

388 taken

Chem 1101A

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

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.

Students MUST count the number of pages in this examination question paper before beginning to write, and report any discrepancy to a proctor. This question paper has 8 pages.

This examination question paper MAY NOT be taken from the examination room.

In addition to this question paper, students require: an examination booklet yes no X
a Scantron sheet yes no X

Chem 1101A Final Exam
Chemistry for Engineers
Name: _____ St.#: _____

20 December 2011
2 - 5 pm

Part I. General Knowledge

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

a) chalk CaCO_3

b) Tritium T OR ^3H

c) 2-ethyl-1-butene

d) trans-2-pentene

e) HBrO_3 Bromic Acid

f) FeCl_2 Iron (II) chloride OR Ferrous chloride

Chem 1101A

2/8

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

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.

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).

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Last Nov 4, 2011 Dr Dave Inglis (NRC-Canada) reported very recent experiments, yet unpublished, that established quantitative agreement between these two experiments.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

The two values are related according to the relation,

$N_A \cdot h = 3.990 \times 10^{10} \text{ J s/mol}$

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 = $3.990 \times 10^{10} \text{ J s/mol}$

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 ?

$$\text{ottawons} = \frac{2.00 \text{ J s/mol}}{3.990 \times 10^{10} \text{ J s/mol}} = 5.01 \times 10^{-9} \text{ ottawons}$$

388 taken

Chem 1101A

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

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.

Students MUST count the number of pages in this examination question paper before beginning to write, and report any discrepancy to a proctor. This question paper has 8 pages.

This examination question paper MAY NOT be taken from the examination room.

In addition to this question paper, students require: an examination booklet yes no X
a Scantron sheet yes no X

Chem 1101A Final Exam
Chemistry for Engineers
Name: _____ St.#: _____

20 December 2011
2 - 5 pm

Part I. General Knowledge

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

a) chalk CaCO_3

b) Tritium T OR ^3H

c) 2-ethyl-1-butene

d) trans-2-pentene

e) HBrO_3 Bromic Acid

f) FeCl_2 Iron (II) chloride OR Ferrous chloride

Chem 1101A

2/8

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

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.

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).

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 the Watt Balance provides a value for Planck's constant (h).

The two values are related according to the relation,

$N_A \cdot h = 3.990 \times 10^{10} \text{ J s/mol}$

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 = $3.990 \times 10^{10} \text{ J s/mol}$

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 ?

$$\text{ottawons} = \frac{2.00 \text{ J s/mol}}{3.990 \times 10^{10} \text{ J s/mol}} = 5.01 \times 10^{-9} \text{ ottawons}$$

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.

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

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

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

$\therefore \text{X} = \text{Cr}$ (Chromium)

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

$$\text{moles MgCl}_2 = 0.0600 \text{ L} \left(0.105 \frac{\text{mol}}{\text{L}} \right)$$

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

3. Consider the following reaction at 1600K



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)

$$K_c = \frac{[\text{Br}]^2}{[\text{Br}_2]}$$

$$\text{at } t=0, [\text{Br}_2]_0 = \frac{1.05 \text{ mol}}{0.980 \text{ L}} = 1.07143 \text{ M}$$

$$\text{at } t=t_{\text{eq}}, [\text{Br}_2]_{\text{eq}} = 20.0121 (1.07143 \text{ M}) = (0.012964 \text{ M}) \times 2$$

$$[\text{Br}_2]_{\text{eq}} = 1.05846 \text{ M}$$

$$\therefore K_c = \frac{(2 \times 0.012964 \text{ M})^2}{1.05846 \text{ M}} = 6.30 \times 10^{-4} \text{ M}$$

$$\text{OR } 6.30 \times 10^{-4} = K_c$$

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

$$Z = 33$$

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

In arrow notation,

$$1s \uparrow \downarrow \quad 2s \uparrow \downarrow \quad 2p \uparrow \downarrow \uparrow \downarrow \quad 3s \uparrow \downarrow \quad 3p \uparrow \downarrow \uparrow \downarrow \quad 4s \uparrow \downarrow \quad 3d \uparrow \downarrow \uparrow \downarrow \uparrow \downarrow \quad 4p \uparrow \downarrow \uparrow$$

$$4s \uparrow \downarrow \quad 3p \uparrow \downarrow \uparrow \downarrow \quad 4p \uparrow \downarrow \uparrow$$

$$4s \uparrow \downarrow \quad 3p \uparrow \downarrow \uparrow \downarrow \quad 4p \uparrow \downarrow \uparrow$$

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, $[\text{A}] = [\text{A}]_0 e^{-kt}$

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

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

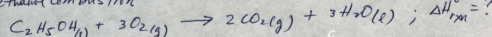
$$(b) 10(28.1 \text{ yr}) = 281 \text{ yr} = t$$

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

$$\text{Fraction} = 9.65 \times 10^{-4} \text{ remains.}$$

Hints: $\Delta H_f^\circ(\text{CO}_2) = -393.5 \frac{\text{kJ}}{\text{mol}}$; $\Delta H_f^\circ(\text{H}_2\text{O}) = -285.8 \frac{\text{kJ}}{\text{mol}}$; $\Delta H_f^\circ(\text{C}_8\text{H}_{18}) = 0 \frac{\text{kJ}}{\text{mol}}$
6. Ethanol ($\text{C}_2\text{H}_5\text{OH}$) 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)

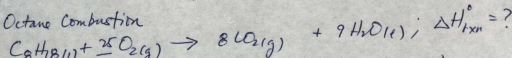
(a) Ethanol Combustion



$$\Delta H_{\text{rxn}}^\circ(\text{EtOH}) = 2(-393.5) + 3(-285.8) - 3(0) - (-277.0)$$

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

(b) Octane Combustion



$$\Delta H_{\text{rxn}}^\circ(\text{Octane}) = 8(-393.5) + 9(-285.8) - \frac{25}{2}(0) - (-249.9)$$

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

(c) Calc heat per dollar of both fuels: Octane = Ethanol

$$-5470.3 \frac{\text{kJ}}{\text{mol}} \left(\frac{\text{mol}}{114.224 \text{ g}} \right) \left(\frac{0.7025 \text{ g}}{\text{mL}} \right) \left(\frac{3.785 \text{ L}}{\text{gal}} \right) \left(\frac{\text{gal}}{\$4.50} \right) =$$

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

$$\therefore \text{Ethanol Price} = \$3.13/\text{gal}$$

Chem 1101A MPM #1/8

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 $1.2 \times 10^{16} \text{ Bq}$ and $1.1 \times 10^{16} \text{ Bq}$, 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 (becquerel) = 1 disintegration/s (15 pts)

$\text{Avg } [^{137}\text{Cs}]_{\text{released}} = \frac{1.2 \times 10^{16} \text{ Bq} + 1.1 \times 10^{16} \text{ Bq}}{2}$
 $\text{Avg} = 1.15 \times 10^{16} \text{ Bq}$
 $\frac{\text{PBq}}{\text{peta-bequerel}} = \frac{1.15 \times 10^{16} \text{ Bq}}{10^{15} \text{ Bq}} = 11.5 \text{ PBq}$
 $\frac{\text{TBq}}{\text{tera-bequerel}} = \frac{1.15 \times 10^{16} \text{ Bq}}{10^{12} \text{ Bq}} = 1.15 \times 10^4 \text{ TBq}$

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

Useful Physical Constants:
 Avogadro's constant $6.022 \times 10^{23} \text{ mol}^{-1}$
 Speed of Light $3.00 \times 10^8 \text{ m/s}$
 Gas Constant = $0.082 \text{ L atm/(mol K)}$
 1 pound = 2.2 kg

Planck's constant $6.62 \times 10^{-34} \text{ J s}$
 Rydberg's Constant $2.18 \times 10^{-18} \text{ J}$
 1 inch = 2.54 cm



Chem 1101A MPM

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

No. of Students: 418

DURATION: 3 HOURS

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.

Students **MUST** count the number of pages in this examination question paper before beginning to write, and report any discrepancy to a proctor. This question paper has 8 pages.

This examination question paper MAY NOT be taken from the examination room.

In addition to this question paper, students require: an examination booklet yes no ☒
 a Scantron sheet yes no ☒

Chem 1101A Final Exam 20 December 2011
 Chemistry for Engineers 2 - 5 pm
 Name: _____ St #: _____

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

a) chalk CaCO_3

b) Tritium T OR ^3_1H

c) 2-ethyl-1-butene $\text{CH}_3\text{CH}(\text{CH}_2\text{CH}_3)\text{CH}=\text{CH}_2$

d) trans-2-pentene $\text{CH}_3\text{CH}=\text{CHCH}_2\text{CH}_3$

e) HBrO_3 Bromic Acid

f) FeCl_2 Iron (II) chloride OR Ferrous chloride