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 B 7:30 "	C 6:30 DH 1211 D 7:30 "	E 6:30 DH 1217 F 7:30 "	G 6:30 DH 2122 H 7:30 "	I 6:30 WeH 8427 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)?

sucrose = (0.100 L)(0.250 mol/L)
+ (0.085 L)(0.800 mol/L)
+ (0.050 L)(0.500 mol/L)
+ (0.050 L)(1.250 mol/L)

= 0.0250 + 0.0680 + 0.025 + 0.0625 mols
= 0.1805 moles sucrose (5)

volume = 0.100 + 0.085 + 0.050 + 0.050 = 0.285 L (5)

molarity = $\frac{0.1805 \text{ mols}}{0.285 \text{ L}}$
= 0.633 M (5)

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?

0.1805 moles sucrose

→ (0.1805 moles sucrose)(12 $\frac{\text{moles C}}{\text{mole sucrose}}$) = 2.166 moles C (5)

→ (2.166 mols)(12.011 $\frac{g}{mol}$) = 26.0 g C (5)

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 $CuS + Cu_2S + 2O_2 \rightarrow 3Cu + 2SO_2$

(−20 pts)

x = mass of Cu_2S

Cu_2S mol. wt. = 159.2
CuS mol. wt. = 95.62
Cu at. wt. = 63.546

$Cu_2S + O_2 \rightarrow 2Cu + SO_2$

$\frac{x}{159.2}$ mols $Cu_2S \rightarrow 2\left(\frac{x}{159.2}\right)$ mols Cu

$= 2\left(\frac{x}{159.2}\right)(63.55)$ g Cu

$= 0.7985x$ gms Cu (10)

$CuS + O_2 \rightarrow Cu + SO_2$

$\frac{9.87-x}{95.62}$ mols CuS $\rightarrow \frac{9.87-x}{95.62}$ mols Cu

$= \left(\frac{9.87-x}{95.62}\right)(63.55)$ gms Cu

$= 6.56 - 0.6646x$ gms Cu (5)

Total Cu = 7.01 = 6.56 − 0.6646x + 0.7985x (5)

$0.45 = 0.1339x$

$x = 3.36$ gms Cu_2S (3)

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

$C:H:O = 6.5706 : 7.0086 : 0.8761$

Divide by 0.8761

$C:H:O = 7.4998 : 7.9998 : 1$ (5)

Double

$C:H:O = 14.9996 : 15.9995 : 2$ (5)

$C_{15}H_{16}O_2$ (6)

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).

$$BF_3 + H_2O \rightarrow HBF_4 + H_3BO_3$$

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?

Balanced: $4 BF_3 + 3H_2O \rightarrow 3HBF_4 + H_3BO_3$ (10)

mol. wts. 67.81 18.02 87.82 61.83

start 1000 g 150 g 0 0

$= \frac{1000 g}{67.81 g/mol}$ $\frac{150 g}{18.02 g/mol}$

$=$ 14.75 mol 8.324 mol

3 H_2O consume 4 BF_3

8.324 mols H_2O consume $\frac{4}{3}(8.324)$ mols BF_3 = 11.10 mol BF_3

leaving 14.75 − 11.10 = 3.65 mols BF_3 unreacted

producing 8.324 mols HBF_4

and $\frac{1}{3}(8.324)$ mols H_3BO_3 = 2.775 mols H_3BO_3

Remain: 3.65 mols BF_3 → (3.65 mol)(67.81 g/mol) = 248 g (4) = 0.248 kg (1)

8.324 mols HBF_4 → (8.324 mol)(87.82 g/mol) = 731 g (4) = 0.731 kg (1)

2.775 mols H_3BO_3 → (2.775 mol)(61.83 g/mol) = 172 g (4) = 0.172 kg (1)

1.151 kg

check sum

starting sum = 1.000 + 0.150 = 1.150 kg ✓