CHEMISTRY 102B/C
Hour Exam II
October 30, 2019
T. Hummel

NAME _____

SIGNATURE _____

SECTION _____

FORM "A"

This exam is made up of an answer sheet, two cover sheets and 7 numbered pages. Below are instructions for coding the answer sheet. The last page of this exam contains some useful equations and constants, plus the periodic table.

On the answer sheet:

1. **Use #2 pencil. Erase cleanly**.
2. Print your **NAME** in the appropriate designated spaces, then blacken in the letter boxes below each printed letter, last name first, then your first name initial.
3. Fill in your university **ID** number under **STUDENT NUMBER**.
4. Under **SECTION** write the five digit number that corresponds to your section designation, and then blacken in the corresponding number of boxes. **For 102B students,** the numbers are: BQ1 = 00011, BQ2 = 00012, BQ4 = 00014, BQ6 = 00016, BQ7 = 00017, BQ8 = 00018, BQA = 00021, BQB = 00022, BQD = 00024, BQG = 00027, BQH = 00028, BQI = 00029. **For 102C students**, the numbers are: CQ1 = 00031, CQ2 = 00032, CQ3 = 00033, CQ5 = 00035, CQ6 = 00036, CQ7 = 00037, CQ8 = 00038, CQ9 = 00039, CQA = 00041, CQB = 00042, CQC = 00043, CQE = 00045.
5. Under **NETWORK ID** print your University Network ID beginning on the left hand side with box #1, and then blacken in the corresponding letters, numbers and/or dashes under each character. Do not fill in a character for any unused boxes.
6. Under **TEST FORM** blacken the letter corresponding to the form designated on the upper left hand corner of the exam booklet.
7. Your TA's name should be printed for **INSTRUCTOR** and write your section number for **SECTION** in the lines provided.
8. **Sign** your name (do not print) on the line provided. Print your name underneath it.
9. **Mark** only one answer per question and do not use the answer sheet for scratch paper or make any stray marks on it. Erase cleanly if you wish to change an answer. The exam itself can be used for scratch paper.

Work carefully and efficiently. If your answer differs from one given in the last proper significant figure, mark that answer as correct and not the response "none of these". All questions are worth the same.

Solubility rules:

1. Most nitrate salts are soluble.
2. Most salts of alkali metals and ammonium cations are soluble.
3. Most chloride, bromide, and iodide salts are soluble.
   Exceptions: salts containing Ag^+, Pb^{2+}, and Hg_2^{2+} ions are insoluble.
4. Most sulfate salts are soluble.
   Exceptions: sulfates containing Ca^{2+}, Ba^{2+}, Pb^{2+}, and Hg_2^{2+} ions are insoluble.
5. Most hydroxide salts are insoluble.
   Exceptions: hydroxides containing alkali metals, Ba^{2+}, Sr^{2+}, and Ca^{2+} ions are soluble.
6. Most sulfide, carbonate, chromate, and phosphate salts are insoluble.
   Exceptions: salts of alkali metals and ammonium cations are soluble.

For the next two questions, consider the reaction between 150.0 mL of 0.300 *M* $Ba(NO_3)_2$ with 120.0 mL of 0.300 *M* Na_3PO_4. Assume the reaction has 100% yield.

1. Which ions are present in solution after the reaction has gone to completion?

   a) There are no ions in solution after completion.

   b) Ba^{2+}, NO_3^-, Na^+, and PO_4^{3-} ions are all present after completion.

   c) Only Ba^{2+}, NO_3^-, and Na^+ ions present after completion.

   d) Only NO_3^- and Na^+ ions are present after completion.

   e) Only NO_3^-, Na^+, and PO_4^{3-} ions are present after completion.

2. How many moles of precipitate form after the reaction has gone to completion?

   a) 0.0450 mol b) 0.0300mol c) 0.0360mol

   d) 0.0150 mol e) 0.0180 mol

3. Consider a substance that has a high vapor pressure. Which of the following is **not** characteristic of a substance with a high vapor pressure?

   a) The substance is an ionic compound.

   b) The temperature of the substance is relatively high.

   c) The substance is a small, nonpolar covalent compound.

   d) The substance has a relatively small value for the enthalpy of vaporization (ΔH_{vap}).

4. Consider a strong acid solution. When lead nitrate is added to some of the strong acid solution, a precipitate forms. In a second experiment, 50.0 mL of the strong acid solution requires 201.5 mL of 1.00 *M* KOH for complete reaction. If the 50.0 mL of strong acid solution contains 16.3 g of the strong acid, which of the following is the identity of the strong acid?

   a) HF b) HCl c) HBr

   d) HI e) HNO_3

5. Which of the following statements **best** explains why HCl has a higher boiling point than Ar?

a) HCl and Ar have similar strength London dispersion forces, but HCl has additional dipole forces that Ar does not possess.

b) HCl and Ar have similar strength London dispersion forces, but HCl has additional ionic forces that Ar does not possess.

c) HCl and Ar have similar strength London dispersion forces, but HCl has additional hydrogen bonding forces that Ar does not possess.

d) HCl has stronger London dispersion forces than Ar.

e) HCl is a strong electrolyte but Ar is not.

6. Consider 100.0 mL of a 0.875 *M* K_2CO_3 solution sitting in an uncovered beaker. Some water from the solution evaporates. After several days, you determine the K^+ concentration in the remaining solution to be 2.334 *M*. What volume of water **evaporated** from the original solution?

a) 100.0 mL b) 80.0 mL c) 75.0 mL

d) 25.0 mL e) 10.0 mL

7. Consider the reaction of 4.60 g of sodium metal with excess oxygen to form Na_2O (molar mass = 61.98 g/mol). The actual yield of the reaction is 5.88 g of Na_2O. What is the percent yield of the reaction?

a) 94.8% b) 63.8% c) 47.4%

d) 86.4% e) 73.8%

8. A 0.10 *M* $Ba(NO_3)_2$ solution is added to four separate beakers. The four beakers contain 0.10 *M* Na_2SO_4, 0.10 *M* K_2CO_3, 0.10 *M* NH_4Cl, and 0.10 *M* RbOH. In how many of the four beakers did a precipitate form?

a) 0 (none) b) 1 c) 2 d) 3

e) 4 (A precipitate will form in all four beakers).

9. Consider the following four substances:

HF, HCl, HI, Cl_2

How many of these substances have a boiling point that is/are higher than the boiling point for HBr?

a) 0 (none) b) 1 c) 2 d) 3

e) 4 (All of the substances have a higher boiling point than HBr.)

10. Air bags are activated when a severe impact causes a steel ball to compress a spring and electronically ignite a detonator cap. This causes sodium azide (NaN_3) to decompose explosively according to the following equation:

$$2\ NaN_3(s) \rightarrow 2\ Na(s) + 3\ N_2(g)$$

What mass of $NaN_3(s)$ must be reacted to inflate an air bag to 70.0 L at STP assuming 100% yield?

a) 203 g b) 43.8 g c) 75.0 g

d) 304 g e) 135 g

11. Which of the following net ionic equations will **not** occur?

a) $Ag^+(aq) + Cl^-(aq) \rightarrow AgCl(s)$

b) $Hg_2^{2+}(aq) + SO_4^{2-}(aq) \rightarrow Hg_2SO_4(s)$

c) $Fe^{2+}(aq) + OH^-(aq) \rightarrow Fe(OH)_2(s)$

d) $Mn^{2+}(aq) + CrO_4^{2-}(aq) \rightarrow MnCrO_4(s)$

e) $Co^{2+}(aq) + I^-(aq) \rightarrow CoI_2(s)$

12. A sample of gas containing 0.50 moles of Kr at 25°C exerts a pressure 0.75 atm. More Kr gas is added to the rigid container and the temperature is increased to 50.°C. The resulting pressure is 2.5 atm. How many moles of Kr were **added** to the rigid container?

a) 0.83 moles b) 0.33 moles c) 1.5 moles

d) 1.0 mole e) 0.50 moles

13. Consider the following **unbalanced** equation:

$$N_2(g) + H_2(g) \rightarrow NH_3(g)$$

In which of the following cases (a-d) is/are nitrogen the limiting reactant?

a) Reacting 2.0 moles of N_2 with 5.0 moles of H_2.

b) Reacting 60.0 g of N_2 with 10.0 g H_2.

c) Reacting 3.0 moles of N_2 with 3.0 moles of H_2.

d) Reacting 250.0 g of N_2 with 60.0 g of H_2.

e) Nitrogen is limiting in at least two of the above cases (a-d).

14. The compound adrenaline contains 56.79% C, 28.37% O, and 8.28% N by mass, with hydrogen the remaining element in the compound. What is the empirical formula of adrenaline?

a) $C_4H_5O_2N$ b) $C_6H_3O_2N$ c) C_2H_5ON

d) $C_6H_5O_2N$ e) $C_8H_{11}O_3N$

15. Consider the following four substances:

$CH_3\text{-}CH_2\text{-}CH_2\text{-}CH_2\text{-}CH_3$, Ar, $CH_3\text{-}O\text{-}CH_3$, I_2

How many of these four substances **only** exhibit London dispersion forces (LDF)?

a) 0 (none) b) 1 c) 2 d) 3

e) 4 (All four of these substances only exhibit London dispersion forces.)

16. Some argon gas is collected over water. The wet gas occupies 2.0 L at 60.°C and 783 torr. If the 2.0 L of wet gas contains 0.0144 moles of water, what is the partial pressure of Ar in the 2.0 L of wet gas at 60.°C?

a) 633 torr b) 150. torr c) 715 torr

d) 762 torr e) 300. torr

17. Glutamic acid, one of the 20 naturally occurring amino acids, has a molecular formula of $C_5H_9O_4N$. A 0.250 g-sample of glutamic acid (molar mass = 147.1 g/mol) dissolved in 75.0 mL of solution requires 17.0 mL of 0.100 *M* $Ca(OH)_2$ to react completely with all of the acid. Which of the following is the best formula for glutamic acid?

a) $HC_5H_8O_4N$ b) $H_2C_5H_7O_4N$ c) $H_3C_5H_6O_4N$

d) $H_4C_5H_5O_4N$ e) $H_6C_5H_3O_4N$

For the next two questions, consider the reaction between 20.00 g of $NH_3(g)$ and 45.00 g of $O_2(g)$ by the following **unbalanced** equation:

	$NH_3(g)$	+	$O_2(g)$	→	$NO(g)$	+	$H_2O(g)$
Molar mass:	17.03		32.00		30.01		18.02 g/mol

18. What mass of NO(g) can form assuming 100% yield?

a) 30.41 g b) 33.76 g c) 35.24 g

d) 42.37 g e) 49.83 g

19. What mass of excess reactant remains after the reaction has gone to completion?

a) 0.84 g b) 1.15 g c) 3.14 g

d) 7.43 g e) 8.62 g

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20. Calcium phosphate is an insoluble ionic compound. What is the mass percent of calcium in calcium phosphate?

a) 21.96% b) 29.68% c) 38.76%

d) 45.77% e) 55.87%

21. At STP, 1.0 L of $Cl_2(g)$ reacts completely with 5.0 L of $F_2(g)$ to produce $ClF_5(g)$. What volume of $ClF_5(g)$ is produced in this reaction at STP?

a) 1.0 L b) 2.0 L c) 3.0 L d) 5.0 L e) 6.0 L

22. Caproic acid has an odor that is often associated with dirty socks; it is composed of C, H, and O. A 20.00 g-sample of caproic acid reacts with 44.08 g of O_2 to produce 45.46 g of CO_2 and some H_2O. What is the mass percent of hydrogen in caproic acid? Hint: Mass is conserved in a chemical reaction.

a) 7.25% H b) 10.4% H c) 3.36% H

d) 5.21% H e) 4.73% H

23. Caproic acid has an odor that is often associated with dirty socks; it is composed of C, H, and O. A 20.00 g-sample of caproic acid reacts with 44.08 g of O_2 to produce 45.46 g of CO_2 and some H_2O. What is the empirical formula of caproic acid? Hint: Mass is conserved in a chemical reaction.

a) C_2H_4O b) C_4H_2O c) $C_2H_6O_3$

d) C_3H_6O e) $C_2H_3O_2$

24. Consider the following four statements (I-IV) regarding real gases:

I. Gases behave most ideally at high temperatures and low pressures.

II. Real gas molecules have a volume and do exert intermolecular forces.

III. In the van der Waals gas equation, a term is added to the measured pressure to correct for the intermolecular forces exerted by a real gas.

IV. In the van der Waals gas equation, the "b" constant in the equation helps correct for the volume taken up by the gas particles themselves.

How many of the above four statements (I-IV) is/are **true**? Hint: refer to the van der Waals gas equation on the constants page.

a) 0 (none) b) 1 c) 2 d) 3

e) 4 [All of the statements (I-IV) are true].

25. Which of the following 1.0 *M* solutions is the **worst** conductor of electricity?

a) $SrCl_2$ b) HF c) CH_3OH

d) NH_4NO_3 e) $CuSO_4$

26. Over a ten minute period, 0.32 moles of oxygen gas effuses from a container. How many moles of methane (CH_4) gas will effuse from the same container in 10 minutes?

a) 0.64 moles b) 0.32 moles c) 0.23 moles d) 0.16 moles e) 0.45 mol

27. Which of the following gas samples (a-d) has the same average kinetic energy as nitrogen gas at 232 K?

a) $O_2(g)$ at 200 K b) Ar(g) at −41°C c) Ne(g) at 41°C d) $CO_2(g)$ at 200 K

e) None of these gases have the same average kinetic energy as $N_2(g)$ at 232 K.

28. Which of the following gas samples has the fastest average velocity?

a) $O_2(g)$ at 200 K b) Ar(g) at −41°C c) Ne(g) at 41°C

d) $CO_2(g)$ at 200 K e) $N_2(g)$ at 232 K

29. Consider the reaction between 100.0 mL of 0.200 *M* KOH and 100.0 mL of 0.200 *M* $Mg(NO_3)_2$. Calculate the concentration of Mg^{2+} ions in solution after the reaction has gone to completion.

a) 0 *M* b) 0.00500 *M* c) 0.0100 *M*

d) 0.0150 *M* e) 0.0200 *M*

30. Consider two steel containers with the same volume and at the same temperature. You have 25 g of Ar(g) in one of the tanks producing a pressure of 1.0 atm. In the other tank, you have 20. g of a gas which produces a pressure of 2.0 atm. Which of the following could be the gas in the second container?

a) CH_4 b) N_2 c) He

d) O_2 e) SO_2

31. My answers for this Chemistry 102 exam should be graded with the answer sheet associated with:

a) Form A b) Form B c) Form C d) Form D e) Form E

USEFUL CONSTANTS/EQUATIONS

$K = °C + 273$

$PV = nRT$

1 kg = 1000 g

$R = 0.08206$ L atm/K•mol

1 L = 1000 mL

Avogadro's number, $N = 6.022 \times 10^{23}$

1 atm = 760 torr = 760 mm Hg

$$\text{Mass \% of A} = \frac{\text{mass of A}(100)}{\text{total mass}}$$

$$\frac{\text{rate 1}}{\text{rate 2}} = \sqrt{\frac{M_2}{M_1}} \quad (M = \text{molar mass})$$

$KE_{AVE} = (3/2)\,RT$, $R = 8.3145$ J/K•mol

$$M = \text{Molarity} = \frac{\text{mol solute}}{\text{L solution}}$$

$$\%\ \text{yield} = \frac{\text{actual}}{\text{theoretical}}\ (100)$$

$P_{total} = P_1 + P_2 + P_3 + \ldots$

STP = 1 atm, 273 K

d = density = mass/volume

$P \bullet M = dRT$, M = molar mass

$$\frac{P_1V_1}{n_1T_1} = \frac{P_2V_2}{n_2T_2}$$

Kinetic Energy $= (1/2)\,mv^2$

$$\left(P_{measured} + \frac{an^2}{V^2}\right)(V_{measured} - nb) = nRT$$

PERIODIC TABLE OF THE ELEMENTS

1 1A												13 3A	14 4A	15 5A	16 6A	17 7A	18 8A
1 H 1.008	2 2A																2 He 4.003
3 Li 6.941	4 Be 9.012					26 Fe 55.85 ← Atomic number / ← Atomic mass						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	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
19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.90	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.85	27 Co 58.93	28 Ni 58.70	29 Cu 63.55	30 Zn 65.39	31 Ga 69.72	32 Ge 72.59	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	57 La* 138.9	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	89 Ac† 227	104 Rf 261	105 Db 262	106 Sg 266	107 Bh 262	108 Hs 265	109 Mt 266	110 Ds 271	111	112						

*Lanthanides	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	90 Th 232.0	91 Pa 231	92 U 238	93 Np 244	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