

HL First-Year Chemistry

1. Atomic Structure and Stoichiometry

Further problems:

- Write the appropriate symbol for each of the following isotopes: (a) $Z = 26, A = 55$; (b) $Z = 37, A = 86$; (c) 81 protons and 123 neutrons, (d) 24 protons, 123 neutrons
- List the steps involved in mass spectroscopy. (**NOT** required for Standard Level.)
- The following values of isotopic relative abundances and masses are obtained for titanium: 7.95% for Ti-46, 7.75% for Ti-47, 73.45% for Ti-48, 5.51% for Ti-49, and 5.34 for Ti-50. Determine the relative atomic mass of titanium.
- Explain why the relative atomic masses of some elements (such as Cl or Cu, for example) are so far from whole numbers.
- What are the numbers of protons, neutrons, and electrons in each of the following: (a) ${}^{132}_{55}\text{Cs}$, (b) ${}^{115}_{48}\text{Cd}^{2+}$, (c) ${}^{194}_{81}\text{Tl}$, (d) ${}^{105}_{47}\text{Ag}^{+}$, (e) ${}^{78}_{34}\text{Se}^{2-}$
- Give an outline of what happens between introduction of a sample into a mass spectrometer and detection of particles. (**NOT** required for Standard Level.)
- How many atoms of each kind are represented in the following formulas? (a) Na_2CO_3 , (b) $(\text{NH}_4)_3\text{PO}_4$, (c) $\text{Na}_3\text{Ag}(\text{S}_2\text{O}_3)_2$
- How many moles of atoms of each kind are represented in a mole of the formulas in the question above.
- List the products of the following reaction and indicate whether or not the equation is balanced:
$$\text{Fe}_2\text{O}_3 + 2\text{CO} \rightarrow 2\text{Fe} + 2\text{CO}_2$$
- Consider the following equation: $\text{CaCO}_3 + \text{HCl} \rightarrow \text{CaCl}_2 + \text{CO}_2 + \text{H}_2\text{O}$
 - Identify the products and reactants.
 - Is the equation balanced or unbalanced?
 - Give the physical state of each substance in the equation.
- Write a balanced equation for the following reaction, giving state symbols for each substance. When solid mercury(II) sulphide, HgS , is heated with oxygen, liquid mercury metal and gaseous sulfur dioxide, SO_2 , are produced.
- What are the units for (a) relative molecular mass, (b) molar mass?
- Find the relative molecular or formula mass of each of the following, to 3 significant figures. (a) $\text{C}_2\text{H}_4\text{O}_2$, (b) K_2SO_4 , (c) $\text{Ca}(\text{OH})_2$.
- Calculate the mass (in grams) of each of the following: (a) one atom of Fe atom, (b) 5×10^{10} N_2O molecules.
- Find the percentage composition of (the percent by weight of each element in) each of the following compounds:
 - NH_3
 - $\text{C}_2\text{H}_4\text{O}_2$
 - K_2SO_4
 - $\text{Ca}(\text{OH})_2$
 - $\text{Zn}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$
 - Streptomycin, $\text{C}_{22}\text{H}_{20}\text{O}_{12}\text{N}_7$
- How many moles are in 1.00 lb of each compound in the preceding problem? (2.2 lb = 1 kg)
- Calculate the following:
 - the number of atoms in 15.4 g Al
 - number of molecules in 14.8 g N_2O_5
 - number of sodium ions in 83.2 g Na_2CO_3
- Glycerol has the formula $\text{C}_3\text{H}_8\text{O}_3$. If a certain quantity of glycerol contains 7 mol of C, how many mol of O are present?

19. When copper is heated with an excess of sulfur, copper (I) sulfide is formed. How many g of the sulfide would be produced if 100.0 g of copper were heated with 50.5 g of sulfur?
20. Calculate the mass of carbon tetrachloride that can be produced by the reaction of 10.0 g of carbon with 100.0 g of chlorine. Determine the mass of excess reagent left unreacted.
21. For the reaction between iron and oxygen, 4.80 g of oxygen is used to burn 0.150 mol of iron. What mass of iron(III) oxide will be produced? What mass of iron will be left over at the end of the reaction? What mass of oxygen will be left over at the end of the reaction?
22. What is the empirical formula for each of the following? (a) $(\text{NH}_4)_2\text{S}_2\text{O}_8$, (b) C_6H_6 , (c) $\text{C}_3\text{H}_8\text{O}_3$, (d) Hg_2SO_4 .
23. The following are (condensed) structural formulae for some organic compounds. Give their molecular formula and empirical formula for the compounds. a) $\text{CH}_3\text{CH}_2\text{COOH}$ b) CH_3OH c) $\text{CH}_3\text{COOCH}_2\text{CH}_3$ d) CH_3OCH_3 e) $\text{CH}_3\text{CH}_2\text{NH}_2$ e) 1,2 dihydroxyethane, used as a permanent anti-freeze, $\text{HO}-\text{CH}_2-\text{CH}_2-\text{OH}$.
24. If 5.34 g of an oxide of tungsten contains 4.23 g of tungsten, what is its empirical formula?
25. From the following analytical results (percent by weight), determine the empirical formulas for the compounds analyzed:
(a) 42.9% C, 57.1% O; (b) 27.3% C, 72.7% O; (c) 19.3% Na, 26.8% S, 53.9% O; (d) 29.1% Na, 40.5% S, and the rest O
26. Weighed samples of the following hydrates are heated to drive off the water, and then the cooled residues are weighed. From the data given, find the formulas of the hydrates:
(a) 0.520 g of $\text{NiSO}_4 \cdot x\text{H}_2\text{O}$ gave a residue of 0.306 g
(b) 0.895 g of $\text{MnI}_2 \cdot x\text{H}_2\text{O}$ gave a residue of 0.726 g
(c) 0.654 g of $\text{MgSO}_4 \cdot x\text{H}_2\text{O}$ gave a residue of 0.320 g
(d) 1.216 g of $\text{CdSO}_4 \cdot x\text{H}_2\text{O}$ gave a residue of 0.988 g
(e) 0.783 g of $\text{KAl}(\text{SO}_4)_2 \cdot x\text{H}_2\text{O}$ gave a residue of 0.426 g
27. A sample of organic compound containing C, H, and O, which weighs 12.13 mg, gives 30.6 mg of CO_2 and 5.36 mg of H_2O when combusted. The amount of oxygen in the original sample is obtained by difference. Determine the empirical formula of this compound.
28. A compound that contains only nitrogen and oxygen is 30.4% N by mass; the molar mass of the compound is 92 g/mol. What is the empirical formula of the compound? What is the molecular formula of the compound?
29. Adipic acid is an organic compound composed of 49.31% C, 43.79% o, and the rest hydrogen. If the molar mass of adipic acid is 146.1 g/mol what are the empirical and molecular formulas of the compound?
30. Maleic acid is an organic compound composed of 41.39% C, 3.47% H, and the rest oxygen. If 0.129 mol of maleic acid has a mass of 15.0 g, what are the empirical and molecular formulas of maleic acid?