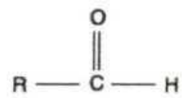
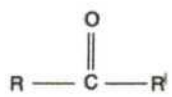
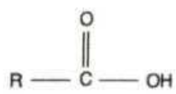
(c) aldehyde:



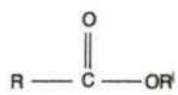
(d) ketone:



(e) carboxylic acid:



(f) ester:



(g) amines: RNH_2

Problems by Topic

Chemical Formulas and Molecular View of the Elements

3.23 The chemical formula gives you the kind of atom and the number of each atom in the compound.

(a) $Mg_3(PO_4)_2$ contains: 3 magnesium atoms, 2 phosphorus atoms, and 8 oxygen atoms

(b) $BaCl_2$ contains: 1 barium atom and 2 chlorine atoms

(c) $Fe(NO_2)_2$ contains: 1 iron atom, 2 nitrogen atoms, and 4 oxygen atoms

(d) $Ca(OH)_2$ contains: 1 calcium atom, 2 oxygen atoms, and 2 hydrogen atoms

3.24 The chemical formula gives you the kind of atom and the number of each atom in the compound.

(a) $Ca(NO_2)_2$ contains: 1 calcium atom, 2 nitrogen atoms, and 4 oxygen atoms

(b) $CuSO_4$ contains: 1 copper atom, 1 sulfur atom, and 4 oxygen atoms

(c) $Al(NO_3)_3$ contains: 1 aluminum atom, 3 nitrogen atoms, and 9 oxygen atoms

(d) $Mg(HCO_3)_2$ contains: 1 magnesium atom, 2 hydrogen atoms, 2 carbon atoms, and 6 oxygen atoms

3.25 (a) 1 blue = nitrogen, 3 white = hydrogen: NH_3

(b) 2 black = carbon, 6 white = hydrogen: C_2H_6

(c) 1 yellow – green = sulfur, 3 red = oxygen: SO_3

3.26 (a) 1 blue = nitrogen, 2 red = oxygen: NO_2

(b) 1 yellow – green = sulfur, 2 white = hydrogen: SH_2

(c) 1 black = carbon, 4 white = hydrogen: CH_4

3.27 (a) Neon is an element and it is not one of the elements that exist as diatomic molecules, therefore it is an atomic element.

(b) Fluorine is one of the elements that exist as diatomic molecules, therefore it is a molecular element.

(c) Potassium is not one of the elements that exist as diatomic molecules, therefore it is an atomic element.

(d) Nitrogen is one of the elements that exist as diatomic molecules, therefore it is a molecular element.

3.28 (a) Hydrogen is one of the elements that exist as diatomic molecules, therefore it has a molecule as its basic unit.

(b) Iodine is one of the elements that exist as diatomic molecules, therefore it has a molecule as its basic unit.

(c) Lead is not one of the elements that exist as a diatomic molecule, therefore it does not have a molecule as its basic unit.

(d) Oxygen is one of the elements that exist as diatomic molecules, therefore it has a molecule as its basic unit.

3.29 (a) CO_2 is a compound composed of a nonmetal and a nonmetal, therefore it is a molecular compound.

(b) $NiCl_2$ is a compound composed of a metal and a nonmetal, therefore it is an ionic compound.

(c) NaI is a compound composed of a metal and a nonmetal, therefore it is an ionic compound.

(d) PCl_3 is a compound composed of a nonmetal and a nonmetal, therefore it is a molecular compound.

3.30 (a) CF_2Cl_2 is a compound composed of a nonmetal and 2 other nonmetals, therefore it is a molecular compound.

(b) CCl_4 is a compound composed of a nonmetal and a nonmetal, therefore it is a molecular compound.

(c) PtO_2 is a compound composed of a metal and a nonmetal, therefore it is an ionic compound.

(d) SO_3 is a compound composed of a nonmetal and a nonmetal, therefore it is a molecular compound.

3.31 (a) white – hydrogen: a molecule composed of two of the same element, therefore it is a molecular element.

(b) blue – nitrogen, white – hydrogen: a molecule composed of a nonmetal and a nonmetal, therefore it is a molecular compound.

(c) purple – sodium: a substance composed of all the same atoms, therefore it is an atomic element.

3.32 (a) green – chlorine, purple – sodium: a compound composed of metal and nonmetal, therefore it is an ionic compound.

(b) green – chlorine: a molecule composed of two of the same element, therefore it is a molecular element.

(c) red – oxygen, black – carbon, white – hydrogen: a molecule composed of nonmetals, therefore it is a molecular compound.

Formulas and Names for Ionic Compounds

3.33 To write the formula for an ionic compound do the following: 1) Write the symbol for the metal cation and its charge and the symbol for the nonmetal anion and its charge. 2) Adjust the subscript on each cation and anion to balance the overall charge. 3) Check that the sum of the charges of the cations equals the sum of the charges of the anions.

(a)	calcium and oxygen:	Ca^{2-}	O^{2-}	CaO	cations 2+, anions 2–
(b)	zinc and sulfur:	Zn^{2+}	S^{2-}	ZnS	cations 2+, anions 2–
(c)	rubidium and bromine:	Rb^{+}	Br^{-}	RbBr	cation +, anions –
(d)	aluminum and oxygen:	Al^{3+}	O^{2-}	Al_2O_3	cation 2(3+) = 6+, anions 3(2–) = 6–

3.34 To write the formula for an ionic compound do the following: 1) Write the symbol for the metal cation and its charge and the symbol for the nonmetal anion and its charge. 2) Adjust the subscript on each cation and anion to balance the overall charge. 3) Check that the sum of the charges of the cations equals the sum of the charges of the anions.

(a)	silver and chlorine:	Ag^{+}	Cl^{-}	$AgCl$	cation +, anions –
(b)	sodium and sulfur:	Na^{+}	S^{2-}	Na_2S	cation 2(1+) = 2+, anion 2–
(c)	aluminum and sulfur:	Al^{3+}	S^{2-}	Al_2S_3	cation 2(3+) = 6+, anions 3(2–) = 6–
(d)	potassium and chlorine:	K^{+}	Cl^{-}	KCl	cation +, anion –

3.35 To write the formula for an ionic compound do the following: 1) Write the symbol for the metal cation and its charge and the symbol for the polyatomic anion and its charge. 2) Adjust the subscript on each cation and anion to balance the overall charge. 3) Check that the sum of the charges of the cations equals the sum of the charges of the anions.

Cation = calcium: Ca^{2+}

(a)	hydroxide:	OH^{-}	$Ca(OH)_2$	cation 2+, anion 2(1–) = 2–
(b)	chromate:	CrO_4^{2-}	$CaCrO_4$	cation 2+, anion 2–
(c)	phosphate:	PO_4^{3-}	$Ca_3(PO_4)_2$	cation 3(2+) = 6+, anion 2(3–) = 6–
(d)	cyanide:	CN^{-}	$Ca(CN)_2$	cation 2+, anion 2(1–) = 2–

3.36 To write the formula for an ionic compound do the following: 1) Write the symbol for the metal cation and its charge and the symbol for the nonmetal anion and its charge. 2) Adjust the subscript on each cation and anion to balance the overall charge. 3) Check that the sum of the charges of the cations equals the sum of the charges of the anions.

Cation = potassium: K^{+}

(a)	carbonate:	CO_3^{2-}	K_2CO_3	cation 2(1+) = 2+, anion 2–
(b)	phosphate:	PO_4^{3-}	K_3PO_4	cation 3(1+) = 3+, anion 3–
(c)	hydrogen phosphate:	HPO_4^{2-}	K_2HPO_4	cation 2(1+) = 2+, anion 2–
(d)	acetate:	$C_2H_3O_2^{-}$	$KC_2H_3O_2$	cation 1+, anion 1–

3.37 To name a binary ionic compound name the metal cation followed by the base name of the anion + *-ide*.

(a) Mg_3N_2: The cation is magnesium; the anion is from nitrogen, which becomes nitride: magnesium nitride.

(b) KF: The cation is potassium; the anion is from fluorine, which becomes fluoride: potassium fluoride.

(c) Na_2O: The cation is sodium; the anion is from oxygen, which becomes oxide: sodium oxide.

(d) Li_2S: The cation is lithium; the anion is from sulfur, which becomes sulfide: lithium sulfide.

(e) CsF: The cation is cesium; the anion is fluorine, which becomes fluoride: cesium fluoride.

(f) KI: The cation is potassium; the anion is iodine, which becomes iodide: potassium iodide.

(g) $SrCl_2$: The cation is strontium; the anion is chlorine, which becomes chloride: strontium chloride.

(h) $BaCl_2$: The cation is barium; the anion is chlorine, which becomes chloride: barium chloride.

3.38 To name an ionic compound with a metal cation that can have more than one charge, name the metal cation followed by parentheses with the charge in roman numerals followed by the base name of the anion + *-ide*.

(a) $SnCl_4$: The charge on Sn must be 4+ for the compound to be charge neutral: The cation is tin(IV); the anion is from chlorine, which becomes chloride: tin(IV) chloride.

(b) PbI_2: The charge on Pb must be 2+ for the compound to be charge neutral: The cation is lead(II); the anion is from iodine, which becomes iodide: lead(II) iodide.

(c) Fe_2O_3: The charge on Fe must be 3+ for the compound to be charge neutral: The cation is iron(III); the anion is from oxygen, which becomes oxide: iron(III) oxide.

(d) CuI_2: The charge on Cu must be 2+ for the compound to be charge neutral: The cation is copper(II); the anion is from iodine, which becomes iodide: copper(II) iodide.

(e) SnO_2: The charge on Sn must be 4+ for the compound to be charge neutral: The cation is tin(IV); the anion is from oxygen, which becomes oxide: tin(IV) oxide.

(f) $HgBr_2$: The charge of Hg must be 2+ for the compound to charge neutral: The cation is mercury(II); the anion is from bromine, which becomes bromide: mercury(II) bromide.

(g) $CrCl_2$: The charge on Cr must be 2+ for the compound to be charge neutral: The cation is chromium(II); the anion is from chlorine, which becomes chloride: chromium(II) chloride.

(h) $CrCl_3$: The charge on Cr must be 3+ for the compound to be charge neutral: The cation is chromium(III); the anion is from chlorine, which becomes chloride: chromium(III) chloride.

3.39 To name these compounds you must first decide if the metal cation is invariant or can have more than one charge. Then, name the metal cation followed by the base name of the anion + *-ide*.

(a) SnO: Sn can have more than one charge. The charge on Sn must be 2+ for the compound to be charge neutral: The cation is tin(II); the anion is from oxygen, which becomes oxide: tin(II) oxide.

(b) Cr_2S_3: Cr can have more than one charge. The charge on Cr must be 3+ for the compound to be charge neutral: The cation is chromium(III); the anion is from sulfur, which becomes sulfide: chromium(III) sulfide.

(c) RbI: Rb is invariant: The cation is rubidium; the anion is from iodine, which becomes iodide: rubidium iodide.

(d) $BaBr_2$: Ba is invariant: The cation is barium; the anion is from bromine, which becomes bromide: barium bromide.

3.40 To name these compounds you must first decide if the metal cation is invariant or can have more than one charge. Then, name the metal cation followed by the base name of the anion + *-ide*.

(a) BaS: Ba is invariant: The cation is barium; the anion is from sulfur, which becomes sulfide: barium sulfide.

(b) $FeCl_3$: Fe can have more than one charge. The charge on Fe must be 3+ for the compound to be charge neutral: The cation is iron(III); the anion is from chlorine, which becomes chloride: iron(III) chloride.

(c) PbI_4: Pb can have more than one charge. The charge on Pb must be 4+ for the compound to be charge neutral: The cation is lead(IV); the anion is from iodine, which becomes iodide: lead(IV) iodide.

(d) $SrBr_2$: Sr is invariant: The cation is strontium; the anion is from bromine, which becomes bromide: strontium bromide.

3.41 To name these compounds you must first decide if the metal cation is invariant or can have more than one charge. Then, name the metal cation followed by the name of the polyatomic anion.

(a) $CuNO_2$: Cu can have more than one charge. The charge on Cu must be 1+ for the compound to be charge neutral: The cation is copper(I); the anion is nitrite: copper(I) nitrite.

(b) $Mg(C_2H_3O_2)_2$: Mg is invariant: The cation is magnesium; the anion is acetate: magnesium acetate.

(c) $Ba(NO_3)_2$: Ba is invariant: The cation is barium; the anion is nitrate: barium nitrate.

(d) $Pb(C_2H_3O_2)_2$: Pb can have more than one charge. The charge on Pb must be 2+ for the compound to be charge neutral: The cation is lead(II); the anion is acetate: lead(II) acetate.

(e) $KClO_3$: K is invariant: The cation is potassium; the anion is chlorate: potassium chlorate.

(f) $PbSO_4$: Pb can have more than one charge. The charge on Pb must be 2+ for the compound to be charge neutral: The cation is lead(II); the anion is sulfate: lead(II) sulfate.

3.42 To name these compounds you must first decide if the metal cation is invariant or can have more than one charge. Then, name the metal cation followed by the name of the polyatomic anion.

(a) $Ba(OH)_2$: Ba is invariant: The cation is barium; the anion is hydroxide: barium hydroxide.

(b) NH_4I: The cation is ammonium; the anion is from iodine, which becomes iodide: ammonium iodide.

(c) $NaBrO_4$: Na is invariant: The cation is sodium; the anion is perbromate: sodium perbromate.

(d) $Fe(OH)_3$: Fe can have more than one charge. The charge on Fe must be 3+ for the compound to be charge neutral: The cation is iron(III); the anion is hydroxide: iron(III) hydroxide.

(e) $CoSO_4$: Co can have more than one charge. The charge on Co must be 2+ for the compound to be charge neutral: The cation is cobalt(II); the anion is sulfate: cobalt(II) sulfate.

(f) $KClO$: K is invariant: The cation is potassium; the anion is hypochlorite: potassium hypochlorite.

3.43 To write the formula for an ionic compound do the following: 1) Write the symbol for the metal cation and its charge and the symbol for the nonmetal anion or polyatomic anion and its charge. 2) Adjust the subscript on each cation and anion to balance the overall charge. 3) Check that the sum of the charges of the cations equals the sum of the charges of the anions.

(a)	sodium hydrogen sulfite:	Na^+	HSO_3^-	$NaHSO_3$	cation 1+, anion 1–
(b)	lithium permanganate:	Li^+	MnO_4^-	$LiMnO_4$	cation 1+, anion 1–
(c)	silver nitrate:	Ag^+	NO_3^-	$AgNO_3$	cation 1+, anion 1–
(d)	potassium sulfate:	K^+	SO_4^{2-}	K_2SO_4	cation 2(1+) = 2+, anion 2–
(e)	rubidium hydrogen sulfate:	Rb^+	HSO_4^-	$RbHSO_4$	cation 1+, anion 1–
(f)	potassium hydrogen carbonate:	K^+	HCO_3^-	$KHCO_3$	cation 1+, anion 1–

3.44 To write the formula for an ionic compound do the following: 1) Write the symbol for the metal cation and its charge and the symbol for the nonmetal anion or polyatomic anion and its charge. 2) Adjust the subscript on each cation and anion to balance the overall charge. 3) Check that the sum of the charges of the cations equals the sum of the charges of the anions.

(a)	copper(II) chloride:	Cu^{2+}	Cl^-	$CuCl_2$	cation 2+, anion 2(1–) = 2–
(b)	copper(I) iodate:	Cu^+	IO_3^-	$CuIO_3$	cation 1+, anion 1–
(c)	lead(II) chromate:	Pb^{2+}	CrO_4^{2-}	$PbCrO_4$	cation 2+, anion 2–
(d)	calcium fluoride:	Ca^{2+}	F^-	CaF_2	cation 2+, anion 2(1–) = 2–
(e)	potassium hydroxide:	K^+	OH^-	KOH	cation 1+, anion 1–
(f)	iron(II) phosphate:	Fe^{2+}	PO_4^{3-}	$Fe_3(PO_4)_2$	cation 3(2+) = 6+, anion 2(3–) = 6–

3.45 Hydrates are named the same way as other ionic compounds with the addition of the term *prefix*hydrate, where the prefix is the number of water molecules associated with each formula unit.

(a)	$CoSO_4 \cdot 7H_2O$	cobalt(II) sulfate heptahydrate
(b)	iridium(III) bromide tetrahydrate	$IrBr_3 \cdot 4H_2O$
(c)	$Mg(BrO_3)_2 \cdot 6H_2O$	magnesium bromate hexahydrate
(d)	potassium carbonate dihydrate	$K_2CO_3 \cdot 2H_2O$

3.46 Hydrates are named the same way as other ionic compounds with the addition of the term *prefix*hydrate, where the prefix is the number of water molecules associated with each formula unit.

(a)	cobalt(II) phosphate octahydrate	$Co_3(PO_4)_2 \cdot 8H_2O$
(b)	$BeCl_2 \cdot 2H_2O$	beryllium chloride dihydrate
(c)	chromium(III) phosphate trihydrate	$CrPO_4 \cdot 3H_2O$
(d)	$LiNO_2 \cdot H_2O$	lithium nitrite monohydrate

Formulas and Names for Molecular Compounds and Acids

3.47 (a) CO The name of the compound is the name of the first element, *carbon*, followed by the base name of the second element, *ox*, prefixed by *mono-* to indicate one and given the suffix *-ide*: carbon monoxide.

(b) NI_3 The name of the compound is the name of the first element, *nitrogen*, followed by the base name of the second element, *iod*, prefixed by *tri-* to indicate three and given the suffix *-ide*: nitrogen triiodide.

(c) $SiCl_4$ The name of the compound is the name of the first element, *silicon*, followed by the base name of the second element, *chlor*, prefixed by *tetra-* to indicate four and given the suffix *-ide*: silicon tetrachloride.

(d) N_4Se_4 The name of the compound is the name of the first element, *nitrogen*, prefixed by *tetra-* to indicate four followed by the base name of the second element, *selen*, prefixed by *tetra-* to indicate four and given the suffix *-ide*: tetranitrogen tetraselenide.

(e) I_2O_5 The name of the compound is the name of the first element, *iodine*, prefixed by *di-* to indicate two followed by the base name of the second element, *ox*, prefixed by *penta-* to indicate five and given the suffix *-ide*: diiodine pentaoxide.

3.48 (a) SO_3 The name of the compound is the name of the first element, *sulfur*, followed by the base name of the second element, *ox*, prefixed by *tri-* to indicate three and given the suffix *-ide*: sulfur trioxide.

(b) SO_2 The name of the compound is the name of the first element, *sulfur*, followed by the base name of the second element, *ox*, prefixed by *di-* to indicate two and given the suffix *-ide*: sulfur dioxide.

(c) BrF_5 The name of the compound is the name of the first element, *bromine*, followed by the base name of the second element, *fluor*, prefixed by *penta-* to indicate five and given the suffix *-ide*: bromine pentafluoride.

(d) NO The name of the compound is the name of the first element, *nitrogen*, followed by the base name of the second element, *ox*, prefixed by *mono-* to indicate one and given the suffix *-ide*: nitrogen monoxide.

(e) XeO_3 The name of the compound is the name of the first element, *xenon*, followed by the base name of the second element, *ox*, prefixed by *tri-* to indicate three and given the suffix *-ide*: xenon trioxide.

3.49 (a) phosphorus trichloride: PCl_3

(b) chlorine monoxide: ClO

(c) disulfur tetrafluoride: S_2F_4

(d) phosphorus pentafluoride: PF_5

(e) diphosphorus pentasulfide: P_2S_5

3.50 (a) boron tribromide: BBr_3

(b) dichlorine monoxide: Cl_2O

(c) xenon tetrafluoride: XeF_4

(d) carbon tetrabromide: CBr_4

(e) diboron tetrachloride: B_2Cl_4

3.51 (a) HI: The base name of I is *iod* so the name is hydroiodic acid.

(b) HNO_3: The oxyanion is *nitrate,* which ends in *-ate;* therefore, the name of the acid is nitric acid.

(c) H_2CO_3: The oxyanion is *carbonate,* which ends in *-ate;* therefore, the name of the acid is carbonic acid.

(d) $HC_2H_3O_2$: The oxyanion is *acetate,* which ends in *-ate;* therefore, the name of the acid is acetic acid.

3.52 (a) HCl: The base name of Cl is *chlor,* so the name is hydrochloric acid.

(b) $HClO_2$: The oxyanion is *chlorite,* which ends in *-ite;* therefore, the name of the acid is chlorous acid.

(c) H_2SO_4: The oxyanion is *sulfate,* which ends in *-ate;* therefore, the name of the acid is sulfuric acid.

(d) HNO_2: The oxyanion is *nitrite,* which ends in *-ite;* therefore, the name of the acid is nitrous acid.

3.53 (a) hydrofluoric acid: HF

(b) hydrobromic acid: HBr

(c) sulfurous acid: H_2SO_3

3.54 (a) phosphoric acid: H_3PO_4

(b) hydrocyanic acid: HCN

(c) chlorous acid: $HClO_2$

Formula Mass and the Mole Concept for Compounds

3.55 To find the formula mass, we sum the atomic masses of each atom in the chemical formula.

(a) NO_2 formula mass = 1 x (atomic mass N) + 2 x (atomic mass O)
= 1 x (14.01 amu) + 2 x (16.00 amu)
= 46.01 amu

(b) C_4H_{10} formula mass = 4 x (atomic mass C) + 10 x (atomic mass H)
= 4 x (12.01 amu) + 10 x (1.008 amu)
= 58.12 amu

(c) $C_6H_{12}O_6$ formula mass = 6 x (atomic mass C) + 12 x (atomic mass H) + 6 x (atomic mass O)
= 6 x (12.01 amu) + 12 x (1.008 amu) + 6 x (16.00 amu)
= 180.16 amu

(d) $Cr(NO_3)_3$ formula mass = 1 x (atomic mass Cr) + 3 x (atomic mass N) + 9 x (atomic mass O)
= 1 x (52.00 amu) + 3 x (14.01 amu) + 9 x (16.00 amu)
= 238.03 amu

3.56 To find the formula mass, we sum the atomic masses of each atom in the chemical formula.

(a) $MgBr_2$ formula mass = 1 x (atomic mass Mg) + 2 x (atomic mass Br)
= 1 x (24.31 amu) + 2 x (79.90 amu)
= 184.11 amu

(b) HNO_2 formula mass = 1 x (atomic mass H) + 1 x (atomic mass N) + 2 x (atomic mass O)
= 1 x (1.008 amu) + 1 x (14.01 amu) + 2 x (16.00 amu)
= 47.02 amu

(c) CBr_4 formula mass = 1 x (atomic mass C) + 4 x (atomic mass Br)
= 1 x (12.01 amu) + 4 x (79.90 amu)
= 331.61 amu

(d) $Ca(NO_3)_2$ formula mass = 1 x (atomic mass Ca) + 2 x (atomic mass N) + 6 x (atomic mass O)
= 1 x (40.08 amu) + 2 x (14.01 amu) + 6 x (16.00 amu)
= 164.10 amu

3.57 (a) **Given:** 25.5 g NO_2 **Find:** number of moles
Conceptual Plan: $\textbf{g NO}_2 \rightarrow \textbf{mole NO}_2$

$$\frac{1\text{ mol}}{46.01\text{ g NO}_2}$$

Solution: $25.5\ \text{g NO}_2 \times \dfrac{1\text{ mol NO}_2}{46.01\text{ g NO}_2} = 0.554\text{ mol NO}_2$

Check: The units of the answer (mole NO_2) are correct. The magnitude is appropriate because it is less than 1 mole of NO_2.

(b) **Given:** 1.25 kg CO_2 **Find:** number of moles
Conceptual Plan: $\textbf{kg CO2} \rightarrow \textbf{g CO2} \rightarrow \textbf{mole CO2}$

$$\frac{1000\text{ g CO}_2}{\text{kg CO}_2} \qquad \frac{1\text{ mol}}{44.01\text{ g NO}_2}$$

Solution: $1.25\ \text{kg CO}_2 \times \dfrac{1000\text{ g CO}_2}{\text{kg CO}_2} \times \dfrac{1\text{ mol CO}_2}{44.01\text{ g CO}_2} = 28.4\text{ mol CO}_2$

Check: The units of the answer (mole CO_2) are correct. The magnitude is appropriate because there is over a kg of CO_2 present.

(c) **Given:** 38.2 g KNO_3 **Find:** number of moles
Conceptual Plan: $\textbf{g KNO}_3 \rightarrow \textbf{mole KNO}_3$

$$\frac{1\text{ mol}}{101.11\text{ g KNO}_3}$$

Solution: $38.2\ \text{g KNO}_3 \times \dfrac{1\text{ mol KNO}_3}{101.11\text{ g KNO}_3} = 0.378\text{ mol KNO}_3$

Check: The units of the answer (mole KNO_3) are correct. The magnitude is appropriate because there is less than 1 mole of KNO_3.

(d) **Given:** 155.2 kg Na_2SO_4 **Find:** number of moles
Conceptual Plan: $\textbf{kg Na}_2\textbf{SO}_4 \rightarrow \textbf{g Na}_2\textbf{SO}_4 \rightarrow \textbf{mole Na}_2\textbf{SO}_4$

$$\frac{1000\text{ g Na}_2\text{SO}_4}{\text{kg Na}_2\text{SO}_4} \qquad \frac{1\text{ mol}}{142.05\text{ g Na}_2\text{SO}_4}$$

Solution: $155.2\ \text{kg Na}_2\text{SO}_4 \times \dfrac{1000\text{g Na}_2\text{SO}_4}{\text{kg Na}_2\text{SO}_4} \times \dfrac{1\text{ mol Na}_2\text{SO}_4}{142.05\text{ g Na}_2\text{SO}_4} = 1092\text{ mol Na}_2\text{SO}_4$

Check: The units of the answer (mole Na_2SO_4) are correct. The magnitude is appropriate because there is over 100 kg of Na_2SO_4 present.

3.58 (a) **Given:** 55.98 g CF_2Cl_2 **Find:** number of moles
Conceptual Plan: $\textbf{g CF}_2\textbf{Cl}_2 \rightarrow \textbf{mole CF}_2\textbf{Cl}_2$

$$\frac{1\text{ mol}}{120.91\text{ g CF}_2\text{Cl}_2}$$

Solution: $55.98 \text{ g } CF_2Cl_2 \times \frac{1 \text{ mol } CF_2Cl_2}{120.91 \text{ g } CF_2Cl_2} = 0.46298 \text{ mol } CF_2Cl_2 = 0.4630 \text{ mol } CF_2Cl_2$

Check: The units of the answer (mole CF_2Cl_2) are correct. The magnitude is appropriate because it is less than 1 mole of CF_2Cl_2.

(b) **Given:** 23.6 kg $Fe(NO_3)_2$ **Find:** number of moles

Conceptual Plan: kg $Fe(NO_3)_2$ → g $Fe(NO_3)_2$ → mole $Fe(NO_3)_2$

$\frac{1000 \text{ g } Fe(NO_3)_2}{\text{kg } Fe(NO_3)_2}$ $\frac{1 \text{ mol}}{179.87 \text{ g} Fe(NO_3)_2}$

Solution: $23.6 \text{ kg } Fe(NO_3)_2 \times \frac{1000 \text{ g } Fe(NO_3)_2}{\text{kg } Fe(NO_3)_2} \times \frac{1 \text{ mol } Fe(NO_3)_2}{179.87 \text{ g } Fe(NO_3)_2} = 131 \text{ mol } Fe(NO_3)_2$

Check: The units of the answer (mole $Fe(NO_3)_2$) are correct. The magnitude is appropriate because there is over a kg of $Fe(NO_3)_2$ present.

(c) **Given:** 0.1187g C_8H_{18} **Find:** number of moles

Conceptual Plan: g C_8H_{18} → mole C_8H_{18}

$\frac{1 \text{ mol}}{114.22 \text{ g } C_8H_{18}}$

Solution: $0.1187 \text{ g } C_8H_{18} \times \frac{1 \text{ mol } C_8H_{18}}{114.22 \text{ g } C_8H_{18}} = 1.039 \times 10^{-3} \text{ mol } C_8H_{18}$

Check: The units of the answer (mole C_8H_{18}) are correct. The magnitude is appropriate because it is much less than 1 mole of C_8H_{18}.

(d) **Given:** 195 kg CaO **Find:** number of moles

Conceptual Plan: kg CaO → g CaO → mole CaO

$\frac{1000 \text{g CaO}}{\text{kg CaO}}$ $\frac{1 \text{ mol}}{56.08 \text{ g CaO}}$

Solution: $195 \text{ kg CaO} \times \frac{1000 \text{ g CaO}}{\text{kg CaO}} \times \frac{1 \text{ mol CaO}}{56.08 \text{ CaO}} = 3477 \text{ mol CaO} = 3.48 \times 10^3 \text{ mol CaO}$

Check: The units of the answer (mole CaO) are correct. The magnitude is appropriate because there is over a kg of CaO present.

3.59 (a) **Given:** 6.5 g H_2O **Find:** number of molecules

Conceptual Plan: g H_2O → mole H_2O → number H_2O molecules

$\frac{1 \text{ mol}}{18.02 \text{ g } H_2O}$ $\frac{6.022 \times 10^{23} \text{ } H_2O \text{ molecules}}{\text{mol } H_2O}$

Solution: $6.5 \text{ g } H_2O \times \frac{1 \text{ mol } H_2O}{18.02 \text{ g } H_2O} \times \frac{6.022 \times 10^{23} \text{ } H_2O \text{ molecules}}{\text{mol } H_2O} = 2.2 \times 10^{23} \text{ } H_2O \text{ molecules}$

Check: The units of the answer (H_2O molecules) are correct. The magnitude is appropriate: it is smaller than Avogadro's number, as expected, since we have less than 1 mole of H_2O.

(b) **Given:** 389 g CBr_4 **Find:** number of molecules

Conceptual Plan: g CBr_4 → mole CBr_4 → number CBr_4 molecules

$\frac{1 \text{ mol}}{331.6 \text{ g } CBr_4}$ $\frac{6.022 \times 10^{23} \text{ } CBr_4 \text{ molecules}}{\text{mol } CBr_4}$

Solution: $389 \text{ g } CBr_4 \times \frac{1 \text{ mol } CBr_4}{331.6 \text{ g } CBr_4} \times \frac{6.022 \times 10^{23} \text{ } CBr_4 \text{ molecules}}{\text{mol } CBr_4} = 7.06 \times 10^{23} \text{ } CBr_4 \text{ molecules}$

Check: The units of the answer (CBr_4 molecules) are correct. The magnitude is appropriate: it is larger than Avogadro's number, as expected, since we have more than 1 mole of CBr_4.

(c) **Given:** 22.1 g O_2 **Find:** number of molecules

Conceptual Plan: g O_2 → mole O_2 → number O_2 molecules

$\frac{1 \text{ mol}}{32.00 \text{ g } O_2}$ $\frac{6.022 \times 10^{23} \text{ } O_2 \text{ molecules}}{\text{mol } O_2}$

Solution: $22.1 \text{ g } O_2 \times \frac{1 \text{ mol } O_2}{32.00 \text{ g } O_2} \times \frac{6.022 \times 10^{23} \text{ } O_2 \text{ molecules}}{\text{mol } O_2} = 4.16 \times 10^{23} \text{ } O_2 \text{ molecules}$

Check: The units of the answer (O_2 molecules) are correct. The magnitude is appropriate: it is smaller than Avogadro's number, as expected, since we have less than 1 mole of O_2.

(d) **Given:** 19.3 g C_8H_{10} **Find:** number of molecules
Conceptual Plan: g C_8H_{10} → mole C_8H_{10} → number C_8H_{10} molecules

$$\frac{1\ \text{mol}}{106.16\ \text{g}\ C_8H_{10}} \quad \frac{6.022 \times 10^{23}\ C_8H_{10}\ \text{molecules}}{\text{mol}\ C_8H_{10}}$$

Solution:

$$19.3\ \text{g}\ C_8H_{10} \times \frac{1\ \text{mol}\ C_8H_{10}}{106.16\ \text{g}\ C_8H_{10}} \times \frac{6.022 \times 10^{23}\ C_8H_{10}\ \text{molecules}}{\text{mol}\ C_8H_{10}} = 1.09 \times 10^{23}\ C_8H_{10}\ \text{molecules}$$

Check: The units of the answer (C_8H_{10} molecules) are correct. The magnitude is appropriate: it is smaller than Avogadro's number, as expected, since we have less than 1 mole of C_8H_{10}.

3.60 (a) **Given:** 85.26 g CCl_4 **Find:** number of molecules
Conceptual Plan: g CCl_4 → mole CCl_4 → number CCl_4 molecules

$$\frac{1\ \text{mol}}{153.81\ \text{g}\ CCl_4} \quad \frac{6.022 \times 10^{23}\ CCl_4\ \text{molecules}}{\text{mol}\ CCl_4}$$

Solution: $85.26\ \text{g}\ CCl_4 \times \frac{1\ \text{mol}\ CCl_4}{153.81\ \text{g}\ CCl_4} \times \frac{6.022 \times 10^{23}\ CCl_4\ \text{molecules}}{\text{mol}\ CCl_4}$

$= 3.3381 \times 10^{23}\ CCl_4$ molecules $= 3.338 \times 10^{23}\ CCl_4$ molecules

Check: The units of the answer (CCl_4 molecules) are correct. The magnitude is appropriate: it is smaller than Avogadro's number, as expected, since we have less than 1 mole of CCl_4.

(b) **Given:** 55.93 kg $NaHCO_3$ **Find:** number of molecules
Conceptual Plan: kg $NaHCO_3$ → g $NaHCO_3$ → mole $NaHCO_3$ → number $NaHCO_3$ molecules

$$\frac{1000\ \text{g}}{\text{kg}} \quad \frac{1\ \text{mol}}{84.01\ \text{g}\ NaHCO_3} \quad \frac{6.022 \times 10^{23}\ NaHCO_3\ \text{molecules}}{\text{mol}\ NaHCO_3}$$

Solution:

$$55.93\ \text{kg}\ NaHCO_3 \times \frac{1000\ \text{g}\ NaHCO_3}{\text{kg}\ NaHCO_3} \times \frac{1\ \text{mol}\ NaHCO_3}{84.01\ \text{g}\ NaHCO_3} \times \frac{6.022 \times 10^{23}\ NaHCO_3\ \text{molecules}}{\text{mol}\ NaHCO_3}$$

$= 4.009 \times 10^{26}\ NaHCO_3$ molecules

Check: The units of the answer ($NaHCO_3$ molecules) are correct. The magnitude is appropriate: it is more than Avogadro's number, as expected, since we have many moles of $NaHCO_3$.

(c) **Given:** 119.78 g C_4H_{10} **Find:** number of molecules
Conceptual Plan: g C_4H_{10} → mole C_4H_{10} → number C_4H_{10} molecules

$$\frac{1\ \text{mol}}{58.12\ \text{g}\ C_4H_{10}} \quad \frac{6.022 \times 10^{23}\ C_4H_{10}\ \text{molecules}}{\text{mol}\ C_4H_{10}}$$

Solution:

$$119.78\ \text{g}\ C_4H_{10} \times \frac{1\ \text{mol}\ C_4H_{10}}{58.12\ \text{g}\ C_4H_{10}} \times \frac{6.022 \times 10^{23}\ C_4H_{10}\ \text{molecules}}{\text{mol}\ C_4H_{10}} = 1.241 \times 10^{24}\ C_4H_{10}\ \text{molecules}$$

Check: The units of the answer (C_4H_{10} molecules) are correct. The magnitude is appropriate: it is larger than Avogadro's number, as expected, since we have more than 1 mole of C_4H_{10}.

(d) **Given:** 4.59×10^5 g Na_3PO_4 **Find:** number of molecules
Conceptual Plan: g Na_3PO_4 → mole Na_3PO_4 → number Na_3PO_4 molecules

$$\frac{1\ \text{mol}}{163.94\ \text{g}\ Na_3PO_4} \quad \frac{6.022 \times 10^{23}\ Na_3PO_4\ \text{molecules}}{\text{mol}\ Na_3PO_4}$$

Solution: $4.59 \times 10^5\ \text{g}\ Na_3PO_4 \times \frac{1\ \text{mol}\ Na_3PO_4}{163.94\ \text{g}\ Na_3PO_4} \times \frac{6.022 \times 10^{23}\ Na_3PO_4\ \text{molecules}}{\text{mol}\ Na_3PO_4}$

$= 1.686 \times 10^{27}\ Na_3PO_4$ molecules $= 1.69 \times 10^{27}\ Na_3PO_4$ molecules

Check: The units of the answer (Na_3PO_4 molecules) are correct. The magnitude is appropriate: it is larger than Avogadro's number, as expected, since we have more than 1 mole of Na_3PO_4.

3.61 (a) **Given:** $5.94 \times 10^{20}\ SO_3$ molecules **Find:** mass in g
Conceptual Plan: number SO_3 molecules → mole SO_3 → g SO_3

$$\frac{1\ \text{mol}\ SO_3}{6.022 \times 10^{23}\ SO_3\ \text{molecules}} \quad \frac{80.07\ \text{g}\ SO_3}{1\ \text{mol}\ SO_3}$$

Solution: $5.94 \times 10^{20}\ \cancel{SO_3\ molecules} \times \frac{1\ \cancel{mol\ SO_3}}{6.022 \times 10^{23}\ \cancel{SO_3\ molecules}} \times \frac{80.07\ g\ SO_3}{1\ \cancel{mol\ SO_3}} = 0.0790\ g\ SO_3$

Check: The units of the answer (grams SO_3) are correct. The magnitude is appropriate: there is less than Avogadro's number of molecules so we have less than 1 mole of SO_3.

(b) **Given:** 2.8×10^{22} H_2O molecules **Find:** mass in g

Conceptual Plan: number H_2O molecules $\rightarrow$ mole H_2O $\rightarrow$ g H_2O

$$\frac{1\ mol\ H_2O}{6.022 \times 10^{23}\ H_2O\ molecules} \qquad \frac{18.02\ g\ H_2O}{1\ mol\ H_2O}$$

Solution: $2.8 \times 10^{22}\ \cancel{H_2O\ molecules} \times \frac{1\ \cancel{mol\ H_2O}}{6.022 \times 10^{23}\ \cancel{H_2O\ molecules}} \times \frac{18.02\ g\ H_2O}{1\ \cancel{mol\ H_2O}} = 0.84\ g\ H_2O$

Check: The units of the answer (grams H_2O) are correct. The magnitude is appropriate: there is less than Avogadro's number of molecules so we have less than 1 mole of H_2O.

(c) **Given:** 1 $C_6H_{12}O_6$ molecule **Find:** mass in g

Conceptual Plan: number $C_6H_{12}O_6$ molecules $\rightarrow$ mole $C_6H_{12}O_6$ $\rightarrow$ g $C_6H_{12}O_6$

$$\frac{1\ mol\ C_6H_{12}O_6}{6.022 \times 10^{23}\ C_6H_{12}O_6\ molecules} \qquad \frac{180.16\ g\ C_6H_{12}O_6}{1\ mol\ C_6H_{12}O_6}$$

Solution:

$$1\ \cancel{C_6H_{12}O_6\ molecule} \times \frac{1\ \cancel{mol\ C_6H_{12}O_6}}{6.022 \times 10^{23}\ \cancel{C_6H_{12}O_6\ molecules}} \times \frac{180.16\ g\ C_6H_{12}O_6}{1\ \cancel{mol\ C_6H_{12}O_6}} = 2.992 \times 10^{-22}\ g\ C_6H_{12}O_6$$

Check: The units of the answer (grams $C_6H_{12}O_6$) are correct. The magnitude is appropriate: there is much less than Avogadro's number of molecules so we have much less than 1 mole of $C_6H_{12}O_6$.

3.62 (a) **Given:** 4.5×10^{25} O_3 molecules **Find:** mass in g

Conceptual Plan: number O_3 molecules $\rightarrow$ mole O_3 $\rightarrow$ g O_3

$$\frac{1\ mol\ O_3}{6.022 \times 10^{23}\ O_3\ molecules} \qquad \frac{48.00\ g\ O_3}{1\ mol\ O_3}$$

Solution: $4.5 \times 10^{25}\ \cancel{O_3\ molecules} \times \frac{1\ \cancel{mol\ O_3}}{6.022 \times 10^{23}\ \cancel{O_3\ molecules}} \times \frac{48.00\ g\ O_3}{1\ \cancel{mol\ O_3}} = 3.6 \times 10^{3}\ g\ O_3$

Check: The units of the answer (grams O_3) are correct. The magnitude is appropriate: there is more than Avogadro's number of molecules so we have more than 1 mole of O_3.

(b) **Given:** 9.85×10^{19} CCl_2F_2 molecules **Find:** mass in g

Conceptual Plan: number CCl_2F_2 molecules $\rightarrow$ mole CCl_2F_2 $\rightarrow$ g CCl_2F_2

$$\frac{1\ mol\ O_3}{6.022 \times 10^{23}\ O_3\ molecules} \qquad \frac{120.91\ g\ CCl_2F_2}{1\ mol\ CClF_2}$$

Solution:

$$9.85 \times 10^{19}\ \cancel{CCl_2F_2\ molecules} \times \frac{1\ \cancel{mol\ CCl_2F_2}}{6.022 \times 10^{23}\ \cancel{CCl_2F_2\ molecules}} \times \frac{120.91\ g\ CCl_2F_2}{1\ \cancel{mol\ CCl_2F_2}} = 1.98 \times 10^{-2}\ g\ CCl_2F_2$$

Check: The units of the answer (grams CCl_2F_2) are correct. The magnitude is appropriate: there is less than Avogadro's number of molecules so we have less than 1 mole of CCl_2F_2.

(c) **Given:** 1 H_2O molecule **Find:** mass in g

Conceptual Plan: number H_2O molecules $\rightarrow$ mole H_2O $\rightarrow$ g H_2O

$$\frac{1\ mol\ H_2O}{6.022 \times 10^{23}\ H_2O\ molecules} \qquad \frac{18.02\ g\ H_2O}{1\ mol\ H_2O}$$

Solution: $1\ \cancel{H_2O\ molecule} \times \frac{1\ \cancel{mol\ H_2O}}{6.022 \times 10^{23}\ \cancel{H_2O\ molecules}} \times \frac{18.02\ g\ H_2O}{1\ \cancel{mol\ H_2O}} = 2.992 \times 10^{-23}\ g\ H_2O$

Check: The units of the answer (grams H_2O) are correct. The magnitude is appropriate: there is much less than Avogadro's number of molecules so we have much less than 1 mole of H_2O.

3.63 **Given:** 1.8×10^{17} $C_{12}H_{22}O_{11}$ molecule **Find:** mass in mg

Conceptual Plan: number $C_{12}H_{22}O_{11}$ molecules → mole $C_{12}H_{22}O_{11}$ → g $C_{12}H_{22}O_{11}$ → mg $C_{12}H_{22}O_{11}$

$$\frac{1 \text{ mol } C_{12}H_{22}O_{11}}{6.022 \times 10^{23} \text{ } C_{12}H_{22}O_{11} \text{ molecules}} \quad \frac{342.3 \text{ g } C_{12}H_{22}O_{11}}{1 \text{ mol } C_{12}H_{22}O_{11}} \quad \frac{1 \times 10^{3} \text{ mg } C_{12}H_{22}O_{11}}{1 \text{ g } C_{12}H_{22}O_{11}}$$

Solution:

$$1.8 \times 10^{17} \text{ } C_{12}H_{22}O_{11} \text{ molecules} \times \frac{1 \text{ mol } C_{12}H_{22}O_{11}}{6.022 \times 10^{23} \text{ } C_{12}H_{22}O_{11} \text{ molecules}} \times \frac{342.3 \text{ g } C_{12}H_{22}O_{11}}{1 \text{ mol } C_{12}H_{22}O_{11}} \times \frac{1 \times 10^{3} \text{ mg } C_{12}H_{22}O_{11}}{1 \text{ g } C_{12}H_{22}O_{11}}$$

$= 0.10 \text{ mg } C_{12}H_{22}O_{11}$

Check: The units of the answer (milligrams $C_{12}H_{22}O_{11}$) are correct. The magnitude is appropriate: there is much less than Avogadro's number of molecules so we have much less than 1 mole of $C_{12}H_{22}O_{11}$.

3.64 **Given:** 0.12 mg NaCl **Find:** number of formula units

Conceptual Plan: mg NaCl → g NaCl → mole NaCl → number of formula units NaCl

$$\frac{1 \text{ g NaCl}}{1 \times 10^{3} \text{ mg NaCl}} \quad \frac{1 \text{ mol NaCl}}{58.44 \text{ g NaCl}} \quad \frac{6.022 \times 10^{23} \text{ NaCl formula units}}{1 \text{ mol NaCl}}$$

Solution:

$$0.12 \text{ mg NaCl} \times \frac{1 \text{ g NaCl}}{1 \times 10^{3} \text{ mg NaCl}} \times \frac{1 \text{ mol NaCl}}{58.44 \text{ g NaCl}} \times \frac{6.022 \times 10^{23} \text{ formula units NaCl}}{1 \text{ mol NaCl}} = 1.2 \times 10^{18} \text{ formula units NaCl}$$

Check: The units of the answer (formula units NaCl) are correct. The magnitude is appropriate: there is less than 1 mole of NaCl so we have less than Avogadro's number of formula units.

Composition of Compounds

3.65 (a) **Given:** CH_4 **Find:** mass percent C

Conceptual Plan: $\text{mass \% C} = \frac{1 \times \text{molar mass C}}{\text{molar mass } CH_4} \times 100$

Solution:

$1 \times \text{molar mass C} = 1(12.01 \text{ g/mol}) = 12.01 \text{ g C}$

$\text{molar mass } CH_4 = 1(12.01 \text{ g/mol}) + 4(1.008 \text{ g/mol}) = 16.04 \text{ g/mol}$

$$\text{mass \% C} = \frac{1 \times \text{molar mass C}}{\text{molar mass } CH_4} \times 100\% = \frac{12.01 \text{ g/mol}}{16.04 \text{ g/mol}} \times 100\% = 74.87\%$$

Check: The units of the answer (%) are correct. The magnitude is reasonable because it is between 0 and 100% and carbon is the heaviest element.

(b) **Given:** C_2H_6 **Find:** mass percent C

Conceptual Plan: $\text{mass \% C} = \frac{2 \times \text{molar mass C}}{\text{molar mass } C_2H_6} \times 100$

Solution:

$2 \times \text{molar mass C} = 2(12.01 \text{ g/mol}) = 24.02 \text{ g C}$

$\text{molar mass } C_2H_6 = 2(12.01 \text{ g/mol}) + 6(1.008 \text{ g/mol}) = 30.07 \text{ g/mol}$

$$\text{mass \% C} = \frac{2 \times \text{molar mass C}}{\text{molar mass } C_2H_6} \times 100\% = \frac{24.02 \text{ g/mol}}{30.07 \text{ g/mol}} \times 100\% = 79.89\%$$

Check: The units of the answer (%) are correct. The magnitude is reasonable because it is between 0 and 100% and carbon is the heaviest element.

(c) **Given:** C_2H_2 **Find:** mass percent C

Conceptual Plan: $\text{mass \% C} = \frac{2 \times \text{molar mass C}}{\text{molar mass } C_2H_2} \times 100$

Solution:

$$2 \text{ x molar mass C} = 2(12.01 \text{g/mol}) = 24.02 \text{ g C}$$
$$\text{molar mass } C_2H_2 = 2(12.01 \text{ g/mol}) + 2(1.008 \text{ g/mol}) = 26.04 \text{ g/mol}$$
$$\text{mass \% C} = \frac{2 \text{ x molar mass C}}{\text{molar mass } C_2H_2} \text{ x } 100\%$$
$$= \frac{24.02 \cancel{\text{g/mol}}}{26.04 \cancel{\text{g/mol}}} \text{ x } 100\%$$
$$= 92.26 \%$$

Check: The units of the answer (%) are correct. The magnitude is reasonable because it is between 0 and 100% and carbon is the heaviest element.

(d) **Given:** C_2H_5Cl **Find:** mass percent C

Conceptual Plan: $\text{mass \% C} = \frac{2 \text{ x molar mass C}}{\text{molar mass } C_2H_5Cl} \text{ x } 100$

Solution:

$$2 \text{ x molar mass C} = 2(12.01 \text{g/mol}) = 24.02 \text{ g C}$$
$$\text{molar mass } C_2H_5Cl = 2(12.01 \text{ g/mol}) + 5(1.008 \text{ g/mol}) + 1(35.45 \text{ g/mol}) = 64.51 \text{ g/mol}$$
$$\text{mass \% C} = \frac{2 \text{ x molar mass C}}{\text{molar mass } C_2H_5Cl} \text{ x } 100\%$$
$$= \frac{24.02 \cancel{\text{g/mol}}}{64.51 \cancel{\text{g/mol}}} \text{ x } 100\%$$
$$= 37.23 \%$$

Check: The units of the answer (%) are correct. The magnitude is reasonable because it is between 0 and 100% and chlorine is heavier than carbon.

3.66 (a) **Given:** N_2O **Find:** mass percent N

Conceptual Plan: $\text{mass \% N} = \frac{2 \text{ x molar mass N}}{\text{molar mass } N_2O} \text{ x } 100$

Solution:

$$2 \text{ x molar mass N} = 2(14.01 \text{g/mol}) = 28.02 \text{ g N}$$
$$\text{molar mass } N_2O = 2(14.01 \text{ g/mol}) + (16.00 \text{ g/mol}) = 44.02 \text{ g/mol}$$
$$\text{mass \% N} = \frac{2 \text{ x molar mass N}}{\text{molar mass } N_2O} \text{ x } 100\%$$
$$= \frac{28.02 \cancel{\text{g/mol}}}{44.02 \cancel{\text{g/mol}}} \text{ x } 100\%$$
$$= 63.65 \%$$

Check: The units of the answer (%) are correct. The magnitude is reasonable because it is between 0 and 100% and there are 2 nitrogens per molecule.

(b) **Given:** NO **Find:** mass percent N

Conceptual Plan: $\text{mass \% N} = \frac{1 \text{ x molar mass N}}{\text{molar mass NO}} \text{ x } 100$

Solution:

$$1 \text{ x molar mass N} = 1(14.01 \text{g/mol}) = 14.01 \text{ g N}$$
$$\text{molar mass NO} = (14.01 \text{ g/mol}) + (16.00 \text{ g/mol}) = 30.01 \text{ g/mol}$$
$$\text{mass \% N} = \frac{1 \text{ x molar mass N}}{\text{molar mass NO}} \text{ x } 100\%$$
$$= \frac{14.01 \cancel{\text{g/mol}}}{30.01 \cancel{\text{g/mol}}} \text{ x } 100\%$$
$$= 46.68 \%$$

Check: The units of the answer (%) are correct. The magnitude is reasonable because it is between 0 and 100% and the mass of nitrogen is less than the mass of oxygen.

(c) **Given:** NO_2 **Find:** mass percent N

Conceptual Plan: $\text{mass \% N} = \frac{1 \text{ x molar mass N}}{\text{molar mass } NO_2} \text{ x } 100$

Check: The units of the answer (%) are correct. The magnitude is reasonable because it is between 0 and 100% and iron provides most of the formula mass.

Given: $FeCO_3$ **Find:** mass percent Fe

Conceptual Plan: $\text{mass \% Fe} = \frac{1 \times \text{molar mass Fe}}{\text{molar mass } FeCO_3} \times 100$

Solution:

$1 \times \text{molar mass Fe} = (55.85\ g/mol) = 55.85\ g\ Fe$

$\text{molar mass } FeCO_3 = 1(55.85\ g/mol) + 1(12.01\ g/mol) + 3(16.00\ g/mol) = 115.86\ g/mol$

$$\text{mass \% Fe} = \frac{1 \times \text{molar mass Fe}}{\text{molar mass } FeCO_3} \times 100\% = \frac{55.85\ \cancel{g/mol}}{115.86\ \cancel{g/mol}} \times 100\% = 48.20\ \%$$

Check: The units of the answer (%) are correct. The magnitude is reasonable because it is between 0 and 100% and iron provides slightly less than half of the formula mass.

The ore with the highest iron content is Fe_3O_4 with an Fe content of 72.37% Fe.

3.69 **Given:** 55.5 g CuF_2: 37.42 % F **Find:** g F in CuF_2

Conceptual Plan: **g CuF_2 → g F**

$\frac{37.42\ g\ F}{100.0\ g\ CuF_2}$

Solution: $55.5\ \cancel{g\ CuF_2} \times \frac{37.42\ g\ F}{100.0\ \cancel{g\ CuF_2}} = 20.77 = 20.8\ g\ F$

Check: The units of the answer (g F) are correct. The magnitude is reasonable because it is less than the original mass.

3.70 **Given:** 155 mg Ag; 75.27 % Ag in AgCl **Find:** mg AgCl

Conceptual Plan: **mg Ag → g Ag → g AgCl → mg AgCl**

$\frac{1\ g\ Ag}{1000\ mg\ Ag}$ $\frac{100.0\ g\ AgCl}{75.27\ g\ Ag}$ $\frac{1000\ mg\ AgCl}{1\ g\ AgCl}$

Solution: $155\ \cancel{mg\ Ag} \times \frac{1\ \cancel{g\ Ag}}{1000\ \cancel{mg\ Ag}} \times \frac{100.0\ \cancel{g\ AgCl}}{75.27\ \cancel{g\ Ag}} \times \frac{1000\ mg\ AgCl}{1\ \cancel{g\ AgCl}} = 206\ mg\ AgCl$

Check: The units of the answer (g AgCl) are correct. The magnitude is reasonable because it is greater than the original mass.

3.71 **Given:** 150 μg I; 76.45% I in KI **Find:** μg KI

Conceptual Plan: **μg I → g I → g KI → μg KI**

$\frac{1\ g\ I}{1 \times 10^6\ \mu g\ I}$ $\frac{100.0\ g\ KI}{76.45\ g\ I}$ $\frac{1 \times 10^6\ \mu g\ KI}{1\ g\ KI}$

Solution: $150\ \cancel{\mu g\ I} \times \frac{1\ \cancel{g\ I}}{1 \times 10^6\ \cancel{\mu g\ I}} \times \frac{100.0\ \cancel{g\ KI}}{76.45\ \cancel{g\ I}} \times \frac{1 \times 10^6\ \mu g\ KI}{1\ \cancel{g\ KI}} = 196\ \mu g\ KI$

Check: The units of the answer (μg KI) are correct. The magnitude is reasonable because it is greater than the original mass.

3.72 **Given:** 3.0 mg F; 45.24 % F in NaF **Find:** mg NaF

Conceptual Plan: **mg F → g F → g NaF → mg NaF**

$\frac{1\ g\ F}{1000\ mg\ F}$ $\frac{100.0\ g\ NaF}{45.24\ g\ F}$ $\frac{1000\ mg\ NaF}{1\ g\ NaF}$

Solution: $3.0\ \cancel{mg\ F} \times \frac{1\ \cancel{g\ F}}{1000\ \cancel{mg\ F}} \times \frac{100.0\ \cancel{g\ NaF}}{45.24\ \cancel{g\ NaF}} \times \frac{1000\ mg\ NaF}{1\ \cancel{g\ NaF}} = 6.6\ mg\ NaF$

Check: The units of the answer (mg NaF) are correct. The magnitude is reasonable because it is greater than the original mass.

3.78 (a) **Given:** 25 kg CF_2Cl_2 **Find:** kg Cl

Conceptual Plan: **kg CF_2Cl_2 → g CF_2Cl_2 → mole CF_2Cl_2 → mol Cl → g Cl → kg Cl**

$$\frac{1000\ g\ CF_2Cl_2}{1\ kg\ CF_2Cl_2} \quad \frac{1\ mol\ CF_2Cl_2}{120.91\ g\ CF_2Cl_2} \quad \frac{2\ mol\ Cl}{1\ mol\ CF_2Cl_2} \quad \frac{35.45\ g\ Cl}{1\ mol\ Cl} \quad \frac{1\ kg\ Cl}{1000\ g\ Cl}$$

Solution: $25\ kg\ CF_2Cl_2 \times \frac{1000\ g\ CF_2Cl_2}{1\ kg\ CF_2Cl_2} \times \frac{1\ mol\ CF_2Cl_2}{120.91\ g\ CF_2Cl_2} \times \frac{2\ mol\ Cl}{1\ mol\ CF_2Cl_2} \times \frac{35.45\ g\ Cl}{1\ mol\ Cl} \times \frac{1\ kg\ Cl}{1000\ g\ Cl}$

$= 15\ kg\ Cl$

Check: The units of the answer (kg Cl) are correct. The magnitude is reasonable because it is less than the original kg CF_2Cl_2.

(b) **Given:** 25 kg $CFCl_3$ **Find:** kg Cl

Conceptual Plan: **kg $CFCl_3$ → g $CFCl_3$ → mole $CFCl_3$ → mol Cl → g Cl → kg Cl**

$$\frac{1000\ g\ CFCl_3}{1\ kg\ CFCl_3} \quad \frac{1\ mol\ CFCl_3}{137.4\ g\ CFCl_3} \quad \frac{3\ mol\ Cl}{1\ mol\ CFCl_3} \quad \frac{35.45\ g\ Cl}{1\ mol\ Cl} \quad \frac{1\ kg\ Cl}{1000\ g\ Cl}$$

Solution: $25\ kg\ CFCl_3 \times \frac{1000\ g\ CFCl_3}{1\ kg\ CFCl_3} \times \frac{1\ mol\ CFCl_3}{137.4\ g\ CFCl_3} \times \frac{3\ mol\ Cl}{1\ mol\ CFCl_3} \times \frac{35.45\ g\ Cl}{1\ mol\ Cl} \times \frac{1\ kg\ Cl}{1000 g Cl}$

$= 19\ kg\ Cl$

Check: The units of the answer (kg Cl) are correct. The magnitude is reasonable because it is less than the original kg CF_2Cl_2.

(c) **Given:** 25 kg $C_2F_3Cl_3$ **Find:** kg Cl

Conceptual Plan: **kg $C_2F_3Cl_3$ → g $C_2F_3Cl_3$ → mole $C_2F_3Cl_3$ → mol Cl → g Cl → kg Cl**

$$\frac{1000\ g\ C_2F_3Cl_3}{1\ kg\ C_2F_3Cl_3} \quad \frac{1\ mol\ C_2F_3Cl_3}{187.4\ g\ C_2F_3Cl_3} \quad \frac{3\ mol\ Cl}{1\ mol\ C_2F_3Cl_3} \quad \frac{35.45\ g\ Cl}{1\ mol\ Cl} \quad \frac{1\ kg\ Cl}{1000\ g\ Cl}$$

Solution: $25\ kg\ C_2F_3Cl_3 \times \frac{1000\ g\ C_2F_3Cl_3}{1 kg\ C_2F_3Cl_3} \times \frac{1\ mol\ C_2F_3Cl_3}{187.4\ g\ C_2F_3Cl_3} \times \frac{3\ mol\ Cl}{1\ mol\ C_2F_3Cl_3} \times \frac{35.45\ g\ Cl}{1\ mol\ Cl} \times \frac{1\ kgCl}{1000\ gCl}$

$= 14\ kg\ Cl$

Check: The units of the answer (kg Cl) are correct. The magnitude is reasonable because it is less than the original kg $C_2F_3Cl_3$.

(d) **Given:** 25 kg CF_3Cl **Find:** kg Cl

Conceptual Plan: **kg CF_3Cl → g CF_3Cl → mole CF_3Cl → mol Cl → g Cl → kg Cl**

$$\frac{1000\ g\ CF_3Cl}{1\ kg\ CF_3Cl} \quad \frac{1\ mol\ CF_3Cl}{104.46\ g\ CF_3Cl} \quad \frac{1\ mol\ Cl}{1\ mol\ CF_3Cl} \quad \frac{35.45\ g\ Cl}{1\ mol\ Cl} \quad \frac{1\ kg\ Cl}{1000\ g\ Cl}$$

Solution: $25\ kg\ CF_3Cl \times \frac{1000\ g\ CF_3Cl}{1\ kg\ CF_3Cl} \times \frac{1\ mol\ CF_3Cl}{104.46\ g\ CF_3Cl} \times \frac{1\ mol\ Cl}{1\ mol\ CF_3Cl} \times \frac{35.45\ g\ Cl}{1\ mol\ Cl} \times \frac{1\ kg\ Cl}{1000\ g\ Cl}$

$= 8.5\ kg\ Cl$

Check: The units of the answer (kg Cl) are correct. The magnitude is reasonable because it is less than the original kg CF_3Cl.

Chemical Formulas from Experimental Data

3.79 (a) **Given:** 1.651 g Ag; 0.1224 g O **Find:** empirical formula

Conceptual Plan:

convert mass to mol of each element → write pseudoformula → write empirical formula

$$\frac{1\ mol\ Ag}{107.9\ g\ Ag} \quad \frac{1\ mol\ O}{16.00\ g\ O}$$ divide by smallest number

Solution: $1.651\ g\ Ag \times \frac{1\ mol\ Ag}{107.9\ g\ Ag} = 0.01530\ mol\ Ag$

$0.1224\ g\ O \times \frac{1\ mol\ O}{16.00\ g\ O} = 0.007650\ mol\ O$

$Ag_{0.01530}O_{0.007650}$

$Ag_{\frac{0.01530}{0.007650}}O_{\frac{0.007650}{0.007650}} \rightarrow Ag_2O$

The correct empirical formula is Ag_2O.

(b) **Given:** 0.672 g Co; 0.569 g As; 0.486 g O **Find:** empirical formula
Conceptual Plan:
convert mass to mol of each element → write pseudoformula → write empirical formula

$\frac{1 \text{ mol Co}}{58.93 \text{ g Co}}$ $\frac{1 \text{ mol As}}{74.92 \text{ g As}}$ $\frac{1 \text{ mol O}}{16.00 \text{ g O}}$ divide by smallest number

Solution: $0.672 \text{ g Co} \times \frac{1 \text{ mol Co}}{58.93 \text{ g Co}} = 0.0114 \text{ mol Co}$

$0.569 \text{ g As} \times \frac{1 \text{ mol As}}{74.92 \text{ g As}} = 0.00759 \text{ mol O}$

$0.486 \text{ g O} \times \frac{1 \text{ mol O}}{16.00 \text{ g O}} = 0.0304 \text{ mol O}$

$Co_{0.0114}As_{0.00759}O_{0.0304}$

$Co_{\frac{0.0114}{0.00759}}As_{\frac{0.00759}{0.00759}}O_{\frac{0.0304}{0.00759}} \rightarrow Co_{1.5}As_1O_4$

$Co_{1.5}As_1O_4 \times 2 \rightarrow Co_3As_2O_8$

The correct empirical formula is $Co_3As_2O_8$.

(c) **Given:** 1.443 g Se; 5.841 g Br **Find:** empirical formula
Conceptual Plan:
convert mass to mol of each element → write pseudoformula → write empirical formula

$\frac{1 \text{ mol Se}}{78.96 \text{ g Se}}$ $\frac{1 \text{ mol Br}}{79.90 \text{ g Br}}$ divide by smallest number

Solution: $1.443 \text{ g Se} \times \frac{1 \text{ mol Se}}{78.96 \text{ g Se}} = 0.01828 \text{ mol Se}$

$5.841 \text{ g Br} \times \frac{1 \text{ mol Br}}{79.90 \text{ g Br}} = 0.07310 \text{ mol Br}$

$Se_{0.01828}Br_{0.07310}$

$Se_{\frac{0.01828}{0.01828}}Br_{\frac{0.07310}{0.01828}} \rightarrow SeBr_4$

The correct empirical formula is $SeBr_4$.

3.80 (a) **Given:** 1.245 g Ni; 5.381 g I **Find:** empirical formula
Conceptual Plan:
convert mass to mol of each element → write pseudoformula → write empirical formula

$\frac{1 \text{ mol Ni}}{58.69 \text{ g Ni}}$ $\frac{1 \text{ mol I}}{126.9 \text{ g I}}$ divide by smallest number

Solution: $1.245 \text{ g Ni} \times \frac{1 \text{ mol Ni}}{58.69 \text{ g Ni}} = 0.02121 \text{ mol Ni}$

$5.381 \text{ g I} \times \frac{1 \text{ mol I}}{126.9 \text{ g I}} = 0.04240 \text{ mol I}$

$Ni_{0.02121}I_{0.04240}$

$Ni_{\frac{0.02121}{0.02121}}I_{\frac{0.04240}{0.02121}} \rightarrow NiI_2$

The correct empirical formula is NiI_2.

(b) **Given:** 2.677 g Ba; 3.115 g Br **Find:** empirical formula
Conceptual Plan:
convert mass to mol of each element → write pseudoformula → write empirical formula

$\frac{1 \text{ mol Ba}}{137.3 \text{ g Ba}}$ $\frac{1 \text{ mol Br}}{79.90 \text{ g Br}}$ divide by smallest number

Solution: $2.677 \text{ g Ba} \times \frac{1 \text{ mol Ba}}{137.3 \text{ g Ba}} = 0.01950 \text{ mol Ba}$

$3.115 \text{ g Br} \times \frac{1 \text{ mol Br}}{79.90 \text{ g Br}} = 0.03899 \text{ mol Br}$

$Ba_{0.01950}Br_{0.03899}$

$Ba_{\frac{0.01950}{0.01950}}Br_{\frac{0.03899}{0.01950}} \rightarrow BaBr_2$

The correct empirical formula is $BaBr_2$.

(c) **Given:** 2.128 g Be; 7.557 g S; 15.107 g O **Find:** empirical formula
Conceptual Plan:
convert mass to mol of each element → write pseudoformula → write empirical formula
$\frac{1\text{ mol Be}}{9.012\text{ g Be}}$ $\frac{1\text{ mol S}}{32.07\text{ g S}}$ $\frac{1\text{ mol O}}{16.00\text{ g O}}$ divide by smallest number

Solution: $2.128\,\cancel{\text{g Be}} \times \frac{1\text{ mol Be}}{9.012\,\cancel{\text{g Be}}} = 0.2361\text{ mol Be}$

$7.557\,\cancel{\text{g S}} \times \frac{1\text{ mol S}}{32.07\,\cancel{\text{g S}}} = 0.2356\text{ mol S}$

$15.107\,\cancel{\text{g O}} \times \frac{1\text{ mol O}}{16.00\,\cancel{\text{g O}}} = 0.9442\text{ mol O}$

$Be_{0.2361}S_{0.2356}O_{0.9442}$

$Be_{\frac{0.2361}{0.2356}}S_{\frac{0.2356}{0.2356}}O_{\frac{0.9442}{0.2356}} \rightarrow BeSO_4$

The correct empirical formula is $BeSO_4$.

3.81 (a) **Given:** In a 100 g sample: 74.03 g C, 8.70 g H, 17.27 g N **Find:** empirical formula
Conceptual Plan:
convert mass to mol of each element → write pseudoformula → write empirical formula
$\frac{1\text{ mol C}}{12.01\text{ g C}}$ $\frac{1\text{ mol H}}{1.008\text{ g H}}$ $\frac{1\text{ mol N}}{14.01\text{ g N}}$ divide by smallest number

Solution: $74.03\,\cancel{\text{g C}} \times \frac{1\text{ mol C}}{12.01\,\cancel{\text{g C}}} = 6.164\text{ mol C}$

$8.70\,\cancel{\text{g H}} \times \frac{1\text{ mol H}}{1.008\,\cancel{\text{g H}}} = 8.63\text{ mol H}$

$17.27\,\cancel{\text{g N}} \times \frac{1\text{ mol N}}{14.01\,\cancel{\text{g N}}} = 1.233\text{ mol N}$

$C_{6.164}H_{8.63}N_{1.233}$

$C_{\frac{6.164}{1.233}}H_{\frac{8.63}{1.233}}N_{\frac{1.233}{1.233}} \rightarrow C_5H_7N$

The correct empirical formula is C_5H_7N.

(b) **Given:** In a 100 g sample: 49.48 g C, 5.19 g H, 28.85 g N, 16.48 g O **Find:** empirical formula
Conceptual Plan:
convert mass to mol of each element → write pseudoformula → write empirical formula
$\frac{1\text{ mol C}}{12.01\text{ g C}}$ $\frac{1\text{ mol H}}{1.008\text{ g H}}$ $\frac{1\text{ mol N}}{14.01\text{ g N}}$ $\frac{1\text{ mol O}}{16.00\text{ g O}}$ divide by smallest number

Solution: $49.48\,\cancel{\text{g C}} \times \frac{1\text{ mol C}}{12.01\,\cancel{\text{g C}}} = 4.120\text{ mol C}$

$5.19\,\cancel{\text{g H}} \times \frac{1\text{ mol H}}{1.008\,\cancel{\text{g H}}} = 5.15\text{ mol H}$

$28.85\,\cancel{\text{g N}} \times \frac{1\text{ mol N}}{14.01\,\cancel{\text{g N}}} = 2.059\text{ mol N}$

$16.48\,\cancel{\text{g O}} \times \frac{1\text{ mol O}}{16.00\,\cancel{\text{g O}}} = 1.030\text{ mol O}$

$C_{4.120}H_{5.15}N_{2.059}O_{1.030}$

$C_{\frac{4.120}{1.030}}H_{\frac{5.15}{1.030}}N_{\frac{2.059}{1.030}}O_{\frac{1.030}{1.030}} \rightarrow C_4H_5N_2O$

The correct empirical formula is $C_4H_5N_2O$.

3.82 (a) **Given:** In a 100 g sample: 58.80 g C, 9.87 g H, 31.33 g O **Find:** empirical formula
Conceptual Plan:
convert mass to mol of each element → write pseudoformula → write empirical formula
$\frac{1\text{ mol C}}{12.01\text{ g C}}$ $\frac{1\text{ mol H}}{1.008\text{ g H}}$ $\frac{1\text{ mol O}}{16.00\text{ g O}}$ divide by smallest number

Solution: $58.80 \text{ g C} \times \frac{1 \text{ mol C}}{12.01 \text{ g C}} = 4.896 \text{ mol C}$

$9.87 \text{ g H} \times \frac{1 \text{ mol H}}{1.008 \text{ g H}} = 9.79 \text{ mol H}$

$31.33 \text{ g O} \times \frac{1 \text{ mol O}}{16.00 \text{ g O}} = 1.958 \text{ mol O}$

$C_{4.896}H_{9.79}O_{1.958}$

$C_{\frac{4.896}{1.958}}H_{\frac{9.79}{1.958}}O_{\frac{1.958}{1.958}} \rightarrow C_{2.5}H_5O$

$C_{2.5}H_5O \times 2 = C_5H_{10}O_2$

The correct empirical formula is $C_5H_{10}O_2$.

(b) **Given:** In a 100 g sample: 63.15 g C, 5.30 g H, 31.55 g O **Find:** empirical formula

Conceptual Plan:

convert mass to mol of each element → write pseudoformula → write empirical formula

$\frac{1 \text{ mol C}}{12.01 \text{ g C}}$ $\frac{1 \text{ mol H}}{1.008 \text{ g H}}$ $\frac{1 \text{ mol O}}{16.00 \text{ g O}}$ divide by smallest number

Solution: $63.15 \text{ g C} \times \frac{1 \text{ mol C}}{12.01 \text{ g C}} = 5.258 \text{ mol C}$

$5.30 \text{ g H} \times \frac{1 \text{ mol H}}{1.008 \text{ g H}} = 5.26 \text{ mol H}$

$31.55 \text{ g O} \times \frac{1 \text{ mol O}}{16.00 \text{ g O}} = 1.972 \text{ mol O}$

$C_{5.258}H_{5.26}O_{1.972}$

$C_{\frac{5.258}{1.972}}H_{\frac{5.26}{1.972}}O_{\frac{1.972}{1.972}} \rightarrow C_{2.67}H_{2.67}O$

$C_{2.67}H_{2.67}O \times 3 = C_8H_8O_3$

The correct empirical formula is $C_8H_8O_3$.

3.83 **Given:** In a 100 g sample: 75.69 g C, 8.80 g H, 15.51 g O **Find:** empirical formula

Conceptual Plan:

convert mass to mol of each element → write pseudoformula → write empirical formula

$\frac{1 \text{ mol C}}{12.01 \text{ g C}}$ $\frac{1 \text{ mol H}}{1.008 \text{ g H}}$ $\frac{1 \text{ mol O}}{16.00 \text{ g O}}$ divide by smallest number

Solution: $75.69 \text{ g C} \times \frac{1 \text{ mol C}}{12.01 \text{ g C}} = 6.302 \text{ mol C}$

$8.80 \text{ g H} \times \frac{1 \text{ mol H}}{1.008 \text{ g H}} = 8.73 \text{ mol H}$

$15.51 \text{ g O} \times \frac{1 \text{ mol O}}{16.00 \text{ g O}} = 0.9694 \text{ mol O}$

$C_{6.302}H_{8.73}O_{0.9694}$

$C_{\frac{6.302}{0.9694}}H_{\frac{8.73}{0.9694}}O_{\frac{0.9694}{0.9694}} \rightarrow C_{6.50}H_{9.01}O$

$C_{6.50}H_{9.01}O \times 2 = C_{13}H_{18}O_2$

The correct empirical formula is $C_{13}H_{18}O_2$.

3.84 **Given:** In a 100 g sample: 40.92 g C, 4.58 g H, 54.50 g O **Find:** empirical formula

Conceptual Plan:

convert mass to mol of each element → write pseudoformula → write empirical formula

$\frac{1 \text{ mol C}}{12.01 \text{ g C}}$ $\frac{1 \text{ mol H}}{1.008 \text{ g H}}$ $\frac{1 \text{ mol O}}{16.00 \text{ g O}}$ divide by smallest number

Solution: $40.92 \text{ g C} \times \frac{1 \text{ mol C}}{12.01 \text{ g C}} = 3.407 \text{ mol C}$

$4.58 \text{ g H} \times \frac{1 \text{ mol H}}{1.008 \text{ g H}} = 4.54 \text{ mol H}$

$54.50 \text{ g O} \times \frac{1 \text{ mol O}}{16.00 \text{ g O}} = 3.406 \text{ mol O}$

$C_{3.407}H_{4.54}O_{3.406}$

Solution:

$$14.08\ \text{g CO}_2 \times \frac{1\ \text{mol CO}_2}{44.01\ \text{g CO}_2} = 0.3199\ \text{mol CO}_2$$

$$4.32\ \text{g H}_2\text{O} \times \frac{1\ \text{mol H}_2\text{O}}{18.02\ \text{g H}_2\text{O}} = 0.2397\ \text{mol H}_2\text{O}$$

$$0.3199\ \text{mol CO}_2 \times \frac{1\ \text{mol C}}{1\ \text{mol CO}_2} = 0.3199\ \text{mol C}$$

$$0.2397\ \text{mol H}_2\text{O} \times \frac{2\ \text{mol H}}{1\ \text{mol H}_2\text{O}} = 0.4795\ \text{mol H}$$

$$0.3199\ \text{mol C} \times \frac{12.01\ \text{g C}}{1\ \text{mol C}} = 3.842\ \text{g C}$$

$$0.4795\ \text{mol H} \times \frac{1.008\ \text{g H}}{1\ \text{mol H}} = 0.4833\ \text{g H}$$

$$12.01\ \text{g} - 3.842\ \text{g} - 0.4833\ \text{g} = 7.68\ \text{g O}$$

$$7.68\ \text{g O} \times \frac{1\ \text{mol O}}{16.00\ \text{g O}} = 0.480\ \text{mol O}$$

$C_{0.3199}H_{0.4795}O_{0.480}$

$C_{\frac{0.3199}{0.3199}}H_{\frac{0.4795}{0.3199}}O_{\frac{0.480}{0.3199}} \rightarrow CH_{1.5}O_{1.5}$

$CH_{1.5}O_{1.5} \times 2 = C_2H_3O_3$

The correct empirical formula is $C_2H_3O_3$.

Writing and Balancing Chemical Equations

3.93 **Conceptual Plan: write a skeletal reaction → balance atoms in more complex compounds → balance elements that occur as free elements → clear fractions**

Solution: Skeletal reaction: $SO_2(g) + O_2(g) + H_2O(l) \rightarrow H_2SO_4(aq)$
Balance O: $SO_2(g) + 1/2O_2(g) + H_2O(l) \rightarrow H_2SO_4(aq)$
Clear fraction: $2SO_2(g) + O_2(g) + 2H_2O(l) \rightarrow 2H_2SO_4(aq)$

Check:

left side	right side
2 S atoms	2 S atoms
8 O atoms	8 O atoms
4 H atoms	4 H atoms

3.94 **Conceptual Plan: write a skeletal reaction → balance atoms in more complex compounds → balance elements that occur as free elements → clear fractions**

Solution: Skeletal reaction: $NO_2(g) + O_2(g) + H_2O(l) \rightarrow HNO_3(aq)$
Balance H: $NO_2(g) + O_2(g) + H_2O(l) \rightarrow 2HNO_3(aq)$
Balance N: $2NO_2(g) + O_2(g) + H_2O(l) \rightarrow 2HNO_3(aq)$
Balance O: $2NO_2(g) + 1/2O_2(g) + H_2O(l) \rightarrow 2HNO_3(aq)$
Clear fraction: $4NO_2(g) + O_2(g) + 2H_2O(l) \rightarrow 4HNO_3(aq)$

Check:

left side	right side
4 N atoms	4 N atoms
12 O atoms	12 O atoms
4 H atoms	4 H atoms

3.95 **Conceptual Plan: write a skeletal reaction → balance atoms in more complex compounds → balance elements that occur as free elements → clear fractions**

Solution: Skeletal reaction: $Na(s) + H_2O(l) \rightarrow H_2(g) + NaOH(aq)$
Balance H: $Na(s) + H_2O(l) \rightarrow 1/2H_2(g) + NaOH(aq)$
Clear fraction: $2Na(s) + 2H_2O(l) \rightarrow H_2(g) + 2NaOH(aq)$

Check:

left side	right side
2 Na atoms	2 Na atoms
4 H atoms	4 H atoms
2 O atoms	2 O atoms

3.96 **Conceptual Plan: write a skeletal reaction → balance atoms in more complex compounds → balance elements that occur as free elements → clear fractions**

Solution: Skeletal reaction: $Fe(s) + O_2(g) \rightarrow Fe_2O_3(s)$
Balance O: $Fe(s) + 3O_2(g) \rightarrow 2Fe_2O_3(s)$
Balance Fe: $4Fe(s) + 3O_2(g) \rightarrow 2Fe_2O_3(s)$

Check:

left side	right side
4 Fe atoms	4 Fe atoms
6 O atoms	6 O atoms

3.97 **Conceptual Plan: write a skeletal reaction → balance atoms in more complex compounds → balance elements that occur as free elements → clear fractions**

Solution: Skeletal reaction: $C_{12}H_{22}O_{11}(aq) + H_2O(l) \rightarrow C_2H_5OH(aq) + CO_2(g)$
Balance H: $C_{12}H_{22}O_{11}(aq) + H_2O(l) \rightarrow 4C_2H_5OH(aq) + CO_2(g)$
Balance C: $C_{12}H_{22}O_{11}(aq) + H_2O(l) \rightarrow 4C_2H_5OH(aq) + 4CO_2(g)$

Check:

left side	right side
12 C atoms	12 C atoms
24 H atoms	24 H atoms
12 O atoms	12 O atoms

3.98 **Conceptual Plan: write a skeletal reaction → balance atoms in more complex compounds → balance elements that occur as free elements → clear fractions**

Solution: Skeletal reaction: $CO_2(g) + H_2O(l) \rightarrow C_6H_{12}O_6(aq) + O_2(g)$
Balance C: $6CO_2(g) + H_2O(l) \rightarrow C_6H_{12}O_6(aq) + O_2(g)$
Balance H: $6CO_2(g) + 6H_2O(l) \rightarrow C_6H_{12}O_6(aq) + O_2(g)$
Balance O: $6CO_2(g) + 6H_2O(l) \rightarrow C_6H_{12}O_6(aq) + 6O_2(g)$

Check:

left side	right side
6 C atoms	6 C atoms
18 O atoms	18 O atoms
12 H atoms	12 H atoms

3.99 (a) **Conceptual Plan: write a skeletal reaction → balance atoms in more complex compounds → balance elements that occur as free elements → clear fractions**

Solution: Skeletal reaction: $PbS(s) + HBr(aq) \rightarrow PbBr_2(s) + H_2S(g)$
Balance Br: $PbS(s) + 2HBr(aq) \rightarrow PbBr_2(s) + H_2S(g)$

Check:

left side	right side
1 Pb atom	1 Pb atom
1 S atom	1 S atom
2 H atoms	2 H atoms
2 Br atoms	2 Br atoms

(b) **Conceptual Plan: write a skeletal reaction → balance atoms in more complex compounds → balance elements that occur as free elements → clear fractions**

Solution: Skeletal reaction: $CO(g) + H_2(g) \rightarrow CH_4(g) + H_2O(l)$
Balance H: $CO(g) + 3H_2(g) \rightarrow CH_4(g) + H_2O(l)$

Check:

left side	right side
1 C atom	1 C atom
1 O atom	1 O atom
6 H atoms	6 H atoms

Check:	left side	right side
	4 N atoms	4 N atoms
	6 H atoms	6 H atoms
	10 O atoms	10 O atoms

3.101 (a) **Conceptual Plan: balance atoms in more complex compounds → balance elements that occur as free elements → clear fractions**

Solution: Skeletal reaction: $CO_2(g) + CaSiO_3(s) + H_2O(l) \rightarrow SiO_2(s) + Ca(HCO_3)_2(aq)$

Balance C: $2CO_2(g) + CaSiO_3(s) + H_2O(l) \rightarrow SiO_2(s) + Ca(HCO_3)_2(aq)$

Check:	left side	right side
	2 C atoms	2 C atoms
	8 O atoms	8 O atoms
	1 Ca atom	1 Ca atom
	1 Si atom	1 Si atom
	2 H atoms	2 H atoms

(b) **Conceptual Plan: balance atoms in more complex compounds → balance elements that occur as free elements → clear fractions**

Solution: Skeletal reaction: $Co(NO_3)_3(aq) + (NH_4)_2S(aq) \rightarrow Co_2S_3(s) + NH_4NO_3(aq)$

Balance S: $Co(NO_3)_3(aq) + 3(NH_4)_2S(aq) \rightarrow Co_2S_3(s) + NH_4NO_3(aq)$

Balance Co: $2Co(NO_3)_3(aq) + 3(NH_4)_2S(aq) \rightarrow Co_2S_3(s) + NH_4NO_3(aq)$

Balance N: $2Co(NO_3)_3(aq) + 3(NH_4)_2S(aq) \rightarrow Co_2S_3(s) + 6NH_4NO_3(aq)$

Check:	left side	right side
	2 Co atoms	2 Co atoms
	12 N atoms	12 N atoms
	18 O atoms	18 O atoms
	24 H atoms	24 H atoms
	3 S atoms	3 S atoms

(c) **Conceptual Plan: balance atoms in more complex compounds → balance elements that occur as free elements → clear fractions**

Solution: Skeletal reaction: $Cu_2O(s) + C(s) \rightarrow Cu(s) + CO(g)$

Balance Cu: $Cu_2O(s) + C(s) \rightarrow 2Cu(s) + CO(g)$

Check:	left side	right side
	2 Cu atoms	2 Cu atoms
	1 O atom	1 O atom
	1 C atom	1 C atom

(d) **Conceptual Plan: balance atoms in more complex compounds → balance elements that occur as free elements → clear fractions**

Solution: Skeletal reaction: $H_2(g) + Cl_2(g) \rightarrow HCl(g)$

Balance Cl: $H_2(g) + Cl_2(g) \rightarrow 2HCl(g)$

Check:	left side	right side
	2 H atoms	2 H atoms
	2 Cl atoms	2 Cl atoms

3.102 (a) **Conceptual Plan: balance atoms in more complex compounds → balance elements that occur as free elements → clear fractions**

Solution: Skeletal reaction: $Na_2S(aq) + Cu(NO_3)_2(aq) \rightarrow NaNO_3(aq) + CuS(s)$

Balance Na: $Na_2S(aq) + Cu(NO_3)_2(aq) \rightarrow 2NaNO_3(aq) + CuS(s)$

Check:	left side	right side
	2 Na atoms	2 Na atoms
	1 S atom	1 S atom
	1 Cu atom	1 Cu atom
	2 N atoms	2 N atoms
	6 O atoms	6 O atoms

Problems for Chapter 3

- 23 – 63
- 65, 66, 69
- 79 – 83
- 93 -97
- 101