



Carleton
UNIVERSITY

CHEM 1006 A
Winter 2018

Midterm #2: Thursday, March 8th, 2018

Test duration: 80 minutes

Instructor: Alyssa Nause

Student Name: _____

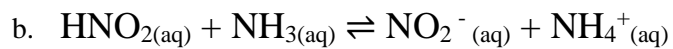
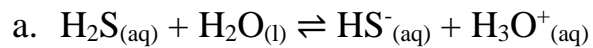
Student Number: _____

Answer the questions on the exam paper.

If more space is needed, use reverse of exam pages.

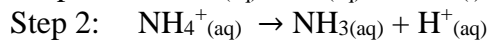
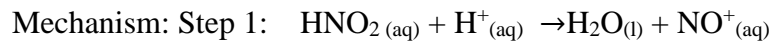
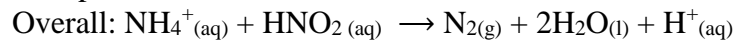
Part A: Short Answer (5 marks each)

1. For each acid-base reaction below, identify the conjugate pairs:

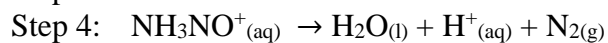


2. a) Define the relation between the rate of a reaction and the temperature of the reaction.
b) Describe what impact temperature has on the activation energy of the reaction and the progress of the reaction.

3. The following overall reaction has part of a potential mechanism listed below. Predict the unknown step of the mechanism.



Step 3: unknown

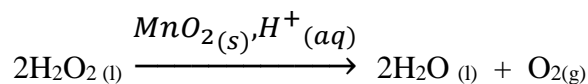


4. Define an amphiprotic acid or base, and give an example of a compound that is amphiprotic.

Part B: Long Answer Problems (10 marks each)

5. MnO_2 is often used to improve the efficiency of the decomposition of hydrogen peroxide to water and oxygen gas. The overall reaction has an energy change of -108 kJ/mol .
- Sketch an energy profile for the overall reaction and its catalyzed mechanism (sketch both on the same plot).
 - On your sketched energy profile, include arrows to indicate each activation energy and the energy change of the reaction.
 - Note each non-catalyst species in the catalyzed mechanism in its appropriate location on the energy profile.

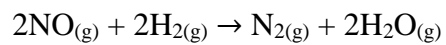
Overall: $E_{a,\text{overall}} = 275 \text{ kJ/mol}$



Catalyzed Mechanism:

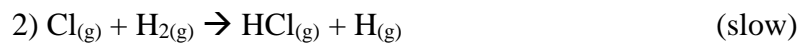
- | | |
|--|-------------------------------|
| 1) $\text{MnO}_2(s) + \text{H}_2\text{O}_2(l) + 2\text{H}^+(aq) \rightarrow \text{Mn}^{2+}(aq) + 2\text{H}_2\text{O}(l) + \text{O}_2(g)$ | $E_{a,1} = 55 \text{ kJ/mol}$ |
| 2) $\text{Mn}^{2+}(aq) + 2\text{H}_2\text{O}(l) \rightarrow \text{Mn}(\text{OH})_2(aq) + 2\text{H}^+(aq)$ | $E_{a,2} = 95 \text{ kJ/mol}$ |
| 3) $\text{Mn}(\text{OH})_2(aq) + \text{H}_2\text{O}_2(l) \rightarrow \text{MnO}_2(s) + 2\text{H}_2\text{O}(l)$ | $E_{a,3} = 35 \text{ kJ/mol}$ |

6. The reaction of nitric oxide with hydrogen at 1280°C. For the following reaction and experimental data:
- determine the rate law and overall reaction order.
 - determine the rate constant.



Run	[NO] _o (M)	[H ₂] _o (M)	Initial Rate (M/min)
1	0.0100	0.0100	0.00600
2	0.0200	0.0300	0.144
3	0.0100	0.0200	0.0120

7. Determine the overall reaction and the rate law for the following mechanism. If possible, substitute any invalid compounds in the predicted rate law to determine the corrected predicted rate law.



Equations and Constants:

$$R = 8.314 \text{ J K}^{-1} \text{ mol}^{-1}$$

$$1/[A] = 2kt + 1/[A]_o$$

$$N_{Av} = 6.022 \times 10^{23} \text{ mol}^{-1}$$

$$\text{Rate} = k[A]^x[B]^y$$

$$n = m/M$$

$$k_1[A_2] = k_{-1}[A]^2$$

$$c = n/V$$

$$k = Ae^{-E_a/RT}$$

$$\rho = m/V$$

$$\ln(k) = \ln(A) - E_a/RT$$

$$b = n/m$$

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

$$X_C = n_C/n_{\text{total}}$$

$$t_{1/2} = \ln 2 / ak$$

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

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

$$0 = ax^2 + bx + c$$

$$\ln[A] = -akt + \ln[A]_o$$

$$1 \text{ atm} = 1.01325 \times 10^5 \text{ Pa} = 760 \text{ Torr} = 1.01325 \text{ bar}$$

$$T(K) = T(^{\circ}\text{C}) + 273.15$$

