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Chemistry 107 : Exam 2B

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 : 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^3 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^3.

(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.

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(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 call t-butyl mercaptan and has the formula C_4H_9SH. 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.

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Problem 2 : Nomenclature Provide either the molecular formula or compound name for the following. (12 pts)

(a) Magnesium oxide

(b) Carbon Monoxide

(c) $HClO_4$

(d) $Ca(HCO_3)_2$

(e) Carbonic acid

(f) H_3PO_4

(g) $(NH_4)_2Cr_2O_7$

(h) BF_3

(i) Phosphorus pentafluoride

(j) Sulfurous acid

(k) Chromium(VI) oxide

(l) V_2O_5

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Problem 3 : 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.

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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 ($CaCl_2 \cdot 2H_2O$) 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 $CaCl_2 \cdot 2H_2O$ 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.

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Problem 5 : 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.

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Problem 6 : Limiting Reagent and Percent Yield Small amounts of chlorine gas can be generated in the laborator from the reaction of manganese(IV) oxide with hydrochloric acd. Report to 3 significant figures. (14 pts)

(a) Balance the following chemical equation :
$HCl(aq) + MnO_2(s) \rightarrow H_2O(l) + MnCl_2(s) + Cl_2(g)$.

(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 $Cl_2(g)$ is collected, determine the percent yield.

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Problem 7 : 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 aqeuous Copper(II) Sulfate and aqueous sodium hydroxide

Problem 8 : 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 ?

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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		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 72.630	33 As Arsenic 74.922	34 Se Selenium 78.97	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 [97]	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 118.710	51 Sb Antimony 121.760	53 Te Tellurium 127.60	53 I Iodine 126.904	54 Xe Xenon 131.293
55 Cs Cesium 132.905	56 Ba Barium 137.327	* 57 - 70	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	78 Ir Iridium 192.217	79 Pt Platinum 195.084	80 Au Gold 196.997	81 Hg Mercury 200.592	81 Tl Thallium 204.38	82 Pb Lead 207.2	83 Bi Bismuth 208.980	84 Po Polonium [209]	85 At Astatine [210]	86 Rn Radon [222]
87 Fr Francium [223]	88 Ra Radium [226]	** 89 - 102	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]	110 Ds Darmstadtium [281]	111 Rg Roentgenium [281]	112 Cn Copernicium [285]	113 Nh Nihonium [286]	114 Fl Flerovium [289]	115 Mc Moscovium [289]	116 Lv Livermorium [293]	117 Ts Tennessine [293]	118 Og Oganesson [294]

*Lanthanide series	57 La Lanthanum 138.905	58 Ce Cerium 140.116	59 Pr Praseodymium 140.908	60 Nd Neodymium 144.242	61 Pm Promethium [145]	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 173.045
**Actinide series	89 Ac Actinium [227]	90 Th Thorium 232.038	91 Pa Protactinium 231.036	92 U Uranium 238.029	93 Np Neptunium [237]	94 Pu Plutonium [244]	95 Am Americium [243]	96 Cm Curium [247]	97 Bk Berkelium [247]	98 Cf Californium [251]	99 Es Einsteinium [252]	100 Fm Fermium [257]	101 Md Mendelevium [258]	102 No Nobelium [259]

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Chemistry 107 : Apppendix 2 - Formulas and Constants

$$q = mC\Delta T$$
$$E = \frac{hc}{\lambda} = h\nu$$
$$h = 6.626 \times 10^{-34} \text{J s}$$
$$c = \lambda\nu$$
$$c = 3.00 \times 10^{8} \text{m/s}$$