CHEMISTRY 102B/C
Hour Exam II
October 26, 2022
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: 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, 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.

1. How many of the following five compounds exhibit only London dispersion forces and no other type of intermolecular forces?

   NaF, CaF_2, CrF_3, CF_4, HF

   a) 1 b) 2 c) 3 d) 4

   e) 5; all only exhibit London dispersion forces.

2. A 27.0 g sample of an unknown hydrocarbon was burned in excess oxygen to form some CO_2 and 27.0 g of H_2O. Which of the following is a possible **molecular** formula?

   a) CH_4 b) C_2H_2 c) C_4H_3 d) C_4H_6 e) C_4H_{10}

3. How many moles of $O_2(g)$ in the presence of excess P (phosphorus) are needed to produce 14.2 g of P_4O_{10} (molar mass = 283.9 g/mol)? Assume this is a synthesis reaction.

   a) 0.0500 mol b) 0.0625 mol c) 0.125 mol d) 0.250 mol e) 0.500 mol

4. Which of the following statements is **true**?

   a) Because more intermolecular forces are broken when water vaporizes than when ice melts, $\Delta H_{vaporization}$ (in kJ/mol) should be greater than ΔH_{fusion} (in kJ/mol).

   b) As the size of a covalent molecule increases, the strength of the London dispersion forces decreases.

   c) Molecules which exhibit hydrogen bonding intermolecular forces have unusually low melting points.

   d) A polar covalent compound will generally have a lower vapor pressure at some temperature than an ionic compound.

   e) In general, the strength of the intermolecular forces exhibited in the gaseous state are much stronger than the intermolecular forces exhibited in the liquid or solid state.

5. Consider the following reaction:

   $N_2(g) + 3\ H_2(g) \rightarrow 2\ NH_3(g)$

   If the reaction has a 75.0% yield, how many grams of H_2 are needed to obtain an actual yield of 1.00 g of NH_3?

   a) 0.178 g b) 0.133 g c) 0.237 g d) 0.157 g e) 0.100 g

6. Consider the van der Waals gas equation where **a** and **b** are the van der Waals constants:

$$\left(P + \frac{\mathbf{a}n^2}{V^2}\right)(V - n\mathbf{b}) = nRT$$

Which of the following statements concerning the van der Waals equation and real gases is **false**?

a) A term is added to the measured pressure (P) in the van der Waals equation to correct for the effect of intermolecular forces in real gases.
b) A term is subtracted from the measured volume (V) in the van der Waals equation to correct for the effect that real gas molecules have a finite volume.
c) One would expect CH_4 to have a larger **a** constant value in the van der Waals equation as compared to H_2O.
d) One would expect Xe to have a larger **b** constant value in the van der Waals equation as compared to Ne.
e) At high temperatures, the effect of intermolecular attractions in real gases are minimized and the gas behaves more ideally.

7. The effusion rate of an unknown gas is determined to be 4 mL/min. Under the same conditions, the effusion rate of CH_4 is 8 mL/min. Which of the following could be the unknown gas?

a) H_2 (molar mass = 2 g/mol) b) He (molar mass = 4 g/mol)
c) O_2 (molar mass = 32 g/mol) d) SO_2 (molar mass = 64 g/mol)

8. The alkenes are compounds composed of carbon and hydrogen having the general formula C_nH_{2n}, where n is some whole number greater than one. If 0.561 gram of any alkene is combusted in excess oxygen, what number of moles of H_2O is formed?

a) 0.0400 mol b) 0.0600 mol c) 0.0800 mol
d) 0.400 mol e) 0.800 mol

9. How many of the following five compounds is/are **not** strong electrolytes?

PCl_5 H_2CO_3 HNO_3 H_2O $C_{12}H_{22}O_{11}$

a) zero (All are strong electrolytes.) b) one c) two d) three
e) four (4 of the compounds are not strong electrolytes.)

10. You are holding two balloons, one blue and one orange. The blue balloon contains He and is 4 times the volume of the orange balloon. The orange balloon contains Ne. Which of following best represents the mass ratio of He:Ne in the balloons? Assume constant temperature and pressure.

a) 4:5 b) 2:4 c) 4:1 d) 1:4 e) 20:1

11. Consider 2 reactants, A and B. The molar mass of A is greater than the molar mass of B. You add equal masses of A and B together and let them react. Which of the following statements (a-d) **must** be true?

a) Reactant A **must** be limiting.
b) Reactant B **must** be limiting.
c) If the coefficient for B is greater than the coefficient of A in the balanced equation, then reactant B **must** be limiting.
d) If the coefficient for A is greater than the coefficient of B in the balanced equation, then reactant A **must** be limiting.
e) None of the above choices **must** be true.

12. A 9.00 L flask containing neon gas at 2.00 atm and a 3.00 L flask containing helium gas at 4.00 atm are connected by valve (see figure below):

Ne
9.00 L
2.00 atm

He
3.00 L
4.00 atm

After the valve between the two flasks is opened and the two gases have time to mix, which of the following statements regarding the partial pressures of Ne and He is **true**? Assume constant temperature and assume that no chemical reaction occurs between Ne and He.

a) The partial pressure of neon is 1.50 times greater than the partial pressure of helium.
b) The partial pressure of neon is 2.00 times greater than the partial pressure of helium.
c) The partial pressure of helium is 1.50 times greater than the partial pressure of neon.
d) The partial pressure of helium is 2.00 times greater than the partial pressure of neon.
e) The partial pressures of helium and neon are equal.

13. If the molecules in 1.0 L sample of hydrogen gas and 1.0 L sample of oxygen gas and 1.0 L sample of carbon dioxide gas are all moving with the same average velocity, which gas sample is at the highest temperature?

a) H_2 b) O_2 c) CO_2

d) The temperature is the same in all three of the gas samples.

14. Tryptophan is one of the 20 standard amino acids and contains 64.69% C, 5.92% H, 13.72% N, and 15.67% O by mass. What is the empirical formula of tryptophan?

a) $C_{12}H_{24}N_2O_2$ b) $C_{11}H_{12}N_2O_2$ c) $C_6H_{10}NO$

d) $C_{11}H_{12}NO$ e) $C_{12}H_{16}N_2O_2$

15. In each of the following pairs, which compound will have the higher boiling point?

CO_2 vs. COS CH_4 vs. SiH_4 KCl vs. HI

a) CO_2; SiH_4; KCl b) COS; CH_4; HI c) CO_2; CH_4; KCl

d) COS; SiH_4; KCl e) CO_2; SiH_4; HI

16. Equal masses of three different gases, X, Y, and Z, are mixed in a sealed rigid container at constant temperature. If the molar mass of gas X is greater than either of the molar masses of gases Y or Z, which of the following statements about the partial pressure of gas X is **true**? Assume ideal gas behavior.

a) The partial pressure of gas X is equal to 1/3 of the total pressure.
b) The partial pressure of gas X is less than 1/3 of the total pressure.
c) The partial pressure of gas X is greater than 1/3 of the total pressure.
d) The partial pressure of gas X may be equal to or less than or greater than 1/3 of the total pressure.

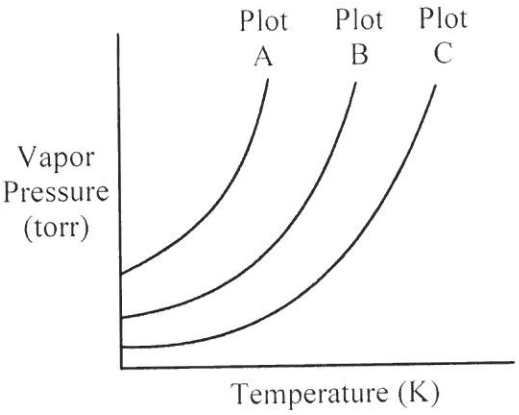
17. In a 3.00 liter rigid container at 25°C, 1.20 moles of O_2 gas and 1.60 moles of solid C (graphite) are reacted to form CO gas. After the reaction has gone to completion, what will be the final total pressure in the container at 25°C?

a) 4.89 atm b) 13.0 atm c) 9.78 atm d) 20.0 atm e) 16.3 atm

18. Consider a soluble ionic compound. When this compound is dissolved in water, it is found to produce two cations for every anion. Which of the following could be this compound?

a) Ag_2CrO_4 b) $Ca(OH)_2$ c) K_2S d) $NaNO_3$ e) Hg_2Cl_2

19. Consider the following vapor pressure vs. temperature plots for three different compounds.



If the three compounds are CH_2O, HF and CH_3CH_3, which of the following correctly matches the plot (A, B or C) to the identity of the compound? CH_3CH_3 exists as $H_3C–CH_3$.

	Plot A	Plot B	Plot C
a)	HF	CH_2O	CH_3CH_3
b)	CH_3CH_3	CH_2O	HF
c)	CH_3CH_3	HF	CH_2O
d)	HF	CH_3CH_3	CH_2O
e)	CH_2O	CH_3CH_3	HF

20. Consider an element designated as E. If 2.00 g of E reacts exactly with 10.10 g of chlorine (Cl_2) to form a compound with the formula ECl_4, what is the identity of E?

a) Cl b) P c) Si d) Al e) Ge

21. A 5.00 g sample of iron reacts with oxygen in the air to form 6.91 g of an oxide of iron. What is the empirical formula for this compound?

a) FeO b) Fe_2O c) Fe_2O_3 d) Fe_9O_{13} e) Fe_3O_4

22. At 1000°C and 10 torr, the density of a certain element in the gaseous state is 2.9×10^{-3} g/L. The element is:

a) Ne b) He c) Hg d) Ar e) Na

23. The chemical process of rusting is described by the following **unbalanced** equation:

$$Fe(s) + O_2(g) \rightarrow Fe_2O_3(s)$$

The maximum amount of rust (Fe_2O_3) that can be produced from 56 g Fe and 32 g O_2 is:

a) 160 g b) 80. g c) 40. g d) 120 g e) 110 g

24. For which one of the following acid solutions will 100.0 mL of the acid solution exactly neutralize (react with) 50.0 mL of a 0.20 *M* $Ba(OH)_2$ solution?

a) 0.050 *M* HCl b) 0.10 *M* HNO_3 c) 0.40 *M* HBr
d) 0.20 *M* H_2SO_4 e) 0.10 *M* H_2SO_3

25. When 70. mL of 3.0 *M* sodium carbonate is added to 30. mL of 1.0 *M* sodium bicarbonate ($NaHCO_3$), the resulting concentration of Na^+ is:

a) 2.0 *M* b) 2.4 *M* c) 4.0 *M* d) 4.5 *M* e) 7.0 *M*

26. Iron(II) sulfate reacts with potassium hydroxide in aqueous solution to form a precipitate. The net ionic equation for this reaction is:

a) $Fe^{2+}(aq) + SO_4^{2-}(aq) \rightarrow FeSO_4(s)$
b) $2\ K^+(aq) + SO_4^{2-}(aq) \rightarrow K_2SO_4(s)$
c) $Fe^{2+}(aq) + 2\ OH^-(aq) \rightarrow Fe(OH)_2(s)$
d) $2\ Fe^{3+}(aq) + 3\ SO_4^{2-}(aq) \rightarrow Fe_2(SO_4)_3(s)$
e) $K^+(aq) + Fe^{2+}(aq) \rightarrow K(s) + Fe^{3+}(aq)$

27. A 20.0 mL sample of 0.200 *M* K_2CO_3 solution is added to 30.0 mL of 0.400 *M* $Ba(NO_3)_2$ solution. Barium carbonate precipitates. Calculate the concentration of barium ions (Ba^{2+}) in solution **after** precipitation has gone to completion.

a) 0.150 *M* b) 0.160 *M* c) 0.200 *M*
d) 0.240 *M* e) 0.267 *M*

28. Consider the following two gas samples:

Sample A	**Sample B**
contents = $Cl_2(g)$	contents = $O_2(g)$
n = 1 mol	n = 1 mol
T = 300 K	T = 3000 K
P = 0.4 atm	P = 0.2 atm

Which of the following statements is **true** regarding these two gas samples?

a) The gas in sample B should behave more ideally than the gas in sample A.
b) The volume of the gas in sample B is five times larger than the volume of the gas in sample A.
c) The average kinetic of the gas molecules in Sample A is larger than the average kinetic energy of the gas molecules in Sample B.
d) The average velocity of the gas molecules in Sample A is greater than the average velocity of the gas molecules in Sample B.
e) The number of gas molecules in Sample A is larger than the number of gas molecules in Sample B.

29. A 5.00 g sample of an unknown metal chloride compound is dissolved in 50.0 mL of solution. To this solution, 70.0 mL of 0.400 *M* $Pb(NO_3)_2$ is added in order to precipitate all of the chloride ion as $PbCl_2(s)$. Calculate the mass percent of chloride ion in the metal chloride compound.

a) 0.0993% b) 14.0% c) 19.9% d) 28.0% e) 39.7%

30. You mix 75.0 mL of 0.100 *M* aqueous Na_3PO_4 with 100.0 mL of 0.100 *M* aqueous $Ca(NO_3)_2$. Once the reaction has gone to completion, how many moles of precipitate can form?

a) 0.00250 mol b) 0.00333 mol c) 0.00375 mol

d) 0.00500 mol e) 0.00750 mol

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												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 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