

CHEQ 1094 EMPIRICAL FORMULAS: ANSWERS

1.		C	:	H	:	O	:	N
	mass ratio	74.05		7.46		9.86		8.63
	mole ratio	$\frac{74.05}{12.0}$		$\frac{7.46}{1.01}$		$\frac{9.86}{16.0}$		$\frac{8.63}{14.0}$
		= 6.17		7.39		0.616		0.616
	divide by 0.616	= $\frac{6.17}{0.616}$		$\frac{7.39}{0.616}$		$\frac{0.616}{0.616}$		$\frac{0.616}{0.616}$
		= 10		12		1		1

The empirical formula of quinine is $C_{10}H_{12}ON$

2.		C	:	H	:	N
	mass ratio	54.50		13.72		31.78
	mole ratio	$\frac{54.50}{12.01}$		$\frac{13.72}{1.008}$		$\frac{31.78}{14.01}$
		= 4.538		13.61		2.268
	divide by 2.268	$\frac{4.538}{2.268}$		$\frac{13.61}{2.268}$		$\frac{2.268}{2.268}$
		= 2.0		6.0		1

The empirical formula of putrescine is C_2H_6N

3.		Ca	:	P	:	O	:	H
	mass ratio	39.985		18.498		41.406		0.201
	mole ratio	$\frac{39.985}{40.08}$		$\frac{18.498}{30.97}$		$\frac{41.406}{16.00}$		$\frac{0.201}{1.008}$
		= 0.995		0.597		2.588		0.199
	divide by 0.199	$\frac{0.995}{0.199}$		$\frac{0.597}{0.199}$		$\frac{2.588}{0.199}$		$\frac{0.199}{0.199}$
		= 5.0		3.0		13.0		1

The formula of hydroxyl apatite is $Ca_5P_3O_{13}H$

4.		C	:	H	:	N	:	O	
	mass ratio	73.25		12.01		3.85		10.7	12.2
	mole ratio	$\frac{73.25}{12.01}$		$\frac{12.01}{12.01}$		$\frac{3.85}{1.01}$		$\frac{10.7}{14.0}$	$\frac{12.2}{16.0}$
	=	6.10		1.0		3.81		0.764	0.763
	divide by 0.763	$\frac{6.10}{0.763}$		$\frac{1.0}{0.763}$		$\frac{3.81}{0.763}$		$\frac{0.764}{0.763}$	$\frac{0.763}{0.763}$
	=	8.0		1.3		5.0		1.0	1

(i) The empirical formula of indigo is C_8H_5NO

(ii) Emp. FW = $(8 \times 12) + (5 \times 1) + 14 + 16 = 131$

Molecular formula is $(C_8H_5NO)_n$ where $n = MW / \text{Emp FW}$
 $n = 260 / 131 = 2$ Therefore, molecular formula is $C_{16}H_{10}N_2O_2$

5. % O = $100 - 40.92 - 4.58 = 54.50$

		C	:	H	:	O	
	mass ratio	40.92		4.58		54.50	
	mole ratio	$\frac{40.92}{12.01}$		$\frac{4.58}{1.01}$		$\frac{54.50}{16.00}$	
	=	3.41		4.53		3.41	
	divide by 3.41	$\frac{3.41}{3.41}$		$\frac{4.53}{3.41}$		$\frac{3.41}{3.41}$	
	=	1		1.33		1	
	multiply by 3 =	3		4		3	

The empirical formula of vitamin C is $C_3H_4O_3$ and its Emp. FW is $(3 \times 12) + (4 \times 1) + (3 \times 16) = 88$

$n = MW / \text{Emp. FW} = 177 / 88 = 2$ Molecular formula is $C_6H_8O_6$

6. mass of N = $(10.19 - 8.26) \text{ g} = 1.93 \text{ g}$

mass ratio (Ca : N) = $8.26 : 1.93$

mole ratio (Ca : N) = $8.26 / 40.08 : 1.93 / 14.01 = 0.206 : 0.138$

= $1.5 : 1 = 3 : 2$ Hence, empirical formula is Ca_3N_2

7. molar mass of $\text{Na}_2\text{CO}_3 = 106.0 \text{ g/mol}$
 molar mass of $\text{H}_2\text{O} = 18.02 \text{ g/mol}$
 mass of $\text{H}_2\text{O} = (2.3527 - 0.8719) \text{ g} = 1.4808 \text{ g}$

$$\text{moles of H}_2\text{O} = 1.4808 \text{ g H}_2\text{O} \times \frac{1 \text{ mol H}_2\text{O}}{18.02 \text{ g H}_2\text{O}} = 0.08218 \text{ mol H}_2\text{O}$$

$$\text{moles of Na}_2\text{CO}_3 = 0.8719 \text{ g Na}_2\text{CO}_3 \times \frac{1 \text{ mol Na}_2\text{CO}_3}{106.0 \text{ g Na}_2\text{CO}_3} = 0.008225 \text{ mol Na}_2\text{CO}_3$$

$$n = \frac{\text{mols H}_2\text{O}}{\text{mols Na}_2\text{CO}_3} = \frac{0.08218}{0.008225} = 10$$

8. Since $\text{CaSO}_4 \cdot \text{XH}_2\text{O}$ is 20.91% water, 100 g of $\text{CaSO}_4 \cdot \text{XH}_2\text{O}$ contains 20.91 g of H_2O and $(100 - 20.91) \text{ g} = 79.09 \text{ g CaSO}_4$
 molar mass of $\text{H}_2\text{O} = 18.02 \text{ g/mol}$
 molar mass of $\text{CaSO}_4 = 136.1 \text{ g/mol}$

$$\text{moles H}_2\text{O} = 20.91 \text{ g H}_2\text{O} \times \frac{1 \text{ mol H}_2\text{O}}{18.02 \text{ g H}_2\text{O}} = 1.160 \text{ mol H}_2\text{O}$$

$$\text{moles CaSO}_4 = 79.09 \text{ g CaSO}_4 \times \frac{1 \text{ mol CaSO}_4}{136.1 \text{ g CaSO}_4} = 0.5811 \text{ mol CaSO}_4$$

$$X = \frac{\text{mols H}_2\text{O}}{\text{mols CaSO}_4} = \frac{1.160}{0.5811} = 2$$

9. mass of $\text{H}_2\text{O} = (0.5826 - 0.2846) \text{ g} = 0.2980 \text{ g}$

$$\text{moles H}_2\text{O} = 0.2980 \text{ g H}_2\text{O} \times \frac{1 \text{ mol H}_2\text{O}}{18.02 \text{ g H}_2\text{O}} = 0.01637 \text{ mol H}_2\text{O}$$

$$\text{moles MSO}_4 = 0.01637 \text{ mol H}_2\text{O} \times \frac{1 \text{ mol MSO}_4}{7 \text{ mol H}_2\text{O}} = 0.002362 \text{ mol MSO}_4$$

$$\text{molar mass of MSO}_4 = \frac{0.2846 \text{ g}}{0.002362 \text{ mol}} = 120.5 \text{ g/mol}$$

AW (molar mass) of M = $120.5 - 32.06 - 64.00 = 24.4 \text{ g/mol}$
 therefore, M is Mg (AW 24.31)