410. A compound has the empirical formula CH_2O. When 0.0866 g is dissolved in 1.000 g of ether, the solution's boiling point is 36.5°C. Determine the molecular formula of this substance.

411. What is the freezing point of a 28.6% (by mass) aqueous solution of HCl? Assume the HCl is 100% ionized.

412. What mass of ethylene glycol, $HOCH_2CH_2OH$, must be dissolved in 4.510 kg of water to result in a freezing point of −18.0°C? What is the boiling point of the same solution?

413. A water solution containing 2.00 g of an unknown molecular substance dissolved in 10.00 g of water has a freezing point of −4.0°C.
a. Calculate the molality of the solution.
b. When 2.00 g of the substance is dissolved in acetone instead of in water, the boiling point of the solution is 58.9°C. The normal boiling point of acetone is 56.00°C, and its K_b is 1.71°C/*m*. Calculate the molality of the solution from this data.

414. A chemist wants to prepare a solution with a freezing point of −22.0°C and has 100.00 g of glycerol on hand. What mass of water should the chemist mix with the glycerol?

415. An unknown carbohydrate compound has the empirical formula CH_2O. A solution consisting of 0.515 g of the carbohydrate dissolved in 1.717 g of acetic acid freezes at 8.8°C. What is the molar mass of the carbohydrate? What is its molecular formula?

416. An unknown organic compound has the empirical formula C_2H_2O. A solution of 3.775 g of the unknown compound dissolved in 12.00 g of water is cooled until it freezes at a temperature of −4.72°C. Determine the molar mass and the molecular formula of the compound.

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417. The hydroxide ion concentration of an aqueous solution is 6.4×10^{-5} M. What is the hydronium ion concentration?

418. Calculate the H_3O^+ and OH^- concentrations in a 7.50×10^{-4} M solution of HNO_3, a strong acid.

419. Determine the pH of a 0.001 18 M solution of HBr.

420. **a.** What is the pH of a solution that has a hydronium ion concentration of 1.0 M?
b. What is the pH of a 2.0 M solution of HCl, assuming the acid remains 100% ionized?
c. What is the theoretical pH of a 10. M solution of HCl?

421. What is the pH of a solution with the following hydroxide ion concentrations?
a. 1×10^{-5} M
b. 5×10^{-8} M
c. 2.90×10^{-11} M

422. What are the pOH and hydroxide ion concentration of a solution with a pH of 8.92?

423. What are the pOH values of solutions with the following hydronium ion concentrations?
a. 2.51×10^{-13} M
b. 4.3×10^{-3} M
c. 9.1×10^{-6} M
d. 0.070 M

424. A solution is prepared by dissolving 3.50 g of sodium hydroxide in water and adding water until the total volume of the solution is 2.50 L. What are the OH^- and H_3O^+ concentrations?

425. If 1.00 L of a potassium hydroxide solution with a pH of 12.90 is diluted to 2.00 L, what is the pH of the resulting solution?

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426. Calculate the H_3O^+ and OH^- concentrations in the following solutions. Each is either a strong acid or a strong base.
a. 0.05 M sodium hydroxide
b. 0.0025 M sulfuric acid
c. 0.013 M lithium hydroxide
d. 0.150 M nitric acid
e. 0.0200 M calcium hydroxide
f. 0.390 M perchloric acid

427. What is the pH of each solution in item 426?

428. Calculate $[H_3O^+]$ and $[OH^-]$ in a 0.160 M solution of potassium hydroxide. Assume that the solute is 100% dissociated at this concentration.

429. The pH of an aqueous solution of NaOH is 12.9. What is the molarity of the solution?

430. What is the pH of a 0.001 25 M HBr solution? If 175 mL of this solution is diluted to a total volume of 3.00 L, what is the pH of the diluted solution?

431. What is the pH of a 0.0001 M solution of NaOH? What is the pH of a 0.0005 M solution of NaOH?

432. A solution is prepared using 15.0 mL of 1.0 M HCl and 20.0 mL of 0.50 M HNO_3. The final volume of the solution is 1.25 L. Answer the following questions:
a. What are the $[H_3O^+]$ and $[OH^-]$ in the final solution?
b. What is the pH of the final solution?

433. A container is labeled 500.0 mL of 0.001 57 M nitric acid solution. A chemist finds that the container was not sealed and that some evaporation has taken place. The volume of solution is now 447.0 mL.
a. What was the original pH of the solution?
b. What is the pH of the solution now?

434. Calculate the hydroxide ion concentration in an aqueous solution that has a 0.000 35 M hydronium ion concentration.

435. A solution of sodium hydroxide has a pH of 12.14. If 50.00 mL of the solution is diluted to 2.000 L with water, what is the pH of the diluted solution?

436. An acetic acid solution has a pH of 4.0. What are the $[H_3O^+]$ and $[OH^-]$ in this solution?

437. What is the pH of a 0.000 460 M solution of $Ca(OH)_2$?