



CHEMISTRY

BOOKS - A N EXCEL PUBLICATION

THERMODYNAMICS

Question Bank

1. Calculate the change in internal energy of a system which absorbs 100 J of heat and does 215 J of work.



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2. Calculate the amount of work done when 1 mole of a gas expands from a volume of 1 litre to a volume of 5 litres against the constant external pressure of 1 atmosphere (1 litre atmosphere = 101.3J)



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3. The heat of combustion of methane at constant volume measured in a bomb calorimeter at 298K is found to be $-885389 \text{ J mol}^{-1}$, Calculate the value of heat of combustion at constant pressure.



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4. Molar enthalpy change for vapourisation of 1 mol of water at $100^{\circ}C$ and 1 bar pressure is 41 kJmol^{-1} . Assuming water vapour to be a perfect gas, calculate the internal energy change when (i) 1 mol of water is vapourised at 1 bar pressure and $100^{\circ}C$

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5. Molar enthalpy change for vapourisation of 1 mol of water at $100^{\circ}C$ and 1 bar pressure is 41 kJmol^{-1} . Assuming water vapour to be a perfect gas, calculate the internal energy change when (ii) 1 mol of water is converted to ice

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6. A cylinder of cooking gas contains 14.0 kg of butane. If a family needs 20,000kJ of energy per day for cooking, how long will the cylinder last? The enthalpy of combustion of butane is $-2658 \text{ kJ mol}^{-1}$

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7. Calculate the standard enthalpy change for the reaction $CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(l)$ Given that the standard enthalpies of formation of $CH_4(g)$, $CO_2(g)$, and $H_2O(l)$ are $-74.8 \text{ kJ mol}^{-1}$, $-393.5 \text{ kJ mol}^{-1}$ and $-285.8 \text{ kJ mol}^{-1}$ respectively.

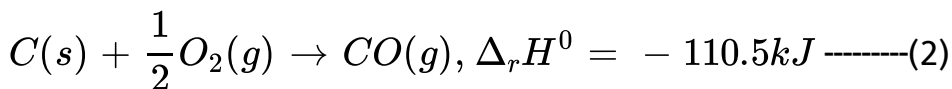
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8. A glass vessel after washing contains 54 g of water in it. How much heat must be supplied to evaporate this water? Standard enthalpy of vapourisation of water is $40.79 \text{ kJ mol}^{-1}$.

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9. Calculate the enthalpy of the reaction

$CO(g) + \frac{1}{2}O_2(g) \rightarrow CO_2(g)$ from the following data



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10. a) The enthalpy of combustion of $CH_4(g)$, $C_{graphite}$ and $H_2(g)$ at 298 K are $-890.3 \text{ kJ mol}^{-1}$, $-393.5 \text{ kJ mol}^{-1}$ and $-285.8 \text{ kJ mol}^{-1}$ respectively. Calculate the enthalpy of formation of $CH_4(g)$.

b) Match the following:

$W = -\Delta u$	- Enthalpy change
$\Delta u = 0$	- Universal gas constant
$C_p - C_v$	- Adiabatic process
q_p	- Isothermal process
	- Cyclic process

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11. Calculate ΔH_r^θ for reaction $H_2(g) + Br_2(g) \rightarrow 2HBr(g)$ given that the bond energies of H-H, Br-Br and H-Br are 435, 192 and 364 kJ mol^{-1} respectively.

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12. Enthalpy and entropy changes of a reaction are $40.63 \text{ kJ mol}^{-1}$ and 108.8 JK^{-1} . Predict the feasibility of the reaction at 27°C .

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13. ΔH and ΔS for the reaction $\text{Ag}_2\text{O}(s) \rightleftharpoons 2\text{Ag}(s) + \frac{1}{2}\text{O}_2(g)$ are $30.56 \text{ kJ mol}^{-1}$ and 66.0 JK^{-1} respectively. Calculate the temperature at which the reaction would be at equilibrium. Also predict the direction of the reaction above this temperature.

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14. 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?

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15. Express the change in internal energy of a system when (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?

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16. 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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17. Two litres of an ideal gas at a pressure of 10 atm expands isothermally 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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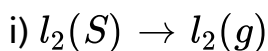
18. Consider the same expansion, but this time against a constant external pressure of 1 atm.

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19. Predict in which of the following, entropy increases:(i) A liquid crystallizes into a solid.

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20. a) Predict whether entropy increases or decreases in the following changes:



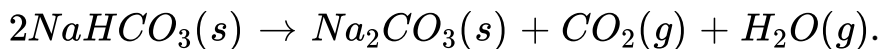
ii) Temperature of a crystalline solid is raised from 0 K and 115 K.

iii) Freezing of water

b) Calculate the enthalpy of combustion of methane. Given that standard enthalpies of formation of CH_4 , CO_2 and H_2O are -75.2 , -394 and -285.6 kJ/mol respectively.

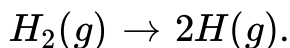
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21. Predict in which of the following, entropy increases:(iii)



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22. Predict in which of the following, entropy increases:(iii)

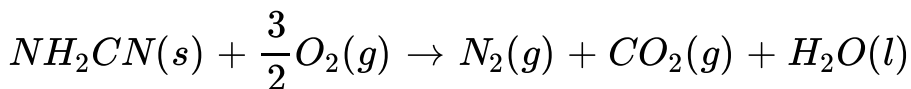


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23. In a process, 701 J of heat is absorbed by a system and 394 J of work is done by the system. What is the change in internal energy for the process?

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24. The reaction of cyanamide, $NH_2CN(s)$ with O_2 was carried out in a bomb calorimeter and ΔU was found to be $-742.7 \text{ kJmol}^{-1}$ at 298 K. Calculate enthalpy change for the reaction at 298K.



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25. Calculate the number of KJ of heat necessary to raise the temperatures of 60g of Al from $35^{\circ}C$ to $55^{\circ}C$. Molar heat capacity of Al is $24 \text{ J mol}^{-1} \text{ K}^{-1}$

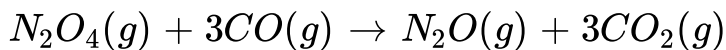
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26. Enthalpy of combustion of C to CO_2 is $-393.5 \text{ KJ mol}^{-1}$. Calculate the heat released upon formation of 35.2 g of CO_2 from carbon and oxygen gas.

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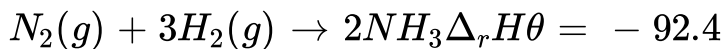
27. Enthalpies of formation of $CO(g)$, $CO_2(g)$, $N_2O(g)$ and $N_2O_4(g)$ are -110 , -393.81 and 9.7 kJ mol^{-1} respectively. Find

the value of $\Delta_r H$ from the reaction



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28. Given that

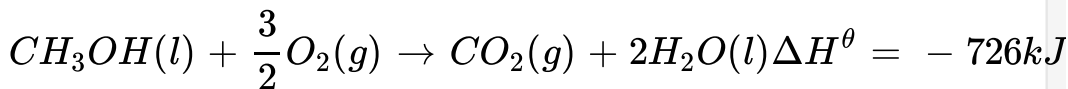


What is the standard enthalpy of formation of NH_3 gas?

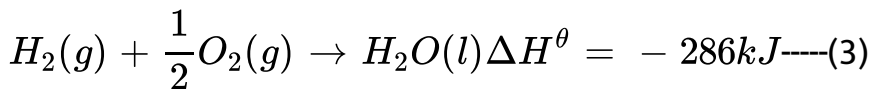
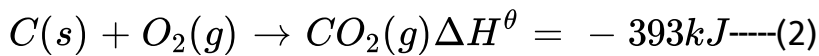
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29. Calculate the standard enthalpy of formation of CH_3OH

(l) from the following data



----(1)



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

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31. For the reaction $2A+B \rightarrow C$ at 298 K, $\Delta H = 400kJmol^{-1}$ and $\Delta S = 0.2kJk^{-1}mol^{-1}$. At what temperature will the reaction become spontaneous considering ΔH and ΔS to be constant over the temperature range.

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32. For the reaction, $2\text{Cl}(g) \rightarrow \text{Cl}_2(g)$ what are the signs of ΔH and ΔS ?

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33. For the reaction $2\text{A}(g)+\text{B}(g) \rightarrow 2\text{D}(g)$, $\Delta U^\theta = -10.5 \text{ kJ}$ and $\Delta S^\theta = -44.1 \text{ J K}^{-1}$ Calculate ΔG^θ for the reaction and predict whether the reaction may occur spontaneously.

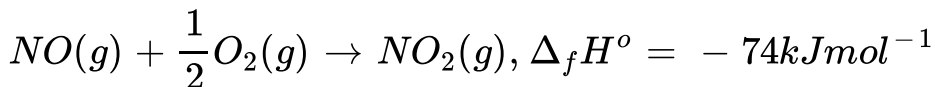
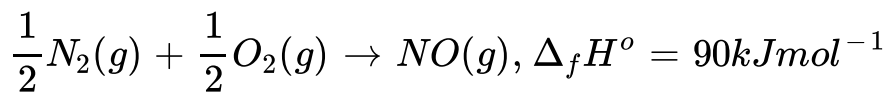
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34. The equilibrium constant for a reaction is 10. What will be the value of ΔG^θ at 300 K

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35. Comment on the thermodynamic stability of $\text{NO}(g)$ and

$\text{NO}_2(g)$ given :



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36. Calculate the entropy change in surrounding when 1.0 mol of $\text{H}_2\text{O}(l)$ is formed under standard conditions. Given

$$\Delta_f H^\circ = -286\text{kJmol}^{-1}.$$

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37. A system in thermodynamics refers to that part of the universe in which observations are made.(a) What do you

mean by an isolated system? Give an example.

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38. Distinguish between intensive and extensive properties.

Give two examples for each.

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39. Define lattice enthalpy

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40. Lattice enthalpy of an ionic salt is a factor that determines its stability. Draw the Born-Haber cycle for the calculation of

lattice enthalpy of the ionic crystal NaCl.

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41. What is meant by a change in Gibbs energy of a system?

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42. The spontaneity of a process is expressed in terms of a change in Gibbs energy.

- a) What is meant by a change in Gibbs energy of a system?
- b) How is it related to the enthalpy and entropy of a system?
- c) How is it useful in predicting the feasibility of a process?

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43. The spontaneity of a process is expressed in terms of a change in Gibbs energy.

- a) What is meant by a change in Gibbs energy of a system?
- b) How is it related to the enthalpy and entropy of a system?
- c) How is it useful in predicting the feasibility of a process?

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44. A spontaneous process is an irreversible process and may only be reversed by some external agency.

- a) Decrease in enthalpy is the only criterion for spontaneity. Do you agree? Why?
- b) Calculate the work done for the reversible isothermal expansion of 1 mole of an ideal gas at 27°C , from a volume of 10 dm^3 to a volume of 20 dm^3 .

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45. Calculate the work done for the reversible isothermal expansion of 1 mole of an ideal gas at $27^{\circ}C$, from a volume of 10 dm^3 to a volume of 20 dm^3



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46. Thermodynamics deals with energy changes of macroscopic system.

a) Consider a chemical reaction taking place in a closed insulated vessel. To which type of thermodynamic system does it belong?

b) State the first law of thermodynamics.

c) 3 mol of an ideal gas at 1.5 atm and $25^{\circ}C$ expands isothermally in a reversible manner to twice its original

volume against an external pressure of 1 atm. Calculate the work done.

$$[R = 8.314JK^{-1}mol^{-1}]$$



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47. Thermodynamics deals with energy changes of macroscopic system. State the first law thermodynamics?



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48. Thermodynamics deals with energy changes of macroscopic system.

a) Consider a chemical reaction taking place in a closed insulated vessel. To which type of thermodynamic system does it belong?

b) State the first law of thermodynamics.

c) 3 mol of an ideal gas at 1.5 atm and 25°C expands isothermally in a reversible manner to twice its original volume against an external pressure of 1 atm. Calculate the work done.

$$[R = 8.314 \text{ JK}^{-1} \text{ mol}^{-1}]$$

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49. Lattice enthalpy of an ionic salt is a factor that determine its stability.

a) Define the lattice enthalpy.

b) Draw the Born-Haber cycle for the calculation of lattice enthalpy of the ionic crystal NaCl.

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50. Enthalpy and entropy changes of a reaction are $40.63 \text{ kJ mol}^{-1}$ and 108.8 JK^{-1} . Predict the feasibility of the reaction at 27°C .

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51. Explain the Hess's law of constant heat summation

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52. Draw the enthalpy diagram for exothermic and endothermic reaction.

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53. Give the criteria for spontaneity of a process in terms of free energy change (ΔG)

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54. Most of the naturally occurring processes are spontaneous.

a) Give the criteria for spontaneity of a process in terms of free energy change (ΔG)

b) Exothermic reactions associated with a decrease in entropy are spontaneous at lower temperatures. Justify on the basis of Gibbs equation.

c) Find the temperature above which the reaction



$Mg_{(s)} + CO_{(g)}$ becomes spontaneous.

(Given ($\Delta_r H^\theta = 490 \text{ kJ mol}^{-1}$ & $\Delta_r S^\theta = 198 \text{ JK mol}^{-1}$)



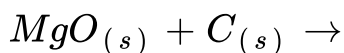
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55. Most of the naturally occurring processes are spontaneous.

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56. a) The enthalpy of combustion of $CH_4(g)$, $C_{graphite}$ and $H_2(g)$ at 298 K are $-890.3 \text{ kJ mol}^{-1}$, $-393.5 \text{ kJ mol}^{-1}$ and $-285.8 \text{ kJ mol}^{-1}$ respectively. Calculate the enthalpy of formation of $CH_4(g)$.

b) Match the following:

$W = -\Delta u$	- Enthalpy change
$\Delta u = 0$	- Universal gas constant
$C_p - C_v$	- Adiabatic process
q_p	- Isothermal process
	- Cyclic process

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57. a) For the oxidation of iron $4 Fe_{(s)} + 3O_{2(g)} \rightarrow 2Fe_2O_{3(s)}$, entropy change is $-549.4 \text{ JK}^{-1} \text{ mol}^{-1}$ at 298 K. In spite of the negative entropy change of this reaction, why is the reaction spontaneous?

(ΔH_r^0 for the reaction is $-1648 \times 10^3 \text{ J mol}^{-1}$).

b) Write the difference between extensive and intensive properties. Give one example of each.

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58. Distinguish between extensive and intensive properties.

Give two example of each.

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59. Classify the following into intensive and extensive properties (i) Internal energy (ii) Density (iii) Heat capacity (iv)

Temperature

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60. a) Classify the following into intensive and extensive properties.

i) Internal energy ii) Density

iii) Heat Capacity iv) Temperature

b) Calculate the standard free energy change (ΔG^θ) for the conversion of oxygen to ozone $\frac{3}{2}O_{3(g)} \rightarrow O_{3(g)}$ at 298 K if the equilibrium constant for the conversion is 2.47×10^{-29} .

(Given $R = 8.314 \text{ JK}^{-1}\text{mol}^{-1}$)



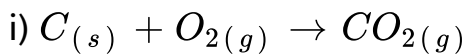
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61. The enthalpy change in a process is the same, whether the process is carried out in a single step or in several steps.

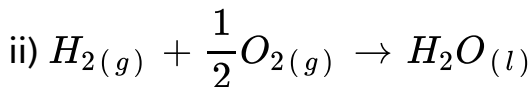
a) Identify the law stated here.

b) Calculate the enthalpy of formation of CH_4 from the

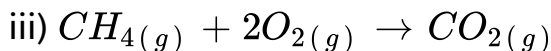
following data :



$$\Delta H = -393.7 \text{ kJ/mol}$$



$$\Delta H = -285.8 \text{ kJ/mol}$$



$$\Delta H = -890.4 \text{ kJ/mol}$$

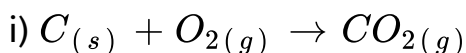


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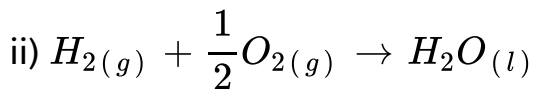
62. The enthalpy change in a process is the same, whether the process is carried out in a single step or in several steps.

a) Identify the law stated here.

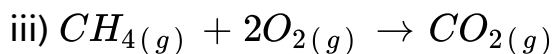
b) Calculate the enthalpy of formation of CH_4 from the following data :



$$\Delta H = -393.7\text{kJ/mol}$$



$$\Delta H = -285.8\text{kJ/mol}$$



$$\Delta H = -890.4\text{kJ/mol}$$



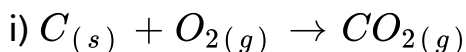
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63. The enthalpy change in a process is the same, whether the process is carried out in a single step or in several steps.

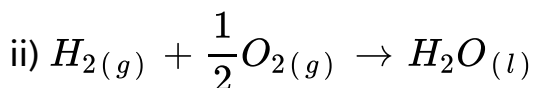
a) Identify the law stated here.

b) Calculate the enthalpy of formation of CH_4 from the

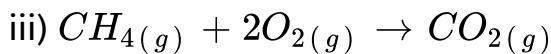
following data :



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$$\Delta H = -890.4\text{kJ/mol}$$

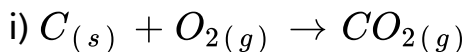


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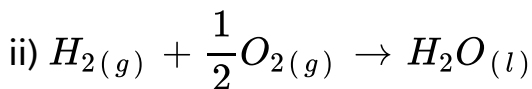
64. The enthalpy change in a process is the same, whether the process is carried out in a single step or in several steps.

a) Identify the law stated here.

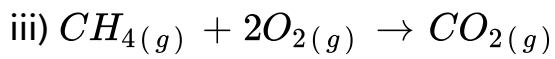
b) Calculate the enthalpy of formation of CH_4 from the following data :



$$\Delta H = -393.7\text{kJ/mol}$$



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$\Delta H = -890.4 \text{ kJ/mol}$



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