

CHAPTERS 10-12

BRINGING IT TOGETHER

Here is another chance for you to test your understanding of concepts, your knowledge of scientific terms, and your skills at problem solving. Read through the following questions carefully, and answer each as fully as possible. Review topics when necessary. When you are able to answer these questions correctly, you are ready to go on to the next group of chapters.

- A 15.5 L sample of neon at 25.0 °C and a pressure of 748 torr is kept at 25.0 °C as it is allowed to expand to a final volume of 25.4 L. What is the final pressure?
- An 8.95 L sample of nitrogen at 25.0 °C and 1.00 atm is compressed to a volume of 0.895 L and a pressure of 5.56 atm. What must its final temperature be?
- A mixture of propane and air will explode if it is heated to 466 °C. If a 20.0 L sample of such a mixture originally at 25.0 °C and 1.00 atm is to be detonated by the heat that is generated by compression alone, what will the pressure of the mixture be at 466 °C if its volume is to be 1.00 L?
- A sample of oxygen-enriched air with a volume of 12.5 L at 25.0 °C and 1.00 atm consists of 45.0% (v/v) oxygen and 55.0% (v/v) nitrogen. What are the partial pressures of oxygen and nitrogen (in torr) in this sample after it has been warmed to a temperature of 37.0 °C and is still at a final volume of 12.5 L?
- If a gas in a cylinder pushes back a piston against a constant opposing pressure of 3.0×10^5 pascals and undergoes a volume change of 0.50 m³, how much work will the gas do, expressed in joules?
- What is the formula mass of a gaseous element if 6.45 g occupies 1.92 L at 745 torr and 25.0 °C? Which element is it?
- What is the formula mass of a gaseous element if at room temperature it effuses through a pinhole 2.16 times as rapidly as xenon? Which element is it?
- Briefly and qualitatively explain how the model of an ideal gas, as described by the kinetic theory of gases, explains the following.
 - Boyle's law
 - Graham's law
 - Charles' law
 - the meaning of gas temperature
 - pressure-temperature law
 - absolute zero
- Which has a higher value of the van der Waals constant *a*, a gas whose molecules are polar or one whose molecules are nonpolar? Explain.
- What is the van der Waals constant *b* used to correct for, and in what way is this correction accomplished?
- How many milliliters of dry CO₂, measured at STP, could be evolved in the reaction between 20.0 mL of 0.100 M NaHCO₃ and 30.0 mL of 0.0800 M HCl?
- How many milliliters of Cl₂ gas, measured at 25 °C and 740 torr, are needed to react with 10.0 mL of 0.10 M NaI if the I⁻ is oxidized to IO₃⁻ and Cl₂ is reduced to Cl⁻?
- Potassium hypobromite, KOBr, converts ammonia to nitrogen by the following reaction.

$$3\text{KOBr} + 2\text{NH}_3 \longrightarrow \text{N}_2 + 3\text{KBr} + 3\text{H}_2\text{O}$$

To prepare 475 mL of dry N₂, when measured at 24.0 °C and 738 torr, what is the minimum number of grams of KOBr required?
- Hydrogen peroxide, H₂O₂, is decomposed by potassium permanganate according to the following reaction.

$$5\text{H}_2\text{O}_2 + 2\text{KMnO}_4 + 3\text{H}_2\text{SO}_4 \longrightarrow 5\text{O}_2 + 2\text{MnSO}_4 + \text{K}_2\text{SO}_4 + 8\text{H}_2\text{O}$$

What is the minimum number of milliliters of 0.125 M KMnO₄ required to prepare 375 mL of dry O₂ when the gas volume is measured at 22.0 °C and 738 torr?
- One way to make chlorine is to let manganese dioxide, MnO₂, react with hydrochloric acid according to the following equation.

$$4\text{HCl} + \text{MnO}_2 \longrightarrow \text{Cl}_2 + \text{MnCl}_2 + 2\text{H}_2\text{O}$$

What is the minimum volume (in mL) of 6.44 M HCl needed to prepare 525 mL of dry chlorine when the gas is obtained at 24.0 °C and 742 torr?
- A sample of 248 mL of wet nitrogen gas was collected over water at a total gas pressure of 736 torr and a temperature of 21.0 °C. (The vapor pressure of water at 21.0 °C is 18.7 torr.) The nitrogen was produced by the reaction of sulfamic acid, HNH₂SO₃, with 425 mL of a solution of sodium nitrite according to the following equation.

$$\text{NaNO}_2 + \text{HNH}_2\text{SO}_3 \longrightarrow \text{N}_2 + \text{NaHSO}_4 + \text{H}_2\text{O}$$

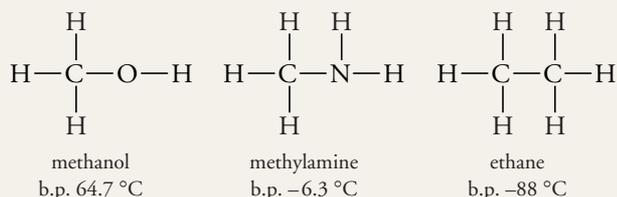
Calculate what must have been the molar concentration of the sodium nitrite.
- What two factors are principally responsible for the differences in the behavior of gases and liquids?
- If the ideal gas law worked well for all substances at all temperatures and pressures, what volume would 1.00 mol of water vapor occupy at 25 °C and 1.00 atm? What volume does 1.00 mol of water actually occupy under these conditions?
- Which properties of liquids and solids are controlled chiefly by the closeness of the packing of molecules in these states? Which properties are determined chiefly by the strengths of the intermolecular attractions?
- Consider the molecule POCl₃, in which phosphorus is the central atom and is bonded to an oxygen atom and three chlorine atoms.
 - Draw the Lewis structure of POCl₃ and predict its geometry.
 - Is the molecule polar or nonpolar? Explain.
 - What kinds of attractive forces would be present between POCl₃ molecules in the liquid?
- What kinds of attractive forces, including chemical bonds, would be present between the particles in the following?
 - H₂O(l)
 - CCl₄(l)
 - CH₃OH(l)
 - BrCl(l)
 - NaCl(s)
 - Na₂SO₄(s)
- What is a change of state? What terms are used to describe the energy changes associated with the change (a) solid → liquid, (b) solid → gas, and (c) liquid → gas?
- What is a *dynamic equilibrium*? In terms of Le Châtelier's principle and the "equation"

$$\text{Liquid} + \text{heat} \rightleftharpoons \text{vapor}$$

explain why raising the temperature of a liquid increases the liquid's equilibrium vapor pressure.
- Can a solid have a vapor pressure? How would the vapor pressure of a solid vary with temperature?

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25. Trimethylamine, $(\text{CH}_3)_3\text{N}$, is a substance responsible in part for the smell of fish. It has a boiling point of 3.5°C and a molecular weight of 59.1. Dimethylamine, $(\text{CH}_3)_2\text{NH}$, has a similar odor and boils at a slightly higher temperature, 7°C , even though it has a somewhat lower molecular mass (45.1). How can this be explained in terms of the kinds of attractive forces between their molecules?
26. Methanol, CH_3OH , commonly known as wood alcohol, has a boiling point of 64.7°C . Methylamine, a fishy-smelling chemical found in herring brine, has a boiling point of -6.3°C . Ethane, a hydrocarbon present in petroleum, has a boiling point of -88°C .



Each has nearly the same molecular mass. Account for the large differences in their boiling points in terms of the attractive forces between their molecules.

27. Based on what you've learned in these chapters, explain the following.
- A breeze cools you when you're perspiring.
 - Droplets of water form on the outside of a glass of cold soda on a warm, humid day.
 - You feel more uncomfortable on a warm, humid day than on a warm, dry day.
 - The origin of the energy in a violent thunderstorm.
 - Clouds form as warm, moist air flows over a mountain range.
28. How do the magnitudes of ΔH_{fusion} , $\Delta H_{\text{vaporization}}$, and $\Delta H_{\text{sublimation}}$ compare for a given substance?
29. Make sketches of (a) a face-centered cubic unit cell, (b) a body-centered cubic unit cell, and (c) a simple cubic unit cell. Which type of unit cell does NaCl have?
30. Aluminum has a density of 2.70 g cm^{-3} and crystallizes in a face-centered cubic lattice. Use these and other data to calculate the atomic radius of an aluminum atom.
31. What is the difference between the closest packed structures identified as ccp and hcp? In each of these structures, how many atoms are in contact with any given atom?
32. Tin tetraiodide (stannic iodide) has the formula SnI_4 . It forms soft, yellow to reddish crystals that melt at about 143°C . What kind of solid does SnI_4 form? What kind of bonding occurs in SnI_4 ?
33. A certain compound has the formula $M\text{Cl}_2$. Crystals of the compound melt at 772°C and give a liquid that is electrically conducting. What kind of crystal does this compound form?
34. What general properties are expected of covalent crystals?
35. Silicon dioxide, SiO_2 , forms very hard crystals that melt at 1610°C to yield a liquid that does not conduct electricity. What crystal type does SiO_2 form?
36. Sketch the phase diagram for a substance that has a triple point at 25°C and 100 torr, a normal boiling point of 150°C , and a melting point at 1 atm of 27°C . Is the solid more dense or less dense than the liquid? Where on the curve would the critical temperature and critical pressure be? What phase would exist at 30°C and 10.0 torr?
37. How many grams of 4.00% (w/w) solution of KOH in water are needed to neutralize completely the acid in 10.0 mL $0.256 \text{ M H}_2\text{SO}_4$?
38. Calculate the molar concentration of 15.00% (w/w) Na_2CO_3 solution at 20.0°C given that its density is 1.160 g mL^{-1} .
39. The solubility of pure oxygen in water at 20.0°C and 760 torr is $4.30 \times 10^{-2} \text{ g O}_2$ per liter of H_2O . When air is in contact with water and the air pressure is 585 torr at 20°C , how many grams of oxygen from the air dissolve in 1.00 L of water? The average concentration of oxygen in the air is 21.1% (v/v).
40. Compound A is a white solid with a high melting point. When it melts, it conducts electricity. In which solvent is it likely to be more soluble, water or gasoline? Explain.
41. Compound XY is an ionic compound that dissociates as it dissolves in water. The lattice energy of XY is -600 kJ mol^{-1} . The hydration energy of its ions is -610 kJ mol^{-1} .
- Write the thermochemical equations for the two steps in the formation of a solution of XY in water.
 - Write the sum of these two equations in the form of a thermochemical equation, showing the net ΔH .
 - Draw an enthalpy diagram for the formation of this solution.
42. A 0.270 M KOH solution has a density of 1.01 g mL^{-1} . Calculate the percent concentration (w/w) of KOH.
43. A 5.30 M solution of glycerol in water has a density of 1.11 g mL^{-1} . Calculate the percent concentration by mass of glycerol ($\text{C}_3\text{H}_8\text{O}_3$) and the mole fraction of glycerol present.
44. At 20°C a 40.00% (v/v) solution of ethyl alcohol, $\text{C}_2\text{H}_5\text{OH}$, in water, has a density of 0.9369 g mL^{-1} . The density of pure ethyl alcohol at this temperature is 0.7907 g mL^{-1} and that of water is 0.9982 g mL^{-1} .
- Calculate the molar concentration and the molal concentration of $\text{C}_2\text{H}_5\text{OH}$ in this solution.
 - Calculate the mole fraction and mole percent of $\text{C}_2\text{H}_5\text{OH}$ in this solution.
 - The vapor pressure of ethyl alcohol at 20°C is 41.0 torr and that of water is 17.5 torr. If the 40.00% (v/v) solution were ideal, what would be the vapor pressure of each component over the solution?
45. Estimate the boiling point of 1.0 molal $\text{Al}(\text{NO}_3)_3$, assuming that it dissociates entirely into Al^{3+} and NO_3^- ions in solution.
46. Squalene is an oil found chiefly in shark liver oil but also present in low concentrations in olive oil, wheat germ oil, and yeast. A qualitative analysis disclosed that its molecules consist entirely of carbon and hydrogen. When a sample of squalene with a mass of 0.5680 g was burned in pure oxygen, there was obtained 1.8260 g of carbon dioxide and 0.6230 g of water.
- Calculate the empirical formula of squalene.
 - When 0.1268 g of squalene was dissolved in 10.50 g of molten camphor, the freezing point of this solution was 177.3°C . (The melting point of pure camphor is 178.4°C , and its molal freezing point depression constant is $37.7^\circ\text{C kg camphor}^{-1}$). Calculate the molar mass of squalene and determine its molecular formula.