

CHAPTER 3

THERMODYNAMICS

Advanced Multiple-Choice Questions

20 Questions

15 Conceptual

5 Calculations

Instructions: Select the single best answer for each question. All answer choices are arranged vertically. The complete answer key is provided at the end of the document.

Based exclusively on the chapter content and equations.

SECTION I - CONCEPTUAL QUESTIONS

Questions 1-15

- 1** Iodine is distributed between water and hexane contained in a sealed separatory funnel. Which description is thermodynamically most accurate?
- A. Each liquid phase and the total system are isolated systems.
 - B. Each liquid phase is closed, whereas the combined system is open.
 - C. Each liquid phase may be considered open, whereas the combined two-phase system is closed.
 - D. Each liquid phase is isolated, whereas the combined system is closed.
- 2** Which statement most precisely distinguishes an isolated system from a closed system?
- A. An isolated system exchanges energy but not matter with its surroundings.
 - B. A closed system exchanges matter but not energy with its surroundings.
 - C. An isolated system exchanges neither energy nor matter, whereas a closed system may exchange energy but not matter.
 - D. A closed system exchanges neither energy nor matter, whereas an isolated system exchanges only heat.
- 3** The internal energy U of a thermodynamic system is best defined as:
- A. The kinetic energy associated only with molecular translation.
 - B. The heat stored within the system at constant pressure.
 - C. The sum of all kinetic and potential energy contributions of the atoms, ions, and molecules in the system.
 - D. The maximum amount of work obtainable from the system.
- 4** A system reaches the same final temperature, pressure, and volume through two different processes. Which statement must be correct?
- A. The values of Q , W , and ΔU must all be identical for both processes.
 - B. Only Q must be identical because heat is a state function.
 - C. Only W must be identical because work depends exclusively on volume.
 - D. ΔU must be identical, although Q and W may differ.
- 5** Which conclusion applies to a closed system undergoing an isochoric process involving only pressure-volume work?
- A. The pressure must remain constant.
 - B. The expansion work is zero because $\Delta V = 0$.
 - C. The process must be adiabatic.
 - D. The internal energy cannot change.

6 According to the sign convention used in the chapter, which combination correctly describes an exothermic expansion?

- A. $Q > 0$ and $W > 0$
- B. $Q > 0$ and $W < 0$
- C. $Q < 0$ and $W > 0$
- D. $Q < 0$ and $W < 0$

7 Why is enthalpy change generally more useful than internal-energy change for chemical and biochemical processes?

- A. Enthalpy is path-dependent, whereas internal energy is path-independent.
- B. Most chemical processes occur at constant volume in isolated containers.
- C. Many chemical processes occur at approximately constant atmospheric pressure and may involve expansion or contraction.
- D. Enthalpy represents only the kinetic energy of gaseous molecules.

8 For a chemical process involving only solids and liquids, the approximation $\Delta H \approx \Delta U$ is usually valid because:

- A. The pressure of solids and liquids is always zero.
- B. Their entropy changes are negligible.
- C. Their volume changes are generally small, making $P\Delta V$ negligible.
- D. Solids and liquids cannot perform work.

9 Which phase transition must have a positive enthalpy change in the forward direction?

- A. Gas $\rightarrow$ liquid
- B. Liquid $\rightarrow$ solid
- C. Gas $\rightarrow$ solid
- D. Solid $\rightarrow$ gas

10 Which expression correctly defines the enthalpy of vaporization of one mole of a substance?

- A. $\Delta H_{\text{vap}} = H_{\text{liquid}} - H_{\text{gas}}$
- B. $\Delta H_{\text{vap}} = H_{\text{gas}} - H_{\text{liquid}}$
- C. $\Delta H_{\text{vap}} = H_{\text{solid}} - H_{\text{liquid}}$
- D. $\Delta H_{\text{vap}} = H_{\text{gas}} - H_{\text{solid}}$

11 When a thermochemical equation is reversed without changing its stoichiometric coefficients:

- A. The magnitude and sign of ΔH remain unchanged.
- B. The magnitude of ΔH doubles.
- C. The magnitude of ΔH remains unchanged, but its sign is reversed.
- D. The sign of ΔH changes only if the reaction is exothermic.

12 An overall chemical reaction can occur either directly or through several intermediate reactions. Which statement follows from enthalpy being a state function?

- A. The direct route must always release more heat.
- B. The reaction enthalpy depends on the activation energy of each intermediate step.
- C. The overall enthalpy change equals the sum of the enthalpy changes of the intermediate reactions.
- D. The overall enthalpy change is zero whenever intermediates are formed.

13 Which observation demonstrates that a negative enthalpy change alone is not sufficient to establish spontaneity?

- A. Heat naturally flows from a warmer object to a colder object.
- B. A gas expands from a high-pressure region to a low-pressure region.
- C. Ice melts spontaneously at 25°C even though the melting process absorbs heat.
- D. Condensation releases heat and may occur spontaneously.

14 According to the second law of thermodynamics, which condition identifies a system at equilibrium?

- A. $\Delta S_{\text{system}} = 0$ under all circumstances.
- B. $\Delta S_{\text{surroundings}} > 0$ regardless of the system.
- C. $\Delta S_{\text{universe}} = 0$
- D. $\Delta S_{\text{universe}} < 0$

15 A process has $\Delta H < 0$ and $\Delta S < 0$. Based on $\Delta G = \Delta H - T\Delta S$, which statement is most accurate?

- A. The process is spontaneous at all temperatures.
- B. The process is non-spontaneous at all temperatures.
- C. Lower temperatures favor spontaneity, whereas sufficiently high temperatures may make the process non-spontaneous.
- D. Higher temperatures always make ΔG more negative.

SECTION II - CALCULATION QUESTIONS

Questions 16-20

Use the equations and sign conventions stated in the chapter. Convert units when required before substitution.

16 A gas expands against a constant external pressure of 1.50 atm from 2.00 L to 5.50 L. Using $W = -P\Delta V$, what is the work associated with the process?

- A. +5.25 L·atm
- B. -5.25 L·atm
- C. -2.25 L·atm
- D. +8.25 L·atm

17 A closed system absorbs 850 J of heat and performs 320 J of work on its surroundings. According to $\Delta U = W + Q$, what is the change in internal energy?

- A. +1170 J
- B. +530 J
- C. -530 J
- D. -1170 J

18 For a gas-phase reaction at 298 K, the internal-energy change is -125.0 kJ mol⁻¹, and the change in the number of moles of gas is $\Delta n = -2.00$. Using $\Delta H = \Delta U + (\Delta n)RT$ and $R = 8.314 \text{ J mol}^{-1} \text{ K}^{-1}$, calculate ΔH .

- A. -120.05 kJ mol⁻¹
- B. -125.00 kJ mol⁻¹
- C. -129.95 kJ mol⁻¹
- D. -134.91 kJ mol⁻¹

SECTION II - CALCULATION QUESTIONS

Continued

19 A process has $\Delta H = +24.0 \text{ kJ mol}^{-1}$ and $\Delta S = +85.0 \text{ J mol}^{-1} \text{ K}^{-1}$ at 350 K. What is ΔG , and what does it indicate?

- A. $+53.75 \text{ kJ mol}^{-1}$; non-spontaneous
- B. $+5.75 \text{ kJ mol}^{-1}$; non-spontaneous
- C. $-5.75 \text{ kJ mol}^{-1}$; spontaneous
- D. $-29.75 \text{ kJ mol}^{-1}$; spontaneous

20 During a process, $\Delta S_{\text{system}} = -42 \text{ J K}^{-1}$ while $\Delta S_{\text{surroundings}} = +60 \text{ J K}^{-1}$. What is the entropy change of the universe, and how is the process classified?

- A. -102 J K^{-1} ; non-spontaneous
- B. -18 J K^{-1} ; non-spontaneous
- C. $+18 \text{ J K}^{-1}$; spontaneous
- D. $+102 \text{ J K}^{-1}$; equilibrium

ANSWER KEY

Correct responses for all twenty questions

1. C	6. D	11. C	16. B
2. C	7. C	12. C	17. B
3. C	8. C	13. C	18. C
4. D	9. D	14. C	19. C
5. B	10. B	15. C	20. C

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