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Chemistry 14A - Fall 2019: Test 1

Student Name: Christina Kilkeary Student ID Number: 605416454

TA Name: Jose Moreno Discussion Section: 1H

Write in Pen. Check your significant figures and units. Good Luck.

All work must be shown to get credit. Box your final answer.

Total points: 50 Total time: 50 minutes

Planck's constant, $h = 6.62608 \times 10^{-34}$ J.s

Avogadro's constant, $N_A = 6.02214 \times 10^{23}$ mol$^{-1}$

Rydberg constant, $R = 3.28984 \times 10^{15}$ Hz

Boltzmann's constant, $k = 1.38 \times 10^{-23}$ J·K$^{-1}$

Faraday's constant, F = 96,485 C·mol$^{-1}$

Gas constant, R = 8.314 J·K$^{-1}$·mol$^{-1}$ = $8.206 \times 10^{-2}$ L·atm·K$^{-1}$·mol$^{-1}$

= $8.314 \times 10^{-2}$ L·bar·K$^{-1}$·mol$^{-1}$ = 62.364 L·Torr·K$^{-1}$·mol$^{-1}$

Mass of electron, $m_e = 9.1095 \times 10^{-31}$ kg Charge of an electron = $1.602 \times 10^{-19}$ coulombs

Mass of proton, $m_p = 1.6726 \times 10^{-27}$ kg Mass of neutron, $m_n = 1.6749 \times 10^{-27}$ kg

1 eV = $1.602 \times 10^{-19}$ J Speed of light, $c = 2.99792 \times 10^{8}$ m.s$^{-1}$

$C_2$ = Second radiation constant = 0.0144 K·m 1 J = 1 kg.m$^2$.s$^{-2}$

0°C = 273.15 K 1L = 1 dm$^3$ 1 atm = 101.325 kPa $\pi = 3.14$

Water Density = 1g.ml$^{-1}$ $\ln(X) = 2.303 \log_{10}(X)$ 1 kcal = 4.18 kJ 1 W = 1 J.s$^{-1}$

1mW = $1 \times 10^{-3}$ W 1 kg = 1000 g PV = nRT pH = -log[H$^+$]

1 nm = $10^{-9}$ m 1 Å = $10^{-10}$ m 1 pm = $10^{-12}$ m

$c = \lambda \nu$ $E = h\nu$ $E = pc$ $p = mv$ $E_n = -\frac{hR}{n^2}$

$\lambda = \frac{h}{p}$ $E_k = \frac{1}{2}mv^2$ $T\,\lambda_{MAX} = \frac{1}{5}C_2$ $\Delta p \Delta x \geq \frac{h}{4\pi}$ $E_n = \frac{h^2n^2}{8\,m\,L^2}$

$E_{TOTAL}\,\psi(x) = E_K\,\psi(x) + V(x)\,\psi(x) = -\frac{h^2}{8\pi^2 m}\frac{d^2\psi(x)}{dx^2} + V(x)\,\psi(x)$

1. Silicon nitride $Si_3N_4$, a material used for spinal fusion devices, is made by reacting Si and Nitrogen gas ($N_2$) at high temperatures. How much Si (in g) is needed to react with an excess of $N_2$ to prepare 50 g of $Si_3N_4$ if the percent yield for the reaction is 86%. (8 points)

limiting = Si

$$3Si + 2N_2 \rightarrow 1Si_3N_4$$

$\frac{50g}{0.86} = 58.14g$

$Si_3N_4$ molar mass

Si = 28.0855
N = 14.0067

$Si_3N_4 = 140.2833\ g\,mol^{-1}$

$\frac{50\ g\ Si_3N_4}{140.2833} = .356\ mol\ Si_3N_4$

molar ratio:
3 Si : 1 $Si_3N_4$

Si needed: 1.068 mol Si

$1.068\ mol \cdot \frac{28.0855\ g}{1\ mol} = 30.00\ g\ Si$

for 100% yield

$\frac{x}{30\ g} = .86$ ← actual yield

$x = 25.8\ g$

**25.8 g Si**

2. Balance these equations (4 points)

Sodium peroxide reacts with moisture to form sodium hydroxide and oxygen. Sodium peroxide can be used to bleach wood pulp for the production of paper and textiles.

$2\ Na_2O_2 + 2\ H_2O \rightarrow 4\ NaOH + O_2$

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**$Na_2O_2 + H_2O \rightarrow 2NaOH + O_2$**

Calcium reacts with aluminum chloride

$Ca + AlCl_3 \rightarrow CaCl_2 + Al$

3 2 3 2

**$3\ Ca + 2\ AlCl_3 \rightarrow 3CaCl_2 + 2Al$**

3. N-Acetylneuraminic acid, $C_{11}H_{19}NO_9$, is a common sialic acid found in mammalian cells which plays a role in preventing infections from viruses. Determine the mass percentage composition of N-Acetylneuraminic acid. (8 points)

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C: $\frac{132.1177\ g\ C}{309.27\ g\ C_{11}H_{19}NO_9} \times 100\% = \boxed{42.7\%\ C}$

H: $\frac{19.15086\ g\ H}{309.27\ g\ C_{11}H_{19}NO_9} \times 100\% = \boxed{6.2\%\ H}$

N: $\frac{14.0067\ g\ N}{309.27\ g\ C_{11}H_{19}NO_9} \times 100\% = \boxed{4.5\%\ N}$

O: $\frac{143.9946\ g\ O}{309.27\ g\ C_{11}H_{19}NO_9} \times 100\% = \boxed{46.5\%\ O}$

total mass

132.1177
19.15086
14.0067
+ 143.9946
309.26916 g·mol⁻¹
$C_{11}H_{19}NO_9$

4. Combustion analysis shows the chemical composition of a compound is 38.67% C, 16.22% H, and 45.11% N. Mass spectrometry gives a molar mass of 124.232 $gmol^{-1}$ for the same unknown sample found at a crime scene. Help determine the a) empirical formula and b) molecular formula of the compound (12 points).

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$0.3867 \cdot 124.232 = 48.0405\ g\ C$ $\quad \frac{48.0405}{12.0107} \approx 4$

$0.1622 \cdot 124.232 = 20.1504\ g\ H$ $\quad \frac{20.1504}{1.00794} \approx 20$

$0.4511 \cdot 124.232 = 56.0410\ g\ N$ $\quad \frac{56.0410}{14.0067} \approx 4$

a) empirical formula: $CH_5N$ ✓

b) molecular formula: $C_4H_{20}N_4$ ✓



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5. Aspirin is a common over the counter drug used for a variety of ailments including pain and headaches. Aspirin is more soluble in ethanol compared to water. Aspirin has a molar mass of 180.158 g/mol. (6 points)

a.) Calculate the molarity if 12.0 grams of aspirin are added to 255 mL of ethanol.

M

$M = n/V$

$12.0 / 180.158 = .0666$ mol

$M = .0666 \text{ mol} / .255 \text{ L}$

$M = 0.261 \text{ mol} \cdot \text{L}^{-1}$

b.) What volume (mL) of concentrated aspirin solution from part A would need to be diluted in order to obtain 255 mL of solution at $8.71 \times 10^{-3}$ M.

$M_1 V_1 = M_2 V_2$

$M_2 = 8.71 \times 10^{-3} \text{ mol} \cdot \text{L}^{-1}$

$V_2 = .255 \text{ mL}$

$V_1 = x \qquad M_1 = .261 \text{ mol} \cdot \text{L}^{-1}$

$V_1 = 8.51 \times 10^{-3} \text{ L}$

$V_1 =$ 8.51 mL of concentrated aspirin solution

6. Cellular Respiration is an important process for breaking down sugars so that cells can use energy. If 5.00 g of glucose ($C_6H_{12}O_6$) is present with 5.00 g of oxygen, what is the limiting reagent? How much of the excess reagent is left over? (glucose is 180.156 g/mol) (10 points)

$$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + \text{ENERGY}$$

$\frac{5.00 \text{ g}}{180.156 \text{ g mol}^{-1}} = 0.02775 \text{ mol } C_6H_{12}O_6$

$\frac{5.00 \text{ g}}{15.9946 \text{ g mol}^{-1}} = .3126 \text{ mol } O_2$

$O_2 = 32 \text{ g/mol}$

molar ratio:

.02775 : .3126

1 : 6

.02775 : .05210

$C_6H_{12}O_6$ is the limiting reactant

.02775 mol $C_6H_{12}O_6$ given

We would need only 0.1665 mol $O_2$

but given .3126 mol $O_2$

0.1461 mol $O_2$ left over

What is Å = x 10^0

(7) Answer the Following Fundamental Chemistry Questions. (2 points)

a) All of the organic compounds contain C and H as their essential elements, the bond length of C-H is 110 pm. Express the C-H bond length in Angstrom.

↳ x $10^{-19}$ ?

Å = x $10^{-21}$ ?

1.1 Ångstrom?

b) All the things that are visible to us absorb in the visible region of light. Convert the visible light of wavelength 700 nm to Angstroms.

↳ x $10^{-23}$ ?

7.00 x $10^{2}$ Ångstrom ?



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