_f^\circ(\text{CaO}) = -635 \text{ kJ mol}^{-1}$$



$$\Delta H_r^\circ = \Delta H_f^\circ(\text{Al}_2\text{O}_3) - 3\Delta H_f^\circ(\text{CaO})$$

$$= -1675 - 3(-635)$$

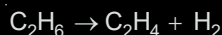
$$= 230 \text{ kJ mol}^{-1}$$

58. Answer (3)

For A, B, C and D entropy decreases

While in case of E, entropy increases.

59. Answer (128)



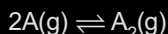
$$\Delta_r H = (\text{B.E.})_{\text{C-C}} + 6 \times (\text{B.E.})_{\text{C-H}}$$

$$-[(\text{B.E.})_{\text{C=C}} + 4 \times (\text{B.E.})_{\text{C-H}} + (\text{B.E.})_{\text{H-H}}]$$

$$= 347 + 6 \times 414 - (611 + 4 \times 414 + 436)$$

$$= 128 \text{ kJ mol}^{-1}$$

60. Answer (166)



$$\Delta G^\circ = 25.2 \text{ kJ mol}^{-1} \text{ at } 400 \text{ K}$$

$$\Delta G^\circ = -RT \ln K_p$$

$$25.2 \times 10^3 = -8.3 \times 400 \times 2.3 \log K_p$$

$$\log K_p = \frac{-25.2 \times 10^3}{8.3 \times 400 \times 2.3}$$

$$\log K_p = -3.3$$

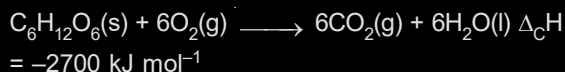
$$K_p = 5 \times 10^{-4}$$

$$K_p = K_c (RT)^{-1}$$

$$K_c = 5 \times 10^{-4} \times 8.3 \times 400 = 1.66$$

$$= 166 \times 10^{-2}$$

61. Answer (667)



1 mole of $\text{C}_6\text{H}_{12}\text{O}_6$ gives 2700 kJ energy

$$\frac{10000}{2700} \text{ mole of } \text{C}_6\text{H}_{12}\text{O}_6 \text{ gives } 10000 \text{ kJ of energy}$$

Weight of $\text{C}_6\text{H}_{12}\text{O}_6$ needs to meet the energy

$$= \frac{100}{27} \times 180 = 666.67 \text{ g}$$

$$\approx 667 \text{ g}$$

62. Answer (336)

$$\Delta G = -49.4 \text{ kJ/mol}$$

$$\Delta H = 51.4 \text{ kJ/mol}$$

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

$$-49400 = 51400 - 300\Delta S$$

$$\Delta S = \frac{+100800}{300} = 336 \text{ JK}^{-1} \text{ mol}^{-1}$$

63. Answer (21)

Heat of combustion per mol (for 12 g)

$$= -2.48 \times 10^2 \text{ KJ}$$

$$\text{for 1 g of graphite} = \frac{-2.48 \times 10^2}{12}$$

$$= -20.66 \text{ KJ}$$

64. Answer (101)

$$\Delta_{\text{sub}} H = \Delta_{\text{fus}} H + \Delta_{\text{vap}} H \quad (\text{These values should be at a given temperature})$$

$$\Delta_{\text{sub}} H = 98.2 + 2.8$$

$$\Delta_{\text{sub}} H = 101 \text{ kJ mol}^{-1}$$

65. Answer (50)

$$\Delta U = q + w \text{ (according first law of thermodynamics)}$$

$$= 150 - 200$$

$$= -50 \text{ J}$$

66. Answer (31)

$$\begin{aligned}\Delta H - \Delta U &= \Delta n_g RT \\ &= 1 \times 8.31 \times 373 \\ &= 30.99 \times 10^2 \text{ J mol}^{-1} \\ &\approx 31 \times 10^2 \text{ J mol}^{-1}\end{aligned}$$

67. Answer (82)

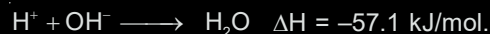
$$\text{millimoles of H}_2\text{SO}_4 = 400 \times 0.2 = 80$$

$$\text{meq of NaOH} = 600 \times 0.1 = 60$$



t = 0	80	60	—	—
	50	—	30	

30 mmoles of product is formed.



$$\text{Moles of H}^+ \text{ \& \; OH}^- \text{ neutralised} = \frac{60}{1000}$$

$$\therefore \Delta H = \frac{60}{1000} \times (-57.1) = 3426 \text{ J/mol}$$

$$\text{Total volume} = 1 \text{ L, Mass} = 1000 \text{ g}$$

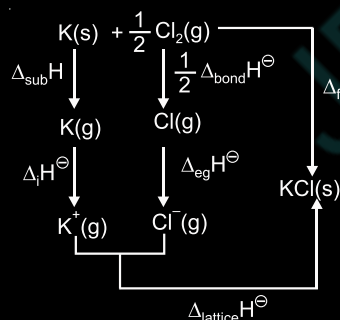
$$1000 \times 4.18 \times \Delta T = 3426$$

$$\Delta T = 0.8196$$

$$= 81.9 \times 10^{-2} \text{ K} \approx 82 \times 10^{-2} \text{ K}$$

68. Answer (718)

Born-Haber cycle of KCl is



$$\Delta_{\text{sub}}H + \Delta_{\text{I}}H^\circ + \frac{1}{2}\Delta_{\text{bond}}H^\circ + \Delta_{\text{eg}}H^\circ + \Delta_{\text{lattice}}H^\circ$$

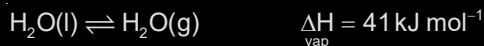
$$= \Delta_{\text{f}}H^\circ$$

$$89.2 + 419.0 + \frac{1}{2}(243.0) - 348.6 + \Delta_{\text{lattice}}H^\circ$$

$$= -436.7$$

$$\Delta_{\text{lattice}}H^\circ = -717.8 \text{ kJ/mol}$$

69. Answer (38)



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

$$41 = \Delta E + 1 \times 8.3 \times 10^{-3} \times 373$$

$$\Delta E \approx (41 - 3) = 38 \text{ kJ mol}^{-1}$$

70. Answer (82)

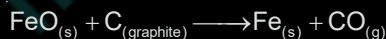
	HCl	+ NaOH	→ NaCl	+ H ₂ O
Moles	0.04	0.03	—	—
	0.01	—	0.03	0.03

$$Q, \text{ Heat released} = 0.03 \times 57.1 \text{ kJ} = 1.713 \text{ kJ}$$

$$Q = m \times s \times \Delta T$$

$$\Delta T = \frac{1.713 \times 1000}{500 \times 4.18} = 81.96 \times 10^{-2} \approx 82 \times 10^{-2}$$

71. Answer (964)



$$\begin{aligned}\Delta_{\text{f}}H^\circ(\text{reaction}) &= (0 + (-110.5)) - (-266.3) \\ &= 155.8 \text{ kJ/mol}\end{aligned}$$

$$\begin{aligned}\Delta S^\circ(\text{reaction}) &= 27.28 + 197.6 - (57.49 + 5.74) \\ &= 224.88 - 63.23 \\ &= 161.65 \text{ J mol}^{-1} \text{ K}^{-1}\end{aligned}$$

For spontaneity

$$\Delta G = \Delta H - T\Delta S \quad (\Delta G = 0)$$

$$\Delta H = T\Delta S$$

$$\begin{aligned}T &= \frac{\Delta H}{\Delta S} = \frac{155.8 \times 1000}{161.65} = 963.8 \\ &\approx 964 \text{ (nearest integer)}\end{aligned}$$

72. Answer (3)

Correct expressions are,

$$W_{\text{rev}} = -nRT \ln\left(\frac{V_f}{V_i}\right)$$

$$\Delta G_{\text{sys}} = -T\Delta S_{\text{Total}} \text{ (at constant-P)}$$

$$\begin{aligned}\Delta G^\circ &= \Delta H^\circ - T\Delta S^\circ \\ -RT \ln K &= \Delta H^\circ - T\Delta S^\circ \\ \ln K &= \frac{\Delta H^\circ - T\Delta S^\circ}{-RT} \\ \ln K &= \frac{T\Delta S^\circ - \Delta H^\circ}{RT}\end{aligned}$$

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

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

$$\Rightarrow K = e^{-\frac{\Delta G^\circ}{RT}}$$

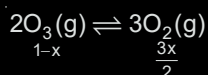
73. Answer (5)

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

$$\Delta G = -57.8 + 298 \times 176 \times 10^{-3}$$

$$\Delta G \approx -5 \text{ kJ mol}^{-1}$$

74. Answer (747)



$$\text{Given, } x = 0.5$$

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

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

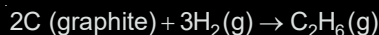
$$\Delta G^\circ = -2.303 RT \log K_p$$

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

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

$$= -747 \text{ J mol}^{-1}$$

75. Answer (3)



$$\Delta H_f = +1560 + 2(-394) + 3(-286)$$

$$= -86.0 \text{ kJ mol}^{-1}$$

Enthalpy of formation

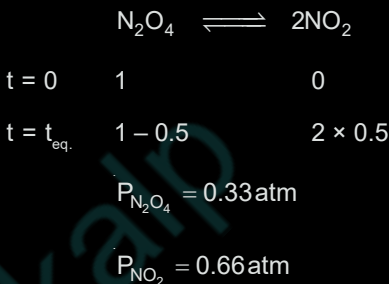
76. Answer (300)

$$\therefore \Delta S = \frac{\Delta H}{T}$$

$$\therefore T = \frac{\Delta H}{\Delta S}$$

$$= \frac{165 \times 10^3}{550} = 300 \text{ K}$$

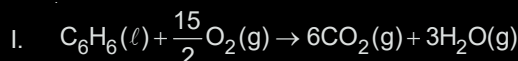
77. Answer (710)



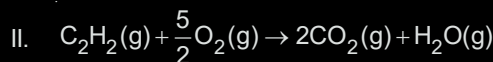
$$K_p = \frac{(P_{\text{NO}_2})^2}{P_{\text{N}_2\text{O}_4}} = \frac{(0.66)^2}{0.33} = 1.33$$

$$\begin{aligned}\therefore \Delta G &= -RT \ln K_p \\ &= -8.31 \times 300 \times 2.3 \times \log 1.33 \\ &\approx 710 \text{ J mol}^{-1}\end{aligned}$$

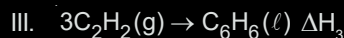
78. Answer (3)



$$\Delta H_1 = -3268 \text{ kJ/mol}$$



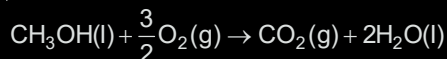
$$\Delta H_2 = -1300 \text{ kJ/mol}$$



Applying Hess's law of constant heat summation

$$\begin{aligned}\Delta H_3 &= 3 \times \Delta H_2 - \Delta H_1 \\ &= 3 \times (-1300) - (-3268) \\ &= -632 \text{ kJ/mol}\end{aligned}$$

79. Answer (727)

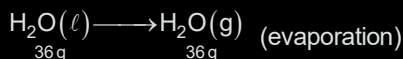


$$\Delta H = \Delta U + \Delta n_g RT$$

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

$$\approx -727 \text{ kJ mol}^{-1}$$

80. Answer (38)



$$n_{\text{H}_2\text{O}} = \frac{36}{18} = 2$$

$$\Delta n_g = 1 - 0 = 1$$

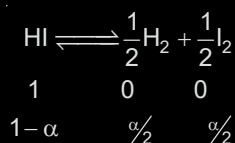
$$\Delta U_{\text{vap}} = \Delta H_{\text{vap}} - \Delta n_g RT$$

$$= 41.1 - (1) \times 8.31 \times 10^{-3} \times 373$$

$$= 41.1 - 3.099$$

$$= 38 \text{ kJ/mol}$$

81. Answer (2735)



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

$$= -RT \ln \frac{\left(\frac{\alpha}{2}\right)^{\frac{1}{2}} \left(\frac{\alpha}{2}\right)^{\frac{1}{2}}}{1 - \alpha}$$

$$= -RT \ln \frac{\alpha}{2(1 - \alpha)} \quad (\alpha = 0.4)$$

$$= -8.314 \times 300 \ln \frac{0.4}{2 \times 0.6}$$

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

$$= 2735 \text{ J/mol}$$

82. Answer (2)

Correct match is

(A) Spontaneous process

(B) Process with $\Delta P = 0$, $\Delta T = 0$

(C) $\Delta H_{\text{reaction}}$

(D) Exothermic process (I) $\Delta H < 0$

Hence, the correct option is (2).

(II) $\Delta G_{\text{T,P}} < 0$

(Constant

temperature and

pressure condition)

(III) Isothermal and

isobaric process

(IV) [Bond energies of

molecules in

reactants – bond

energies of product

molecules]

83. Answer (8630)

$$W_{\text{rev}} = -2.303 nRT \log_{10} \left(\frac{V_2}{V_1} \right)$$

$$= -2.303 \times 5 \times 8.3 \times 300 \times \log_{10} \left(\frac{20}{10} \right)$$

$$\approx -8630 \text{ J}$$

84. Answer (0)

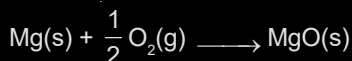
$$\text{Work done} = -P_{\text{ext}} \Delta V$$

$$\therefore P_{\text{ext}} = 0 \quad (\text{vacuum})$$

$$\therefore w = 0, \Delta U = 0 \quad (\text{as the process is isothermal})$$

$$\text{So, } q = 0$$

85. Answer (600)



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

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

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

$$\Delta U = -601.70 + 1.245$$

$$\Delta U \approx -600 \text{ kJ}$$

Magnitude of change in internal energy is 600 kJ.

86. Answer (117)

Number of moles of $\text{NH}_3 = 5$

So, required $\Delta H = 5 \times 23.4$

$$= 117 \text{ kJ}$$

87. Answer (195)

$$\Delta T = -40 \text{ K}$$

$$\Delta U = q + w$$

$$= \frac{100 \times 2.2}{44} (-40) - (-49.39) \times 10^{-3} \times 101.325$$

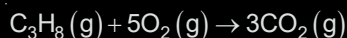
$$= -200 + 5$$

$$= -195 \text{ J}$$

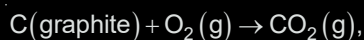
$$x = 195$$

88. Answer (104)

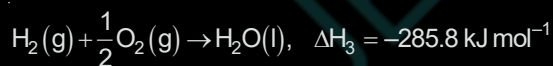
Enthalpy of combustion of propane, graphite and H_2 at 298K are



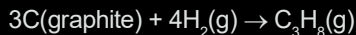
$$+4\text{H}_2\text{O}(\text{l}), \Delta H_1 = -2220 \text{ kJ mol}^{-1}$$



$$\Delta H_2 = -393.5 \text{ kJ mol}^{-1}$$



The desired reaction is



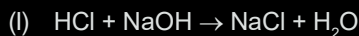
$$\Delta H_r = 3\Delta H_2 + 4\Delta H_3 - \Delta H_1$$

$$= 3(-393.5) + 4(-285.8) - (-2220)$$

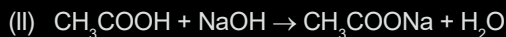
$$= -103.7 \text{ kJ mol}^{-1}$$

$$|\Delta H_r| \approx 104 \text{ kJ mol}^{-1}$$

89. Answer (2)

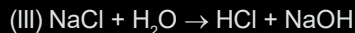


$$\Delta H_1 = -57.3 \text{ kJ mol}^{-1}$$



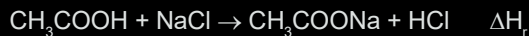
$$\Delta H_2 = -55.3 \text{ kJ mol}^{-1}$$

Reaction (I) can be written as



$$\Delta H_3 = 57.3 \text{ kJ mol}^{-1}$$

By adding (II) and (III)



$$\Delta H_r = \Delta H_3 + \Delta H_2 = 57.3 - 55.3$$

$$= 2 \text{ kJ mol}^{-1}$$

90. Answer (200)

$$Q \text{ (Heat evolved)} = -\frac{C_{\text{system}} \Delta T}{n}$$

$$n_{\text{coal}} = \frac{2.4}{12}$$

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

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

$$x = 200$$

91. Answer (57)



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

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

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

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

92. Answer (2)

$$C_p = 20.785 \text{ J K}^{-1} \text{ mol}^{-1}$$

$$\text{and } \Delta U = nC_v \Delta T$$

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

and we know that

$$C_p - C_v = R$$

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

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

93. Answer (35.00)

$$\Delta U = C \Delta T$$

$$= 2.5 \times 10^3 \times 0.45$$

$$= 1.125 \text{ kJ}$$

Considering $\Delta H \approx \Delta U$

$$\Delta H = 9 \text{ kJ/mol} \approx \Delta U$$

$$\therefore \text{Mass of gas burnt} = \frac{1.125}{9} \times 280 = 35 \text{ g}$$

94. Answer (1)

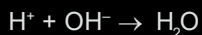
$$\Delta H = \Delta U + P\Delta V$$

Hence option A is incorrect.

95. Answer (3)

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

96. Answer (54)



$$\begin{array}{ccc} \text{m moles} & 120 & 40 & - \end{array}$$

$$\begin{array}{ccc} 80 & - & 40 \end{array}$$

Heat liberated from reaction

$$= 40 \times 10^{-3} \times 57 \times 10^3 \text{ J} \quad \dots(1)$$

Heat gained by solution = $mC\Delta T$

$$\begin{aligned} m &= \text{mass of solution} = V \times d = 1000 \times 1 \\ &= 1000 \text{ g} \end{aligned}$$

$$\text{Heat gained by solution} = 1000 \times 4.2 \times \Delta T \quad \dots(2)$$

From (1) and (2)

Heat liberated = Heat gained

$$40 \times 10^{-3} \times 57 \times 10^3 = 1000 \times 4.2 \times \Delta T$$

$$\Delta T = 54 \times 10^{-2} ^\circ\text{C}$$

(Rounded off to the nearest integer)

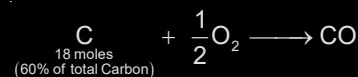
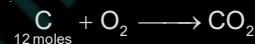
97. Answer (4)

$$\text{Weight of coal} = 0.6 \text{ kg} = 600 \text{ gm}$$

\therefore 60% of it is carbon

$$\text{So weight of carbon} = 600 \times \frac{60}{100} = 360 \text{ g}$$

$$\therefore \text{moles of carbon} = \frac{360}{12} = 30 \text{ moles}$$



$$\therefore \text{Heat generated} = 12 \times 400 + 18 \times 100 = 6600 \text{ kJ}$$

