CHEMISTRY 102B/C
Hour Exam II
October 25, 2023
T. Hummel

NAME _____

SIGNATURE _____

SECTION _____

FORM "A"

This exam is made up of an answer sheet, two cover sheets and 8 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: BQ2 = 00012, BQ3 = 00013, BQ4 = 00014, BQ6 = 00016, BQ7 = 00017, BQ8 = 00018, BQA = 00021, BQB = 00022, BQC = 00023, BQD = 00024, BQG = 00027, BQH = 00028, BQI = 00029. **For 102C students**, the numbers are: CQ1 = 00031, CQ2 = 00032, CQ3 = 00033, CQ4 = 00034, CQ5 = 00035, CQ6 = 00036, CQ8 = 00038, CQA = 00041, CQB = 00042, CQC = 00043, CQD = 00044, CQE = 00045, CQF = 00046.
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. 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.

1. You find a bottle on the shelf in the Chem 103 lab. The label says "0.10 *M* $MgSO_4$." Which of the following statements **best** describes what is in the bottle?

   a) The $MgSO_4$ is a solid on the bottom of the bottle because it is not soluble in water.

   b) There are $MgSO_4$ molecules floating around in solution.

   c) There are magnesium ions, sulfur ions, and oxygen ions floating around in solution.

   d) There are magnesium ions and sulfate ions floating around in solution.

2. A solution of 1.0 *M* KBr is diluted. Which of the following happens during the dilution?

   a) molarity increases; volume is constant; moles of KBr decrease

   b) molarity increases; volume increases; moles of KBr are constant

   c) molarity decreases; volume decreases; moles of KBr are constant

   d) molarity decreases; volume increases; moles of KBr are constant

   e) molarity increases; volume is constant; moles of KBr increase

3. An unknown ionic compound having the formula MX_3 is prepared by the following unbalanced chemical equation:

$$M + X_2 \rightarrow MX_3$$

   A 0.105-g sample of X_2 contains 8.92×10^{20} molecules. The compound MX_3 consists of 54.47% X by mass. What is the identity of the metal M?

   a) Te b) Fe c) Mg d) Al e) Y

4. Which of the following gas samples (a-d) has/have the largest average kinetic energy **and** has/have the fastest average velocity for the gas molecules in the gas sample?

   a) 1.0 mol of $CO_2(g)$ at P = 1.0 atm and T = 0.°C

   b) 1.0 mol of $F_2(g)$ at P = 1.0 atm and T = 0.°C

   c) 1.0 mol of $N_2(g)$ at P = 1.0 atm and T = 100.°C

   d) 1.0 mol of $Cl_2(g)$ at P = 1.0 atm and T = 100.°C

   e) The gas samples in answers c and d both have the same average kinetic energy and have the same average molecular velocity.

5. Consider 2 different containers each filled with two moles of Ne(g). One of the containers is rigid and is of constant volume; the other container is flexible (like a balloon) and can change its volume to keep the external pressure and internal pressure equal. If you raise the temperature in both containers, which of the following is **true** concerning the pressure and density of the gas inside each container? Assume constant external pressure.

a) Rigid container: Pressure and density both increase.
Flexible container: Pressure and density are both constant.

b) Rigid container: Pressure is constant, density decreases.
Flexible container: Pressure increases, density decreases.

c) Pressure increases and density is constant in both containers.

d) Rigid container: Pressure increases, density is constant.
Flexible container: Pressure is constant, density decreases.

e) Rigid container: Pressure increases, density decreases.
Flexible container: Pressure increases, density is constant.

6. Consider the following balanced equation:

$$2\ C_3H_6(g) + 2\ NH_3(g) + 3\ O_2(g) \rightarrow 2\ C_3H_3N(g) + 6\ H_2O(g)$$

When 5.0 mol of C_3H_6, 5.0 mol of NH_3 and 6.0 mol of O_2 are reacted, 3.0 mol of C_3H_3N are actually produced. What is the percent yield of the reaction?

a) 33% b) 50.% c) 60.% d) 67% e) 75%

7. For water, the molar heat of vaporization ($\Delta H_{vaporization}$) is 40.6 kJ/mol while the molar heat of fusion (ΔH_{fusion}) is 6.02 kJ/mol. Which of the following best explains why $\Delta H_{vaporization}$ is larger than ΔH_{fusion}?

a) More intermolecular forces are broken when water boils than when water melts.

b) The gas phase has the strongest amount of intermolecular forces present.

c) The fusion process refers to breaking ionic forces in water which are weaker than the intermolecular forces broken in the vaporization process.

d) For water, the solid phase is less dense than the liquid phase.

e) $\Delta H_{vaporization}$ and ΔH_{fusion} are inversely related to the strength of the intermolecular forces present.

8. Consider an organic compound which contains only carbon, hydrogen, and oxygen. Combustion of 10.68 g of the compound yields 16.01 g CO_2 and 4.37 g H_2O. What is the mass percent of hydrogen in this compound?

a) 3.87% H b) 2.98% H c) 5.67% H d) 3.23% H e) 4.58% H

9. Consider an organic compound which contains only carbon, hydrogen, and oxygen. Combustion of 10.68 g of the compound yields 16.01 g CO_2 and 4.37 g H_2O. If the molar mass of the compound is between 250 g/mol and 280 g/mol, which of the following is the <u>molecular</u> formula?

a) $C_3H_4O_3$ b) $C_2H_3O_4$ c) $C_{12}H_{18}O_6$

d) $C_9H_{12}O_9$ e) $C_6H_9O_{12}$

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10. Silver sulfadiazine burn-treating cream creates a barrier against bacterial invasion and releases antimicrobial agents directly into the wound. If 25.0 g of Ag_2O (molar mass = 231.8 g/mol), is reacted with 50.0 g of $C_{10}H_{10}N_4SO_2$ (molar mass = 250.3 g/mol), what mass of silver sulfadiazine, $AgC_{10}H_9N_4SO_2$ (molar mass = 357.2 g/mol), can be produced assuming 100% yield?

$$Ag_2O + 2\ C_{10}H_{10}N_4SO_2 \rightarrow 2\ AgC_{10}H_9N_4SO_2 + H_2O$$

a) 100. g b) 77. 0 g c) 71.4 g d) 35.7 g e) 38.5 g

11. At elevated temperatures, sodium chlorate decomposes to produce sodium chloride and oxygen gas:

$$2\ NaClO_3(s) \rightarrow 2\ NaCl(s) + 3\ O_2(g)$$

A 0.8765-g sample of impure sodium chlorate was heated until the production of oxygen gas ceased. The oxygen gas collected over water occupied 57.2 mL at a temperature of 22°C and a total pressure of 734 torr. Calculate the mass percent of $NaClO_3$ in the original sample. At 22°C, the vapor pressure of water is 21 torr and assume 100% yield in the reaction. The molar mass of $NaClO_3$ is 106.44 g/mol.

a) 17.9% b) 26.9% c) 62.2% d) 75.0% e) 87.1%

12. 45.0 mL of 5.50 *M* KOH are required to react completely with 22.0 mL of an H_2SO_3 solution. What is the molarity of the H_2SO_3 solution?

a) 22.5 *M* b) 5.63 *M* c) 2.72 *M* d) 1.34 *M* e) 11.3 *M*

13. A roach killer, dibutyl succinate, was analyzed and found to be composed of 62.58% C, 9.63% H and 27.79% O. What is the empirical formula of dibutyl succinate?

a) C_3H_5O b) $C_6H_{11}O_2$ c) $C_5H_9O_3$

d) $C_8H_{12}O_6$ e) $C_4H_6O_3$

14. On a typical August day in Champaign, the temperature is 35°C and the relative humidity is 90%. A 10.0 L sample of air on this 35°C day contains 0.356 g of $H_2O(g)$. From this data, calculate the partial pressure of water on a 35°C day having a relative humidity of 90%.

a) 62.3 torr b) 28.5 torr c) 12.6 torr

d) 37.9 torr e) 684 torr

Consider the following information for the next three questions. 100.0 mL of 0.100 *M* lead(II) nitrate is added to 75.0 mL of 0.100 *M* ammonium phosphate and a precipitate forms.

15. Which of the following is the correct net ionic equation for the precipitation reaction?

a) $3\ Pb^{2+}(aq) + 2\ PO_4^{3-}(aq) \rightarrow Pb_3(PO_4)_2(s)$

b) $Pb^{2+}(aq) + PO_4^{2-}(aq) \rightarrow PbPO_4(s)$

c) $Pb^{2+}(aq) + 2\ PO_4^{-}(aq) \rightarrow Pb(PO_4)_2(s)$

d) $NH_4^{2+}(aq) + 2\ NO_3^{-}(aq) \rightarrow NH_4(NO_3)_2(s)$

e) $NH_4^{+}(aq) + NO_3^{-}(aq) \rightarrow NH_4NO_3(s)$

16. How many moles of precipitate form assuming 100% yield?

a) 0.0100 mol b) 0.00750 mol c) 0.00500 mol

d) 0.00375 mol e) 0.00333 mol

17. Calculate the molarity of the ammonium ions after precipitation is complete.

a) 0.100 *M* b) 0.129 *M* c) 0.0429 *M*

d) 0.300 *M* e) 0.250 *M*

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18. Under which of the following conditions will a sample of $SO_2(g)$ behave **most** ideally?

a) 40 K, 500 atm b) 4000 K, 0.50 atm

c) 40 K, 0.50 atm d) 4000 K, 500 atm

19. When $N_2(g)$ reacts with $F_2(g)$, $NF_3(g)$ is produced. If 1.0 L of $F_2(g)$ is reacted with an excess of $N_2(g)$, how many moles of $NF_3(g)$ can be produced at STP?

a) 0.030 mol b) 0.045 mol c) 0.13 mol d) 0.089 mol e) 0.10 mol

20. An ideal gas occupies a volume of 10.0 L at 38°C and 0.20 atm. If the gas sample is cooled to 7°C and the volume is decreased to 3.60 L, what is the new pressure of the gas sample?

a) 1.7 atm b) 0.20 atm c) 0.92 atm d) 0.11 atm e) 0.50 atm

21. Rank the following three substances from weakest to strongest electrolyte.

HNO_3, $C_{12}H_{22}O_{11}$, $HC_2H_3O_2$

a) $C_{12}H_{22}O_{11} < HC_2H_3O_2 < HNO_3$ b) $C_{12}H_{22}O_{11} < HNO_3 < HC_2H_3O_2$

c) $C_{12}H_{22}O_{11} < HNO_3 \approx HC_2H_3O_2$ d) $HNO_3 < HC_2H_3O_2 < C_{12}H_{22}O_{11}$

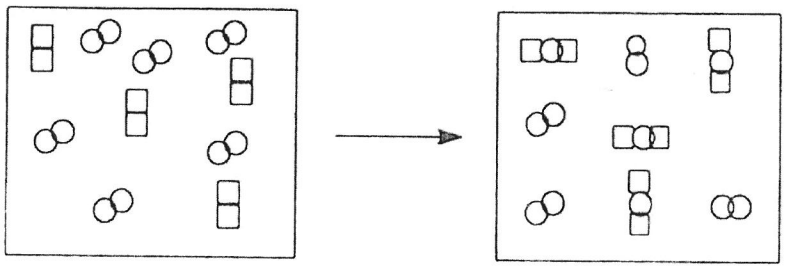
e) $HC_2H_3O_2 < C_{12}H_{22}O_{11} < HNO_3$

22. A new form of saccharin has a molecular formula of $C_{14}H_{10}N_2O_6S_2$. A 0.589 g mixture containing saccharin and glucose was dissolved in water. The saccharin in the mixture was reacted to convert all the sulfur in saccharin into the sulfate ion. The sulfate ion was then precipitated by adding an excess of barium chloride solution. The mass of $BaSO_4$ obtained was 0.503 g. What is the mass percent of saccharin ($C_{14}H_{10}N_2O_6S_2$) in the mixture? The molar mass of this form of saccharin ($C_{14}H_{10}N_2O_6S_2$) is 366.38 g/mol, the molar mass of glucose ($C_6H_{12}O_6$) is 180.16 g/mol, and the molar mass of $BaSO_4$ is 233.4 g/mol.

a) 75.0% saccharin b) 67.0% saccharin c) 50.0% saccharin

d) 33.0% saccharin e) 25.0% saccharin

23. Which of the following statements does **not** describe the reaction pictured below?



a)  and  combine in a 2:1 mole ratio.

b)  is the limiting reactant.

c) The reaction produces two different products.

d) The reactants pictured both represent diatomic elements.

24. Consider a container holding a "real" gas at some temperature and pressure, i.e., the gas is not behaving "ideally." Which of the following is **true** regarding the measured pressure and the measured volume of the "real" gas as compared to the pressure and the volume of the container if the gas were behaving "ideally?" Hint: look at the van der Waals equation given on the constants/equations page of this exam.

a) $P_{measured} > P_{ideal}$; $V_{measured} > V_{ideal}$

b) $P_{measured} > P_{ideal}$; $V_{ideal} = V_{measured}$

c) $P_{ideal} > P_{measured}$; $V_{measured} > V_{ideal}$

d) $P_{ideal} > P_{measured}$; $V_{ideal} > V_{measured}$

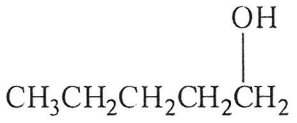
e) $P_{ideal} = P_{measured}$; $V_{ideal} > V_{measured}$

25. Consider a classroom containing ten evenly spaced rows of students. If a student in row 1 releases laughing gas (N_2O) and a student in row 10 simultaneously releases a lachrymator (a gas which causes tears) with molar mass 176, in which row do the students first laugh and cry at the same time, i.e., in which row do the two gases first meet? Hint: the molar mass of the lachrymator is 4 times greater than the molar mass of N_2O, i.e., molar mass lachrymator = 4 × molar mass N_2O.

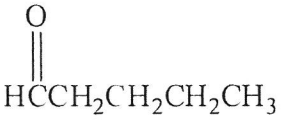
a) row 2 b) row 3 c) row 7 d) row 8 e) row 9

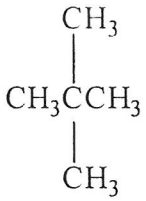
26. The five compounds in the answers below have boiling points of 9.5°C, 36°C, 69°C, 103°C, and 137°C. Which compound boils at 9.5°C?

a) $CH_3CH_2CH_2CH_2CH_3$

b) 

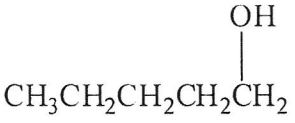
c) $CH_3CH_2CH_2CH_2CH_2CH_3$

d) 

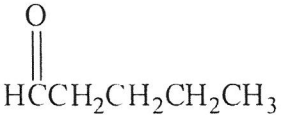
e) 

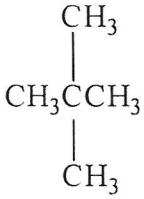
27. At some temperature, which of the following compounds will have the lowest vapor pressure?

a) $CH_3CH_2CH_2CH_2CH_3$

b) 

c) $CH_3CH_2CH_2CH_2CH_2CH_3$

d) 

e) 

28. Lithium and nitrogen react to form lithium nitride. What mass of lithium nitride can be produced when 20.0 g of Li is reacted with excess nitrogen?

a) 33.5 g b) 41.8 g c) 50.2 g d) 100. g e) 121 g

29. Consider the following four compounds:

KF HF Br_2 ICl

Which of the following statements about these four compounds is **true**?

a) HF has a higher boiling point than KF because HF can form relatively strong hydrogen bonding intermolecular forces.

b) Br_2 has a higher boiling point than KF because Br_2 will have the stronger London dispersion forces.

c) ICl has a higher boiling point than Br_2 because ICl has additional dipole forces that are not present in Br_2.

d) HF has the strongest London dispersion forces of all these compounds.

e) ICl has the strongest ionic forces of all these compounds.

30. Consider the following five reactions:

I. $Hg_2(NO_3)_2(aq) + CuSO_4(aq) \rightarrow$

II. $Ni(NO_3)_2(aq) + CaCl_2(aq) \rightarrow$

III. $K_2CO_3(aq) + MgI_2(aq) \rightarrow$

IV. $H_3PO_4(aq) + Ca(OH)_2(aq) \rightarrow$

V. $Na_2CrO_4(aq) + AlBr_3(aq) \rightarrow$

In how many of these five reactions will a precipitate form?

a) 0 (none) b) 1 c) 2 d) 4

e) 5 [A precipitate will form in all five (I-V) of these reactions.]

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

$P \cdot M = dRT$, 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																	18 8A
1 H 1.008	2 2A											13 3A	14 4A	15 5A	16 6A	17 7A	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