Chem 1a PSet 1 Responses

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Question 1.

(a)

A single basketball game burns the following amount of calories:

$$1\text{ game}(\frac{112\text{ length}}{1\text{ game}})(\frac{94\text{ feet}}{1\text{ length}})(\frac{1\text{ km}}{3281\text{ feet}})(\frac{62\text{ cal}}{1\text{ km}}) = 198.942\text{ cal} \quad (2\text{SF}).$$

Swimming burns calories at the following rate:

$$\frac{17\text{ cal}}{1\text{ lap}} \; (2\text{SF}).$$

Laps needed to burn the same number of calories as he would from a game of basketball:

$$198.942\text{ cal}(\frac{1\text{ lap}}{17\text{ cal}}) = 11.702\text{ lap} = 12\text{ lap(s)}.$$

(b)

The number of atoms that can be fit in between the lines is:

$$(\frac{0.7\text{ mm}}{170\text{ pm/1 atom}}) = (\frac{0.7\text{ mm}}{170\text{ pm/1 atom}})(\frac{10^{12}\text{ pm}}{1\text{ m}})(\frac{1\text{m}}{10^3\text{ mm}}) = 4.118 \cdot 10^6\text{ atom} = 4 \cdot 10^6\text{ atom(s)}.$$

(c)

The rotation video's length is:

$$20\text{ min}(\frac{60\text{ s}}{1\text{ min}}) + 39\text{ s} = 1239\text{ s } (4\text{SF}).$$

She could watch the following number of TikTok videos:

$$\frac{1239\text{ s}}{32.4 \cdot 10^9\text{ ns}} = (\frac{1239\text{ s}}{32.4 \cdot 10^9\text{ ns/1 video}})(\frac{10^9\text{ ns}}{1\text{ s}}) = 38.24\text{ video} = 38.24\text{ video} = 38.2\text{ video(s)}.$$

Question 2.

(a)

The total charge fired is:

$$173\text{ mA}\cdot 6.000\text{ h} = 173\text{ mA}(\frac{1\text{ A}}{10^3\text{ mA}})\cdot 6.000\text{ h}(\frac{3600\text{ s}}{1\text{ h}})(\frac{1\text{ C}}{1\text{ As}}) = 3736.8\text{ C} = 3.74\cdot 10^3\text{ C}.$$

(b)

The total mass of collected electronics, in grams, is:

$$(\frac{3736.8\text{ C}}{1.758820\cdot 10^{11}\text{ C kg}^{-1}})(\frac{1000\text{ g}}{1\text{ kg}}) = 2.1246\cdot 10^{-5}\text{ g} = 2.12\cdot 10^{-5}\text{ g}.$$

(c)

i.

We assume a square lattice configuration for the gold atoms. The number of gold atoms that can fit on one side of the gold film is:

$$\frac{10.0\text{ cm}}{2\cdot 0.146\text{ nm}} = (\frac{10.0\text{ cm}}{2\cdot 0.146\text{ nm}})(\frac{1\text{ m}}{100\text{ cm}})(\frac{10^9\text{ nm}}{1\text{ m}}) = 3.42466\cdot 10^8\text{ (3SF)}.$$

The total number of gold atoms is:

$$(3.42466\cdot 10^8)^2 = 1.1728\cdot 10^{17} = 1.17\cdot 10^{17}.$$

ii.

The total number of moles is:

$$1.1728\cdot 10^{17}\cdot\frac{1\text{ mol}}{6.022\cdot 10^{23}} = 1.9475\cdot 10^{-7}\text{ mol} = 1.95\cdot 10^{-7}\text{ mol}.$$

(d)

i.

The total area of the gold film is:

$$(10.0\text{ cm}\frac{1\text{ m}}{100\text{ cm}})^2 = 1.00\cdot 10^{-2}\text{ m}^2.$$

ii.

The total area of all the nuclei is:

$$1.1728\cdot 10^{17}(\pi(7.0\cdot 10^{-15}\text{ m})^2) = 1.8053853\cdot 10^{-11}\text{ m}^2 = 1.81\cdot 10^{-11}\text{ m}^2.$$

(e)

The probability is

$$\frac{1.8053853\cdot 10^{-11}\text{ m}^2}{1.00\cdot 10^{-2}\text{ m}^2} = 1.81\cdot 10^{-9}.$$

This means that the size of the nucleus is minuscule when compared to the size of the atom.

Question 3.

The number of protons is 53, the number of neutrons is 78, the number of electrons is 53.

Question 4.

(a)

$$2\mathrm{Fe} + 3\mathrm{O}_2 \rightarrow 2\mathrm{Fe}_2\mathrm{O}_3$$

(b)

$$3\mathrm{C}_2\mathrm{H}_2\mathrm{O}_4 + \mathrm{Fe}_2\mathrm{O}_3 \rightarrow \mathrm{Fe}_2(\mathrm{C}_2\mathrm{O}_4)_3 + 3\mathrm{H}_2\mathrm{O}$$

(c)

$$6\mathrm{CH}_3\mathrm{COOH} + \mathrm{Fe}_2\mathrm{O}_3 \rightarrow 2\mathrm{Fe}(\mathrm{CH}_3\mathrm{COO})_3 + 3\mathrm{H}_2\mathrm{O}$$

(d)

$$\mathrm{C}_6\mathrm{H}_8\mathrm{O}_7 + \mathrm{Fe}_2\mathrm{O}_3 \rightarrow 2\mathrm{FeO} + 6\mathrm{CO} + 2\mathrm{H}_2 + 2\mathrm{H}_2\mathrm{O}$$

(e)

The mass of acetic acid in a bottle of vinegar is:

$$16.0 \text{ fl.oz.}(\frac{29.5735 \text{ cm}^3}{1 \text{ fl.oz.}})(\frac{1.006 \text{ g}}{1 \text{ cm}^3}) \cdot 5.00\% = 23.800 \text{ g (3SF)}.$$

The mass of rust (molar mass 159.7) that the acetic acid (molar mass 60.052) can remove is:

$$23.8 \text{ g}(\frac{1 \text{ mol}}{60.052 \text{ g}})(\frac{1 \text{ mol}}{6 \text{ mol}})(\frac{159.7 \text{ g}}{1 \text{ mol}}) = 10.549 \text{ g (3SF)}$$

The mass of citric acid in a bottle of lemon juice:

$$4.00 \text{ fl.oz.}(\frac{29.5735 \text{ cm}^3}{1 \text{ fl.oz.}})(\frac{1.01 \text{ g}}{1 \text{ cm}^3}) \cdot 7.00\% = 8.363 \text{ g (3SF)}.$$

The mass of rust that the citric acid (molar mass 192.124) can remove is:

$$8.363 \text{ g}(\frac{1 \text{ mol}}{192.124 \text{ g}})(\frac{1 \text{ mol}}{1 \text{ mol}})(\frac{159.7 \text{ g}}{1 \text{ mol}}) = 6.952 \text{ g (3SF)}$$

Therefore, the bottle of vinegar can remove more rust. The difference is

$$10.549 \text{ g} - 6.952 \text{ g} = 3.597 \text{ g} = 3.60 \text{ g}$$

Question 5.

(a)

Let

$$\mathrm{a_1K_2Cr_2O_7 + a_2H_2SO_4 \to b_1K_2SO_4 + b_2Cr_2(SO_4)_3 + b_3H_2O + b_4O_2}.$$

The equations are

$$\begin{cases} 2a_1 & = 2b_1 \ \text{(K)} \\ 2a_1 & = 2b_2 \ \text{(Cr)} \\ 7a_1 + 4a_2 & = 4b_1 + 12b_2 + b_3 + 2b_4 \ \text{(O)} \\ 2a_2 & = 2b_2 \ \text{(H)}. \end{cases}$$

The relatively prime, integer solution is:

$$\mathrm{2K_2Cr_2O_7 + 8H_2SO_4 \to 2K_2SO_4 + 2Cr_2(SO_4)_3 + 8H_2O + 3O_2}.$$

(b)

Let

$$\mathrm{a_1K_2Cr_2O_7 + a_2H_2SO_4 + a_3K_3(Fe(SCN)_6) \to}$$

$$\mathrm{b_1Fe_2(SO_4)_3 + b_2Cr_2(SO_4)_3 + b_3CO_2 + b_4H_2O + b_5K_2SO_4 + b_6KNO_3}.$$

The equations are

$$\begin{cases} 2a_1 + 3a_3 & = 2b_5 + b_6 \ \text{(K)} \\ 2a_1 & = 2b_2 \ \text{(Cr)} \\ 7a_1 + 4a_2 & = 12b_1 + 12b_2 + 2b_3 + b_4 + 4b_5 + 3b_6 \ \text{(O)} \\ 2a_2 & = 2b_4 \ \text{(H)} \\ a_2 + 6a_3 & = 3b_1 + 3b_2 + b_5 + b_6 \ \text{(S)} \\ a_3 & = 2b_1 \ \text{(Fe)} \\ 6a_3 & = b_6 \ \text{(N)}. \end{cases}$$

The relatively prime, integer solution is:

$$\mathrm{32K_2Cr_2O_7 + 116H_2SO_4 + 2K_3(Fe(SCN)_6) \to}$$

$$\mathrm{Fe_2(SO_4)_3 + 32Cr_2(SO_4)_3 + 12CO_2 + 116H_2O + 29K_2SO_4 + 12KNO_3}.$$

Question 6.

(a)

Mass spectrometry measures individual atoms and molecules to determine their atomic and molecular weights.

(b)

We would be able to determine sources of atmospheric and water pollution.