More Examples of Empirical Formula Problems

The following compounds contain only carbon and hydrogen.

1. A compound is 92.26% by mass carbon and 7.74% by mass hydrogen. What is the empirical formula?

   Solution: Assume 100g of sample total.

   $$92.26\ g\ C \cdot \frac{mol}{12.011\ g} = 7.681\ mol\ C \qquad 7.74\ g\ H \cdot \frac{mol}{1.008\ g} = 7.679\ mol\ H$$

   $$\frac{7.681\ mol\ C}{7.679\ mol\ H} = 1.0003\ {}^{C}\!/_{H}$$

   So there is 1 carbon atom per every hydrogen atom. The empirical formula is **CH**.

2. A compound is 85.63% by mass carbon and 14.37% by mass hydrogen. What is the empirical formula?

   Solution: Assume 100g of sample total.

   $$85.63\ g\ C \cdot \frac{mol}{12.011\ g} = 7.129\ mol\ C \qquad 14.37\ g\ H \cdot \frac{mol}{1.008\ g} = 14.26\ mol\ H$$

   $$\frac{14.26\ mol\ H}{7.129\ mol\ C} = 2.0003\ {}^{H}\!/_{C}$$

   So there are 2 hydrogen atoms per every carbon atom. The empirical formula is $\mathbf{CH_2}$.

3. A compound is 88.82% by mass carbon and 11.18% by mass hydrogen. What is the empirical formula?

   Solution: Assume 100g of sample total.

   $$88.82\ g\ C \cdot \frac{mol}{12.011\ g} = 7.395\ mol\ C \qquad 11.18\ g\ H \cdot \frac{mol}{1.008\ g} = 11.09\ mol\ H$$

   $$\frac{11.09\ mol\ H}{7.395\ mol\ C} = 1.4997\ {}^{H}\!/_{C}$$

   So there are 1.5 H atoms per C atom or 3 H atoms per every 2 C atoms. The empirical formula is $\mathbf{C_2H_3}$.

4. A compound is 89.49% by mass carbon and 10.51% by mass hydrogen. What is the empirical formula? (This one is hard!)

Solution: Assume 100g of sample total.

$$89.49\ g\ C \cdot \frac{mol}{12.011\ g} = 7.451\ mol\ C \qquad 10.51\ g\ H \cdot \frac{mol}{1.008\ g} = 10.43\ mol\ H$$

$$\frac{10.43\ mol\ H}{7.451\ mol\ C} = 1.3994\ {}^{H}\!/_{C}$$

So there are 1.4 H atoms per every C atom. This could also be interpreted as 14 H atoms for every 10 C atoms . . or 7 H atoms for every 5 C atoms. The empirical formula is **C_5H_7.**

5. A compound is 82.66% by mass carbon and 17.34% by mass hydrogen. What is the empirical formula? (*Ans*: C_2H_5)

6. A compound is 87.73% by mass carbon and 12.27% by mass hydrogen. What is the empirical formula? (*Ans*: C_3H_5)

7. A compound is 90.85% by mass carbon and 9.15% by mass hydrogen. What is the empirical formula? (*Ans*: C_5H_6 – this is another hard one!)

8. A compound is 83.24% by mass carbon and 16.76% by mass hydrogen. What is the empirical formula? (*Ans*: C_5H_{12})

<u>The following compounds contain carbon, hydrogen and oxygen</u>.

9. A compound is 40.00% by mass carbon, 6.71% by mass hydrogen and 53.28% by mass oxygen. What is the empirical formula? (*Ans*: CH_2O)

Solution: Assume 100g of sample total.

$$40.00\ g\ C \cdot \frac{mol}{12.011\ g} = 3.330\ mol\ C \qquad \frac{3.330\ mol\ C}{3.330\ mol\ O} = 1.0\ {}^{C}\!/_{O}$$

$$6.71\ g\ H \cdot \frac{mol}{1.008\ g} = 6.657\ mol\ H \qquad \frac{6.657\ mol\ H}{3.330\ mol\ O} = 1.9991\ {}^{H}\!/_{O}$$

$$53.28\ g\ O \cdot \frac{mol}{15.995\ g} = 3.330\ mol\ O$$

So there is 1 C atoms per every O atom and 2 H atoms for every O atom. The empirical formula is **CH_2O.**

10. A compound is 52.14% by mass carbon, 13.13% by mass hydrogen and 34.73% by mass oxygen. What is the empirical formula? (*Ans*: C_2H_6O)

Solution: Assume 100g of sample total.

$$52.14\ g\ C \cdot \frac{mol}{12.011\ g} = 4.341\ mol\ C$$

$$\frac{4.341\ mol\ C}{2.171\ mol\ O} = 1.9995\ {}^{C}\!/_{O}$$

$$6.71\ g\ H \cdot \frac{mol}{1.008\ g} = 13.026\ mol\ H$$

$$\frac{13.026\ mol\ H}{2.171\ mol\ O} = 6.0\ {}^{H}\!/_{O}$$

$$34.73\ g\ O \cdot \frac{mol}{15.995\ g} = 2.171\ mol\ O$$

So there are 2 C atoms per every O atom and 6 H atoms for every O atom. The empirical formula is **C_2H_6O.**

11. A compound is 26.68% by mass carbon, 2.24% by mass hydrogen and 71.08% by mass oxygen. What is the empirical formula?

Solution: Assume 100g of sample total.

$$26.68\ g\ C \cdot \frac{mol}{12.011\ g} = 2.221\ mol\ C$$

$$\frac{2.221\ mol\ C}{2.22\ mol\ H} = 1.0005\ {}^{C}\!/_{H}$$

$$2.24\ g\ H \cdot \frac{mol}{1.008\ g} = 2.22\ mol\ H$$

$$71.08\ g\ O \cdot \frac{mol}{15.995\ g} = 4.443\ mol\ O$$

$$\frac{4.443\ mol\ O}{2.22\ mol\ H} = 2.0014\ {}^{O}\!/_{H}$$

So there are 1 C atoms and 2 O atoms for every H atom. The empirical formula is **CHO_2.**

12. A compound is 53.31% by mass carbon, 11.18% by mass hydrogen and 35.51% by mass oxygen. What is the empirical formula? (*Ans*: C_2H_5O)

13. A compound is 47.35% by mass carbon, 10.60% by mass hydrogen and 42.05% by mass oxygen. What is the empirical formula? (*Ans*: $C_3H_8O_2$)

14. A compound is 39.13% by mass carbon, 8.76% by mass hydrogen and 52.12% by mass oxygen. What is the empirical formula? (*Ans*: $C_3H_8O_3$)

15. A compound is 48.64% by mass carbon, 8.16% by mass hydrogen and 43.20% by mass oxygen. What is the empirical formula? (*Ans*: $C_3H_6O_2$)

16. A compound is 68.85% by mass carbon, 4.95% by mass hydrogen and 26.20% by mass oxygen. What is the empirical formula? (*Ans*: $C_7H_6O_2$ – this one is hard!)