Solubility and Distribution Phenomena

15 Hard Multiple-Choice Questions

Theoretical Concepts + Calculation Problems

Format	Choose the single best answer (A-E).
Coverage	Solubility expressions and prediction, solvent effects, gases, liquid miscibility, solid-state effects, pH-solubility, solubility products, common-ion effect, formulation problems, and partitioning.
Answer key	Model answers are placed at the end of the file.

Questions

1. Which relationship between solute concentration and solubility correctly identifies the state of a solution?

A) Concentration below solubility: supersaturated; equal: undersaturated; above: saturated.
B) Concentration below solubility: saturated; equal: supersaturated; above: undersaturated.
C) Concentration below solubility: undersaturated; equal: saturated; above: supersaturated.
D) Concentration below solubility: saturated; equal: undersaturated; above: supersaturated.
E) The terms are determined only by pressure, not concentration.

2. A solute requires approximately 50 mL of solvent to dissolve 1 g. According to the pharmacopeial descriptive terms shown in the chapter, it is:

A) Freely soluble
B) Soluble
C) Sparingly soluble
D) Slightly soluble
E) Very slightly soluble

3. If the cohesive attraction between solvent molecules A-A is much greater than the solute-solvent attraction A-B, what outcome is expected?

A) The solute must dissolve because solvent cohesion favors mixing.
B) The solvent molecules aggregate with one another and tend to exclude the solute.
C) The solute becomes ionized regardless of its chemical structure.
D) Complete miscibility occurs because A-B is smaller.
E) The result depends only on particle size.

4. Which structural change is most consistent with increased aqueous solubility according to the chapter?

A) Lengthening a nonpolar hydrocarbon chain while removing polar groups.

B) Replacing a polar group with a methyl group.

C) Increasing molecular symmetry to improve crystal packing.

D) Adding polar groups or increasing branching in a way that reduces the nonpolar effect.

E) Increasing melting point while leaving intermolecular interactions unchanged.

5. Which statement best distinguishes nonpolar and semipolar solvents as presented in the chapter?

A) Nonpolar solvents have high dielectric constants and readily separate ions.

B) Semipolar solvents cannot interact with either polar or nonpolar liquids.

C) Nonpolar solvents mainly dissolve ionic compounds through hydrogen bonding.

D) Semipolar solvents are identical to water in dielectric behavior.

E) Nonpolar solvents can dissolve nonpolar solutes by weak van der Waals forces, while semipolar solvents can promote miscibility between polar and nonpolar liquids.

6. [Calculation] At constant temperature, a gas has a dissolved concentration of 2.4 mM when its partial pressure is 0.60 atm. Assuming Henry's law applies, what concentration is expected at 1.50 atm?

A) 0.96 mM

B) 3.0 mM

C) 4.8 mM

D) 6.0 mM

E) 9.0 mM

7. Which statement about gas solubility is correct?

A) Increasing temperature generally increases the solubility of most gases because kinetic energy decreases.

B) Adding NaCl always increases gas solubility by salting in.

C) Henry's law is most rigorous for gases that react strongly with the solvent.

D) Increasing temperature generally decreases gas solubility, and adding salts may liberate dissolved gas by salting out.

E) Hydrogen chloride follows Henry's law perfectly because it does not react with water.

8. Complete miscibility of two liquids is favored when:

A) Adhesive A-B interactions are much stronger than the cohesive A-A or B-B interactions.

B) A-A and B-B interactions are each infinitely stronger than A-B.

C) The liquids form two layers containing no dissolved material from the other phase.

D) Both liquids are necessarily nonpolar.

E) The boiling points of the two liquids are identical.

9. Which statement about solid-state effects on solubility is most consistent with the chapter?

A) The most stable crystal form is always the most soluble.

B) Amorphous, metastable, or anhydrous forms may be more soluble than the stable form, and micronization may increase solubility if the crystal lattice is disrupted.

C) Particle size always controls solubility even for very large particles.

D) Higher melting point generally indicates weaker crystal interactions and higher aqueous solubility.

E) Exothermic dissolution always becomes more soluble when temperature rises.

10. [Calculation] A weak acid has pKa = 4.50 and intrinsic solubility S0 = 2.00 x 10^-3 M. What is its total saturation solubility S at pH 6.00 using pH - pKa = log[(S-S0)/S0]?

A) 0.0040 M

B) 0.0126 M

C) 0.0316 M

D) 0.0652 M

E) 0.200 M

11. [Calculation] A weak base has pKa = 8.00 and intrinsic solubility S0 = 1.00 x 10^-3 M. At pH 6.00, use pH - pKa = log[S0/(S-S0)]. What is the approximate total solubility S?

A) 0.00101 M

B) 0.0101 M

C) 0.0505 M

D) 0.101 M

E) 1.01 M

12. [Calculation] For AgCl in pure water, Ksp = 1.25 x 10^-10. If the molar mass of AgCl is 143.32 g/mol, what is the approximate solubility in g/L?

A) 1.60 x 10^-5 g/L

B) 1.60 x 10^-4 g/L

C) 1.60 x 10^-3 g/L

D) 1.60 x 10^-2 g/L

E) 1.60 x 10^-1 g/L

13. [Calculation] Estimate the molar solubility of AgCl in a solution already containing 0.010 M Cl-. Use Ksp = 1.25 x 10^-10 and assume the added chloride concentration remains essentially constant.

A) 1.25 x 10^-4 M

B) 1.25 x 10^-6 M

C) 1.25 x 10^-8 M

D) 1.12 x 10^-5 M

E) 1.25 x 10^-10 M

14. Which statement correctly describes the formulation problem and solution presented for Septrin infusion?

A) Both components are strong acids and are stabilized by raising the pH to 14.

B) Sulfamethoxazole and trimethoprim are both neutral and therefore never precipitate together.

C) The formulation contains 40% propylene glycol to improve mutual dissolution; after recommended 1 in 25 dilution, stability is about 7 hours.

D) The formulation is stabilized only by adding NaCl as a common ion.

E) Dilution increases the stability indefinitely because it removes incompatibility.

15. [Calculation + Concept] A drug has concentration 0.060 M in octanol and 0.015 M in water. Which statement is correct?

A) P = 0.25 and log P = -0.60, indicating strong hydrophilicity.

B) P = 4.0 and log P = 0.60; for an ionizable drug, the experimentally observed pH-dependent distribution is described by an apparent partition coefficient (Papp).

C) P = 4.0 and log P = 4.0; partitioning is independent of ionization and pH.

D) P = 0.60 and log P = 4.0; octanol is treated as the aqueous phase.

E) P cannot be calculated because partition coefficients are defined only for gases.

Model Answers

Correct answers are listed below. Calculation items include a compact numerical check.

Q	Answer	Correct option / result
1	**C**	Below solubility = undersaturated; equal to solubility = saturated; above solubility = supersaturated.
2	**C**	30-100 mL of solvent per gram corresponds to the pharmacopeial term sparingly soluble.
3	**B**	When A-A >> A-B, solvent molecules strongly prefer one another, forming associations that exclude the solute.
4	**D**	Additional polar groups increase water interaction, and branching reduces the effective nonpolar character of the carbon chain.
5	**E**	Nonpolar solvents dissolve nonpolar solutes mainly by weak van der Waals forces; semipolar solvents can bridge polar/nonpolar miscibility.
6	**D**	Henry's law: C2/C1 = P2/P1. C2 = 2.4 x (1.50/0.60) = 6.0 mM.
7	**D**	Most gases become less soluble as temperature rises; electrolytes such as NaCl can cause salting out. Henry's law is for gases that do not react significantly with solvent.
8	**A**	Complete miscibility is favored when adhesive A-B forces dominate over like-molecule cohesive interactions.
9	**B**	Less stable solids can be more soluble, and micronization may increase solubility when it disrupts the crystal lattice.
10	**D**	(S-S0)/S0 = 10^(6.00-4.50) = 31.62. S = S0(1 + 31.62) = 0.0652 M.
11	**D**	10^(6-8) = 0.01 = S0/(S-S0). Thus S-S0 = 0.100 M and S = 0.101 M.
12	**C**	For AgCl, s = sqrt(Ksp) = 1.12 x 10^-5 M. In g/L: 1.12 x 10^-5 x 143.32 = about 1.60 x 10^-3 g/L.
13	**C**	With [Cl-] about 0.010 M, s = Ksp/[Cl-] = 1.25 x 10^-10 / 0.010 = 1.25 x 10^-8 M.
14	**C**	The chapter uses 40% propylene glycol to improve mutual dissolution; at the recommended 1 in 25 dilution, stability is about 7 hours.
15	**B**	P = Co/Cw = 0.060/0.015 = 4.0; log P = log10(4) = 0.60. For ionizable drugs, pH-dependent observed distribution is expressed as Papp.

End of Question Set