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## CHEMISTRY

## BOOKS - VGS PUBLICATION-BRILLIANT

## THERMODYNAMICS

Very Short Answer Questions

1. What is the information given by the terms thermodynamics?

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2. What is the relationship between the laws of thermodynamics and equilibrium state?

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3. Define a system. Give an example.

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4. The wall is adiabatic and $\Delta U=W_{a d}$. What do you understand about the heat and work with respect to the system?
5. The system loses ' $q$ ' amount of heat though no work is done on the system. What type of wall does the system have?

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6. Work is done by the system and ' $q$ ' amount of beat is supplied the system. What type of system would it be?

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7. What is the work done in the free expansion of an ideal gas in reversible and irreversible processes?
8. From the equation $\Delta U q-p_{e x} \Delta V$, if the volume is constant what is the value of $\Delta U$ ?

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9. In isothermal free expansion of an ideal gas find the value of q and $\Delta U$.

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10. In isothermal irreversible change of ideal gas what is the value of $q$ ?
11. In isothermal reversible change of an ideal gas, what is the value of $q$ ?

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12. For an adiabatic change of in an ideal gas what is the relationship between its $\Delta U$ and W (adiabatic)?

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13. State the first law of thermodynamics.
14. What are the sign conventions of the work done on the system and work done by the system?

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15. Volume (V), Pressure (P) and Temperature ( T ) are state functions. Is the statement true?

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16. What are the heat (q) sign conventions when heat is transferred from the surroundings to the system and that transferred from system to the surrounding?

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17. 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?

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18. No work is done on the system, but heat (q) is taken out from the system by the surroundings. What type of wall does the system have?

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19. Work is done by the system and heat (q) is supplied to the system. What type of system would it be?

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20. If the boundary of system moves by an infinitesimal amount, the work involved is given by $d w=-P_{\text {ext }} d V$ for irreversible
process
$w=-P_{\text {ext }} \Delta V \quad\left(\right.$ where $\left.\Delta V=V_{f}-V_{i}\right)$
for reversible process $P_{\text {ext }}=P_{\text {int }} \pm d P \cong P_{\text {int }}$
so for reversible isothermal process $w=-n R T \ln . \frac{V_{f}}{V_{i}}$
2 mole of an ideal gas undergoes isothermal compression
along three different plaths :
(i) reversible compression from $P_{i}=2$ bar and $V_{i}=8 L$
to $P_{f}=20 \mathrm{bar}$
(ii) a single stage compression against a constant external pressure of 20 bar, and
(iii) a two stage compression consisting initially of compression against a constant external pressure of 10 bar until $P_{\text {gas }}=P_{\text {ext }}$, followed by compression against a constant pressure of 20 bar until $P_{\text {gas }}=P_{\text {ext }}$

Work done on the gas in single stage compression is :

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21. $q=-w=n R T 1 n\left(v_{f}-v_{i}\right)$ is for isothermal change.
22. What are the ' $\Delta H^{\prime}$ ' sign conventions for exothermic and endothermic reactions?

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23. What are intensive and extensive properties?

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24. In the equation $q=C . \Delta . m . \Delta T$, if $\Delta T$ is change in temperature ' $m$ ' mass of the substance, and ' q ' is heat required, what is ' $C$ '?
25. Give the equation that gives the relationship between $\Delta U$ and $\Delta H$.

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26. What is the relationship between $C_{p}$ and $C_{v}$ ?

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27. 1 g of graphite is burnt in a bomb calorimeter in excess of $O_{2}$ at 298 K and 1 atm. Pressure according to the equations.
$C_{\text {graphite }}+O_{2(g)} \rightarrow C O_{2(g)}$
During the reaction the temperature rises from 298 K to

200K. Heat capacity of the bomb calorimeter is 20.7KJK ${ }^{-1}$. What is the enthalpy change for the above reaction at 298 K 1 atm?

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28. For the above reaction what is the internal energy change, $\Delta U$ ?

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29. 

What
is
$\Delta_{r} H$
for
$\mathrm{CH}_{4(g)}+20_{2(g)} \rightarrow \mathrm{CO}_{2(g)}+2 \mathrm{H}_{2} \mathrm{O}(l)$ in terms of molar enthaples of the respective reaction and products?
30. Enthalpy decreases is not the criterion for spontaneity. Why?

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31. Is increase of entropy the criterion for spontaneity ?

Why?

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32. Explain the relationship between Gibbs energy change and equilibrium constant.
33. If we measure $\Delta H^{\theta}$ and $\Delta S^{\theta}$ it is possible to estimate $\Delta G^{\theta}$. Is it true? Why?

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34. Equilibrium constant ' $K$ ' is measured accurately in the laboratory at given temperature. Is it possible to calculate $\Delta G^{\theta}$ at any other temperature ? How?

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35. Comment on the thermodynamics stability of $N O_{(g)}$
given that
$\frac{1}{2} N_{2(g)}+\frac{1}{2} O_{2(g)} \rightarrow N O_{g}, \Delta_{r} H^{\theta}=90 \mathrm{kJmol}^{-1}$
$N O_{(g)}+\frac{1}{2} O_{2(g)} \rightarrow N O_{2(g)}, \Delta_{r} H^{\theta} d=-74 \mathrm{Kjmol}^{-1}$

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36. Calculate the entropy change in surroundings when 1.00 mole of $\mathrm{H}_{2} \mathrm{O}_{(l)}$ is formed under standard conditions
$\Delta_{f} H^{\theta}=-286 \mathrm{kJmol}^{-1}$.

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37. The equilibrium constant for a reaction is 10 . What will be the value of $\Delta G^{\theta}$ ?
$R=8.314 \mathrm{JK}^{-1} \mathrm{~mol}^{-1}, T=300 \mathrm{~K}$.

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38. State the third law of thermodynamics.

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## Short Answer Questions

1. What are open, closed and isolated systems ? Give one example for each.
2. Define the state function and state variables. Give examples.

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3. "Internal energy is a state function." Explain.

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4. "Work is not a state function." Explain.
5. What is heat? Explain.

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6. Derive the equation for ' $W_{\text {rev }}$ ' in isothermal reversible process.

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7. Two litres of an ideal gas at a pressure of 10 atm expands isothermally into a vacuum until its total volume is 20 litres. How much heat is absorbed and how much work is done in the expansion?
8. If the ideal gas given in the problem 45 expands against constant external pressure of 1 atm what is the $q$ value?

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9. If the ideal gas given in the problem 45 expands to a final volume of 10 L conducted reversibly what is $q$ value?

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10. Explain the state function 'enthalpy, H'. What is the relationship between $\Delta U$ and $\Delta H$ ?
11. Show that $\Delta H=\Delta U+\Delta n_{(g)}, R T$

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12. If water vapour is assumed to be a perfect gas, molar enthalpy change for vapouration of 1 mole of water at 1 bar and $100^{\circ} \mathrm{C}$ is $41 \mathrm{~kJ} \mathrm{~mol}{ }^{-1}$. Calculate the internal energy change when
a) 1 mol of water is vapourised at 1 bar and $100^{\circ} \mathrm{C}$
b) 1 mol of water liquid is converted into ice.

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13. Explain extensive and intensive properties.

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14. Define heat capacity. What are $C_{p}$ and $C_{v}$ ? Show that
$C_{p}-C_{v}=R$.

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15. Explain the determination of $\Delta U$ of a reaction calorimetrically.
16. Explain the determination of $\Delta H$ of a reaction calorimetrically:

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17. What is enthalpy of a reaction? Explain the standard enthalpy of a reaction.

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18. What is the standard enthalpy of formation? Explain it with example.
19. Define and explain enthalpy of phase transformation.

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20. Define the explain the standard enthalpy of fusion (Molar enthalpy of fusion).

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21. Define and explain the standard enthalpy of vapourisation (Molar enthalpy of vapourisation).

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22. Define and explain the standard enthalpy of vapourisation of sublimation.

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23. Define and explain the standard enthalpy of formation $\left(\Delta_{r} H^{\theta}\right)$.

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24. State and explain the Hess's law of constant heat summation.

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25. Define and explain the enthalpy of combustion $\left(\Delta_{c} H^{\theta}\right)$.

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26. Define and explain the enthalpy of atomisation $\left(\Delta_{a} H^{\theta}\right)$.

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27. Define and explain the bond enthalpy $\left(\Delta_{\text {bond }} H^{\theta}\right)$.

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28. What is the bond enthalpy of $\mathrm{C}-\mathrm{H}$ bond of $\mathrm{CH}_{4}$ ?

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29. Define heat of solution $\left(\Delta_{\text {sol }} H^{\theta}\right)$ and heat of dilution.

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30. Define ionisation enthalpy and electron affinity.

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31. Explain the spontaneity of a process.
32. Is decrease in enthalpy a criterion for spontaneity?

Explain.

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33. What is entropy? Explain with examples.

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34. Is increases in entropy a criterion for spontaneity?

Explain.
35. Can $\Delta U$ and $\Delta S$ discriminate between irreversible and reversible process? Explain.

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36. In which of the following process entropy increases?
a) A liquid evaporates to vapour.
b) Temperature of a crystalline solid lowered from 115 K to

0 K.
c) $\mathrm{CaCO}_{3(\mathrm{~s})} \rightarrow \mathrm{CaO}_{(\mathrm{s})}+\mathrm{CO}_{2(g)}$
d) $\mathrm{Cl}_{2(g)} \rightarrow 2 C l_{(g)}$

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37. For the oxidation of iron
$4 \mathrm{Fc}_{(s)}+3 \mathrm{O}_{2(g)} \rightarrow 2 \mathrm{Fe}_{(2)} \mathrm{O}_{3(s)}$,
the entropy change is $-549.45 \mathrm{JK}^{-1} \mathrm{~mol}^{-1}$ at 298 K .
Though it has negative entropy change the reaction is
spontaneous. Why?
$\left(\Delta_{r} H^{\theta}=-164 \times 10^{3} J m l^{-1}\right)$

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38. Which formulate in the following are correct?
a) $G=H-T S$
b) $\Delta G_{\mathrm{sys}}=\Delta H_{\mathrm{sys}}-T \Delta S_{\mathrm{sys}}$
c) $\Delta S_{\text {surr }}=\frac{\Delta H_{\text {surr }}}{T}=\frac{-\Delta H_{\text {sys }}}{T}$
d) $\Delta S_{\text {total }}=\Delta S_{\text {sys }}+\frac{\left(-\Delta H_{\text {sys }}\right)}{T}$
e) $\Delta S_{\text {total }}=T \Delta S_{\text {sys }}-\Delta H_{\text {sys }}$

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39. Calculate $\Delta_{r} G^{\theta}$ for conversion of oxygen to ozone $\frac{3}{2} O_{2(g)} \rightarrow O_{3(g)}$ at $298 \mathrm{~K} . K_{p}$ for the reaction is $2.43 \times 10^{-29}$.

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40. State the second law of thermodynamics and explain it.
41. State the third law of thermodynamics.

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42. What is entropy? Explain with examples.

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43. Explain spontaneity of a process in terms of Gibbs energy.
44. The sign and magnitude of Gibbs energy change of a chemical process tells about its spontaneity and useful work that could be extracted from it. Explain.

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45. In a process 701 J of heat is absorbed by a system and

394 J of work is done by the system. What is the change in internal energy for the process?

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46. The reaction of cyanamide (s), with dioxygen was
carried out in a bomb calorimeter and $\Delta U$ was found to
be $-742.7 \mathrm{~kJ} \mathrm{~mol}^{-1}$ at 298 K . Calculate the enthalpy change for the reaction at 298 K .
$\mathrm{NH}_{2} \mathrm{CN}_{(g)}+\frac{3}{2} \mathrm{O}_{2}(\mathrm{~g}) \rightarrow \mathrm{N}_{2(\mathrm{~g})}+\mathrm{CO}_{2(g)}+\mathrm{H}_{2} \mathrm{O}_{l}$

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47. Calculate the number of $k J$ of heat necessary to rise the temperature of 60.0 g of aluminum from $35^{\circ} \mathrm{C} \rightarrow 55^{\circ} \mathrm{C}$. Molar heat capacity of aluminum is 24 J $\mathrm{mol}^{-1} K^{-1}$.

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48. Calculate the enthalpy change on freezing of 1.0 mol of water at $10.0^{\circ} \mathrm{C}$ to ice at $-10.0^{\circ} \mathrm{C}$.
$\Delta_{\mathrm{fus}} H=6.03 \mathrm{kJmol}^{-1} a t 0^{\circ} \mathrm{C}$
$C_{p}\left[H_{2} O(l)\right]=75.3 \mathrm{Jmol}^{-1} K^{-1}$
$C_{p}\left[H_{2} O(s)\right]=36.8 \mathrm{Jmol}^{-1} \mathrm{~K}^{-1}$

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49. Enthalpy of combustion of carbon to $\mathrm{CO}_{2}$ is
$-393.5 \mathrm{kJmol}^{-1}$. Calculate the heat released upon formation of 35.2 g of $\mathrm{CO}_{2}$ from carbon and dioxygen gas.

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50. Enthalpies of formation of $\mathrm{CO}(\mathrm{g})$,
$\mathrm{CO}_{2}(g), \mathrm{N}_{2} \mathrm{O}(g)$ and $\mathrm{N}_{2} \mathrm{O}_{4}(g)$ are -110, -393.81 and 9.7 kJ
$\mathrm{mol}^{-1}$ respectively. Find the value of $D_{r} H$ for the reaction:
$\mathrm{N}_{2} \mathrm{O}_{4}(\mathrm{~g})+3 \mathrm{CO}(\mathrm{g}) \rightarrow \mathrm{N}_{2} \mathrm{O}(\mathrm{g})+3 \mathrm{CO}_{2}(\mathrm{~g})$

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51. 

Given
$\mathrm{N}_{2}(\mathrm{~g})+3 \mathrm{H}_{2}(\mathrm{~g}) \rightarrow 2 \mathrm{NH}_{3}(\mathrm{~g}), \Delta_{r} \mathrm{H}^{\theta}=-92.4 \mathrm{kJmol}^{-1}$
What is the standard enthalpy of formation of $\mathrm{NH}_{3}$ gas ?

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52. From the following data
$\mathrm{CH}_{3} \mathrm{OH}(\mathrm{l})+\frac{3}{2} \mathrm{O}_{2}(\mathrm{~g}) \rightarrow \mathrm{CO}_{2}(\mathrm{~g})+2 \mathrm{H}_{2} \mathrm{O}(\mathrm{l})$
$\Delta_{r} H^{\circ}=-726 \mathrm{kJmol}^{-1}$
$\mathrm{H}_{2}(\mathrm{~g})+\frac{1}{2} \mathrm{O}_{2}(\mathrm{~g}) \rightarrow \mathrm{H}_{2} \mathrm{O}(\mathrm{l}), \Delta_{r} H^{\circ}=-286 \mathrm{kJmol}^{-1}$
$C($ graphite $)+\mathrm{O}_{2}(\mathrm{~g}) \rightarrow \mathrm{CO}_{2}(\mathrm{~g}), \Delta_{r} H^{\circ}=-393 \mathrm{kJmol}^{-1}$
The standard enthalpy of formation of
$\mathrm{CH}_{3} \mathrm{OH}(\mathrm{l})$ in $\mathrm{kJmol}^{-1}$ is

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53. Calculate the enthalpy change for the process
$\mathrm{CCl}_{4}(g) \rightarrow C(g)+4 C I(g)$
and calculate bond enthalpy of $C-C l \in C C l_{4}(g)$.
$\Delta_{\text {vap }} H^{\theta}\left(\mathrm{C} \mathrm{Cl}_{4}\right)=30.5 \mathrm{kJmol}^{-1}$.
$\Delta_{f} H^{\theta}\left(\mathbb{C l}_{4}\right)=-135.5 \mathrm{kJmol}^{-1}$.
$\Delta_{0} H^{\theta}(C)=715.0 \mathrm{kJmol}^{-1}$, where $\Delta_{a} H^{\theta}$ is enthalpy of atomisation.
$\Delta_{a} H^{\theta}\left(C l_{2}\right)=242 \mathrm{kJmol}^{-1}$.

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

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55. For the reaction at 298 K ,
$2 A+B \rightarrow C$
$\Delta H=400 \mathrm{kJmol}^{-1}$ and $\Delta S=0.2 \mathrm{kJK}^{-1} \mathrm{~mol}^{-1}$.
At what temperature will the reaction becomes spontaneous considering $\Delta H$ and $\Delta S$ to be constant over the temperature range?
56. For the reaction,
$2 C l(g) \rightarrow C l_{2}(g)$, what are the signs of $\Delta H$ and $\Delta S ?$

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57. For the reaction,
$2 A(g)+B(g) \rightarrow 2 D(g)$
$\Delta U^{\theta}=-10.5 k J$ and $\Delta S^{\theta}=-44.1 J K^{-1}$
Calculate $\Delta G^{\theta}$ for the reaction, and predict whether the reaction can occur spontaneously or not.
58. The equilibrium constant for a reaction is 10 . What will be the value of $\Delta G$ ?
$R=8.314 J K^{-1} \mathrm{~mol}^{-1}, T=300 K$.

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59. State the first law of thermodynamics. Explain its mathematical notation.

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60. State the second law of thermodynamics in any two
ways.

# 61. Explain spontaneity of a process in terms of Gibbs 

 energy.
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62. Explain spontaneity of a process in terms of Gibbs energy.

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## Long Answer Questions

1. State and explain the Hess's law of constant heat summation.

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2. Explain the experiment to determine the internal energy change of a chemical reaction.

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3. Explain the experiment to determine the enthalpy change of a chemical reaction.
4. Explain the spontaneity of a reaction in terms of enthalpy change, entropy change and Gibbs energy change.

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## Additional Questions Answers

1. When no heat is absorbed by the system them from the
surroundings, but work $(w)$ is done on the system, the change in internal energy of the system is given as
2. No work is done on the system, but heat (q) is taken out from the system by the surroundings. What type of wall does the system have?

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3. Express the change in internal energy of a system when
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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4. Two litres of an ideal gas at a pressure of 10 atm expands isothermally into a vacuum until its total volume is 20 litres. How much heat is absorbed and how much work is done in the expansion?

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5. If the ideal gas given in the problem 45 expands against constant external pressure of 1 atm what is the $q$ value?

## D Watch Video Solution

6. Consider the same expansion, to a final volume of 10 litres conducted reversibly.

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