Note Title 8/12/2019

Stoichiometry + Reactions

quiz review

1) SO_3 $\quad S + (3 \times -2) = 0$

$S - 6 = 0$

$+6 \quad +6$

$S = +6$

$Ca_3(PO_4)_2$ $\quad Ca = +2$

$3(Ca) = 2(-3)$

$K^+ MnO_4^-$ $\quad MnO_4 = -1$

$Mn + (4 \times -2) = -1$

$Mn - 8 = -1$

$+8 \quad +8$

$Mn = +7$

$C_6H_{12}O_6$

$(6 \times C) + (12 \times 1) + (6 \times -2) = 0$

$6C + 12 - 12 = 0$

$\frac{6C}{6} = \frac{0}{6}$ $\quad C = 0$

CO_2 $\quad C + (2 \times -2) = 0$

$C - 4 = 0$

$+4 \quad +4$

$C = +4$

2) least to most oxygen atoms

a) 16g of O_2 1/2 mol O_2 = 1 mol oxygen atoms (a = 1)
b) 1 mol sulfuric acid H_2SO_4 = 4 mol " " (b = 4)
c) 10×10^{23} molecules of water H_2O = > 1 mol " "

6×10^{23} molecules = 1 mol $a < c < b$

$$16\,g \text{ of } O_2 \times \frac{1\,mol\,O_2}{32\,g} = \frac{1}{2} \text{ mol } O_2$$

$$0.5\,mol\,O_2 \times \frac{2\,mol\,O}{1\,mol\,O_2} = 1 \text{ mol } O_x$$

$$10 \times 10^{23}\,molec \times \frac{1\,mol}{6 \times 10^{23}\,molec} \quad \frac{10}{6}\,mol \quad 1\frac{4}{6} \quad 1\frac{2}{3} = 1.67\,mol$$

Calculate molar mass

a) H_2O H = 1 O = 16

(2 x H) + (1 x Ox)

2 + 16 = **18 g/mol**

O_2 = 32 (16 x 2)

b) CO_2 C = 12 Ox = 16

12 + 32 = **44 g/mol**

c) NH_3 N = 14 + H = 3 = **17 g/mol**

d) $C_6H_{12}O_6$ (6·C) + (12·H) + (6·Ox)

(6x12) + (12x1) + (6x16)

72 + 12 + ~90

> 172

6x16 ~ 6x15

6x10 = 60

6x6 = 36

96

180 g/mol

$\frac{C_6H_{12}O_6}{6}$ CH_2O x 6

12 + 2 + 16 = 30 x 6 = 180

e) Valine = $C_5H_{11}NO_2$

60 + 11 + 14 + 32 = 117

1 g/mol = 1 Da

* avg AA = 110 g/mol = 110 Da

4) mass % of oxygen

$$\% \text{ anything} = \frac{\text{part}}{\text{whole}} \times 100\%$$

$$\frac{\text{mass Ox}}{\text{total mass}} \times 100\%$$

a) H_2O = 18 g/mol

$$\frac{16\text{ g}}{18\text{ g}} \times \quad \frac{8}{9} \quad \frac{9}{10} \sim 90\%$$

$$\frac{8}{9} = \frac{1}{9} \times 8 = 0.11 \times 8 = 0.88 = 88\%$$

b) CO_2 = 44 g/mol

$$\frac{33}{44} \quad \frac{3}{4} \qquad \frac{32}{44} \sim \frac{30}{40} \quad 75\% \qquad \frac{30}{45} \quad 67\%$$

calc = 72.7%

d) $C_6H_{12}O_6$ = 180 g/mol

6×16
$\sim 6 \times 15 \sim 90$

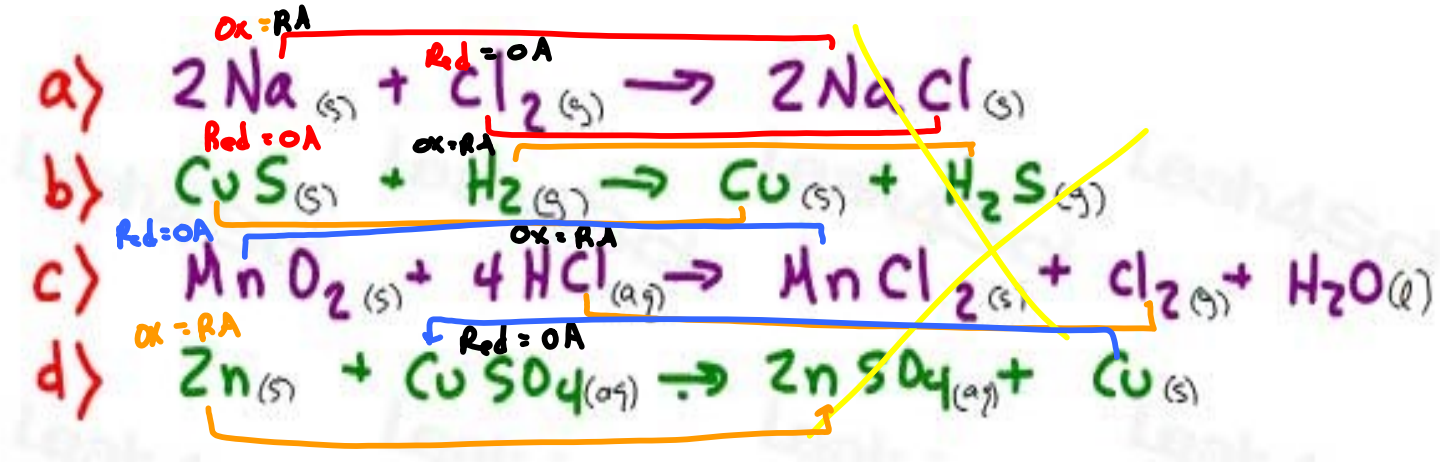
$$\frac{96\text{ g}}{180\text{ g}} \quad \frac{\sim 90}{180} = > 50\% \qquad \text{calc} = 53.3\%$$

CH_2O = 30 g/mol $\quad \frac{16}{30} \sim \frac{15}{30} = 50\%$

e) $C_5H_{11}NO_2$ = 117 g/mol

$$\frac{32}{117} = \frac{30}{120} = 25\%$$ calc -27.4%

5)



Ox = Oxidized = RA = Red agent

Red = Reduced = OA = ox agent

Red

$\overset{+4}{Mn}\overset{-4}{O_2} = 0$ → $\overset{+2}{Mn}\overset{-2}{Cl_2} = 0$

⑥ find # C atoms

a) 1g of C-12 → 1 mol C = 12g → $\frac{1}{12} \cdot 6 \times 10^{23}$ → $\frac{1}{2}$ → 0.5×10^{23} → 5×10^{22}

$$1\text{g C-12} \times \frac{1\text{mol C-12}}{12\text{g}} \times \frac{6 \times 10^{23}\text{ C atoms}}{1\text{mol C-12}} = 5 \times 10^{22}\text{ C atoms}$$

$$\frac{1 \times 1 \times 6 \times 10^{23}}{12_2} = 0.5 \times 10^{23}$$

$5 \times 10^{24} = 50 \times 10^{23}$

b) 1 mol acetic acid $CH_3COOH = C_2H_4O_2$

$$2\text{mol C} \times \frac{6 \times 10^{23}\text{ atoms}}{1\text{mol C}} \quad 12 \times 10^{23} \quad 1.2 \times 10^{24}$$

c) 3×10^3 molecules CH_4 1:1 = 3×10^3 atoms C

1 molecule CH_4 has 1 C atom

1 molecule CH_4 = 1 atom C + 4 atoms H

7 find mass

a) 1 g of C-12 = 1 g

b) 1 mol $C_2H_4O_2$

$2(4) + 4 + 3(2) = 60$ g/mol

$X \cdot CH_2O = 30$ g/mol

c) 3×10^3 molecules CH_4

$12 + 4 = 16$

$$3 \times 10^3 \text{ molec} \times \frac{1 \text{ mol } CH_4}{6 \times 10^{23} \text{ molec}} \times \frac{16 \text{ g/mol}}{1 \text{ mol } CH_4}$$

$$\frac{1 \cancel{3} \times 10^3 \cdot \cancel{16}\ 8}{1 \cancel{2}\ \cancel{6} \times 10^{23}} = \frac{8 \times 10^3}{1 \times 10^{23}} = 8 \times 10^{-20}$$

$3 - 23$

$-(23 - 3) = 20$

(8) find L/mL

$L \cancel{M} = \frac{mol}{\cancel{L} M} \Rightarrow L = \frac{mol}{M}$

a) 0.015 mol gluc → 0.3 M

$L = \frac{0.015\ mol}{0.300\ M} = \frac{15}{300} = \frac{\cancel{15}^{1}}{\cancel{30}_{2} \times 10} \quad \frac{0.5}{10} = 0.05\ L = 50\ mL$

$\frac{5\ \cancel{15}}{\cancel{3} \cdot 100} \quad \frac{5}{100} = 0.05$

b) 1×10^{-4} mol of $CaCO_3$ → 9 $\overset{10^{-3}}{mM}$

$L = \frac{mol}{M} = \frac{1 \times 10^{-4}}{9 \times 10^{-3}\ M} = 0.11 \times 10^{-1} = 0.011\ L$

$-4 - 3 = -1$

$0.11 \times 10^{-1} \quad 1.1 \times 10^{-2}\ L$

0.3g $CaCO_3$ → 0.125 M

$L = \frac{mol}{M} = \frac{0.003\ mol}{0.125\ M} = \frac{3}{125} = \frac{\sim 3}{120}$ 0.25

0.025 L

calc = 0.024 L

$CaCO_3$

$40 + 12 + 48 = 100\ g/mol \quad \cancel{0.3g} \times \frac{1\ mol}{100\ \cancel{g}} = 0.003\ mol$

(9) Balance & type

a) $2\,C_6H_{10} + 17\,O_2 \rightarrow 12\,CO_2 + 10\,H_2O$

12	6 C	12	
20	10 H	20	
34	2 O	34	

b) $2\,Mg + O_2 \rightarrow 2\,MgO$

c) $1\,NH_4NO_3 \rightarrow 1\,N_2O + 2\,H_2O$

2	N	2
4	H	4
3	O	3

d) $3\,KNO_3 + AlCl_3 \rightarrow Al(NO_3)_3 + 3\,KCl$

3	K	3
3	NO_3	3
1	Al	1
3	Cl	3

e) $2\,Ni_2O_3 \rightarrow 4\,Ni + 3\,O_2$

f) $2\,Na + CoSO_4 \rightarrow Na_2SO_4 + Co$

Na
Co
SO_4

9) $1\,C_6H_4O_2 + 6\,O_2 \rightarrow 6\,CO_2 + 2\,H_2O$

14 − 2 = 12 ; 12 / 2 = 6

6	C	✗ 6	
4	H	✗ 2	4
4	O	✗ 3	14

10)

a) ? g CO_2 100 g C_2H_6

$2\,C_2H_6 + 7\,O_2 \rightarrow 4\,CO_2 + 6\,H_2O$ (100 g; ? ; 6)

$C_2H_6 + O_2 \rightarrow 2\,CO_2 + 3\,H_2O$

$100\text{ g Et} \times \frac{1\text{ mol}}{30\text{ g}}$; $\frac{100\text{ g Et}}{30\text{ g/mol}}$; $\frac{1}{3} = 3.3\text{ mol Et}$

C_2H_6

24 + 6 = 30

$100\text{ g Et} \times \frac{1\text{ mol Et}}{30\text{ g Et}} \times \frac{2\text{ mol } CO_2}{1\text{ mol Et}} \times \frac{44\text{ g } CO_2}{1\text{ mol } CO_2}$

$\frac{100 \times 2 \times 44}{30} = 300\text{ g } CO_2$

calc = 293

10 b ? g H_2O 24 g glucose

24 g → mol mol → g ★ Memorize

$1\,C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$

$24\ g\ gl \times \frac{1\ mol\ gl}{180\ g\ gl} \times \frac{6\ H_2O}{1\ gl} \times \frac{18\ g\ H_2O}{1\ mol\ H_2O} = g\,H_2O$

$\frac{24 \times 6 \times 18}{180} = 12 = 15\ 18$

$\frac{150}{10} = 15\ g\ H_2O$

calc = 14.4

H
C N O F =32 =O2
P S Cl
Br
I

(11) a) mol oxygen in 25g of H_2SO_4

$$25\,g\,H_2SO_4 \times \frac{1\,mol\,H_2SO_4}{100\,g} \times \frac{4\,mol\,O}{1\,mol\,H_2SO_4} \quad \frac{100}{100} = 1\,mol\,O$$

H_2SO_4
2 32 +32 +32 ~100

b) mol cl in 1.8×10^7 molec NaCl

$$1.8 \times 10^7\,molec\,NaCl \times \frac{1\,mol}{1.6 \times 10^{23}\,molec} = 0.3 \times 10^{-16} \downarrow -17$$

3×10^{-17}

7 - 23

c) CO_2 in 0.00109 kg CO_2 44 g/mol

kg >> g

$$1.09\,g\,CO_2 \times \frac{1\,mol}{44\,g} = 0.025\,mol\,CO_2$$

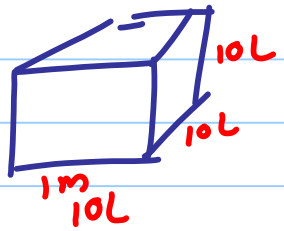
$\frac{1.1}{44}$ $\frac{1}{4}$

0.25

(12) mass of 30 mL Seawater

$\rho_{H_2O} = \frac{1000\,kg}{m^3}$ Seawater $\frac{1029\,kg}{m^3}$ $< 10^6\,mL$

$m^3 \rightarrow L$ $\quad 1m^3 = 1000L$



$V\rho = \frac{mass}{V} \rightarrow mass = V \cdot \rho$

$m = (30 \times 10^{-3}\,L)\left(\frac{1029 \times 10^3\,g}{1000\,L}\right)$

$30 \times 1.03 \quad > 30 \qquad calc = 30.9$

$mass = V \cdot \rho = 30\,mL \left(\frac{1029 \times 10^3\,g}{10^6\,mL}\right) = 30 \times 1.03 = > 30$

(13) find ρ of 1L of 0.3 molal NaCl > 1

dilute solution molal ~ Molarity

Na = 23
Cl = 36
59 g/mol

$\rho_{H_2O} = \frac{1000\,kg}{1000\,L}$ 1kg/L or 1g/mL

$0.3\,mol \times \frac{58.5}{1\,mol}$ $\quad 18$

$\rho_{s.H_2O} = \frac{1029\,kg}{1000L} = 1.03\,kg/L = 1.03\,g/mL$

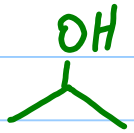
$> 1\,g/mL$

0.3 molal $= \frac{0.3\,mol\ NaCl}{1\,kg\ H_2O}$ $\quad 1000g + 18g = 1018g$

$\rho = \frac{m}{V} = \frac{1018}{1L}$ $\quad 1.02\,g/mL$

$> 1\,g/mL$

(14)

a) Isopropanol 

$2C_3H_8O + 9O_2 \rightarrow 6CO_2 + 8H_2O$

20 − 2 = 18 / 2

6	6	C	x → 6	
16	8	H	2 x 8	16
20	3	O	3	10 / 20

b) $2C_6H_6 + 15O_2 \rightarrow 12CO_2 + 6H_2O$

c) $H_2CO_3 + 2KOH \rightarrow 2H\text{-}OH \; (H_2O) \; K_2CO_3$

2	H	x	2
2	OH^-	x	2
2	K^+	x	2
1	CO_3^{2-}		1

d) $CH_3COOH \; (HA) + NaOH \rightarrow HOH \; (H_2O) \; NaCH_3COO \; (A^-)$

e) $2(NH_4)_3PO_4^{-3} + 3Ca(NO_3)_2^{+2} \rightarrow 1Ca_3(PO_4)_{2(s)} + 6NH_4NO_3$

6	3	NH_4^+	x 3 = 6
2	x	PO_4^{-3}	2
3	x	Ca^{2+}	3
6	2	NO_3^-	x 3 = 6

(15) a (in acid)

ox

$Cu + \overset{+5}{N}O_3^- \rightarrow Cu^{2+} + \overset{+4}{N}O_2$

Rd

ox $\quad Cu \rightarrow Cu^{2+} + 2e^-$

Rd 2x $\quad 2e^- + 4H^+ + 2NO_3^- \rightarrow 2NO_2 + 2H_2O$

$+2 - 1 + 1 - 1 = 0 \qquad 0$

$Cu + 4H^+ + 2NO_3^- \rightarrow Cu^{2+} + 2NO_2 + 2H_2O$

$+4 - 2 = +2 \qquad +2$

b) $MnO_4^- + I^- \rightarrow Mn^{2+} + I_2$

5x $10\ I^- \rightarrow 5\ I_2 + 10e^-$

2 $10e^- + 16H^+ + 2MnO_4^- \rightarrow 2Mn^{2+} + 8H_2O$

+8 −1 = +7 ; +2

$10\ I^- + 16H^+ + 2MnO_4^- \rightarrow 5\ I_2 + 2Mn^{2+} + 8H_2O$

+4

$-10 + 16 - 2 = +4$

c) (base) $Cl_2 \rightarrow Cl^- + ClO^-$

Red $+2e^- + Cl_2 \rightarrow 2Cl^-$

Ox $2H_2O + Cl_2 \rightarrow 2ClO^- + 4H^+ + 2e^-$

-2 ; +4 = +2

$4OH^- + 2H_2O + 2Cl_2 \rightarrow 2Cl^- + 2ClO^- + 4H^+ + 4H_2O$ (×2)

$4OH^- + 2Cl_2 \rightarrow 2Cl^- + 2ClO^- + 2H_2O$

$2H_2O + Cl_2 \rightarrow 2ClO^- + 4H^+$

(16) a) 0.05 mg NaCl in 10 mL H_2O

$$M = \frac{mol}{L}$$

$$0.05 \text{ mg} \times \frac{1 \text{ mol}}{60 \text{ g}} \times \frac{1}{10 \text{ mL}}$$

$5 \times 12 = 60$

$\frac{5}{60} \quad \boxed{\frac{1}{12}}$

$$\frac{0.08}{12 \times 10^{-2}} \quad 8.3 \times 10^{-3} \text{ M}$$

molality $n = \frac{mol}{kg} = \frac{8.3 \times 10^{-5}}{1 \times 10^{-2}} = 8.3 \times 10^{-3} n$

9/mL

10g → 10×10^{-3} kg

$$\frac{0.05 \times 10^{-3} \text{ g}}{60 \text{ g/mol}} = \frac{8.3}{5} \times 10^{-5}$$

b) 47g Fe (II) Cl $FeCl_2$ 800 mL H_2O

Fe = 55.8

Cl = (35.45)2

71 + 56

$$M = \frac{mol}{L} = 47 \text{ g } FeCl_2 \times \frac{1 \text{ mol}}{127} \times \frac{1}{0.8 \text{ L}}$$

$$\frac{47}{5 \times 127 \times 0.8} \quad \frac{1}{5(0.4)} \quad \frac{1}{2} = 0.5 \text{ M} \text{ & molality}$$

EF & MF

(17) C_xH_y ? + O_2 → 2.6 kg CO_2 + 0.27 kg H_2O

$\frac{300}{5}$ $2600\,g \times \frac{1\,mol}{45\,g} = 60\,mol\ CO_2$ $= \frac{60}{30}\,mol\ C$ EF = C_2H

$270\,g\ H_2O \times \frac{1\,mol}{18\,g} \times 1\,mol\ H_2O \times 2 = \frac{30}{30}\,mol\ H$ 2:1 x 30

$\frac{30}{6}$ C_2H : 5 $C_{10}H_5$ = MF

$\frac{2500}{50} = 50\ C$, $30\ H$ $\frac{30}{30} \sim \frac{6}{3} = 2$

C H
60 : 30
2 : 1

6 mol X → 60 CO_2 + 15 H_2O
60 C + 30 H

C_2H 30
30 30

(18) a) ? CO_2 & H_2O 1.2 kg glucose 200g O_2

$$\underset{1200g}{C_6H_{12}O_6} + \underset{200g}{6O_2} \rightarrow 6CO_2 + 6H_2O$$

(~7) (~7)

$1200\,g\ G \times \frac{1\,mol}{180\,g}$ $\quad \frac{1200}{180} \sim \frac{21}{3} = 7\ mol$

$200\,g \times \frac{1\,mol}{32\,g}$ $\quad \frac{200}{32} = 6$ $\quad \frac{200}{30} \sim 6.7$ (6.25)

$7\ mol\ O_2 \rightarrow 7\ mol\ CO_2 \times \frac{44g}{1mol} \sim 7 \times 40 = 280g\ CO_2$

$\rightarrow 7\ mol\ H_2O \times \frac{18g}{1mol} < 140\ g\ H_2O$

% yield lost 80 g H_2O evolve

$\% \frac{part}{whole} \times 100\%$ $\quad \frac{80\,g}{140} \sim \frac{4}{7}$

$\frac{2}{3}\frac{80}{120} > 67\%$

18 b $PbBr_{2(s)}$ = ? 280 g $PbCl_2$ + 120 g KBr (limit)

use 1/2 1 1 1/2

$PbCl_2 + 2KBr \rightarrow PbBr_{2(s)} + 2KCl$

280 g 120 g

$280\ g\ PbCl_2 \times \frac{1\ mol}{280\ g} = 1\ mol\ PbCl_2$

$120\ g\ KBr \times \frac{1\ mol}{120\ g} = 1\ mol\ KBr$

Pb = 207.2
Cl = 35.45
K = 39.1
Br = 79.9

$PbCl_2 = 207.2 + (2 \times 35.45)$ ~~35~~ 70

KBr = ~~39.1~~ 40 + ~~79.9~~ 80

$0.5\ mol\ PbBr_2 \times \frac{370 \rightarrow 150 \rightarrow 35}{1\ mol} = 185\ g\ PbBr_2$

Pb = 210 (2.80)
160

185 g ppt

$\% = \frac{part}{whole} \times 100\%$ $\frac{50}{185} \sim \frac{50}{200}$ $\frac{1}{4} \sim 25\%$

calc = 27%