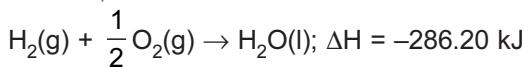
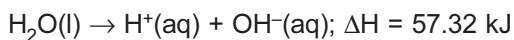


Thermodynamics

1. On the basis of the following thermochemical data

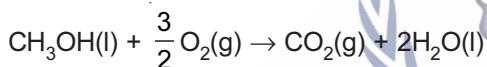
$$: (\Delta_f G^\circ H_{(aq)}^+ = 0)$$



The value of enthalpy of formation of OH^- ion at 25°C is [AIEEE-2009]

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

2. 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%

3. 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

4. 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

$C_2H_5OOH_{(1)} + 3O_{2(g)} \rightarrow 2CO_{2(g)} + 3H_2O_{(1)}$ at 27°C is $-1366.5 \text{ kJ mol}^{-1}$. The value of internal energy change for the above reaction at this temperature will be [AIEEE-2011]

- (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, $W_{\text{reversible}} = -nRT \ln \frac{V_t}{V_i}$

$$(2) \ln K = \frac{\Delta H^\circ - T\Delta S^\circ}{RT}$$

$$(3) K = e^{-\Delta G^\circ / RT}$$

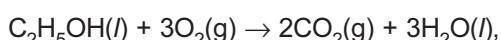
$$(4) \frac{\Delta G_{\text{system}}}{\Delta S_{\text{Total}}} = -T$$

9. 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 [JEE (Main)-2013]

(R = 8.314 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) $q = + 208 \text{ J}, w = + 208 \text{ J}$

10. For complete combustion of ethanol,

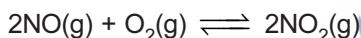


the amount of heat produced as measured in bomb calorimeter, is 1364.47 kJ mol⁻¹ at 25°C. Assuming ideality the enthalpy of combustion, $\Delta_c H$, for the reaction will be (R = 8.314 kJ mol⁻¹)

[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) $-1350.50 \text{ kJ mol}^{-1}$

11. The following reaction is performed at 298 K.



The standard free energy of formation of NO(g) is 86.6 kJ/mol at 298 K. What is the standard free energy of formation of NO₂(g) at 298 K?

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

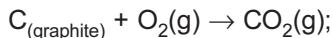
[JEE (Main)-2015]

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

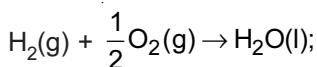
12. The heats of combustion of carbon and carbon monoxide are -393.5 and $-283.5 \text{ kJ mol}^{-1}$, respectively. The heat of formation (in kJ) of carbon monoxide per mole is [JEE (Main)-2016]

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

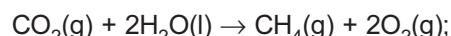
13. Given



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

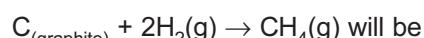


$$\Delta_f H^\circ = -285.8 \text{ kJ mol}^{-1}$$



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

Based on the above thermochemical equations, the value of $\Delta_f H^\circ$ 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

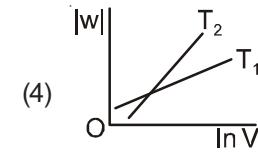
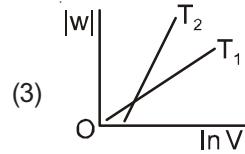
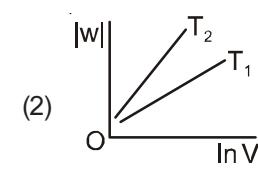
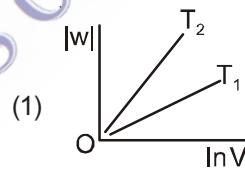
15. The combustion of benzene (l) gives CO₂(g) and H₂O(l). Given that heat of combustion of benzene at constant volume is $-3263.9 \text{ kJ mol}^{-1}$ at 25°C; heat of combustion (in kJ mol⁻¹) of benzene at constant pressure will be (R = 8.314 JK⁻¹ mol⁻¹)

[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 T₁ and T₂ (T₁ < T₂). 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 kJ K⁻¹ kg⁻¹ and 2.0 kJ K⁻¹ 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) $2.64 \text{ kJ kg}^{-1} \text{ K}^{-1}$

18. A process had $\Delta H = 200 \text{ J mol}^{-1}$ and $\Delta S = 40 \text{ JK}^{-1} \text{ mol}^{-1}$. Out of the values given below, choose the minimum temperature above which the process will be spontaneous. [JEE (Main)-2019]

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

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

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

20. 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 $T = 350 \text{ K}$

21. 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) $2C_P \ln\left[\frac{(T_1 + T_2)^{\frac{1}{2}}}{T_1 T_2}\right]$

22. 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]

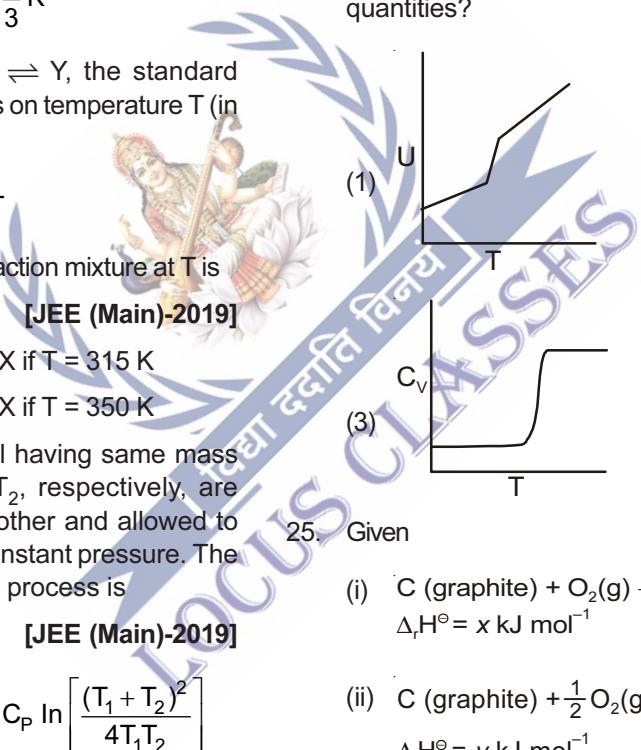
(1) 2040.5 K (2) 1890.0 K
 (3) 2480.3 K (4) 2380.5 K

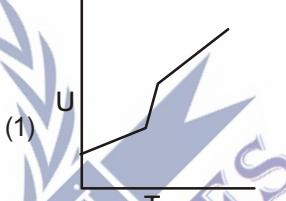
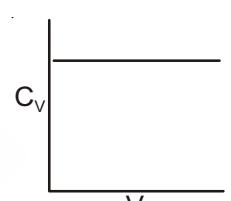
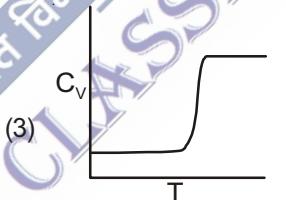
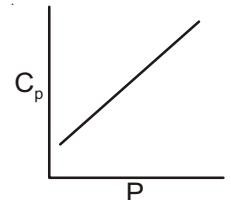
23. The standard reaction Gibbs energy for a chemical reaction at an absolute temperature T is given by $\Delta_r G^\circ = A - BT$

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]



(1)  (2) 
 (3)  (4) 

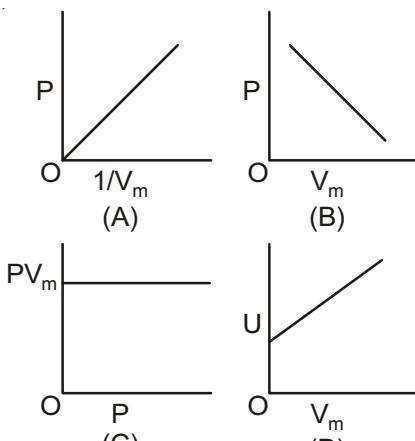
25. Given

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

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) $z = x + y$

26. The combination of plots which does not represent isothermal expansion of an ideal gas is



[JEE (Main)-2019]

- (1) (A) and (C) (2) (A) and (D)
 (3) (B) and (C) (4) (B) and (D)
27. 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 : $\Delta U = -w$
28. 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

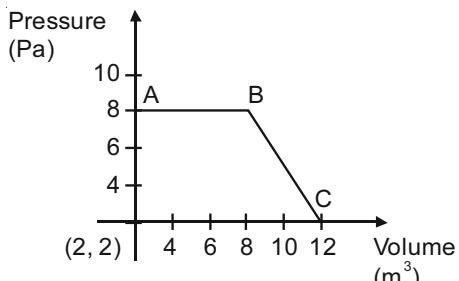
29. 5 moles of an ideal gas at 100 K are allowed to undergo reversible compression till its temperature becomes 200 K. If $C_V = 28 \text{ J K}^{-1} \text{ mol}^{-1}$, calculate ΔU and ΔpV for this process. ($R = 8.0 \text{ J K}^{-1} \text{ mol}^{-1}$)

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

30. Among the following, the set of parameters that represents path functions, is
- (A) $q + w$
 (B) q
 (C) w
 (D) $H - TS$
- [JEE (Main)-2019]
- (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 I₂(s) and I₂(vap) are 0.055 and 0.031 cal g⁻¹K⁻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. If enthalpy of atomisation for Br_{2(l)} is x kJ/mol and bond enthalpy for Br₂ is y kJ/mol, the relation between them
- [JEE (Main)-2020]
- (1) is x > y (2) does not exist
 (3) is x = y (4) is x < y

37. The true statement amongst the following is
[JEE (Main)-2020]
- S is not a function of temperature but ΔS is a function of temperature
 - S is a function of temperature but ΔS is not a function of temperature
 - Both ΔS and S are functions of temperature
 - Both S and ΔS are not functions of temperature
38. 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]**
- 2 and 0.5
 - 1 and 2
 - 1 and 0.5
 - 1 and 1
39. For one mole of an ideal gas, which of these statements must be true?
- U and H each depends only on temperature
 - Compressibility factor z is not equal to 1
 - $C_{P,m} - C_{V,m} = R$
 - $dU = C_V dT$ for any process
- [JEE (Main)-2020]**
- (a) and (c)
 - (a), (c) and (d)
 - (b), (c) and (d)
 - (c) and (d)
40. 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]**
- Zero
 - $-RT \ln V_2/V_1$
 - $C_V(T_2 - T_1)$
 - $-RT(V_2 - V_1)$
41. 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]**
42. The magnitude of work done by a gas that undergoes reversible expansion along the path ABC shown in the figure is _____.

**[JEE (Main)-2020]**

43. 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]**
44. The internal energy change (in J) when 90 g of water undergoes complete evaporation at 100°C is _____.
 (Given : ΔH_{vap} for water at 373 K = 41 kJ/mol, $R = 8.314 \text{ JK}^{-1} \text{ mol}^{-1}$) **[JEE (Main)-2020]**
45. 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]**
46. A soft drink was bottled with a partial pressure of CO₂ of 3 bar over the liquid at room temperature. The partial pressure of CO₂ over the solution approaches a value of 30 bar when 44 g of CO₂ is dissolved in 1 kg of water at room temperature. The approximate pH of the soft drink is _____ $\times 10^{-1}$.
 (First dissociation constant of H₂CO₃ = 4.0×10^{-7} ; log 2 = 0.3; density of the soft drink = 1 g mL⁻¹) **[JEE (Main)-2020]**
47. For a dimerization reaction,
 $2\text{A(g)} \rightarrow \text{A}_2\text{(g)}$,
 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
 $\text{A(l)} \rightarrow 2\text{B(g)}$
 $\Delta U = 2.1 \text{ kcal}$, $\Delta S = 20 \text{ cal K}^{-1}$ at 300 K.
 Hence ΔG in kcal is _____. **[JEE (Main)-2020]**