

Chemistry 107 : Exam 2A

The 100 pts exam consists of 8 questions and students have 2 hours to complete the exam. Answers must be written in the box provided or else no credit is provided. Use the empty space provided to do your work. A periodic table and formulas are provided at the end. Additional scratch paper will be provided. Fill in your name along with your student ID number.

Problem 1 : True/False Determine whether the statement is true or false. (20 pts)

- (a) Catalysts speed up the chemical reaction by lowering the activation Energy. (E_A)

- (b) Chemical reactions that release heat to the surrounding are endothermic reactions.

- (c) For a solution at concentration M , doubling the volume of the solution leads to doubling the concentration.

- (d) When mixing 1L of 90°C water and 0.5L of 10°C water, the final temperature at thermal equilibrium is 50°C.

- (e) For a chemical reaction, the theoretical yield of a product depends on the excess reagent.

- (f) As the wavelength increases, the energy of the photon decreases.

- (g) Chemical equations are balanced by changing the subscripts of the compounds.

- (h) An example of an endothermic process is the melting of ice into water.

- (i) Suppose a system is in thermal equilibrium with a heat bath. When the temperature of the heat bath increases, the temperature of the system increases.

- (j) The Bohr model can accurately predict the spectra of large atoms.

Problem 2 : Thermal Equilibrium (12 pts)

(a) 700.0g of Cu metal block is heated to 350.0°C and then, dropped into 1,000.g of water at 0°C. The specific heats of water and copper are 4.184 J/(g °C) and 0.3850 J/(g °C), respectively. Determine the final temperature at which the Cu and water are in thermal equilibrium. Report to 4 significant figures.

(b) Describe using illustrations and/or equations to show how thermal equilibrium is achieved. Include the initial and final states of the Cu and water.

Problem 3 : Nomenclature Provide either the molecular formula or compound name for the following. (12 pts)

(a) Magnesium oxide

(b) Carbon Monoxide

(c) HClO_4

(d) $\text{Ca}(\text{HCO}_3)_2$

(e) Carbonic acid

(f) H_3PO_4

(g) $(\text{NH}_4)_2\text{Cr}_2\text{O}_7$

(h) BF_3

(i) Phosphorus pentafluoride

(j) Sulfurous acid

(k) Chromium(VI) oxide

(l) V_2O_5

Problem 4 : Preparing Solutions Anhydrous calcium chloride (CaCl_2) can easily absorb water from the air. To prepare a solution, the stable solid calcium chloride dihydrate ($\text{CaCl}_2 \cdot 2\text{H}_2\text{O}$) is more suitable to prepare stock solutions. Answer the following questions and report to 3 significant figures. (12 pts)

- (a) A scientist prepares 2L stock solution of 5M CaCl_2 . Determine what mass (in g) of $\text{CaCl}_2 \cdot 2\text{H}_2\text{O}$ needed to prepare the solution.

- (b) Using the prepared 5M CaCl_2 stock solution, the scientist is diluting the solution to make 250.mL of 1.5M CaCl_2 . What volume in L of stock solution is needed to dilute to prepare 250.mL of 1.5M CaCl_2 ?

- (c) From part (b), describe how to dilute concentrated 5M CaCl_2 solution to make 250.mL of 1.5M CaCl_2 . Include the solvent and main lab equipment(s) used to perform the dilution.

Problem 5 : Predicting Chemical Reactions For the following reagents, determine the products formed by writing the balanced chemical equation including states and if there is no reaction, write “no reaction.” (10 pts)

- (a) Solid iron wool ignited in the presence of oxygen gas

- (b) Placing solid lithium metal into water

- (c) The combustion of fructose ($C_6H_{12}O_6$) in the presence of oxygen gas

- (d) Mixing aqueous silver nitrate and aqueous potassium dichromate

- (e) Mixing aqueous Copper(II) Sulfate and aqueous sodium hydroxide

Problem 6 : Acid-Base Reaction To neutralize phosphoric acid, sodium hydroxide is used to form a salt and water. Report to 3 significant figures. (6 pts)

- (a) Write the balanced chemical equation including states.

- (b) Suppose there is 50mL of 1M phosphoric acid, how much volume in L of 1.25M sodium hydroxide is needed to completely react with phosphoric acid?

Problem 7 : Combustion Reaction Methane is a colorless, odorless gas which is used as a fuel in most gas stoves to cook food. Per year, the US uses approximately 31.13 trillion ($\times 10^{12}$) ft³ of methane per year. Approximately 2% of that is used for cooking. Report to 4 significant figures. (14 pts)

- (a) Write the balanced chemical equation including states of the combustion reaction of methane.

- (b) In the presence of excess oxygen gas, determine the amount of carbon dioxide is produced in g? Report in scientific notation and the density of methane is 19.06g/ft³.

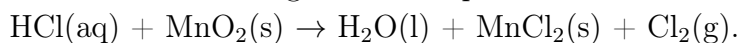
- (c) The combustion reaction of methane releases 810.0 kJ/mol. Is this an exothermic or endothermic reaction? How much heat is generated from cooking? Report in scientific notation.

- (d) Gas companies add a compound which has an odor to help detect gas leaks should they arise. The compound that is added to natural gas is called t-butyl mercaptan and has the formula C₄H₉SH. Predict the products by writing out the balanced chemical equation including states.

- (e) From part (c), determine the amount of carbon dioxide in kg is produced from 1kg of t-butyl mercaptan.

Problem 8 : Limiting Reagent and Percent Yield Small amounts of chlorine gas can be generated in the laboratory from the reaction of manganese(IV) oxide with hydrochloric acid. Report to 3 significant figures. (14 pts)

- (a) Balance the following chemical equation :



- (b) What is the theoretical yield of Cl_2 produced from 42.7g HCl and 67.0g MnO_2 ?

- (c) How much of the excess reagent in g is leftover ?

- (d) If 50g of $\text{Cl}_2(\text{g})$ is collected, determine the percent yield.

Chemistry 107 : Appendix 1 - Periodic Table

1 H Hydrogen 1.008	3 Li Lithium 6.94	11 Na Sodium 22.990	19 K Potassium 39.098	37 Rb Rubidium 85.468	55 Cs Cesium 132.905	87 Fr Francium [223]	2 He Helium 4.003	10 Ne Neon 20.180	18 Ar Argon 39.948	36 Kr Krypton 83.798	54 Xe Xenon 131.293	86 Rn Radon [222]
4 Be Beryllium 9.012	12 Mg Magnesium 24.305	20 Ca Calcium 40.078	38 Sr Strontium 87.62	56 Ba Barium 137.327	88 Ra Radium [226]	9 F Fluorine 18.998	17 Cl Chlorine 35.45	35 Br Bromine 79.904	53 I Iodine 126.904	85 At Astatine [210]	118 Og Oganesson [294]	
5 B Boron 10.81	13 Al Aluminum 26.982	31 Ga Gallium 69.723	49 In Indium 114.818	81 Tl Thallium 204.38	113 Nh Nihonium [286]	6 C Carbon 12.011	14 Si Silicon 28.085	32 Ge Germanium 72.630	50 Sn Tin 118.710	82 Pb Lead 207.2	114 Fl Flerovium [289]	
7 N Nitrogen 14.007	15 P Phosphorus 30.974	33 As Arsenic 74.922	51 Sb Antimony 121.760	83 Bi Bismuth 208.980	115 Mc Moscovium [289]	8 O Oxygen 15.999	16 S Sulfur 32.06	34 Se Selenium 78.97	52 Te Tellurium 127.60	84 Po Polonium [209]	116 Lv Livermorium [293]	
9 F Fluorine 18.998	17 Cl Chlorine 35.45	35 Br Bromine 79.904	53 I Iodine 126.904	85 At Astatine [210]	117 Ts Tennessine [293]	1 H Hydrogen 1.008	3 Li Lithium 6.94	11 Na Sodium 22.990	19 K Potassium 39.098	37 Rb Rubidium 85.468	55 Cs Cesium 132.905	87 Fr Francium [223]
2 He Helium 4.003	10 Ne Neon 20.180	18 Ar Argon 39.948	36 Kr Krypton 83.798	54 Xe Xenon 131.293	86 Rn Radon [222]	5 B Boron 10.81	13 Al Aluminum 26.982	31 Ga Gallium 69.723	49 In Indium 114.818	81 Tl Thallium 204.38	113 Nh Nihonium [286]	115 Mc Moscovium [289]
6 C Carbon 12.011	14 Si Silicon 28.085	32 Ge Germanium 72.630	50 Sn Tin 118.710	82 Pb Lead 207.2	114 Fl Flerovium [289]	13 Al Aluminum 26.982	31 Ga Gallium 69.723	49 In Indium 114.818	81 Tl Thallium 204.38	113 Nh Nihonium [286]	115 Mc Moscovium [289]	117 Ts Tennessine [293]
7 N Nitrogen 14.007	15 P Phosphorus 30.974	33 As Arsenic 74.922	51 Sb Antimony 121.760	83 Bi Bismuth 208.980	115 Mc Moscovium [289]	15 P Phosphorus 30.974	33 As Arsenic 74.922	51 Sb Antimony 121.760	83 Bi Bismuth 208.980	115 Mc Moscovium [289]	117 Ts Tennessine [293]	119 Nh Nihonium [286]
8 O Oxygen 15.999	16 S Sulfur 32.06	34 Se Selenium 78.97	52 Te Tellurium 127.60	84 Po Polonium [209]	116 Lv Livermorium [293]	16 S Sulfur 32.06	34 Se Selenium 78.97	52 Te Tellurium 127.60	84 Po Polonium [209]	116 Lv Livermorium [293]	118 Og Oganesson [294]	120 Ds Darmstadtium [281]
9 F Fluorine 18.998	17 Cl Chlorine 35.45	35 Br Bromine 79.904	53 I Iodine 126.904	85 At Astatine [210]	117 Ts Tennessine [293]	17 Cl Chlorine 35.45	35 Br Bromine 79.904	53 I Iodine 126.904	85 At Astatine [210]	117 Ts Tennessine [293]	119 Nh Nihonium [286]	121 Nh Nihonium [286]
10 Ne Neon 20.180	18 Ar Argon 39.948	36 Kr Krypton 83.798	54 Xe Xenon 131.293	86 Rn Radon [222]	118 Og Oganesson [294]	18 Ar Argon 39.948	36 Kr Krypton 83.798	54 Xe Xenon 131.293	86 Rn Radon [222]	118 Og Oganesson [294]	120 Ds Darmstadtium [281]	122 Nh Nihonium [286]
11 Na Sodium 22.990	19 K Potassium 39.098	37 Rb Rubidium 85.468	55 Cs Cesium 132.905	87 Fr Francium [223]	119 Nh Nihonium [286]	19 K Potassium 39.098	37 Rb Rubidium 85.468	55 Cs Cesium 132.905	87 Fr Francium [223]	119 Nh Nihonium [286]	121 Nh Nihonium [286]	123 Nh Nihonium [286]
12 Mg Magnesium 24.305	20 Ca Calcium 40.078	38 Sr Strontium 87.62	56 Ba Barium 137.327	88 Ra Radium [226]	120 Ds Darmstadtium [281]	20 Ca Calcium 40.078	38 Sr Strontium 87.62	56 Ba Barium 137.327	88 Ra Radium [226]	120 Ds Darmstadtium [281]	122 Nh Nihonium [286]	124 Nh Nihonium [286]
13 Al Aluminum 26.982	31 Ga Gallium 69.723	49 In Indium 114.818	81 Tl Thallium 204.38	113 Nh Nihonium [286]	121 Nh Nihonium [286]	31 Ga Gallium 69.723	49 In Indium 114.818	81 Tl Thallium 204.38	113 Nh Nihonium [286]	121 Nh Nihonium [286]	123 Nh Nihonium [286]	125 Nh Nihonium [286]
14 Si Silicon 28.085	32 Ge Germanium 72.630	50 Sn Tin 118.710	82 Pb Lead 207.2	114 Fl Flerovium [289]	122 Nh Nihonium [286]	32 Ge Germanium 72.630	50 Sn Tin 118.710	82 Pb Lead 207.2	114 Fl Flerovium [289]	122 Nh Nihonium [286]	124 Nh Nihonium [286]	126 Nh Nihonium [286]
15 P Phosphorus 30.974	33 As Arsenic 74.922	51 Sb Antimony 121.760	83 Bi Bismuth 208.980	115 Mc Moscovium [289]	123 Nh Nihonium [286]	33 As Arsenic 74.922	51 Sb Antimony 121.760	83 Bi Bismuth 208.980	115 Mc Moscovium [289]	123 Nh Nihonium [286]	125 Nh Nihonium [286]	127 Nh Nihonium [286]
16 S Sulfur 32.06	34 Se Selenium 78.97	52 Te Tellurium 127.60	84 Po Polonium [209]	116 Lv Livermorium [293]	124 Nh Nihonium [286]	34 Se Selenium 78.97	52 Te Tellurium 127.60	84 Po Polonium [209]	116 Lv Livermorium [293]	124 Nh Nihonium [286]	126 Nh Nihonium [286]	128 Nh Nihonium [286]
17 Cl Chlorine 35.45	35 Br Bromine 79.904	53 I Iodine 126.904	85 At Astatine [210]	117 Ts Tennessine [293]	125 Nh Nihonium [286]	35 Br Bromine 79.904	53 I Iodine 126.904	85 At Astatine [210]	117 Ts Tennessine [293]	125 Nh Nihonium [286]	127 Nh Nihonium [286]	129 Nh Nihonium [286]
18 Ar Argon 39.948	36 Kr Krypton 83.798	54 Xe Xenon 131.293	86 Rn Radon [222]	118 Og Oganesson [294]	126 Nh Nihonium [286]	36 Kr Krypton 83.798	54 Xe Xenon 131.293	86 Rn Radon [222]	118 Og Oganesson [294]	126 Nh Nihonium [286]	128 Nh Nihonium [286]	130 Nh Nihonium [286]
19 K Potassium 39.098	37 Rb Rubidium 85.468	55 Cs Cesium 132.905	87 Fr Francium [223]	119 Nh Nihonium [286]	127 Nh Nihonium [286]	37 Rb Rubidium 85.468	55 Cs Cesium 132.905	87 Fr Francium [223]	119 Nh Nihonium [286]	127 Nh Nihonium [286]	129 Nh Nihonium [286]	131 Nh Nihonium [286]
20 Ca Calcium 40.078	38 Sr Strontium 87.62	56 Ba Barium 137.327	88 Ra Radium [226]	120 Ds Darmstadtium [281]	128 Nh Nihonium [286]	38 Sr Strontium 87.62	56 Ba Barium 137.327	88 Ra Radium [226]	120 Ds Darmstadtium [281]	128 Nh Nihonium [286]	130 Nh Nihonium [286]	132 Nh Nihonium [286]
21 Sc Scandium 44.956	39 Y Yttrium 88.906	71 Lu Lutetium 174.967	103 Lr Lawrencium [262]	129 Nh Nihonium [286]	129 Nh Nihonium [286]	39 Y Yttrium 88.906	71 Lu Lutetium 174.967	103 Lr Lawrencium [262]	129 Nh Nihonium [286]	129 Nh Nihonium [286]	131 Nh Nihonium [286]	133 Nh Nihonium [286]
22 Ti Titanium 47.867	40 Zr Zirconium 91.224	72 Hf Hafnium 178.49	104 Rf Rutherfordium [267]	130 Nh Nihonium [286]	130 Nh Nihonium [286]	40 Zr Zirconium 91.224	72 Hf Hafnium 178.49	104 Rf Rutherfordium [267]	130 Nh Nihonium [286]	130 Nh Nihonium [286]	132 Nh Nihonium [286]	134 Nh Nihonium [286]
23 V Vanadium 50.942	41 Nb Niobium 92.906	73 Ta Tantalum 180.948	105 Db Dubnium [270]	131 Nh Nihonium [286]	131 Nh Nihonium [286]	41 Nb Niobium 92.906	73 Ta Tantalum 180.948	105 Db Dubnium [270]	131 Nh Nihonium [286]	131 Nh Nihonium [286]	133 Nh Nihonium [286]	135 Nh Nihonium [286]
24 Cr Chromium 51.996	42 Mo Molybdenum 95.95	74 W Tungsten 183.84	106 Sg Seaborgium [269]	132 Nh Nihonium [286]	132 Nh Nihonium [286]	42 Mo Molybdenum 95.95	74 W Tungsten 183.84	106 Sg Seaborgium [269]	132 Nh Nihonium [286]	132 Nh Nihonium [286]	134 Nh Nihonium [286]	136 Nh Nihonium [286]
25 Mn Manganese 54.938	43 Tc Technetium [97]	75 Re Rhenium 186.207	107 Bh Bohrium [270]	133 Nh Nihonium [286]	133 Nh Nihonium [286]	43 Tc Technetium [97]	75 Re Rhenium 186.207	107 Bh Bohrium [270]	133 Nh Nihonium [286]	133 Nh Nihonium [286]	135 Nh Nihonium [286]	137 Nh Nihonium [286]
26 Fe Iron 55.845	44 Ru Ruthenium 101.07	76 Os Osmium 190.23	108 Hs Hassium [270]	134 Nh Nihonium [286]	134 Nh Nihonium [286]	44 Ru Ruthenium 101.07	76 Os Osmium 190.23	108 Hs Hassium [270]	134 Nh Nihonium [286]	134 Nh Nihonium [286]	136 Nh Nihonium [286]	138 Nh Nihonium [286]
27 Co Cobalt 58.933	45 Rh Rhodium 102.906	78 Ir Iridium 192.217	109 Mt Meitnerium [278]	135 Nh Nihonium [286]	135 Nh Nihonium [286]	45 Rh Rhodium 102.906	78 Ir Iridium 192.217	109 Mt Meitnerium [278]	135 Nh Nihonium [286]	135 Nh Nihonium [286]	137 Nh Nihonium [286]	139 Nh Nihonium [286]
28 Ni Nickel 58.693	46 Pd Palladium 106.42	79 Pt Platinum 195.084	110 Ds Darmstadtium [281]	136 Nh Nihonium [286]	136 Nh Nihonium [286]	46 Pd Palladium 106.42	79 Pt Platinum 195.084	110 Ds Darmstadtium [281]	136 Nh Nihonium [286]	136 Nh Nihonium [286]	138 Nh Nihonium [286]	140 Nh Nihonium [286]
29 Cu Copper 63.546	47 Ag Silver 107.868	80 Au Gold 196.967	111 Rg Roentgenium [281]	137 Nh Nihonium [286]	137 Nh Nihonium [286]	47 Ag Silver 107.868	80 Au Gold 196.967	111 Rg Roentgenium [281]	137 Nh Nihonium [286]	137 Nh Nihonium [286]	139 Nh Nihonium [286]	141 Nh Nihonium [286]
30 Zn Zinc 65.38	48 Cd Cadmium 112.414	81 Hg Mercury 200.592	112 Cn Copernicium [285]	138 Nh Nihonium [286]	138 Nh Nihonium [286]	48 Cd Cadmium 112.414	81 Hg Mercury 200.592	112 Cn Copernicium [285]	138 Nh Nihonium [286]	138 Nh Nihonium [286]	140 Nh Nihonium [286]	142 Nh Nihonium [286]
31 Ga Gallium 69.723	49 In Indium 114.818	81 Tl Thallium 204.38	113 Nh Nihonium [286]	139 Nh Nihonium [286]	139 Nh Nihonium [286]	49 In Indium 114.818	81 Tl Thallium 204.38	113 Nh Nihonium [286]	139 Nh Nihonium [286]	139 Nh Nihonium [286]	141 Nh Nihonium [286]	143 Nh Nihonium [286]
32 Ge Germanium 72.630	50 Sn Tin 118.710	82 Pb Lead 207.2	114 Fl Flerovium [289]	140 Nh Nihonium [286]	140 Nh Nihonium [286]	50 Sn Tin 118.710	82 Pb Lead 207.2	114 Fl Flerovium [289]	140 Nh Nihonium [286]	140 Nh Nihonium [286]	142 Nh Nihonium [286]	144 Nh Nihonium [286]
33 As Arsenic 74.922	51 Sb Antimony 121.760	83 Bi Bismuth 208.980	115 Mc Moscovium [289]	141 Nh Nihonium [286]	141 Nh Nihonium [286]	51 Sb Antimony 121.760	83 Bi Bismuth 208.980	115 Mc Moscovium [289]	141 Nh Nihonium [286]	141 Nh Nihonium [286]	143 Nh Nihonium [286]	145 Nh Nihonium [286]
34 Se Selenium 78.97	52 Te Tellurium 127.60	84 Po Polonium [209]	116 Lv Livermorium [293]	142 Nh Nihonium [286]	142 Nh Nihonium [286]	52 Te Tellurium 127.60	84 Po Polonium [209]	116 Lv Livermorium [293]	142 Nh Nihonium [286]	142 Nh Nihonium [286]	144 Nh Nihonium [286]	146 Nh Nihonium [286]
35 Br Bromine 79.904	53 I Iodine 126.904	85 At Astatine [210]	117 Ts Tennessine [293]	143 Nh Nihonium [286]	143 Nh Nihonium [286]	53 I Iodine 126.904	85 At Astatine [210]	117 Ts Tennessine [293]	143 Nh Nihonium [286]	143 Nh Nihonium [286]	145 Nh Nihonium [286]	147 Nh Nihonium [286]
36 Kr Krypton 83.798	54 Xe Xenon 131.293	86 Rn Radon [222]	118 Og Oganesson [294]	144 Nh Nihonium [286]	144 Nh Nihonium [286]	54 Xe Xenon 131.293	86 Rn Radon [222]	118 Og Oganesson [294]	144 Nh Nihonium [286]	144 Nh Nihonium [286]	146 Nh Nihonium [286]	148 Nh Nihonium [286]
37 Rb Rubidium 85.468	55 Cs Cesium 132.905	87 Fr Francium [223]	119 Nh Nihonium [286]	145 Nh Nihonium [286]	145 Nh Nihonium [286]	55 Cs Cesium 132.905	87 Fr Francium [223]	119 Nh Nihonium [286]	145 Nh Nihonium [286]	145 Nh Nihonium [286]	147 Nh Nihonium [286]	149 Nh Nihonium [286]
38 Sr Strontium 87.62	56 Ba Barium 137.327	88 Ra Radium [226]	120 Ds Darmstadtium [281]	146 Nh Nihonium [286]	146 Nh Nihonium [286]	56 Ba Barium 137.327	88 Ra Radium [226]	120 Ds Darmstadtium [281]	146 Nh Nihonium [286]	146 Nh Nihonium [286]	148 Nh Nihonium [286]	150 Nh Nihonium [286]
39 Y Yttrium 88.906	71 Lu Lutetium 174.967	103 Lr Lawrencium [262]	129 Nh Nihonium [286]	147 Nh Nihonium [286]	147 Nh Nihonium [286]	71 Lu Lutetium 174.967	103 Lr Lawrencium [262]	129 Nh Nihonium [286]	147 Nh Nihonium [286]	147 Nh Nihonium [286]	149 Nh Nihonium [286]	151 Nh Nihonium [286]
40 Zr Zirconium 91.224	72 Hf Hafnium 178.49	104 Rf Rutherfordium [267]	130 Nh Nihonium [286]	148 Nh Nihonium [286]	148 Nh Nihonium [286]	72 Hf Hafnium 178.49	104 Rf Rutherfordium [267]	130 Nh Nihonium [286]	148 Nh Nihonium [286]	148 Nh Nihonium [286]	150 Nh Nihonium [286]	152 Nh Nihonium [286]
41 Nb Niobium 92.906	73 Ta Tantalum 180.948	105 Db Dubnium [270]	131 Nh Nihonium [286]	149 Nh Nihonium [286]	149 Nh Nihonium [286]	73 Ta Tantalum 180.948	105 Db Dubnium [270]	131 Nh Nihonium [286]	149 Nh Nihonium [286]	149 Nh Nihonium [286		

Chemistry 107 : Apppendix 2 - Formulas and Constants

$$q = mC\Delta T$$

$$E = \frac{hc}{\lambda} = h\nu$$

$$h = 6.626 \times 10^{-34} \text{ J s}$$

$$c = \lambda\nu$$

$$c = 3.00 \times 10^8 \text{ m/s}$$