CHEMISTRY 102C/102D
Exam II
March 27, 2024
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 102C students,** the numbers are: CQ1 = 00011, CQ2 = 00012, CQ3 = 00013, CQ4 = 00014, CQ5 = 00015, CQ6 = 00016, CQ7 = 00017, CQ9 = 00019, CQA = 00021, CQB = 00022, CQF = 00026, CQG = 00027, CQH = 00028, CQI = 00029. **For 102D students,** the numbers are: DQ1 = 00031, DQ2 = 00032, DQ3 = 00033, DQ4 = 00034, DQ5 = 00035, DQ6 = 00036, DQ7 = 00037, DQ8 = 00038, DQA = 00041. DQB = 00042.
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 following reaction for the production of methanol (CH_3OH):

$$CO(g) + 2\ H_2(g) \rightarrow CH_3OH(g)$$

1. How many moles of $CH_3OH(g)$ can be produced when 16.0 L of $H_2(g)$ are reacted with 25.0 L of $CO(g)$, with all gases measured at STP? Assume 100% yield.

   a) 0.357 mol b) 1.16 mol c) 0.558 mol d) 0.714 mol e) 0.279 mol

2. If 5.30 g of $CH_3OH(g)$ are actually produced at STP in the above reaction, what is the percent yield of the reaction?

   a) 53.7% b) 23.9% c) 76.1% d) 3.13% e) 46.3%

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3. A 100.00 mL sample of a $Sr(OH)_2$ solution requires 28.40 mL of 0.150 *M* H_3PO_4 to react completely with it. Calculate the concentration of the $Sr(OH)_2$ solution.

   a) 0.128 *M* b) 0.0639 *M* c) 0.0213 *M* d) 0.107 *M* e) 0.0426 *M*

For the next two questions, consider the following reaction involving two hypothetical elements A and B:

$$2\ A(g) + 3\ B_3(g) \rightarrow A_2B_9(g)$$

(Molar masses: A: 40.0 g/mol; A_2B_9: 125 g/mol)

Initially a reaction vessel contains 11.0 moles of A and 12.0 moles of B_3. Assuming the above reaction goes to completion with 100% yield, answer the following two questions.

4. If 4.0 moles of A_2B_9 are formed in the reaction, how many moles of A remain **unreacted**?

   a) 0 mol b) 1.0 mol c) 2.0 mol d) 3.0 mol e) 8.0 mol

5. What is the total mass of B_3 consumed in the reaction?

   a) 60.0 g b) 180. g c) 45.0 g d) 15.0 g e) 120. g

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6. Which of the following is the net ionic equation when 0.10 *M* solutions of $HgCl_2$ and K_2S are mixed together?

a) $HgCl_2(aq) + K_2S(aq) \rightarrow HgS(s) + 2\ KCl(aq)$
b) $HgCl_2(aq) + K_2S(aq) \rightarrow 2\ KCl(s) + HgS(aq)$
c) $Hg^{2+}(aq) + S^{2-}(aq) \rightarrow HgS(s)$
d) $K^+(aq) + Cl^-(aq) \rightarrow KCl(s)$
e) No reaction will occur.

7. A solution is made by mixing 50.0 mL of 3.00 *M* $CaBr_2$ with 400.0 mL of 0.250 *M* KBr. This mixture is diluted by adding water until the final solution volume is 800.0 mL. What is the molarity of the Br^- ions in the final solution?

a) 0.125 *M* b) 0.250 *M* c) 0.500 *M* d) 0.750 *M* e) 1.00 *M*

8. A bag of potato chips is packed and sealed in Los Angeles, California, and later shipped to Deming, New Mexico. In Deming it is noticed that the volume of the bag of potato chips has increased. Which of the following external conditions (a-c) could cause the volume of the bag of potato chips to increase in Deming as compared to Los Angeles? (Assume no gas molecules can enter or leave the sealed bag of potato chips and assume no chemical reaction occurs inside the bag.)

a) The temperature outside the bag decreased.
b) The pressure outside the bag decreased.
c) The moles of air molecules outside the bag increased.
d) None of the above (a-c) could cause the volume of the bag of potato chips to increase.

9. Consider a 2.0 L sample of SO_2 gas and a 2.0 L sample of F_2 gas, both of which are at STP. Which of the following statements (a-d) about the two gas samples is **true**?

a) The F_2 molecules and SO_2 molecules collide with the container walls of their respective containers, on average, with identical frequency.
b) The moles of F_2 molecules is greater than the moles of SO_2 molecules.
c) The average kinetic energy of the SO_2 molecules is greater than the average kinetic energy of the F_2 molecules.
d) The SO_2 molecules collide with the container walls of their respective containers, on average, more forcefully than the F_2 molecules.
e) None of the statements (a-d) are true.

10. Consider the synthesis reaction between aluminum (Al) and iodine (I_2) to form aluminum iodide (AlI_3). What mass of I_2 is required to produce 10.0 g of AlI_3 assuming excess aluminum is present?

a) 6.23 g b) 4.89 g c) 18.7 g d) 10.0 g e) 9.34 g

11. A 0.486-g pesticide sample contains a mixture of Tl_2SO_4 with some other non-thallium containing compounds. The sample is dissolved in water and an excess of KI is added, producing a precipitate of thallium(I) iodide. If 0.1824 g of TlI was produced, calculate the mass percent of Tl_2SO_4 in the original pesticide sample. The molar mass of Tl_2SO_4 is 504.9 g/mol, the molar mass of KI is 166.0 g/mol, the molar mass of TlI is 331.3 g/mol, and the molar mass of Tl is 204.4 g/mol.

a) 22.1% b) 57.2% c) 28.6% d) 64.7% e) 32.4%

12. Which of the answers (a-d) **always** correctly completes the following sentence.

The limiting reactant in a reaction:

a) is the reactant for which there is the smallest amount in grams present.
b) is the reactant which has the smallest coefficient in the balanced equation.
c) is the reactant with the smallest molar mass.
d) is the reactant for which there is the smallest number of moles present.
e) None of the above (a-d) always correctly completes the sentence.

13. How many of the following four statements (I-IV) about gases is/are **true**?

I. A non-ideal gas will more nearly behave like an ideal gas at low pressures.
II. Real gases deviate from ideal gases because real gas molecules have a volume and real gas molecules exert intermolecular forces.
III. The effect of attractive forces between gas particles can be minimized by heating the gas.
IV. 1.00×10^{23} gas molecules placed in a closed 5.0 liter container at 150. K would behave more ideally than the same number of molecules placed in a closed 50.0 liter container at the same temperature.

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

e) 4 (All of the statements are true.)

14. Difluoromethane, CF_2H_2, has been considered as a replacement for the chlorofluorocarbon freon, CF_2Cl_2. The boiling point of CF_2H_2 is –56°C and the boiling point of CF_2Cl_2 is –29°C. Which of the following statements concerning these two compounds is **false**? (Carbon is the central atom in both molecules.)

a) CF_2H_2 exhibits hydrogen bonding intermolecular forces.

b) Both compounds are gases at room temperature.

c) CF_2Cl_2 exhibits stronger London dispersion forces as compared to CF_2H_2.

d) Overall, CF_2Cl_2 exhibits stronger intermolecular forces as compared to CF_2H_2.

Consider the following information for the next two questions. 50.00 mL of 1.00 *M* $AgNO_3$ is mixed with 25.00 mL of 1.00 *M* K_3PO_4 and a precipitate forms.

15. How many moles of precipitate can form assuming the reaction has 100% yield?

a) 0.0500 mol b) 0.0375 mol c) 0.0250 mol

d) 0.0167 mol e) 0.0100 mol

16. Calculate the concentration of phosphate (PO_4^{3-}) anions in the mixture after the reaction has gone to completion.

a) 0 *M* b) 0.11 *M* c) 0.25 *M* d) 0.50 *M* e) 0.75 *M*

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17. An ideal gas in a container 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) 0.50 atm b) 0.20 atm c) 0.92 atm d) 0.11 atm e) 1.7 atm

18. A compound containing carbon, hydrogen and oxygen that is responsible for the odor of pineapples is found to have 62.04% C and 10.41% H by mass. The empirical formula of this compound is:

a) CH_2O b) $C_6H_{12}O_2$ c) C_3H_6O d) $C_6H_{10}O_2$ e) C_3H_5O

19. Which of the following statements (a-d) about hydrogen bonding intermolecular forces is **true**?

a) Compounds that can H-bond have higher boiling points than ionic compounds.

b) A compound must contain a C–H, N–H, O–H, or F–H covalent bond in the molecule in order to H–bond.

c) Given two covalent compounds having about the same molar mass, the compound that can H–bond will have the higher vapor pressure as compared to a compound that cannot H–bond.

d) H–bonding is a form of London dispersion forces.

e) None of the above statements (a-d) are true.

20. The diffusion rate of N_2 gas is 1.73 times greater than the diffusion rate of a certain noble gas (both gases are at the same temperature). What is the noble gas?

a) He b) Ne c) Ar d) Kr e) Xe

21. Which of the following three statements (I-III) about gases is/are **true**?

I. Equal masses of ideal gases at the same temperature and pressure contain equal numbers of molecules.

II. At constant pressure and moles, as the temperature of a gas sample increases, the volume of the container holding the gas increases.

III. On average, an H_2 molecule has a faster average velocity than a N_2 molecule at the same temperature.

a) I and II b) II and III c) I and III d) I, II, and III

e) Only statement I is true.

22. Nitrogen dioxide, NO_2, decomposes by the following unbalanced reaction:

$$NO_2(g) \rightarrow N_2(g) + O_2(g)$$

If 3.0 atm of pure $NO_2(g)$ are decomposed initially, what is the final total pressure in the reaction container? Assume the above reaction goes to completion and assume a constant temperature and container volume.

a) 4.5 atm b) 6.0 atm c) 9.0 atm d) 3.0 atm e) 1.5 atm

23. The compounds below are classified as either a strong electrolyte, a weak electrolyte, or a nonelectrolyte. Which compound is **incorrectly** classified?

a) Ethanol, C_2H_5OH, is a strong electrolyte.

b) Fingernail polish remover, C_3H_6O, is a nonelectrolyte.

c) Vinegar, $HC_2H_3O_2$, is a weak electrolyte.

d) Slaked lime, $Ca(OH)_2$, is a strong electrolyte.

e) Washing soda, Na_2CO_3, is a strong electrolyte.

24. Separate samples of a solution of an unknown soluble ionic compound are treated with KCl, Na_2SO_4 and NaOH. A precipitate forms only when Na_2SO_4 is added. Which one of the following cations could the solution contain?

a) K^+ b) Ag^+ c) Ba^{2+} d) Hg_2^{2+} e) Pb^{2+}

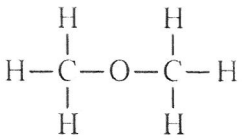
25. Determine the density of uranium hexafluoride (UF_6) gas at 60.°C and 745 torr. Uranium is element #92.

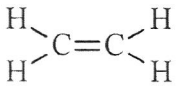
a) 12.6 g/L b) 2.54 g/mL c) 8.97 g/L

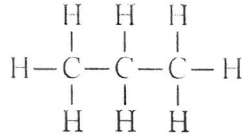
d) 6.74 g/mL e) 0.0269 g/L

26. Which of the following four organic compounds has the **lowest** vapor pressure at −50°C?

a) CH_4

b)


c)


d)


27. An unknown organic compound contains only C, H, and Cl. When a 1.500 g-sample of the compound was combusted, 0.3678 g of H_2O was formed. In a separate experiment, all of the chlorine in a 1.000 g-sample of the same unknown compound was reacted by suitable methods to form 1.950 g of AgCl. Determine the mass percent of chlorine in the unknown compound. The molar mass of AgCl = 143.35 g/mol.

a) 16.25% Cl b) 23.45% Cl c) 38.92% Cl

d) 48.22% Cl e) 57.84% Cl

28. An unknown organic compound contains only C, H, and Cl. When a 1.500 g-sample of the compound was combusted, 0.3678 g of H_2O was formed. In a separate experiment, all of the chlorine in a 1.000 g-sample of the same unknown compound was reacted by suitable methods to form 1.950 g of AgCl. Determine the empirical formula of the unknown compound.

a) $C_2H_3Cl_2$ b) $C_4H_6Cl_3$ c) C_3H_2Cl d) CH_3Cl_2 e) C_2H_5Cl

29. F_2 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 F_2?

a) HF b) Cl_2 c) Ne d) HCl e) Ar

30. A compound composed of element X and chlorine has a formula of XCl_6 and is 13.10% X by mass. Which of the following is the identity of X?

a) Mo b) Cr c) Xe d) Se e) S

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

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

$PV = nRT$

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•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