LAST NAME: _____

FIRST NAME: _____

Student Number: _____

CHM 1311 D
Prof. Goto
Midterm #1
Fall 2018

Please keep your work covered at all times and keep your eyes on your own paper! Cheating or any appearance of cheating will result in an F in the course and possible expulsion from the university.

There are 8 pages in this test, for a total of 40 marks. A periodic table and data sheets are provided at the end. You may rip these pages off of the exam and use them to cover your work during the test. Any scratch work should be done on the back of these pages.

Please show all work to receive partial credit.

Make sure that units are included in your final answer.

You have 90 minutes to complete the test.

Warning:
Cellular phones, unauthorized electronic devices or course notes are not allowed during this exam. Phones and devices must be turned off and stored in your bag. Do not keep them in your possession, such as in your pockets. If caught with such a device or document, academic fraud allegations will be filed which may result in your obtaining a **0** (zero) for the midterm.

Question 1. Short answer questions (8 marks)

a) The height of the mercury in the open-end side of a manometer is 12.0 mm higher than the gas side. If atmospheric pressure is 760 torr, what is the pressure of the gas sample?

b) You use a 100 mL graduated cylinder that is specified to be accurate to within 0.5 mL to measure out 95 mL of water. How many significant figures should you use to record this volume?

c) What is the nuclear symbol for the gold isotope that contains 116 neutrons?

d) What is the overall yield of a multistep synthesis with a 92% yield for the first step, 85% yield for the second step and 54% yield for the last step?

e) Suppose a brick of dry ice (solid CO_2) is put into a glass flask containing a mixture of oxygen and carbon dioxide gas. What will happen to the partial pressure of the oxygen as the dry ice undergoes sublimation? (Sublimation is solid to gas phase transition. Assume that the temperature does not change.)

f) The temperature of water decreases when solid urea is dissolved to make a solution. Is the reaction urea (s) $\rightarrow$ urea (aq) endothermic or exothermic?

g) Is the average kinetic energy of a hydrogen gas molecule under standard conditions greater than, less than or equal to the average kinetic energy of an oxygen gas molecule under standard conditions?

h) A gas absorbs 500 J of heat while it does 500 J of work. What is ΔU for the gas?

Question 2. Short calculations

a) How many nm^3 are in 5 mm^3? (2 marks)

b) A tablespoon of pure vanilla extract contains 14.8 mL of ethanol (C_2H_6O, 46.07 g/mol). If the density of ethanol at 20 ^oC is 0.789 g/mL, calculate the total number of H atoms present in one tablespoon of vanilla extract. (4 marks)

c) A sample of propane (C_3H_8) was burned in a calorimeter with a heat capacity of 3.50 kJ/^oC that contained 1.5 kg of water (heat capacity = 4.184 J ^oC g^{-1}). The temperature of the calorimeter and water increased from 23.0 ^oC to 32.0 ^oC. How much heat is released from the combustion? (4 marks)

i) For a hypothetical reaction:

$$3\ A + B \rightarrow\ 2\ C$$

with standard enthalpies of formation ΔH_f^o for A = 2.0 kJ/mol, B = 1.5 kJ/mol, and C = 4.2 kJ/mol, what is $\Delta H_{reaction}^o$? (2 marks)

d) How many Joules of work is done when 3.65 L of an ideal gas is isothermally compressed by a constant external pressure of 4.5 atm until its volume is half its initial size? (2 marks)

e) What is the concentration of Na^+ if 50.0 mL of 0.345 M Na_3BO_3 is mixed with 25.0 mL of 0.635 Na_2HPO_4? (4 marks)

Question 3.

1.45 g of a solid hydrocarbon is subjected to combustion analysis and found to produce 5.01 g of CO_2 and 0.821 g of H_2O.

a) What is the empirical formula for this compound? (4 marks)

b) Suppose some of the solid hydrocarbon enters into the gas phase at 350. K to give a partial pressure of 7893 Pa and density of 0.3476 g/L. What is the molecular formula of this compound? (4 marks)

Question 6. (6 marks)

For the chemical reaction:

$$8\ Al\,(s) + 3\ Fe_3O_4\,(s) \rightarrow 9\ Fe\,(s) + 4\ Al_2O_3\,(s)$$

What mass of iron (55.85 g/mol) will be formed if 2.75 g of aluminum (26.98 g/mol) is allowed to react with 8.00 g of iron oxide (231.55 g/mol)?

Constants and Conversion Factors

1 mmHg = 1 torr	760 mmHg = 1 atm	1 atm = 101325 Pa	
1 atm = 1.013125 bar	1 L atm = 101.325 J	1 bar = 10^5 Pa	1 kPa = 1000 Pa
1 cm^3 = 1 mL = 1000 µL	1 dm^3 = 1000 mL = 1 L	1 m^3 = 1000 L	1 cal = 4.184 J
1 L = 1000 mL	1 m = 100 cm = 1000 mm	1 m = 10^9 nm = 10^{12} pm	

Avogadro's Number	N_A	6.022×10^{23} mol^{-1}
Gas constant	R	8.31451 $J \cdot K^{-1} \cdot mol^{-1}$
	R	0.08206 $atm \cdot L \cdot K^{-1} \cdot mol^{-1}$
	R	8.31451 $L \cdot kPa \cdot K^{-1} \cdot mol^{-1}$
	R	0.0831451 bar $L \cdot K^{-1} \cdot mol^{-1}$

Equations

$$T(\text{in K}) = T(\text{in } ^\circ\text{C}) + 273.15 \text{ K}$$

$$n = \frac{m}{M} = \frac{N}{N_A}$$

$$\%\ \text{Yield} = \frac{\text{actual yield}}{\text{theoretical yield}} \times 100\%$$

$$c(\text{mol/L}) = \frac{n}{V}$$

$$c_1V_1 = c_2V_2 = n$$

$$p = \frac{mg}{A}$$

$$p = dgh$$

$$pV = nRT$$

$$\frac{p_1V_1}{T_1} = \frac{p_2V_2}{T_2}$$

$$p_T = p_1 + p_2 + p_3 + \ldots$$

$$p_A = X_A \times p_T$$

$$X_A = \frac{n_A}{n_T}$$

$$d = \frac{m}{V} = \frac{p \cdot M}{RT}$$

$$E_K = \frac{1}{2}mv^2$$

$$\bar{E} = \frac{3RT}{2N_A}$$

$$\frac{Rate\ A}{Rate\ B} = \sqrt{\frac{M_B}{M_A}}$$

$$p = \frac{nRT}{(V - nb)} - a\frac{n^2}{V^2}$$

$$\Delta E = w + q$$

$$w = F \times d = -p\Delta V$$

$$q_{\text{calorimeter}} = C_{cal}\Delta T$$

$$\Delta E_{\text{reaction}} = \Sigma BE_{\text{reactant bonds broken}} - \Sigma BE_{\text{product bonds formed}}$$

$$\Delta H^o_{\text{reaction}} = \Sigma v_p \Delta H^o_{f,p} - \Sigma v_r \Delta H^o_{f,r}$$

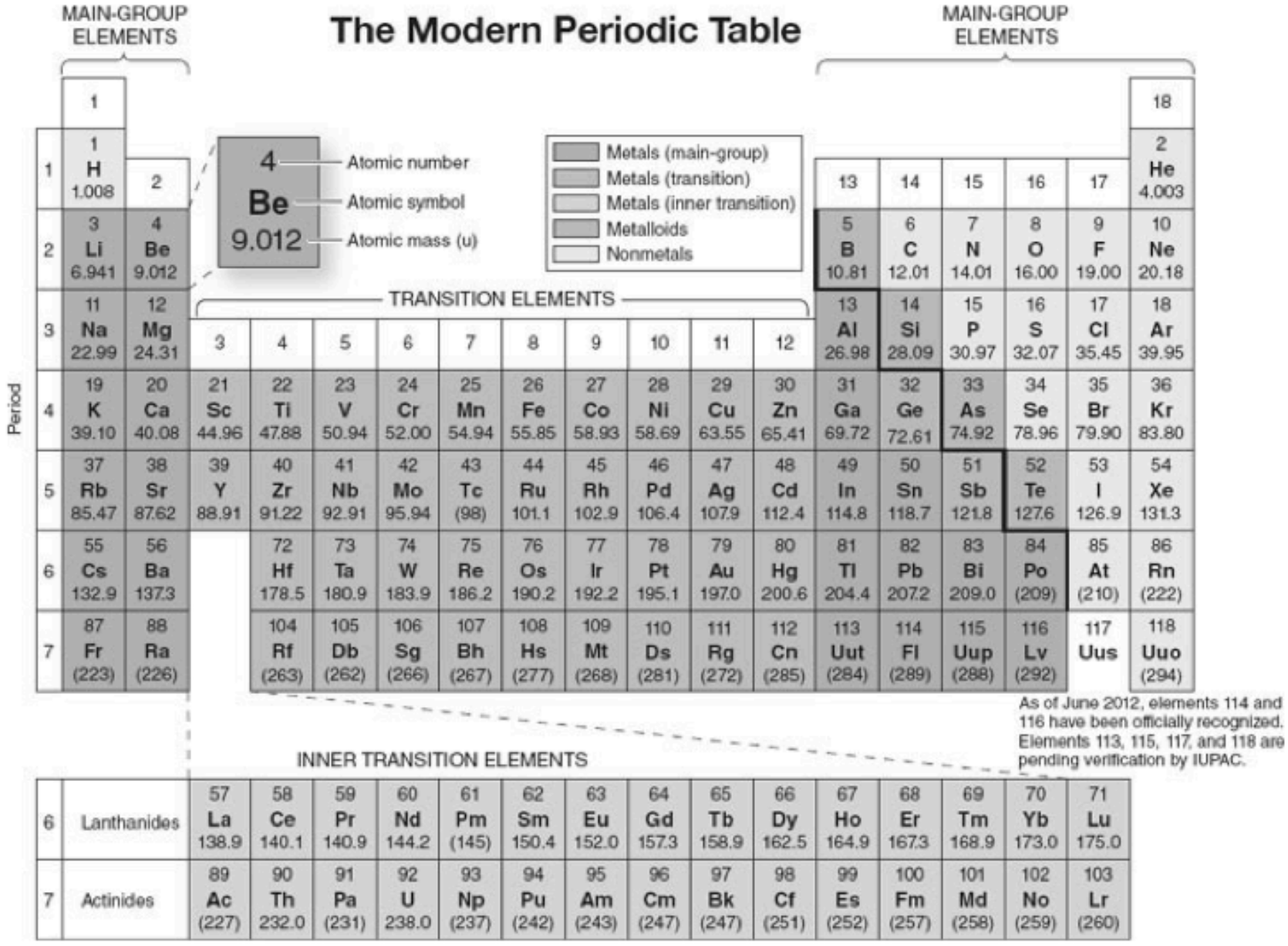
$$q = mc\Delta T$$

$$q = nC_m\Delta T$$

$$\Delta E_{\text{molar}} = \frac{\Delta E}{n}$$

$$\Delta H_{\text{reaction}} = \Delta E_{\text{reaction}} + RT\Delta n_{gas}$$

$$H = E + pV$$


The Modern Periodic Table
MAIN-GROUP ELEMENTS
MAIN-GROUP ELEMENTS
4
Be
9.012
Atomic number
Atomic symbol
Atomic mass (u)
Metals (main-group)
Metals (transition)
Metals (inner transition)
Metalloids
Nonmetals
TRANSITION ELEMENTS
Period
1 1 H 1.008 2 He 4.003
2 3 Li 6.941 4 Be 9.012 5 B 10.81 6 C 12.01 7 N 14.01 8 O 16.00 9 F 19.00 10 Ne 20.18
3 11 Na 22.99 12 Mg 24.31 3 4 5 6 7 8 9 10 11 12 13 Al 26.98 14 Si 28.09 15 P 30.97 16 S 32.07 17 Cl 35.45 18 Ar 39.95
4 19 K 39.10 20 Ca 40.08 21 Sc 44.96 22 Ti 47.88 23 V 50.94 24 Cr 52.00 25 Mn 54.94 26 Fe 55.85 27 Co 58.93 28 Ni 58.69 29 Cu 63.55 30 Zn 65.41 31 Ga 69.72 32 Ge 72.61 33 As 74.92 34 Se 78.96 35 Br 79.90 36 Kr 83.80
5 37 Rb 85.47 38 Sr 87.62 39 Y 88.91 40 Zr 91.22 41 Nb 92.91 42 Mo 95.94 43 Tc (98) 44 Ru 101.1 45 Rh 102.9 46 Pd 106.4 47 Ag 107.9 48 Cd 112.4 49 In 114.8 50 Sn 118.7 51 Sb 121.8 52 Te 127.6 53 I 126.9 54 Xe 131.3
6 55 Cs 132.9 56 Ba 137.3 72 Hf 178.5 73 Ta 180.9 74 W 183.9 75 Re 186.2 76 Os 190.2 77 Ir 192.2 78 Pt 195.1 79 Au 197.0 80 Hg 200.6 81 Tl 204.4 82 Pb 207.2 83 Bi 209.0 84 Po (209) 85 At (210) 86 Rn (222)
7 87 Fr (223) 88 Ra (226) 104 Rf (263) 105 Db (262) 106 Sg (266) 107 Bh (267) 108 Hs (277) 109 Mt (268) 110 Ds (281) 111 Rg (272) 112 Cn (285) 113 Uut (284) 114 Fl (289) 115 Uup (288) 116 Lv (292) 117 Uus 118 Uuo (294)
As of June 2012, elements 114 and 116 have been officially recognized. Elements 113, 115, 117, and 118 are pending verification by IUPAC.
INNER TRANSITION ELEMENTS
6 Lanthanides 57 La 138.9 58 Ce 140.1 59 Pr 140.9 60 Nd 144.2 61 Pm (145) 62 Sm 150.4 63 Eu 152.0 64 Gd 157.3 65 Tb 158.9 66 Dy 162.5 67 Ho 164.9 68 Er 167.3 69 Tm 168.9 70 Yb 173.0 71 Lu 175.0
7 Actinides 89 Ac (227) 90 Th 232.0 91 Pa (231) 92 U 238.0 93 Np (237) 94 Pu (242) 95 Am (243) 96 Cm (247) 97 Bk (247) 98 Cf (251) 99 Es (252) 100 Fm (257) 101 Md (258) 102 No (259) 103 Lr (260)