

CHEM 222 Exam 3

- You may access the exam between 8:00 and 9:30 AM Friday, April 3.
- You may use your book, notes, or online resources, **but you MAY NOT receive assistance from anyone other than Dr. Lamp.**
- Complete five (5) of the six problems on separate paper. There is no need to print out the exam. You must show your work to receive credit for problems requiring math. Report your answers with the appropriate number of significant figures. For discussion problems, be concise in your answers.
- Once you have completed the exam, scan your work as pdf and upload it to Blackboard.
- Submission of your work is your pledge that the exam was completed in an ethical manner! Any unethical work will result in a grade of zero on the exam and the Student Affairs office will be notified.
- Your exam materials must be uploaded by 9:30 AM.** You may turn the exam in earlier if you wish.

Possibly Useful Information

$K_w = 1.0 \times 10^{-14} = [\text{H}^+][\text{OH}^-]$	$K_a K_b = K_w$
$\alpha_{\text{A}^{2-}} = \frac{K_{a1} K_{a2}}{[\text{H}^+]^2 + [\text{H}^+] K_{a1} + K_{a1} K_{a2}}$	$\alpha_{\text{H}_2\text{A}} = \frac{[\text{H}^+]^2}{[\text{H}^+]^2 + [\text{H}^+] K_{a1} + K_{a1} K_{a2}}$
$\text{pH} = \text{p}K_a + \log \frac{[\text{conjugate base}]}{[\text{weak acid}]}$	$\text{pH} = \frac{1}{2}(\text{p}K_{a1} + \text{p}K_{a2})$
$[\text{H}^+] = \sqrt{\frac{K_{a1} K_{a2} F + K_{a1} K_w}{K_{a1} + F}} \approx \sqrt{K_{a1} K_{a2}}$	$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

Periodic Table of the Elements

	IA 1A																	VIII 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 47.867	23	V Vanadium 50.942	24	Cr Chromium 51.996	25	Mn Manganese 54.938	26	Fe Iron 55.845	27	Co Cobalt 58.933	28	Ni Nickel 58.693	29	Cu Copper 63.546	30	Zn Zinc 65.38	31	Ga Gallium 69.723	32	Ge Germanium 72.631	33	As Arsenic 74.922	34	Se Selenium 78.971	35	Br Bromine 79.904	36	Kr Krypton 83.798																				
37	Rb Rubidium 85.468	38	Sr Strontium 87.62	39	Y Yttrium 88.906	40	Zr Zirconium 91.224	41	Nb Niobium 92.906	42	Mo Molybdenum 95.95	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 112.414	49	In Indium 114.818	50	Sn Tin 118.711	51	Sb Antimony 121.760	52	Te Tellurium 127.6	53	I Iodine 126.904	54	Xe Xenon 131.294	55	Cs Cesium 132.905	56	Ba Barium 137.328	57-71	Lanthanide Series	72	Hf Hafnium 178.49	73	Ta Tantalum 180.948	74	W Tungsten 183.84	75	Re Rhenium 186.207	76	Os Osmium 190.23	77	Ir Iridium 192.217	78	Pt Platinum 195.085	79	Au Gold 196.967	80	Hg Mercury 200.592	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	Actinide Series	104	Rf Rutherfordium [261]	105	Db Dubnium [262]	106	Sg Seaborgium [266]	107	Bh Bohrium [264]	108	Hs Hassium [269]	109	Mt Meitnerium [278]	110	Ds Darmstadtium [281]	111	Ds Roentgenium [280]	112	Cn Copernicium [285]	113	Nh Nihonium [286]	114	Fl Flerovium [289]	115	Mc Moscovium [289]	116	Lv Livermorium [293]	117	Ts Tennessine [294]	118	Og Oganesson [294]																																				
57	La Lanthanum 138.905	58	Ce Cerium 140.116	59	Pr Praseodymium 140.908	60	Nd Neodymium 144.243	61	Pm Promethium 144.913	62	Sm Samarium 150.36	63	Eu Europium 151.964	64	Gd Gadolinium 157.25	65	Tb Terbium 158.925	66	Dy Dysprosium 162.500	67	Ho Holmium 164.930	68	Er Erbium 167.259	69	Tm Thulium 168.934	70	Yb Ytterbium 173.055	71	Lu Lutetium 174.967																																										
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]																																										

Complete five (5) of the following problems. 16 points each

1. Solution A was prepared by dissolving 0.0134 grams potassium hydroxide (molar mass 56.10 g/mol) in water and diluting to a total volume of 1000.0 mL. Next, 1.00 mL of solution A was transferred into a 3.000 L volumetric flask and diluted to the mark to prepare solution B. Calculate the pH of solution A and calculate the pH of solution B.
2. You need to prepare a pH 3.50 buffer with a total concentration of 100.0 mM. Any of the following monoprotic acid/conjugate base combinations could be used to prepare the buffer.
 - a. Choose which of the three combinations you feel is the best option,
 - b. justify your choice in a sentence or two, and,
 - c. calculate the masses of acid and conjugate base needed to prepare the buffer.

Acid, HA (molar mass)	Conjugate Base, NaA (molar mass)	K_a
Butanoic acid (88.106 g/mol)	Sodium butanoate (110.088 g/mol)	1.52×10^{-5}
Formic acid (46.025 g/mol)	Sodium formate (68.007 g/mol)	1.80×10^{-4}
Pyruvic acid (88.06 g/mol)	Sodium Pyruvate (110.044 g/mol)	3.30×10^{-3}

3. Malonic acid is a weak, diprotic acid of the form H_2A with $K_{a1} = 1.42 \times 10^{-3}$ and $K_{a2} = 2.01 \times 10^{-6}$. What volume, in milliliters, of 0.489 M hydrochloric acid must be added to 250.0 mL of a 0.105 M solution of disodium malonate (Na_2A) to prepare a solution with pH 2.50?
4. Consider arsenic acid (H_3AsO_4 , represented as H_3A), a triprotic acid with acid dissociation constants of 5.8×10^{-3} , 1.1×10^{-7} , and 3.2×10^{-12} . Describe the process you would use to determine the pH where the concentration of H_2A^- is at its maximum. You **do not need to calculate the pH**, but explain the relationship(s) that would be useful and how they could be used to find the pH.
5. Consider the titration below. Calculate the pH at any **three** of the following points along the titration, 0.00 mL, 10.00 mL, 20.00 mL, 40.00, 60.00 mL titrant added. Sketch the titration curve you would expect. Clearly label your graph.

Analyte in flask	Titrant in buret
20.0 mL 0.100 M oxalic acid ($pK_{a1} = 1.25$, $pK_{a2} = 4.27$)	0.100 M KOH

6. You are attempting to determine the identity of a **dibasic** weak base by titrating with standardized hydrochloric acid. You believe the base is either hydrazine ($C_2N_2H_4$), ethylenediamine ($C_2N_2H_8$), or piperazine ($C_4N_2H_{10}$). You weigh out 0.145 grams of the weak base, dissolve it in 50.00 mL water and titrate with 0.105 M HCl. If it requires 32.06 mL of titrant to reach the endpoint, what is the identity of the weak base? (*hint: dibasic is analogous to diprotic when describing an acid*)