Directions: You have two hours to complete this exam. This exam is closed book and electronic device. The only allowed device for this exam is a calculator. You may remove this equation sheet/periodic table. Make sure to write your name on the first page of the exam.

$$\pi = MRT$$

$$\Delta T = k_{\mathrm{f}} m$$

$$\Delta T = k_{\mathrm{b}} m$$

$$R = 0.08206 \ \frac{L.atm}{mol\ K}$$

$$P = Xsolvent\ P°solvent$$

$$[A]t = \ -kt + [A]o$$

$$t\frac{1}{2} = \ \frac{[A]o}{2k}$$

$$\ln[A]\,t = \ -kt + \ln[\mathrm{A}]\ \mathrm{o}$$

$$t\frac{1}{2} = \frac{0.693}{k}$$

$$\frac{1}{[A]t} = \ kt + \ \frac{1}{[A]o}$$

$$t\frac{1}{2} = \ \frac{1}{k[A]o}$$

$$Sgas = k_H\ Pgas$$

$$1\ atm = 760\ mm\ Hg = 760\ torr$$

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

$$ln\frac{k2}{k1} = \ \frac{Ea}{R}\ (\frac{1}{T1} \quad - \quad \frac{1}{T2})$$

$$R = 8.314 \frac{J}{mol\ K}$$

$$K = \ °C + 273$$

Periodic Table of the Elements

1 IA 1A	2 IIA 2A	3 IIIB 3B	4 IVB 4B	5 VB 5B	6 VIB 6B	7 VIIB 7B	8	9 VIII 8	10	11 IB 1B	12 IIB 2B	13 IIIA 3A	14 IVA 4A	15 VA 5A	16 VIA 6A	17 VIIA 7A	18 VIIIA 8A
1 **H** Hydrogen 1.008																	2 **He** Helium 4.003
3 **Li** Lithium 6.941	4 **Be** Beryllium 9.012											5 **B** Boron 10.811	6 **C** Carbon 12.011	7 **N** Nitrogen 14.007	8 **O** Oxygen 15.999	9 **F** Fluorine 18.998	10 **Ne** Neon 20.180
11 **Na** Sodium 22.990	12 **Mg** Magnesium 24.305											13 **Al** Aluminum 26.982	14 **Si** Silicon 28.086	15 **P** Phosphorus 30.974	16 **S** Sulfur 32.066	17 **Cl** Chlorine 35.453	18 **Ar** Argon 39.948
19 **K** Potassium 39.098	20 **Ca** Calcium 40.078	21 **Sc** Scandium 44.956	22 **Ti** Titanium 47.88	23 **V** Vanadium 50.942	24 **Cr** Chromium 51.996	25 **Mn** Manganese 54.938	26 **Fe** Iron 55.933	27 **Co** Cobalt 58.933	28 **Ni** Nickel 58.693	29 **Cu** Copper 63.546	30 **Zn** Zinc 65.39	31 **Ga** Gallium 69.732	32 **Ge** Germanium 72.61	33 **As** Arsenic 74.922	34 **Se** Selenium 78.09	35 **Br** Bromine 79.904	36 **Kr** Krypton 84.80
37 **Rb** Rubidium 84.468	38 **Sr** Strontium 87.62	39 **Y** Yttrium 88.906	40 **Zr** Zirconium 91.224	41 **Nb** Niobium 92.906	42 **Mo** Molybdenum 95.94	43 **Tc** Technetium 98.907	44 **Ru** Ruthenium 101.07	45 **Rh** Rhodium 102.906	46 **Pd** Palladium 106.42	47 **Ag** Silver 107.868	48 **Cd** Cadmium 112.411	49 **In** Indium 114.818	50 **Sn** Tin 118.71	51 **Sb** Antimony 121.760	52 **Te** Tellurium 127.6	53 **I** Iodine 126.904	54 **Xe** Xenon 131.29
55 **Cs** Cesium 132.905	56 **Ba** Barium 137.327	57-71	72 **Hf** Hafnium 178.49	73 **Ta** Tantalum 180.948	74 **W** Tungsten 183.85	75 **Re** Rhenium 186.207	76 **Os** Osmium 190.23	77 **Ir** Iridium 192.22	78 **Pt** Platinum 195.08	79 **Au** Gold 196.967	80 **Hg** Mercury 200.59	81 **Tl** Thallium 204.383	82 **Pb** Lead 207.2	83 **Bi** Bismuth 208.980	84 **Po** Polonium [208.982]	85 **At** Astatine 209.987	86 **Rn** Radon 222.018
87 **Fr** Francium 223.020	88 **Ra** Radium 226.025	89-103	104 **Rf** Rutherfordium [261]	105 **Db** Dubnium [262]	106 **Sg** Seaborgium [266]	107 **Bh** Bohrium [264]	108 **Hs** Hassium [269]	109 **Mt** Meitnerium [268]	110 **Ds** Darmstadtium [269]	111 **Rg** Roentgenium [272]	112 **Cn** Copernicium [277]	113 **Uut** Ununtrium unknown	114 **Fl** Flerovium [289]	115 **Uup** Ununpentium unknown	116 **Lv** Livermorium [298]	117 **Uus** Ununseptium unknown	118 **Uuo** Ununoctium unknown

Lanthanide Series	57 **La** Lanthanum 138.906	58 **Ce** Cerium 140.115	59 **Pr** Praseodymium 140.908	60 **Nd** Neodymium 144.24	61 **Pm** Promethium 144.913	62 **Sm** Samarium 150.36	63 **Eu** Europium 151.966	64 **Gd** Gadolinium 157.25	65 **Tb** Terbium 158.925	66 **Dy** Dysprosium 162.50	67 **Ho** Holmium 164.930	68 **Er** Erbium 167.26	69 **Tm** Thulium 168.934	70 **Yb** Ytterbium 173.04	71 **Lu** Lutetium 174.967
Actinide Series	89 **Ac** Actinium 227.028	90 **Th** Thorium 232.038	91 **Pa** Protactinium 231.036	92 **U** Uranium 238.029	93 **Np** Neptunium 237.048	94 **Pu** Plutonium 244.064	95 **Am** Americium 243.061	96 **Cm** Curium 247.070	97 **Bk** Berkelium 247.070	98 **Cf** Californium 251.080	99 **Es** Einsteinium [254]	100 **Fm** Fermium 257.095	101 **Md** Mendelevium 258.1	102 **No** Nobelium 259.101	103 **Lr** Lawrencium [262]

Ch 104
Summer 2024
Exam 1 Friday July 19th
Watkins

Name: _____

1. When 14.7 grams of a compound (a non-electrolyte) is dissolved in 941.4 grams of benzene (C_6H_6) the new freezing point is 4.90 °C. The freezing point of pure benzene is 5.50 °C and the k_f of benzene is 5.12 °C. What is the molar mass of the organic compound? (**10 pts)**

2. Sea water has a sodium chloride concentration of 3.5 grams of NaCl/100.0 mL of solution. The osmotic pressure of blood is 7.1 atm at 37.0°C. Does sea water have the same osmotic pressure as blood if it is at 37.0 °C? **Yes or no? AND show all calculations used to determine your answer. (8 pts)**

3. Concentrated nitric acid has a concentration of 67% by mass (67 grams of HNO_3/100.0 g of solution). The density of this solution is 1.40 g/mL . Answer the following questions **(8 pts)**

a. What is the mole fraction of water?

b. What is the molarity?

c. What is the molality?

4. A student obtained the following data for decomposition of hydrogen peroxide,
   $2H_2O_2$ (l) → $2H_2O$ (l)+ O_2 (g)
   Answer the following questions. Graphs ARE NOT required but graph paper is provided on the next page if you want to make plots. The student wants to determine the rate law,
   rate = $k[H_2O_2]^m$. **(10 pts)**

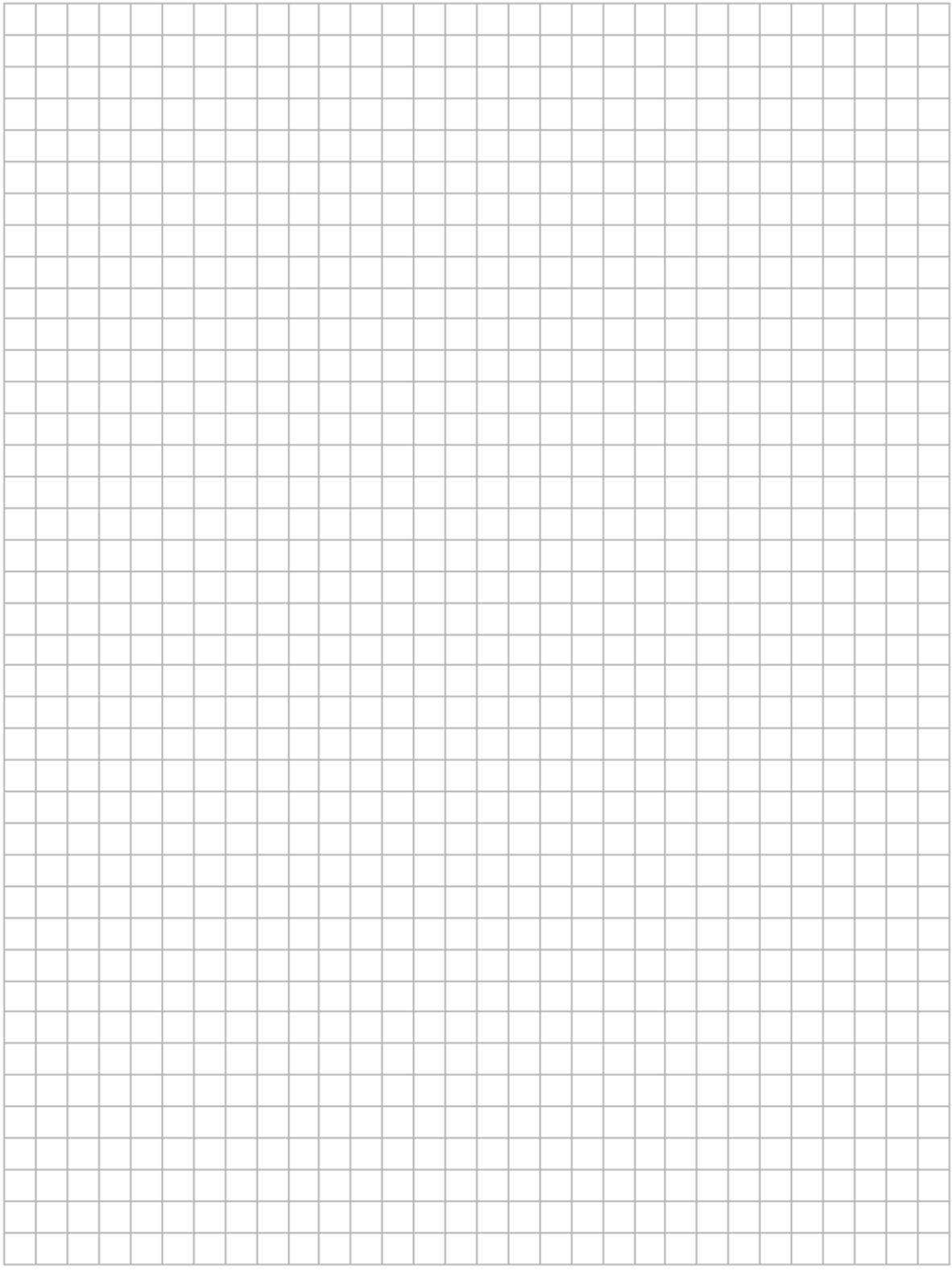
Time (s)	$[H_2O_2]$ mol/L
0	1.0
120	0.91
300	0.78
600	0.59
1200	0.37
1800	0.22
2400	0.13
3000	0.082
3600	0.050

a. Is the reaction zero, first or second order with respect to hydrogen peroxide?

b. What is the rate law and rate constant with units?

c. What is the concentration of hydrogen peroxide after 5000.0 seconds?

d. Describe two ways to increase the rate of the reaction for decomposition of hydrogen peroxide.



5. Determine whether each of the following solutes are miscible in water or hexane (C_6H_{14}) and explain your choice. **(6 pts)**

a. Potassium iodide

b. Acetic Acid (CH_3COOH)

c. Benzene (C_6H_6)

6. Given the proposed mechanism for the reaction below answer the following questions. **(10 pts)**

$$H_2(g)+2ICl(g)\longrightarrow I_2(g)+2HCl(g)\ \Delta H<0$$

Experimental rate law: $\text{rate}= k[H_2][ICl]$

Step 1 (slow) $H_{2\,(g)} + ICl\,(g) \longrightarrow HI\,(g) + HCl\,(g)$

Step 2 (fast) $HI\,(g) + ICl\,(g) \longrightarrow I_{2\,(g)} + HCl(g)$

a. Write a rate law for each elementary step

Step 1 :

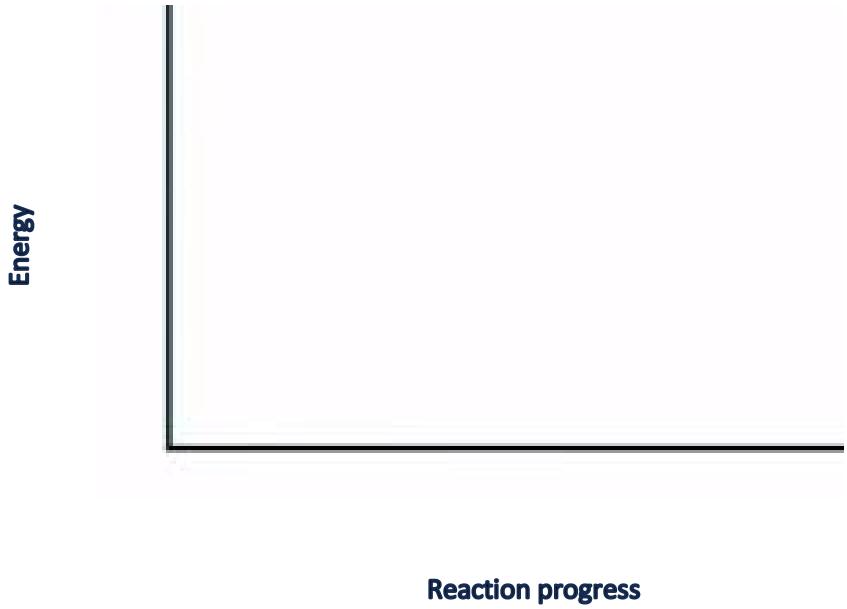
Step 2:

b. Is the proposed mechanism is valid for the reaction studied in the lab and experimentally determined rate law? Yes or No and explain your answer.

c. What molecule is the intermediate for this reaction mechanism?

6 continued

d. Draw and label a reaction coordinate diagram for the reaction mechanism from #6. **You can use the following abbreviations (P for products, R for reactants, TS1 and TS2 for transition state for step 1 and step 2 Ea1 and Ea2 for activation energy for step 1 and step 2, and ΔH).**



7. Given the data below please answer the following questions, make sure to include the rate constant with units. The reaction is: NH_4^+ (aq) + NO_2^- (aq) → N_2(g) + $2H_2O$ (l) and the reaction rate is defined at rate = $-\Delta[NH_4^+]/\Delta t$. **(10 pts)**

Experiment	$[NH_4^+]$	$[NO_2^-]$	Initial rate (mol/L-s)
1	0.100 M	0.0050 M	1.35×10^{-7}
2	0.100 M	0.010 M	2.70×10^{-7}
3	0.200 M	0.010 M	5.40×10^{-7}

a. What is the rate law for this reaction?

b. What is the rate constant (k)?

c. What is the rate of the reaction if the concentration of ammonium ion and nitrite ion are 0.100 M?

8. The reaction, $C_4H_8(g) \longrightarrow 2C_2H_4(g)$, has an activation energy of 262 kJ/mol. At 327.0 °C, the rate constant, k, is 6.1×10^{-8} s−1. What is the value of the rate constant at 300.0°C? **(8 pts)**

9. The equilibrium constant (Kp) for the reaction $COCl_2(g) \rightleftharpoons CO(g)+Cl_2(g)$ at 100 °C is **2.2×10^{-10}**. Answer the following questions **(10 pts).**

    a. If the initial pressure is 0.100 atm for $COCl_2$ what is the partial pressure of each gas at equilibrium?

    b. Is this equilibrium reactant or product favored? Briefly explain your answer.

    c. If the volume of the reaction vessel is decreased which direction will the reaction shift (reactants or products) to offset the stress and re-establish equilibrium?

10. When 0.0322 moles of NO gas and 1.70 grams of bromine gas are placed in a 2.00 L reaction vessel at 25.0°C, the equilibrium pressure of NOBr was 0.438 atm. What is the equilibrium constant, Kp, at 25.0°C? **PV=nRT (8 pts)**

$$2NO(g) + Br_2(g) \rightleftharpoons 2NOBr(g)$$

11. For the following reaction: $H_{2\,(g)} + I_2\,(g) \rightleftharpoons 2HI\,(g)$, **$\Delta H<0$ determine whether the reaction will shift towards the reactants, products or neither. (6 pts)**

a. Increase in pressure

b. Increase in temperature

c. Addition of hydrogen gas

d. Removal of iodine gas

12. At 0.0°C the solubility of oxygen gas is 0.0221 M at a pressure of 1.0 atm. At the same temperature, 0.0°C if the pressure is increased to 5.0 atm what mass of oxygen gas can be dissolved in two liters of water? **(6 pts)**

BONUS (2 pts)

If you had to name a cat what periodic element name would you give the cat and why? For example, my cat's Argon because he is just like a noble gas content and doesn't want to interact (aka react) with any other cats.