CHEMISTRY

NCERT - NCERT CHEMISTRY(ENGLISH)

THERMODYNAMICS

Solved Example

1. Express the change in internal energy of a system when

(i) No heat is absorbed by the system from the surroundings, but work (w) is done on the system. What type of wall does the system have ?

ii) No work is done on the system, but q amount of heat is taken out from the system and given to the surroundings. What type of wall does the system have?

(iii) w amount of work is done by the system and q amount of heat is supplied to the system. What type of system would it be?

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2. Two litres of an ideal gas at a pressure of 10 atm expands isothermally at $25^{\circ} C$ into a vacuum until its total volume is 10 litres. How much heat is absorbed and how much work is done in the expansion ?

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3. Two litres of an ideal gas at a pressure of 10 atm expands isothermally at 25 ^{o}C against a constant external pressure of 1 atm.How much heat is absorbed and how much work is done in the expansion ?

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4. one mole an ideal gas having volume 2 litre and at a pressure of 10 atm expands isothermally at 25 ^{o}C into a vacuum until its total volume is 10 litres. How much heat is absorbed and how much work is done in the expansion ?

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5. If water vapour is assumed to be a perfect gas, molar enthalpy change for vapourisation of 1 mol of water at 1bar and $100^{\circ}C$ is 41kJ mol^{-1}. Calculate the internal energy change, when 1 mol of water is vapourised at 1 bar pressure and $100^{\circ}C$.

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6. 1g of graphite is burnt in a bomb calorimeter in excess of oxygen at 298 K and 1 atmospheric pressure according to the equation

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

During the reaction, temperature rises from 298 K to 299 K. If the heat capacity of the bomb calorimeter is 20.7kJ/K, what is the enthalpy change for the above reaction at 298 K and 1 atm?

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7. A swimmer coming out from a pool is covered with a film of water weighing about 18g. How much heat must be supplied to evaporate this water at 298 K ? Calculate the internal energy of vaporisation at 298K.

$\Delta_{vap}H^{\ominus}$ for water

at 298K =44.01 kJ mol^{-1}

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8. Assuming the water vapour to be a perfect gas, calculate the internal energy change when 1 mol of water at $100^{\circ}C$ and 1 bar pressure is converted to ice at $0^{\circ}C$. Given the enthalpy of fusion of ice is 6.00 kJ mol^{-1} heat capacity of water is $4.2J/g^{\circ}C$

The change take place as follows:

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9. The combustion of $1mol$ of benzene takes place at $298K$ and $1atm$. After combustion, $CO_2(g)$ and $H_2O(l)$ are produced and $3267.0kJ$ of

heat is librated. Calculate the standard entalpy of formation, $\Delta_f H^{\Theta}$ of benzene

Given: $\Delta_f H^{\Theta} CO_2(g) = -393.5 kJmol^{-1}$

$\Delta_f H^{\Theta} H_2O(l) = -285.83 kJmol^{-1}$.

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10. Predict in which of the following entropy of the system increases / decreases:

(P) A liquid crystalizes into a solid

(Q) Temperature of a crystalline solid is raised

(R) $2NaHCO_3(s) \rightarrow Na_2CO_3(s) + H_2O(g) + CO_2(g)$

(S) $H_2(g) \rightarrow 2H(g)$

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11. For oxidation of iron.

$4Fe(s) + 3O_2(g) \rightarrow 2Fe_2O_3(s)$

entropy change is $-549.4 JK^{-1}mol^{-1}$ at 298 K. Inspite of negative

entropy change of this reaction, why is the reaction spontaneous?

$\left(\Delta_r H^{\ominus}\right.$ for this reaction is $-1648 \times 10^3 J\text{mol}^{-1}$)

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12. Calculate $\Delta G^{\ominus}$ for the conversion of oxygen to ozone, $\left(\frac{3}{2}\right) O_2(g) \Leftrightarrow O_3(g) at 298K$, of K_p for this conversion is 2.47×10^{-29}.

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13. Find out the value of equilibrium constant for the following reaction at 298 K.

$2NH_3(g) + CO_2(g) \Leftrightarrow NH_2CONH_2(aq) + H_2O(1)$

Standard Gibbs energy change, $\Delta_r G^{\ominus}$ at the given temperature is $-13.6 kJ\text{mol}^{-1}$

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14. At $60^{\circ} C$, dinitrogen tetroxide is 50 per cent dissociated. Calculate the standard free energy change at this temperature and at one atmosphere.

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Exercise

1. Choose the correct answer.

A thermodynamic state function is a quantity.

(a) used to determine heat changes.

(b) whose value is independent of path.

(c) used to determine pressure volume work.

(d) whose value depends on temperature only.

A. used to determine heat changes

B. whose value is independent of path

C. used to determine pressure volume work

D. whose value depends on temperature only.

Answer:

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2. For the process to occur under adiabatic conditions, the correct condition is

A. $\Delta T = 0$

B. $\Delta p = 0$

C. q=0

D. w=0

Answer:

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3. The enthalpies of the elements in their standard states are arbitrarily assumed to be

A. unity

B. zero

C. < 0

D. different for each element

Answer:

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4. ΔU^{Θ} of combustion of methane is $-XkJmol^{-1}$. The value of ΔH^{Θ} is

A. $= \Delta U^{\Theta}$

B. $> \Delta U^{\Theta}$

C. $< \Delta U^{\Theta}$

D. $= 0$

Answer:

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5. The enthalpy of combustion of methane, graphite and dihydrogen at $298K$ are, $-890.3kJmol^{-1} - 393.5kJmol^{-1}$, and $-285.8kJmol^{-1}$ respectively. Enthapy of formation of $CH_4(g)$ will be

A. $-74.8kJmol^{-1}$

B. $-52.27kJmol^{-1}$

C. $+74.8kJmol^{-1}$

D. $+52.26kJmol^{-1}$

Answer:

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6. A reaction $A + B \rightarrow C + D + q$ is found to have a positive entropy change, the reaction will be:

A. possible at high temperature

B. possible only at low temperature

C. not possible at any temperature

D. possible at any temperature

Answer:

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7. In a process, $701J$ of heat is absorbed by a system and $394J$ of work is done by the system. What is the change in internal energy for the process?

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8. The reaction of cyanamide, $NH_2CN(s)$, with dioxygen was carried out in a bomb calorimeter, and ΔU was found to be $-742.7kJmol^{-1}$ at

$298K$. Calculate enthalpy change for the reaction at $298K$.

$$NH_2CN(g) + \frac{3}{2}O_2(g) \rightarrow N_2(g) + CO_2(g) + H_2O(l)$$

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9. Calculate the number of kJ of heat necessary to raise the temperature of $60.0g$ of aluminium from $35^\circ C$ to $55^\circ C$. Molar heat capacity of Al is $24Jgm^{-1}$.

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10. Calculate the enthalpy change of freezing of 1.0 mol of water at $10^\circ C$ to ice at $-10^\circ C$, $\Delta_{fus}H = 6.03kJmol^{-1}$ at $0^\circ C$.

$C_P[H_2O(l)] = 75.3Jmol^{-1}K^{-1}$

$C_P[H_2O(s)] = 36.8Jmol^{-1}K^{-1}$

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11. Enthalpy of combustion of carbon to CO_2 is $-393.5kJmol^{-1}$. Calculate the heat released upon formation of $35.2g$ of CO_2 from carbon and dioxygen gas.

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12. Find the value of $\Delta_f H^\circ$ for the reaction

$N_2O_4(g) + 3CO(g) \rightarrow N_2O(g) + 3CO_2(g)$

Standard enthalpies of formation of $CO(g), CO_2(g), N_2O(g)$, and $N_2O_4(g)$ are $-110, -393, 81$, and $9.7kJmol^{-1}$, respectively.

Strategy : The standard enthalpy change of a reaction is equal to the sum of the standard molar enthalpie of formation of the products each multiplied by its stiochiometric coefficient in the balanced equation, minus the corresponding sum of the standard molar enthalpies of formation of the reactants

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13. Given

$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g), \Delta_r H^{\ominus} = -92.4 kJmol^{-1}$

What is the standard enthalpy of formation of NH_3 gas?

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14. Calculate the standard enthalpy of formation of $CH_3OH(l)$ from the following data:

$CH_3OH(l) + \frac{3}{2}O_2(g) \rightarrow CO_2(g) + 2H_2O(l), \ldots(i), \Delta_r H_1^{\ominus} = -726 kJm$

$C(g) + O_2(g) \rightarrow CO_2(g), \ldots(ii), \Delta_c H_2^{\ominus} = -393 kJmol^{-1}$

$H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l), \ldots(iii), \Delta_f H_3^{\ominus} = -286 kJmol^{-1}$

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15. Calculate the enthalpy change for the process

$CCl_4(g) \rightarrow C(g) + 4Cl(g)$

and calculate bond enthalpy of $C - Cl$ in $CCl_4(g)$.

$\Delta_{vap} H^{\ominus}(CCl_4) = 30.5 kJmol^{-1}$

$\Delta_f H^{\Theta}(CCl_4) = -135.5 kJmol^{-1}$

$\Delta_a H^{\Theta}(C) = 715.0 kJmol^{-1}$, where $\Delta_a H^{\Theta}$ is enthalpy of atomisation

$\Delta_a H^{\Theta}(Cl_2) = 242 kJmol^{-1}$

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16. For an isolated system, $\Delta U = 0$, what will be ΔS?

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17. For the reaction at $298K$

$2A + B \to C$

$\Delta H = 400 kJmol^{-1}$ and $\Delta S = 0.2 kJK^{-1}mol^{-1}$

At what temperature will the reaction becomes spontaneous considering

ΔH and ΔS to be contant over the temperature range.

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18. For the reaction

$2Cl(g) \rightarrow Cl_2(g)$, what are the signs of ΔH and ΔS?

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19. For the reaction,

$2A(g) + B(g) \rightarrow 2D(g)$

$\Delta U^{\Theta} = -10.5kJ$ and $\Delta S^{\Theta} = -44.1JK^{-1}$

Calculate ΔG^{Θ} for the reaction, and predict whether the reaction may occur spontaneously.

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20. The equilibrium constant for a reaction is 10. What will be the value of ΔG^{Θ}? $R = 8.314JK^{-1}mol^{-1}, T = 300K.$

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21. Comment on the thermodynamic stability of $NO(g)$, given

$\frac{1}{2}N_2(g) + \frac{1}{2}O_2(g) \rightarrow NO(g), \Delta_r H^{\Theta} = 90kJmol^{-1}$

$NO(g) + \frac{1}{2}O_2(g) \rightarrow NO_2(g), \Delta_r H^{\Theta} = -74kJmol^{-1}$

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22. Calculate the entropy change in surroundings when 1.00 mol of $H_2O(l)$ is formed under standard conditions, $\Delta_r H^{\Theta} = -286kJmol^{-1}$.

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