



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?



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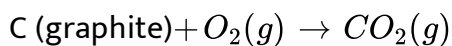
4. one mole an ideal gas having volume 2 litre and at a pressure of 10 atm expands isothermally at $25^{\circ}C$ into a vacuum until its total volume is 10 litres. How much heat is absorbed and how much work is done in the expansion ?

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



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.

$\Delta_{\text{vap}}H^\ominus$ 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°C and 1 bar pressure is converted to ice at 0°C. Given the enthalpy of fusion of ice is 6.00 kJ mol⁻¹ heat capacity of water is 4.2J/g°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, CO₂(g) and H₂O(l) are produced and 3267.0kJ of

heat is liberated. Calculate the standard enthalpy of formation, $\Delta_f H^\ominus$ of benzene

$$\text{Given: } \Delta_f H^\ominus \text{CO}_2(g) = -393.5 \text{kJmol}^{-1}$$

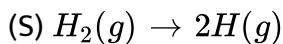
$$\Delta_f H^\ominus \text{H}_2\text{O}(l) = -285.83 \text{kJmol}^{-1}.$$

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

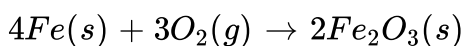
(P) A liquid crystalizes into a solid

(Q) Temperature of a crystalline solid is raised



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11. For oxidation of iron.



entropy change is $-549.4 \text{JK}^{-1}\text{mol}^{-1}$ at 298 K. In spite of negative

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

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

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12. Calculate ΔG^\ominus for the conversion of oxygen to ozone,

$\left(\frac{3}{2}\right) O_2(g) \rightleftharpoons O_3(g)$ at 298 K, 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.



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

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14. At 60°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^\ominus of combustion of methane is $-XkJmol^{-1}$. The value of ΔH^\ominus is

A. $= \Delta U^\ominus$

B. $> \Delta U^\ominus$

C. $< \Delta U^\ominus$

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. Enthalpy 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:

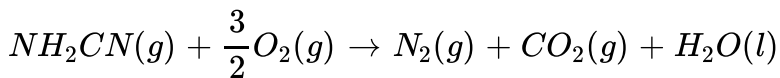
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7. In a process, $701J$ of heat is absorbed by a system and $394J$ of work is done by the system. What is the change in internal energy for the process?

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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.



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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 $0^\circ C$.

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

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

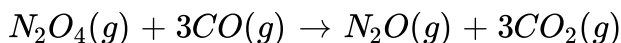
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11. Enthalpy of combustion of carbon to CO_2 is $-393.5kJmol^{-1}$.

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

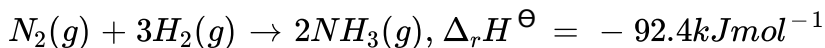


Standard enthalpies of formation of $CO(g)$, $CO_2(g)$, $N_2O(g)$, and $N_2O_4(g)$ are -110 , -393 , 81 , and $9.7kJmol^{-1}$, respectively.

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 stoichiometric 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

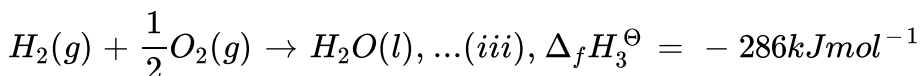
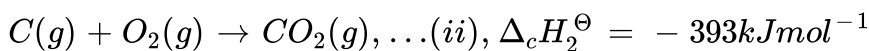
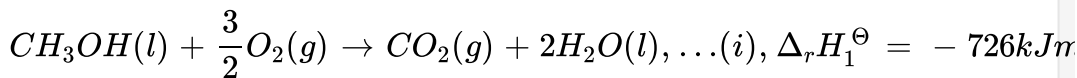


What is the standard enthalpy of formation of NH_3 gas?



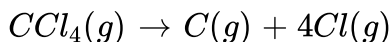
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14. Calculate the standard enthalpy of formation of $CH_3OH(l)$ from the following data:

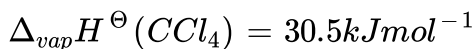


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15. Calculate the enthalpy change for the process



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



$$\Delta_f H^\ominus(\text{CCl}_4) = -135.5 \text{ kJ mol}^{-1}$$

$\Delta_a H^\ominus(\text{C}) = 715.0 \text{ kJ mol}^{-1}$, where $\Delta_a H^\ominus$ is enthalpy of atomisation

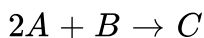
$$\Delta_a H^\ominus(\text{Cl}_2) = 242 \text{ kJ mol}^{-1}$$

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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

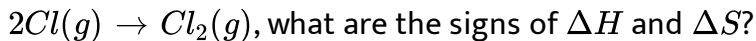


$$\Delta H = 400 \text{ kJ mol}^{-1} \text{ and } \Delta S = 0.2 \text{ kJ K}^{-1} \text{ mol}^{-1}$$

At what temperature will the reaction becomes spontaneous considering ΔH and ΔS to be constant over the temperature range.

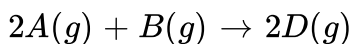
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18. For the reaction



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19. For the reaction,



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

Calculate ΔG^\ominus for the reaction, and predict whether the reaction may occur spontaneously.

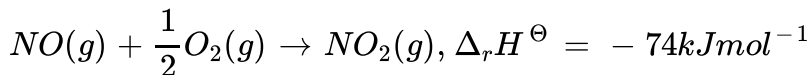
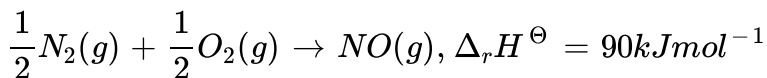
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20. The equilibrium constant for a reaction is 10. What will be the value of

$$\Delta G^\ominus? R = 8.314 \text{ JK}^{-1} \text{ mol}^{-1}, T = 300 \text{ K}.$$

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



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

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