

Chem 1101C

KEY

184 takers

Perfect 105% / 100 1/8 MM

Chem 1101C
EXAMINATION
9 APRIL 2010

DURATION: 3 HOURS

No. of Students: 205

Department Name & Course Number: Chem 1101C

Course Instructor(s)

Dr. Bawagan MM

Students MUST count the number of pages in this examination question paper before

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.

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

Name: Key

St. Number:

Signature:

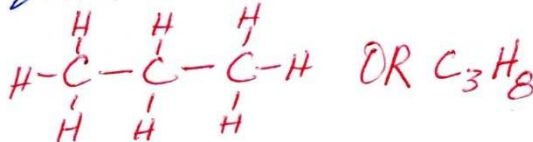
Part I: General Knowledge

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

(a) Deuterium



✓ (b) propane



✓ (c) Eka-Silicon

Ge or Germanium

✓ (d) Official Symbol of element 112

Cn

✓ (e) laughing gas

N_2O or nitrous oxide

✓ (e) HClO_2

Chlorous Acid OR hydrogen chlorite

2. History & Principles of Chemistry

In 1807 H. Davy isolated the element K (potassium) from potash by electrolysis. Efforts to purify metals and isolate chemical elements were part of a trend first started by the alchemists 1000 years before then. However, the discovery of more chemical elements did not lead to better understanding but rather to more confusion. There was a strong desire to establish some "order in the elements". In the year 1869, the Russian chemist Mendeleev formulated the periodic table for the first time wherein he arranged the elements in order of increasing atomic weight.

The spontaneity of a chemical reaction (ie. whether a reaction proceeds as written) is given by ΔG also known as the Gibbs Free Energy. Write down the mathematical expression relating ΔG and enthalpy (ΔH) and entropy (ΔS).

What is entropy? (18pts).

3 (a) $\Delta G = \Delta H - T \Delta S$ ← Entropy

↑ ↑ ↙

Gibb's Free Enthalpy Absolute Temperature

Energy

3 (b) Entropy is a measure of the randomness of the system with symbol ΔS .

$$\Delta S = k \ln W$$

↑ ↙

Boltzmann # of possible states

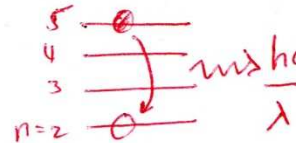
Constant

Part II: Problems. **Support your answers with calculations/arguments.** Encircle final answers and check for significant figures. Useful Hints are provided in last page.

1. Calculate the wavelength (in nanometers) of a photon emitted by a hydrogen atom when its electron drops from the $n = 5$ state to the $n = 3$ state. (10pts)

$$\Delta E = |E_5 - E_3| = R_H \left(\frac{1}{3^2} - \frac{1}{5^2} \right)$$

$$\Delta E = 2.18 \times 10^{-18} \text{ J} \left(\frac{1}{9} - \frac{1}{25} \right) = 0.1550 \times 10^{-18} \text{ J}$$



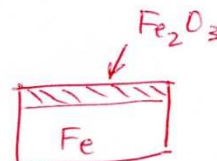
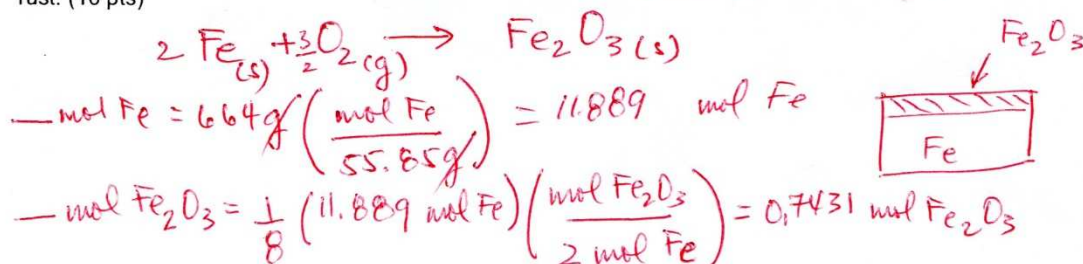
$$\text{also } \Delta E = \frac{hc}{\lambda}$$

$$\therefore \lambda = \frac{hc}{\Delta E} = \frac{(6.62 \times 10^{-34} \text{ J}\cdot\text{s})(3.00 \times 10^8 \text{ m/s})}{0.1550 \times 10^{-18} \text{ J}} = 12.813 \times 10^{-7} \text{ m}$$

$$\lambda = 12.813 \times 10^{-7} \text{ m} \left(\frac{10^9 \text{ nm}}{1 \text{ m}} \right) = 1281.3 \text{ nm} \Rightarrow \boxed{1280 \text{ nm}}$$

3 sig figs

2. An iron bar weighed 664 g. After the bar had been standing in moist air for a month, exactly one-eighth of the iron turned to rust (Fe_2O_3). Calculate the final mass of the iron bar and rust. (10 pts)



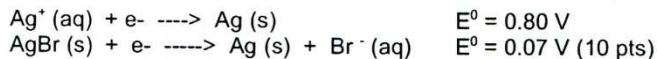
$$\text{— g total} = \text{mass Fe} + \text{mass Fe}_2\text{O}_3$$

$$= 11.889 \text{ mol Fe} \left(\frac{7}{8} \right) \left(\frac{55.85 \text{ g}}{\text{mol}} \right) + 0.7431 \text{ mol Fe}_2\text{O}_3 \left(\frac{159.7 \text{ g}}{\text{mol}} \right)$$

$$= 699.7 \text{ g} \quad \underbrace{581.0}_{118.7} \Rightarrow \boxed{700 \text{ g}}$$

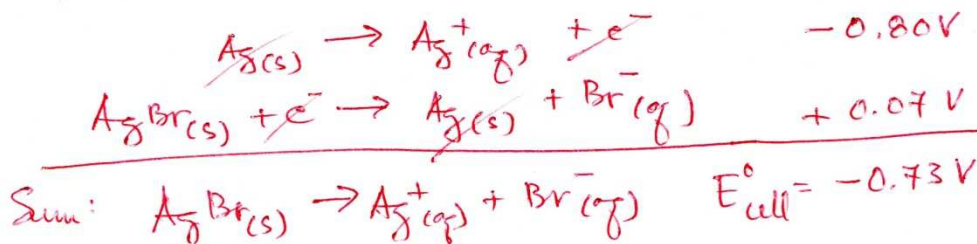
3 sig fig

3. From the following information, calculate the solubility product of AgBr (assume 25degC):



Hints: 1 Faraday(F) = 96500 Coulomb/mol e⁻; 1 Coulomb = 1.0 J/V

5 (a) Solve for K_{sp} given $\text{AgBr}_{(s)} \rightleftharpoons \text{Ag}^+_{(aq)} + \text{Br}^-_{(aq)}$
from standard reduction potentials



5 (b) Since $E^\circ_{\text{cell}} = \frac{RT}{nF} \ln K_{sp}$; $n=1$

$$\ln K_{sp} = \frac{n E^\circ_{\text{cell}}}{F/RT} = \frac{(1)(-0.73 \text{ V})}{96500 \frac{\text{Coul}}{\text{mol}} / (8.314 \frac{\text{J}}{\text{mol} \cdot \text{K}} * 298 \text{ K})}$$

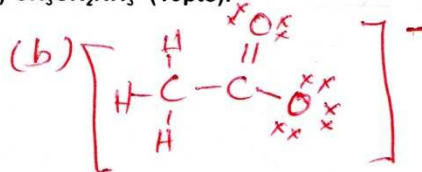
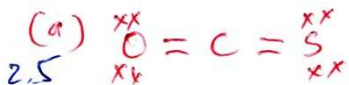
$$K_{sp} = e^{(-0.73 / 0.0257)}$$

$$K_{sp} = 4.6 \times 10^{-13}$$

OR

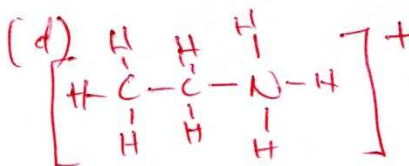
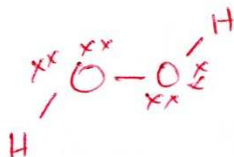
$$K_{sp} \approx 5 \times 10^{-13} \text{ M}^2$$

4. Write Lewis structures for the following molecules and ions:
 (a) OCS, (b) CH₃COO⁻, (c) H₂O₂ and (d) CH₃CH₂NH₃⁺ (10pts):



2.5

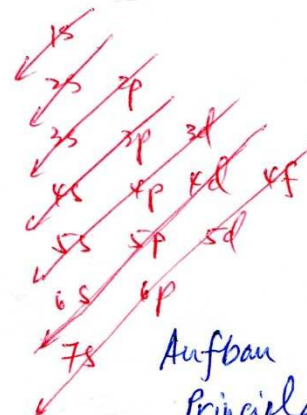
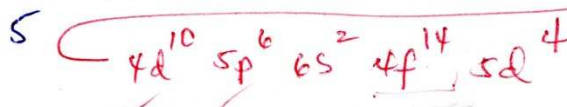
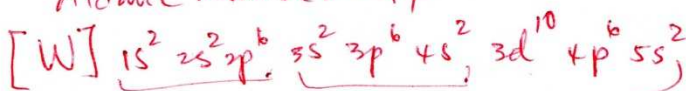
2.5
(c)



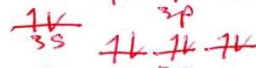
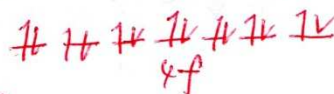
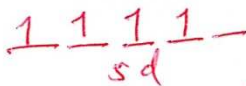
2.5

5. Write the ground state electron configuration of Tungsten (W) Use the arrow notation and illustrate all the electrons. (10pts)

Atomic Number = 74



Aufbau Principle



5

6. Ethanol (C_2H_5OH) and gasoline (assumed to be all octane, C_8H_{18}) are both used as automobile fuel. If ethanol 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 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. Write down the balanced combustion reactions. Calculate ΔH_{rxn} .

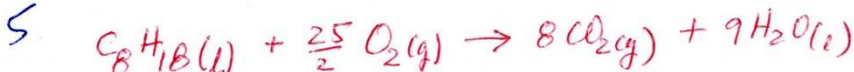
Hints: 1 gal = 3.785 L (10pts)

$$\Delta H_f(CO_2) = -393.5 \frac{kJ}{mol} ; \Delta H_f(H_2O) = -285.8 \frac{kJ}{mol}$$

(a) Balance the Fuel combustion Rxns:



$$\Delta H_{rxn}^{eth} = 2(-393.5) + 3(-285.8) - [-277.0 + 3(0)] = -1367.4 \frac{kJ}{mol}$$



$$\Delta H_{rxn}^{gasol} = 8(-393.5) + 9(-285.8) - [-249.9 + \frac{25}{2}(0)] = -5467.6 \frac{kJ}{mol}$$

(b) Find the Price of Gasoline:

Assume pricing involves same amount of heat per dollar.

For gasoline,

$$\left[\frac{\text{heat}}{\text{gal}} \right] = 5467.6 \frac{kJ}{mol} \left(\frac{mol}{114.2g} \right) \left(\frac{0.7025g}{ml} \right) \left(\frac{10^3 ml}{L} \right) \left(\frac{3.785L}{gal} \right) \left(\frac{gal}{?} \right)$$

For ethanol,

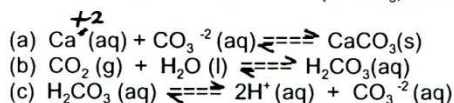
$$\left[\frac{\text{heat}}{\text{gal}} \right] = 1367.4 \frac{kJ}{mol} \left(\frac{mol}{46.07g} \right) \left(\frac{0.7894g}{ml} \right) \left(\frac{10^3 ml}{L} \right) \left(\frac{3.785L}{gal} \right) \left(\frac{gal}{\$4.50} \right)$$

Equate both terms then solve for price of gasoline (?):

$$\text{Price} = \$6.50/\text{gal}$$

Since the typo may have caused some confusion (although corrections were provided during exam), everybody gets full credit for part-b (i.e. pricing of gasoline) for their efforts.

7. **Bird Time (15pts):** On March 21, 2010 the New York Times reported a novel scheme for converting CO₂ from coal power plants to cement using sea water. The method involves formation of calcium carbonate (CaCO₃, the stuff of egg-shells!),



} Not these are all,
Reversible Rxns!

A farmer wondered whether the scheme made sense. The farmer decided to conduct a little experiment. He fed half of his chickens with normal water and the other half with carbonated water (ie. water with CO₂). **Which group of chickens will have thicker egg-shells? WHY?**

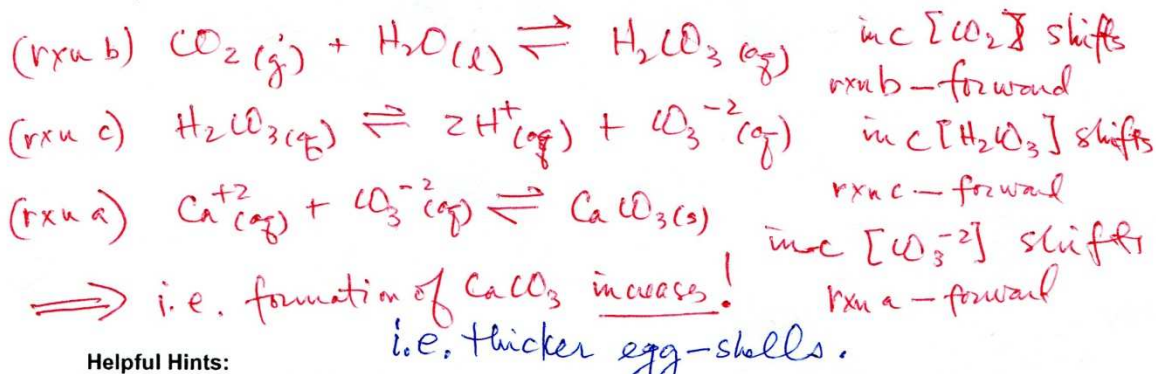
Ref: www.calera.com; www.co2solution.com

Assume unlimited [Ca⁺²].

A: chickens with normal water

B: chickens with carbonated water (water with CO₂)

10 Group B chickens will have thicker egg-shells on the basis of Le Chatelier's Principle which states that
5 "systems @ equilibrium shift to relieve the stress".



Helpful Hints:

Avogadro's number 6.022x10²³

Planck's constant 6.62x10⁻³⁴ J s

Speed of light 3.00x10⁸ m/s

atomic mass unit 1.66x10⁻²⁴ g

1 inch = 2.54 cm

Atomic weights (amu):

H 1.008

He 4.00

C 12.01

N 14.01

O 16.00

Ne 20.18

Na 23.00

Mg 24.30

Al 26.98

Si 28.08

P 30.97

Ar 39.95

Ni 58.69

Cu 63.55

Mn 54.94

Br 79.90

K 39.10

Cl 35.45

Specific Heat (Au) = 0.129 J/g·C

Specific Heat (Fe) = 0.444 J/g·C

Rydberg's Constant = 2.18 x 10⁻¹⁸ J

Gas Constant = 0.082 L atm / (mol K)

1 pound = 2.2 kg 1 tonne = 1000 kg