

CARNEGIE MELLON UNIVERSITY
Introduction to Modern Chemistry (09-105)

MASTERY EXAM V
November 22, 2010

First and Last Name KEY
Circle Section (See below) A B C D E F G H I J

Do not remove this page.

Show all work.
Use significant figures correctly.
Don't be careless!
Double-check your results!

1 L = 1000 mL
1 kg = 1000 g

Relative atomic weights (g/mol)

H	1.0079 g/mol
B	10.811
C	12.011
O	15.999
F	18.998
S	32.065
Cu	63.546

1. _____/25
2. _____/25
3. _____/25
4. _____/25
_____/100

Sections:

Jose Flores-Canales	Anisha Gupta	Jared McWilliams	James Woods	Chris Legaspi
A 6:30 WeH 6423	C 6:30 DH 1211	E 6:30 DH 1217	G 6:30 DH 2122	I 6:30 WeH 8427
B 7:30 "	D 7:30 "	F 7:30 "	H 7:30 "	J 7:30 "

1. Four sucrose solutions are mixed. One is 100.0 mL of 0.250 M $C_{12}H_{22}O_{11}$, the second is 85.0 mL of 0.800 M $C_{12}H_{22}O_{11}$, the third is 50.0 mL of 0.500 M $C_{12}H_{22}O_{11}$, and the other is 50.0 mL of 1.250 M $C_{12}H_{22}O_{11}$. What is the molarity M of $C_{12}H_{22}O_{11}$ of the final solution (assuming volume is additive)?

$$\begin{aligned}
 \text{Sucrose} &= (0.100\text{L})(0.250\text{ mol/L}) \\
 &+ (0.085\text{L})(0.800\text{ mol/L}) \\
 &+ (0.050\text{L})(0.500\text{ mol/L}) \\
 &+ (0.050\text{L})(1.250\text{ mol/L}) \\
 &= 0.0250 + 0.0680 + 0.025 + 0.0625\text{ mols} \\
 &= 0.1805\text{ moles sucrose} \quad (5) \\
 \text{Volume} &= 0.100 + 0.085 + 0.050 + 0.050 = 0.285\text{L} \quad (5)
 \end{aligned}$$

$$\begin{aligned}
 \text{molarity} &= \frac{0.1805\text{ mols}}{0.285\text{L}} \\
 &= \underline{0.633\text{ M}} \quad (5)
 \end{aligned}$$

All the water from the above final solution is allowed to completely evaporate away leaving behind a dry residue of sucrose crystals. What is the total mass of carbon in this residue?

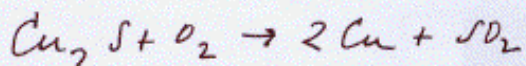
$$\begin{aligned}
 &0.1805\text{ moles sucrose} \\
 \rightarrow &(0.1805\text{ moles sucrose}) \left(12 \frac{\text{mols C}}{\text{mole sucrose}} \right) = 2.166\text{ mols C} \quad (5) \\
 \rightarrow &(2.166\text{ mols}) \left(12.011 \frac{\text{g}}{\text{mol}} \right) = \underline{26.0\text{ g C}} \quad (5)
 \end{aligned}$$

2. An ore containing CuS and Cu_2S is roasted in air, releasing all the sulfur as sulfur dioxide gas (SO_2), leaving behind metallic copper (Cu). 9.87 g of the ore treated in this way yielded 7.01 g of pure Cu . What was the percent of the original ore that was in the form Cu_2S ?

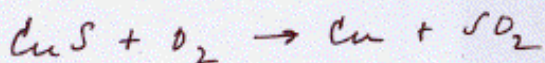
Cannot use $\text{CuS} + \text{Cu}_2\text{S} + 2\text{O}_2 \rightarrow 3\text{Cu} + 2\text{SO}_2$
 (-20 pts)

$$x = \text{mass of } \text{Cu}_2\text{S}$$

$$\begin{aligned} \text{Cu}_2\text{S} \text{ mol. wt.} &= 159.2 \\ \text{CuS} \text{ mol. wt.} &= 95.62 \\ \text{Cu} \text{ at. wt.} &= 63.546 \end{aligned}$$



$$\begin{aligned} \frac{x}{159.2} \text{ mols } \text{Cu}_2\text{S} &\rightarrow \frac{2\left(\frac{x}{159.2}\right)}{159.2} \text{ mols } \text{Cu} \\ &= \frac{2\left(\frac{x}{159.2}\right)(63.55)}{159.2} \text{ g } \text{Cu} \\ &= 0.7985x \text{ gms } \text{Cu} \quad (10) \end{aligned}$$



$$\begin{aligned} \frac{9.87-x}{95.62} \text{ mols } \text{CuS} &\rightarrow \frac{9.87-x}{95.62} \text{ mols } \text{Cu} \\ &= \left(\frac{9.87-x}{95.62}\right)(63.55) \text{ gms } \text{Cu} \end{aligned}$$

$$= 6.56 - 0.6646x \text{ gms } \text{Cu} \quad (5)$$

$$\text{Total Cu} = 7.01 = 6.56 - 0.6646x + 0.7985x \quad (5)$$

$$0.45 = 0.1339x$$

$$x = 3.36 \text{ gms } \text{Cu}_2\text{S} \quad (3)$$

$$\% = \frac{3.36}{9.87} \times 100 = \underline{34\%} \quad (2)$$

3. A 2010 report from the United States Food and Drug (FDA) raised concerns regarding exposure of fetuses, infants and young children to the compound *bisphenol-A* (BPA). In September 2010, Canada became the first country to declare BPA as a toxic substance. Chemical analysis shows BPA to be 78.920% carbon, 7.064% hydrogen, and 14.016% oxygen by mass. What is the empirical formula for BPA consistent with the precision of the reported composition?

Assume you have 100.000 g BPA

$$78.920 \text{ g C} \rightarrow \frac{78.920 \text{ g}}{12.011 \text{ g/mol}} = 6.5706 \text{ mol C}$$

$$7.064 \text{ g H} \rightarrow \frac{7.064 \text{ g}}{1.0079 \text{ g/mol}} = 7.0086 \text{ mol H}$$

$$14.016 \text{ g O} \rightarrow \frac{14.016 \text{ g}}{15.999 \text{ g/mol}} = 0.8761 \text{ mol O}$$

(9)
3 each

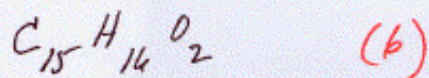
$$\text{C:H:O} = 6.5706 : 7.0086 : 0.8761$$

Divide by 0.8761

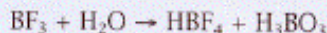
$$\text{C:H:O} = 7.4998 : 7.9998 : 1 \quad (5)$$

Double

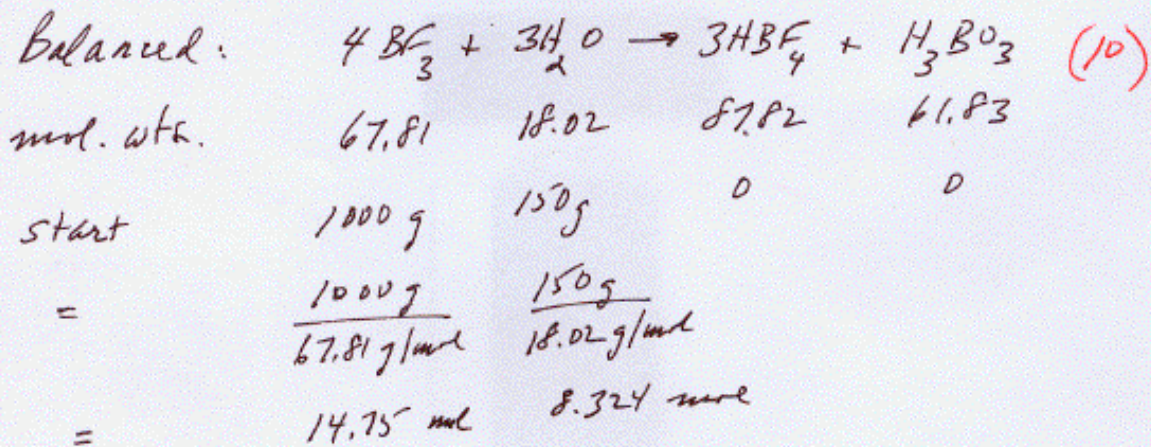
$$\text{C:H:O} = 14.9996 : 15.9995 : 2 \quad (5)$$



4. Boron trifluoride (BF_3) is used around nuclear research facilities as a neutron detector. It must be handled with care because it is toxic and also because it reacts with water according to the following unbalanced reaction, to produce boric acid (H_3BO_3) and fluoroboric acid (HBF_4).



A vessel contains 1.000 kg of BF_3 and an accident occurs in which 0.150 kg of water are added. What masses (in kg) of what resulting chemicals exist in the vessel after the reaction has gone as far as it can go according to the above information?



3 H_2O consume 4 BF_3
 8.324 mole H_2O consume $\frac{4}{3}(8.324)$ mole $\text{BF}_3 = 11.10$ mole BF_3

leaving $14.75 - 11.10 = 3.65$ mole BF_3 unreacted

producing 8.324 mole HBF_4
 and $\frac{1}{3}(8.324)$ mole $\text{H}_3\text{BO}_3 = 2.775$ mole H_3BO_3

Remain: 3.65 mole $\text{BF}_3 \rightarrow (3.65 \text{ mole})(67.81 \frac{\text{g}}{\text{mol}}) = 248 \text{ g} = 0.248 \text{ kg}$ (4) (1)

8.324 mole $\text{HBF}_4 \rightarrow (8.324 \text{ mole})(87.82 \frac{\text{g}}{\text{mol}}) = 731 \text{ g} = 0.731 \text{ kg}$ (4) (1)

2.775 mole $\text{H}_3\text{BO}_3 \rightarrow (2.775 \text{ mole})(61.83 \frac{\text{g}}{\text{mol}}) = 172 \text{ g} = 0.172 \text{ kg}$ (4) (1)

1.151 kg

check sum

starting sum = $1.000 + 0.150 = 1.150 \text{ kg}$ ✓