Molarity

1. Calculate the molarity of the following solutions.

a) 825 cm^3 that contains 30.0 g of acetic acid. CH_3COOH or $HC_2H_3O_2$

$mol = \frac{30.0\ g}{60.05258\ g/mol} = 0.500\ mol$

$C = \frac{0.500\ mol}{0.825\ L} = 0.606\ mol/L$

b) 2050 cm^3 that contains 49.0 g of phosphoric acid. H_3PO_4

$mol = \frac{49.0\ g}{97.99518\ g/mol} = 0.500\ mol$

$C = \frac{0.500\ mol}{2.050\ L} = 0.244\ mol/L$

c) 1.50 dm^3 that contains 1.0 g of potassium hydroxide. KOH

$mol = \frac{1.00\ g}{56.10564\ g/mol} = 0.0178\ mol$

$C = \frac{0.0178\ mol}{1.50\ dm^3} = 0.012\ mol/L$

d) 500.0 cm^3 that contains 82.0 g of calcium nitrate. $Ca(NO_3)_2$

$mol = \frac{82.0\ g}{164.0878\ g/mol} = 0.500\ mol$

$C = \frac{0.500\ mol}{0.5000\ L} = 0.999\ mol/L$

e) 250.0 cm^3 that contains 50.0 g of copper(II) sulfate pentahydrate. $CuSO_4 \cdot 5H_2O$

$mol = \frac{50.0\ g}{249.686\ g/mol} = 0.200\ mol$

$C = \frac{0.200\ mol}{0.2500\ L} = 0.801\ mol/L$

f) 1000.0 cm^3 that contains 116 g of sodium carbonate heptahydrate. $Na_2CO_3 \cdot 7H_2O$

$mol = \frac{116\ g}{232.0957\ g/mol} = 0.500\ mol$

$C = \frac{0.500\ mol}{1.0000\ L} = 0.500\ mol/L$

g) 2.00 L that contains 36.0 g of glucose ($C_6H_{12}O_6$).

$mol = \frac{36.0\ g}{180.15768\ g/mol} = 0.200\ mol$

$C = \frac{0.200\ mol}{2.00\ L} = 0.0999\ mol/L$

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. $NaOH$

$$mol = \frac{80.0\ g}{39.9971\ g/mol} = 2.00\ mol \qquad V = \frac{n}{C} = \frac{2.00\ mol}{2.00\ mol/L} = 1.00\ L$$

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

$$mol = \frac{80.0\ g}{39.9971\ g/mol} = 2.00\ mol \qquad V = \frac{n}{C} = \frac{2.00\ mol}{0.500\ mol/L} = 4.00\ L$$

c) A 6.00 M solution using 126 g of calcium nitrate. $Ca(NO_3)_2$

$$mol = \frac{126\ g}{164.0878\ g/mol} = 0.768\ mol \qquad V = \frac{n}{C} = \frac{0.768\ mol}{6.00\ mol/L} = 0.128\ L$$

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

$$mol = \frac{117\ g}{58.44277\ g/mol} = 2.00\ mol \qquad V = \frac{n}{C} = \frac{2.00\ mol}{0.100\ mol/L} = 20.0\ L$$

e) A 1.00 M solution using 50.0 g of copper(II) sulfate pentahydrate. $CuSO_4 \cdot 5H_2O$

$$mol = \frac{50.0\ g}{249.686\ g/mol} = 0.200\ mol \qquad V = \frac{n}{C} = \frac{0.200\ mol}{1.00\ M} = 0.200\ L$$

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

$$mol = \frac{200.0\ g}{78.04554\ g/mol} = 2.563\ mol \qquad V = \frac{n}{C} = \frac{2.563\ mol}{0.200\ mol/L} = 12.8\ L$$

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

a) 750.0 mL of 0.500 M calcium chloride. $CaCl_2$

$n = C \cdot V = (0.500\ mol/L)(0.7500\ L) = 0.375\ mol$

$mass = (0.375\ mol)(110.984\ g/mol) = 41.6\ g$

b) 3000.0 mL of 2.50 M potassium hydroxide. KOH

$n = C \cdot V = (2.50\ mol/L)(3.0000\ L) = 7.50\ mol$

$mass = (7.50\ mol)(56.10564\ g/mol) = 421\ g$

c) 250.0 mL of 2.00 M sodium sulfate. Na_2SO_4

$n = C \cdot V = (2.00\ mol/L)(0.2500\ L) = 0.500\ mol$

$mass = (0.500\ mol)(142.04314\ g/mol) = 71.0\ g$

d) 250.0 cm^3 of 2.00 M sodium sulfate heptahydrate. $Na_2SO_4 \cdot 7\ H_2O$

$n = C \cdot V = (2.00\ mol/L)(0.2500\ L) = 0.500\ mol$

$mass = (0.500\ mol)(268.1501\ g/mol) = 134\ g$

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

$n = C \cdot V = (0.240\ mol/L)(1.500\ L) = 0.360\ mol$

$mass = (0.360\ mol)(136.08554\ g/mol) = 49.0\ g$

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

$n = C \cdot V = (4.00\ mol/L)(2.5000\ L) = 10.0\ mol$

$mass = (10.0\ mol)(158.0339\ g/mol) = 1580\ g$

g) 250.0 mL of 2.00 M calcium chloride. $CaCl_2$

$n = C \cdot V = (2.00\ mol/L)(0.2500\ L) = 0.500\ mol$

$mass = (0.500\ mol)(110.984\ g/mol) = 55.5\ g$

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

$n = C \cdot V = (0.03500\ mol/L)(0.225\ L) = 0.00788\ mol$

$(0.00788\ mol)(110.984\ g/mol) = 0.874\ g$

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

$n = C \cdot V = (0.175\ mol/L)(3.45\ L) = 0.604\ mol$

$mass = (0.604\ mol)(163.94067 + 117.46113\ g/mol) = 171.2\ g$

$= 99.0\ g$

*4. How would you prepare the following solutions?

a) 1.00 L of 0.500 kmol/m^3 $MnSO_4$, using solid $MnSO_4 \cdot 7H_2O$

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

$Mass = (0.500\ mol)(277.10856\ g/mol) = 139\ g$

Dissolve 139 g $MnSO_4 \cdot 7H_2O$ in enough water to make 1.00 L of solution.

b) 125 mL of 0.100 kmol/m^3 $Fe_2(SO_4)_3$, using solid $Fe_2(SO_4)_3 \cdot 9H_2O$

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

$Mass = (0.0125\ mol)(562.02232\ g/mol) = 7.03\ g$

Dissolve 7.03 g $Fe_2(SO_4)_3 \cdot 9H_2O$ in enough water to make 125 mL of sol'n

c) 250.0 mL of 0.0250 kmol/m^3 $Co(NO_3)_2$, using solid $Co(NO_3)_2 \cdot 6H_2O$

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

$Mass = (0.00625\ mol)(291.03468\ g/mol) = 1.82\ g$

Dissolve 1.82 g $Co(NO_3)_2 \cdot 6H_2O$ in enough water to make 250.0 mL sol'n

d) 35.5 mL of 0.001 25 kmol/m^3 Cl^-, using solid $SnCl_2 \cdot 2H_2O$

$n = (0.001\ 25\ mol/L)(0.0355\ L) = 4.44 \times 10^{-5}\ mol\ Cl^- \left(\frac{1}{2}\right) = 2.22 \times 10^{-5}\ mol$

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

Dissolve 0.005 01 g $SnCl_2 \cdot 2H_2O$ in enough water to make 35.5 mL of solution.

e) 55.0 mL of 0.550 kmol/m^3 SO_4^{2-}, using solid $Al_2(SO_4)_3 \cdot 18H_2O$

$n = (0.550\ mol/L)(0.0550\ L) = 0.0302\ mol\ SO_4^{2-} \left(\frac{1}{3}\right) = 0.0101\ mol$

$Mass = (0.0101\ mol)(666.42892\ g/mol) = 6.72\ g$

Dissolve 6.72 g of $Al_2(SO_4)_3 \cdot 18H_2O$ in enough

f) 225 mL of 0.002 00 kmol/m^3 OH^-, using solid $Ca(OH)_2$.

$n = (0.002\ 00\ mol/L)(0.225\ L) = 4.50 \times 10^{-4}\ mol\ OH^- \left(\frac{1}{2}\right) = 2.25 \times 10^{-4}\ mol$

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

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

b) $(1.08\ mol)(180.157\,68\ g/mol) = 195\,g$

$V = \frac{n}{C} = \frac{1.08\ mol}{0.519\ mol/L} = 2.08\,L$

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

$(1.75\ mol)(180.157\,68\ g/mol) = 315\,g$

6. A teacher needs to prepare 15 sets of solutions for a chemistry lab. Each se must have 70.0 cm^3 of 0.200 M iron(II) sulfate heptahydrate. What mass of iron(II) sulfate heptahydrate is required to prepare enough solution for the class?

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

$n = C \cdot V = (0.200\ mol/L)(1.05\,L) = 0.210\ mol$

mass = (mol)(mol mass)

$FeSO_4 \cdot 7H_2O$

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

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

$$C_1V_1 = C_2V_2$$

7. How would you prepare the following solutions?

a) 2.50 L of 0.375 kmol/m^3 solution using 15.4 kmol/m^3 nitric acid?

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

⇒ Dissolve 60.9 mL of 15.4 M HNO_3 in enough water to make 2.50 L sol'n

b) 45.5 L of 0.0375 kmol/m^3 solution using 14.6 kmol/m^3 phosphoric acid?

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

⇒ Dissolve 0.117 L 14.6 M H_3PO_4 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.

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

⇒ 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.

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

⇒ Dissolve 0.800 L of 0.500 M $MgSO_4$ 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.

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

⇒ Dissolve 2.50 mL of 4.00 mol/L KNO_3 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.

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

⇒ Dissolve 24.4 mL 15.4 M HNO_3 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?

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

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

$$= 0.365\ mol/L$$

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?

$$C_1V_1 = C_2V_2 \qquad C_2 = \frac{C_1V_1}{V_2} = \frac{(0.200\ mol/L)(0.000050\ L)}{0.10005\ L}$$

$$= 1.0 \times 10^{-4} \text{ or } 0.00010\ mol/L$$

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.

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

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

$$= 1.47\ mol/L$$

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 form the mixture of solutions A and B?

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

$$= 1.14\ mol\ KCl$$

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

*12. Solution A is 0.475 (C_a) kmol/m^3 in sodium hydroxide. Solution B also contains sodium hydroxide. When 250.0 (V_a) mL of solution A is mixed with 400.0 (V_b) mL of solution B, the resulting solution is 0.325 (C_{ab}) kmol/m^3 in sodium hydroxide. What is the molar concentration of solution B?

$$C_{ab} = \frac{C_aV_a + C_bV_b}{V_a + V_b}$$

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

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

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

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

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

*13. Solution X is 0.135 (C_a) kmol/m^3 in sodium chloride. Solution Y also contains sodium chloride. When 55.0 (V_a) mL of solution X is mixed with 125 (V_b) mL of solution Y, the resulting solution is 0.165 (C_{ab}) kmol/m^3 in sodium chloride. How many grams of sodium chloride are contained in 300.0 mL of solution y?

$$C_{ab} = \frac{C_aV_a + C_bV_b}{V_a + V_b}$$

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

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

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

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

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

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

C_b

$$n = C \cdot V = (0.178\ \text{mol/L})(0.3000\text{L})$$

$$= 0.0535\ \text{mol}$$

$$\text{mass} = (0.0535\ \text{mol})(58.4417\ \text{g/mol})$$

$$= 3.12\ \text{g}$$

*14. Solution A is 0.125 (C_a) M sodium hydroxide and Solution B is 2.50 (C_b) M sodium hydroxide. What volume (V_a) of Solution B must be added to 400.0 mL of Solution A if the concentration of the resulting solution is 1.75 (C_{ab}) M sodium hydroxide?

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

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

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

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

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

$$0.650\ mol = (0.750\ mol/L)V_b$$

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

15. What is the concentration (C_{ab}) of a sodium hydroxide solution that results when 75.0 (V_a) mL of 0.125 (C_a) M sodium hydroxide is mixed with 50.0 (V_b) mL of 2.50 (C_b) M sodium hydroxide?

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

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

$$C_{ab} = \frac{0.009\,38\ mol + 0.125\ mol}{0.125\ L}$$

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

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