Thermodynamics

Question1

Given below are two statements.

Statement-I : Adiabatic work done is positive when work is done on the system and internal energy of the system increases.

Statement - II : No work is done during free expansion of an ideal gas.

In the light of the above statements, choose the correct answer from the options given below.

KCET 2025

Options:

A. Both statements - I and Statement - II are false

B. Statement - I is true but statement - II is false

C. Statement - I is false but statement - II is true

D. Both statements - I and Statement - II are true.

Answer: D

Solution:

Option D

Explanation:

Statement I

For an adiabatic process $Q = 0$.

If "work done" W is taken positive when done on the system, then the first law gives

$\Delta U = Q + W = 0 + W = W.$

Thus if work is done on the system $(W > 0)$, its internal energy increases $(\Delta U > 0)$.

Statement II

In a free (Joule) expansion the external pressure $P_{\text{ext}} = 0$, so

$W = \int P_{\text{ext}}\, dV = 0.$

Hence no work is done during the free expansion of an ideal gas.

Both statements are therefore true.

Question2

Which one of the following reactions has $\Delta \mathrm{H} = \Delta \mathrm{U}$?

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Options:

A. $\mathrm{CaCO_3(\ s)} \xrightarrow{\Delta} \mathrm{CaO(s) + CO_2(\ g)}$

B. $\mathrm{C_6H_6(I) + \frac{15}{2}O_2(\ g) \longrightarrow 6CO_2(\ g) + 3H_2O(I)}$

C. $\mathrm{2HI(g) \rightleftharpoons H_2(\ g) + I_2(\ g)}$

D. $\mathrm{N_2(\ g) + 3H_2(\ g) \rightleftharpoons 2NH_3(\ g)}$

Answer: C

Solution:

To determine which reaction has $\Delta H = \Delta U$, we use the equation:

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

Where:

ΔH is the change in enthalpy.

ΔU is the change in internal energy.

Δn_g is the change in the number of moles of gas.

R is the ideal gas constant.

T is the temperature in Kelvin.

For the reaction:

$2HI_{(g)} \rightleftharpoons H_{2(g)} + I_{2(g)}$

The change in the number of moles of gas (Δn_g) can be calculated as follows:

On the reactant side, there are 2 moles of gas.

On the product side, there are 1 mole of H_2 plus 1 mole of I_2, totaling 2 moles.

Thus, $\Delta n_g = 2 - 2 = 0$.

Since $\Delta n_g = 0$, it follows that:

$\Delta H = \Delta U$

Therefore, for this reaction, the change in enthalpy is equal to the change in internal energy.

Question3

Identify the incorrect statements among the following:

(a) All enthalpies of fusion are positive

(b) The magnitude of enthalpy change does not depend on the strength of the intermolecular interactions in the substance undergoing phase transformations.

(c) When a chemical reaction is reversed, the value of ΔrH° is reversed in sign.

(d) The change in enthalpy is dependent of path between initial state (reactants) and final state (products)

(e) For most of the ionic compounds, $\Delta_{sol}\ H^\circ$ is negative

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Options:

A. a, b and d

B. b, d and e

C. a, d and e

D. a and e only

Answer: B

Solution:

The incorrect statements are (b), (d) and (e), so the correct choice is Option B.

• (b) is false: ΔH for a phase change does depend on how strong the intermolecular forces are—you must supply enough energy to overcome them.

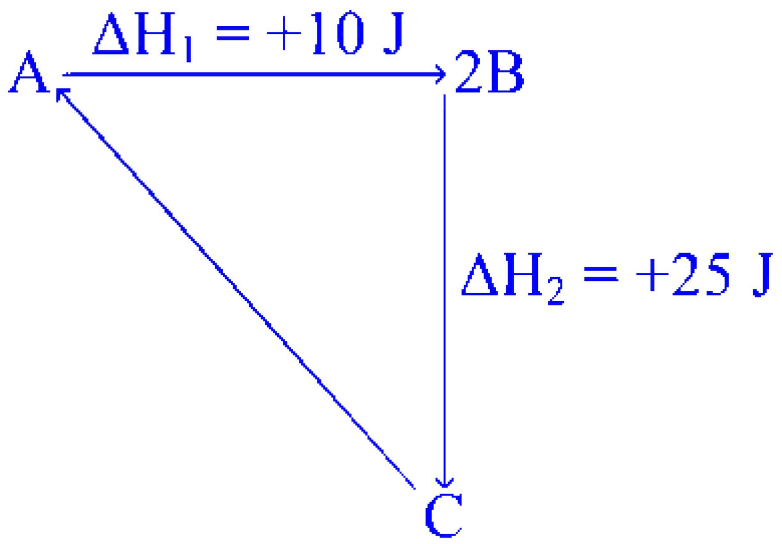
• (d) is false: Enthalpy is a state function, so ΔH depends only on initial and final states, not on the path.

• (e) is false: Many ionic salts dissolve endothermically (ΔsolH° > 0); only some give off heat on dissolving (ΔsolH° < 0).

(a) and (c) are both true.

Question4

From the diagram $(Z) = \frac{V_{\text{real}}}{V_{\text{ideal}}}$



$\Delta_r H$ for the reaction, $C \rightarrow A$ is

KCET 2024

Options:

A. $+35$ J

B. -15 J

C. -35 J

D. $+15$ J

Answer: C

Solution:

$\Delta_r H$ for $C \rightarrow A$ is given by

$$\underset{(A\rightarrow C)}{\Delta H_C} = \underset{(A\rightarrow B)}{\Delta H_1} + \underset{(B\rightarrow C)}{\Delta H_2}$$

$$\underset{(A\rightarrow C)}{\Delta H} = 10 + 25 = 35 \text{ J}$$

$$\underset{C\rightarrow A}{\Delta H} = -\underset{A\rightarrow C}{\Delta H}$$

$$\underset{C\rightarrow A}{\Delta H} = -35 \text{ J}$$

Question5

A gas at a pressure of 2 atm is heated from 25°C to 323°C and simultaneously compressed of $\frac{2}{3}$rd of its original value. Then the final pressure is

KCET 2023

Options:

A. 1.33 atm

B. 6 atm

C. 2 atm

D. 4 atm

Answer: B

Solution:

Given, $p_1 = 2$ atm

$p_2 = ?$
$V_1 = 1$ L
$V_2 = \frac{3}{2}$
$T_1 = 298$ K
$T_2 = 596$ K

Using combined gas law, we get

$$\frac{p_1 V_1}{T_1} = \frac{p_2 V_2}{T_2}$$
$$\Rightarrow \quad p_2 = \frac{2 \times 1}{298} \times \frac{3 \times 596}{2} = 6 \text{ atm}$$

Question6

Lattice enthalpy for NaCl is $+788$ kJ mol^{-1} and $\Delta H^{\circ}_{\text{hyd}} = -784$ kJ mol^{-1}. Enthalpy of solution of NaCl is

KCET 2023

Options:

A. $+572$ kJ mol^{-1}

B. $+4$ kJ mol^{-1}

C. -572 kJ mol^{-1}

D. -4 kJ mol^{-1}

Answer: B

Solution:

$$\Delta H_{\text{sol}} = \Delta H_{\text{lattice}} + \Delta H_{\text{hydration}}$$
$$= 788 + (-784) = 4 \text{ kJ mol}^{-1}$$

Question7

Temperature of $25^{\circ}\mathrm{C}$ in Fahrenheit and Kelvin scale respectively are

KCET 2023

Options:

A. $77^{\circ}\mathrm{F}$ and $298.15\ \mathrm{K}$

B. $17^{\circ}\mathrm{F}$ and $298.15\ \mathrm{K}$

C. $45^{\circ}\mathrm{F}$ and $260.15\ \mathrm{K}$

D. $47^{\circ}\mathrm{F}$ and $312.15\ \mathrm{K}$

Answer: A

Solution:

$$\mathrm{F} = \frac{9}{5}^{\circ}\mathrm{C} + 32$$

$$= \frac{9}{5}(25) + 32 = 77^{\circ}\mathrm{F}$$

$$\mathrm{K} = 273.15 + {}^{\circ}\mathrm{C} = 273.15 + 25 = 298.15\ \mathrm{K}$$

Question8

The work done when 2 moles of an ideal gas expands rèversibly and isothermally from a volume of $1\ \mathrm{L}$ to $10\ \mathrm{L}$ at $300\ \mathrm{K}$ is($R = 0.0083\ \mathrm{kJ\ K\ mol^{-1}}$)

KCET 2022

Options:

A. 5.8 kJ

B. 0.115 kJ

C. 58.5 kJ

D. 11.5 kJ

Answer: D

Solution:

Given, initial volume $V_1 = 1$ L

Final volume, $V_2 = 2$ L
Temperature $= 300$ K
$R = 0.0083$ kJ K mol^{-1}

Moles $(n) = 2$ moles

We know that,

Work done, $W = 2.303nRT \log \frac{V_2}{V_1}$

$= 2.303 \times 2 \times 0.0083 \times 300 \log 10 = 11.5$ kJ

Question9

When the same quantity of heat is absorbed by a system at two different temperatures T_1 and T_2, such that $T_1 > T_2$, change in entropies are ΔS_1 and ΔS_2 respectively. Then

KCET 2020

Options:

A. $\Delta S_1 < \Delta S_2$

B. $\Delta S_1 = \Delta S_2$

C. $S_1 > S_2$

D. $\Delta S_2 < \Delta S_1$

Answer: A

Solution:

When the same quantity of heat is absorbed by a system at two different temperatures, T_1 and T_2, such that $T_1 > T_2$, the change in entropies are ΔS_1 and ΔS_2 respectively.

Given that entropy change is given by :

$\Delta S = \frac{Q}{T}$

For the same heat absorbed,

$\Delta S_1 = \frac{Q}{T_1}$

$\Delta S_2 = \frac{Q}{T_2}$

Since $T_1 > T_2$,

$\Delta S_1 < \Delta S_2$.

Option A :

$\Delta S_1 < \Delta S_2$

Question10

The reaction in which $\Delta H = \Delta U$ is

KCET 2019

Options:

A. $\mathrm{N_2}(g) + \mathrm{O_2}(g) \rightarrow 2\mathrm{NO}(g)$

B. $\mathrm{CaCO_3(s)} \rightarrow \mathrm{CaO(s)} + \mathrm{CO_2(g)}$

C. $\mathrm{N_2}(g) + 3\mathrm{H_2}(g) \rightarrow 2\mathrm{NH_3}(g)$

D. $\mathrm{CH_4}(g) + 2\mathrm{O_2}(g) \rightarrow \mathrm{CO_2}(g) + 2\mathrm{H_2O}(l)$

Answer: B

Solution:

Key Idea Relation between ΔH and ΔU is given as $\Delta H = \Delta U + \Delta ngRT$

when $\Delta ng = 0$, then $\Delta H = \Delta U$

$\Delta ng = +ve,$ then $\Delta H > \Delta U$
$\Delta ng = -ve,$ then $\Delta H < \Delta U$

The reaction in which $\Delta H > \Delta U$ is

$CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$

Here, $\Delta ng = \Sigma n_{\text{produsts}} - \Sigma n_{\text{reactants}} = 1 - 0 = 1$

As we know $\Delta H = \Delta U + \Delta ngRT$

$\therefore \quad \Delta H > \Delta U$

Question11

A reaction has both ΔH and ΔS -ve. The rate of reaction

KCET 2017

Options:

A. increases with increases in temperature

B. cannot be predicted for change in temperature

C. increases with decreases in temperature

D. remains unaffected by change in temperature

Answer: C

Solution:

In this scenario, both the change in enthalpy (ΔH) and the change in entropy (ΔS) are negative.

To determine the effect of temperature on the reaction, we consider the Gibbs free energy equation:

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

For a reaction to be spontaneous, ΔG must be negative. Given that both ΔH and ΔS are negative, we want the absolute value of ΔH to be greater than $T\Delta S$ to ensure ΔG remains negative:

$\Delta H > T\Delta S$

This inequality suggests that at lower temperatures, the negative enthalpy term (ΔH) dominates, making it more likely for ΔG to be negative. Therefore, the reaction is exothermic and more favorable at lower temperatures, increasing its rate as the temperature decreases.