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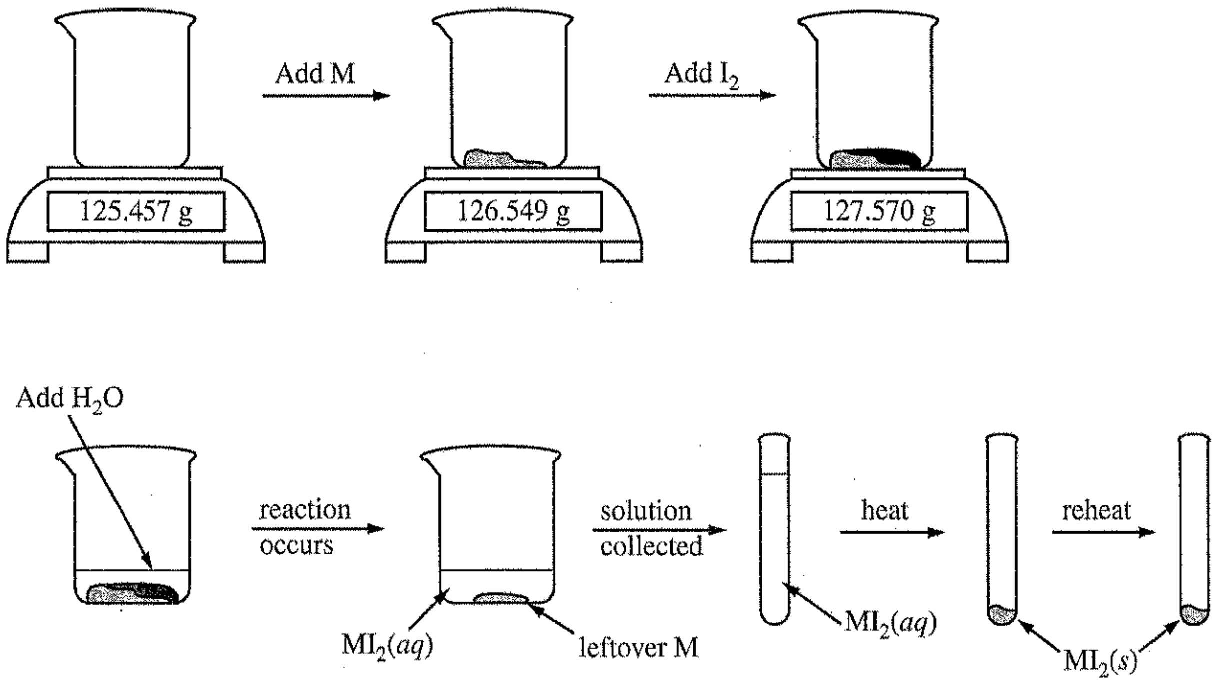
AP Free Response Practice #1 (2016, modified) [10 points]

$$M + I_2 \rightarrow MI_2$$

1. To determine the molar mass of an unknown metal, M, a student reacts iodine with an excess of the metal to form the water-soluble compound MI_2, as represented by the equation above. The reaction proceeds until all of the I_2 is consumed. The $MI_2(aq)$ solution is quantitatively collected and heated to remove the water, and the product is dried and weighed to constant mass. The experimental steps are represented below, followed by a data table.



Data for Unknown Metal Lab	
Mass of beaker	125.457 g
Mass of beaker + metal M	126.549 g
Mass of beaker + metal M + I_2	127.570 g
Mass of MI_2, first weighing	1.284 g
Mass of MI_2, second weighing	1.284 g

a) Given that the metal M is in excess, calculate the number of moles of I_2 that reacted. [*2 points*]

b) Determine the following for the unknown metal M.

   i. Calculate the molar mass of the unknown metal M. [*2 points*]

   ii. What is the most likely identity of the unknown metal M? [*1 point*]

   iii. Calculate the number of moles of unknown metal M that reacted. [*2 points*]

c) Provide a calculation to confirm the empirical formula of the compound MI_2 based on the data shown. [*2 points*]

d) If the student failed to heat to constant mass, would the calculated molar mass of the unknown metal M be greater than, less than, or equal to the actual molar mass? Explain. [*1 point*]

(a) $127.570 - 126.549 = 1.021\text{ g } I_2 \times \frac{1\text{ mol } I_2}{253.82\text{ g } I_2} = \boxed{4.023 \times 10^{-3}\text{ mol } I_2}$

(b.) (i) Since $M + I_2 \rightarrow MI_2$, 1 mole M : 1 mol I_2

$\Rightarrow$ mol MI_2 = mol I_2 = 4.023 E−3 mol

molar mass (MM) of $MI_2 = \frac{1.284\text{ g } MI_2}{4.023\text{E}{-3}\text{ mol}} = 319.2\text{ g/mol}$

MM (M) = MM(MI_2) − MM(I_2)
= 319.2 − 253.82 = $\boxed{65.4\text{ g/mol}}$

(ii) Zn

(iii) 1.284 g ZnI_2 − 1.021 g I_2 = 0.263 g Zn

$0.263\text{ g Zn} \times \frac{1\text{ mol Zn}}{65.39\text{ g Zn}} = \boxed{4.02 \times 10^{-3}\text{ mol Zn}}$

(c.) $4.023\text{E}{-3}\text{ mol } I_2 \times \frac{2\text{ mol I}}{1\text{ mol } I_2} = 8.046\text{E}{-3}\text{ mol I}$

Zn : 4.02 E−3 mol ÷ 4.02E−3 = 1
I : 8.046 E−3 mol ÷ 4.02E−3 = 2
} ZnI_2

(d.) Failure to heat to constant mass would cause the calculated molar mass of M to be greater than the actual, b/c the mass of MI_2 used to calculate molar mass in part (b)(i) would be too large (if all H_2O wasn't removed) but the moles of M divided by would be the same (since this value was calculated from the mass of I_2). Thus, subtracting MM(I_2) from this larger molar mass of MI_2 gives a molar mass of M which is too large.