STATES OF MATTER

30 Advanced Multiple-Choice Questions

25 conceptual questions and 5 calculation questions

Instructions: Choose the single best answer for each question. Mark one option only.

PART I - CONCEPTUAL QUESTIONS

1. At the equilibrium separation between two interacting molecules, which combination is correct?

A. Attractive forces exceed repulsive forces, and potential energy is maximal.
B. Attractive and repulsive forces are equal, and potential energy is minimal.
C. Repulsive forces disappear completely, and molecular motion stops.
D. Attractive forces disappear, and the molecules become infinitely separated.

2. Which interaction most accurately describes the predominant attraction between two acetone molecules?

A. Ion-induced dipole interaction
B. London dispersion interaction only
C. Keesom interaction between permanent dipoles
D. Debye interaction between a permanent and an induced dipole

3. Which statement most accurately describes the interaction between water and molecular oxygen?

A. Water and oxygen interact through ion-dipole forces because oxygen behaves as an anion.
B. Oxygen permanently polarizes water, producing a Keesom interaction.
C. Both molecules possess permanent dipoles and interact through orientation forces.
D. The permanent dipole of water induces a temporary dipole in oxygen, and the interaction increases with oxygen polarizability.

4. Which statement regarding London dispersion forces is correct?

A. They occur between all atoms and molecules and generally increase as molecular polarizability increases.
B. They occur exclusively between nonpolar molecules with low molecular weights.
C. They become weaker as the number of electrons in a molecule increases.
D. They require one molecule to possess a permanent dipole.

5. Which sequence correctly ranks the intermolecular interactions from strongest to weakest according to the chapter?

A. Hydrogen bond > ion-dipole > Keesom > ion-induced dipole > Debye > London
B. Ion-induced dipole > ion-dipole > hydrogen bond > London > Keesom > Debye
C. Ion-dipole > ion-induced dipole > hydrogen bond > Keesom > Debye > London
D. Ion-dipole > hydrogen bond > ion-induced dipole > Debye > Keesom > London

6. During the dissolution of an ionic crystal in water, which molecular orientation is expected?

A. Both cations and anions are preferentially surrounded by the oxygen atoms of water.
B. Cations attract the oxygen end of water, whereas anions attract the hydrogen end.
C. Cations attract the hydrogen end of water, whereas anions attract the oxygen end.
D. Water molecules orient randomly because ion-dipole interactions are insignificant.

7. Which statement correctly characterizes an ion-induced dipole interaction?

A. It occurs between two ions carrying opposite full charges.
B. It occurs when two nonpolar molecules simultaneously form permanent dipoles.
C. It requires a polar molecule to induce a dipole in another polar molecule.
D. It occurs when an ion distorts the electron distribution of a nonpolar molecule, as in the formation of the triiodide complex.

8. Which condition is essential for the formation of the hydrogen bond described in the chapter?

A. Hydrogen must be covalently attached to an electronegative atom such as fluorine, oxygen, or nitrogen.
B. Hydrogen must carry a complete positive ionic charge.
C. The interacting molecules must both be nonpolar.
D. The hydrogen atom must be bonded directly to carbon.

9. Which combination uniquely characterizes the gaseous state?

A. Definite shape, definite volume, and high resistance to compression
B. Definite volume, indefinite shape, and negligible molecular motion
C. Rapid mixing, uniform filling of the container, and high compressibility
D. Long-range molecular order, fixed volume, and low kinetic energy

10. Which set of assumptions is consistent with an ideal gas?

A. Negligible molecular volume, absence of intermolecular forces, and perfectly elastic collisions
B. Finite molecular volume, strong attractions, and partially inelastic collisions
C. Negligible molecular volume, strong repulsions, and continuous energy loss
D. Finite molecular volume, no molecular motion, and perfectly elastic collisions

11. According to kinetic molecular theory, which statement is correct?

A. Average kinetic energy is inversely proportional to absolute temperature.
B. Average kinetic energy is directly proportional to absolute temperature and may be expressed as $E = (3/2)RT$.
C. Molecular collisions permanently reduce the total kinetic energy of the gas.
D. Gas molecules exert substantial attractive and repulsive forces at all pressures.

12. Under which conditions would a real gas be expected to show the greatest deviation from ideal behavior?

A. Low pressure and high temperature
B. Low pressure and low molecular concentration
C. High temperature and large container volume
D. High pressure and low temperature

13. Which interpretation of the van der Waals equation is most accurate?

A. The parameter a corrects for molecular volume, whereas b corrects for intermolecular attraction.
B. The parameter a accounts for intermolecular attraction, whereas b accounts for excluded molecular volume.
C. Both a and b correct only for collision elasticity.
D. Both constants become more important as pressure decreases and temperature increases.

14. When applying the ideal gas law to a compressed-gas aerosol container, the gas volume should be taken as:

A. The total internal container volume without correction
B. The volume occupied by the liquid concentrate
C. The internal container volume minus the volume occupied by the concentrate
D. The external geometric volume of the container

15. Which condition defines equilibrium vapor pressure?

A. The rate of vaporization equals the rate of condensation in a closed system at constant temperature.
B. All liquid molecules have entered the vapor state.
C. Condensation has stopped while vaporization continues.
D. The vapor pressure has become equal to zero.

16. Why does the vapor pressure of a liquid increase as temperature rises?

A. Intermolecular attractions become ionic at elevated temperatures.
B. The number of molecules in the liquid phase permanently increases.
C. The external pressure automatically decreases.
D. A greater fraction of molecules acquires sufficient kinetic energy to escape from the liquid surface.

17. Which statement concerning boiling is correct?

A. Boiling begins when the liquid vapor pressure becomes lower than the external pressure.
B. A liquid boils when its vapor pressure equals the external pressure, and reduced external pressure lowers its boiling point.
C. The normal boiling point is measured at zero external pressure.
D. Increasing altitude increases atmospheric pressure and therefore raises the boiling point.

18. Which comparison is most consistent with the effect of intermolecular forces on boiling behavior?

A. Nonpolar compounds generally possess higher boiling points than hydrogen-bonded compounds of similar molecular weight.
B. London forces produce higher heats of vaporization than hydrogen bonding.
C. Nonpolar substances generally have relatively low boiling points, whereas hydrogen-bonded substances generally have higher boiling points.
D. Boiling point is independent of the magnitude of intermolecular attraction.

19. Which pair of trends is correctly stated?

A. Boiling points of normal homologous compounds generally increase with molecular weight, whereas branching generally lowers boiling point.
B. Boiling points decrease with molecular weight, whereas branching increases boiling point.
C. Both molecular weight and branching always increase boiling point.
D. Molecular weight affects only melting point, whereas branching affects only vapor pressure.

20. Which method would be appropriate for producing a supersaturated solution during crystallization?

A. Heating indefinitely while continuously adding solvent
B. Removing solvent, cooling when solubility decreases with temperature, or adding an antisolvent
C. Adding a solvent in which the solute is highly soluble until complete dilution occurs
D. Preventing both evaporation and temperature change

21. Which statement correctly distinguishes nucleation from crystal growth?

A. Nucleation is the addition of molecules to an existing crystal, whereas growth creates the first molecular cluster.
B. Nucleation and growth occur only in unsaturated solutions.
C. Growth occurs before any nucleation site has formed.
D. Nucleation forms a small initial mass, whereas growth adds further solute molecules to that site.

22. Which situation is an example of polymorphism rather than a change in crystal habit?

A. The same internal lattice develops two different external shapes because crystal faces grow at different rates.
B. A crystal is mechanically broken into particles of different sizes.
C. The same chemical material crystallizes into two distinct repeating molecular packing arrangements.
D. A liquid solvent becomes adsorbed onto the external crystal surface.

23. Which relationship between stable and metastable polymorphs is generally correct?

A. The stable form has the lowest melting point and fastest dissolution rate.
B. The stable form generally has the highest melting point and slowest dissolution rate.
C. Metastable forms cannot transform into a stable form.
D. Stable and metastable forms must have identical apparent solubilities.

24. Why may polymorphism significantly alter the oral bioavailability of a poorly water-soluble drug?

A. Different polymorphs may exhibit different apparent solubilities and dissolution rates, producing different amounts of drug available for absorption.
B. Polymorphism changes the chemical identity and intrinsic pharmacological activity of the drug.
C. Every metastable polymorph is completely insoluble in gastrointestinal fluids.
D. Polymorphism affects only crystal color and has no effect on pharmaceutical performance.

25. Which statement about hydrates and solvates is most accurate?

A. A hydrate contains an organic solvent, whereas a solvate exclusively contains water.
B. Solvent molecules are retained only on the crystal surface and never enter the lattice.
C. Stoichiometric incorporation of solvent into the lattice produces a solvate; when the solvent is water, the product is a hydrate, and hydrate dissolution may be either faster or slower than the anhydrous form.
D. Hydrates always dissolve more rapidly than their corresponding anhydrous forms.

PART II - CALCULATION QUESTIONS

Questions 26-30 are the only calculation questions in this set.

26. A gas occupies 45.0 mL at 25 degrees C and 735 mmHg. Assuming ideal behavior, what volume will it occupy at 0 degrees C and 760 mmHg?

A. 34.8 mL
B. 39.9 mL
C. 45.0 mL
D. 50.4 mL

27. A 0.520 g sample of a vapor occupies 250 mL at 127 degrees C and 1.10 atm. Calculate its approximate molecular weight. Use R = 0.08206 L atm mol^-1 K^-1.

A. 31.0 g/mol
B. 46.0 g/mol
C. 62.1 g/mol
D. 91.0 g/mol

28. **The vapor pressure of a liquid is 0.355 atm at 80 degrees C. If its molar heat of vaporization is 9720 cal/mol, calculate its vapor pressure at 100 degrees C. Use R = 1.987 cal mol^-1 K^-1.**

A. 0.169 atm
B. 0.355 atm
C. 0.746 atm
D. 1.420 atm

29. **An aerosol container has an internal volume of 500 cm^3 and contains 320 cm^3 of liquid concentrate. It is filled with 0.030 mol of nitrogen at 27 degrees C. Assuming ideal behavior, calculate the pressure inside the container. Use R = 8.314 Pa m^3 mol^-1 K^-1.**

A. 1.50 x 10^5 Pa
B. 4.16 x 10^5 Pa
C. 2.31 x 10^6 Pa
D. 4.16 x 10^2 Pa

30. **The vapor pressure of a liquid is 0.50 atm at 80 degrees C and 1.20 atm at 110 degrees C. Calculate its average molar heat of vaporization using the Clausius-Clapeyron equation. Use R = 1.987 cal mol^-1 K^-1.**

A. 7.84 x 10^3 cal/mol
B. 3.92 x 10^3 cal/mol
C. 1.57 x 10^4 cal/mol
D. 8.76 x 10^2 cal/mol

ANSWER KEY

Use this section after completing all questions.

Question	Answer	Question	Answer	Question	Answer
1	B	11	B	21	D
2	C	12	D	22	C
3	D	13	B	23	B
4	A	14	C	24	A
5	C	15	A	25	C
6	B	16	D	26	B
7	D	17	B	27	C
8	A	18	C	28	C
9	C	19	A	29	B
10	A	20	B	30	A

Calculation answer check

26. Using P1V1/T1 = P2V2/T2 gives V2 = (735 x 45.0 x 273)/(760 x 298) = 39.9 mL (B).
27. M = gRT/PV = (0.520 x 0.08206 x 400)/(1.10 x 0.250) = 62.1 g/mol (C).
28. P2 = 0.355 exp[9720(373 - 353)/(1.987 x 353 x 373)] = 0.746 atm (C).
29. Gas volume = (500 - 320) cm^3 = 180 cm^3; PV = nRT gives P = 4.16 x 10^5 Pa (B).
30. ln(P2/P1) = DeltaHv(T2 - T1)/(R T1 T2) gives DeltaHv = 7.84 x 10^3 cal/mol (A).

Prepared from Chapter 1: States of Matter - Dr Nizar Al-Zoubi