LAST NAME: _____

FIRST NAME: _____

Student Number: _____

CHM 1311 B
Midterm #1
Fall 2016

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.

A

Question 1. Short answer questions (1 mark each)

a) The specifications for a 10 mL volumetric flask state that it is guaranteed to contain the specified volume to within 0.01 mL when filled. How many significant figures should you use to record the volume contained in this flask?

b) Compute the total number of hydrogen atoms present in 0.55 mol H_2O.

c) In an open-end mercury manometer the mercury was 35 mm lower on the side connected to the gas, and the atmospheric pressure was 755 mmHg. What was the pressure of the gas?

d) An object has a mass of 200 g and a speed of 10 m/s. What is the kinetic energy of the object in units of Joules?

e) What is the nuclear symbol for the iron isotope that contains 28 neutrons?

f) If the gas tank of a car holds 45.4 L, what is the mass of gasoline required to fill it (density = 0.70 g/mL)?

g) There are _____ electrons and _____ protons in Mg^{2+}. (Fill in the numbers.)

h) If ammonium nitrate is dissolved in water the temperature of the solution decreases. The reaction is (circle one):

Exothermic Endothermic

i) Energy is released when a high energy bond is broken.

True False

Question 2. Short calculations (2 mark each)

a) A 50.0 mL sample of 0.50 M K_3PO_4 is diluted with 450.0 mL of water. What is the concentration of potassium in this new solution?

b) What is the molecular mass of an unknown gas if argon gas effuses at a rate 2.634 times faster than this unknown gas?

c) Calculate the work in units of Joules that is done by an ideal gas in a balloon that expands under a constant pressure of 2.0×10^5 Pa from a volume of 5.0 L to 10.0 L.

d) The diameter of an argon atom is 7.1×10^1 pm. How many argon atoms lined up end to end would form a line 1.25 cm long?

e) Given reaction A + 2 B → 3 C, with standard enthalpies of formation ΔH_f^o of:

A = 10.0 kJ/mol, B = 5.0 kJ/mol, C = 2.0 kJ/mol

What is the enthalpy change if 2 moles of A are used in the reaction?

Question 3.

A 47.9 g sample of an unknown crystalline compound containing carbon, oxygen and hydrogen is subjected to airproof combustion analysis. The sample gives 134.4 g of CO_2 and 27.5 g of H_2O.

a) What is the empirical formula of the compound? (6 marks)

b) A combustion reaction was done on 3.88×10^{-2} mol of this organic compound in a bomb calorimeter with a heat capacity of 11.24 kJ K^{-1}. As a result of the reaction, the temperature of the calorimeter increased from 25.0 ^{o}C to 35.5 ^{o}C. Calculate the heat of the reaction per mole of water formed. (4 marks)

Question 4.

Nitrogen fixation is done industrially through the reaction of hydrogen and nitrogen gas to form ammonia gas (NH_3). Suppose a 500.0 L reaction vessel contains nitrogen at 358 bar and 595 K, and 4500 mol of H_2.

a) Write the balanced chemical equation for this reaction. (1 mark)

b) Based on your balanced chemical reaction use bond energies to estimate ΔE for this reaction. (Data on last page.) (2 marks)

c) After the reaction is allowed to run to completion, the temperature is brought down to 233 K, which is below the boiling point of ammonia, and the liquid ammonia removed from the vessel. What is the pressure inside the reaction vessel after the liquid ammonia has been removed? (7 marks)

Constants and Conversion Factors

1 mmHg = 1 torr	760 mmHg = 1 atm	1 atm = 101.325 kPa	1 atm = 1.013125 bar
1 bar = 10^5 Pa	1 cm^3 = 1 mL	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	1 m = 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 $bar\ L \cdot K^{-1} \cdot mol^{-1}$

Average Bond Energies

H—H 435 kJ mol^{-1} N≡N 945 kJ mol^{-1} N—H 390 kJ mol^{-1} C—H 412 kJ mol^{-1}

Equations

$$T\left(\text{in K}\right) = T\left(\text{in }^{\circ}\text{C}\right) + 273.15\text{ K} \qquad n = \frac{m}{M} = \frac{N}{N_A} \qquad \%\text{ Yield} = \frac{\text{actual yield}}{\text{theoretical yield}}$$

$$c\left(\text{mol/L}\right) = \frac{n}{V} \qquad c_1V_1 = c_2V_2 = n \qquad p = \frac{mg}{A}$$

$$p = dgh \qquad pV = nRT \qquad \frac{p_1V_1}{T_1} = \frac{p_2V_2}{T_2}$$

$$p_T = p_1 + p_2 + p_3 + \ldots \qquad p_A = X_A \times p_T \qquad X_A = \frac{n_A}{n_T}$$

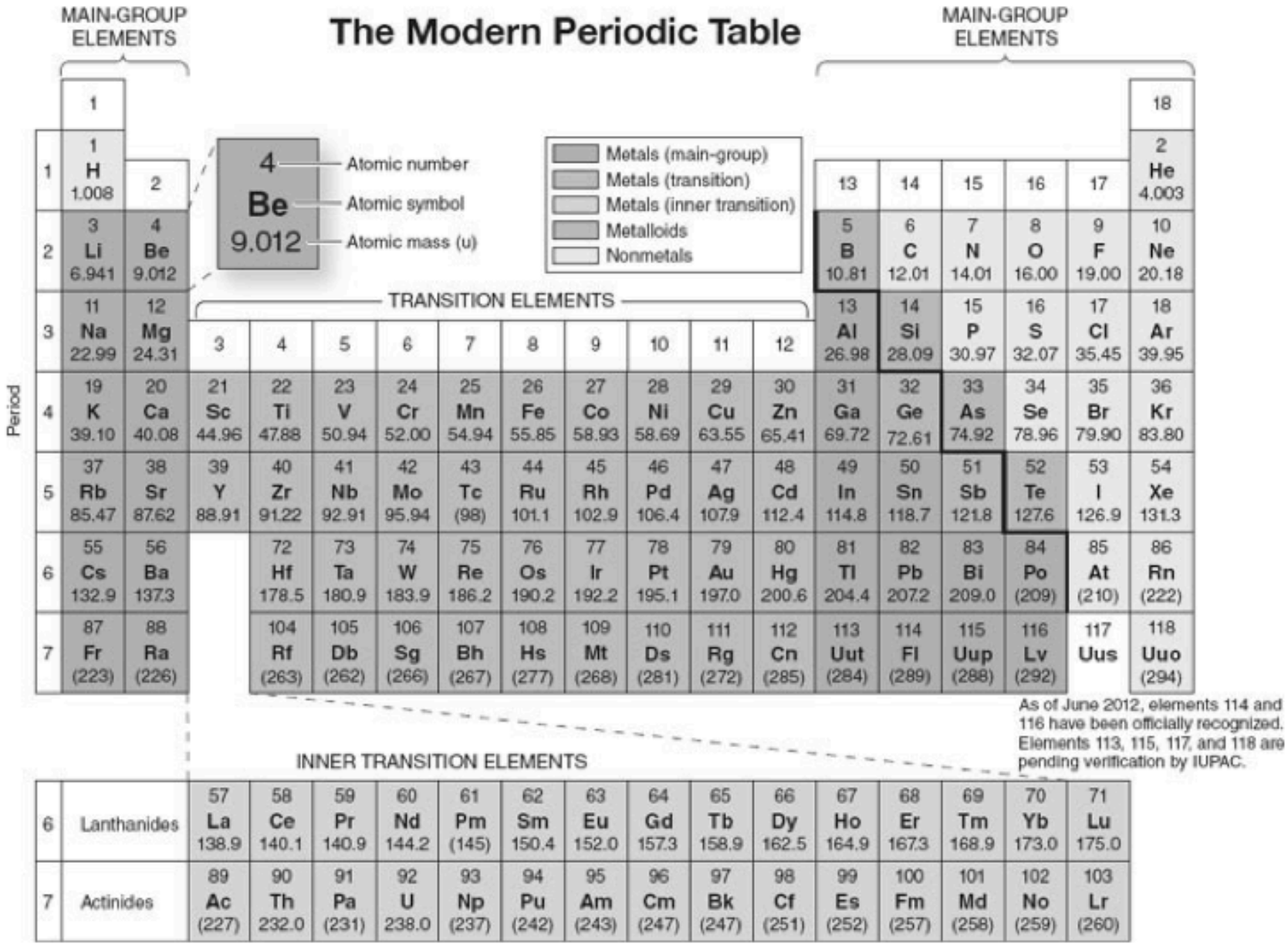
$$d = \frac{m}{V} = \frac{p \cdot M}{RT} \qquad E_K = \frac{1}{2}m\text{v}^2 \qquad \bar{E} = \frac{3RT}{2N_A}$$

$$\bar{v} = \sqrt{\frac{3RT}{M}} \qquad \frac{Rate\ A}{Rate\ B} = \sqrt{\frac{M_B}{M_A}} \qquad p = \frac{nRT}{\left(V - nb\right)} - a\frac{n^2}{V^2}$$

$$\Delta E = w + q \qquad w = F \times d = -p\Delta V \qquad q_{\text{calorimeter}} = C_{cal}\Delta T$$

$$\Delta E_{\text{reaction}} = \Sigma BE_{\text{reactant bonds broken}} - \Sigma BE_{\text{product bonds formed}} \qquad \Delta E_{\text{molar}} = \frac{\Delta E}{n}$$

$$\Delta H^o_{\text{reaction}} = \Sigma v_p \Delta H^o_{f,p} - \Sigma v_r \Delta H^o_{f,r} \qquad \Delta H_{\text{reaction}} = \Delta E_{\text{reaction}} + RT\Delta n_{gas} \qquad H = E + pV$$


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 H 1.008
2 He 4.003
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
11 Na 22.99
12 Mg 24.31
13 Al 26.98
14 Si 28.09
15 P 30.97
16 S 32.07
17 Cl 35.45
18 Ar 39.95
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
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
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)
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
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
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)