

CHEMISTRY 102A

Exam II

March 29, 2023

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:

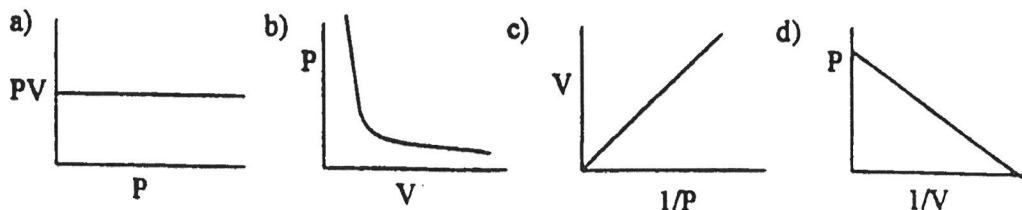
1. **Use #2 pencil. Erase cleanly.**
2. Print your **NAME** in the appropriate designated spaces, then blacken in the letter boxes below each printed letter, last name first, then your first name initial.
3. Fill in your university **ID** number under **STUDENT NUMBER**.
4. Under **SECTION** write the five digit number that corresponds to your section designation, and then blacken in the corresponding number of boxes. **For 102A students**, the numbers are: AQA = 00011, AQB = 00012, AQC = 00013, AQD = 00014, AQE = 00015, AQF = 00016, AQH = 00018, AQJ = 00020, AQK = 00021, AQL = 00022, AQN = 00024, AQO = 00025, AQP = 00026.
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.

1. Boyle's law can be represented graphically in several ways. Which of the following plots does **not** correctly represent Boyle's law (assuming constant T and n)?



2. Consider two separate gas containers at the following conditions:

Container A

Contents: $C_2H_6(g)$
Pressure = P_A
Moles of gas = 1.0 mol
Volume = 1.0 L
Temperature = 280 K

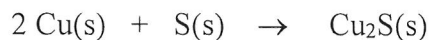
Container B

Contents: unknown gas
Pressure = P_B
Moles of gas = 2.0 mol
Volume = 2.0 L
Temperature = 560 K

Which of the following correctly relates P_B to P_A , assuming ideal gas behavior?

- a) $P_B = \frac{1}{2} P_A$ b) $P_B = P_A$ c) $P_B = 2P_A$
d) $P_B = 4P_A$ e) $P_B = 8P_A$
3. Tetraphenylporphyrin is composed of only C, H, and N atoms. Experiments reveal that tetraphenylporphyrin is 85.96% C and 9.12% N by mass. What is the empirical formula of tetraphenylporphyrin?
- a) C_7H_5N b) $C_{22}H_{15}N_2$ c) $C_{11}H_8N$
d) C_7HN_5 e) $C_{11}H_{15}N$
4. An unknown gas has an average velocity which is $\frac{1}{4}$ (one-fourth) that of the He average velocity at some temperature. Which of the following is the best choice for the unknown gas?
- a) CH_4 b) SO_2 c) H d) O_2 e) H_2

5. Consider the following reaction between copper and sulfur:



If 5.00 g Cu is reacted with 1.50 g S, calculate the theoretical mass of copper(I) sulfide that can form?

- a) 7.44 g b) 6.50 g c) 7.26 g d) 4.39 g e) 6.26 g
6. Which of the following statements is **false**?
- a) HCl is a strong electrolyte.
b) $\text{C}_{12}\text{H}_{22}\text{O}_{11}$ is a nonelectrolyte.
c) NH_4NO_3 is a nonelectrolyte.
d) $\text{HC}_2\text{H}_3\text{O}_2$ is a weak electrolyte.
e) Na_3PO_4 is a strong electrolyte.
7. Douglasite is a mineral which contains chlorine. A 0.455 g sample of douglasite is destroyed, releasing all the chlorine as the chloride ion. It took 37.2 mL of 0.100 M $\text{Pb}(\text{NO}_3)_2$ solution to precipitate all the Cl^- from the douglasite sample as $\text{PbCl}_2(\text{s})$. Calculate the mass percent of chlorine in douglasite. The molar mass of Cl is 35.45 g/mol and the molar mass of PbCl_2 is 278.1 g/mol. Assume that douglasite contains no Pb^{2+} ions.
- a) 58.0% b) 29.0% c) 26.4% d) 14.5% e) 13.2%
8. Menthol, an aromatic substance used in some cough drops, is composed of C, H, and O. When a 0.1006 g sample of menthol is combusted with excess oxygen, 0.2833 g CO_2 and 0.1160 g H_2O are produced. What is the mass percent of oxygen in menthol?
- a) 25% b) 20.% c) 15% d) 10.% e) 5.0%
9. Menthol, an aromatic substance used in some cough drops, is composed of C, H, and O. When a 0.1006 g sample of menthol is combusted with excess oxygen, 0.2833 g CO_2 and 0.1160 g H_2O are produced. What is the empirical formula of menthol?
- a) $\text{C}_1\text{H}_2\text{O}_3$ b) $\text{C}_2\text{H}_4\text{O}$ c) $\text{C}_3\text{H}_5\text{O}$ d) $\text{C}_6\text{H}_{10}\text{O}_2$ e) $\text{C}_{10}\text{H}_{20}\text{O}$

10. Silicon carbide, SiC, a hard material used as an abrasive on sandpaper, is prepared by the reaction of pure sand, SiO₂, with carbon, C. Carbon monoxide is the other product. Assuming 100% yield, what is the maximum amount of SiC that can be produced from the reaction of 1.11×10^3 g of C and excess SiO₂? The molar mass of C is 12.01 g/mol, the molar mass of SiO₂ is 60.09 g/mol, the molar mass of SiC is 40.10 g/mol, and the molar mass of CO is 28.01 g/mol.
- a) 7.40×10^2 g SiC b) 1.24×10^3 g SiC c) 2.47×10^3 g SiC
d) 3.71×10^3 g SiC e) 5.56×10^3 g SiC
11. A compound has an empirical formula of C₃H₂Cl. If the density of the gaseous compound is 2.25 g/L at 120.°C and 250. torr, what is the molecular formula of the compound?
- a) C₃H₂Cl b) C₆H₄Cl₂ c) C₉H₆Cl₃ d) C₁₂H₈Cl₄ e) C₁₅H₁₀Cl₅
12. Which of the following three compounds (a-c) has the largest mass percent of carbon?
- a) CH₂O
b) C₂H₄O₂
c) C₆H₁₂O₆
d) All of these compounds (a-c) have the same mass percent of carbon present.

Consider the following gases for the next two questions:

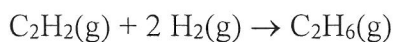
Ne N₂ Ar H₂

13. Which gas has the smallest average kinetic energy at 300. K?
- a) Ne b) N₂ c) Ar d) H₂
e) All of the gases have the same average kinetic energy at 300. K.
14. Which gas has the slowest average velocity at 300. K?
- a) Ne b) N₂ c) Ar d) H₂
e) All of the gases have the same average velocity at 300. K.

15. When aluminum nitrate $[\text{Al}(\text{NO}_3)_3]$ reacts with potassium carbonate (K_2CO_3), a precipitate forms. Which of the following is the correct net ionic equation for the precipitation reaction?
- a) $\text{K}^+(\text{aq}) + \text{NO}_3^-(\text{aq}) \rightarrow \text{KNO}_3(\text{s})$
b) $2 \text{Al}^+(\text{aq}) + \text{CO}_3^{2-}(\text{aq}) \rightarrow \text{Al}_2\text{CO}_3(\text{s})$
c) $\text{K}^{2+}(\text{aq}) + 2 \text{NO}_3^-(\text{aq}) \rightarrow \text{K}(\text{NO}_3)_2(\text{s})$
d) $\text{Al}^{3+}(\text{aq}) + 3 \text{CO}_3^-(\text{aq}) \rightarrow \text{Al}(\text{CO}_3)_3(\text{s})$
e) $2 \text{Al}^{3+}(\text{aq}) + 3 \text{CO}_3^{2-}(\text{aq}) \rightarrow \text{Al}_2(\text{CO}_3)_3(\text{s})$
16. If 75.0 mL of 0.200 M $\text{Al}(\text{NO}_3)_3$ reacts with 100.0 mL of 0.200 M K_2CO_3 , how many moles of precipitate can form assuming 100% yield?
- a) 0.0200 mol b) 0.0150 mol c) 0.00750 mol d) 0.00667 mol e) 0.00500 mol
17. If 75.0 mL of 0.200 M $\text{Al}(\text{NO}_3)_3$ reacts with 100.0 mL of 0.200 M K_2CO_3 , what is the concentration of nitrate ions after the reaction has gone to completion?
- a) 0.600 M b) 0.257 M c) 0.200 M d) 0.189 M e) 0.107 M
18. Consider the following **unbalanced** equation:
- $$\text{NH}_3(\text{g}) + \text{O}_2(\text{g}) \rightarrow \text{NO}(\text{g}) + \text{H}_2\text{O}(\text{g})$$
- A container initially has 10 molecules of O_2 and 10 molecules of NH_3 . Assuming the NH_3 and O_2 molecules react to completion by the above reaction, how many total molecules (reactant molecules plus product molecules) will be present in the container?
- a) 18 molecules b) 20 molecules c) 22 molecules
d) 24 molecules e) 26 molecules
19. A 10.00-mL sample of sulfuric acid (H_2SO_4) from a car battery requires 35.08 mL of 2.13 M sodium hydroxide (NaOH) for complete reaction. What is the molarity of the sulfuric acid?
- a) 3.74 M b) 7.48 M c) 14.9 M d) 2.50 M e) 5.00 M

20. Ascorbic acid, a weak acid commonly known as vitamin C, has a molecular formula of $C_6H_8O_6$. A 1.76 g sample of ascorbic acid dissolved in some water requires 25.0 mL of 0.800 M NaOH for complete neutralization. Which of the following is the best formula for ascorbic acid?
- a) $HC_6H_7O_6$
 - b) $H_2C_6H_6O_6$
 - c) $H_3C_6H_5O_6$
 - d) $H_4C_6H_4O_6$
 - e) $H_8C_6O_6$
21. A 2.00 L sample of $O_2(g)$ was collected over water at a total pressure of 785 torr and $25^\circ C$. When the $O_2(g)$ was dried (water vapor removed), the gas had a volume of 1.94 L at $25^\circ C$ and 785 torr. Calculate the vapor pressure of water at $25^\circ C$.
- a) 24 torr b) 15 torr c) 30. torr d) 78 torr e) 785 torr
22. If a student needs to prepare a 0.10 M solution of $NaHCO_3$, what volume of solution can be prepared using 0.37 g of $NaHCO_3$? (The molar mass of $NaHCO_3$ is 84.01 g/mol.)
- a) 3.5 mL b) 4.4 mL c) 16 mL d) 35 mL e) 44 mL
23. Sulfuric acid can be produced by the following 3-step process:
- $$4 FeS_2 + 11 O_2 \rightarrow 2 Fe_2O_3 + 8 SO_2$$
- $$2 SO_2 + O_2 \rightarrow 2 SO_3$$
- $$SO_3 + H_2O \rightarrow H_2SO_4$$
- How many moles of H_2SO_4 can be produced when 5.00 moles of FeS_2 reacts completely with excess O_2 and H_2O ? Assume 100% yield for each reaction.
- a) 2.50 mol b) 5.00 mol c) 10.0 mol d) 12.2 mol e) 20.0 mol
24. Ar boils at a temperature very close to the boiling point of one of the following substances. Which substance below has a boiling point similar to that of Ar?
- a) HF
 - b) Cl_2
 - c) Ne
 - d) F_2
 - e) HCl

25. Ethyne can be converted to ethane by the reaction:



C_2H_2 flows into a reaction vessel at 25.0 atm and 300.°C with a flow rate of 2000. L/min. Hydrogen at 25.0 atm and 300.°C flows into the reaction vessel also at a flow rate of 2000. L/min. If 480 mol of C_2H_6 are formed per minute of reaction, what is the percent yield of the reaction?

- a) 90.% b) 80.% c) 50.% d) 45% e) 40.%
26. Consider the following compounds:

Compound
water, H_2O
methanol, CH_3OH
ethanol, $\text{CH}_3\text{CH}_2\text{OH}$
dimethyl ether, $\text{CH}_3\text{--O--CH}_3$
ethylene glycol, $\text{HO--CH}_2\text{--CH}_2\text{--OH}$

Which compound will have the highest vapor pressure at room temperature?

- a) water b) methanol c) ethanol
- d) dimethyl ether e) ethylene glycol
27. What happens to the vapor pressure of a gas over a liquid as the strength of the intermolecular forces increase (at constant temperature)?
- a) Vapor pressure decreases because the molecules are held more strongly in the liquid phase and not as many molecules can escape into the gas phase.
- b) Vapor pressure decreases because the molecules do not have as much kinetic energy.
- c) Vapor pressure increases because the molecules in the gas phase attract more molecules into the gas phase.
- d) Vapor pressure increases because a higher temperature is needed to vaporize the liquid and pressure is greater at higher temperature.
- e) Vapor pressure depends on the identity of the substance; some substances will have a higher vapor pressure with increasing intermolecular forces and some substances will have a lower vapor pressure with increasing intermolecular forces.

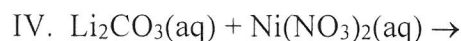
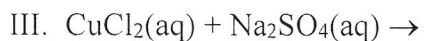
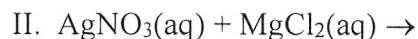
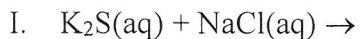
28. Rank the following substances in order of increasing boiling point (lowest boiling point to highest boiling point).

LiF NH₃ NO O₂

- a) O₂ < NO < NH₃ < LiF b) NO < O₂ < LiF < NH₃
c) LiF < NH₃ < NO < O₂ d) LiF < NH₃ < O₂ < NO
e) LiF < NO < O₂ < NH₃
29. Shown below are the postulates of the kinetic molecular theory:
- I. Gases are mostly empty space; the volume of the gas particles is negligible.
 - II. Gas particles are in constant random motion.
 - III. Gas particles neither attract nor repel each other.
 - IV. Pressure is due to collisions of gas particles with the walls of the container.
 - V. The average kinetic energy of a gas sample is proportional to the Kelvin temperature.

Which of the above postulates do **not** always hold true for real gases?

- a) I and II b) I and III c) III and IV d) II and IV e) II and III
30. Consider the products for the following four aqueous reactions:



In how many of the above four reactions does a precipitate form?

- a) 0 (none) b) 1 c) 2 d) 3
e) 4 (A precipitate forms in all the 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

$$K = ^\circ\text{C} + 273$$

$$PV = nRT$$

$$1 \text{ kg} = 1000 \text{ g}$$

$$R = 0.08206 \text{ L atm/K mol}$$

$$1 \text{ L} = 1000 \text{ mL}$$

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

$$1 \text{ atm} = 760 \text{ torr} = 760 \text{ mm Hg}$$

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

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

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

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

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

$$P_{\text{total}} = P_1 + P_2 + P_3 + \dots$$

$$\text{STP} = 1 \text{ atm, } 273 \text{ K}$$

$$d = \text{density} = \text{mass/volume}$$

$$P \cdot M = dRT, M = \text{molar mass}$$

$$\frac{P_1 V_1}{n_1 T_1} = \frac{P_2 V_2}{n_2 T_2}$$

$$\text{Kinetic Energy} = (1/2) mv^2$$

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

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	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						