

# Chem 1a PSet 1 Responses

Gavin Hua

September 2023

## Question 1.

(a)

A single basketball game burns the following amount of calories:

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

Swimming burns calories at the following rate:

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

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

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

(b)

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

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

(c)

The rotation video's length is:

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

She could watch the following number of TikTok videos:

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

## Question 2.

(a)

The total charge fired is:

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

(b)

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

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

(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:

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

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:

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

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

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

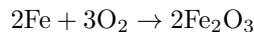
This means that the size of the nucleus is minuscule when compared to the size of the atom.

### **Question 3.**

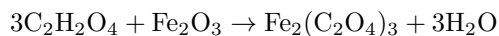
The number of protons is 53, the number of neutrons is 78, the number of electrons is 53.

## Question 4.

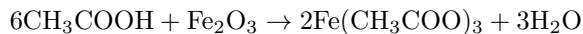
(a)



(b)



(c)



(d)



(e)

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

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

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

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

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

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

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

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

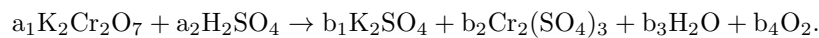
Therefore, the bottle of vinegar can remove more rust. The difference is

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

## Question 5.

(a)

Let



The equations are

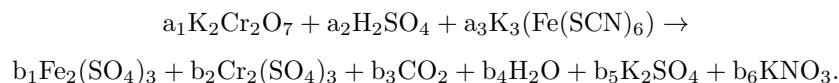
$$\begin{cases} 2a_1 &= 2b_1 \text{ (K)} \\ 2a_1 &= 2b_2 \text{ (Cr)} \\ 7a_1 + 4a_2 &= 4b_1 + 12b_2 + b_3 + 2b_4 \text{ (O)} \\ 2a_2 &= 2b_2 \text{ (H)}. \end{cases}$$

The relatively prime, integer solution is:



(b)

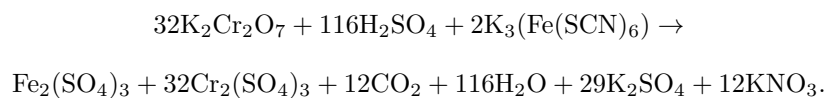
Let



The equations are

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

The relatively prime, integer solution is:



## 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.