Stoichiometry – Sheet #2

1. In the reaction shown here, what mass of iron is needed to react completely with 32.0 g of sulfur? $Fe + S \rightarrow FeS$

$$\left(\frac{32.0\ g\ S}{32.066\ g/mol}\right)\left(\frac{1\ mol\ Fe}{1\ mol\ S}\right)\left(55.847\ g/mol\right) = 55.7\ g\ Fe$$

2. When zinc reacts with sulphuric acid, as shown here, what mass of hydrogen is produced from 31.8 g of zinc? $Zn + H_2SO_4 \rightarrow ZnSO_4 + H_2\uparrow$

$$\left(\frac{31.8\ g\ Zn}{65.38\ g/mol}\right)\left(\frac{1\ mol\ H_2}{1\ mol\ Zn}\right)\left(2.01588\ g/mol\right) = 0.980\ g\ H_2$$

3. What mass of sulphurous acid can be produced when 128 g of sulfur dioxide combines with water? $SO_2 + H_2O \rightarrow H_2SO_3$

$$\left(\frac{128\ g\ SO_2}{64.0648\ g/mol}\right)\left(\frac{1\ mol\ H_2SO_3}{1\ mol\ SO_2}\right)\left(82.08\ g/mol\right) = 164\ g\ H_2SO_3$$

4. Silver bromide can be precipitated by the reaction of silver nitrate with sodium bromide. What mass of precipitate can be produced starting with 34.3 g of sodium bromide?

$NaBr + AgNO_3 \rightarrow NaNO_3 + AgBr\downarrow$

$$\left(\frac{34.3\ g\ NaBr}{102.894\ g/mol}\right)\left(\frac{1\ mol\ AgBr}{1\ mol\ NaBr}\right)\left(187.772\ g/mol\right) = 62.6\ g\ AgBr$$

5. Hydrochloric acid is added to 50.0 g of iron(II) sulfide. What mass of hydrogen sulfide is produced? $FeS + 2\,HCl \rightarrow FeCl_2 + H_2S\uparrow$

$$\left(\frac{50.0\ g\ FeS}{87.913\ g/mol}\right)\left(\frac{1\ mol\ H_2S}{1\ mol\ FeS}\right)\left(34.082\ g/mol\right) = 19.4\ g\ H_2S$$

6. How much nitric acid is needed to react completely with 25.0 g of magnesium in the following reaction? $Mg + 2\,HNO_3 \rightarrow Mg(NO_3)_2 + H_2\uparrow$

$$\left(\frac{25.0\text{ g Mg}}{24.305\text{ g/mol}}\right)\left(\frac{2\text{ mol }HNO_3}{1\text{ mol Mg}}\right)\left(63.0128\ \frac{\text{g}}{\text{mol}}\right) = 130.\text{ g }HNO_3$$

7. How much copper(I) chloride can be produced beginning with 75.0 g of copper(I) oxide? $Cu_2O + 2\,HCl \rightarrow 2\,CuCl + H_2O$

$$\left(\frac{75.0\text{ g }Cu_2O}{143.0914\text{ g/mol}}\right)\left(\frac{2\text{ mol CuCl}}{1\text{ mol }Cu_2O}\right)\left(98.999\ \frac{\text{g}}{\text{mol}}\right) = 104\text{ g CuCl}$$

8. What volume of oxygen gas (at STP) is produced by the decomposition of 100.0 g of sodium nitrate? $2\,NaNO_3 \rightarrow 2\,NaNO_2 + O_2\uparrow$

$$\left(\frac{100.0\text{ g }NaNO_3}{84.995\text{ g/mol}}\right)\left(\frac{1\text{ mol }O_2}{2\text{ mol }NaNO_3}\right)\left(22.4\ \frac{\text{L}}{\text{mol}}\right) = 13.2\text{ L }O_2$$

9. What volume of oxygen (at STP) is produced when 75.0 g of water is decomposed by electrolysis? $2\,H_2O \rightarrow 2\,H_2 + O_2$

$$\left(\frac{75.0\text{ g }H_2O}{18.01528\text{ g/mol}}\right)\left(\frac{1\text{ mol }O_2}{2\text{ mol }H_2O}\right)\left(22.4\ \frac{\text{L}}{\text{mol}}\right) = 46.6\text{ L }O_2$$

10. What volume of carbon dioxide is required to produce 50.0 L of carbon monoxide according to the following reaction? $CO_2 + C \rightarrow 2\,CO$

$$\left(\frac{50.0\text{ L CO}}{22.4\text{ L/mol}}\right)\left(\frac{1\text{ mol }CO_2}{2\text{ mol CO}}\right)\left(22.4\ \frac{\text{L}}{\text{mol}}\right) = 25.0\text{ L }CO_2$$

11. When aluminum is heated in oxygen, aluminum oxide is formed. What mass of aluminum oxide can be obtained from 25.0 g of aluminum?

$$4\,Al + 3O_2 \rightarrow 2\,Al_2O_3$$

$$\left(\frac{25.0\text{ g Al}}{26.98154\text{ g/mol}}\right)\left(\frac{2\text{ mol }Al_2O_3}{4\text{ mol Al}}\right)\left(101.961\text{ g/mol}\right) = 47.2\text{ g }Al_2O_3$$

12. When steam is passed over iron, hydrogen gas and iron(III) oxide are formed. What mass of steam would be needed to react completely with 100.0 g of iron?

$$3\,H_2O + 2\,Fe \rightarrow 3\,H_2 + Fe_2O_3$$

$$\left(\frac{100.0\text{ g Fe}}{55.847\text{ g/mol}}\right)\left(\frac{3\text{ mol }H_2O}{2\text{ mol Fe}}\right)\left(18.01528\text{ g/mol}\right) = 48.39\text{ g }H_2O$$

13. What mass of ammonium hydroxide is needed to react completely with 75.0 g of copper(II) nitrate in a double displacement reaction?

$$2\,NH_4OH + Cu(NO_3)_2 \rightarrow 2\,NH_4NO_3 + Cu(OH)_2$$

$$\left(\frac{75.0\text{ g }Cu(NO_3)_2}{187.5558\text{ g/mol}}\right)\left(\frac{2\text{ mol }NH_4OH}{1\text{ mol }Cu(NO_3)_2}\right)\left(35.0458\text{ g/mol}\right) = 28.0\text{ g }NH_4OH$$

14. When ammonia is burned in oxygen, nitrogen gas and water are produced. What volume of ammonia will react completely with 25.0 L of oxygen?

$$4\,NH_3 + 3O_2 \rightarrow 2\,N_2 + 6\,H_2O$$

$$\left(\frac{25.0\text{ L }O_2}{22.4\text{ L/mol}}\right)\left(\frac{4\text{ mol }NH_3}{3\text{ mol }O_2}\right)\left(22.4\text{ L/mol}\right) = 33.3\text{ L }NH_3$$

15. When sodium carbonate reacts with hydrochloric acid, the carbonic acid that is formed immediately breaks down into carbon dioxide and water. What mass of sodium carbonate would have been present originally if 5.00 L of carbon dioxide were obtained this way?

$$Na_2CO_3 + 2\,HCl \rightarrow 2\,NaCl + H_2O + CO_2$$

$$\left(\frac{5.00\text{ L }CO_2}{22.4\text{ L/mol}}\right)\left(\frac{1\text{ mol }Na_2CO_3}{1\text{ mol }CO_2}\right)\left(105.98874\text{ g/mol}\right) = 23.7\text{ g }Na_2CO_3$$

16. What mass of copper metal can be obtained by the single replacement reaction between copper(I) nitrate and 30.0 g of iron metal? (Iron(II) nitrate is formed).

$$2\ CuNO_3 + Fe \rightarrow Fe(NO_3)_2 + 2\ Cu$$

$$\left(\frac{30.0\ g\ Fe}{55.847\ g/mol}\right)\left(\frac{2\ mol\ Cu}{1\ mol\ Fe}\right)\left(63.546\ g/mol\right) = 68.3\ g\ Cu$$

17. What mass of sulfuric acid will be needed to react completely with 35.5 g of ammonia in the production of ammonium sulfate?

$$2\ NH_3 + H_2SO_4 \rightarrow (NH_4)_2SO_4$$

$$\left(\frac{35.5\ g\ NH_3}{17.030\ 52\ g/mol}\right)\left(\frac{1\ mol\ H_2SO_4}{2\ mol\ NH_3}\right)\left(98.079\ g/mol\right) = 102\ g\ H_2SO_4$$

18. What volume of chlorine gas will be needed to react completely with 85.8 g of potassium iodide in a single replacement reaction?

$$Cl_2 + 2\ KI \rightarrow I_2 + 2\ KCl$$

$$\left(\frac{85.8\ g\ KI}{166.0028\ g/mol}\right)\left(\frac{1\ mol\ Cl_2}{2\ mol\ KI}\right)\left(22.4\ L/mol\right) = 5.79\ L\ Cl_2$$

19. In the neutralization reaction between sulphuric acid and potassium hydroxide, how much potassium sulfate can be produced if you have 150.0 g of sulfuric acid to begin with?

$$H_2SO_4 + 2\ KOH \rightarrow K_2SO_4 + 2\ H_2O$$

$$\left(\frac{150.0\ g\ H_2SO_4}{98.079\ g/mol}\right)\left(\frac{1\ mol\ K_2SO_4}{1\ mol\ H_2SO_4}\right)\left(174.2602\ g/mol\right) = 266.5\ g\ K_2SO_4$$

20. What volume of nitrogen gas is needed to react completely with 150.0 L of hydrogen in the production of ammonia?

$$N_2 + 3\ H_2 \rightarrow 2\ NH_3$$

$$\left(\frac{150.0\ L\ H_2}{22.4\ L/mol}\right)\left(\frac{1\ mol\ N_2}{3\ mol\ H_2}\right)\left(22.4\ L/mol\right) = 50.0\ L\ N_2$$

21. What mass of aluminum metal is needed to replace all of the iron from 27.8 g of iron(III) oxide?

$$2\ Al + Fe_2O_3 \rightarrow Al_2O_3 + 2\ Fe$$

$$\left(\frac{27.8\ g\ Fe_2O_3}{159.6922\ g/mol}\right)\left(\frac{2\ mol\ Al}{1\ mol\ Fe_2O_3}\right)\left(26.98154\ g/mol\right) = 9.39\ g\ Al$$

22. What volume of chlorine gas will react with antimony in order to produce 58.9 g of antimony(III) chloride?

$$3\ Cl_2 + 2\ Sb \rightarrow 2\ SbCl_3$$

$$\left(\frac{58.9\ g\ SbCl_3}{228.109\ g/mol}\right)\left(\frac{3\ mol\ Cl_2}{2\ mol\ SbCl_3}\right)\left(22.4\ L/mol\right) = 8.68\ L\ Cl_2$$

23. What mass of iron metal will be required to produce 20.8 g of iron(III) oxide in the reaction with pure oxygen?

$$4\ Fe + 3\ O_2 \rightarrow 2\ Fe_2O_3$$

$$\left(\frac{20.8\ g\ Fe_2O_3}{159.6922\ g/mol}\right)\left(\frac{4\ mol\ Fe}{2\ mol\ Fe_2O_3}\right)\left(55.847\ g/mol\right) = 14.5\ g\ Fe$$

24. What mass of potassium chlorate is required in the preparation of 90.0 L of oxygen gas?

$$2\ KClO_3 \rightarrow 2\ KCl + 3\ O_2$$

$$\left(\frac{90.0\ L\ O_2}{22.4\ L/mol}\right)\left(\frac{2\ mol\ KClO_3}{3\ mol\ O_2}\right)\left(122.54955\ g/mol\right)$$

$$= 328\ g\ KClO_3$$

25. Silver reacts with nitric acid to form nitrogen monoxide, silver nitrate and water. Determine the volume of nitrogen monoxide gas that can be produced at STP from 5.00 g of silver.

$3Ag + 4HNO_3 \rightarrow NO + 3AgNO_3 + 2H_2O$

$$\left(\frac{5.00\text{ g Ag}}{107.8682\text{ g/mol}}\right)\left(\frac{1\text{ mol NO}}{3\text{ mol Ag}}\right)\left(22.4\text{ L/mol}\right) = 0.346\text{ L NO}$$

26. Zinc reacts with phosphoric acid to produce zinc phosphate and hydrogen gas. Determine the mass of zinc required to produce 15.0 L of hydrogen gas at STP. $3Zn + 2H_3PO_4 \rightarrow Zn_3(PO_4)_2 + 3H_2$

$$\left(\frac{15.0\text{ L } H_2}{22.4\text{ L/mol}}\right)\left(\frac{3\text{ mol Zn}}{3\text{ mol } H_2}\right)\left(65.38\text{ g/mol}\right) = 43.8\text{ g Zn}$$

27. During photosynthesis, a sweet potato pant combines carbon dioxide gas and water to produce sucrose ($C_{12}H_{22}O_{11}$) and oxygen gas. Determine the volume of carbon dioxide gas at STP required to produce 455 g of sucrose. $12CO_2 + 11H_2O \rightarrow C_{12}H_{22}O_{11} + 12O_2$

$$\left(\frac{455\text{ g } C_{12}H_{22}O_{11}}{342.30008\text{ g/mol}}\right)\left(\frac{12\text{ mol } CO_2}{1\text{ mol } C_{12}H_{22}O_{11}}\right)\left(22.4\text{ L/mol}\right) = 357\text{ L } CO_2$$

28. The charcoal briquettes used to cook in an outdoor grill are composed of 99% carbon. What volume of oxygen gas (at STP) is required when a 100.0 g briquette is burned to produce carbon dioxide?

$(0.99)(100.0) = 99.\text{ g C}$

$C + O_2 \rightarrow CO_2$

$$\left(\frac{99.0\text{ g C}}{12.011\text{ g/mol}}\right)\left(\frac{1\text{ mol } O_2}{1\text{ mol C}}\right)\left(22.4\text{ L/mol}\right) = 185\text{ L } O_2$$

29. NO_2 is a toxic gas that forms acid rain when mixed with water in the air. The major source of NO_2 is the combustion of N_2 in the cylinders of automobile engines. Determine the mass of NO2 produced from $5.00 \times 108\ dm^3$ of N_2. $N_2 + 2O_2 \rightarrow 2NO_2$

$$\left(\frac{5.00 \times 10^8\ dm^3\ N_2}{22.4\ dm^3/mol}\right)\left(\frac{2\text{ mol } NO_2}{1\text{ mol } N_2}\right)\left(46.0055\text{ g/mol}\right) = 2.05 \times 10^9\text{ g } NO_2$$