Key - Unit 4 Review - Chemical Reactions, Moles, & Stoichiometry

Types of Reactions

1. $AlCl_3 + Na_2SO_4 \rightarrow Al_2(SO_4)_3 + NaCl$ — double-replacement
2. $Zn + S_8 \rightarrow ZnS$ (one product) — synthesis
3. $H_2SO_4 + Fe \rightarrow H_2 + FeSO_4$ — single-replacement
4. $C_5H_{12} + O_2 \rightarrow H_2O + CO_2$ — combustion
5. $Al_2S_3 \rightarrow Al + S_8$ (one reactant) — decomposition
6. $Li_2CO_3 + MgCl_2 \rightarrow LiCl + MgCO_3$ — double-replacement
7. $Fe + O_2 \rightarrow FeO$ (one product) — synthesis
8. $Zn + HBr \rightarrow H_2 + ZnBr_2$ — single-replacement
9. $C_5H_{10}O_4 + O_2 \rightarrow CO_2 + H_2O$ — combustion
10. $MgO \rightarrow Mg + O_2$ (one reactant) — decomposition

Law of Conservation of Mass

11. Mass cannot be created or destroyed in a chemical reaction, only rearranged.

Balancing Chemical Equations

12. $2\,AlCl_3(aq) + 3\,Na_2SO_4(aq) \rightarrow Al_2(SO_4)_3(s) + 6\,NaCl(aq)$
13. $8\,Zn(s) + S_8(s) \rightarrow 8\,ZnS(s)$
14. $H_2SO_4(aq) + Fe(s) \rightarrow H_2(g) + FeSO_4(aq)$ already balanced.
15. $C_5H_{12}(l) + 8\,O_2(g) \rightarrow 6\,H_2O(g) + 5\,CO_2(g)$

16. $8\ Al_2S_3(s) \rightarrow 16\ Al(s) + 3\ S_8(s)$

17. $Li_2CO_3(aq) + MgCl_2(s) \rightarrow 2\ LiCl(aq) + MgCO_3(aq)$

18. $2\ Fe(s) + O_2(g) \rightarrow 2\ FeO(s)$

19. $Zn(s) + 2\ HBr(aq) \rightarrow H_2(g) + ZnBr_2(aq)$

20. $2\ C_5H_{10}O_4(l) + 11\ O_2(g) \rightarrow 10\ CO_2(g) + 10\ H_2O(g)$

Skeleton Equations

21. $NH_4Cl(aq) + NaOH(aq) \rightarrow H_2O(l) + NH_3(g) + NaCl(aq)$ (1+ 1− 1+ 1− 1+ 1−)

22. $NaOH(s) + H_3PO_4(aq) \rightarrow H_2O(l) + Na_3PO_4(aq)$ (1+ 1− 1− 3− 1+ 3−)

23. $Cu(s) + O_2(g) \rightarrow CuO(s)$ (2+ 2−)

Predicting Products

- single-Replacement

24. $2\ Ag(s) + CuSO_4(aq) \rightarrow Cu(s) + Ag_2SO_4(aq)$ (1+ 2−)

25. $AlCl_3(aq) + 3\ Cs(s) \rightarrow Al(s) + 3\ CsCl(aq)$ (1+ 1−)

26. $Sn(s) + Fe(CN)_2(aq) \rightarrow Fe(s) + Sn(CN)_2(aq)$

- double-replacement

27. $2\ KCl(s) + Mg(OH)_2(aq) \rightarrow 2\ KOH(aq) + MgCl_2(aq)$ (1+ 1− 2+ 1−)

28. $6\ LiBr(s) + Co_2(SO_3)_3(aq) \rightarrow 3\ Li_2SO_3(aq) + 2\ CoBr_3(aq)$ (1+ 2− 3+ 1−)

- synthesis

29. $H_2(g) + S(s) \rightarrow H_2S(g)$ (1+ 2−)

30. $Be(s) + Cl_2(g) \rightarrow BeCl_2(s)$ (2+ 1−)

- decomposition

31. $2\ NaO_2(s) \rightarrow 4\ Na(s) + O_2(g)$

32. $2\ AlCl_3(s) \rightarrow 2\ Al(s) + 3\ Cl_2(g)$

- combustion

33. $C_5H_{12}(l) + 8\ O_2(g) \rightarrow 5\ CO_2(g) + 6\ H_2O(g)$

34. $2\ CH_3OH(aq) + 3\ O_2(g) \rightarrow 2\ CO_2(g) + 4\ H_2O(g)$

Moles

35(a) $Al(OH)_3$ - 1 Al, 3O, & 3H
(b) $H_2C_2O_4$ - 2H, 2C, & 4O
(c) $(NH_4)_2HPO_4$ - 2N, 9H, 1P, 4O
(d) $C_4H_{10}O$ - 4C, 10H, 1O

36. Each compound contains 6.02×10^{23} molecules because 1.00 moles of any substance contains 6.02×10^{23} particles.

37 (a) H_3PO_4

H: $3 \times 1.01g = 3.03g$
P: $1 \times 30.97g = 30.97g$
O: $4 \times 16.00g = 64.00g$
$98.00g$

(b) N_2O_3

N: $2 \times 14.01g = 28.02g$
O: $3 \times 16.00g = 48.00g$
$76.02g$

(c) $C_4H_9O_2$

C: $4 \times 12.01g = 48.04g$
H: $9 \times 1.01g = 9.09g$
O: $2 \times 16.00g = 32.00g$
$89.13g$

(d) $(NH_4)_2SO_4$

N: $2 \times 14.01g = 28.02g$
H: $8 \times 1.01g = 8.08g$
S: $1 \times 32.07g = 32.07g$
O: $4 \times 16.00g = 64.00g$
$132.17g$

38. (a) $15.5\text{g } SiO_2 \left| \frac{1\text{ mol}}{60.09\text{g}} \right. = .258\text{ mol } SiO_2$

Si: 28.09 g
2-O: 32.00 g
60.09 g

(b) $.0688\text{g } AgCl \left| \frac{1\text{ mol}}{143.32\text{g}} \right. = .000480\text{mol } AgCl$

Ag: 107.87 g
Cl: 35.45 g
143.32 g

39. (a) $.780\text{ mol } Ca(CN)_2 \left| \frac{92.12\text{ g}}{1\text{ mol}} \right. = 71.9\text{g } Ca(CN)_2$

Ca: 40.08 g
2C: 24.02 g
2N: 28.02 g
92.12 g

(b) $7.00\text{ mol } H_2O_2 \left| \frac{34.02\text{g}}{1\text{ mol}} \right. = 238\text{g } H_2O_2$

2H: 2.02 g
2O: 32.00 g
34.02 g

40. (a) $7.6\text{ mol Ar} \left| \frac{22.4\text{L}}{1\text{ mol}} \right. = 170\text{L Ar}$

(b) $.44\text{mol } C_2H_6 \left| \frac{22.4\text{L}}{1\text{ mol}} \right. = 9.86\text{L } C_2H_6$

41 (a) $14.4\text{L } F_2 \left| \frac{1\text{ mol}}{22.4\text{L}} \right. = .643\text{mol } F_2$

(b) $3.21\times10^2\text{L } CO_2 \left| \frac{1\text{ mol}}{22.4\text{L}} \right. = 14.3\text{ mol } CO_2$

42 (a) $3.00\text{mol Sn} \left| \frac{6.02\times10^{23}\text{ atoms}}{1\text{ mol}} \right. = 1.81\times10^{24}\text{ atoms Sn}$

(b) $.400\text{ mol KCl} \left| \frac{6.02\times10^{23}\text{ f.units}}{1\text{ mol}} \right. = 2.41\times10^{23}\text{ f.units KCl}$

43 (a) $4.80\times10^{20}\text{ f.units NaI} \left| \frac{1\text{ mol}}{6.02\times10^{23}\text{ f.units}} \right. = .000797\text{mol NaI}$

(b) $7.50\times10^{24}\text{ molecules } SO_2 \left| \frac{1\text{ mol}}{6.02\times10^{23}\text{ molecules}} \right. = 12.5\text{ mol } SO_2$

44. (a) $835\text{g } SO_3 \left|\frac{1\text{ mol}}{80.07\text{g}}\right.\left|\frac{22.4\text{ L}}{1\text{ mol}}\right. = 234\text{ L } SO_3$

S: 32.07g
3O: 48.00g
80.07g

(b) $1\text{ molecule } C_9H_8O_4 \left|\frac{1\text{ mol}}{6.02\times10^{23}\text{ molecules}}\right.\left|\frac{180.17\text{g}}{1\text{ mol}}\right. = 3\times10^{-22}\text{ g } C_9H_8O_4$

9C 108.09g
8H 8.08g
4O 64.00g
180.17g

(c) $146\text{ g } O_3 \left|\frac{1\text{ mol}}{22.4\text{ L}}\right.\left|\frac{6.02\times10^{23}\text{ molecules}}{1\text{ mol}}\right. = 3.92\times10^{24}\text{ molecules } O_3$

45 (a) H_2S

2H: 2.02g
S: 32.07g
34.07g

$\%H = \frac{2.02\text{g}}{34.07\text{g}}\times100 = 5.93\%$

$\%S = \frac{32.07\text{g}}{34.07\text{g}}\times100 = 94.1\%$

(b) $Mg(OH)_2$

Mg: 24.31g
2O: 32.00g
2H: 2.02g
58.33g

$\%Mg = \frac{24.31\text{g}}{58.33\text{g}}\times100 = 41.7\%$

$\%O = \frac{32.00\text{g}}{58.33\text{g}}\times100 = 54.9\%$

$\%H = \frac{2.02\text{g}}{58.33\text{g}}\times100 = 3.46\%$

46 (a) S_2Cl_2 is an M.F
(b) $C_6H_{10}O_4$ is an M.F.
(c) NO_2SO_3 is an E.F.
(d) $C_5H_{10}O_5$ is an M.F.
(e) $C_{17}H_{19}NO_3$ is an E.F.
(f) $(NH_4)_2CO_3$ is an E.F.

47 (a) $\frac{79.8\text{g C}}{12.01\text{ g/mol}}$ $\frac{20.2\text{g H}}{1.01\text{ g/mol}}$

$= \frac{6.6446\text{ mol C}}{6.6446\text{ mol}}$ $\frac{20.00\text{ mol H}}{6.6446\text{ mol}}$

$= 1\text{ C}$ $= 3\text{H}$

E.F. = CH_3

47(b) $\frac{62.1\text{ g C}}{12.01\text{ g/mol}}$ $\frac{13.8\text{ g H}}{1.01\text{ g/mol}}$ $\frac{24.1\text{ N}}{14.01\text{ g/mol}}$ EF = C_3H_8N

$= \frac{5.17069\text{ mol C}}{1.7202\text{ mol}}$ $\frac{13.6634\text{ mol H}}{1.7202\text{ mol}}$ $\frac{1.7202\text{ mol N}}{1.7202\text{ mol}}$

$= 3\text{C}$ $= 8\text{ H}$ $= 1\text{ N}$

48 (a) EF - CH_2O

MM C: 12.01g
2H: 2.02g
O: 16.00g
30.03g

$\frac{90}{\sim 30} = 3$

MF = $C_3H_6O_3$

(b) EF - HgCl

MM Hg: 200.59g
Cl: 35.45g
236.04g

$\frac{472}{\sim 236} = 2$

MF = Hg_2Cl_2

49. $\frac{58.8\text{g C}}{12.01\text{ g/mol}}$ $\frac{9.8\text{g H}}{1.01\text{ g/mol}}$ $\frac{31.4\text{g O}}{16.00\text{ g/mol}}$

$= \frac{4.89592\text{ mol C}}{1.9625\text{ mol}}$ $= \frac{9.70297\text{ mol H}}{1.9625\text{ mol}}$ $= \frac{1.9625\text{ mol O}}{1.9625\text{ mol}}$

2(2.5 C) 2(5 H) 2(1 O)

EF = $C_5H_{10}O_2$

MM 5C: 60.05g
10H: 10.10g
2O: 32.00g
102.15g

$\frac{102}{102} = 1$ MF = $C_5H_{10}O_2$

50. $\frac{81.78\text{g C}}{12.01\text{ g/mol}}$ $\frac{6.1133\%\text{ H}}{1.01\text{ g/mol}}$ $\frac{12.10569\text{ g O}}{16.00\text{ g/mol}}$

$= \frac{6.80933\text{ mol C}}{.7566\text{ mol}}$ $= \frac{6.05277\text{ mol H}}{.7566\text{ mol}}$ $= \frac{.7566\text{ mol O}}{.7566\text{ mol}}$

$= 9\text{ C}$ $= 8\text{ H}$ $= 1\text{ O}$

EF = C_9H_8O

MM 9C: 108.09g
8H: 8.08g
O: 16.00g
132.17g

$\frac{132}{132} = 1$ MF = C_9H_8O

Stoichiometry

51. $2\ Al(OH)_3(s) + 3\ H_2SO_4(aq) \rightarrow Al_2(SO_4)_3(aq) + 6\ H_2O(l)$

(a) $.88\ \text{mol } Al(OH)_3 \left| \frac{6\ \text{mol } H_2O}{2\ \text{mol } Al(OH)_3} \right. = 2.6\ \text{mol } H_2O$

(b) $.88\ \text{g } Al(OH)_3 \left| \frac{1\ \text{mol } Al(OH)_3}{78.01\ \text{g } Al(OH)_3} \right. \left| \frac{1\ \text{mol } Al_2(SO_4)_3}{2\ \text{mol } Al(OH)_3} \right. = .0056\ \text{mol } Al_2(SO_4)_3$

Al: 26.98 g
3 O: 48.00 g
3 H: + 3.03 g
78.01 g

(c) $.88\ \text{g } H_2O \left| \frac{1\ \text{mol } H_2O}{18.02\ \text{g } H_2O} \right. \left| \frac{1\ \text{mol } Al_2(SO_4)_3}{6\ \text{mol } H_2O} \right. \left| \frac{342.17\ \text{g } Al_2(SO_4)_3}{1\ \text{mol } Al_2(SO_4)_3} \right. = 2.8\ \text{g } Al_2(SO_4)_3$

2H: 2.02 g
O: + 16.00 g
18.02 g

2Al: 53.96 g
3S: 96.21 g
12O: + 192.00 g
342.17 g

8S: 256.56 g

52 (a) $8\ H_2S(g) + 4\ O_2(g) \rightarrow S_8(l) + 8\ H_2O(l)$

2H: 2.02 g
S: + 32.07 g
34.09 g

$102.27\ \text{g } H_2S \left| \frac{1\ \text{mol } H_2S}{34.09\ \text{g } H_2S} \right. \left| \frac{1\ \text{mol } S_8}{8\ \text{mol } H_2S} \right. \left| \frac{256.56\ \text{g } S_8}{1\ \text{mol } S_8} \right. = 96.210\ \text{g } S_8$

$64.00\ \text{g } O_2 \left| \frac{1\ \text{mol } O_2}{32.00\ \text{g } O_2} \right. \left| \frac{1\ \text{mol } S_8}{4\ \text{mol } O_2} \right. \left| \frac{256.56\ \text{g } S_8}{1\ \text{mol } S_8} \right. = 128.28\ \text{g } S_8$

TY = 96.210 g S_8 LR = H_2S ER = O_2

(b) $\%\ \text{yield} = \frac{84.78\ \text{g } S_8}{96.210\ \text{g } S_8} \times 100 = 88.12\%$

53 $Fe_2O_3(s) + 3CO(g) \rightarrow 3CO_2(g) + 2Fe(s)$

C: 12.01g
O: 16.00g
28.01g

(a) $150.0\,g\,Fe_2O_3 \left|\frac{1\,mol\,Fe_2O_3}{159.70\,g\,Fe_2O_3}\right|\frac{3\,mol\,CO}{1\,mol\,Fe_2O_3}\left|\frac{28.01\,g\,CO}{1\,mol\,CO}\right. = 78.93\,g\,CO$

2Fe: 111.70g
3O: 48.00g
159.70g

(b) $2.50\,mol\,CO \left|\frac{2\,mol\,Fe}{3\,mol\,CO}\right|\frac{55.85\,g\,Fe}{1\,mol\,Fe} = 93.1\,g\,Fe$

C: 12.01g
2O: 32.00g
44.01g

(c) $100.0\,g\,Fe_2O_3 \left|\frac{1\,mol\,Fe_2O_3}{159.70\,g\,Fe_2O_3}\right|\frac{3\,mol\,CO_2}{1\,mol\,Fe_2O_3}\left|\frac{44.01\,g\,CO_2}{1\,mol\,CO_2}\right. = 82.67\,g\,CO_2$

$100.0\,g\,CO \left|\frac{1\,mol\,CO}{28.01\,g\,CO}\right|\frac{3\,mol\,CO_2}{3\,mol\,CO}\left|\frac{44.01\,g\,CO_2}{1\,mol\,CO_2}\right. = 157.1\,g\,CO_2$

TY = $82.67\,g\,CO_2$ LR = Fe_2O_3 TY = CO

(d) $\%\,yield = \frac{60.5\,g\,CO_2}{82.67\,g\,CO_2} \times 100 = 73.2\%$