

Molarity

1. Calculate the molarity of the following solutions.

a) 825 cm³ that contains 30.0 g of acetic acid. CH₃COOH or HC₂H₃O₂

$$\begin{aligned} \text{mol} &= \frac{30.0 \text{ g}}{60.05258 \text{ g/mol}} \\ &= 0.500 \text{ mol} \end{aligned} \quad C = \frac{0.500 \text{ mol}}{0.825 \text{ L}} = 0.606 \text{ mol/L}$$

b) 2050 cm³ that contains 49.0 g of phosphoric acid. H₃PO₄

$$\begin{aligned} \text{mol} &= \frac{49.0 \text{ g}}{97.99518 \text{ g/mol}} \\ &= 0.500 \text{ mol} \end{aligned} \quad C = \frac{0.500 \text{ mol}}{2.050 \text{ L}} = 0.244 \text{ mol/L}$$

c) 1.50 dm³ that contains 1.0 g of potassium hydroxide. KOH

$$\begin{aligned} \text{mol} &= \frac{1.00 \text{ g}}{56.10564 \text{ g/mol}} \\ &= \frac{0.0178 \text{ mol}}{0.0178 \text{ mol}} \end{aligned} \quad C = \frac{0.0178 \text{ mol}}{1.50 \text{ dm}^3} = 0.012 \text{ mol/L}$$

d) 500.0 cm³ that contains 82.0 g of calcium nitrate. Ca(NO₃)₂

$$\begin{aligned} \text{mol} &= \frac{82.0 \text{ g}}{164.0878 \text{ g/mol}} \\ &= 0.500 \text{ mol} \end{aligned} \quad C = \frac{0.500 \text{ mol}}{0.5000 \text{ L}} = 0.999 \text{ mol/L}$$

e) 250.0 cm³ that contains 50.0 g of copper(II) sulfate pentahydrate. CuSO₄·5H₂O

$$\begin{aligned} \text{mol} &= \frac{50.0 \text{ g}}{249.686 \text{ g/mol}} \\ &= 0.200 \text{ mol} \end{aligned} \quad C = \frac{0.200 \text{ mol}}{0.2500 \text{ L}} = 0.801 \text{ mol/L}$$

f) 1000.0 cm³ that contains 116 g of sodium carbonate heptahydrate. Na₂CO₃·7H₂O

$$\begin{aligned} \text{mol} &= \frac{116 \text{ g}}{232.0957 \text{ g/mol}} \\ &= 0.500 \text{ mol} \end{aligned} \quad C = \frac{0.500 \text{ mol}}{1.0000 \text{ L}} = 0.500 \text{ mol/L}$$

g) 2.00 L that contains 36.0 g of glucose (C₆H₁₂O₆).

$$\begin{aligned} \text{mol} &= \frac{36.0 \text{ g}}{180.15768 \text{ g/mol}} \\ &= 0.200 \text{ mol} \end{aligned} \quad C = \frac{0.200 \text{ mol}}{2.00 \text{ L}} = 0.0999 \text{ mol/L}$$

2. Calculate the volume of solution that can be made from each of the following.

a) A 2.00 M solution using 80.0 g of sodium hydroxide. NaOH

$$\text{mol} = \frac{80.0 \text{ g}}{39.99711 \text{ g/mol}}$$

$$= 2.00 \text{ mol}$$

$$V = \frac{n}{C} = \frac{2.00 \text{ mol}}{2.00 \text{ mol/L}} = 1.00 \text{ L}$$

b) A 0.500 M solution using 80.0 g of sodium hydroxide. NaOH

$$\text{mol} = \frac{80.0 \text{ g}}{39.99711 \text{ g/mol}}$$

$$= 2.00 \text{ mol}$$

$$V = \frac{n}{C} = \frac{2.00 \text{ mol}}{0.500 \text{ mol/L}} = 4.00 \text{ L}$$

c) A 6.00 M solution using 126 g of calcium nitrate. $\text{Ca}(\text{NO}_3)_2$

$$\text{mol} = \frac{126 \text{ g}}{164.0878 \text{ g/mol}}$$

$$= 0.768 \text{ mol}$$

$$V = \frac{n}{C} = \frac{0.768 \text{ mol}}{6.00 \text{ mol/L}} = 0.128 \text{ L}$$

d) A 0.100 M solution using 117 g of sodium chloride. NaCl

$$\text{mol} = \frac{117 \text{ g}}{58.44277 \text{ g/mol}}$$

$$= 2.00 \text{ mol}$$

$$V = \frac{n}{C} = \frac{2.00 \text{ mol}}{0.100 \text{ mol/L}} = 20.0 \text{ L}$$

e) A 1.00 M solution using 50.0 g of copper(II) sulfate pentahydrate. $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$

$$\text{mol} = \frac{50.0 \text{ g}}{249.686 \text{ g/mol}}$$

$$= 0.200 \text{ mol}$$

$$V = \frac{n}{C} = \frac{0.200 \text{ mol}}{1.00 \text{ M}} = 0.200 \text{ L}$$

f) a 0.200 M solution using 200.0 g of sodium sulfide. Na_2S

$$\text{mol} = \frac{200.0 \text{ g}}{78.04554 \text{ g/mol}}$$

$$= 2.563 \text{ mol}$$

$$V = \frac{n}{C} = \frac{2.563 \text{ mol}}{0.200 \text{ mol/L}} = 12.8 \text{ L}$$

3. Calculate the mass of solute in the following solutions.

a) 750.0 mL of 0.500 M calcium chloride. CaCl_2

$$n = C \cdot V = (0.500 \text{ mol/L})(0.7500 \text{ L}) = 0.375 \text{ mol}$$
$$\text{mass} = (0.375 \text{ mol})(110.984 \text{ g/mol}) = 41.6 \text{ g}$$

b) 3000.0 mL of 2.50 M potassium hydroxide. KOH

$$n = C \cdot V = (2.50 \text{ mol/L})(3.0000 \text{ L}) = 7.50 \text{ mol}$$
$$\text{mass} = (7.50 \text{ mol})(56.1056 \text{ g/mol}) = 421 \text{ g}$$

c) 250.0 mL of 2.00 M sodium sulfate. Na_2SO_4

$$n = C \cdot V = (2.00 \text{ mol/L})(0.2500 \text{ L}) = 0.500 \text{ mol}$$
$$\text{mass} = (0.500 \text{ mol})(142.04314 \text{ g/mol}) = 71.0 \text{ g}$$

d) 250.0 cm^3 of 2.00 M sodium sulfate heptahydrate. $\text{Na}_2\text{SO}_4 \cdot 7 \text{H}_2\text{O}$

$$n = C \cdot V = (2.00 \text{ mol/L})(0.2500 \text{ L}) = 0.500 \text{ mol}$$
$$\text{mass} = (0.500 \text{ mol})(268.15015 \text{ g/mol}) = 134 \text{ g}$$

e) 1.500 dm^3 of 0.240 M potassium dihydrogen phosphate. KH_2PO_4

$$n = C \cdot V = (0.240 \text{ mol/L})(1.500 \text{ L}) = 0.360 \text{ mol}$$
$$\text{mass} = (0.360 \text{ mol})(136.08554 \text{ g/mol}) = 49.0 \text{ g}$$

f) 2500.0 cm^3 of 4.00 M potassium permanganate. KMnO_4

$$n = C \cdot V = (4.00 \text{ mol/L})(2.5000 \text{ L}) = 10.0 \text{ mol}$$
$$\text{mass} = (10.0 \text{ mol})(158.0339 \text{ g/mol}) = 1580 \text{ g}$$

g) 250.0 mL of 2.00 M calcium chloride. CaCl_2

$$n = C \cdot V = (2.00 \text{ mol/L})(0.2500 \text{ L}) = 0.500 \text{ mol}$$
$$\text{mass} = (0.500 \text{ mol})(110.984 \text{ g/mol}) = 55.5 \text{ g}$$

h) 225 mL of 0.0350 kmol/m^3 calcium chloride. CaCl_2

$$n = C \cdot V = (0.03500 \text{ mol/L})(0.225 \text{ L}) = 0.00788 \text{ mol}$$
$$(0.00788 \text{ mol})(110.984 \text{ g/mol}) = 0.874 \text{ g}$$

i) 3.45 L of 0.175 kmol/m^3 sodium phosphate. Na_3PO_4

$$n = C \cdot V = (0.175 \text{ mol/L})(3.45 \text{ L}) = 0.604 \text{ mol}$$
$$\text{mass} = (0.604 \text{ mol}) \left(\frac{163.94067}{117.96113} \text{ g/mol} \right) = \cancel{71.2 \text{ g}}$$
$$= 99.0 \text{ g}$$

*4. How would you prepare the following solutions?

a) 1.00 L of 0.500 kmol/m³ MnSO₄, using solid MnSO₄•7H₂O

$$n = C \cdot V = (0.500 \text{ mol/L})(1.00 \text{ L}) = 0.500 \text{ mol}$$

$$\text{mass} = (0.500 \text{ mol})(277.10856 \text{ g/mol}) = 139 \text{ g}$$

Dissolve 139 g MnSO₄•7H₂O in enough water to make 1.00 L of solution.

b) 125 mL of 0.100 kmol/m³ Fe₂(SO₄)₃, using solid Fe₂(SO₄)₃•9H₂O

$$n = (0.100 \text{ mol/L})(0.125 \text{ L}) = 0.0125 \text{ mol}$$

$$\text{mass} = (0.0125 \text{ mol})(562.02232 \text{ g/mol}) = 7.03 \text{ g}$$

Dissolve 7.03 g Fe₂(SO₄)₃•9H₂O in enough water to make 125 mL of sol'n

c) 250.0 mL of 0.0250 kmol/m³ Co(NO₃)₂, using solid Co(NO₃)₂•6H₂O

$$n = (0.0250 \text{ mol/L})(0.2500 \text{ L}) = 0.00625 \text{ mol}$$

$$\text{mass} = (0.00625 \text{ mol})(291.03468 \text{ g/mol}) = 1.82 \text{ g}$$

Dissolve 1.82 g Co(NO₃)₂•6H₂O in enough water to make 250.0 mL sol'n

d) 35.5 mL of 0.00125 kmol/m³ Cl⁻, using solid SnCl₂•2H₂O

$$n = (0.00125 \text{ mol/L})(0.0355 \text{ L}) = 4.44 \times 10^{-5} \text{ mol Cl}^- \left(\frac{1}{2}\right) = 2.22 \times 10^{-5} \text{ mol}$$

$$\text{mass} = (2.22 \times 10^{-5} \text{ mol})(225.64656 \text{ g/mol}) = 0.00501 \text{ g}$$

Dissolve 0.00501 g SnCl₂•2H₂O in enough water to make 35.5 mL of solution.

e) 55.0 mL of 0.550 kmol/m³ SO₄²⁻, using solid Al₂(SO₄)₃•18H₂O

$$n = (0.550 \text{ mol/L})(0.0550 \text{ L}) = 0.0302 \text{ mol SO}_4^{2-} \left(\frac{1}{3}\right) = 0.0101 \text{ mol}$$

$$\text{mass} = (0.0101 \text{ mol})(666.42892 \text{ g/mol}) = 6.72 \text{ g}$$

Dissolve 6.72 g of Al₂(SO₄)₃•18H₂O in enough

f) 225 mL of 0.00200 kmol/m³ OH⁻, using solid Ca(OH)₂.

$$n = (0.00200 \text{ mol/L})(0.225 \text{ L}) = 4.50 \times 10^{-4} \text{ mol OH}^- \left(\frac{1}{2}\right) = 2.25 \times 10^{-4} \text{ mol}$$

$$\text{mass} = (2.25 \times 10^{-4})(74.09268 \text{ g/mol}) = 0.0167 \text{ g}$$

Dissolve 0.0167 g of Ca(OH)₂ in enough water to prepare 225 mL sol'n

5. Complete the following table for aqueous solutions of glucose, $C_6H_{12}O_6$.

	Mass of Solute	Moles of Solute	Volume of Solution	Molarity
a	12.5g	0.0694 mol	219 mL	0.317 M
b	195g	1.08 mol	2.08 L	0.519 M
c	315g	1.75 mol	1.62 L	1.08 M

$$a) \frac{12.5 \text{ g}}{180.15768 \text{ g/mol}} = 0.0694 \text{ mol} \quad C = \frac{n}{V} = \frac{0.0694 \text{ mol}}{0.219 \text{ L}} = 0.317 \text{ mol/L}$$

$$b) (1.08 \text{ mol})(180.15768 \text{ g/mol}) = 195 \text{ g}$$

$$V = \frac{n}{c} = \frac{1.08 \text{ mol}}{0.519 \text{ mol/L}} = 2.08 \text{ L}$$

$$c) n = C \cdot V = (1.08 \text{ mol/L})(1.62 \text{ L}) = 1.75 \text{ mol}$$

$$(1.75 \text{ mol})(180.15768 \text{ g/mol}) = 315 \text{ g}$$

6. A teacher needs to prepare 15 sets of solutions for a chemistry lab. Each set must have 70.0 cm³ of 0.200 M iron(II) sulfate heptahydrate. What mass of iron(II) sulfate heptahydrate is required to prepare enough solution for the class?

$$\text{Volume} = (15 \text{ sets})(70.0 \text{ cm}^3/\text{set}) = 1050 \text{ cm}^3 = 1.05 \text{ L}$$

$$n = C \cdot V = (0.200 \text{ mol/L})(1.05 \text{ L}) = 0.210 \text{ mol}$$

$$\text{mass} = (\text{mol})(\text{mol mass})$$

$$\text{Fe}_2\text{SO}_4 \cdot 7\text{H}_2\text{O}$$

$$= (0.210 \text{ mol}) \left(\frac{214.01496 \text{ g/mol}}{278.01056 \text{ g/mol}} \right)$$

$$= \cancel{44.9} \text{ g} \quad 58.4 \text{ g}$$

$$C_1V_1 = C_2V_2$$

7. How would you prepare the following solutions?

a) 2.50 L of 0.375 kmol/m³ solution using 15.4 kmol/m³ nitric acid?

$$V_2 = \frac{C_1V_1}{C_2} = \frac{(0.375 \text{ mol/L})(2.50 \text{ L})}{(15.4 \text{ mol/L})} = 0.0609 \text{ L} = 60.9 \text{ mL}$$

⇒ Dissolve 60.9 mL of 15.4 M HNO₃ in enough water to make 2.50 L sol'n

b) 45.5 L of 0.0375 kmol/m³ solution using 14.6 kmol/m³ phosphoric acid?

$$V_2 = \frac{C_1V_1}{C_2} = \frac{(0.0375 \text{ mol/L})(45.5 \text{ L})}{(14.6 \text{ mol/L})} = 0.117 \text{ L}$$

⇒ Dissolve 0.117 L 14.6 M H₃PO₄ in enough water to make 45.5 L sol'n.

c) 500.0 mL of 0.500 mol/L solution, using 2.00 mol/L sodium chloride.

$$V_2 = \frac{C_1V_1}{C_2} = \frac{(0.500 \text{ mol/L})(0.5000 \text{ L})}{2.00 \text{ mol/L}} = 0.125 \text{ L}$$

⇒ Dissolve 0.125 L of 2.00 M NaCl in enough water to make 500.0 mL sol'n.

d) 2.00 L of 0.200 mol/L solution, using 0.500 mol/L magnesium sulfate.

$$V_2 = \frac{C_1V_1}{C_2} = \frac{(0.200 \text{ mol/L})(2.00 \text{ L})}{(0.500 \text{ mol/L})} = 0.800 \text{ L}$$

⇒ Dissolve 0.800 L of 0.500 M MgSO₄ in enough water to make 2.00 L sol'n

e) 50.0 mL of 0.200 mol/L solution, using 4.00 mol/L potassium nitrate.

$$V_2 = \frac{C_1V_1}{C_2} = \frac{(0.200 \text{ mol/L})(0.0500 \text{ L})}{4.00 \text{ mol/L}} = 0.00250 \text{ L} = 2.50 \text{ mL}$$

⇒ Dissolve 2.50 mL of 4.00 mol/L KNO₃ in enough water to make 50.0 mL sol'n

f) 1.50 L of 0.250 mol/L solution, using 15.4 mol/L nitric acid.

$$V_2 = \frac{C_1V_1}{C_2} = \frac{(0.250 \text{ mol/L})(1.50 \text{ L})}{(15.4 \text{ mol/L})} = 0.0244 \text{ L} = 24.4 \text{ mL}$$

⇒ Dissolve 24.4 mL 15.4 M HNO₃ in enough water to make 1.50 L of sol'n.

8. What is the molar concentration of the nitric acid solution resulting from the mixture of 5.00 mL of 3.50 kmol/m^3 nitric acid and 95.0 mL of 0.200 kmol/m^3 nitric acid?

$$C_{ab} = \frac{C_a V_a + C_b V_b}{V_a + V_b} = \frac{(3.50 \text{ mol/L})(0.00500 \text{ L}) + (0.200 \text{ mol/L})(0.0950 \text{ L})}{0.00500 \text{ L} + 0.0950 \text{ L}}$$

$$= \frac{0.0175 \text{ mol} + 0.0190 \text{ mol}}{0.100 \text{ L}} = \frac{0.0365 \text{ mol}}{0.100 \text{ L}}$$

$$= 0.365 \text{ mol/L}$$

9. If one drop (0.050 mL) of 0.200 kmol/m^3 sodium bromide is added to 100.00 mL of water, what is the concentration of the resulting solution?

$$C_1 V_1 = C_2 V_2 \quad C_2 = \frac{C_1 V_1}{V_2} = \frac{(0.200 \text{ mol/L})(0.000050 \text{ L})}{0.10005 \text{ L}}$$

$$= 1.01 \times 10^{-4} \text{ or } 0.00010 \text{ mol/L}$$

10. What is the concentration of the solution that results when 250.0 mL of 0.400 M sodium hydroxide is mixed with 500.0 mL of 2.00 M sodium hydroxide.

$$C_{ab} = \frac{C_a V_a + C_b V_b}{V_a + V_b} = \frac{(0.400 \text{ mol/L})(0.2500 \text{ L}) + (2.00 \text{ mol/L})(0.5000 \text{ L})}{0.2500 \text{ L} + 0.5000 \text{ L}}$$

$$= \frac{0.100 \text{ mol} + 1.00 \text{ mol}}{0.7500 \text{ L}} = \frac{1.10 \text{ mol}}{0.7500 \text{ L}}$$

$$= 1.47 \text{ mol/L}$$

11. If 300.0 mL of solution A contains 25.0 g of potassium chloride and 250.0 mL of solution B contains 60.0 g of potassium chloride, what is the molar concentration of the potassium chloride solution resulting from the mixture of solutions A and B?

$$C = \frac{\text{total mol}}{\text{total vol}} \quad \text{total mol} = \frac{\text{total mass}}{\text{mol mass}} = \frac{85.0 \text{ g KCl}}{74.5513 \text{ g/mol}}$$

$$= 1.14 \text{ mol KCl}$$

$$C = \frac{\text{total mol}}{\text{total vol}} = \frac{1.14 \text{ mol}}{0.5500 \text{ L}} = 2.07 \text{ mol/L}$$

*12. Solution A is 0.475 kmol/m^3 in sodium hydroxide. Solution B also contains sodium hydroxide. When 250.0 mL of solution A is mixed with 400.0 mL of solution B, the resulting solution is 0.325 kmol/m^3 in sodium hydroxide. What is the molar concentration of solution B?

$$C_{ab} = \frac{C_a V_a + C_b V_b}{V_a + V_b}$$

$$0.325 \text{ mol/L} = \frac{(0.475 \text{ mol/L})(0.2500 \text{ L}) + C_b(0.4000 \text{ L})}{0.2500 \text{ L} + 0.4000 \text{ L}}$$

$$0.325 \text{ mol/L} = \frac{0.119 \text{ mol} + (0.4000 \text{ L})C_b}{0.6500 \text{ L}}$$

$$0.211 \text{ mol} = 0.119 \text{ mol} + (0.4000 \text{ L})C_b$$

$$0.0925 \text{ mol} = (0.4000 \text{ L})C_b$$

$$\frac{0.0925 \text{ mol}}{0.4000 \text{ L}} = C_b \quad C_b = 0.231 \text{ mol/L}$$

*13. Solution X is 0.135 kmol/m^3 in sodium chloride. Solution Y also contains sodium chloride. When 55.0 mL of solution X is mixed with 125 mL of solution Y, the resulting solution is 0.185 kmol/m^3 in sodium chloride. How many grams of sodium chloride are contained in 300.0 mL of solution y?

$$C_{ab} = \frac{C_a V_a + C_b V_b}{V_a + V_b}$$

$$0.165 \text{ mol/L} = \frac{(0.135 \text{ mol/L})(0.0550 \text{ L}) + C_b(0.125 \text{ L})}{0.0550 \text{ L} + 0.125 \text{ L}}$$

$$0.165 \text{ mol/L} = \frac{0.00742 \text{ mol} + (0.125 \text{ L})C_b}{0.180 \text{ L}}$$

$$0.0297 \text{ mol} = 0.00742 \text{ mol} + (0.125 \text{ L})C_b$$

$$0.0223 \text{ mol} = (0.125 \text{ L})C_b$$

$$C_b = \frac{0.0223 \text{ mol}}{0.125 \text{ L}}$$

$$= 0.178 \text{ mol/L}$$

$$\begin{aligned} C_b &= \\ n &= C \cdot V = (0.178 \text{ mol/L})(0.3000 \text{ L}) \\ &= 0.0535 \text{ mol} \\ \text{mass} &= (0.0535 \text{ mol})(58.442 \text{ g/mol}) \\ &= 3.12 \text{ g} \end{aligned}$$

*14. Solution A is 0.125 M sodium hydroxide and Solution B is 2.50 M sodium hydroxide. What volume of Solution B must be added to 400.0 mL of Solution A if the concentration of the resulting solution is 1.75 M sodium hydroxide?

$$C_{ab} = \frac{C_a V_a + C_b V_b}{V_a + V_b}$$

$$1.75 \text{ mol/L} = \frac{(0.125 \text{ mol/L})(0.4000 \text{ L}) + (2.50 \text{ mol/L}) V_b}{0.4000 \text{ L} + V_b}$$

$$(1.75 \text{ mol/L})(0.4000 \text{ L} + V_b) = 0.0500 \text{ mol} + (2.50 \text{ mol/L}) V_b$$

$$0.700 \text{ mol} + (1.75 \text{ mol/L}) V_b = 0.0500 \text{ mol} + (2.50 \text{ mol/L}) V_b$$

$$0.700 \text{ mol} - 0.0500 \text{ mol} = (2.50 \text{ mol/L}) V_b - (1.75 \text{ mol/L}) V_b$$

$$0.650 \text{ mol} = (0.750 \text{ mol/L}) V_b$$

$$V_b = \frac{0.650 \text{ mol}}{0.750 \text{ mol/L}} = 0.867 \text{ L of Solution B}$$

15. What is the concentration of a sodium hydroxide solution that results when 75.0 mL of 0.125 M sodium hydroxide is mixed with 50.0 mL of 2.50 M sodium hydroxide?

$$C_{ab} = \frac{C_a V_a + C_b V_b}{V_a + V_b}$$

$$C_{ab} = \frac{(0.125 \text{ mol/L})(0.0750 \text{ L}) + (2.50 \text{ mol/L})(0.0500 \text{ L})}{0.0750 \text{ L} + 0.0500 \text{ L}}$$

$$C_{ab} = \frac{0.00938 \text{ mol} + 0.125 \text{ mol}}{0.125 \text{ L}}$$

$$C_{ab} = \frac{0.134 \text{ mol}}{0.125 \text{ L}}$$

$$C_{ab} = 1.075 \Rightarrow 1.08 \text{ mol/L}$$