Test of Facts and Concepts Chapters 1 – 4

1. (a) 24.6 cm 3 sig. fig. 0.35140 m 5 sig fig 7,424 mm 4 sig. fig.

(b) $\text{vol} = 24.6\text{ cm} \times 0.35410\text{m}\left(\frac{100\text{ cm}}{1\text{ m}}\right) \times 7.424\text{ mm}\left(\frac{1\text{ cm}}{10\text{ mm}}\right) = 64.6\text{ cm}^3$

(c) $\#\text{ ft}^3 = 64.7\text{ cm}^3\left(\frac{1\text{ ft}}{30.48\text{ cm}}\right)^3 = 2.12\text{ ft}^3$

(d) $\#\text{ kg} = 64.7\text{ cm}^3\left(\frac{7.140\text{ g}}{1\text{ cm}^3}\right)\left(\frac{1\text{ kg}}{1000\text{ g}}\right) = 0.462\text{ kg}$

2. An atom is the smallest representative sample of an element while a molecule is the smallest representative sample of a compound. Molecules are made of atoms. A mole is a unit of measure for the amount of a substance; 6.022×10^{23} things are in a mole.

3. The atomic mass of element X is half the size of the atomic mass of element Y.

4. According to Dalton's atomic theory, a chemical reaction is simply a reordering of atoms from one combination to another. If no atoms are gained or lost and if the masses of the atoms cannot change, then the mass after the reaction must be the same as the mass before.

For the law of definite proportions, the theory states a given compound always has atoms of the same elements in the same numerical ratio. The same mass ratio would exist regardless of how many molecules were in the sample.

5. A and B do not necessarily need to be the same element. They could be two different elements with the same number of neutrons by coincidence.

6. $\#\text{ cm}^3 = 3.14\text{ ft}^3\left(\frac{30.48\text{ cm}}{1\text{ ft}}\right)^3$

7. ${}^{204}_{94}\text{Pu}$ ${}^{244}_{94}\text{Pu}$

8. Protons: 28
Neutrons 32
Electrons 28

9. ${}^{23}_{11}\text{Na}^{+}$

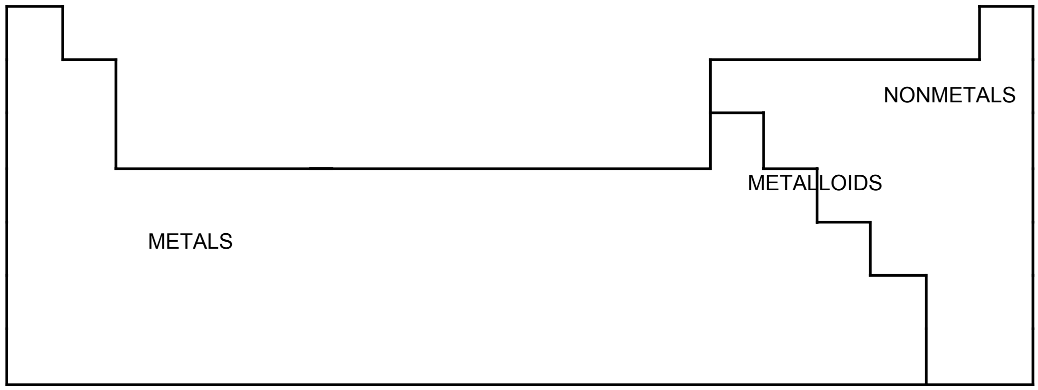
10.

(a)	ion	particle
(b)	mixture	substance
(c)	isotope	substance
(d)	atom	particle
(e)	compound	substance
(f)	molecule	particle
(g)	element	substance
(h)	nucleus	particle

11.

(a)	An isotope of iron	Possible
(b)	An atom of iron	Not possible – atoms cannot be seen by eye
(c)	A molecule of water	Not possible – water molecules are too small to be seen by eye
(d)	A mole of water	Possible
(e)	An ion of sodium	Not possible – Na^+ is too small to be seen
(f)	A formula unit of sodium chloride	Not possible – one NaCl is too small to be seen.

12.



13. Zr and Hf

14.

Calcium	Alkaline earth metal
Iron	Transition metal
Helium	Noble gas
Gadolinium	Inner transition metal
Iodine	Halgen
Sodium	Alkali metal

15. Ductile is the ability to be drawn into wire.
Malleable is the ablility to be hammmered or rolled into thin sheets.

16. Mercury (m.p. –39 °C) Tungsten (m.p. 3400 °C)

17. Metalloids are semiconductors.

18. Ga, In, Sn, Tl, Ob, Bi

19.

(a)	KNO_3	(b)	$CaCO_3$
(c)	$Co_3(PO_4)_2$	(d)	$MgSO_3$
(e)	$FeBr_3$	(f)	Mg_3N_2
(g)	Al_2Se_3	(h)	$Cu(ClO_4)_2$
(i)	BrF_5	(j)	N_2O_5
(k)	$Sr(C_2H_3O_2)_2$	(l)	$(NH_4)_2Cr_2O_7$
(m)	Cu_2S		

20.
(a) sodium chlorate
(b) calcium phosphate
(c) sodium permanganate
(d) aluminum phosphide
(e) iodine trichloride
(f) phosphorous trichloride
(g) potassium chromate
(h) calcium cyanide
(i) manganese(II) chloride
(j) sodium nitrite
(k) iron(II) nitrate

21. Ionic

22. Empirical formula are written for ionc compounds since discrete molecules do not exist, the smallest set of subscripts that specify the correct ratio of the ions is used.

23. Al_2O_3, MgO, NO_2

24. $$\text{\# g of one molecule} = \left(\frac{60.2\text{ g}}{1\text{ mol}}\right)\left(\frac{1\text{ mol}}{6.022\times10^{23}\text{ molecules}}\right) = 1.00\times10^{-22}\text{ g}$$

25. $$\text{MM} = \left(\frac{204\text{ g}}{1.00\times10^{23}\text{ molecules}}\right)\left(\frac{6.022\times10^{23}\text{ molecules}}{1\text{ mol molecules}}\right) = 1230\text{ g mol}^{-1}$$

26. $Fe_4[Fe(CN)_6]_3$ = 7Fe + 18C + 18N
= $(7\times55.85) + (18\times12.01) + (18\times14.01)$
= 859.3 g/mole

27. $$\text{\# g } Cu(NO_3)_2\cdot3H_2O = 0.118\text{ mol}\left(\frac{241.6\text{ g }Cu(NO_3)_2\cdot3H_2O}{1\text{ mol }Cu(NO_3)_2\cdot3H_2O}\right) = 28.5\text{ g }Cu(NO_3)_2\cdot3H_2O$$

28. $$\text{\# mol } NiI_2\cdot6H_2O = 15.7\text{ g }NiI_2\cdot6H_2O\left(\frac{1\text{ mol }NiI_2\cdot6H_2O}{420.6\text{ g }NiI_2\cdot6H_2O}\right) = 3.73\times10^{-2}\text{ mol }NiI_2\cdot6H_2O$$

29. $$\%\text{C} = \frac{0.4343\text{ g C}}{0.5866\text{ g nicotine}}\times100\% = 74.04\%$$
$$\%\text{H} = \frac{0.05103\text{ g H}}{0.5866\text{ g nicotine}}\times100\% = 8.699\%$$
$$\%\text{N} = \frac{0.1013\text{ g N}}{0.5866\text{ g nicotine}}\times100\% = 17.27\%$$

30. $$\text{\# moles K} = (37.56\text{ g K})\left(\frac{1\text{ mole K}}{39.098\text{ g K}}\right) = 0.9607\text{ moles K}$$
$$\text{\# moles H} = (1.940\text{ g H})\left(\frac{1\text{ mole H}}{1.00794\text{ g H}}\right) = 1.925\text{ moles H}$$
$$\text{\# moles P} = (29.79\text{ g P})\left(\frac{1\text{ mole P}}{30.974\text{ g P}}\right) = 0.9618\text{ moles P}$$
Amount of O:
% O = 100% – 37.56% K – 1.940% H – 29.79% P = 30.71% O
$$\text{\# moles O} = (30.71\text{ g O})\left(\frac{1\text{ mole O}}{15.9994\text{ g O}}\right) = 1.919\text{ moles O}$$

Now we divide each of these numbers of moles by the smallest of the three numbers, in order to obtain the simplest mole ratio among the three elements in the compound:

for K, 0.9607 moles / 0.9607 moles = 1.00
for H, 1.925 moles / 0.9607 moles = 2.00
for H, 0.9618 moles / 0.9607 moles = 1.00
for O, 1.919 moles / 0.9607 moles = 2.00

These relative mole amounts give us the empirical formula: KH_2PO_2.

31. $$\#\text{ molecules } C_2H_5OH = 1.00\text{ fl. oz.}\left(\frac{29.57\text{ mL } C_2H_5OH}{1\text{ fl. oz. } C_2H_5OH}\right)\left(\frac{0.798\text{ g } C_2H_5OH}{1\text{ mL } C_2H_5OH}\right)$$
$$\times\left(\frac{1\text{ mol } C_2H_5OH}{46.07\text{ g } C_2H_5OH}\right)\left(\frac{6.022\times10^{23}\text{ molecules } C_2H_5OH}{1\text{ mol } C_2H_5OH}\right) = 3.08\times10^{23}\text{ molecules } C_2H_5OH$$

32. $$\#\text{ L } C_2H_6O_2 = 5.00\times10^{24}\text{ molecules}\left(\frac{1\text{ mol } C_2H_6O_2}{6.022\times10^{23}\text{ molecules } C_2H_6O_2}\right)\left(\frac{62.07\text{ g } C_2H_6O_2}{1\text{ mol } C_2H_6O_2}\right)\left(\frac{1\text{ mL } C_2H_6O_2}{1.11\text{ g } C_2H_6O_2}\right)$$
$$\times\left(\frac{1\text{ L } C_2H_6O_2}{1000\text{ mL } C_2H_6O_2}\right) = 0.464\text{ L}$$

33. $$\#\text{ mol } O_2 = 2.56\text{ g } Cl_2\left(\frac{1\text{ mol } Cl_2}{70.91\text{ g } Cl_2}\right)\left(\frac{1\text{ mol } Cl_2O_7}{1\text{ mol } Cl_2}\right)\left(\frac{7\text{ mol } O_2}{2\text{ mol } Cl_2O_7}\right) = 0.126\text{ mol } O_2$$
$$\#\text{ g } O_2 = 0.126\text{ mol } O_2\left(\frac{16.00\text{ g } O_2}{1\text{ mol } O_2}\right) = 2.02\text{ mol } O_2$$

34. (a) $2Fe_2O_3 + 12HNO_3 \rightarrow 4Fe(NO_3)_3 + 6H_2O$
(b) $2C_{21}H_{30}O_2 + 55O_2 \rightarrow 42CO_2 + 30H_2O$

35. $$\#\text{ mol } HNO_3 = 2.56\text{ mol Cu}\left(\frac{8\ HNO_3}{3\text{ mol Cu}}\right) = 6.83\text{ mol } HNO_3$$

36. $$\#\text{ mol } O_2 = 56.8\text{ g } NH_3\left(\frac{1\text{ mol } NH_3}{17.03\text{ g } NH_3}\right)\left(\frac{5\text{ mol } O_2}{4\text{ mol } NH_3}\right) = 4.17\text{ mol } O_2$$
$$\#\text{ g } O_2 = 4.17\text{ mol } O_2\left(\frac{16.00\text{ g } O_2}{1\text{ mol } O_2}\right) = 66.7\text{ mol } O_2$$

37. (a) $CaCO_3 \xrightarrow{\text{heat}} CaO + CO_2$
$MgCO_3 \xrightarrow{\text{heat}} MgO + CO_2$

(b) Let x = # g $CaCO_3$ and y = # g $MgCO_3$
x g $CaCO_3$ + y g $MgCO_3$ = 5.78 g sample

$$\#\text{ g CaO} = x\text{ g } CaCO_3\left(\frac{1\text{ mol } CaCO_3}{100.09\text{ g } CaCO_3}\right)\left(\frac{1\text{ mol CaO}}{1\text{ mol } CaCO_3}\right)\left(\frac{52.09\text{ g CaO}}{1\text{ mol CaO}}\right) = 0.520x\text{ g CaO}$$
$$\#\text{ g MgO} = y\text{ g } MgCO_3\left(\frac{1\text{ mol } MgCO_3}{84.31\text{ g } MgCO_3}\right)\left(\frac{1\text{ mol MgO}}{1\text{ mol } MgCO_3}\right)\left(\frac{40.30\text{ g MgO}}{1\text{ mol MgO}}\right) = 0.478y\text{ g MgO}$$

0.520x g CaO + 0.478y g MgO = 3.02 g total
x = 5.78 – y
0.520(5.78 – y) g CaO + 0.478y g MgO = 3.02 g
3.01 – 0.520y + 0.478y = 3.02
y = 0.343 g $MgCO_3$
x = 5.78 – 0.343 = 5.44 g $CaCO_3$

$$\% \ CaCO_3 = \frac{5.44 \text{ g } CaCO_3}{5.78 \text{ g sample}} \times 100\% = 94.1\% \ CaCO_3$$

$$\% \ MgCO_3 = \frac{0.343 \text{ g } MgCO_3}{5.78 \text{ g sample}} \times 100\% = 5.9\% \ MgCO_3$$

38. (a) 100% yeild adipic acid would be $\frac{12.5 \text{ g adipic acid}}{0.686} = 18.2 \text{ g}$

Amount of cyclohexene needed:

$$\# \text{ g } C_6H_{10} = 18.2 \text{ g}\left(\frac{1 \text{ mol } C_6H_{10}O_4}{146.1 \text{ g } C_6H_{10}O_4}\right)\left(\frac{3 \text{ mol } C_6H_{10}}{3 \text{ mol } C_6H_{10}O_4}\right)\left(\frac{82.14 \text{ g } C_6H_{10}}{1 \text{ mol } C_6H_{10}}\right) = 10.2 \text{ g } C_6H_{10}$$

(b) $$\# \text{ g } Na_2Cr_2O_7{\cdot}2H_2O = 18.2 \text{ g}\left(\frac{1 \text{ mol } C_6H_{10}O_4}{146.1 \text{ g } C_6H_{10}O_4}\right)\left(\frac{4 \text{ mol } Na_2Cr_2O_7 \cdot 2H_2O}{3 \text{ mol } C_6H_{10}O_4}\right)$$

$$\times\left(\frac{298.00 \text{ g } Na_2Cr_2O_7 \cdot 2H_2O}{1 \text{ mol } Na_2Cr_2O_7 \cdot 2H_2O}\right) = 49.5 \text{ g } Na_2Cr_2O_7{\cdot}2H_2O$$

39. $$\# \text{ tons ore} = 1.00 \text{ ton Fe}\left(\frac{91.5 \text{ ton Fe possible}}{100 \text{ ton Fe recovered}}\right)\left(\frac{2000 \text{ lb Fe possible}}{1 \text{ ton Fe possible}}\right)\left(\frac{454 \text{ g Fe}}{1 \text{ lb Fe}}\right)\left(\frac{1 \text{ mol Fe}}{55.8 \text{ g Fe}}\right)$$

$$\times\left(\frac{1 \text{ mol } Fe_2O_3}{1 \text{ mol Fe}}\right)\left(\frac{160 \text{ g } Fe_2O_3}{1 \text{ mol } Fe_2O_3}\right)\left(\frac{1 \text{ lb } Fe_2O_3}{454 \text{ g } Fe_2O_3}\right)\left(\frac{1 \text{ ton } Fe_2O_3}{2000 \text{ lb } Fe_2O_3}\right)\left(\frac{1 \text{ ton ore}}{0.341 \text{ ton } Fe_2O_3}\right) = 7.69 \text{ ton ore}$$

40. (a) $$\# \text{ tons seawater} = 1.0 \text{ troy ounce}\left(\frac{31.1 \text{ g Au}}{1.0 \text{ troy ounce Au}}\right)\left(\frac{1000 \text{ mg Au}}{1 \text{ g Au}}\right)\left(\frac{1 \text{ ton seawater}}{1.5 \text{ mg Au}}\right)$$

$$\times\left(\frac{65 \text{ ton seawater}}{100 \text{ ton seawater}}\right) = 1.3 \times 10^4 \text{ tons seawater}$$

(b) $$\text{breakeven point} = \frac{\$455 \text{ per troy ounce}}{1.3 \times 10^4 \text{ tons seawater}} = \$0.034 \text{ per ton seawater}$$

41. $\# \text{ g O} = 2.164 \text{ g} - (0.5259 \text{ g Fe} + 0.7345 \text{ g Cr}) = 0.9036 \text{ g O}$

$$\# \text{ mol Fe} = 0.5259 \text{ g Fe}\left(\frac{1 \text{ mole Fe}}{55.85 \text{ g Fe}}\right) = 0.009416 \text{ mol Fe}$$

$$\# \text{ mol Cr} = 0.7345 \text{ g Cr}\left(\frac{1 \text{ mole Cr}}{51.9961 \text{ g Cr}}\right) = 0.01413 \text{ mol Cr}$$

$$\# \text{ mol O} = 0.9036 \text{ g O}\left(\frac{1 \text{ mole O}}{15.9994 \text{ g O}}\right) = 0.05648 \text{ mol O}$$

Now we divide each of these numbers of moles by the smallest of the three numbers, in order to obtain the simplest mole ratio among the three elements in the compound:

for Fe, 0.009416 mol / 0.009416 mol = 1.00
for Cr, 0.01413 mol / 0.009416 mol = 1.50
for O, 0.05648 mol / 0.009416 mol = 6.00
Multiply by 2 in order to have whole numbers.
These relative mole amounts give us the empirical formula: $Fe_2Cr_3O_{12}$

To calculate the molecular mass, the molecular formula is needed.

42. The amount of water removed was

6.584 g sample – 2.889 g dry sample = 3.695 g H_2O

$$\# \text{ mol } H_2O = 3.695 \text{ g } H_2O \left(\frac{1 \text{ mol } H_2O}{18.015 \text{ g } H_2O}\right) = 0.2051 \text{ mol } H_2O$$

$$\# \text{ mol } Na_2SO_4 = 2.889 \text{ g } Na_2SO_4 \left(\frac{1 \text{ mol } Na_2SO_4}{142.04 \text{ g } Na_2SO_4}\right) = 0.02034 \text{ mol } Na_2SO_4$$

Determine the mole ratio:

For Na_2SO_4 0.02034 mol / 0.02034 mol = 1

For H_2O 0.2051 mol / 0.02034 mol = 10.08

Formula $Na_2SO_4 \cdot 10H_2O$

43. First determine the amount of NH_3 that would be required to react completely with the given amount of O_2:

$$\# \text{ g } NH_3 = (58.0 \text{ g } O_2)\left(\frac{1 \text{ mol } O_2}{32.0 \text{ g } O_2}\right)\left(\frac{4 \text{ mole } NH_3}{5 \text{ moles } O_2}\right)\left(\frac{17.03 \text{ g } NH_3}{1 \text{ mole } NH_3}\right) = 24.7 \text{ g } NH_3$$

Since 45.0 g of NH_3 are supplied, O_2 is the limiting reactant.

An excess (45.0 g – 24.7 g = 20.3 g) of NH_3 is present.

The number of moles and grams of NO formed is:

$$\# \text{ mol NO} = 24.7 \text{ g } NH_3 \left(\frac{1 \text{ mol } NH_3}{17.03 \text{ g } NH_3}\right)\left(\frac{4 \text{ mol NO}}{4 \text{ mol } NH_3}\right) = 1.45 \text{ mol NO}$$

$$\# \text{ g NO} = 1.45 \text{ mol NO} \left(\frac{30.01 \text{ g NO}}{1 \text{ mol NO}}\right) = 43.5 \text{ g NO}$$