CHEMISTRY 102
HOUR EXAM II

Fall 2020

1. Which of the following compounds is expected to have the highest vapor pressure at some temperature, T?

   a) CH_4 b) SiH_4 c) NH_3 d) H_2O e) HF

2. At STP, 1.0 L of $N_2(g)$ reacts completely with 3.0 L of $F_2(g)$ to produce 2.0 L of a product gas. What is the formula of the product?

   a) NF_6 b) N_2F_6 c) N_2F_2

   d) NF_3 e) N_2F_3

3. In the early development of rockets, a common fuel mixture consisted of reacting hydrazine (N_2H_4) with dinitrogen tetroxide (N_2O_4), to produce a nitrogen gas and water vapor:

$$2\ N_2H_4(l) + N_2O_4(l) \rightarrow 3\ N_2(g) + 4\ H_2O(g)$$

   If 100.0 g of N_2H_4 and 175.0 g of N_2O_4 are reacted by the above reaction, what mass of nitrogen can be produced? The molar masses of the reactants and products are: N_2H_4, 32.05 g/mol; N_2O_4, 92.02 g/mol; N_2, 28.02 g/mol; H_2O, 18.02 g/mol.

   a) 160.0 g b) 87.43 g c) 53.29 g d) 106.6 g e) 131.1 g

4. Consider two 1.0 L containers: container A contains 0.50 mol of Ne(g) at 25°C and container B contains 0.50 mol of He(g) at 50.°C. Which of the following statements (a-c) is/are **true** concerning these two containers?

   a) The average kinetic energy of the Ne atoms in container A is larger than the average kinetic energy of the He atoms in container B.
   b) The Ne atoms in container A collide with the walls of the container more frequently than the He atoms in container B.
   c) The pressure in container A is larger than the pressure in container B.
   d) All of the above statements (a-c) are true.
   e) None of the above statements (a-c) are true.

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

   a) $HF < LiF < HCl < F_2$ b) $F_2 < HCl < HF < LiF$ c) $F_2 < HF < LiF < HCl$

   d) $F_2 < HF < HCl < LiF$ e) $HF < F_2 < HCl < LiF$

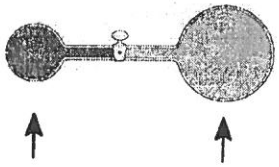
6. One of the following substances is a solid at 25°C and 1 atm, while the others are gases at 25°C and 1 atm. Which substance is a solid at 25°C and 1 atm?

a) He b) Ne c) H_2 d) Cl_2 e) I_2

7. An unknown gas has an effusion rate that is 2.0 times faster than that of $SO_2(g)$. Which of the following is the unknown gas?

a) H_2 b) He c) He_2 d) CH_4 e) O_2

8. A 50.0 mL flask containing $N_2(g)$ at 2.50 atm and a 75.0 mL flask containing Ar(g) at 325 torr are connected by a stopcock (see the illustration below).



$N_2(g)$ Ar(g)

50.0 mL 75.0 mL
2.50 atm 325 torr

After the stopcock valve between the two flasks is opened and the gases have time to mix completely, what is the total pressure inside the entire system? Assume temperature is constant.

a) 955 torr b) 1120 torr c) 526 torr d) 2230 torr e) 1470 torr

9. Dimethyl ether ($CH_3–O–CH_3$) and ethanol (CH_3CH_2OH) have the same molecular formula (C_2H_6O), but very different physical properties. For example, dimethyl ether has a vapor pressure of 400 torr at –37.8°C, while ethanol has a vapor pressure of 400 torr at 63.5°C. Which of the following statements (a-d) about these two compounds is **false**?

a) Increasing the temperature will increase the vapor pressure of both liquids.
b) Intermolecular attractive forces are stronger in (liquid) ethanol than in (liquid) dimethyl ether.
c) The normal boiling point of dimethyl ether will be higher than the normal boiling point of ethanol.
d) The reason that the temperature at which the vapor pressure equals 400 torr is higher for ethanol (than for dimethyl ether) is that there is relatively strong hydrogen bonding in ethanol, unlike in dimethyl ether.
e) None of these statements (a-d) is false.

10. Consider the following reaction:

$$2\ Cu(s) + S(s) \rightarrow Cu_2S(s)$$

If the reaction has a 73.0% yield, what mass of copper is needed to obtain an actual yield of 10.0 g of Cu_2S?

a) 3.99 g Cu b) 5.47 g Cu c) 7.99 g Cu

d) 10.9 g Cu e) 15.2 g Cu

11. A compound containing only Zn, O, and P is 50.80% Zn and 16.04% P by mass. What is the empirical formula of the compound?

a) $Zn_4O_9P_3$ b) $Zn_2O_4P_3$ c) ZnO_3P

d) $Zn_3O_6P_3$ e) $Zn_3O_8P_2$

12. Which of the following statements is **false** concerning ideal gases?

a) For a mixture of gases, the total pressure is the sum of the partial pressures of all the gases present.

b) At constant P and n, a plot of volume (L) vs. temperature (K) is linear.

c) At constant V and T, the moles of gas present is inversely related to the pressure of the gas sample.

d) At constant n and T, as the volume of a gas sample increases, the pressure of the gas decreases.

e) At constant P and T, a 2.0 L sample of $N_2(g)$ contains twice the number of molecules as a 1.0 L sample of $SO_3(g)$.

13. How many of the following five compounds are nonelectrolytes in water?

PCl_3 LiOH HNO_3 $C_{12}H_{22}O_{11}$ NH_4NO_3

a) 0 (None are nonelectrolytes.) b) 1 c) 2 d) 3 e) 4

14. All the arsenic in 1.22 g of a pesticide was converted to AsO_4^{3-} by suitable chemical treatment. All the AsO_4^{3-} was then reacted with Ag^+ to form Ag_3AsO_4 as a precipitate. It took 50.0 mL of 0.0500 *M* $AgNO_3$ to precipitate all the AsO_4^{3-}. Assuming 100% yield, what is the mass percent of As in the pesticide?

a) 2.39% As b) 5.12% As c) 14.1% As d) 7.06% As e) 4.54% As

15. You have a 1.0 *M* solution of aqueous HF. What ions and/or molecules are present in this solution?

a) Only H^+ ions and F^- ions are present.
b) Only HF molecules and H_2O molecules are present.
c) HF molecules, H^+ ions, F^- ions, and H_2O molecules are all present.
d) Only H^+ ions, F^- ions, and H_2O molecules are present.
e) Only HF molecules are present.

16. Explosives are usually effective if they produce a large number of gaseous molecules as products. Nitroglycerin, for example, detonates according to the equation:

$$4\ C_3H_5N_3O_9(s) \rightarrow 12\ CO_2(g) + 6\ N_2(g) + 10\ H_2O(g) + O_2(g)$$

If 0.0400 mol of nitroglycerin explodes in a 10.0 L rigid container, calculate the total pressure of all gases present assuming the temperature is 500.°C.

a) 0.0634 atm b) 10.6 atm c) 1.84 atm d) 21.1 atm e) 5.23 atm

17. Consider the following **unbalanced** reaction:

$$HCl(g) + O_2(g) \rightarrow H_2O(g) + Cl_2(g)$$

How many grams of O_2 are necessary to react completely with 20. mol of HCl?

a) 640 g H_2O b) 160 g O_2 c) 320 g O_2 d) 2600 g O_2 e) 1300 g O_2

18. You take a 1.00 g sample of aspirin (a compound consisting solely of carbon, hydrogen, and oxygen), burn it in excess oxygen, and collect 2.20 g of carbon dioxide and 0.400 g of water. The molar mass of aspirin is between 160 and 190 g/mol. What is the mass percent of oxygen in aspirin?

a) 35.5% b) 23.5% c) 30.0%

d) 16.4% e) 47.0%

19. You take a 1.00 g sample of aspirin (a compound consisting solely of carbon, hydrogen, and oxygen), burn it in excess oxygen, and collect 2.20 g of carbon dioxide and 0.400 g of water. The molar mass of aspirin is between 160 and 190 g/mol. Which of the following is the molecular formula of aspirin?

a) $C_6H_8O_5$ b) $C_9H_8O_4$ c) $C_8H_{10}O_5$

d) $C_{10}H_6O_4$ e) $C_{12}H_{13}O_2$

20. When 1.00 L of 1.00 *M* H_3PO_4 is reacted with 1.00 L of 1.00 *M* $Ca(OH)_2$, what mass of water is produced (assuming 100% yield)?

a) 6.00 g H_2O b) 9.01 g H_2O c) 18.0 g H_2O

d) 36.0 g H_2O e) 54.0 g H_2O

21. A binary compound is composed of an unknown element X and hydrogen. The compound has three times as many H atoms as X atoms in the molecular formula and is 80.0% X by mass. Which of the following could be the element X?

a) N b) C c) B d) Be e) He

22. What volume of a 0.300 *M* $CaCl_2$ solution is needed to prepare 240. mL of a 0.100 *M* Cl^- solution?

a) 40.0 mL b) 80.0 mL c) 120. mL

d) 240. mL e) 480. mL

23. The five most abundant gases in a sample of air are N_2, O_2, Ar, CO_2, and Ne. Consider five separate 2.5 L samples of each individual gas at 352 K and 6.25 atm. Which gas sample would behave **least** ideally?

a) N_2 b) CO_2 c) Ar d) O_2 e) Ne

24. Consider the following balanced equation between gas X to form gas X_2:

$$2\ X(g) \rightarrow X_2(g)$$

Equal moles of X are placed in two separate containers. One container is rigid so the volume cannot change; the other container is flexible (like a balloon) so the volume changes in order to keep the internal pressure equal to the external pressure. The above reaction is run in each container. Which of the following is **true** concerning the pressure and density of the gas inside each container as reactants are converted to products? Assume a constant external pressure and assume a constant temperature.

a) Rigid container: Pressure decreases, density is constant;
Flexible container: Pressure is constant, density increases.
b) Rigid container: Pressure is constant, density is constant;
Flexible container: Pressure is constant, density increases.
c) Rigid container: Pressure decreases, density increases;
Flexible container: Pressure increases, density is constant.
d) Rigid container: Pressure is constant, density is constant;
Flexible container: Pressure decreases, density is constant.

Consider the following information for the next two questions.

When 200.0 mL of 0.10 *M* $Fe(NO_3)_3$ is mixed with 250.0 mL of 0.10 *M* K_2CO_3, a precipitate forms.

25. How many moles of precipitate can form in this reaction?

a) 0.0050 mol b) 0.013 mol c) 0.010 mol d) 0.0083 mol e) 0.020 mol

26. Calculate the concentration of Fe^{3+} ions in the final solution after precipitate formation is complete.

a) 0.0074 *M* b) 0.022 *M* c) 0.028 *M*

d) 0.0086 *M* e) 0.00 *M*

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27. If you dissolve 0.0200 mol of barium hydroxide in enough water to make 250. mL of solution, what volume of 0.100 *M* hydrochloric acid is required to react completely with the barium hydroxide?

a) 100. mL b) 200. mL c) 300. mL

d) 400. mL e) 500. mL

28. An unknown gas has an empirical formula of CH_2. The density of the unknown gas is 2.19 times greater than the density of $O_2(g)$ at the same temperature and pressure. Which of the following is the molecular formula of the unknown gas?

a) CH_2 b) C_2H_4 c) C_3H_6 d) C_4H_8 e) C_5H_{10}

29. Real gases go not always obey the ideal gas equation, PV = nRT. Under which of the following conditions will a gas behave **most** ideally?

a) P = 1.0 atm, T = 273 K
b) P = 0.50 atm, T = 200 K
c) P = 0.50 atm, T = 400 K
d) P = 2.0 atm, T = 400 K
e) P = 2.0 atm, T = 200 K

30. 25.0 mL of 0.50 *M* $Pb(NO_3)_2$ is added to four separate beakers containing:

Beaker I: 50.0 mL of 0.25 *M* NaCl
Beaker II: 50.0 mL of 0.25 *M* NaOH
Beaker III: 50.0 mL of 0.25 *M* Na_3PO_4
Beaker IV: 50.0 mL of 0.25 *M* Na_2SO_4

After addition of the $Pb(NO_3)_2$ solution, in how many of the beakers will a precipitate form?

a) 0 (none) b) 1 c) 2 d) 3 e) 4 (all)

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.

USEFUL CONSTANTS/EQUATIONS

$PV = nRT \quad K = °C + 273$

$R = 0.08206$ L atm/K mol

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

1 atm = 760 torr = 760 mm Hg

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

STP = 1 atm, 273 K

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

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

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

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

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

d = density = mass/volume

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

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

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 mass	←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