STOICHIOMETRY *Mathematics of the Chemical Equation*

1. C3H8 + 5 O2 🡪 3 CO2 + 4 H2O

1 mol x mol

x mol O2 = 1 ~~mol C~~~~3~~~~H~~~~8~~ x (5 mol O2) = 5 mol O2

(1 ~~mol C~~~~3~~~~H~~~~8~~)

2. CH4 + 2 O2 🡪 CO2 + 2 H2O

1 mol x mol

x mol O2 = 1 ~~mol CH~~~~4~~ x (2 mol O2) = 2 mol O2

(1 ~~mol CH~~~~4~~)

3. 3 Na2S2O3 + AgBr 🡪 NaBr + Na5[Ag(S2O3) 3]

x mol 0.1 mol

x mol Na2S2O3 = 0.1 ~~mol AgBr~~ x (3 mol Na2S2O3) = 0.3 mol Na2S2O3

(1 ~~mol AgBr~~)

4. 4 Al + 3 O2 🡪 2 Al2O3

100 g x g

x g Al2O3 = 100 ~~g Al~~ x (1 mol Al) x (2 ~~mol Al~~~~2~~~~O~~~~3~~) x (102 g Al2O3) = 189 g Al2O3

(27 ~~g Al~~) (4 mol Al) (1 ~~mol Al~~~~2~~~~O~~~~3~~)

5. CaO + H2O 🡪 Ca(OH) 2

10 kg x g

x g H2O = 10 ~~kg CaO~~ x (1000 g CaO) x (1 ~~mol CaO~~) x (1 ~~mol H~~~~2~~~~O~~) x (18 g H2O) = 3214 g H2O

(1 ~~kg CaO~~) (56 g CaO) (1 mol CaO) (1 mol H2O)

x g Ca(OH) 2 = 10,000 ~~g CaO~~ x (1 mol CaO) x (1 ~~mol Ca(OH)~~ ~~2~~) x (74 g Ca(OH) 2) = 13214 g

(56 ~~g CaO~~) (1 mol CaO) (1 ~~mol Ca(OH)~~ ~~2~~)

6. 2 C57H110O6 + 163 O2 🡪 114 CO2 + 110 H2O

1 kg "Fat" x g

x g H2O = 1 ~~kg "Fat"~~ x (1000 g "Fat") x (1 ~~mol “Fat"~~) x (110 ~~mol H~~~~2~~~~O~~) x (18 g H2O)

(1 ~~kg "Fat"~~) (890 g “Fat") (2 ~~mol "Fat"~~) (1 ~~mol H~~~~2~~~~O~~)

= 1,112 g H2O

7. B2H6 + 3 O2 🡪 B2O3 + 3 H2O

10 kg x g

x g O2 = 10,000 ~~g B~~~~2~~~~H~~~~6~~ x (1 mol B2H6) x (3 ~~mol O~~~~2~~) x (32 g O2) = 34,783 g O2

(27.6 ~~g B~~~~2~~~~H~~~~6~~) (1 mol B2H6) (1 ~~mol O~~~~2~~)

8. Br2 + 2 NaI 🡪 2 NaBr + I2

0.172 mol x mol

x mol NaBr = 0.172 ~~mol Br~~~~2~~ x (2 mol NaBr) = 0.344 mol NaBr

(1 ~~mol Br~~~~2~~)

9. 2 Ca + O2 🡪 2 CaO

excess 4.9 x 105 x molecules

molecules

x molecules CaO = 4.9 x 105 ~~molecules O~~~~2~~ x (1 mol O2) x (2 ~~mol CaO~~) x (6.02 x 1023 molecules)

(6.02 x 1023 ~~molecules O~~~~2~~) (1 mol O2) (1 ~~mol CaO~~)

= 9.8 x 105 molecules CaO

10. 2 Al + 3 S 🡪 Al2S3

x atoms 1.33 x 1024

atoms

x atoms Al = 1.33 x 1024 ~~atoms S~~ x (1 mol S) x (2 ~~mol Al~~) x (6.02 x 1023 atoms Al)

(6.02 x 1023 ~~atoms S~~) (3 mol S) (1 ~~mol Al~~)

= 8.9 x 1023 atoms Al

11. CH4 + 2 O2 🡪 CO2 + 2 H2O

x g CH4 = 1 ~~g O~~~~2~~ x (1 mol O2) x (1 ~~mol CH~~~~4~~) x (16 g CH4) = 0.25 g CH4

(32 ~~g O~~~~2~~) (2 mol O2) (1 ~~mol CH~~~~4~~)

12. C6H12O6 + 6 O2 🡪 6 CO2 + 6 H2O

x g 10 g

x g C6H12O6 = 10 ~~g O~~~~2~~ x (1 mol O2) x (1 ~~mol C~~~~6~~~~H~~~~12~~~~O~~~~6~~) x (180 g C6H12O6) = 9.375 g C6H12O6

(32 ~~g O~~~~2~~) (6 mol O2) (1 ~~mol C~~~~6~~~~H~~~~12~~~~O~~~~6~~)

13. 6 NH4ClO4 + 10 Al 🡪 5 Al2O3 + 3 N2 + 6 HCl + 9 H2O

5 x 106 g x g

x g Al = 5 x 106 ~~g NH~~~~4~~~~ClO~~~~4~~ x (1 mol NH4ClO4 ) x (10 ~~mol Al~~) x (27 g Al) = 1,914,894 g Al

(117.5 ~~g NH~~~~4~~~~ClO~~~~4~~) (6 mol NH4ClO4) (1 ~~mol Al~~)

14. silver nitrate + potassium chloride 🡪 silver chloride + potassium nitrate

AgNO3 + KCl 🡪 AgCl + KNO3

5 g 5 g

/ 170 g/mol / 74.6 g/mol

"Have" 0.0294 mol 0.067 mol

"Need" 0.067 mol 0.0294 mol

Silver Nitrate is LIMITING REACTANT; KCl is in excess.

15. 2 Ag + I2 🡪 2 AgI

x atoms 531.8 g

2.5 x 1024 atoms / 74.6 g/mol

x 6.02 x 1023 atoms/mol

[2:1]

4.19 mol Ag 🡨 2.09 mol I2

x atoms Ag = 531.8 ~~g I~~~~2~~ x (1 mol I2) x (2 ~~mol Ag~~) x (6.02 x 1023 atoms Ag) = 2.5 x 1024 atoms Ag

(254 ~~g I~~~~2~~) (1 mol I2) (1 ~~mol Ag~~)

16. % Yield = Actual Yield x 100 %

# Theoretical Yield

% Yield = 480 tons x 100 % = 87.3 % Yield

550 tons

17. 1 mol N2 = 22.4 L @ STP

x L N2 = 16.3 ~~mol N~~~~2~~ x (22.4 L N2) = 365 L N2

(1 ~~mol N~~~~2~~)

18. 1 mol F2 = 22.4 L @ STP 1 cc = 1 cm3 = 1 mL 10 cm = 1 dm

(10 cm) 3 = (1dm) 3

& 1 dm3 = 1 L 1000 cm3 = 1 dm3

x mol F2 = 0.269 ~~L F~~~~2~~ x (1 mol F2) = 0.012 mol F2

(22.4 ~~L F~~~~2~~)

19. N2 + 2 O2 🡪 2 NO2

71.11 L excess x L

x L NO2 = 71.11 ~~L NO~~~~2~~ x (1 mol N2) x (2 ~~mol NO~~~~2~~) x (22.4 L NO2) = 142.22 L NO2

(22.4 ~~L N~~~~2~~) (1 mol N2) (1 ~~mol NO~~~~2~~)

20. 2 SO2 + O2 🡪 2 SO3

excess x mol 79.6 mol

x mol O2 = 79.6 ~~mol SO~~~~3~~ x (1 mol O2) = 39.8 mol O2

(2 ~~mol SO~~~~3~~)

21. 2 H2 + O2 🡪 2 H2O

50 g 50 g x g

56.25 g

/ 2 g/mol /32 g/mol x 18 g/mol

[1:2]

"Have" 25 mol H2 1.56 mol O2 3.125 mol H2O

"Need" 3.125 mol H2 12.5 mol O2

Oxygen is the LIMITING REACTANT; hydrogen is in excess.

x g H2O = 50 ~~g O~~~~2~~ x (1 mol O2) x (2 ~~mol H~~~~2~~~~O~~) x (18 g H2O) = 56.25 g H2O

(32 ~~g O~~~~2~~) (1 mol O2) (1 ~~mol H~~~~2~~~~O~~)

2 H2 + O2 🡪 2 H2O + H2

50 g 50 g 56.25 g + 43.75 g

6.25 g + 43.75 g + 50 g = 56.25 g + 43.75 g

100 g Reactant = 100 g Product

Law of Conservation of Mass is observed!

22. 2 C + O2 🡪 2 CO + energy Conversion Factor: 1 mol C = 113 kJ

1 mol 113 kJ

100 g x Joules

x Joules heat = 100 ~~g C~~ x (1 mol C) x (113 ~~kJ~~) x (1000 J) = 942,000 Joules

(12 ~~g C~~) (1 mol C) (1 ~~kJ~~)

23. Cu + 2 AgNO3 🡪 Cu(NO3) 2 + 2 Ag

100 g 200 g x atoms

7.1 x 1023 atoms

/ 63.5 g/mol / 170 g/mol x 6.02 x 1023 atoms

[2:2]

"Have" 1.57 mol Cu 1.18 mol AgNO3 1.18 mol Ag

# "Need" 0.59 mol Cu 3.14 mol AgNO3

Silver nitrate is LIMITING Reactant; copper is in excess.

X atoms Ag = 200 ~~g AgNO~~~~3~~ x (1 mol AgNO3) x (2 ~~mol Ag~~) x (6.02 x 1023 atoms Ag)

(170 ~~g AgNO~~~~3~~) (2 mol AgNO3) (1 ~~mol Ag~~)

= 7.1 x 1023 atoms Ag

24. 2 ZnS + 3 O2 🡪 2 ZnO + 2 SO2

1.58 x 108 1000 L x mol

molecules

/ 6.02 x 1023 / 22.4 L/mol

molecules/mol

# "Have" 2.49 x 10-16 mol ZnS 44.6 mol O2 \_\_\_\_\_\_\_\_\_\_\_\_\_\_ mol

# "Need" [2:2]

Zinc sulfide is LIMITING Reactant; oxygen is in excess.

X mol SO2 = 1.5 x 108 ~~molecules ZnS~~ x (1 mol ZnS) x (2 mol SO2)

(6.02 x 1023 ~~molecules ZnS~~) (2 mol ZnS)

= 2.5 x 10-16 mol SO2

x 0.75 (75 % Yield)

1.9 x 10-16 mol SO2

3a. 6 CO2 + 6 H2O + energy 🡪 C6H12O6 + 6 O2

x molecules 1 molecule

b. 6 molecules H2O

c. 6 CO2 + 6 H2O + energy 🡪 C6H12O6 + 6 O2

2.5 mol x L

x L O2 = 2.5 ~~mol C~~~~6~~~~H~~~~12~~~~O~~~~6~~ x (6 mol O2) x (22.4 L O2) = 336 L O2

(1 ~~mol C~~~~6~~~~H~~~~12~~~~O~~~~6~~) (1 mol O2)

d. 6 CO2 + 6 H2O + energy 🡪 C6H12O6 + 6 O2

x mol 2.5 mol

x mol CO2 = 2.5 ~~mol C~~~~6~~~~H~~~~12~~~~O~~~~6~~ x (6 mol CO2) = 15 mol CO2

(1 mol C6H12O6)

e. 6 CO2 + 6 H2O + energy 🡪 C6H12O6 + 6 O2

x mol 2.5 mol

x mol CO2 = 2.5 ~~mol C~~~~6~~~~H~~~~12~~~~O~~~~6~~ x (6.02 x 1023 molecules C6H12O6) x (6 atoms C) (1 ~~mol C~~~~6~~~~H~~~~12~~~~O~~~~6~~) (1 molecule C6H12O6)

= 9.03 x 1024 atoms C

f. 6 CO2 + 6 H2O + energy 🡪 C6H12O6 + 6 O2

9.32 L x L

x L O2 = 9.32 ~~L CO~~~~2~~ x (1 mol CO2) x (6 ~~mol O~~~~2~~) x (22.4 L O2) = 9.32 L O2

(22.4 ~~L CO~~~~2~~) (6 mol CO2) (1 ~~mol O~~~~2~~)

3. C12H22O11 + 12 O2 🡪 12 CO2 + 11 H2O + energy

816 g x L

(MM = 342 g/mol)

x L O2 = 816 ~~g C~~~~12~~~~H~~~~22~~~~O~~~~11~~ x (1 mol C12H22O11) x (12 ~~mol O~~~~2~~) x (22.4 L O2) = 641 L O2

(342 ~~g C~~~~12~~~~H~~~~22~~~~O~~~~11~~) (1 mol C12H22O11) (1 ~~mol O~~~~2~~)

4. 2 KClO3 🡪 2 KCl + 3 O2

x g x g 5 g

K2CO3  🡪 K2O + CO2

x g 7 g

x g KClO3 = 5 ~~g O~~~~2~~ x (1 mol O2) x (2 ~~mol KClO~~~~3~~) x (122.6 g KClO3) = 12.77 g KClO3

(32 ~~g O~~~~2~~) (3 mol O2) (1 ~~mol KClO~~~~3~~)

x g KCl = 5 ~~g O~~~~2~~ x (1 mol O2) x (2 ~~mol KCl~~) x (74.6 g KCl) = 7.77 g KCl "Produced"

(32 ~~g O~~~~2~~) (3 mol O2) (1 ~~mol KCl~~)

x g K2CO3 = 7 ~~g CO~~~~2~~ x (1 mol CO2) x (1 ~~mol K~~~~2~~~~CO~~~~3~~) x (138.2 g K2CO3) = 21.99 g K2CO3

(44 ~~g CO~~~~2~~) (1 mol CO2) (1 ~~mol K~~~~2~~~~CO~~~~3~~)

Original Mixture: 12.77 g KClO3 + 21.99 g K2CO3 + x g KCl = 50 g

x = 15.24 g KCl

12.77 g KClO3 + 21.99 g K2CO3 + 15.24 g KCl = 50 g