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CH EN 3553
HW 0

1. a) $MW_{Sb} = 121.760 \frac{g}{mol}$ $MW_I = 126.90447 \frac{g}{mol}$

$(1.20 \text{ mol Sb}) / 2 \frac{\text{mol Sb}}{\text{rxn}} = 0.6 \text{ rxns}$

$(2.40 \text{ mol } I_2) / 3 \frac{\text{mol } I_2}{\text{rxn}} = 0.8 \text{ rxns} \Rightarrow$ $\boxed{\text{Sb is the limiting reagent}}$

theoretical yield = mass of products assuming all the limiting reagent react

mass of products $= (0.6 \text{ rxn})(2 \frac{\text{mol}}{\text{rxn}})(121.760 \frac{g}{mol} + 3(126.90447 \frac{g}{mol}))$

$= \boxed{\text{theoretical yield} = 602.97g \ SbI_3 = 1.20 \text{ mol } SbI_3}$

b) $(1.20g \text{ Sb})\left(\frac{1 \text{ mol Sb}}{121.760g \text{ Sb}}\right)\left(\frac{1 \text{ rxn}}{2 \text{ mol Sb}}\right) = 0.00493 \text{ rxn}$

$(2.40g \ I_2)\left(\frac{1 \text{ mol } I_2}{2 \cdot 126.90447g \ I_2}\right)\left(\frac{1 \text{ rxn}}{3 \text{ mol } I_2}\right) = 0.00315 \text{ rxn} \Rightarrow$

$\boxed{I_2 \text{ is the limiting reagent}}$

$(2.40g \ I_2)\left(\frac{1 \text{ mol } I}{126.90447g \ I}\right)\left(\frac{1 \text{ mol } I_2}{2 \text{ mol } I}\right)\left(\frac{2 \text{ mol } SbI_3}{3 \text{ mol } I_2}\right)(121.760 \ g/mol + 3 \cdot 126.90447 \ g/mol) = \boxed{\text{theoretical yield} = 3.168 g \ SbI_3 = 0.0063 \text{ mol}}$

$(2.40g \ I_2)\left(\frac{1 \text{ mol } I_2}{2 \cdot 126.90447g \ I_2}\right)\left(\frac{2 \text{ mol Sb}}{3 \text{ mol } I_2}\right)\left(\frac{121.760g \text{ Sb}}{1 \text{ mol Sb}}\right) = 0.768g$ Sb were used

$\Rightarrow 1.20g \text{ Sb} - 0.768g \text{ Sb} =$ $\boxed{0.432 \ g \text{ Sb remaining} = 0.00355 \text{ mol}}$

2. $3NaOH_{(aq)} + Fe(NO_3)_{3(aq)} \rightarrow Fe(OH)_{3(s)} + 3NaNO_{3(aq)}$

$(50 \text{ mL } NaOH_{(aq)})\left(\frac{1L}{1000mL}\right)\left(\frac{0.200 \text{ mol } NaOH_{(aq)}}{1L \ NaOH_{(aq)}}\right) = 0.01 \text{ mol } NaOH_{(aq)}$

$(30 \text{ mL } Fe(NO_3)_{3(aq)})\left(\frac{1L}{1000mL}\right)\left(\frac{0.125 \text{ mol } Fe(NO_3)_{3(aq)}}{1L \ Fe(NO_3)_{3(aq)}}\right) = 0.00375 \text{ mol } Fe(NO_3)_3$

$(0.01 \text{ mol NaOH})\left(\frac{1 \text{ rxn}}{3 \text{ mol NaOH}}\right) = 0.003\bar{3} \text{ rxn}$

$(0.00375 \text{ mol } Fe(NO_3)_3)\left(\frac{1 \text{ rxn}}{1 \text{ mol } Fe(NO_3)_3}\right) = 0.00375 \text{ rxn} \Rightarrow$

NaOH is the limiting reagent;

assuming actual yield = theoretical yield $\Rightarrow$

$(0.01 \text{ mol NaOH})\left(\frac{1 \text{ mol } Fe(OH)_3}{3 \text{ mol NaOH}}\right) = 0.003\bar{3} \text{ mol } Fe(OH)_3$

MW of $Fe(OH)_3 = 55.845 \frac{g}{mol} + 3(15.999 \frac{g}{mol} + 1.008 \frac{g}{mol}) = 106.866 \frac{g}{mol}$

$$(0.00\overline{3}3 \text{ mol } Fe(OH)_3)\left(\frac{106.866 \text{ g } Fe(OH)_3}{1 \text{ mol } Fe(OH)_3}\right) = \boxed{0.356 \text{g } Fe(OH)_{3(s)}}$$

3. $P_i = 0.950$ atm $T_i = 25°C$
$P_f = ?$ $T_f = 125°C$

assuming ideal gas behavior :

$$PV = nRT \Rightarrow n = \frac{PV}{RT} = \frac{(0.950 \text{ atm})(101325 \text{ Pa/atm})V}{(8.314 \frac{J}{mol \cdot K})(298.15K)}$$

$n = 38.8V$mol total ; $n_{H_2} = \left(\frac{2}{3}\right)(38.8V\text{mol}) = 25.9V\text{mol } H_2$

$$(25.9V\text{mol } H_2)\left(\frac{2 \text{ mol } H_2O}{2 \text{ mo } H_2}\right) = 25.9V\text{mol } H_2O = \text{theoretical yield}$$

$$(0.88)(25.9V\text{mol } H_2O) = 22.8V\text{mol } H_2O = \text{actual yield}$$

$$(25.9V\text{mol } H_2 \text{ initial})(0.12) = 3.108V\text{mol } H_2 \text{ final}$$

$$(22.8V\text{mol } H_2O)\left(\frac{1 \text{ mol } O_2}{2 \text{ mol } H_2O}\right) = 11.4V\text{mol } O_2 \text{ were used}$$

$$(38.8V\text{mol})\left(\frac{1}{3}\right) = 12.9V\text{mol } O_2 \text{ initial} \Rightarrow$$

$$(12.9V \text{ mol } O_2 \text{ initial}) - (11.4V\text{mol } O_2 \text{ used}) = 1.5V\text{mol } O_2 \text{ final}$$

$$1.5V\text{mol } O_2 + 3.108V\text{mol } H_2 + 22.8V\text{mol } H_2O = 27.408V \text{ total final moles}$$

$$P = \frac{nRT}{V} = \frac{(27.408V \text{ mol})(8.314 \frac{J}{mol \cdot K})(398.15 K)}{V}\left(\frac{1 \text{ atm}}{101325 \text{ Pa}}\right) \Rightarrow$$

$$\boxed{P_{Final} = 0.895 \text{ atm}}$$

4. $\Delta H_{rxn} = \sum_{products} \nu H^\circ_{f,i} - \sum_{reactants} \nu H^\circ_{f,i}$

$-73.7\ kJ = 2 \cdot H^\circ_{f,HNO_3} - [H^\circ_{f,N_2O_5} + H^\circ_{f,H_2O(l)}]$

$H^\circ_{f,HNO_3} = -174.1\ kJ$; $H^\circ_{f,H_2O(l)} = \frac{1}{2}(-571.6\ kJ) = -285.8\ kJ$ 11.3

$-73.7kJ = 2(-174.1kJ) - (H^\circ_{f,N_2O_5} + -285.8kJ) \Rightarrow \boxed{H^\circ_{f,N_2O_5} = 11.3\ kJ}$

5. $K_p = (P_{NO_2})^2 / (P_{N_2O_4}) = 11\ atm$ at 373 K

Equation	$N_2O_{4(g)}$ ⇌	$2\ NO_{2(g)}$
Initial	1 atm	0 atm
Change	$-x$	$+2x$
Equilibrium	$1-x$	$2x$

$P_{NO_2} = 2x$

$P_{N_2O_4} = 1-x$

$K_p = (2x)^2 / 1-x$

$K_p = \frac{4x^2}{1-x}$

$(1-x)K_p = 4x^2 \Rightarrow K_p - K_p x = 4x^2 \Rightarrow$

$4x^2 + 11x - 11 = 0 \Rightarrow x = 0.779, -3.529$

$1 - 0.779 = 0.221$ $\quad 2(0.779) = 1.56 \Rightarrow$

$\boxed{P_{N_2O_4} = 0.221 \quad P_{NO_2} = 1.56}$

6. done using Python. see below for work + results.

CH EN 35553 HW0 Problem 6

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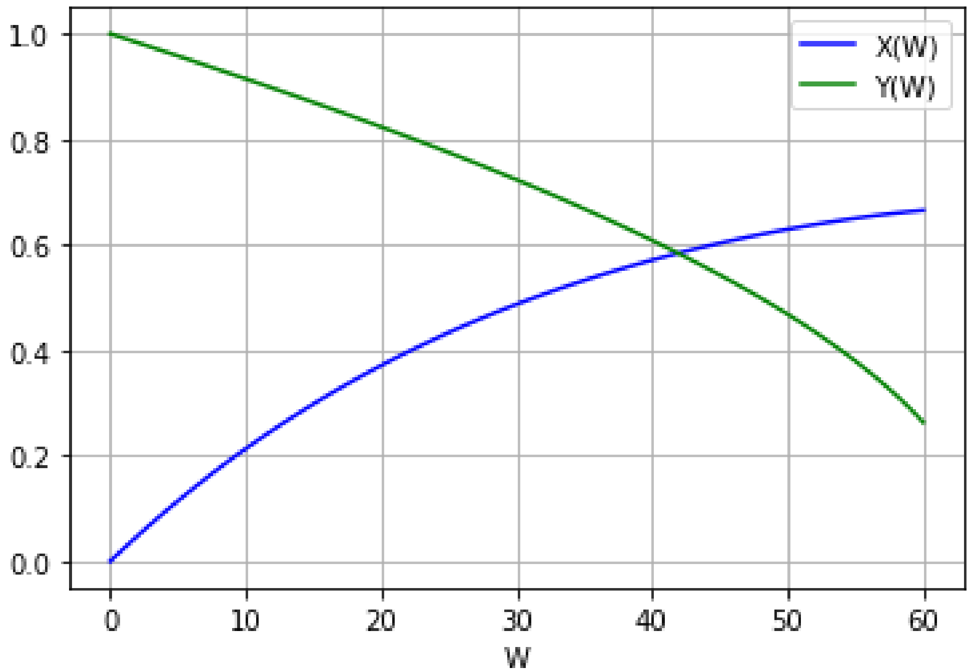
[2]:

```
import numpy as np
from matplotlib import pyplot as plt

 =.0166
 =-0.15
k=0.0266
F=1.08

def func(v,w):
    x,y=v
    dvdw=[(k/F)*((1-x)/(1+ *x)*y),- *(1+ *x)/(2*y)]
    return dvdw

v0=[0,1]

w=np.linspace(0,60,121)

from scipy.integrate import odeint
sol=odeint(func,v0,w)

plt.plot(w, sol[:, 0], 'b', label='X(W)')
plt.plot(w, sol[:, 1], 'g', label='Y(W)')
plt.legend(loc='best')
plt.xlabel('W')
plt.grid()
plt.show()
```



1.0
0.8
0.6
0.4
0.2
0.0
0
10
20
30
40
50
60
W
X(W)
Y(W)