Chemistry CHM 1311C Test 1

October 22, 2013

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Name:_____

Student Number:_____

Laboratory Day (circle one):

Tuesday 2:30	Tuesday 6:30
Wednesday 10:00	Thursday 2:30
Thursday 6:30	Friday 2:30

*Laboratory TA:*_____

DO NOT TURN THE PAGE OR START THE EXAM UNTIL YOU ARE NOTIFIED.

You will have 80 minutes for the exam.

There are data and a periodic table on the last two pages.
Feel free to remove these and use them.

Question	Mark
1	**/ 5**
2	**/ 5**
3	**/ 5**
4	**/ 5**
5	**/ 5**
Total	/30

Good Luck.

1. You are part of a team of scientists investigating a sports "doping" scandal. A sample suspected of being "The Clear" (slang for tetrahydrogestrinone $C_{21}H_{28}O_2$) is collected during the investigation. A combustion analysis of a 0.1570 g sample of this material yields 0.4586 g of CO_2 and 0.1283 g of H_2O. What is the simplest formula for this sample? Could it be tetrahydrogestrinone?

2. A sample of liquid nitrogen trichloride was heated in a 1.50 L, closed container until it decomposed completely into gaseous elements. The resulting mixture exerted a pressure of 744 torr at 75ºC.

$NCl_3(l) \rightarrow N_2(g) + Cl_2(g)$ (*unbalanced!*) $\Delta H = -232$ kJ

What is the partial pressure of each gas in the container?

What was the mass of the original sample?

3. Iodine can be prepared from the reduction of sodium iodate ($Na^+IO_3^-$) using the following series of reactions that are carried out in acid solution:

$IO_3^- + 3HSO_3^- \rightarrow I^- + 3SO_4^{2-}$ (***unbalanced***)

$5I^- + IO_3^- + 6H^+ \rightarrow 3I_2 + 3H_2O$

How many grams of iodine are produced from 100 grams of $NaHSO_3$ if each reaction has a 78.4% yield?

4. Substitute natural gas (SNG) is a gaseous mixture containing $CH_4(g)$ that can be used as a fuel. One of the reactions for producing SNG is:

$4\ CO(g) + 8H_2(g) \rightarrow 3\ CH_4(g) + CO_2(g) + 2H_2O(l)\quad \Delta H^o$

Determine the value of ΔH^o for this reaction using:

$C(\text{graphite}) + \frac{1}{2}\ O_2(g) \rightarrow CO(g)$	$\Delta H^o = -110.5\text{kJ}$
$H_2(g) + \frac{1}{2}\ O_2(g) \rightarrow H_2O(l)$	$\Delta H^o = -285.8\text{kJ}$
$CO(g) + \frac{1}{2}\ O_2(g) \rightarrow CO_2(g)$	$\Delta H^o = -283.0\text{kJ}$
$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(l)$	$\Delta H^o = -890.3\text{kJ}$
$C(\text{graphite}) + 2H_2(g) \rightarrow CH_4(g)$	$\Delta H^o = -74.81\text{kJ}$

5. For each of the following sets of quantum numbers, give the number of orbitals:

Quantum numbers	Number of Orbitals
$n = 4, l = 2$	
$n = 5, l = 1$	
$n = 6, l = 3$	

Write a full set of quantum numbers for each of the following electrons:

The outermost electron in a Li atom	
The highest energy electron in the ground-state B atom	

Identify each element below:

[Ar] $4s^2 3d^{10} 4p^4$	
[Ar] $4s^2 3d^5$	

Using the rules of electron configurations, indicate the

Number of unpaired electrons on an atom of P	
Number of 3d electrons in an atom of Br	
Number of 4f electrons in an atom of Au	

Thermodynamic data for temperature = 298.15 K

	ΔH^o(kJ/mol)	ΔG^o(kJ/mol K)	S^o(J/mol K)
$PCl_3(g)$	-287	-267.8	311.8
$PCl_5(g)$	-374.9	-305.0	364.6
$POCl_3(g)$			222.4
$SO_2Cl_2(g)$	-364.0	-320.0	311.9
$COCl_2(g)$	-218.8	-204.6	283.5
$Cl_2(g)$	0	0	223.1
$O_2(g)$	0	0	205.11
$SO_2(g)$	-296.8	-300.2	248.2
$CO(g)$	-110.5	-137.2	197.7
$SO_3(g)$	-395.7	-371.1	256.8
I(g)	106.8	70.25	180.8
$I_2(g)$	62.44	19.33	260.7
$I_2(s)$	0	0	116.1
$CH_4(g)$	-75.0		186.3
$CH_3OH(l)$	-237		126.8
$O_2(g)$	0	0	205.1
$N_2H_4(g)$	95.4		238.5
$N_2O_4(g)$	11.1		304.4
$H_2O(g)$	-241.8		188.8
$N_2(g)$	0.0		191.6
$N_2H_4(l)$	50.6		121.2
$N_2O_4(l)$	-19.5		209.2
$SnO_2(s)$	-580.7		52.3
C(s)	0		5.74
Sn(s)			51.2
$2CO_2(g)$	-393.5		213.8
H_2			130.7
$Br_2(g)$	30.91		245.5
HBr	-36.4		198.7

Gas Law

$PV = nRT$

$P_{Total} = P_1 + P_2 + P_3 + \ldots$

$d = m/V = P(MW) / RT$

$KE = (1/2)mv_{av}^2$

$$\sqrt{\overline{v}^2} = \sqrt{\frac{3RT}{M}}$$

$$\frac{RateA}{RateB} = \sqrt{\frac{M_b}{M_a}}$$

$$P + \frac{n^2 a}{V^2}(V - nb) = nRT$$

Equilibrium

$K_p = K(RT)^{\Delta n}$

Acid/Base

$pOH = -\log [OH^-]$

$pH = -\log[H^+]$

$pH + pOH = 14$

$K_a \times K_b = K_w$

$pH = pK_a + \log [A^-]/[HA]$

$$pH = \frac{pK_{a1} + pK_{a2}}{2}$$

Thermodynamics

$\Delta U = q + w$

$w_{system} = -P\Delta V$

$\Delta H = \Delta U + P\Delta V$

$q_P = \Delta U + P\Delta V$

$C_p = C_V + R$

$\Delta H_{rxn}^\circ = \Sigma n_p \Delta H_f^\circ(\text{products}) - \Sigma n_r \Delta H_f^\circ(\text{reactants})$

$q_{rev} = -w_{max} = nRT \ln (V_2/V_1)$

$\Delta S = q_{rev} / T$

$\Delta S_{T1\text{-}T2} = nC_p \ln(T_2/T_1)$

$\Delta S_{T1\text{-}T2} = nC_V \ln(T_2/T_1)$

$$\Delta S^0_{surroundings} = \frac{q_{surroundings}}{T} = \frac{-\Delta H_{sys}}{T}$$

$\Delta G^o = \Delta H^o - T\Delta S^o$

$\Delta G = \Delta G^o + RT \ln(Q)$

$\Delta G^o = -RT \ln(K)$

$\ln(K_2/K_1) = -\Delta H^o/R\ (1/T_2 - 1/T_1)$

Data For Water

Density $\rho = 1.00$ g/mL (25°C)
$C = 2.13$ J g$^-$ K$^-$ (solid)
$C = 4.18$ J g$^-$ K$^-$ (liquid)
$C_p = 2.01$ J g$^-$ K$^-$ (gas)

$\Delta H^\circ_{fus} = 6.02$ kJ mol$^-$
$\Delta H^\circ_{vap} = 40.7$ kJ mol$^-$

Constants

Avogadro's Number	N	6.022×10^{23}	mol^{-1}
Boltzmann's constant	k	1.30866×10^{-23}	$J \cdot K^{-1}$
Faraday's constant	F	96,485	$C \cdot mol^{-1}$
Gas constant	R	8.314	$J \cdot K^{-1} \cdot mol^{-1}$
	R	8.314	$kPa \cdot L/(mol \cdot K)$
	R	0.08206	$atm \cdot L \cdot K^{-1} \cdot mol^{-1}$
Planck's constant	h	6.62608×10^{-34}	$J \cdot s$
Speed of Light	c	2.99792458×10^{8}	$m \cdot s^{-1}$