DO NOT OPEN

UNTIL INSTRUCTED TO DO SO

CHEM 110 – Dr. McCorkle – Final Exam ***KEY***

While you wait, please complete the following information:

Name: _____

Student ID: _____

Turn off cellphones and stow them away. No headphones, mp3 players, hats, sunglasses, food, drinks, restroom breaks, graphing calculators, programmable calculators, or sharing calculators. Grade corrections for incorrectly marked or incompletely erased answers will not be made.

Periodic Table of the Elements

PERIOD	GROUP 1 IA												13 IIIA	14 IVA	15 VA	16 VIA	17 VIIA	18 VIIIA
1	1 H 1.01	2 IIA																2 He 4.00
2	3 Li 6.94	4 Be 9.01											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 IIIB	4 IVB	5 VB	6 VIB	7 VIIB	8 VIIIB	9 VIIIB	10 VIIIB	11 IB	12 IB	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 65.39	31 Ga 69.72	32 Ge 72.61	33 As 74.92	34 Se 78.97	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 95.95	43 Tc (98)	44 Ru 101.07	45 Rh 102.91	46 Pd 106.42	47 Ag 107.87	48 Cd 112.41	49 In 114.82	50 Sn 118.71	51 Sb 121.75	52 Te 127.60	53 I 126.90	54 Xe 131.29
6	55 Cs 132.91	56 Ba 137.33	57 La * 138.91	72 Hf 178.49	73 Ta 180.95	74 W 183.85	75 Re 186.21	76 Os 190.23	77 Ir 192.22	78 Pt 195.08	79 Au 196.97	80 Hg 200.59	81 Tl 204.38	82 Pb 207.2	83 Bi 208.98	84 Po (209)	85 At (210)	86 Rn (222)
7	87 Fr (223)	88 Ra (226)	89 Ac ** (227)	104 Rf (267)	105 Db (268)	106 Sg (271)	107 Bh (270)	108 Hs (277)	109 Mt (276)	110 Ds (281)	111 Rg (280)	112 Cn (285)	113 Uut (284)	114 Fl (289)	115 Uup (288)	116 Lv (293)	117 Uus (294)	118 Uuo (294)

Lanthanide Series *	58 Ce 140.12	59 Pr 140.91	60 Nd 144.24	61 Pm (145)	62 Sm 150.36	63 Eu 151.96	64 Gd 157.25	65 Tb 158.93	66 Dy 162.50	67 Ho 164.93	68 Er 167.26	69 Tm 168.93	70 Yb 173.05	71 Lu 174.97
Actinide Series **	90 Th 232.04	91 Pa 231.04	92 U 238.03	93 Np (237)	94 Pu (244)	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 (262)

Multiple Choice – Choose the answer that best completes the question. Use an 815-E Scantron to record your response. [2 points each]

1. A chemical change occurs when
   A) methane gas is burned.
   B) paper is shredded.
   C) water is vaporized.
   D) salt is dissolved in water.
   E) powdered lemonade is stirred into water.

2. Determine the number of protons, neutrons, and electrons in the following: $^{40}_{18}X$

A) $p^+ = 18$	$n^0 = 18$	$e^- = 12$
B) $p^+ = 18$	**$n^0 = 22$**	**$e^- = 18$**
C) $p^+ = 22$	$n^0 = 18$	$e^- = 18$
D) $p^+ = 18$	$n^0 = 22$	$e^- = 40$
E) $p^+ = 40$	$n^0 = 22$	$e^- = 18$

3. Which of the following numbers contains the designated CORRECT number of significant figures?

A) 0.04300	5 significant figures
B) 0.00302	2 significant figures
C) 156 000	**3 significant figures**
D) 1.04	2 significant figures
E) 3.0650	4 significant figures

4. What is the molarity of a solution that contains 3.25 moles of $NaNO_3$ in 250. mL of solution?
   A) 3.25 *M* B) 6.50 *M* C) 0.0130 *M* **D) 13.0 *M*** E) 2.60 *M*

5. How many milliliters of 0.266 *M* $LiNO_3$ solution are required to make 150.0 mL of 0.075 *M* $LiNO_3$ solution?
   A) 53 mL B) 19 mL C) 35 mL **D) 42 mL** E) 24 mL

6. While traveling, an airplane passenger placed a bag of potato chips in his checked luggage. Later after landing, he opened his luggage and discovered the bag had exploded and potato chips were everywhere. Which law is this an example of?
   A) Avogadro's Law
   B) Ideal Gas Law
   C) Charles's Law
   D) Boyle's Law
   E) Dalton's Law

7. Which of the following sings on *q* and *w* represent a system that is doing work on the surroundings, as well as gaining heat from the surroundings.

   A) *q* = +, *w* = –

   B) *q* = –, *w* = +

   C) *q* = +, *w* = +

   D) *q* = –, *w* = –

   E) None of these represent the system referenced above.

8. Calculate the energy of the orange light emitted, per photon, by a neon sign with a frequency of 4.89×10^{14} Hz.

   A) 3.09×10^{-19} J

   B) 6.14×10^{-19} J

   C) 3.24×10^{-19} J

   D) 1.63×10^{-19} J

   E) 5.11×10^{-19} J

9. For $n = 2$, what are the possible values of l?

   A) 0

   B) 0, 1

   C) 0, 1, 2

   D) −1, 0, +1

   E) −2, −1, 0, +1, +2

10. Which element corresponds to the electron configuration $1s^2 2s^2 2p^6 3s^2 3p^6 4s^1 3d^5$?

    A) titanium

    B) vanadium

    C) chromium

    D) manganese

    E) iron

11. Which compound has the longest carbon-carbon bond?

    A) CH_3CH_3

    B) CH_2CH_2

    C) HCCH

    D) All bond lengths are the same

12. Identify the bond with the lowest bond energy.

A) Si=O
B) N=N
C) C=C
D) C=N
E) O=O

13. A molecule that is sp^3d hybridized and has a molecular geometry of seesaw has _____ bonding groups and _____ lone pairs around its central atom.

A) 5, 1
B) 4, 2
C) 4, 1
D) 3, 2
E) 2, 3

14. Capillary action occurs because

A) cohesive forces are greater than adhesive forces.
B) cohesive forces equal adhesive forces.
C) adhesive forces are greater than cohesive forces.
D) surface tension is high.
E) surface tension is low.

15. The strongest interactions between nonpolar molecules of ethane (C_2H_6) are

A) ionic bonds B) hydrogen bonds C) covalent bonds
D) dipole-dipole **E) dispersion forces**

Calculations – Write your initials in the upper-right corner of every page that contains work. For full credit show all work and write neatly; give answers with correct significant figures and units. For calculations, place a box around your final answer.

16. A doctor's order is 0.125 g of ampicillin. The liquid suspension on hand contains 0.250 µg ampicillin/5.0 mL of suspension. How many deciliters of the suspension are required? [5 pts]

$$0.125\ \text{g} \times \frac{1\ \mu\text{g}}{10^{-6}\ \text{g}} \times \frac{5.0\ \text{mL}}{0.250\ \mu\text{g}} \times \frac{10^{-3}\text{L}}{1\ \text{mL}} \times \frac{1\ \text{dL}}{10^{-1}\ \text{L}} = 2.5 \times 10^{4}\ \text{dL}$$

17. A 5.00-L tank contains helium gas at 1.50 atm. If the volume is changed to 1.75×10^3 mL, what is the pressure of the gas <u>in torr</u>? [4]

$$1.50\ \text{atm} \times \frac{760\ \text{mmHg}}{1\ \text{atm}} = 1140\ \text{mmHg}$$

$$1,75 \times 10^{3}\ \text{mL} \times \frac{10^{-3}\ \text{L}}{1\ \text{mL}} = 1.75\ \text{L}$$

$$P_1V_1 = P_2V_2$$

$$P_2 = \frac{P_1V_1}{V_2} = \frac{(1140\ \text{mmHg})(5.00\ \text{L})}{1.75\ \text{L}} = 3260\ \text{mmHg}$$

18. Name the following compounds: [2 points each]

a. $Al_2(CO_3)_3$

aluminum carbonate

b. P_3O_7

triphosphorus heptaoxide

c. $H_3N(aq)$

hydronitric acid

Write the formula for the following compounds:

d. tetrasulfur octafluoride

S_4F_8

e. phosphorous acid

H_3PO_3

f. titanium(IV) perchlorate

$Ti(ClO_4)_4$

19. Consider the molecule ICl_4^-:
    a. Draw the Lewis structure, including any resonance structures: [2 points]

    b. Assign formal charges to each atom in the structure(s) above: [2]

    c. Electron geometry? [2]

    octahedral

    d. What is the hybridization of the central atom? [2]

    sp^3d^2

    e. Molecular geometry? [2]

    square planar

    f. Draw ICl_4^- three-dimensionally using wedge notation AND label all bond angles: [4]

    e. Is the molecule polar or nonpolar? Explain. [2]

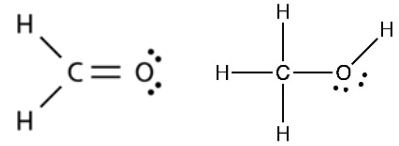
    Even though each I-Cl bond is polar (ΔEN = 0.5), they are arranged symmetrically around the central atom making the overall molecule nonpolar.

20. How many milliliters of 0.200 *M* NaOH are required to completely neutralize 5.00 mL of 0.100 *M* H_2SO_4? (*Hint: Write a balanced chemical equation first.)* [5 points]

$$\mathbf{2\ NaOH(\mathit{aq}) + H_2SO_4(\mathit{aq}) \rightarrow Na_2SO_4(\mathit{aq}) + 2\ H_2O(\mathit{l})}$$

$$\mathbf{5.00\ mL \times \frac{0.100\ mol\ H_2SO_4}{1000\ mL} \times \frac{2\ mol\ NaOH}{1\ mol\ H_2SO_4} \times \frac{1000\ mL}{0.200\ mol\ NaOH} = 5.00\ mL}$$

21. Briefly explain why methanol has a higher boiling point than formaldehyde. [3]



Formaldehyde *Methanol*

Boiling involves separating liquid molecules held together by intermolecular forces so that they can enter the gas phase. Both molecules are polar and so have dipole-dipole intermolecular forces. However, methanol has hydrogen bonding due to its O−H bond. H-bonding is a stronger attraction than dipole-dipole, meaning it will take more energy (higher temperature) to separate the methanol molecules apart when boiling (liquid → gas). Thus, methanol has the higher boiling point.

22. Suppose 316.0 g aluminum sulfide reacts with 493.0 g of water according to the following equation:

$$Al_2S_3(s) + 6\ H_2O(l) \rightarrow 2\ Al(OH)_3(s) + 3\ H_2S(g)$$

What mass of the excess reactant remains? [8 points]

You can choose either product when determining which reactant is limiting. I chose H_2S.

$$\mathbf{316.0\ g\ Al_2S_3 \times \frac{1\ mol\ Al_2S_3}{150.17\ g} \times \frac{3\ mol\ H_2S}{1\ mol\ Al_2S_3} \times \frac{34.09\ g}{1\ mol\ H_2S} = 215.2\ g\ H_2S}$$

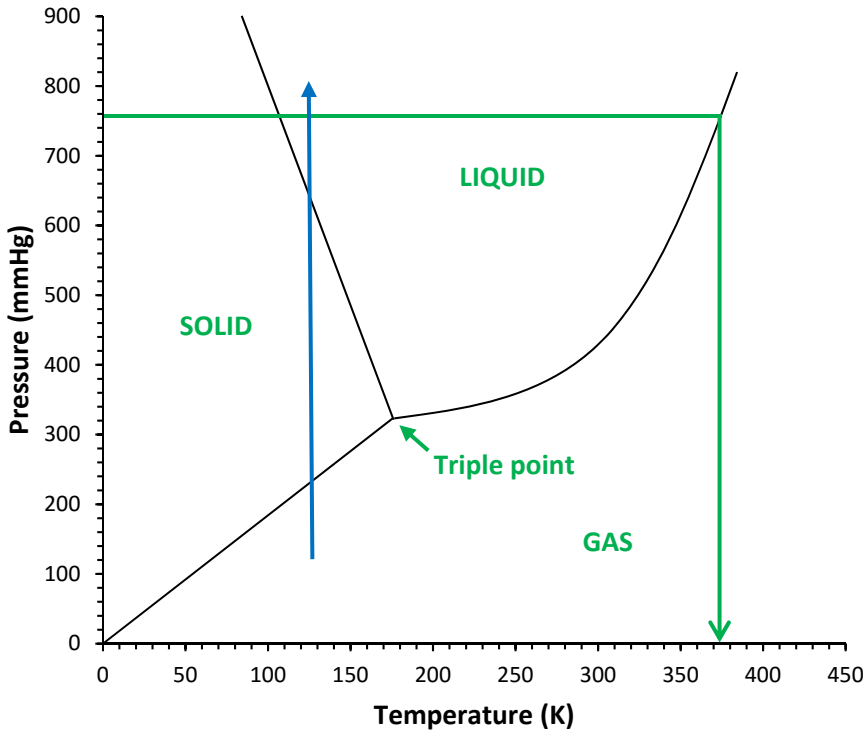
$$\mathbf{493.0\ g\ H_2O \times \frac{1\ mol\ H_2O}{18.02\ g} \times \frac{3\ mol\ H_2S}{6\ mol\ H_2O} \times \frac{34.09\ g}{1\ mol\ H_2S} = 466.3\ g\ H_2S}$$

Al_2S_3 is the limiting reactant so we need to determine how much H_2O remains after the Al_2S_3 is used up.

$$\mathbf{316.0\ g\ Al_2S_3 \times \frac{1\ mol\ Al_2S_3}{150.17\ g} \times \frac{6\ mol\ H_2O}{1\ mol\ Al_2S_3} \times \frac{18.02\ g}{1\ mol\ H_2O} = 227.5\ g\ H_2O\ used}$$

493.0 g H_2O initially – 227.5 g H_2O used = 265.5 g H_2O remain

23. Consider the following phase diagram:



a) Label the solid, liquid, and gas regions. [3 points]

b) Label the triple point. [1]

c) What is the approximate boiling point of this substance at standard pressure? Draw lines to indicate how you would determine this. [2]

375 K

d) Are there any conditions under which the substance would undergo sublimation? If so, what are they? [2]

At pressures below approximately 300 mmHg there is no liquid phase and the substance will transition directly from solid to gas.

e) Describe what happens to the substance at 125 K if its pressure is slowly increased from 100 mmHg to 800 mmHg. [2]

At 100 K the substance is a gas. As the pressure increases it becomes a solid at ~230 mmHg and then a liquid at ~650 mmHg.

24. How much heat (kJ) is needed to raise the temperature of 25.0 g of ethanol (C_2H_5OH) from −135°C to −50.°C? [7 points]

Constant	Value
ΔH_{fus}	5.02 kJ/mol
ΔH_{vap}	38.56 kJ/mol
s (solid)	0.97 J/g·°C
s (liquid)	2.44 J/g·°C
s (gas)	1.88 J/g·°C
Boiling point	78.1°C
Melting point	−114°C

1. Heating solid ethanol from −135°C to −114°C

$$q_1 = m \times s \times \Delta T$$

$$= 25.0\ g \times 0.97 \frac{J}{g \cdot °C} \times (-114°C - -135°C) = 510\ J$$

$$q_1 = 510\ J \times \frac{1\ kJ}{10^3\ J} = 0.51\ kJ$$

2. Melting the solid at −114°C

$$25.0\ g \times \frac{1\ mol\ C_2H_5OH}{46.08\ g} = 0.5425\ mol$$

$$q_2 = 0.5425\ mol \times \frac{5.02\ kJ}{1\ mol} = 2.72\ kJ$$

3. Heating liquid ethanol from −114°C to −50°C

$$q_3 = m \times s \times \Delta T = 25.0\ g \times 2.44 \frac{J}{g \cdot °C} \times (-50°C - -114°C) = 3900\ J$$

$$q_3 = 3900\ J \times \frac{1\ kJ}{10^3\ J} = 3.9\ kJ$$

$$q_{total} = q_1 + q_2 + q_3 = 0.51\ kJ + 2.72\ kJ + 3.9\ kJ = 7.1\ kJ$$

Extra Credit: On the very first day of class we discussed the scientific method and this quote by a famous scientist: *"No amount of experimentation can ever prove me right; a single experiment can prove me wrong."* Who said it? [2 points]

Albert Einstein

Formulas & Constants
(you may or may not need)

1 inch = 2.54 cm (exact)

1 mile = 5280 ft ≈ 1.609 km

1 kg ≈ 2.205 lb

1 lb = 16 oz ≈ 453.6 g

1 gal = 4 qt = 8 pt ≈ 3.785 L

1 L = 1000 cm^3

K = °C + 273.15

°F = 1.8 x °C + 32

°C = (°F – 32)/1.8

1 cal = 4.184 J

1 Cal = 1000 cal

q = m x C x ΔT

Avogadro's # = 6.022×10^{23}

Molar volume = 22.4 L

$R = 0.08206 \frac{L \cdot atm}{mol \cdot K}$

$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$

$u_{rms} = \sqrt{\frac{3RT}{M}}$

$KE = \frac{1}{2}mv^2 = \frac{3}{2}RT$

1 atm = 760 mmHg

1 mmHg = 1 torr

$P_{Total} = P_1 + P_2 + ...$

$P_A = X_A \cdot P_{Total}$

PV = nRT

ΔE = q + w

w = −PΔV

q = C × ΔT

q = m × s × ΔT

$\Delta H°_{rxn} = \Sigma[n\ \Delta H_f°(products)] - \Sigma[n\ \Delta H_f°(reactants)]$

R = 8.314 J/mol·K

h = 6.626×10^{-34} J·s

c = 2.9979×10^{8} m/s

$R_H = 2.18 \times 10^{-18}$ J

1 Hz = s^{-1}

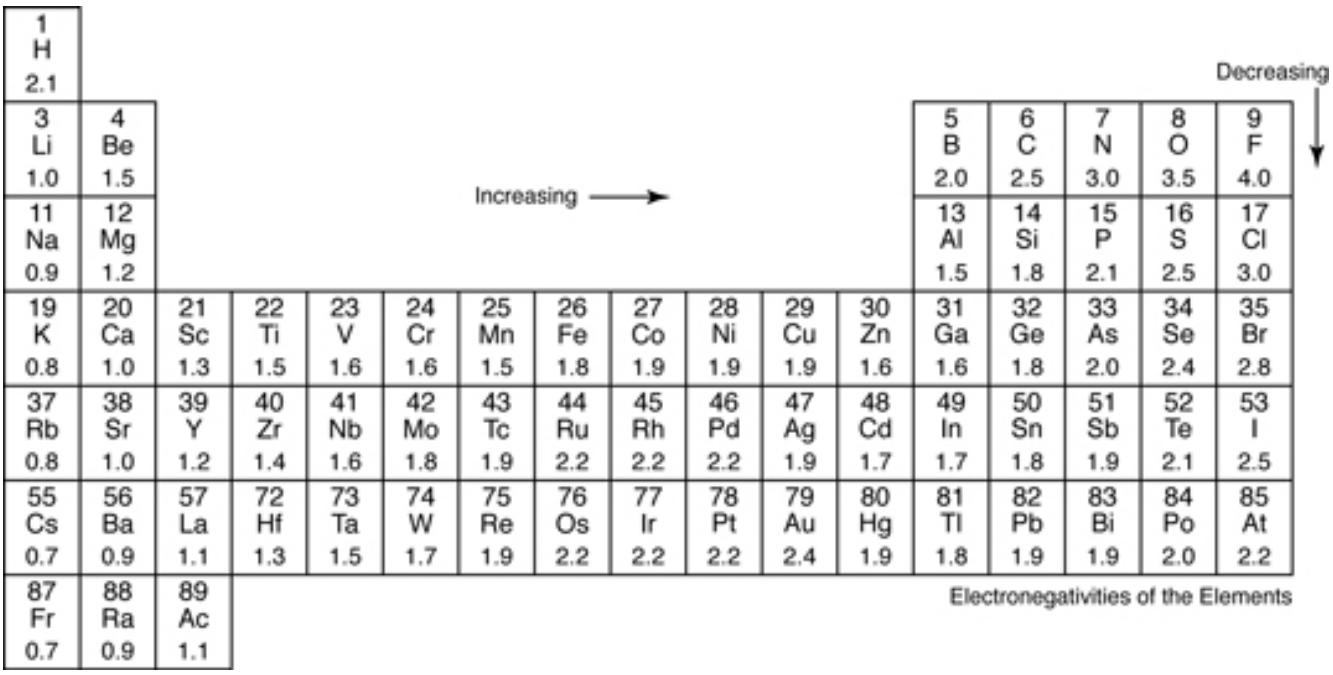
$\lambda = \frac{h}{mv}$

$\Delta x \times m\Delta v \geq \frac{h}{4\pi}$

$E_{photon} = h\nu = \frac{hc}{\lambda}$

$E_{photon} = R_H \left[\left(\frac{1}{n^2_{final}}\right) - \left(\frac{1}{n^2_{initial}}\right)\right]$

Electronegativity



Scratch Page

(to be handed in)