

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	
<u>Total</u>	

“Expressing reaction rates”

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



Question 1a (5 points each): Express the rate of the above reaction in terms of changes in $[\text{N}_2]$ with time, $[\text{H}_2]$ with time, and $[\text{NH}_3]$ with time.

Question 1b (15 points): When $[\text{H}_2]$ is decreasing at $0.175 \text{ molL}^{-1}\text{s}^{-1}$, at what rate is $[\text{NH}_3]$ increasing?

“Initial rates”

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



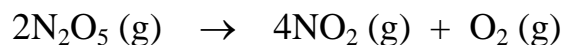
Assuming the above reaction was analyzed using the initial rate method at 25°C, use the data below to determine:

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 (molL ⁻¹ s ⁻¹)
	A	B	C	
1	0.10	0.10	0.50	1.5 x 10 ⁻⁶
2	0.20	0.10	0.50	3.0 x 10 ⁻⁶
3	0.10	0.20	0.50	6.0 x 10 ⁻⁶
4	0.10	0.10	1.00	1.5 x 10 ⁻⁶

“Half - life”

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



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 $5.2 \times 10^{-4} \text{ s}^{-1}$, 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 after exactly one half-life has passed? Recall that $\text{Abs} \propto [\text{N}_2\text{O}_5]$

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

“Arrhenius”

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

“Bloody Solution”

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

Data sheet

Molar volume: $V_m = 22.41 \text{ L}\cdot\text{mol}^{-1}$ 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: $\Pi = MRT$

Dalton's law of partial pressures:

$$P_{\text{Tot}} = P_a + P_b + P_c \dots$$

Beer's law

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

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

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

$$d = m/v$$

$$1.00 \text{ atm} = 760 \text{ mmHg} = 101.5 \text{ kPa}$$

$$\rho_{\text{H}_2\text{O}} = 1.00 \text{ gmL}^{-1}$$

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

Substance	ΔH_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