388 takers

Chem 1101A 1/8

Chem 1101A Final EXAMINATION
Chemistry for Engineers
December 20, 2011

KEY — Perfect 107% / 100

DURATION: 3 HOURS **No. of Students: 418**

Department Name & Course Number: Chem 1101A
Course Instructor(s) Dr. Bawagan
Notes written on a ONE-SIDE of an 8.5"x11" sheet is allowed. Use INK pen. Use non-programmable calculators. Write name and student # on page 1.

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Part I. General Knowledge
1. Provide the chemical name or the corresponding chemical formula of the following atoms and molecules (12pts)

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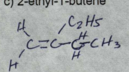
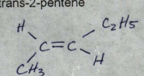
$CaCO_3$

2 b) Tritium
T OR ^3_1H

2 c) 2-ethyl-1-butene


2 d) trans-2-pentene


2 e) $HBrO_3$
Bromic Acid

2 f) $FeCl_2$
Iron (II) chloride
OR Ferrous chloride

Chem 1101A 2/8

2. SI Units: Fill in the blanks (20 pts)

3 Since 1960 the world scientific community has adopted the metric system also called the SI unit system. "SI" is the abbreviation for the *French* words, systeme and Internationale.

3 3 There are **seven base units**: meter, kilogram, second, ampere, kelvin, candela and mole. Of these 7 base units, only the kilogram is based on a physical artefact (ie. a piece of Pt-Ir metal stored in a vault in Sevres, France).

3 Scientists have taken two strategies to address this problem. The **Avogadro Project** sought to create a very pure ^{28}Si ball whereas the **Watt Balance** sought to "weigh" the Pt-Ir artefact by electronic means. The results from both methods *disagreed* beyond their respective error limits for reasons unknown until recently.

Last Nov 4, 2011 Dr Dave Inglis (NRC-Canada) reported very recent experiments, yet unpublished), that established **quantitative agreement** between these two experiments. Technically, the Avogadro Project provides a value for Avogadro's constant (N_A) whereas
3 the Watt Balance provides a value for Planck's constant (h).

The two values are related according to the relation,

$N_A * h = 3.990 \times 10^{-10}$ J s/mol

In light of the fundamental significance of this number, it has been suggested that we define (consistent with the "electron" and the "photon"):

1 ottawon = 3.990×10^{-10} J s/mol

that is, IF and only IF the Canadian experimental values hold up to further international scrutiny.

Q: How many ottawons are there in 2.00 J s/mol ?

$\_\_ \text{ ottawons} = 2.00 \frac{J \cdot s}{mol} \left(\frac{\text{ottawon}}{3.990 \times 10^{-10} \frac{J \cdot s}{mol}} \right)$

5 $= 5.01 \times 10^9$ ottawons

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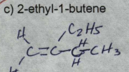
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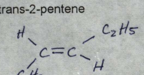
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Part II. Problems. Support your answers with calculations/arguments. Encircle final answers and check for significant figures. Show ALL steps.

1. Analysis of a metal chloride XCl_3 shows that it contains 67.2 percent Cl by mass. Calculate the **molar mass of X** and identify the element. (10pts)

Assume 100g of XCl_3, then there are 67.2g Cl.

$\text{mol Cl} = 67.2\,g\left(\frac{mol}{35.453\,g}\right) = 1.89547\text{ mol}$

$\text{mol X} = \frac{1.89547\,mol}{3} = 0.631822\text{ mol}$

8/ $\text{Molar Mass (X)} = \frac{32.8\,g}{0.631822\,mol} = \boxed{51.9\ g/mol}$

2/ $\therefore X \equiv Cr$ (chromium)

2. How many moles of $MgCl_2$ are present in 60.0 mL of **0.105 M $MgCl_2$ solution** ? (10pts)

5/ $\text{mols } MgCl_2 = 0.0600\,L\left(0.105\,\frac{mol}{L}\right)$

5/ $= \boxed{6.30 \times 10^{-3}\text{ mol}}$

3. Consider the following reaction at 1600K

$Br_2\,(g) \rightleftharpoons 2\,Br\,(g)$

When 1.05 moles of Br_2 are put in a 0.980-L flask, 1.21 percent of the Br_2 undergoes dissociation. Calculate the **equilibrium constant K_c for the reaction.** (10pts)

$K_c = \frac{[Br]^2}{[Br_2]}$

5/ @ $t=0$, $[Br_2]_0 = \frac{1.05\,mol}{0.980\,L} = 1.07143\,M$

@ $t = t_{eq}$, $[Br]_{eq} = 2*0.0121\,(1.07143\,M) = (0.012964\,M)*2$

$[Br_2]_{eq} = 1.05846\,M$

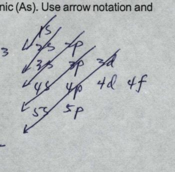
5/ $\therefore K_c = \frac{(2*0.012964\,M)^2}{1.05846\,M} = \boxed{6.36 \times 10^{-4}\,M}$

OR $\boxed{6.36 \times 10^{-4} = K_c}$

4. Write the **ground state electron configuration** for Arsenic (As). Use arrow notation and illustrate <u>all</u> the electrons. (10pts)

$Z = 33$

5/ $[As]\ 1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^3$



In arrow notation,

↑ ↑ ↑ (4p) ↑↓ ↑↓ ↑↓ ↑↓ ↑↓ (3d)
↑↓ (4s)
↑↓ ↑↓ ↑↓ (3p)
↑↓ (3s)
↑↓ ↑↓ ↑↓ (2p)
5/ ↑↓ (2s)
↑↓ (1s)

5. **Strontium-90, a radioactive isotope**, is a major product of an atomic bomb explosion. It has a half-life of 28.1 yr. (a) Calculate the first-order rate constant for the nuclear decay. (b) Calculate the fraction of ^{90}Sr that remains after 10 half-lives. (10pts)

For 1st order rxn, $[A] = [A]_0 e^{-kt}$

$t_{1/2} = \frac{0.693}{k}$

5/ (a) $k = \frac{0.693}{28.1\,yr} = \boxed{2.47 \times 10^{-2}\,yr^{-1}}$

(b) $10(28.1\,yr) = 281\,yr = t$

$\therefore \left(\frac{[A]}{[A]_0}\right) = \exp\left(-2.47 \times 10^{-2}\,yr^{-1} * 281\,yr\right)$

5/ Fraction $= \boxed{9.68 \times 10^{-4}}$ remains.

Hints: $\Delta H_f^\circ(CO_2) = -393.5\,\frac{kJ}{mol}$; $\Delta H_f^\circ(H_2O) = -285.8\,\frac{kJ}{mol}$; $\Delta H_f^\circ(O_2) = 0\,\frac{kJ}{mol}$

6. Ethanol (C_2H_5OH) and gasoline (assumed to be all octane, C_8H_{18}) are both used as automobile fuel. If gasoline is selling for **$4.50/gal**, what would the price of ethanol have to be in order to provide the **same amount of heat per dollar** ? The density and standard heat of formation (ΔH_f°) of octane are 0.7025 g/mL and -249.9 kJ/mol and of ethanol are 0.7894 g/mL and -277.0 kJ/mol, respectively. 1 gal = 3.785 L
Hints: *Calculate heats of reaction for combustion of ethanol and octane.* (10pts).

(a) Ethanol Combustion

$C_2H_5OH_{(l)} + 3O_{2(g)} \rightarrow 2CO_2(g) + 3H_2O(l)$; $\Delta H^\circ_{rxn} = ?$

5/ $\Delta H^\circ_{rxn}(EtOH) = 2(-393.5) + 3(-285.8) - 3(0) - (-277.0)$

$= -1367.4\,\frac{kJ}{mol}$

(b) Octane Combustion

$C_8H_{18}(l) + \frac{25}{2}O_2(g) \rightarrow 8CO_2(g) + 9H_2O(l)$; $\Delta H^\circ_{rxn} = ?$

$\Delta H^\circ_{rxn}(\text{octane}) = 8(-393.5) + 9(-285.8) - \frac{25}{2}(0) - (-249.9)$

$= -5470.3\,\frac{kJ}{mol}$

(c) Calc <u>Heat per Dollar</u> of both fuels: Octane ≡ Ethanol

5/ $-5470.3\,\frac{kJ}{mol}\left(\frac{mol}{114.224\,g}\right)\left(\frac{0.7025\,g}{mL}\right)\left(\frac{10^3\,mL}{L}\right)\left(\frac{3.785\,L}{gal}\right)\left(\frac{gal}{\$4.50}\right) \equiv$

$-1367.4\,\frac{kJ}{mol}\left(\frac{mol}{46.068\,g}\right)\left(\frac{0.7894\,g}{mL}\right)\left(\frac{10^3\,mL}{L}\right)\left(\frac{3.785\,L}{gal}\right)\left(\frac{gal}{?\,\$}\right)$

$\therefore$ $\boxed{\text{Ethanol Price} = \frac{\$3.13}{gal}}$

Chem 1101A M/M 7/8

the Bird!

7. Dimensional Analysis: The *nuclear meltdown* of the **Fukushima Daiichi** nuclear power plant (units 1-3, March 2011) released radioactive Cesium-137 into the surrounding areas. Accurate values of radioactivity released are hard to obtain because the reactor cores are *not* accessible. However, a convergence of expert opinion has been reported by the Japanese Nuclear Agency (NISA) and the French Nuclear Agency (IRSN) for total radioactive ^{137}Cs release of **1.2×10^{16} Bq** and **1.1×10^{16} Bq**, respectively. Calculate the average of these two reported values *(3 sig figs in final result)*. How many **peta-bequerels** are there in the average value? How many **tera-bequerels** are there in the average value? **Ref:** New York Times, Dec 4, 2011; 1 Bq (bequerel) = 1 disintegration/s (15 pts)

$$\text{Avg}[^{137}Cs]\text{ released} = \frac{1.2\times10^{16}\,Bq + 1.1\times10^{16}\,Bq}{2}$$

5

$$\text{Avg} = \boxed{1.15\times10^{16}\,Bq}$$

5 ___ PBq (peta-bequerel) $= 1.15\times10^{16}\,Bq\left(\frac{PBq}{10^{15}\,Bq}\right) = \boxed{11.5\ PBq}$

5 ___ TBq (tera-bequerel) $= 1.15\times10^{16}\,Bq\left(\frac{TBq}{10^{12}\,Bq}\right) = \boxed{1.15\times10^{4}\ TBq}$

Ref: www.irsn.fr (Isnard et al, 2011)
for latest technical lessons from Fukushima accident.

Useful Physical Constants:

Avogadro's constant $6.022 \times 10^{23}\ mol^{-1}$
Speed of Light 3.00×10^{8} m/s
Gas Constant = 0.082 L atm/(mol K)
1 pound = 2.2 kg
Planck's constant 6.62×10^{-34} J s
Rydberg's Constant 2.18×10^{-18} J
1 inch = 2.54 cm

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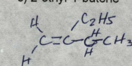

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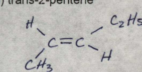

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Adob 10 Jan 2012