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Chemistry 123 : Exam 2A

The 60 pts exam consists of 5 questions and students have the whole class period 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 is provided at the end. Fill in your name along with your student ID number.

Problem 1 : Molarity - Acid/Base Reaction Titration is a technique used to determine an unknown of a solution. (12 pts)

(a) To begin the experiment, 5 mL of 12.00 M NaOH stock solution is diluted to 240 mL. What is the new concentration ?

(b) Given the NaOH(aq) concentration from part a), NaOH(aq) is used to titrate acetic acid (CH_3COOH) by the chemical equation

$$NaOH(aq) + HCN(aq) \rightarrow H_2O(l) + NaCN(aq)$$

Determine what volume of NaOH(aq) solution is needed to react with 0.350g HCN.

(c) Using the NaOH(aq) concentration from part a), you titrate 0.290 g of unknown monoprotic acid, which only releases one hydrogen ion (H^+). To completely react all the acid, you used 25.20 mL of NaOH(aq) solution. What is the molar mass of the uknown acid ? Hint : Recall the units for molar mass (g/mol).

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Problem 2 : Thermal Equilibrium (12 pts)

(a) True/False. If two objects are in contact and reach thermal equilibrium, there is no flow of heat between the two objects.

(b) 450.0g of Fe 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 Fe are 4.184 J/(g °C) and 0.451 J/(g °C), respectively. Determine the final temperature at which the Al and water are in thermal equilibrium. Report to 4 significant figures.

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

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Problem 3 : Hess's Law Given the overall reaction : (12 pts)

$3\ Fe_2O_3(s) + CO(g) \rightarrow 2\ Fe_3O_4(s) + CO_2(g)$

Given the folowing data :

$Fe_2O_3(s) + 3\ CO(g) \rightarrow 2\ Fe(s) + 3CO_2(g)\ \Delta H = -23.44$ kJ/mol

$Fe_3O_4 + CO(g) \rightarrow 3\ FeO(s) + CO_2(g)\ \Delta H = +21.79$ kJ/mol

$Fe(s) + CO_2(g) \rightarrow FeO(s) + CO(g)\ \Delta H = -10.94$ kJ/mol

(a) Determine the enthalpy for the overall reaction :

$3\ Fe_2O_3(s) + CO(g) \rightarrow 2\ Fe_3O_4(s) + CO_2(g)$

(b) Is the overall reaction exothermic or endothermic ?

(c) Given your answer in part (b), sketch the energy diagram for the overall reaction. Include in your diagram the relative energies of the reactants (Fe_2O_3, CO) and products (Fe_3O_4, CO_2), activation energy (E_A), and energy difference (ΔE).

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Problem 4 : Charles' Law Given a fixed amount of gas at constant pressure. Answer the following questions. (12 pts)

(a) Starting from the ideal gas law $PV = nRT$. Show how you can arrive at Charles' law. Include all steps to receive full credit.

(b) If a sample of chlorine gas occupies 100.0mL at 100.°C, what is its volume at 25.0°C ?

(c) Calculate the temperature (in Celsius) when 3.00L at 21.0°C is compressed to 1.00L.

(d) Draw the graph of the relationship between volume (V) and temperature (T) for an ideal gas. Describe the relationship.

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Problem 5 : Limiting Reagent In a precipitation reaction, lead Chloride ($PbCl_2$) is produced by mixing NaCl(aq) and $Pb(NO_3)_2$(aq). The following is the balanced chemical equation. (12 pts)

$2\ NaCl(aq) + Pb(NO_3)_2(aq) \rightarrow 2\ NaNO_3(aq) + PbCl_2(s)$

(a) Given 15.3 g NaCl(aq) and 60.8 g $Pb(NO_3)_2$, which one is the limiting reagent ?

(b) What is the maximum amount of $PbCl_2$(s) produced in g ? This is also known as the theoretical yield.

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

(d) If 34.2 g of $PbCl_2$(s) is collected, determine the percent yield.

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Chemistry 123 : Apppendix 2 - Formulas and Constants

$$\text{percent yield} = \frac{\text{Actual}}{\text{Theoretical}} \times 100\%$$
$$M_1V_1 = M_2V_2$$
$$P_1V_1 = P_2V_2$$
$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$
$$\frac{V_1}{n_1} = \frac{V_2}{n_2}$$
$$q = mc\Delta T$$

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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]