Lecture 2 CH131 Summer 1

Thursday, May 21, 2020

- Example problems: Chemical formulas, equations, and reaction yields
- Limiting reagent recipe

Next lecture: Limiting reagent recipe; Begin ch3

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[TP] Which contains the most molecules? → moles

0%	1.	1 g of H_2
32%	2.	45 g of Cl_2
21%	3.	28 g of N_2
47%	4.	24 g of CH_4

H 1
Cl 35
N 14
C 12

$1\,g * \frac{mol}{(2*1)\,g} = 0.5\ mol$

$45\,g * \frac{mol}{(2*35)\,g} = 0.64$

$28\,g * \frac{mol}{(2*14)\,g} = 1.0\ mol$

$24\,g * \frac{mol}{(12+4*1)\,g} = 1.5\ mol$

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0

3

Mass to molecules

Which contains the most molecules?

4

4

Mass to molecules

Which contains the most molecules?

$1\,g * \frac{1}{2\,g/mol}$

1 g of H_2: $1\,\cancel{g} \times \frac{mol}{2\,\cancel{g}} = 0.5$ mol

45 g of Cl_2: $45\text{ g} \times \frac{\text{mol}}{(2\times 35)\text{ g}} = 0.64$ mol *

28 g of N_2: $28\text{ g} \times \frac{\text{mol}}{(2\times 14)\text{ g}} = 1.0$ mol

24 g of CH_4: $24\text{ g} \times \frac{\text{mol}}{(12+4\times 1)\text{ g}} = 1.5$ mol

$\frac{6\times 10^{23}\ molecules}{mol}$

5

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[Quiz] Which of the following contains the largest number of atoms?

11% 1. 187 g of liquid mercury, Hg
5% 2. 1400 u of uranium, U
79% 3. 6×10^{24} atoms of sodium, Na
5% 4. 2 mol of hydrogen gas, H_2

Hg 200.59
U 238.03
Na 22.990
H 1.008
$N_A = 6 \times 10^{23}$ /mol

$187\,g * \frac{mol}{200.59\,g} \approx 1\,mol \approx N_A$

$1400\,u * \frac{atom}{238.03} \approx 7$ atoms

6×10^{24} atoms $* \frac{1\,mol}{6 \times 10^{23}} \approx 10$ mol

$2\,mol * \frac{2\,mol\,H}{1\,mol\,H_2} = 4$ mols

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0

6

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Problem: 7e 2.1; 8e 1.25

$N_A = 6.022\,141\,29 \times 10^{23}$

1. Compute the mass (in grams) of a single iodine atom if the relative atomic mass of iodine is 126.90447 on the accepted scale of atomic masses (based on 12 as the relative atomic mass of ^{12}C).

1 atom of I weighs $126.90447\,u * \frac{g/N_A}{u}$

$= \frac{126.90447\,g}{6.02214129 \times 10^{23}}$

$= 2.1072981 \times 10^{-22}\,g$

① u
② $1\,u = \frac{g}{N_A}$
③ sig. figs.

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Problem: 7e 2.3; 8e 1.27

3. Compute the relative molecular masses of the following compounds on the ^{12}C scale:
(a) P_4O_{10} (b) BrCl
(c) $Ca(NO_3)_2$ (d) $KMnO_4$
(e) $(NH_4)_2SO_4$

$(NH_4)_2SO_4$

S = 32.065
4 O = 4 * 15.9994 = 63.9976
2 N = 2 * 14.0067 = 28.0134
8 H = 8 * 1.0079

32.065
63.9976
28.0134
8.0632
132.138

8

8

Problem: 7e 2.7; 8e 1.31

7. The vitamin A molecule has the formula $C_{20}H_{30}O$, and a molecule of vitamin A_2 has the formula $C_{20}H_{28}O$. Determine how many moles of vitamin A_2 contain the same number of atoms as 1.000 mol vitamin A.

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Problem: 7e 2.11; 8e 1.35

11. Aluminum oxide (Al_2O_3) occurs in nature as a mineral called corundum, which is noted for its hardness and resistance to attack by acids. Its density is 3.97 g cm^{-3}. Calculate the number of atoms of aluminum in 15.0 cm^3 corundum.

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Problem: 7e 2.33; 8e 2.21

33. For each of the following chemical reactions, calculate the mass of the underlined reactant that is required to produce 1.000 g of the underlined product.

(a) $Mg + \underline{2\,HCl} \longrightarrow \underline{H_2} + MgCl_2$

(b) $\underline{2\,CuSO_4} + 4\,KI \longrightarrow 2\,CuI + \underline{I_2} + 2\,K_2SO_4$

(c) $\underline{NaBH_4} + 2\,H_2O \longrightarrow NaBO_2 + 4\,\underline{H_2}$

$1.000\,g \times \frac{mol\ H_2}{2 \times 1.0079\,g} \times \frac{mol\ NaBH_4}{4\ mol\ H_2} \times \frac{(22.9898 + 10.811 + 4 \times 1.0079)\,g}{mol\ NaBH_4}$

22.9898
10.811
4.0316
37.831

$= \frac{1.000 \times 37.831}{4 \times 2 \times 1.0079}\,g = 4.691\,g$

1.008

4×1.007

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Problem: 7e 2.35, 8e 2.23

35. An 18.6-g sample of K_2CO_3 was treated in such a way that all of its carbon was captured in the compound $K_2Zn_3[Fe(CN)_6]_2$. Compute the mass (in grams) of this product.

$18.6\,g\ K_2CO_3 \longrightarrow K_2Zn_3[Fe(CN)_6]_2$? g

1 mol K_2CO_3
1 mol C

1 mol $K_2Zn_3[Fe(CN)_6]_2$
12 mol C

$2 \times 6 = 12$

$12\,K_2CO_3 + \text{stuff} \longrightarrow 1\,K_2Zn_3[Fe(CN)_6]_2$

$18.6\,g \times \frac{1\ mol\ K_2CO_3}{(2K + C + 3O)\,g} \times \frac{1\ mol\ K_2Zn_3[Fe(CN)_6]_2}{12\ mol\ K_2CO_3} \times \frac{(2K + 3Zn + 2Fe + 12C + 12N)\,g}{mol\ K_2Zn_3[Fe(CN)_6]_2}$

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Problem: 7e 2.39, 8e 2.27

39. Cryolite (Na_3AlF_6) is used in the production of aluminum from its ores. It is made by the reaction

$$6\,NaOH + Al_2O_3 + 12\,HF \longrightarrow 2\,Na_3AlF_6 + 9\,H_2O$$

Calculate the mass of cryolite that can be prepared by the complete reaction of 287 g Al_2O_3.

$g\ HF \times \frac{mol\ HF}{(H+F)\,g} \times \frac{2\ mol\ Na_3AlF_6}{12\ mol\ HF}$

g Al_2O_3 → mol mass → mol Al_2O_3 → chemical equation → mol Na_3AlF_6 → mol mass → g Na_3AlF_6

$287\,g\ Al_2O_3 \rightarrow mol\ Al_2O_3 \times \frac{12\ mol\ HF}{1\ mol\ Al_2O_3} \times \frac{(H+F)\,g}{mol\ HF}$

$287\,g \times \frac{mol\ Al_2O_3}{(2 \times Al + 3O)\,g} \times \frac{2\ mol\ Na_3AlF_6}{1\ mol\ Al_2O_3} \times \frac{(3 \times Na + Al + 6F)\,g}{mol\ Na_3AlF_6}$

$(2 \times 26.982 + 3 \times 15.999)\,g$

$= \frac{287}{(2Al + 3O)} \times \frac{2}{1} \times (3Na + Al + 6F)\,g = g$

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Problem: 7e 2.47, 8e 2.35

$\_NH_3 + \_HCl \rightarrow NH_4Cl$

47. When ammonia is mixed with hydrogen chloride (HCl), the white solid ammonium chloride (NH_4Cl) is produced. Suppose 10.0 g ammonia is mixed with the same mass of hydrogen chloride. What substances will be present after the reaction has gone to completion, and what will their masses be?

	NH_3	HCl	NH_4Cl
I mass	10.0 g	10.0 g	0
I mol	0.587	0.274	0
C mol	−0.274	−0.274	+0.274
F mol	0.313	0	0.274
F mass	5.33 g	0	14.7 g

14.7 g + 5.33 g = 20.0 g

$10.0\,g \times \frac{mol\ NH_3}{(N + 3H)\,g} = 0.587\ mol$

$0.313\ mol\ NH_3 \times \frac{(N+3H)\,g}{mol\ NH_3} = 5.33\,g$

$10.0\,g \times \frac{mol\ HCl}{(H+Cl)\,g} = 0.274\ mol$

$0.274\ mol\ HCl \times \frac{1\ mol\ NH_3}{1\ mol\ HCl}$

$0.274\ mol\ HCl \times \frac{1\ mol\ NH_4Cl}{mol\ HCl} = 0.274\ mol\ NH_4Cl$

$0.274\ mol\ NH_4Cl \times \frac{(N+4H+Cl)\,g}{mol\ NH_4Cl} = 14.7\,g$

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Problem: 7e 2.49, 8e 2.37

49. The iron oxide Fe_2O_3 reacts with carbon monoxide (CO) to give iron and carbon dioxide:

$$Fe_2O_3 + 3\ CO \rightarrow 2\ Fe + 3\ CO_2$$

The reaction of 433.2 g Fe_2O_3 with excess CO yields 254.3 g iron. Calculate the theoretical yield of iron (assuming complete reaction) and its percentage yield.

	Fe_2O_3	CO	Fe
I g	433.2 g	excess	0
I mol	2.713	excess	0
C mol	−2.713		+5.426
F mol	0		5.426
F g			

$2.713\ mol\ Fe_2O_3 \times \frac{2\ mol\ Fe}{1\ mol\ Fe_2O_3}$

theoretical yield = result if all of the 433.2 g of Fe_2O_3 reacts * > 254.3 g

$\%\ yield = 100\% \frac{actual}{maximum} = 100\% \frac{254.3\,g}{\boxed{}} =$

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