Name: ________________________________

Instructor: Mills

Chemistry 102: 1st Practice Examination

Answer all five questions. Each question is worth 30 points. Please ensure you have all *five* pages of questions, as well as a formula sheet and a copy of the periodic table, *before* starting.

SHOW ALL WORK

Question	Score
1	
2	
3	
4	
5	
Total	

"Expressing reaction rates"

The reaction between hydrogen and nitrogen to form ammonia is known as the Haber process:

$$N_2\,(g) \;+\; 3H_2\,(g) \;\rightarrow\; 2NH_3\,(g)$$

<u>Question 1a</u> (5 points each): Express the rate of the above reaction in terms of changes in $[N_2]$ with time, $[H_2]$ with time, and $[NH_3]$ with time.

<u>Question 1b</u> (15 points): When $[H_2]$ is decreasing at 0.175 $molL^{-1}s^{-1}$, at what rate is $[NH_3]$ increasing?

"Initial rates"

Question 2 (30 points): Consider the generic reaction:

$$A + B + C \rightarrow D$$

Assuming the above reaction was analyzed using the initial rate method at 25°C, use the data below to determine:

1. The order of reaction with respect to each reactant and the overall order of the reaction. **Summarize your findings in the form of a complete rate equation**.
2. The value of *k* at this temperature.
3. What is the rate of reaction when the concentrations of *each* reactant is 0.50 M,

Experiment	Initial concentrations ($molL^{-1}$)			Initial rate
	A	B	C	($molL^{-1}s^{-1}$)
1	0.10	0.10	0.50	1.5×10^{-6}
2	0.20	0.10	0.50	3.0×10^{-6}
3	0.10	0.20	0.50	6.0×10^{-6}
4	0.10	0.10	1.00	1.5×10^{-6}

“Half - life”

Question 3a (15 points): The decomposition of N_2O_5 (g) is a first order process:

$$2N_2O_5\ (g) \rightarrow 4NO_2\ (g) + O_2\ (g)$$

The concentration of N_2O_5 (g) may be monitored with time using a simple diode colorimeter. If, during such an experiment, k is determined to be $5.2 \times 10^{-4}\ s^{-1}$, then what is the half-life of the reaction measured in minutes?

Question 3b (15 points): If, in the above experiment, an absorbance of 0.84 is recorded immediately prior to the commencement of N_2O_5 (g) decomposition (i.e. at $t = 0$), then what absorbance value will be recorded record after exactly one half-life has passed? Recall that Abs $\propto [N_2O_5]$

For the above reaction, what Abs value would be detected by the colorimeter after exactly three half-lives had passed?

"Arrhenius"

<u>Question 4</u> (30 points): The activation energy for a certain reaction is 65.7 kJ/mol. How many times faster will the reaction occur at 50^oC than 0^oC?

"Bloody Solution"

<u>Question 5</u> (30 points): Calculate the osmotic pressure of a solution containing 20.5 mg of hemoglobin in 15.0 mL of solution at 25^oC. The molar mass of hemoglobin is 6.5×10^4 g/mol.

Data sheet

Molar volume: $V_m = 22.41\ L.mol^{-1}$ at STP (0.00°C, 1.00 atm)

Ideal gas law: PV= nRT

Combined gas law: $P_1V_1/T_1 = P_2V_2/T_2$

Boyle's Law: $P \propto 1/V$ (at fixed T and n)

Charles's Law: $P \propto T$ (at fixed V and n)

Avagadro's Law: $V = nV_m$

1st order rate equations

$\ln([A]_t/[A]_o) = -kt$

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

Osmotic pressure: $\Pi = MRT$

Daltons law of partial pressures:

$P_{Tot} = P_a + P_b + P_c$ ….

Beer's law

$A = \log(I_o/I) = \varepsilon bc$

$R = 0.0821\ L\ atm\ mol^{-1}\ K^{-1}$

$= 8.315\ Jmol^{-1}K^{-1}$

d = m/v

1.00 atm = 760 mmHg = 101.5 kPa

$\rho H_2O = 1.00\ gmL^{-1}$

2nd order rate equations

$1/[A]_t = kt + 1/[A]_o$

$t_{1/2} = 1/\ k[A]_o$

Arrhenius equation

$$\ln\frac{k_2}{k_1} = \frac{E_a}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)$$

Substance	Specific heat ($Jg^{-1\circ}C^{-1}$)
Water, H_2O (l)	4.18
Iron, Fe	0.450
steel	0.455
Graphite, C	0.711

Substance	ΔH^o_f ($kJmol^{-1}$)
H_2O (g)	-241.8
H_2O (l)	-285.8
CH_4 (g)	-74.9
NH_3 (g)	-45.9
HCN (g)	135