	INDIAN SCHOOL AL WADI AL KABIR	
Class: XI	**DEPARTMENT OF SCIENCE 2025– 2026** **SUBJECT: CHEMISTRY**	**Date: 25/01/2026**
Worksheet No: 08	**CHAPTER 5: THERMODYNAMICS**	**Note:** **A4 FILE FORMAT**
CLASS & SEC:	**NAME OF THE STUDENT:**	**ROLL NO.**

I. MULTIPLE CHOICE QUESTIONS (1M)

1. Standard enthalpy of formation of an element in its most stable form is

A. 1 kJ mol^{-1}
B. −1 kJ mol^{-1}
C. Zero
D. Infinite

2. Entropy of a perfectly crystalline substance at absolute zero is
A. Maximum
B. Minimum
C. Zero
D. Infinite

3. For an isolated system, the change in internal energy (ΔU) is
A. Positive
B. Negative
C. Zero
D. Infinite

4. The entropy change when 1 mol of ice melts at 273 K ($\Delta H = 6.01$ kJ mol^{-1}) is
A. 0.022 kJ K^{-1}
B. 6.01 kJ K^{-1}
C. 273 kJ K^{-1}
D. 1 kJ K^{-1}

5. If $\Delta U = 40$ kJ and the work done by the system is 10 kJ, the heat absorbed by the system is
A. 30 kJ

B. 40 kJ
C. 50 kJ
D. −50 kJ

6. Which of the following reactions will be spontaneous at all temperatures?
A. $\Delta H > 0, \Delta S > 0$
B. $\Delta H < 0, \Delta S < 0$
C. $\Delta H < 0, \Delta S > 0$
D. $\Delta H > 0, \Delta S < 0$

7. The entropy change is maximum for
A. Solid → liquid
B. Liquid → gas
C. Gas → liquid
D. Solid → gas

8. Which of the following statements about entropy is FALSE?
A. Entropy increases with temperature
B. The entropy change of the universe is zero for a spontaneous process
C. Entropy is a state function
D. Entropy is a measure of disorder

9. The condition for maximum work obtained from a process is
A. Reversible
B. Isothermal
C. Adiabatic
D. Irreversible

10. The equations representing the combustion of Carbon and Carbon monoxide are
$C_{(s)} + O_{2(g)} \longrightarrow CO_{2(g)}\ \Delta H = -394$ kJ/mol
$CO_{(g)} + \frac{1}{2} O_2(g) \longrightarrow CO_{2(g)}\ \Delta H = -284.5$ kJ/mol
The heat of formation of 1 mol of CO(g) is:
A. -109.5 kJ/mol
B. +109.5 kJ/mol
C. +180 kJ/mol
D. +100 kJ/mol

<u>*Assertion Reason* type questions</u>

Two statements are given - one labelled as **Assertion (A)** and the other labelled as **Reason (R)**. Select the correct answer to these questions from the codes
a. If both *Assertion* and *Reason* are correct and *Reason* is the correct explanation of *Assertion*.
b. If both *Assertion* and *Reason* are correct, but *Reason* is not the correct explanation of *Assertion*.
c. If *the assertion* is correct and *the reason* is wrong.
d. If *the assertion* is wrong and *the reason* is correct.

11. **Assertion (A):** Enthalpy of vapourisation is greater than enthalpy of fusion**.**
Reason (R): Intermolecular forces are completely overcome during vapourisation.

12. **Assertion(A):** A spontaneous process is an irreversible process and may be reversed by some external agency
Reason (R): Decrease in enthalpy is a contributory factor for spontaneity.

13. **Assertion(A)**: The bond enthalpy of a C-H bond in CH_4 is nearly 416 $kJmol^{-1}$.
Reason (R): First, second, third and fourth C-H bonds in CH_4 have the same bond enthalpy.

14. **Assertion(A):** The enthalpy of atomization is always positive.
Reason(R): Energy is required to break the bonds.

15. **Assertion(A):** Many endothermic reactions, which are non-spontaneous at room temperature become spontaneous on increasing the temperature.
Reason(R): Endothermic reactions become spontaneous at high temperatures if ΔS is +ve and $T\Delta S > \Delta H$

II. VERY SHORT ANSWER TYPE QUESTIONS(2M)

16. State the first law of thermodynamics. Write the mathematical expression for the first law of thermodynamics.

17**.** A. Define the term enthalpy of a reaction.
B. The enthalpy change for a reaction $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$ is -4.0 kJ mol^{-1} at 300K. Calculate the value of ΔU. ($R = 8.314$ J K^{-1} mol^{-1})

18**.** Barium carbonate decomposes in an endothermic reaction as follows:
$BaCO_3(s) \rightarrow BaO(s) + CO_2(g)$
What are the signs of entropy of the system and entropy of the surroundings? Explain.

19. For a reaction, $CH_3COOH\ (l) + 2O_2\ (g) \rightarrow 2CO_2(g) + 2H_2O\ (l)$, $\Delta H = -867$ $KJmol^{-1}$.
If the value of Δ_fH of CO_2 is -393.5 kJ mol^{-1} and Δ_fH of H_2O is -286 kJ mol^{-1}. Calculate the enthalpy of formation of ethanoic acid

20. Combustion of 1 mol of diborane(B_2H_6) produces 1941 KJ of heat according to the equation
$B_2H_6\ (g) + 3O_2\ (g) \rightarrow B_2O_3\ (g) + 3H_2O\ (g)$.
Calculate the heat of formation of $B_2H_6(g)$ if Δ_fH of H_2O (g) and B_2O_3 (g) are -286 and -1183.7 $kJmol^{-1}$ respectively.

III. SHORT ANSWER TYPE QUESTIONS (3M)

21. An ideal gas undergoes free expansion into a vacuum. No heat or work is exchanged. Determine ΔU, ΔH, and ΔS.

22. Calculate ΔH for the synthesis of diborane from its elements according to the equation

$2B(s) + 3H_2(g) \rightarrow B_2H_6(g)$ using the following data

$2B(s) + 3/2O_2 \rightarrow B_2O_3(s)$ $\Delta H = -1273\ KJmol^{-1}$

$B_2H_6(g) + 3O_2(g) \rightarrow B_2O_3(s) + 3H_2O$ $\Delta H = -2035\ KJmol^{-1}$

$H_2(g) + 1/2O_2(g) \rightarrow H_2O(l)$ $\Delta H = -285.5\ KJmol^{-1}$

23. Predict in which of the following, entropy increases/decreases:
    a) Sublimation of dry ice into CO_2 gas.
    b) Temperature of a crystalline solid is raised from 10 K to 115 K.
    c) $4Fe(s) + 3O_2(g) \rightarrow 2Fe_2O_3(s)$

24. A. Which among the following are extensive properties?
    Mass, Internal energy,Pressure,Enthalpy, Entropy and Free energy
    B. State Hess's law of constant heat summation.
    C. Write the second law of Thermodynamics

25. A. State the third law of thermodynamics.
    B. What are extensive properties?
    C. Define the term specific heat capacity.

IV. CASE STUDY BASED QUESTIONS (4M)

26. A chemical reaction is studied under standard conditions. The enthalpy change for the reaction is found to be $-100\ kJ\ mol^{-1}$, while the entropy change is $-200\ J\ mol^{-1}\ K^{-1}$. The feasibility of the reaction depends on temperature and can be predicted using the Gibbs free energy change equation. Based on the above passage, answer the following questions.

A. Write the expression for Gibbs free energy.

B. At what condition will the reaction be at equilibrium?

C. Calculate the Gibbs free energy change (ΔG) at 300 K.

V. LONG ANSWER TYPE QUESTIONS (5M)

27. A. Complete the following table to express the relationship between spontaneity and temperature.

	ΔH<0	ΔH>0
ΔS>0		
ΔS<0		

B. 100 g of water is heated from 25°C to 75°C. Calculate heat absorbed. (Specific heat = $4.18\ J\ g^{-1}\ K^{-1}$)

C. $2A(g) + B(g) \rightarrow C(g)$ $\Delta H = -10.5\ kJmol^{-1}$ and $\Delta S = 44.1\ JK^{-1}mol^{-1}$.
Determine the temperature at which ΔG becomes equal to zero. Predict the nature of this reaction at this temperature, and also above and below this temperature

Answer Key

Q. No.	Answer
I.	**MULTIPLE CHOICE QUESTIONS (1M)**
1	C. Zero
2	C. Zero
3	C. Zero
4	A. 0.022 kJ K^{-1}
5	C. 50 kJ
6	C. $\Delta H < 0, \Delta S > 0$
7	D. Solid → gas
8	B. The entropy change of the universe is zero for a spontaneous process
9	A. Reversible
10	A. -109.5 kJ/mol
11	a. If both *Assertion* and *Reason* are correct, and *Reason* is the correct explanation of *Assertion*.
12	b. If both *Assertion* and *Reason* are correct, but *Reason* is not the correct explanation of *Assertion*.
13	c. If *the assertion* is correct and *the reason* is wrong.
14	a. If both *Assertion* and *Reason* are correct, and *Reason* is the correct explanation of *Assertion*.
15	a. If both *Assertion* and *Reason* are correct, and *Reason* is the correct explanation of *Assertion*.
II	**VERY SHORT ANSWER TYPE QUESTIONS**
16	First law- The energy of an isolated system is constant. $\Delta U = q + W$, ΔU – change in internal energy q- Heat W- work done
17	The standard enthalpy of reaction is the enthalpy change for a reaction when all the participating substances are in their standard states. $\Delta n_g = 2 - (1 + 3) = -2$ $\Delta U = \Delta H - \Delta n_g RT$ $\Delta U = -4000 - (-2 \times 8.314 \times 300)$ $\Delta U = -4000 + 4988.4 = 988.4 \text{ J mol}^{-1}$
18	Entropy of the system is positive (as there is a change from solid to gas) Entropy of the surrounding is negative

	Since the reaction is endothermic, the system absorbs heat from the surroundings. This results in loss of heat of the surrounding. Since heat is transferred from the surroundings into the system, the kinetic energy and thermal motion of the particles in the surroundings decrease. This loss of heat results in a **negative.**
19	$\Delta H_{rxn} = [2\Delta_f H(CO_2) + 2\Delta_f H(H_2O)] - [\Delta_f H(CH_3COOH) + 2\Delta_f H(O_2)]$ $-867 = [2(-393.5) + 2(-286)] - [\Delta_f H(CH_3COOH) + 0]$ $-867 = [-787 - 572] - \Delta_f H(CH_3COOH)$ $-867 = -1359 - \Delta_f H(CH_3COOH)$ $\Delta_f H(CH_3COOH) = -1359 + 867 = -492\,J$
20	$\Delta H_{rxn} = [\Delta_f H(B_2O_3(g)) + 3\Delta_f H(H_2O(g))] - [\Delta_f H(B_2H_6(g)) + 3\Delta_f H(O_2(g))]$ $-1941 = [-1183.7 + 3(-286)] - [\Delta_f H(B_2H_6) + 3(0)]$ $\Delta_f H(B_2H_6) = -2041.7 + 1941$ $\Delta_f H(B_2H_6) = -100.7\ kJ/mol$
III	**SHORT ANSWER TYPE QUESTIONS**
21	Free expansion → isolated system q=0,w=0 ΔU = 0 (ideal gas, depends only on T) ΔH = 0 (ΔH = ΔU + Δng RT, no T change) ΔS > 0 (entropy increases due to increased randomness)
22	$2B(s) + \frac{3}{2}O_2(g) \rightarrow B_2O_3(s) \quad \Delta H_1 = -1273$ kJ/mol -(1) Reverse reaction 2 $B_2O_3(s) + 3H_2O(l) \rightarrow B_2H_6(g) + 3O_2(g) \quad \Delta H_2 = +2035$ kJ/mol -(4) Multiply reaction 3 by 3 $3(H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l)) \rightarrow 3H_2(g) + \frac{3}{2}O_2(g) \rightarrow 3H_2O(l)$ 3x-285.5= - 856.5 kJmol^{-1} -(5) Add reactions (1), (4) and (5); ΔH = -94.5 kJmol^{-1}
23	(a) Entropy increases (b) Entropy increases (c) Entropy decreases
24	A. Mass, Internal energy, Enthalpy, Entropy and Free energy B. If a reaction takes place in several steps then its standard reaction enthalpy is the sum of the standard enthalpies of the intermediate reactions into which the overall reaction may be divided at the same temperature. C. The state of entropy of the entire universe, as an isolated system, will always increase over time.

<table>
<tr><td>25</td><td>A. The entropy of a perfectly ordered, pure crystalline substance approaches zero as its temperature approaches absolute zero.

B. An extensive property is a property whose value depends on the quantity or size of matter present in the system.
C. Specific heat, also called specific heat capacity, is the quantity of heat required to raise the temperature of one unit mass of a substance by one degree Celsius (or one kelvin).</td></tr>
<tr><td>IV</td><td>PASSAGE-BASED QUESTIONS</td></tr>
<tr><td>26</td><td>A. ΔG=ΔH - TΔS (explain the terms)
B. When ΔG=0
C. ΔG=ΔH - TΔS
= -100000 – (300x-200)
= -100000+60000 = -40000 $Jmol^{-1}$</td></tr>
<tr><td>V</td><td>LONG ANSWER TYPE QUESTION</td></tr>
<tr><td>27</td><td>A.
<table>
<tr><td></td><td>ΔH<0</td><td>ΔH>0</td></tr>
<tr><td>ΔS>0</td><td>Spontaneous at all temperatures; ΔG<0</td><td>Spontaneous at high temperature when TΔS is large.</td></tr>
<tr><td>ΔS<0</td><td>Spontaneous at low temperature when TΔS is small.</td><td>Non Spontaneous at all temperatures; ΔG>0</td></tr>
</table>
B. q = CΔT
= 4.18 x 50
= 209 Jg^{-1}
For 100 g, q= 20900J
C.
$$\Delta G = \Delta H - T\Delta S$$
At equilibrium, $\Delta G = 0$. Therefore:
$$0 = \Delta H - T\Delta S \Longrightarrow T = \frac{\Delta H}{\Delta S}$$
$$T = \frac{-10500\ \text{J/mol}}{44.1\ \text{J/K} \cdot \text{mol}}$$
$$T \approx -238.1\ \text{K}$$
Spontaneous at all temperatures.</td></tr>
</table>

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