Analyzing Chemical Formulas

Aim

• to perform calculations based on the information in a chemical formula

Notes

Determining Formula Mass

★ add up the product of the subscript and the mass from the periodic table for each element shown in the formula
  ☆ Examples
    ✶ silver nitrate
      AgNO₃
      Ag = 1 × 108 = 108
      N = 1 × 14 = 14
      O = 3 × 16 = 48
      _____
      170
    ✶ sodium chloride
      NaCl
      Na = 1 × 23 = 23
      Cl = 1 × 35 = 35
      _____
      58

Empirical Formulas

★ Definition: Empirical Formula = The simplest ratio of the atoms present in a molecule
★ Determining empirical formulas from molecular formulas – reduce subscripts to lowest terms
  ☆ Examples
    ✶ glucose: Molecular formula = $C_6H_{12}O_6$; Empirical formula = CH_2O
    ✶ hydrogen peroxide: Molecular formula = H_2O_2; Empirical formula = HO
★ Determining molecular formulas from empirical formulas and formula mass
  ☆ Procedure – molecular formulas are always some multiple of empirical formulas
    ✶ determine the empirical formula mass as described above
    ✶ divide the empirical formula mass into the molecular mass to determine the multiple
    ✶ multiply the empirical formula by the multiple

CONTINUE ☞

☆ Example

> **Sample Problem**
> A compound with an empirical formula of CH_2 has a molecular mass of 42 amu. What is its molecular formula.
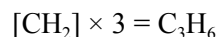>
> **Step 1:** Determine the empirical formula mass.
> CH_2
>   C = 12 × 1 = 12
>   H = 1 × 2 = 2
>   _____
>   14
> **Step 2:** Divide the molecular mass by the empirical formula mass to determine the multiple..
> $$\frac{42}{14} = 3$$
> **Step 3:** Multiply the formula by the by the multiple to find the molecular formula
> $[CH_2] \times 3 = C_3H_6$

Determining Percent Composition

★ Procedure - determine the formula mass and divide the mass of each element by the mass of the compound

> **Sample Problem**
> What is the percent composition of $Ca(OH)_2$?
>
> **Step 1:** Determine the formula mass
> $Ca(OH)_2$
>   Ca = 40 × 1 = 40
>   O = 16 × 2 = 32
>   H = 1 × 2 = 2
>   _____
>   74
> **Step 2:** Divide the mass of each element in the compound by the mass of the compound and multiply by 100.
> $$\%Ca = \frac{40}{74} \times 100 = 54; \quad \%O = \frac{32}{74} \times 100 = 43; \ and$$
> $$\%H = \frac{2}{74} \times 100 = 3$$

Answer the questions below by circling the number of the correct response

1. An example of an empirical formula is (1) C_2H_2, (2) H_2O_2, (3) C_2Cl_2, (4) $CaCl_2$

2. A 10.0 gram sample of a hydrate was heated until all the water of hydration was driven off. The mass of anhydrous product remaining was 8.00 grams What is the percent of water in the hydrate?   (1) 12.5% (2) 20.0% (3) 25.0% (4) 80.0%

3. A compound has the empirical formula NO_2. Its molecular formula could be   (1) NO_2, (2) N_2O, (3) N_4O_2, (4) N_4O_4.

4. The percent by mass of oxygen in $Ca(OH)_2$ (formula mass = 74) is closest to   (1) 16, (2) 22, (3) 43, (4) 74.

5. The empirical formula of a compound is CH. Its molecular mass could be   (1) 21, (2) 40, (3) 51, (4) 78.

6. What is the percent by mass of oxygen in NaOH (formula mass = 40.)?   (1) 80. (2) 40. (3) 32 (4) 16

7. A compound whose empirical formula is CH_2O could be (1) HCOOH, (2) CH_3OH, (3) CH_3COOH, (4) CH_3CH_2OH.

8. The percent by mass of oxygen in CO is approximately   (1) 73%, (2) 57%, (3) 43%, (4) 17%.

9. A compound has an empirical formula of CH_2 and a molecular mass of 56. Its molecular formula is   (1) C_2H_4, (2) C_3H_6, (3) C_4H_8, (4) C_5H_{10}.

10. What is the percent by mass of hydrogen in NH_3 (formula mass = 17.0)?   (1) 5.9% (2) 17.6% (3) 21.4% (4) 82.4%

11. The empirical formula of a compound is CH_2 and its molecular mass is 70. What is the molecular formula of the compound? (1) C_2H_2 (2) C_2H_4 (3) C_4H_{10} (4) C_5H_{10}

12. The percent by mass of nitrogen in $Mg(CN)_2$ is equal to (1) $^{14}/_{76} \times 100$, (2) $^{14}/_{50} \times 100$, (3) $^{28}/_{76} \times 100$, (4) $^{28}/_{50} \times 100$.

13. What is the percent by mass of oxygen in Fe_2O_3 (formula mass = 160)?   (1) 16% (2) 30.% (3) 56% (4) 70.%

14. Which formulas could represent the empirical formula and the molecular formula of a given compound?   (1) CH_2O, $C_4H_6O_4$ (2) CHO $C_6H_{12}O_6$ (3) CH_4, C_3H_{12} (4) CH_2, C_3H_6

15. The percent by mass of carbon in CO_2 is equal to   (1) $^{44}/_{12} \times 100$, (2) $^{12}/_{44} \times 100$, (3) $^{28}/_{12} \times 100$, (4) $^{12}/_{28} \times 100$

16. The percentage by mass of hydrogen in NH_3 is equal to (1) $^{1}/_{17} \times 100$ (2) $^{3}/_{17} \times 100$ (3) $^{17}/_{3} \times 100$ (4) $^{6}/_{17} \times 100$

17. The empirical formula of a compound is CH_4. The molecular formula of the compound could be   (1) CH_4, (2) C_2H_6, (3) C_3H_8, (4) C_4H_{10}

18. A hydrocarbon has the empirical formula CH_3. The most probable molecular formula for this compound is   (1) CH_3, (2) C_2H_6, (3) C_3H_8, (4) C_4H_6

19. A compound with an empirical formula of CH_2 has a molecular mass of 70. What is the molecular formula?   (1) CH_2 (2) C_2H_4 (3) C_4H_8 (4) C_5H_{10}

20. What is the percent by mass of oxygen in CH_3OH?   (1) 50.0 (2) 44.4 (3) 32.0 (4) 16.0

21. The approximate percent by mass of potassium in $KHCO_3$ is (1) 19 %, (2) 24 %, (3) 39 %, (4) 61 %

22. A compound has an empirical formula of CH_2 and a molecular mass of 56. What is its molecular formula?
(1) CH_2 (3) C_3H_6
(2) C_2H_4 (4) C_4H_8

23. What is the percent by mass of hydrogen in CH_3COOH (formula mass = 60.)?
(1) 1.7%   (3) 6.7%
(2) 5.0%   (4) 7.1%

24. What is the percentage by mass of oxygen in CuO?
(1) 16%   (3) 25%
(2) 20%   (4) 50%

25. What is the approximate percent composition by mass of $CaBr_2$ (formula mass = 200)?   (1) 20% calcium and 80% bromine (2) 25% calcium and 75% bromine (3) 30% calcium and 70% bromine (4) 35% calcium and 65% bromine

26. A 60. gram sample of $LiCl \cdot H_2O$ is heated in an open crucible until all of the water has been driven off. What is the total mass of LiCl remaining in the crucible?
(1) 18 g.   (3) 42 g.
(2) 24 g.   (4) 60 g.

27. Which compound contains the greatest percentage of oxygen by mass?
(1) BaO   (3) MgO
(2) CaO   (4) SrO

28. The precent by mass of oxygen in MgO (formula mass = 40) is closest to
(1) 16%   (3) 40%
(2) 24%   (4) 60%