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 caloriemeter at 298K is found to be -885389 Jmol -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 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 kJ mol^-1, -393.5 kJ mol^-1 and $-285.8kJ$ mol^-1` respectively.

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8. A glass vassel after washing contain 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 kJ mol^{-1} .

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9. Calcutae the enthalpy of the reaction

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

$C(s) + O_2(g) \rightarrow CO_2(g), \Delta_r H^0 = -394.7kJ$---------(1)

$C(s) + \frac{1}{2}O_2(g) \rightarrow CO(g), \Delta_r H^0 = -110.5kJ$ ---------(2)

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10. a) The enthalpy of combustion of $CH_{4(g)}$, $C_{graphte}$ and $H_{2(g)}$ at 298 K are - 890.3 kJ mol^{-1}, - 393.5 kJ mol^{-1} and -285.8 kJ mol^{-1} respectively. Calculate the enthalpy of formation of $CH_{4(g)}$.

b) Match the following:

$W = -\Delta u$	-	Enthaly change
$\Delta u = O$	-	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 kJmol^{-1} respectively.

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

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13. ΔH and ΔS for the reaction $Ag_2O(s) \Leftrightarrow 2Ag(s) + \frac{1}{2}O_2(g)$ are 30.56 kJmol^{-1} and $66.0JK^{-1}$ 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 exapansion, 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:

i) $l_2(S) \rightarrow l_2(g)$

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

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22. Predict in which of the following, entropy increases:(iii) $H_2(g) \rightarrow 2H(g)$.

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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 kJmol^{-1} at 298 K. Calculate enthalpy change for the reaction at 298K.

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

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25. Calculate the nuber 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 J $mol^{-1}K^{-1}$

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

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27. Ethalpies 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. Find

the value of $\Delta_r H$from the reaction

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

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28. Given that

$N_2(g) + 3H_2(g) \rightarrow 2NH_3 \Delta_r H\theta = -92.4$

What is the sandard 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

$CH_3OH(l) + \frac{3}{2}O_2(g) \rightarrow CO_2(g) + 2H_2O(l) \Delta H^\theta = -726kJ$

-----(1)

$C(s) + O_2(g) \rightarrow CO_2(g) \Delta H^{\theta} = -393kJ$-----(2)

$H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l) \Delta H^{\theta} = -286kJ$-----(3)

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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 be reaction become spontaneous considering ΔH and ΔS to be constant over the temperature range.

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

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33. For the reaction 2A(g)+B(g) $\rightarrow 2D(g)$, ΔU^{θ}=-10.5 kJ and $\Delta S^{\theta} = -44.1 Jk^{-1}$ 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 NO(g) and $NO_2(g)$ given :

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

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

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36. Calculate the entropy change in surrounding when 1.0 mol of $H_2O(l)$ is formed under standard conditions. Given $\Delta_f H^o = -286kJmol^{-1}$.

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37. A system in themodynamics 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 detemines 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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44. A spontaneous process is an irreversible process and may only by reserved by some external agency.

a) Decrese 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^oC , 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 $25^{o} C$ expands isothermally in a reversible manner to twice its original

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

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

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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 kJ mol^-1 and $108.8JK^{-1}$. Predict the feasibility of the reaction at $27^\circ C$.

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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 sponaneous at lower temperatures. Justify on the basis of Gibbs equation.

c) Find the temperature above which the reactin

$MgO_{(s)} + C_{(s)} \rightarrow$

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

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

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56. a) The enthalpy of combustion of $CH_{4(g)}$, $C_{graphte}$ and $H_{2(g)}$ at 298 K are - 890.3 kJ mol^{-1}, - 393.5 kJ mol^{-1} and -285.8 kJ mol^{-1} respectively. Calculate the enthalpy of formation of $CH_{4(g)}$.

b) Match the following:

$W = -\Delta u$	-	Enthaly change
$\Delta u = O$	-	Universal gas constant
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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 $-549.4 JK^{-1}mol^{-1}$ at 298 K. Inspite of the negative entropy change of this reaction, why is the reaction spontaneous?

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

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) Inernal 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 $JK^{-1}mol^{-1}$)

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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 inseveral steps.

a) Identify tha law stated here.

b) Calculate the enthalpy of formation of CH_4 from the

following data :

i) $C_{(s)} + O_{2(g)} \rightarrow CO_{2(g)}$

ΔH = -393.7kJ/mol

ii) $H_{2(g)} + \frac{1}{2}O_{2(g)} \rightarrow H_2O_{(l)}$

ΔH = -285.8kJ/mol

iii) $CH_{4(g)} + 2O_{2(g)} \rightarrow CO_{2(g)}$

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