

## 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)  $\text{HClO}_4$

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

(e) Carbonic acid

(f)  $\text{H}_3\text{PO}_4$

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

(h)  $\text{BF}_3$

(i) Phosphorus pentafluoride

(j) Sulfurous acid

(k) Chromium(VI) oxide

(l)  $\text{V}_2\text{O}_5$

**Problem 4 : Preparing Solutions** Anhydrous calcium chloride ( $\text{CaCl}_2$ ) 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  $\text{CaCl}_2$ . 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  $\text{CaCl}_2$  stock solution, the scientist is diluting the solution to make 250.mL of 1.5M  $\text{CaCl}_2$ . What volume in L of stock solution is needed to dilute to prepare 250.mL of 1.5M  $\text{CaCl}_2$  ?

- (c) From part (b), describe how to dilute concentrated 5M  $\text{CaCl}_2$  solution to make 250.mL of 1.5M  $\text{CaCl}_2$ . 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 ( $\times 10^{12}$ ) ft<sup>3</sup> 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/ft<sup>3</sup>.

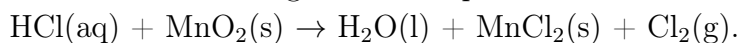
- (c) The combustion reaction of methane releases 810.0 kJ/mol. Is this an exothermic or endothermic reaction? How much heat is generated from cooking? Report in scientific notation.

- (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 C<sub>4</sub>H<sub>9</sub>SH. 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  $\text{Cl}_2$  produced from 42.7g HCl and 67.0g  $\text{MnO}_2$  ?

- (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	2 He Helium 4.003	3 Li Lithium 6.94	4 Be Beryllium 9.012	5 B Boron 10.81	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 28.085	15 P Phosphorus 30.974	16 S Sulfur 32.06	17 Cl Chlorine 35.45	18 Ar Argon 39.948	19 K Potassium 39.098	20 Ca Calcium 40.078
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 [97]	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.906	46 Pd Palladium 106.42
55 Cs Cesium 132.905	56 Ba Barium 137.327	57 - 70 * Lanthanide series	71 Lu Lutetium 174.967	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
87 Fr Francium [223]	88 Ra Radium [226]	89 - 102 ** Actinide series	103 Lr Lawrencium [262]	104 Rf Rutherfordium [267]	105 Db Dubnium [270]	106 Sg Seaborgium [269]	107 Bh Bohrium [270]	108 Hs Hassium [270]	109 Mt Meitnerium [278]
117 Ts Tennessine [293]	118 Og Oganesson [294]	119 Nh Nihonium [286]	120 Dl Darmstadtium [281]	121 Rg Roentgenium [281]	122 Cn Copernicium [285]	123 Nh Nihonium [286]	124 Fl Flerovium [289]	125 Mc Moscovium [289]	126 Lv Livermorium [293]
131 Xe Xenon 131.293	132 At Astatine [210]	133 Po Polonium [209]	134 Bi Bismuth 208.980	135 Pb Lead 207.2	136 Tl Thallium 204.38	137 Pb Lead 207.2	138 Bi Bismuth 208.980	139 Po Polonium [209]	140 At Astatine [210]
151 I Iodine 126.904	152 Te Tellurium 127.60	153 Sb Antimony 121.760	154 Sn Tin 118.710	155 In Indium 114.818	156 Cd Cadmium 112.414	157 Ag Silver 107.868	158 Pd Palladium 106.42	159 Rh Rhodium 102.906	160 Ni Nickel 58.693
171 Br Bromine 79.904	172 Se Selenium 78.97	173 As Arsenic 74.922	174 Ge Germanium 72.630	175 Ga Gallium 69.723	176 Zn Zinc 65.38	177 Cu Copper 63.546	178 Ni Nickel 58.693	179 Co Cobalt 58.933	180 Fe Iron 55.845
191 Kr Krypton 83.798	192 Br Bromine 79.904	193 Se Selenium 78.97	194 As Arsenic 74.922	195 Ga Gallium 69.723	196 Zn Zinc 65.38	197 Cu Copper 63.546	198 Ni Nickel 58.693	199 Co Cobalt 58.933	200 Fe Iron 55.845
211 Rn Radon [222]	212 At Astatine [210]	213 Po Polonium [209]	214 Bi Bismuth 208.980	215 Pb Lead 207.2	216 Tl Thallium 204.38	217 Pb Lead 207.2	218 Bi Bismuth 208.980	219 Po Polonium [209]	220 At Astatine [210]
231 Fr Francium [223]	232 Ra Radium [226]	233 Ac Actinium [227]	234 Th Thorium 232.038	235 Pa Protactinium 231.036	236 U Uranium 238.029	237 Np Neptunium [237]	238 Pu Plutonium [244]	239 Am Americium [243]	240 Cm Curium [247]
251 Db Dubnium [262]	252 Sg Seaborgium [266]	253 Bh Bohrium [270]	254 Hs Hassium [270]	255 Mt Meitnerium [278]	256 Ds Darmstadtium [281]	257 Rg Roentgenium [281]	258 Cn Copernicium [285]	259 Nh Nihonium [286]	260 Fl Flerovium [289]
271 Ts Tennessine [293]	272 Og Oganesson [294]	273 Nh Nihonium [286]	274 Fl Flerovium [289]	275 Mc Moscovium [289]	276 Lv Livermorium [293]	277 Ts Tennessine [293]	278 Og Oganesson [294]	279 Nh Nihonium [286]	280 Fl Flerovium [289]
291 Yb Ytterbium 173.045	292 Lu Lutetium 174.967	293 Hf Hafnium 178.49	294 Ta Tantalum 180.948	295 W Tungsten 183.84	296 Re Rhenium 186.207	297 Os Osmium 190.23	298 Ir Iridium 192.217	299 Pt Platinum 195.084	300 Au Gold 196.967
311 No Nobelium [259]	312 Md Mendelevium [258]	313 Fm Fermium [257]	314 Es Einsteinium [252]	315 Cf Californium [251]	316 Bk Berkelium [247]	317 Cm Curium [247]	318 Am Americium [243]	319 Pu Plutonium [244]	320 Sm Samarium 150.36
331 Yb Ytterbium 173.045	332 Lu Lutetium 174.967	333 Hf Hafnium 178.49	334 Ta Tantalum 180.948	335 W Tungsten 183.84	336 Re Rhenium 186.207	337 Os Osmium 190.23	338 Ir Iridium 192.217	339 Pt Platinum 195.084	340 Au Gold 196.967
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371 Yb Ytterbium 173.045	372 Lu Lutetium 174.967	373 Hf Hafnium 178.49	374 Ta Tantalum 180.948	375 W Tungsten 183.84	376 Re Rhenium 186.207	377 Os Osmium 190.23	378 Ir Iridium 192.217	379 Pt Platinum 195.084	380 Au Gold 196.967
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411 Yb Ytterbium 173.045	412 Lu Lutetium 174.967	413 Hf Hafnium 178.49	414 Ta Tantalum 180.948	415 W Tungsten 183.84	416 Re Rhenium 186.207	417 Os Osmium 190.23	418 Ir Iridium 192.217	419 Pt Platinum 195.084	420 Au Gold 196.967
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731 Yb Ytterbium 173.045	732 Lu Lutetium 174.967	733 Hf Hafnium 178.49	734 Ta Tantalum 180.948	735 W Tungsten 183.84	736 Re Rhenium 186.207	737 Os Osmium 190.23	738 Ir Iridium 192.217	739 Pt Platinum 195.084	740 Au Gold 196.967
751 No Nobelium [259]	752 Md Mendelevium [258]	753 Fm Fermium [257]	754 Es Einsteinium [252]	755 Cf Californium [251]	756 Bk Berkelium [247]	757 Cm Curium [247]	758 Am Americium [243]	759 Pu Plutonium [244]	760 Sm Samarium 150.36
771 Yb Ytterbium 173.045	772 Lu Lutetium 174.967	773 Hf Hafnium 178.49	774 Ta Tantalum 180.948	775 W Tungsten 183.84	776 Re Rhenium 186.207	777 Os Osmium 190.23	778 Ir Iridium 192.217	779 Pt Platinum 195.084	780 Au Gold 196.967
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811 Yb Ytterbium 173.045	812 Lu Lutetium 174.967	813 Hf Hafnium 178.49	814 Ta Tantalum 180.948	815 W Tungsten 183.84	816 Re Rhenium 186.207	817 Os Osmium 190.23	818 Ir Iridium 192.217	819 Pt Platinum 195.084	820 Au Gold 196.967
831 No Nobelium [259]	832 Md Mendelevium [258]	833 Fm Fermium [257]	834 Es Einsteinium [252]	835 Cf Californium [251]	836 Bk Berkelium [247]	837 Cm Curium [247]	838 Am Americium [243]	839 Pu Plutonium [244]	840 Sm Samarium 150.36
851 Yb Ytterbium 173.045	852 Lu Lutetium 174.967	853 Hf Hafnium 178.49	854 Ta Tantalum 180.948	855 W Tungsten 183.84	856 Re Rhenium 186.207	857 Os Osmium 190.23	858 Ir Iridium 192.217	859 Pt Platinum 195.084	860 Au Gold 196.967
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891 Yb Ytterbium 173.045	892 Lu Lutetium 174.967	893 Hf Hafnium 178.49	894 Ta Tantalum 180.948	895 W Tungsten 183.84	896 Re Rhenium 186.207	897 Os Osmium 190.23	898 Ir Iridium 192.217	899 Pt Platinum 195.084	900 Au Gold 196.967
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931 Yb Ytterbium 173.045	932 Lu Lutetium 174.967	933 Hf Hafnium 178.49	934 Ta Tantalum 180.948	935 W Tungsten 183.84	936 Re Rhenium 186.207	937 Os Osmium 190.23	938 Ir Iridium 192.217	939 Pt Platinum 195.084	940 Au Gold 196.967
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971 Yb Ytterbium 173.045	972 Lu Lutetium 174.967	973 Hf Hafnium 178.49	974 Ta Tantalum 180.948	975 W Tungsten 183.84	976 Re Rhenium 186.207	977 Os Osmium 190.23	978 Ir Iridium 192.217	979 Pt Platinum 195.084	980 Au Gold 196.967
991 No Nobelium [259]	992 Md Mendelevium [258]	993 Fm Fermium [257]	994 Es Einsteinium [252]	995 Cf Californium [251]	996 Bk Berkelium [247]	997 Cm Curium [247]	998 Am Americium [243]	999 Pu Plutonium [244]	1000 Sm Samarium 150.36



# Chemistry 107 : Apppendix 2 - Formulas and Constants

$$q = mC\Delta T$$

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

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

$$c = \lambda\nu$$

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