Chapter 2 Suggested end-of-chapter problems with solutions

5. You have a chemical in a sealed glass container filled with air. The setup is sitting on a balance as shown below. The chemical is ignited by means of a magnifying glass focusing sunlight on the reactant. After the chemical has completely burned, which of the following is true? Explain your answer.

a. The balance will read less than **250.0 g**.

b. The balance will read **250.0 g**.

c. The balance will read greater than **250.0 g**.

d. Cannot be determined without knowing the identity of the chemical.

7. You may have noticed that when water boils, you can see bubbles that rise to the surface of the water. Which of the following is inside these bubbles? Explain.

a. air

b. hydrogen and oxygen gas

c. oxygen gas

d. water vapor

e. carbon dioxide gas

9. Dalton assumed that all atoms of the same element were identical in all their properties. Explain why this assumption is not valid.

11. Why do we call $Ba(NO_3)_2$ barium nitrate, but we call $Fe(NO_3)_2$ iron(II) nitrate?

13. The common name for NH_3 is ammonia. What would be the systematic name for NH_3? Support your answer.

14. Which (if any) of the following can be determined by knowing the number of protons in a neutral element? Explain your answer.

a. the number of neutrons in the neutral element

b. the number of electrons in the neutral element

c. the name of the element

15. Which of the following explain how an ion is formed? Explain your answer.

a. adding or subtracting protons to/from an atom

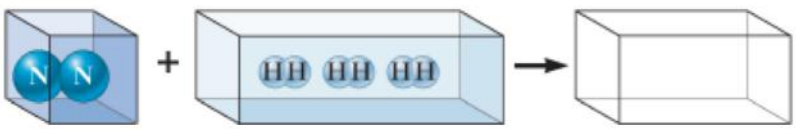
b. adding or subtracting neutrons to/from an atom

c. adding or subtracting electrons to/from an atom

25. For lighter, stable isotopes, the ratio of the mass number to the atomic number is close to a certain value. What is the value? What happens to the value of the mass number to atomic number ratio as stable isotopes become heavier?

27. Consider the elements of Group 4A (the "carbon family"): C, Si, Ge, Sn, and Pb. What is the trend in metallic character as one goes down this group? What is the trend in metallic character going from left to right across a period in the periodic table?

34. Observations of the reaction between nitrogen gas and hydrogen gas show us that 1 volume of nitrogen reacts with 3 volumes of hydrogen to make 2 volumes of gaseous product, as shown below:



Determine the formula of the product and justify your answer.

36. A sample of H_2SO_4 contains 2.02 g of hydrogen, 32.07 g of sulfur, and 64.00 g of oxygen. How many grams of sulfur and grams of oxygen are present in a second sample of H_2SO_4 containing 7.27 g of hydrogen?

38. Consider 100.0-g samples of two different compounds consisting only of carbon and oxygen. One compound contains 27.2 g of carbon and the other has 42.9 g of carbon. How can these data support the law of multiple proportions if 42.9 is not a multiple of 27.2? Show that these data support the law of multiple proportions.

46. If you wanted to make an accurate scale model of the hydrogen atom and decided that the nucleus would have a diameter of 1 **mm**, what would be the diameter of the entire model?

55. For each of the following sets of elements, label each as either noble gases, halogens, alkali metals, alkaline earth metals, or transition metals.

    a. **Ti, Fe, Ag**

    b. **Mg, Sr, Ba**

    c. **Li, K, Rb**

    d. **Ne, Kr, Xe**

    e. **F, Br, I**

56. Identify the elements that correspond to the following atomic numbers. Label each as either a noble gas, a halogen, an alkali metal, an alkaline earth metal, a transition metal, a lanthanide metal, or an actinide metal.

    a. **17**

    b. **4**

    c. **63**

    d. **72**

    e. **2**

    f. **92**

    g. **55**

58. Write the atomic symbol $\left({}^{A}_{Z}\mathrm{X}\right)$ for each of the isotopes described below

    a. **number of protons = 27, number of neutrons = 31**

    b. the isotope of boron with mass number **10**

    c. $Z = 12$, $A = 23$

    d. atomic number **53, number of neutrons = 79**

    e. $Z = 20$, **number of neutrons = 27**

    f. **number of protons = 29**, mass number **65**

62. What number of protons and neutrons are contained in the nucleus of each of the following atoms? Assuming each atom is uncharged, what number of electrons are present?

a. $^{235}_{92}\mathrm{U}$

b. $^{27}_{13}\mathrm{Al}$

c. $^{57}_{26}\mathrm{Fe}$

d. $^{208}_{82}\mathrm{Pb}$

e. $^{86}_{37}\mathrm{Rb}$

f. $^{41}_{20}\mathrm{Ca}$

64. How many protons, neutrons, and electrons are in each of the following atoms or ions?

a. $^{24}_{12}\mathrm{Mg}$

b. $^{24}_{12}\mathrm{Mg}^{2+}$

c. $^{59}_{27}\mathrm{Co}^{2+}$

d. $^{59}_{27}\mathrm{Co}^{3+}$

e. $^{59}_{27}\mathrm{Co}$

f. $^{79}_{34}\mathrm{Se}$

g. $^{79}_{34}\mathrm{Se}^{2-}$

h. $^{63}_{28}\mathrm{Ni}$

i. $^{59}_{28}\mathrm{Ni}^{2+}$

68. Complete the following table:

Symbol	no. of protons	no. of neutrons	no. of electrons	Net charge
$^{53}_{26}Fe^{2+}$				
	26	33		+3
	85	125	86	
	13	14	10	
		76	54	-2

70. For each of the following atomic numbers, use the periodic table to write the formula (including the charge) for the simple *ion* that the element is most likely to form in ionic compounds.

a. **13**

b. **34**

c. **56**

d. **7**

e. **87**

f. **35**

80. Name each of the following compounds.

a. $HC_2H_3O_2$

b. NH_4NO_2

c. Co_2S_3

d. ICl

e. $Pb_3(PO_4)_2$

f. $KClO_3$

g. H_2SO_4

h. Sr_3N_2

i. $Al_2(SO_3)_3$

j. SnO_2

k. Na_2CrO_4

83. Write the formula for each of the following compounds:

a. sulfur difluoride

b. sulfur hexafluoride

c. sodium dihydrogen phosphate

d. lithium nitride

e. chromium(III) carbonate

f. tin(II) fluoride

g. ammonium acetate

h. ammonium hydrogen sulfate

i. cobalt(III) nitrate

j. mercury(I) chloride

k. potassium chlorate

l. sodium hydride

84. Write the formula for each of the following compounds:

a. chromium(VI) oxide

b. disulfur dichloride

c. nickel (II) fluoride

d. potassium hydrogen phosphate

e. aluminum nitride

f. ammonia

g. manganese(IV) sulfide

h. sodium dichromate

i. ammonium sulfite

j. carbon tetraiodide

88. Each of the following compounds is incorrectly named. What is wrong with each name, and what is the correct name for each compound?

a. $\mathbf{FeCl_3}$, iron chloride

b. $\mathbf{NO_2}$, nitrogen(IV) oxide

c. $\mathbf{CaO}$, calcium(II) monoxide

d. $\mathbf{Al_2S_3}$, dialuminum trisulfide

e. $\mathbf{Mg(C_2H_3O_2)_2}$, manganese diacetate

f. $\mathbf{FePO_4}$, iron(II) phosphide

g. $\mathbf{P_2S_5}$, phosphorus sulfide

h. $\mathbf{Na_2O_2}$, sodium oxide

i. $\mathbf{HNO_3}$, nitrate acid

j. $\mathbf{H_2S}$, sulfuric acid

89. Chlorine has two natural isotopes: $^{37}_{17}\mathbf{Cl}$ and $^{35}_{17}\mathbf{Cl}$. Hydrogen reacts with chlorine to form the compound $\mathbf{HCl}$. Would a given amount of hydrogen react with different masses of the two chlorine isotopes? Does this conflict with the law of definite proportion? Why or why not?

92. Which of the following statements is (are) *true*? For the false statements, correct them.

a. All particles in the nucleus of an atom are charged.

b. The atom is best described as a uniform sphere of matter in which electrons are embedded.

c. The mass of the nucleus is only a very small fraction of the mass of the entire atom.

d. The volume of the nucleus is only a very small fraction of the total volume of the atom.

e. The number of neutrons in a neutral atom must equal the number of electrons.

93. The isotope of an unknown element, **X**, has a mass number of **79**. The most stable ion of the isotope has **36** electrons and forms a binary compound with sodium having a formula of Na_2X. Which of the following statements is(are) *true?* For the false statements, correct them.

a. The binary compound formed between **X** and fluorine will be a covalent compound.

b. The isotope of **X** contains **38** protons.

c. The isotope of **X** contains **41** neutrons.

d. The identity of **X** is strontium, **Sr**.

94. For each of the following ions, indicate the total number of protons and electrons in the ion. For the positive ions in the list, predict the formula of the simplest compound formed between each positive ion and the oxide ion. Name the compounds. For the negative ions in the list, predict the formula of the simplest compound formed between each negative ion and the aluminum ion. Name the compounds.

a. Fe^{2+}

b. Fe^{3+}

c. Ba^{2+}

d. Cs^{+}

e. S^{2-}

f. P^{3-}

g. Br^{-}

h. N^{3-}

97. An element's most stable ion forms an ionic compound with bromine, having the formula XBr_2. If the ion of element **X** has a mass number of **230** and has **86** electrons, what is the identity of the element, and how many neutrons does it have?

99. The designations 1A through 8A used for certain families of the periodic table are helpful for predicting the charges on ions in binary ionic compounds. In these compounds, the metals generally take on a positive charge equal to the family number, while the nonmetals take on a negative charge equal to the family number minus eight. Thus the compound between sodium and chlorine contains Na^+ ions and Cl^- ions and has the formula **NaCl**. Predict the formula and the name of the binary compound formed from the following pairs of elements.

a. **Ca** and **N**

b. **K** and **O**

c. **Rb** and **F**

d. **Mg** and **S**

e. **Ba** and **I**

f. **Al** and **Se**

g. **Cs** and **P**

h. **In** and **Br**

110. Reaction of **2.0 L** of hydrogen gas with **1.0 L** of oxygen gas yields **2.0 L** of water vapor. All gases are at the same temperature and pressure. Show how these data support the idea that oxygen gas is a diatomic molecule. Must we consider hydrogen to be a diatomic molecule to explain these results?

(5) Because no material can go in or out of the weighed system, and because of the "Law of Conservation of Mass", it will read the same mass as before the reaction: 250.0 g.

(7) The bubbles in boiling water are water vapor

(9) An element almost always is made up of more than one isotope. Isotopes differ in mass.

(11) Barium can only form Ba^{2+}, so we don't need to clarify it by putting (II) in the name

Iron can form Fe^{2+} or Fe^{3+}, so we need to make clear which ion is in the compound by putting the charge as a roman numeral.

(13) Nitrogen trihydride
We do use the tri prefix because it is a covalent compound (nonmetal - nonmetal)

(14) No. of protons ⇒ (b) equal to the no. of electrons (in a neutral atom)

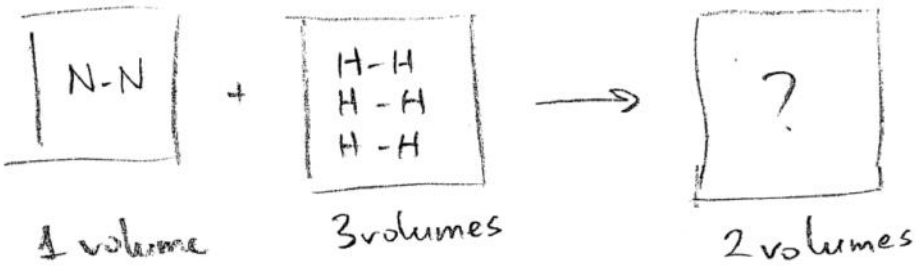
(c) determines the identity of the element, therefore the name

(15) (c) Ions are formed by adding or removing an electron
The nucleus is not involved in doing chemistry, including ion formation

(25) The ratio starts out (except H) at 2, and steadily rises because more and more "glue" (neutrons) is needed to hold the protons together

(27) Elements become more metallic as we go down a group.
Elements become less metallic as we go from left to right across a period

(34) Avogadro's Law: Equal volumes of gas contain equal numbers of molecules



Since volume is proportional to the number of molecules, and the number of atoms brought by these molecules, we can determine the ratio in which the atoms must combine to form the single product.

3 times more H atoms are needed to form the product than the number of N atoms.

The formula implied for the product: NH_3

Note that the molecular formula could also be N_2H_6 or N_3H_9 etc, as long as it has 3 times more H atoms than N atoms.

(36)

$$7.27\ \text{g H} \times \frac{32.07\ \text{g S}}{2.02\ \text{g H}} = 115\ \text{g S}$$

$$7.27\ \text{g H} \times \frac{64.00\ \text{g O}}{2.02\ \text{g H}} = 230.\ \text{g O}$$

38

Same sample mass (100.0 g), not same amount of C

We need to find how much Oxygen there is in each compound for a given amount of Carbon. It's simplest to think in terms of grams of Oxygen per gram of Carbon.

mass of O per 1 gram of C:

Sample 1: mass of C = 27.2 g

mass of O = 100.0 − 27.2 = 72.8 g

$$\frac{\text{grams of O}}{\text{gram of C}} = \frac{72.8}{27.2} = 2.676$$

Sample 2: mass of C = 42.9 g

mass of O = 100.0 − 42.9 = 57.1 g

$$\frac{\text{grams of O}}{\text{grams of C}} = 1.331$$

$$\frac{\text{Oxygen mass per 1 g C in Sample 2}}{\text{Oxygen mass per 1 g C in Sample 1}} = \frac{1.331}{2.676} \simeq \frac{1}{2}$$

$\frac{1}{2}$ is a ratio of small, simple numbers

$\Rightarrow$ Supports the Law of Multiple Proportions"

(42) ethanol + oxygen → water + carbon dioxide

46.0 g + 96.0 g → 54.0 g + ?

142.0 g of reactants = 142.0 g of products

Mass is conserved

Mass of carbon dioxide = 142.0 − 54.0 = 88.0 g

(46) Looking up the size of a proton (the nucleus of the H atom), we find that it is around 0.85 femtometers.
The size of a H atom is calculated to be 53 picometers

$$\frac{\text{Atom size}}{\text{nucleus size}} = \frac{53\times10^{-12}\,m}{0.85\times10^{-15}\,m} = 6.2\times10^{4} \Rightarrow 1\times10^{-3}\,m \times 6.2\times10^{4} = 62\,m$$

(48) We look for a "step size" between measurements
Let's work in units of 10^{-12} zirkombs (pico zircombs)

3.84 − 2.56 = 1.28
7.68 − 6.40 = 1.28
6.40 − 3.84 = 2.56
7.68 − 3.84 = 3.84
7.68 − 2.56 = 5.12
6.40 − 2.56 = 3.84

} all multiples of 1.28

⇒ electron charge would be 1.28×10^{-12} zirkombs

55

(a) Ti, Fe, Ag : transition metals
(b) Mg, Sr, Ba : alkaline earth metals
(c) Li, K, Rb : alkali metals
(d) Ne, Kr, Xe : noble gases
(e) F, Br, I : halogens

56

(a) $Z = 17 \rightarrow Cl$ (halogen)
(b) $Z = 4 \rightarrow Be$ (alkaline earth)
(c) $Z = 63 \rightarrow Eu$ (lanthanide)
(d) $Z = 72 \rightarrow Hf$ (transition metal)
(e) $Z = 2 \rightarrow He$ (noble gas)
(f) $Z = 92 \rightarrow U$ (actinide)
(g) $Z = 55 \rightarrow Cs$ (alkali metal)

58

(a) $^{58}_{27}Co$

(b) $^{10}_{5}B$

(c) $^{23}_{12}Mg$

(d) $^{132}_{53}I$

(e) $^{47}_{20}Ca$

(f) $^{65}_{29}Cu$

(62)

(a) $^{235}_{92}U$ $p = 92$ $e = 92$
$n = 235 - 92 = 143$

(b) $^{27}_{13}Al$ $p = 13$ $e = 13$
$n = 27 - 13 = 14$

(c) $^{57}_{26}Fe$ $p = 26$ $e = 26$
$n = 57 - 26 = 31$

(d) $^{208}_{82}Pb$ $p = 82$ $e = 82$
$n = 208 - 82 = 126$

(e) $^{86}_{37}Rb$ $p = 37$ $e = 37$
$n = 86 - 37 = 49$

(f) $^{40}_{20}Ca$ $p = 20$ $e = 20$
$n = 40 - 20 = 20$

(64)

(a) $^{24}_{12}Mg$ $p = 12$ $e = 12$ $n = 24 - 12 = 12$

(b) $^{24}_{12}Mg^{2+}$ $p = 12$ $e = 12 - 2 = 10$ $n = 24 - 12 = 12$

(c) $^{59}_{27}Co^{2+}$ $p = 27$ $e = 27 - 2 = 25$ $n = 59 - 27 = 32$

(d) $^{59}_{27}Co^{3+}$ $p = 27$ $e = 27 - 3 = 24$ $n = 59 - 27 = 32$

(e) $^{59}_{27}Co$ $p = 27$ $e = 27$ $n = 59 - 27 = 32$

(f) $^{79}_{34}Se$ $p = 34$ $e = 34$ $n = 79 - 34 = 45$

(g) $^{79}_{34}Se^{2-}$ $p = 34$ $e = 34 + 2 = 36$ $n = 79 - 34 = 45$

(h) $^{63}_{28}Ni$ $p = 28$ $e = 28$ $n = 63 - 28 = 35$

(i) $^{59}_{28}Ni^{2+}$ $p = 28$ $e = 28 - 2 = 26$ $n = 59 - 28 = 31$

(68)

Symbol	no. of protons	no. of neutrons	no. of electrons	Net charge
$^{53}_{26}Fe^{2+}$	26 ?	27 ?	24 ?	+2 ?
$^{59}_{26}Fe^{3+}$?	26	33	23 ?	+3
$^{210}_{85}At^{-}$?	85	125	86	-1 ?
$^{27}_{13}Al^{3+}$?	13	14	10	+3 ?
$^{128}_{52}Te^{2-}$?	52 ?	76	54	-2

(70)

(a) $Z = 13 \rightarrow Al$ Group 3A, metal $\rightarrow Al^{3+}$

(b) $Z = 34 \rightarrow Se$ Group 6A, nonmetal $\rightarrow Se^{2-}$

(c) $Z = 56 \rightarrow Ba$ Group 2A, metal $\rightarrow Ba^{2+}$

(d) $Z = 7 \rightarrow N$ Group 5A, nonmetal $\rightarrow N^{3-}$

(e) $Z = 87 \rightarrow Fr$ Group 1A, metal $\rightarrow Fr^{+}$

(f) $Z = 35 \rightarrow Br$ Group 7A, nonmetal $\rightarrow Br^{-}$

(80)

(a) $HC_2H_3O_2$ acetic acid

(b) NH_4NO_2 ammonium nitrite

(c) Co_2S_3 cobalt(III) sulfide

(d) ICl iodine monochloride

(e) $Pb_3(PO_4)_2$ lead(II) phosphate

(f) $KClO_3$ potassium chlorate

(g) H_2SO_4 sulfuric acid

(h) Sr_3N_2 strontium nitride

(i) $Al_2(SO_3)_3$ aluminum sulfite

(j) SnO_2 tin(IV) oxide

(k) Na_2CrO_4 sodium chromate

(l) $HClO$ hypochlorous acid

(83)

(a) SF_2

(b) SF_6

(c) NaH_2PO_4 Even though this is an ionic compound, there is a "di-" prefix in its name. How come? "dihydrogen phosphate" is the anion's name, and the two hydrogens are covalently bonded to the phosphate part. The anion is $H_2PO_4^-$ not PO_4^{3-}

(d) Li_3N Li is a group IA metal, and forms Li^+, and N is a Group VA nonmetal that forms N^{3-} when ionized.

(e) $Cr_2(CO_3)_3$ Two Cr^{3+} cations neutralize three CO_3^{2-} anions

(f) SnF_2 F is a halogen, and as such it forms an anion with −1 charge. Two are needed to neutralize Sn^{2+}.

(g) $NH_4C_2H_3O_2$

(h) NH_4HSO_4 Hydrogen sulfate, HSO_4^- is the anion part.

(i) $Co(NO_3)_3$

(j) Hg_2Cl_2

(k) $KClO_3$

(l) NaH

(84)

(a) CrO_3

(b) S_2Cl_2

(c) NiF_2

(d) K_2HPO_4 Hydrogen phosphate, HPO_4^{2-}, has a -2 charge, and is the anion part. When one H^+ binds covalently to a PO_4^{3-} (phosphate) ion, the charge is reduced by one. The electron pair shared between H and the phosphate can be seen as provided by phosphate, but this "donation" cancels the (+) charge on H and results in a covalent bond.

(e) AlN Al is a Group III A metal and forms a cation with +3 charge, and N forms N^{3-} as we saw before.

(f) NH_3

(g) MnS_2 S is a Group VI A nonmetal, and like oxygen, it forms an anion with -2 charge when ionized.

(h) $Na_2Cr_2O_7$ Two Na^+ are needed to neutralize $Cr_2O_7^{2-}$

(i) $(NH_4)_2SO_3$ Sulfite has one less O than sulfate (SO_4^{2-}) but still has a charge of -2

(j) CI_4

(88) (a) Fe can form Fe^{2+} or Fe^{3+}, so we need to specify the charge with (III):

iron(III) chloride

(b) Roman numerals are not used in covalent compound names:

nitrogen dioxide

(c) Ca only forms Ca^{2+}, so (II) is not needed. Furthermore, prefixes (such as mono-) are not used in ionic compounds:

calcium oxide

(d) Prefixes are not used in ionic compounds:

aluminum sulfide

(e) Prefixes are not used in ionic compounds, and Mg is the symbol for magnesium, not manganese:

magnesium acetate

(f) Iron has +3 charge, not +2, and PO_4^{3-} is called "phosphate", not "phosphide":

iron (III) phosphate

(g) We need to specify the number of atoms in the molecule for covalent compounds:

diphosphorus pentasulfide

(h) Na_2O_2 is an ionic compound, and the formula is the empirical formula containing the smallest possible subscripts for the constituent ions. If the anion were the regular oxide ion, then the formula would have to be NaO, not Na_2O_2. Since it is not, O_2^{2-} (peroxide) is the constituent anion, not oxide:

sodium peroxide (also implied by the charges of the ions)

(i) The acid formed by nitrate is called nitric acid:

nitric acid

(j) H_2S is "hydrogen sulfide" (incidentally, not dihydrogen sulfide because we don't use a prefix for acidic hydrogens, which must, by the way, be put at the front of the formula) $H_2S(aq)$ would have been named "hydrosulfuric acid"

(89) A given amount of hydrogen would react with different masses of the two chlorine isotopes, because the chlorine atoms have different masses.

That does not conflict with the law of definite proportion, because that law only applies to the element, not its individual isotopes.

(92) (a) False. Neutrons are not charged.

(b) False. Atoms are extremely non-uniform. Almost all the mass is concentrated in a very small and dense nucleus, and the rest is in the electrons that are smeared into a much larger volume. (constituting the volume of the atom)

(c) False. See (b).

(d) True.

(e) False. That may be true for the most common isotopes of the lightest elements where the number of neutrons happens to be the same as that of protons (which in turn must be the same number as the number of electrons), but in general that is not true.

(93) Na_2X is an ionic compound sine it is a binary metal-nonmetal compound.

Sodium (Na) only forms Na^+ cation, and two Na^+ cations bring a total charge of +2.

X must have enough charge to neutralize that +2 charge.

This means X has a charge of -2, implying a Group VI A nonmetal.

X would have 2 less electrons than X^{2-}, so its atomic no. is 34.

This means X is a Se isotope.

(a) True

(b) False. No. of protons is equal to the atomic number, 34.

(c) False. (No. of neutrons) = (mass number) - (no. of protons) = 79 - 34 = 45

(d) False. See above.

94

(a) Fe^{2+} : p = 26; e = 26 − 2 = 24; FeO iron(II) oxide

(b) Fe^{3+} : p = 26; e = 26 − 3 = 23; Fe_2O_3 iron(III) oxide

(c) Ba^{2+} : p = 56; e = 56 − 2 = 54; BaO barium oxide

(d) Cs^{+} : p = 55; e = 55 − 1 = 54; Cs_2O cesium oxide

(e) S^{2-} : p = 16; e = 16 + 2 = 18; Al_2S_3 aluminum sulfide

(f) P^{3-} : p = 15; e = 15 + 3 = 18; Al P aluminum phosphide

(g) Br^{-} : p = 35; e = 35 + 1 = 36; $AlBr_3$ aluminum bromide

(h) N^{3-} : p = 7; e = 7 + 3 = 10; Al N aluminum nitride

97

Br (bromine) is a halogen, i.e. a Group 7A element.
As such, its anion always has a charge of −1
Two "bromide" (Br^-) ions bring a total charge of −2.

XBr_2 implies X^{2+}. If X^{2+} has 86 electrons, X has 88, and its atomic number is also 88 (Radium, Ra).

(no. of neutrons) = (mass number) − (no. of protons) = 230 − 88 = 142

99

(a) Ca_3N_2 calcium nitride

(b) K_2O potassium oxide

(c) RbF rubidium fluoride

(d) MgS magnesium sulfide

(e) BaI_2 barium iodic

(f) Al_2Se_3 aluminum s

(g) Cs_3P cesium phosp

(h) $InBr_3$ indium bro

We are assuming that we know nothing about the molecules involved, be it hydrogen, oxygen, or water. So we start with

$H + O \rightarrow HO$

But the ratios of the volumes are the same as the ratios of the molecules involved, so we must have at least

$2H + O \rightarrow 2HO$

But this puts 2 oxygens on the product side and 1 oxygen on the reactant side; not possible. There is no way to balance the reaction unless we accept that oxygen exists as a diatomic molecule, O_2.

$2H + O_2 \rightarrow 2HO$

Since diatomic oxygen explains the result, diatomic hydrogen is <u>not needed</u> to explain the observation in question (without knowledge about the molecular formula of water).

If we did know that the formula of water is H_2O, then we revise the equation as follows

$2H + O_2 \rightarrow 2H_2O$

which is impossible because it cannot be balanced given the molecular ratios observed. It can only work if hydrogen is also a diatomic molecule.

$2H_2 + O_2 \rightarrow 2H_2O$

(110) Not knowing that hydrogen and oxygen gases are composed of diatomic molecules, and not knowing that water has two H atoms per one O molecule, we might think

$$H + O \rightarrow HO$$

But from the ratios of the volumes, we would modify that to

$$2H + O \rightarrow 2HO$$

which doesn't really work because mono-atomic oxygen gas doesn't seem to bring enough O atoms.

But if oxygen is diatomic, the following (although incorrect) explains the observed volumes:

$$2H + O_2 \rightarrow 2HO$$

Without knowing the formula of water precisely (H_2O), we have no reason to think that hydrogen must also be a diatomic gas.

But if we do know that water is H_2O, and not HO:

$$2H + O_2 \rightarrow 2H_2O$$

doesn't work, since two volumes of hydrogen would not bring enough H atoms for 1 volume of oxygen (O_2)..

This would be remedied if we conclude that hydrogen must also be a diatomic gas:

$$2H_2 + O_2 \rightarrow 2H_2O$$