

$\text{pH} = -\log[\text{H}^+], [\text{H}^+] = 10^{-\text{pH}}$	$M_c V_c = M_d V_d$
$\text{pH} + \text{pOH} = 14$	$N_A = 6.02 \times 10^{23} \text{ mol}^{-1}$

Periodic Table of the Elements

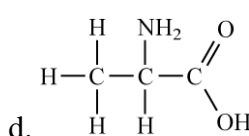
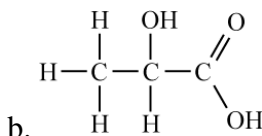
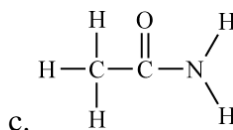
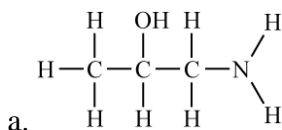
1 1A H Hydrogen 1.008	2 2A He Helium 4.003	3 3A Li Lithium 6.941	4 4A Be Beryllium 9.012	5 5A B Boron 10.811	6 6A C Carbon 12.011	7 7A N Nitrogen 14.007	8 8A O Oxygen 15.999	9 9A F Fluorine 18.998	10 10A Ne Neon 20.180
11 1A Na Sodium 22.990	12 2A Mg Magnesium 24.305	13 3A Al Aluminum 26.982	14 4A Si Silicon 28.086	15 5A P Phosphorus 30.974	16 6A S Sulfur 32.066	17 7A Cl Chlorine 35.453	18 8A Ar Argon 39.948	19 9A K Potassium 39.098	20 10A Ca Calcium 40.078
37 1A Rb Rubidium 85.468	38 2A Sr Strontium 87.62	39 3A Y Yttrium 88.906	40 4A Zr Zirconium 91.224	41 5A Nb Niobium 92.906	42 6A Mo Molybdenum 95.95	43 7A Tc Technetium 98.907	44 8A Ru Ruthenium 101.07	45 9A Rh Rhodium 102.906	46 10A Pd Palladium 106.42
55 1A Cs Cesium 132.905	56 2A Ba Barium 137.328	57-71 3A La Lanthanum 138.905	72 4A Hf Hafnium 178.49	73 5A Ta Tantalum 180.948	74 6A W Tungsten 183.84	75 7A Re Rhenium 186.207	76 8A Os Osmium 190.23	77 9A Ir Iridium 192.217	78 10A Pt Platinum 195.085
87 1A Fr Francium 223.020	88 2A Ra Radium 226.025	89-103 3A La Lanthanum 138.905	104 4A Rf Rutherfordium [261]	105 5A Db Dubnium [262]	106 6A Sg Seaborgium [266]	107 7A Bh Bohrium [264]	108 8A Hs Hassium [269]	109 9A Mt Meitnerium [276]	110 10A Ds Darmstadtium [281]
117 7A Ts Tennessine [294]	118 8A Og Oganesson [294]	119 9A Nh Nihonium [286]	120 10A Fl Flerovium [289]	121 11A Mc Moscovium [289]	122 12A Lv Livermorium [293]	123 13A Ts Tennessine [294]	124 14A Og Oganesson [294]	125 15A Nh Nihonium [286]	126 16A Fl Flerovium [289]
157 7A Uu Ununseptium [294]	158 8A Uu Ununoctium [294]	159 9A Uuh Ununhennium [294]	160 10A Uu Ununnilium [294]	161 11A Uuh Ununhennium [294]	162 12A Uu Ununnilium [294]	163 13A Uuh Ununhennium [294]	164 14A Uu Ununnilium [294]	165 15A Uuh Ununhennium [294]	166 16A Uu Ununnilium [294]
177 7A Uus Ununseptium [294]	178 8A Uuo Ununoctium [294]	179 9A Uuh Ununhennium [294]	180 10A Uu Ununnilium [294]	181 11A Uuh Ununhennium [294]	182 12A Uu Ununnilium [294]	183 13A Uuh Ununhennium [294]	184 14A Uu Ununnilium [294]	185 15A Uuh Ununhennium [294]	186 16A Uu Ununnilium [294]
197 7A Uus Ununseptium [294]	198 8A Uuo Ununoctium [294]	199 9A Uuh Ununhennium [294]	200 10A Uu Ununnilium [294]	201 11A Uuh Ununhennium [294]	202 12A Uu Ununnilium [294]	203 13A Uuh Ununhennium [294]	204 14A Uu Ununnilium [294]	205 15A Uuh Ununhennium [294]	206 16A Uu Ununnilium [294]
217 7A Uus Ununseptium [294]	218 8A Uuo Ununoctium [294]	219 9A Uuh Ununhennium [294]	220 10A Uu Ununnilium [294]	221 11A Uuh Ununhennium [294]	222 12A Uu Ununnilium [294]	223 13A Uuh Ununhennium [294]	224 14A Uu Ununnilium [294]	225 15A Uuh Ununhennium [294]	226 16A Uu Ununnilium [294]
237 7A Uus Ununseptium [294]	238 8A Uuo Ununoctium [294]	239 9A Uuh Ununhennium [294]	240 10A Uu Ununnilium [294]	241 11A Uuh Ununhennium [294]	242 12A Uu Ununnilium [294]	243 13A Uuh Ununhennium [294]	244 14A Uu Ununnilium [294]	245 15A Uuh Ununhennium [294]	246 16A Uu Ununnilium [294]
257 7A Uus Ununseptium [294]	258 8A Uuo Ununoctium [294]	259 9A Uuh Ununhennium [294]	260 10A Uu Ununnilium [294]	261 11A Uuh Ununhennium [294]	262 12A Uu Ununnilium [294]	263 13A Uuh Ununhennium [294]	264 14A Uu Ununnilium [294]	265 15A Uuh Ununhennium [294]	266 16A Uu Ununnilium [294]
277 7A Uus Ununseptium [294]	278 8A Uuo Ununoctium [294]	279 9A Uuh Ununhennium [294]	280 10A Uu Ununnilium [294]	281 11A Uuh Ununhennium [294]	282 12A Uu Ununnilium [294]	283 13A Uuh Ununhennium [294]	284 14A Uu Ununnilium [294]	285 15A Uuh Ununhennium [294]	286 16A Uu Ununnilium [294]
297 7A Uus Ununseptium [294]	298 8A Uuo Ununoctium [294]	299 9A Uuh Ununhennium [294]	300 10A Uu Ununnilium [294]	301 11A Uuh Ununhennium [294]	302 12A Uu Ununnilium [294]	303 13A Uuh Ununhennium [294]	304 14A Uu Ununnilium [294]	305 15A Uuh Ununhennium [294]	306 16A Uu Ununnilium [294]
317 7A Uus Ununseptium [294]	318 8A Uuo Ununoctium [294]	319 9A Uuh Ununhennium [294]	320 10A Uu Ununnilium [294]	321 11A Uuh Ununhennium [294]	322 12A Uu Ununnilium [294]	323 13A Uuh Ununhennium [294]	324 14A Uu Ununnilium [294]	325 15A Uuh Ununhennium [294]	326 16A Uu Ununnilium [294]
337 7A Uus Ununseptium [294]	338 8A Uuo Ununoctium [294]	339 9A Uuh Ununhennium [294]	340 10A Uu Ununnilium [294]	341 11A Uuh Ununhennium [294]	342 12A Uu Ununnilium [294]	343 13A Uuh Ununhennium [294]	344 14A Uu Ununnilium [294]	345 15A Uuh Ununhennium [294]	346 16A Uu Ununnilium [294]
357 7A Uus Ununseptium [294]	358 8A Uuo Ununoctium [294]	359 9A Uuh Ununhennium [294]	360 10A Uu Ununnilium [294]	361 11A Uuh Ununhennium [294]	362 12A Uu Ununnilium [294]	363 13A Uuh Ununhennium [294]	364 14A Uu Ununnilium [294]	365 15A Uuh Ununhennium [294]	366 16A Uu Ununnilium [294]
377 7A Uus Ununseptium [294]	378 8A Uuo Ununoctium [294]	379 9A Uuh Ununhennium [294]	380 10A Uu Ununnilium [294]	381 11A Uuh Ununhennium [294]	382 12A Uu Ununnilium [294]	383 13A Uuh Ununhennium [294]	384 14A Uu Ununnilium [294]	385 15A Uuh Ununhennium [294]	386 16A Uu Ununnilium [294]
397 7A Uus Ununseptium [294]	398 8A Uuo Ununoctium [294]	399 9A Uuh Ununhennium [294]	400 10A Uu Ununnilium [294]	401 11A Uuh Ununhennium [294]	402 12A Uu Ununnilium [294]	403 13A Uuh Ununhennium [294]	404 14A Uu Ununnilium [294]	405 15A Uuh Ununhennium [294]	406 16A Uu Ununnilium [294]
417 7A Uus Ununseptium [294]	418 8A Uuo Ununoctium [294]	419 9A Uuh Ununhennium [294]	420 10A Uu Ununnilium [294]	421 11A Uuh Ununhennium [294]	422 12A Uu Ununnilium [294]	423 13A Uuh Ununhennium [294]	424 14A Uu Ununnilium [294]	425 15A Uuh Ununhennium [294]	426 16A Uu Ununnilium [294]
437 7A Uus Ununseptium [294]	438 8A Uuo Ununoctium [294]	439 9A Uuh Ununhennium [294]	440 10A Uu Ununnilium [294]	441 11A Uuh Ununhennium [294]	442 12A Uu Ununnilium [294]	443 13A Uuh Ununhennium [294]	444 14A Uu Ununnilium [294]	445 15A Uuh Ununhennium [294]	446 16A Uu Ununnilium [294]
457 7A Uus Ununseptium [294]	458 8A Uuo Ununoctium [294]	459 9A Uuh Ununhennium [294]	460 10A Uu Ununnilium [294]	461 11A Uuh Ununhennium [294]	462 12A Uu Ununnilium [294]	463 13A Uuh Ununhennium [294]	464 14A Uu Ununnilium [294]	465 15A Uuh Ununhennium [294]	466 16A Uu Ununnilium [294]
477 7A Uus Ununseptium [294]	478 8A Uuo Ununoctium [294]	479 9A Uuh Ununhennium [294]	480 10A Uu Ununnilium [294]	481 11A Uuh Ununhennium [294]	482 12A Uu Ununnilium [294]	483 13A Uuh Ununhennium [294]	484 14A Uu Ununnilium [294]	485 15A Uuh Ununhennium [294]	486 16A Uu Ununnilium [294]
497 7A Uus Ununseptium [294]	498 8A Uuo Ununoctium [294]	499 9A Uuh Ununhennium [294]	500 10A Uu Ununnilium [294]	501 11A Uuh Ununhennium [294]	502 12A Uu Ununnilium [294]	503 13A Uuh Ununhennium [294]	504 14A Uu Ununnilium [294]	505 15A Uuh Ununhennium [294]	506 16A Uu Ununnilium [294]
517 7A Uus Ununseptium [294]	518 8A Uuo Ununoctium [294]	519 9A Uuh Ununhennium [294]	520 10A Uu Ununnilium [294]	521 11A Uuh Ununhennium [294]	522 12A Uu Ununnilium [294]	523 13A Uuh Ununhennium [294]	524 14A Uu Ununnilium [294]	525 15A Uuh Ununhennium [294]	526 16A Uu Ununnilium [294]
537 7A Uus Ununseptium [294]	538 8A Uuo Ununoctium [294]	539 9A Uuh Ununhennium [294]	540 10A Uu Ununnilium [294]	541 11A Uuh Ununhennium [294]	542 12A Uu Ununnilium [294]	543 13A Uuh Ununhennium [294]	544 14A Uu Ununnilium [294]	545 15A Uuh Ununhennium [294]	546 16A Uu Ununnilium [294]
557 7A Uus Ununseptium [294]	558 8A Uuo Ununoctium [294]	559 9A Uuh Ununhennium [294]	560 10A Uu Ununnilium [294]	561 11A Uuh Ununhennium [294]	562 12A Uu Ununnilium [294]	563 13A Uuh Ununhennium [294]	564 14A Uu Ununnilium [294]	565 15A Uuh Ununhennium [294]	566 16A Uu Ununnilium [294]
577 7A Uus Ununseptium [294]	578 8A Uuo Ununoctium [294]	579 9A Uuh Ununhennium [294]	580 10A Uu Ununnilium [294]	581 11A Uuh Ununhennium [294]	582 12A Uu Ununnilium [294]	583 13A Uuh Ununhennium [294]	584 14A Uu Ununnilium [294]	585 15A Uuh Ununhennium [294]	586 16A Uu Ununnilium [294]
597 7A Uus Ununseptium [294]	598 8A Uuo Ununoctium [294]	599 9A Uuh Ununhennium [294]	600 10A Uu Ununnilium [294]	601 11A Uuh Ununhennium [294]	602 12A Uu Ununnilium [294]	603 13A Uuh Ununhennium [294]	604 14A Uu Ununnilium [294]	605 15A Uuh Ununhennium [294]	606 16A Uu Ununnilium [294]
617 7A Uus Ununseptium [294]	618 8A Uuo Ununoctium [294]	619 9A Uuh Ununhennium [294]	620 10A Uu Ununnilium [294]	621 11A Uuh Ununhennium [294]	622 12A Uu Ununnilium [294]	623 13A Uuh Ununhennium [294]	624 14A Uu Ununnilium [294]	625 15A Uuh Ununhennium [294]	626 16A Uu Ununnilium [294]
637 7A Uus Ununseptium [294]	638 8A Uuo Ununoctium [294]	639 9A Uuh Ununhennium [294]	640 10A Uu Ununnilium [294]	641 11A Uuh Ununhennium [294]	642 12A Uu Ununnilium [294]	643 13A Uuh Ununhennium [294]	644 14A Uu Ununnilium [294]	645 15A Uuh Ununhennium [294]	646 16A Uu Ununnilium [294]
657 7A Uus Ununseptium [294]	658 8A Uuo Ununoctium [294]	659 9A Uuh Ununhennium [294]	660 10A Uu Ununnilium [294]	661 11A Uuh Ununhennium [294]	662 12A Uu Ununnilium [294]	663 13A Uuh Ununhennium [294]	664 14A Uu Ununnilium [294]	665 15A Uuh Ununhennium [294]	666 16A Uu Ununnilium [294]
677 7A Uus Ununseptium [294]	678 8A Uuo Ununoctium [294]	679 9A Uuh Ununhennium [294]	680 10A Uu Ununnilium [294]	681 11A Uuh Ununhennium [294]	682 12A Uu Ununnilium [294]	683 13A Uuh Ununhennium [294]	684 14A Uu Ununnilium [294]	685 15A Uuh Ununhennium [294]	686 16A Uu Ununnilium [294]
697 7A Uus Ununseptium [294]	698 8A Uuo Ununoctium [294]	699 9A Uuh Ununhennium [294]	700 10A Uu Ununnilium [294]	701 11A Uuh Ununhennium [294]	702 12A Uu Ununnilium [294]	703 13A Uuh Ununhennium [294]	704 14A Uu Ununnilium [294]	705 15A Uuh Ununhennium [294]	706 16A Uu Ununnilium [294]
717 7A Uus Ununseptium [294]	718 8A Uuo Ununoctium [294]	719 9A Uuh Ununhennium [294]	720 10A Uu Ununnilium [294]	721 11A Uuh Ununhennium [294]	722 12A Uu Ununnilium [294]	723 13A Uuh Ununhennium [294]	724 14A Uu Ununnilium [294]	725 15A Uuh Ununhennium [294]	726 16A Uu Ununnilium [294]
737 7A Uus Ununseptium [294]	738 8A Uuo Ununoctium [294]	739 9A Uuh Ununhennium [294]	740 10A Uu Ununnilium [294]	741 11A Uuh Ununhennium [294]	742 12A Uu Ununnilium [294]	743 13A Uuh Ununhennium [294]	744 14A Uu Ununnilium [294]	745 15A Uuh Ununhennium [294]	746 16A Uu Ununnilium [294]
757 7A Uus Ununseptium [294]	758 8A Uuo Ununoctium [294]	759 9A Uuh Ununhennium [294]	760 10A Uu Ununnilium [294]	761 11A Uuh Ununhennium [294]	762 12A Uu Ununnilium [294]	763 13A Uuh Ununhennium [294]	764 14A Uu Ununnilium [294]	765 15A Uuh Ununhennium [294]	766 16A Uu Ununnilium [294]
777 7A Uus Ununseptium [294]	778 8A Uuo Ununoctium [294]	779 9A Uuh Ununhennium [294]	780 10A Uu Ununnilium [294]	781 11A Uuh Ununhennium [294]	782 12A Uu Ununnilium [294]	783 13A Uuh Ununhennium [294]	784 14A Uu Ununnilium [294]	785 15A Uuh Ununhennium [294]	786 16A Uu Ununnilium [294]
797 7A Uus Ununseptium [294]	798 8A Uuo Ununoctium [294]	799 9A Uuh Ununhennium [294]	800 10A Uu Ununnilium [294]	801 11A Uuh Ununhennium [294]	802 12A Uu Ununnilium [294]	803 13A Uuh Ununhennium [294]	804 14A Uu Ununnilium [294]	805 15A Uuh Ununhennium [294]	806 16A Uu Ununnilium [294]
817 7A Uus Ununseptium [294]	818 8A Uuo Ununoctium [294]	819 9A Uuh Ununhennium [294]	820 10A Uu Ununnilium [294]	821 11A Uuh Ununhennium [294]	822 12A Uu Ununnilium [294]	823 13A Uuh Ununhennium [294]	824 14A Uu Ununnilium [294]	825 15A Uuh Ununhennium [294]	826 16A Uu Ununnilium [294]
837 7A Uus Ununseptium [294]	838 8A Uuo Ununoctium [294]	839 9A Uuh Ununhennium [294]	840 10A Uu Ununnilium [294]	841 11A Uuh Ununhennium [294]	842 12A Uu Ununnilium [294]	843 13A Uuh Ununhennium [294]	844 14A Uu Ununnilium [294]	845 15A Uuh Ununhennium [294]	846 16A Uu Ununnilium [294]
857 7A Uus Ununseptium [294]	858 8A Uuo Ununoctium [294]	859 9A Uuh Ununhennium [294]	860 10A Uu Ununnilium [294]	861 11A Uuh Ununhennium [294]	862 				

**JBA 2017 – Chemistry Exam 3**

Name: \_\_\_\_\_ Score: \_\_\_\_\_/100 = \_\_\_\_\_/80

**Multiple choice questions are worth two points each.**

1. Amino acids are compounds that contain **both** amine and carboxylic acid groups. Which compound is an amino acid?



Answer   d  

2. If acids are compounds that release protons ( $\text{H}^+$ ), how is it that  $\text{SO}_x$  and  $\text{NO}_x$  cause acid rain?

- a. They react with hydrogen gas in the atmosphere to produce acids.
- b. There is not sufficient evidence to indicate that these compounds actually do cause acid rain.
- c. They react with water to form acids.
- d. They react with ammonia to form acids.

Answer   c  

3. The compound  $\text{CH}_3\text{NH}_2$  reacts with water to form  $\text{CH}_3\text{NH}_3^+$  and  $\text{OH}^-$ . In this reaction,  $\text{CH}_3\text{NH}_2$  is acting as a(n)

- a. salt
- b. base
- c. acid
- d. solvent

Answer   b  

4.  $\text{H}_3\text{O}^+$  is called the

- a. hydroxide ion
- b. hydrogen ion
- c. hydrate ion
- d. hydronium ion

Answer   d  

5. If the concentration of a dilute solution of nitric acid ( $\text{HNO}_3$ ) is 0.00010 M, what is the pH of that solution?

- a. 14.0
- b. 7.0
- c. 4.0
- d. 5.0

Answer   c

Please write legibly! If I can't read it, I can't grade it!

6. The pH of a sample of water from a river is 6.0. A sample of wastewater from a food processing plant has a pH of 4.0. The concentration of hydronium ion in the wastewater is

- a. two times *larger* than the river hydronium ion concentration.
- b. one hundred times *larger* than the river hydronium ion concentration.
- c. two times *smaller* than the river hydronium ion concentration.
- d. one hundred times *smaller* than the river hydronium ion concentration.

Answer   **b**  

7. The primary structure of a protein is determined by

- a. the intertwining of protein molecules.
- b. the order of amino acids in the protein.
- c. the hydrogen bonding that gives the protein three-dimensional shape.
- d. the amino acid composition.

Answer   **b**  

8. All of the following examples are classified as potential energy except

- a. energy in chemical bonds.
- b. energy of a moving object.
- c. energy in nuclear particles.
- d. energy stored by position.

Answer   **b**  

9. There are only four amine-containing bases that comprise DNA. Which of the following bases is not found in DNA (but is found in RNA)? (Hint check your powerpoint notes)

- a. adenine
- b. guanine.
- c. cytosine.
- d. uracil.

Answer   **d**  

10. What volume of 2.00 M HCl is required to prepare 100 mL of 0.200 M HCl?

- a. 0.11 mL
- b. 1.0 mL
- c. 10 mL
- d. 100 mL

Answer   **c**

Please write legibly! If I can't read it, I can't grade it!

11. Match the term with its definition. (10 points)

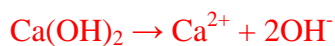
__E__ pH	A. a concentration term expressed in moles per liter
__F__ solvent	B. a water insoluble compound containing at least one carbon-carbon multiple bond
__A__ molarity	C. an substance that donates 2 protons ( $H^+$ )
__C__ diprotic acid	D. a compound with the formula $C_n(H_2O)_n$ .
__B__ unsaturated fat	E. $-\log[H^+]$
__D__ carbohydrate	F. the substance in which a solute is dissolved
__I__ state function	G. the species that forms when an acid has donated its proton
__G__ conjugate base	H. a water insoluble compound with no carbon-carbon multiple bonds
__J__ enzyme	I. a thermodynamic concept that does not depend on pathway (or mechanism).
__H__ saturated fat	J. a biochemical catalyst

12. Write reactions for the following: (2 points each)

a. The dissociation of nitric acid ( $HNO_3$ , a strong acid)



b. The dissociation of calcium hydroxide ( $Ca(OH)_2$ , a strong base)



c. The reaction of hydrochloric acid ( $HCl$ ) with potassium hydroxide ( $KOH$ ).



Please write legibly! If I can't read it, I can't grade it!

13. Complete the following table: (10 points)

Compound	Molarity	pH	pOH	Acidic, Basic or Neutral?
H <sub>2</sub> SO <sub>4</sub>	0.012 M	1.62	12.38	Acidic
KOH	0.0035 M	11.54	2.46	Basic

14. You dissolved 38.0 g of glucose (C<sub>6</sub>H<sub>12</sub>O<sub>6</sub>) in 0.750 L. What is its molarity? (8 points)

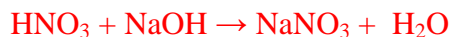
$$38.0 \text{ g C}_6\text{H}_{12}\text{O}_6 \times \frac{1 \text{ mol C}_6\text{H}_{12}\text{O}_6}{180.16 \text{ g C}_6\text{H}_{12}\text{O}_6} = 0.211 \text{ mol C}_6\text{H}_{12}\text{O}_6$$

$$\frac{0.211 \text{ mol C}_6\text{H}_{12}\text{O}_6}{0.750 \text{ L}} = 0.281 \text{ M C}_6\text{H}_{12}\text{O}_6$$

15. In a beaker, you mix 35.0 mL of 0.100 M HNO<sub>3</sub> and 30.0 mL of 0.200 M NaOH (8 points)

**(NOTE there was a typo on the original exam so only part a was graded)**

a. Write the balanced reaction that you would expect to occur. (2 points)



b. When the reaction is complete, will the resulting solution be acidic, basic, or neutral?

Explain your decision. (6 points)

We have

$$0.035 \text{ L HNO}_3 \times \frac{0.100 \text{ mol HNO}_3}{1 \text{ L}} = 0.0035 \text{ mol HNO}_3$$

and

$$0.030 \text{ L NaOH} \times \frac{0.200 \text{ mol NaOH}}{1 \text{ L}} = 0.0060 \text{ mol NaOH}$$

Since we have more moles of NaOH than HNO<sub>3</sub> and since the stoichiometry is 1 mol HNO<sub>3</sub> per 1 mol NaOH, HNO<sub>3</sub> must be the limiting reactant. Therefore, NaOH will remain and since NaOH is a strong base, the solution will be basic.

16. What is the purpose of a catalyst in a chemical reaction? How do enzymes accomplish this purpose? (8 points)

Catalysts increase the rate of a reaction without themselves being consumed in the reaction. They accomplish this by providing an alternate mechanism with a lower activation energy. Enzymes accomplish this by holding molecules in a specific position to allow the reaction to occur.

Please write legibly! If I can't read it, I can't grade it!

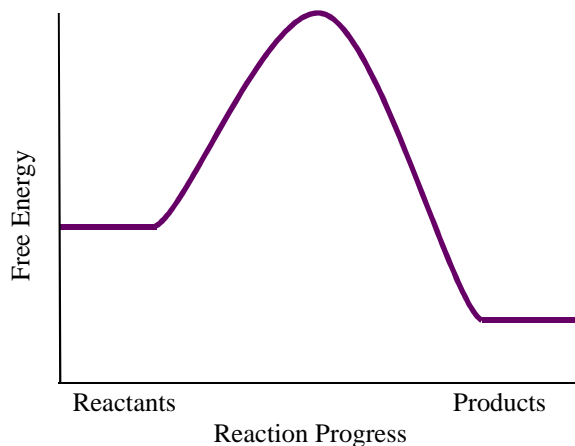
17. In the copper lab, we used 15 mL of 3.0 M sodium hydroxide solution to begin the alloy formation. How many grams of NaOH are present in 15 mL of 3.0 M NaOH? (8 points)

$$0.015 \text{ L NaOH} \times \frac{3.0 \text{ mol NaOH}}{1 \text{ L}} = 0.045 \text{ mol NaOH}$$

$$0.045 \text{ mol NaOH} \times \frac{40.00 \text{ g NaOH}}{1 \text{ mol NaOH}} = 1.8 \text{ g NaOH}$$

18. Draw a reaction coordinate diagram below for a spontaneous (favorable) process. Label the axes and describe how information related to the tendency and rate of the reaction can be extracted from such a diagram. (10 points)

Your diagram for the spontaneous and slow reaction should bear some resemblance to the picture below and meet the following requirements: 1) the axes must be labeled, 2) the free energy for the reactants must be higher than the free energy of the products so that  $\Delta G$  is negative (spontaneous), 3) the size of the activation barrier (hill) must be present, and relatively large to indicate a slow reaction. Your discussion should point out these items and how the tendency is determined by the relative energies of the reactants and products and the rate is determined by the activation energy.



Please write legibly! If I can't read it, I can't grade it!

19. Hydrochloric acid (HCl) is classified as a strong acid, while acetic acid (CH<sub>3</sub>COOH) is classified as a weak acid. Explain what these terms mean. If you could examine a solution of HCl and a separate solution of acetic acid on a molecular level, what would you expect to see in each? (8 points)

Strong acids dissociate completely, while weak acids do not. In a solution of HCl, we would expect to find only H<sup>+</sup> and Cl<sup>-</sup>, but no "HCl". In a solution of CH<sub>3</sub>COOH, we would expect to find H<sup>+</sup>, CH<sub>3</sub>COO<sup>-</sup>, but also a significant amount of CH<sub>3</sub>COOH. A diagram may be useful.

20. Ammonia gas can be created by heating ammonium chloride and calcium hydroxide. Calcium chloride and water are also produced as products. You conduct an experiment where 25.0 mL of 5.89 M ammonium chloride solution is slowly added to 33.0 grams of solid calcium hydroxide while the mixture is heated.

a. Balance reaction for this process. (2 points)



b. How many moles of ammonium chloride are introduced to the reaction? (3 points)

$$0.025 \text{ L NH}_4\text{Cl} \times \frac{5.89 \text{ mol NH}_4\text{Cl}}{1 \text{ L}} = 0.1473 \text{ mol NH}_4\text{Cl}$$

c. How many moles of calcium chloride are introduced to the reaction? (3 points)

$$33.0 \text{ g Ca(OH)}_2 \times \frac{1 \text{ mol Ca(OH)}_2}{74.09 \text{ g Ca(OH)}_2} = 0.445 \text{ mol Ca(OH)}_2$$

d. What mass of ammonia is formed? (4 points)

If NH<sub>4</sub>Cl is limiting reactant:

$$0.1473 \text{ mol NH}_4\text{Cl} \times \frac{2 \text{ mol NH}_3}{2 \text{ mol NH}_4\text{Cl}} \times \frac{17.03 \text{ g NH}_3}{1 \text{ mol NH}_3} = 2.51 \text{ g NH}_3$$

If Ca(OH)<sub>2</sub> is limiting reactant:

$$0.445 \text{ mol Ca(OH)}_2 \times \frac{2 \text{ mol NH}_3}{1 \text{ mol Ca(OH)}_2} \times \frac{17.03 \text{ g NH}_3}{1 \text{ mol NH}_3} = 15.16 \text{ g NH}_3$$

So, ammonium chloride is the limiting reactant and 2.51 g of ammonia is formed.