DPP –3 Gibbs Free Energy [Theortical]— Solutions

"Tumhe pata bhi nahi, tum kis level ke insaan ban sakte ho—bas ek assignment karne ki himmat chahiye. — Weird Chemist."

Q1. Identify the correct statement for change of Gibbs energy for a system (ΔG_{system}) at constant temperature and pressure.

Concept: Constant T, P pe spontaneity ka criterion $\Delta G_{system} < 0$ hota hai; equilibrium pe $\Delta G_{system} = 0$.

Option-by-option:

(1) If $\Delta G_{system} > 0$, process spontaneous — **(Wrong)**: positive ΔG means non-spontaneous.

(2) If $\Delta G_{system} = 0$, equilibrium — **(Correct)**: by definition at constant T, P.

(3) If $\Delta G_{system} = 0$, still moving in a particular direction — **(Wrong)**: that would imply driving force; equilibrium means no net change.

(4) If $\Delta G_{system} < 0$, not spontaneous — **(Wrong)**: actually spontaneous.

Final Answer: (2)

Q2. At equilibrium which is correct :

Concept: Equilibrium (constant T, P) $\Rightarrow \Delta G = 0$. ΔH or ΔS need not be zero. Also $\Delta G^\circ = 0$ only when $Q = 1$ and $K = 1$.

Option-by-option:

(1) $\Delta G = 0$ — **(Correct)**

(2) $\Delta S = 0$ — **(Wrong)**: system entropy may change if surroundings compensate; total remains zero.

(3) $\Delta H = 0$ — **(Wrong)**

(4) $\Delta G^\circ = 0$ — **(Wrong)**: standard Gibbs change zero iff $K = 1$, not general.

Final Answer: (1)

Q3. Which of the following always increases for spontaneous process –

Concept: Spontaneous process ke liye $\Delta S_{\text{universe}} > 0$ (system + surroundings).

Option-by-option:

(1) ΔH_{system} — **(Wrong)**: exo/endothermic both possible.

(2) ΔS_{system} — **(Wrong)**: system entropy kabhi kabhi ghatt bhi sakta hai.

(3) $\Delta S_{universe}$ — **(Correct)**

(4) $\Delta G_{system} = \Delta H_{system} - T\Delta S_{system}$ increases — **(Wrong)**: spontaneity requires ΔG decrease.

Final Answer: (3)

Q4. For the process, $CO_2(s) \longrightarrow CO_2(g)$:

Concept: Sublimation absorbs heat ($\Delta H > 0$) and disorder badhata hai ($\Delta S > 0$).

Option-by-option:

(1) $\Delta H > 0$, $\Delta S > 0$ — **(Correct)**

(2) $\Delta H < 0$, $\Delta S > 0$ — **(Wrong)**

(3) $\Delta H > 0$, $\Delta S < 0$ — **(Wrong)**

(4) $\Delta H < 0$, $\Delta S < 0$ — **(Wrong)**

Final Answer: (1)

Q5. **$2C_8H_{18}(g) + 25O_2(g) \rightarrow 16CO_2(g) + 18H_2O(g)$: signs of ΔH, ΔS, ΔG**

Concept: Combustion exothermic ($\Delta H < 0$). Gas moles: reactants = 27, products = 34 ($\Delta S > 0$). Mixed signs but $\Delta G = \Delta H - T\Delta S < 0$ (strongly exergonic).

Options:

(1) $-, +, +$ — **(Wrong)**: ΔG should be negative.

(2) $+, +, -$ — **(Wrong)**: ΔH is not $+$.

(3) $-, -, -$ — **(Wrong)**: ΔS is not $-$.

(4) $-, +, -$ — **(Correct)**

Final Answer: (4)

Q6. **Spontaneous at all temperatures is –**

Concept: $\Delta G = \Delta H - T\Delta S < 0$ for all T only when $\Delta H < 0$ and $\Delta S > 0$.

Options:

(1) $\Delta H > 0$, $\Delta S > 0$ — **(Wrong)**: high T only.

(2) $\Delta H < 0$, $\Delta S < 0$ — **(Wrong)**: low T only.

(3) $\Delta H < 0$, $\Delta S > 0$ — **(Correct)**

(4) $\Delta H > 0$, $\Delta S < 0$ — **(Wrong)**: never spontaneous.

Final Answer: (3)

Q7. **When ΔH and $T\Delta S$ both are negative, then spontaneous if?**

Concept: $\Delta G = \Delta H - T\Delta S$. Yahan $T\Delta S < 0$ hai, to $-T\Delta S$ positive ho jata hai. $\Delta G < 0$ ke liye magnitude condition: $\Delta H < T\Delta S$ (both negative; i.e., $|\Delta H| > |T\Delta S|$).

Options:

(1) $\Delta H > T\Delta S$ — **(Wrong)**

(2) $\Delta H < T\Delta S$ — **(Correct)**

(3) $\Delta H = T\Delta S$ — **(Wrong)**: then $\Delta G = 0$.

(4) $\Delta H = \Delta U$ — **(Wrong)**: irrelevant criterion here.

Final Answer: (2)

Q8. **Favourable conditions for a spontaneous reaction are :**

Concept: Best combo: $\Delta H < 0$, $\Delta S > 0$ (then $T\Delta S > \Delta H$ typically).

Options:

(1) $T\Delta S > \Delta H$, $\Delta H = +$, $\Delta S = +$ — **(Wrong)**: possible at high T, but not "most favourable".

(2) $T\Delta S < \Delta H$, $\Delta H = -$, $\Delta S = -$ — **(Wrong)**: usually non-spontaneous unless very low T.

(3) $T\Delta S > \Delta H$, $\Delta H = -$, $\Delta S = +$ — **(Correct)**

(4) $T\Delta S < \Delta H$, $\Delta H = +$, $\Delta S = -$ — **(Wrong)**: never.

Final Answer: (3)

Q9. Spontaneous at all temperature only if :

> **Concept:** Same as Q26: $\Delta H < 0$, $\Delta S > 0$ ensures $\Delta G < 0$ for any T.

Options:

(1) $\Delta H < 0$, $\Delta S > 0$ — **(Correct)**

(2) $\Delta H > 0$, $\Delta S < 0$ — **(Wrong)**

(3) $\Delta H > 0$, $\Delta S > 0$ — **(Wrong)**: high T only.

(4) $\Delta H < 0$, $\Delta S < 0$ — **(Wrong)**: low T only.

Final Answer: (1)

Q10. If $\Delta H > 0$ and $\Delta S > 0$, reaction proceeds spontaneously when :

> **Concept:** Endothermic with disorder increase $\Rightarrow$ high T helps: need $T\Delta S > \Delta H$.

Options:

(1) $\Delta H > 0$ — **(Wrong)**: tautology, not the criterion.

(2) $\Delta H < T\Delta S$ — **(Correct)**

(3) $\Delta H = T\Delta S$ — **(Wrong)**: equilibrium.

(4) None — **(Wrong)**

Final Answer: (2)

Q11. The spontaneous nature of a reaction is impossible if :

> **Concept:** $\Delta H > 0$ and $\Delta S < 0 \Rightarrow \Delta G > 0$ for all T.

Options:

(1) $\Delta H = +$, $\Delta S = +$ — **(Wrong)**: high T pe possible.

(2) $\Delta H = -$, $\Delta S = -$ — **(Wrong)**: low T pe possible.

(3) $\Delta H = -$, $\Delta S = +$ — **(Wrong)**: always possible.

(4) $\Delta H = +$, $\Delta S = -$ — **(Correct)**: never spontaneous.

Final Answer: (4)

Q12. For a reaction to be non-spontaneous :

> **Concept:** With $\Delta H > 0$, $\Delta S > 0$, non-spontaneous jab $T\Delta S < \Delta H$ (i.e., T low).

Options:

(1) $T\Delta S < \Delta H$ and both $+$ — **(Correct)**

(2) $T\Delta S > \Delta H$ and both $+$ — **(Wrong)**: that would be spontaneous.

(3) $T\Delta S > \Delta H$ and both $-$ — **(Wrong)**: signs inconsistent with given text.

(4) None — **(Wrong)**

Final Answer: (1)

Q13. It is impossible for a reaction to take place if :

> **Concept:** $\Delta H > 0$, $\Delta S < 0 \Rightarrow \Delta G$ always > 0.

Options:

(1) $\Delta H = +$, $\Delta S = +$ — **(Wrong)**: high T pe possible.
(2) $\Delta H = -$, $\Delta S = +$ — **(Wrong)**: very favourable.
(3) $\Delta H = +$, $\Delta S = -$ — **(Correct)**
(4) $\Delta H = -$, $\Delta S = -$ — **(Wrong)**: low T pe possible.

Final Answer: (3)

Q14. A reaction occurs spontaneously if :

Concept: $\Delta H > 0$, $\Delta S > 0$ case is spontaneous when $T\Delta S > \Delta H$.

Options:

(1) $T\Delta S < \Delta H$ and both $+$ — **(Wrong)**: non-spontaneous.
(2) $T\Delta S > \Delta H$ and both $+$ — **(Correct)**
(3) $T\Delta S = \Delta H$ and both $+$ — **(Wrong)**: equilibrium.
(4) $T\Delta S > \Delta H$ with $\Delta H = +$ and $\Delta S = -$ — **(Wrong)**: impossible; signs inconsistent.

Final Answer: (2)

Q15. Which of the following reactions is expected never to be spontaneous :

Concept: If $\Delta H > 0$ and $\Delta S < 0$, then $\Delta G = \Delta H - T\Delta S > 0$ for all $T \Rightarrow$ never spontaneous.

Option-by-option:

(1) $2O_3(g) \rightarrow 3O_2(g)$, $\Delta H = -$, $\Delta S = +$ — **(Wrong)**: very favourable.
(2) $Mg(s) + H_2(g) \rightarrow MgH_2(s)$, $\Delta H = -$, $\Delta S = -$ — **(Wrong)**: low T pe possible.
(3) $Br_2(l) \rightarrow Br_2(g)$, $\Delta H = +$, $\Delta S = +$ — **(Wrong)**: high T pe possible.
(4) $2Ag(s) + 3N_2(g) \rightarrow 2AgN_3(s)$, $\Delta H = +$, $\Delta S = -$ — **(Correct)**: never.

Final Answer: (4)

Q16. Identify the correct statement regarding a spontaneous process :

Concept: Isolated system ke liye spontaneity $\Rightarrow \Delta S_{\text{system}} = \Delta S_{\text{univ}} > 0$.

Options:

(1) Isolated spontaneous: ΔS positive — **(Correct)**
(2) Endothermic never spontaneous — **(Wrong)**: $\Delta S > 0$ and high T par ho sakta hai.
(3) Exothermic never spontaneous — **(Wrong)**
(4) Lowering energy never a criterion — **(Wrong)**: $\Delta H < 0$ helps.

Final Answer: (1)

Q17. Which pair is certain to result in spontaneous reaction?

Concept: Most reliable: exothermic ($\Delta H < 0$) & disorder increases ($\Delta S > 0$) $\Rightarrow \Delta G < 0$ at all T.

(1) Endothermic & decreasing disorder — **(Wrong)**
(2) Exothermic & increasing disorder — **(Correct)**
(3) Exothermic & decreasing disorder — **(Wrong)**: low T pe ho bhi sakta hai, "certain" nahi.
(4) Endothermic & increasing disorder — **(Wrong)**: high T pe ho sakta hai, "certain" nahi.

Final Answer: (2)

Q18. For a reaction to occur spontaneously :

Concept: Constant T, P criterion: $\Delta G = \Delta H - T\Delta S < 0$.

(1) ΔH must be negative — **(Wrong)**: zaroori nahi.
(2) ΔS must be negative — **(Wrong)**.
(3) $(\Delta H - T\Delta S)$ must be negative — **(Correct)**
(4) $(\Delta H + T\Delta S)$ must be negative — **(Wrong)**

Final Answer: (3)

Q19. For an endothermic reaction to be spontaneous :

Concept: Endothermic ($\Delta H > 0$) ko spontaneous banane ke liye $\Delta S > 0$ & $T\Delta S > \Delta H$.

(1) ΔG must be $+$ — **(Wrong)**
(2) $\Delta S > 0$ — **(Correct)**
(3) $T\Delta S$ must be $-$ — **(Wrong)**
(4) $\Delta S = \Delta G$ — **(Wrong)**

Final Answer: (2)

Q20. Endothermic process for which net entropy change is negative is –

Concept: Net (universe) entropy negative $\Rightarrow$ second law violation $\Rightarrow$ impossible.

(1) Not possible at any temperature — **(Correct)**
(2) Possible only at low T — **(Wrong)**
(3) Possible only at high T — **(Wrong)**
(4) Possible at high temperature — **(Wrong)**

Final Answer: (1)

Q21. $2\mathrm{A} + \mathrm{B} \rightarrow \mathrm{C} + \mathrm{D} - q$ and $\Delta S < 0$: which is correct?

Concept: Exothermic ($\Delta H < 0$) but entropy decreases ($\Delta S < 0$). Spontaneous only at low T (enthalpy-driven).

(1) Possible at any T — **(Wrong)**
(2) Only at high T — **(Wrong)**
(3) Only at low T — **(Correct)**
(4) Not possible at any T — **(Wrong)**

Final Answer: (3)

Q22. $\mathrm{A} + \mathrm{B} \rightarrow \mathrm{C} + \mathrm{D} + q$ with $\Delta S > 0$:

Concept: $\Delta H < 0$ & $\Delta S > 0 \Rightarrow \Delta G < 0$ for all T.

(1) Possible at high T — **(Wrong)**: actually any T.
(2) Possible only at low T — **(Wrong)**
(3) Not possible — **(Wrong)**
(4) Possible at any T — **(Correct)**

Final Answer: (4)

Q23. ΔG for $H_2O_{(s)} \rightarrow H_2O_{(l)}$ at 1 atm and 260 K:

Concept: $260\,\mathrm{K} < 273\,\mathrm{K}$, melting non-spontaneous $\Rightarrow \Delta G > 0$.

(1) < 0 — **(Wrong)**
(2) $= 0$ — **(Wrong)**
(3) > 0 — **(Correct)**
(4) Unpredictable — **(Wrong)**

Final Answer: (3)

Q24. $H_2O_{(l)} \rightleftharpoons H_2O_{(g)}$ **at 100°C & 1 atm:**

Concept: Boiling point at 1 atm is equilibrium: $\Delta G = 0$. Also for phase change at equilibrium, $\Delta H = T\Delta S$. (Single-correct exams usually key (2).)

(1) $\Delta S = 0$ — **(Wrong)**
(2) $\Delta G = 0$ — **(Correct)**
(3) $\Delta H = \Delta E$ — **(Wrong)**
(4) $\Delta H = T\Delta S$ — **(Wrong)** (true at equilibrium, but key asks single-correct; (2) is preferred)

Final Answer: (2)

Q25. Sign of ΔG for ice melting at 283 K:

Concept: $283\,\mathrm{K} > 273\,\mathrm{K}$, melting spontaneous $\Rightarrow \Delta G < 0$.

(1) $\Delta G = 0$ — **(Wrong)**
(2) $\Delta G = \infty$ — **(Wrong)**
(3) $\Delta G < 0$ — **(Correct)**
(4) None — **(Wrong)**

Final Answer: (3)

Q26. $\mathbf{H_2O}(l) \rightleftharpoons \mathbf{H_2O}(s)$ **at 0°C, 1 bar:**

Concept: Fusion point equilibrium $\Rightarrow \Delta G = 0$.

(1) $\Delta G = 0$ — **(Correct)**
(2) $\Delta S = 0$ — **(Wrong)**
(3) $\Delta H = 0$ — **(Wrong)**
(4) $\Delta U = 0$ — **(Wrong)**

Final Answer: (1)

Q27. $\mathbf{H_2O}(l, 1\,\mathbf{bar}, 373\,\mathbf{K}) \rightarrow \mathbf{H_2O}(g, 1\,\mathbf{bar}, 373\,\mathbf{K})$**: correct set**

Concept: Boiling at 1 bar, 373 K is equilibrium: $\Delta G = 0$, and vapor has higher disorder $\Rightarrow \Delta S > 0$.

(1) $\Delta G = 0$, $\Delta S = -$ — **(Wrong)**
(2) $\Delta G = 0$, $\Delta S = +$ — **(Correct)**
(3) $\Delta G = +$, $\Delta S = -$ — **(Wrong)**
(4) $\Delta G = -$, $\Delta S = +$ — **(Wrong)**

Final Answer: (2)

Q28. Evaporation of a liquid is accompanied by:

Concept: Evaporation absorbs heat ($\Delta H > 0$), randomness increases ($\Delta S > 0$), and when it occurs spontaneously under given conditions, $\Delta G < 0$ (system's Gibbs free energy decreases).

(1) Increase in enthalpy — **(Wrong)** (true but not complete alone)
(2) Decrease in free energy — **(Wrong)** (true for spontaneous condition, alone not complete)
(3) Increase in entropy — **(Wrong)** (true but alone not complete)
(4) All — **(Correct)**

Final Answer: (4)

Q29. A gas expands under reversible adiabatic conditions; what is zero?

Concept: Reversible adiabatic: $\delta q = 0$ and $\Delta S = 0$ (isentropic). $\Delta T \neq 0$ generally.

(1) $\Delta G = 0$ — **(Wrong)**
(2) $\Delta T = 0$ — **(Wrong)**
(3) $\Delta S = 0$ — **(Correct)**
(4) None — **(Wrong)**

Final Answer: (3)

Q30. For the precipitation of AgCl by Ag^+ and HCl :

Concept: Insoluble salt formation (ionic product $> K_{sp}$) drives precipitation $\Rightarrow \Delta G < 0$.

(1) $\Delta G = 0$ — **(Wrong)**
(2) $\Delta G = -$ — **(Correct)**
(3) $\Delta H = \Delta G$ — **(Wrong)**
(4) None — **(Wrong)**

Final Answer: (2)