Form A/B C/D

Exam 2 Fall 23 Detailed Key

CHEMISTRY 102 Fall 2023
EXAM II

$MgSO_4$ is a soluble ionic compound by the solubility rules. $MgSO_4(aq)$ exists as $Mg^{2+}(aq) + SO_4^{2-}(aq)$ ions in solution.

4 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.

$$\text{Molarity} = \frac{\text{moles solute}}{\text{volume of solution}}$$

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

In a dilution, water is added. We have the same moles of KBr in a larger volume of solution.

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

$$\text{molar mass } X_2 = \frac{0.105\text{ g } X_2}{8.92\times10^{20}\text{ molecules } X_2 \left(\frac{1\text{ mol } X_2}{6.022\times10^{23}\text{ molecules}}\right)} = 70.9\text{ g/mol}$$

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

$X_2 = Cl_2$ (from periodic table)

The MCl_3 compound is 54.47% Cl and 100 − 54.47 = 45.53% M.

$$2M + 3X_2 \rightarrow MX_3$$

$$\text{Mol M in 100.00 g } MCl_3 = 54.47\text{ g Cl}\left(\frac{1\text{ mol Cl}}{35.45\text{ g}}\right)\left(\frac{1\text{ mol M}}{3\text{ mol Cl}}\right) = 0.5122\text{ mol M}$$

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?

0.5122 mol M has a mass of 45.53 g M.

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

$$\text{Molar mass M} = \frac{\text{mass}}{\text{mol}} = \frac{45.53\text{ g M}}{0.5122\text{ mol M}} = 88.9\text{ g/mol};\ M = Y\ (\text{yttrium})$$

(from periodic table)

4 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?

$KE_{Ave} = \frac{3}{2}RT$; highest temp answers have the largest average kinetic energy (this is answers c and d). The molar mass of N_2 is 28.02 g/mol; the molar mass of Cl_2 is 70.90 g/mol. The smaller N_2 molecules at 100°C must have the faster average velocity in order for the N_2 and Cl_2 gas samples to have the same average KE.

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.

$KE = \frac{1}{2}mv^2$

Rigid container: volume and moles are constant, $PV=nRT$. As temp increases, P increases. Since mass of Ne and volume of Ne are constant in rigid container, density is constant (density = mass/volume).

5 ✓

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.

Flexible container: P constant, n is also constant. As T increases, V increases. We have the same mass of neon in a larger container. Density decreases.

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.

If C_3H_6 or NH_3 limiting: $5\text{ mol} \left|\frac{2\text{ mol } C_3H_3N}{2\text{ mol}}\right. = 5.0\text{ mol } C_3H_3N$ produced

6 ✓

6. Consider the following balanced equation:

If O_2 limiting: $6.0\text{ mol } O_2\left(\frac{2\text{ mol } C_3H_3N}{3\text{ mol } O_2}\right) = 4.0\text{ mol } C_3H_3N$ produced

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

O_2 is limiting and 4.0 mol C_3H_3N is the theoretical yield.

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?

$\%\text{ yield} = \frac{\text{actual}}{\text{theoretical}} \times 100 = \frac{3.0\text{ mol}}{4.0\text{ mol}} \times 100 = 75\%$

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

7 ✓

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}?

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

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

F c) The fusion process refers to breaking ionic forces in water which are weaker than the intermolecular forces broken in the vaporization process. ✗ no ionic forces in H_2O

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

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

So what in terms of why $\Delta H_{vap} > \Delta H_{fus}$?

$H_2O(\ell) \rightarrow H_2O(g)$ $\quad \Delta H_{vap} = 40.6\text{ kJ/mol}$

$H_2O(s) \rightarrow H_2O(\ell)$ $\quad \Delta H_{fusion} = 6.02\text{ kJ/mol}$

Form A/B C/D

mass H in compound $= 4.37\text{g } H_2O \left|\frac{1\text{mol } H_2O}{18.02\text{g}}\right|\frac{2\text{mol H}}{1\text{mol } H_2O}\left|\frac{1.008\text{g}}{\text{mol H}}\right. = 0.4889\text{ g H}$

CHEMISTRY 102
EXAM II

$\text{Mass \% H} = \frac{0.4889\text{g H}}{10.68\text{g compd}} \times 100 = 4.58\%\text{ H}$

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?

$\text{Mass C in compound} = 16.01\text{g } CO_2\left(\frac{1\text{mol } CO_2}{44.01\text{g}}\right)\left(\frac{1\text{mol C}}{1\text{mol } CO_2}\right)\left(\frac{12.01\text{g C}}{\text{mol C}}\right) = 4.369\text{g C}$

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

$\text{Mass O in compound} = 10.68\text{g compd} - 0.4889\text{g H} - 4.369\text{g C} = 5.822\text{g O}$

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 molecular formula?

$\text{mol C} = 4.369\text{g C}\left(\frac{1\text{mol C}}{12.01\text{g}}\right) = 0.3638\text{ mol C}/0.3638 = 1\text{ mol C}$ ∴ $(CH_{1.33}O)_{\times 3} = C_3H_4O_3$ is empirical formula. This has a mass of 88 g/mol.

$\text{mol H} = 0.4889\text{g H}\left(\frac{1\text{mol H}}{1.008\text{g}}\right) = 0.4850\text{ mol H}/0.3638 = 1.33\text{ mol H}$

$\text{mol O} = 5.822\text{g O}\left(\frac{1\text{mol O}}{16.00\text{g}}\right) = 0.3639\text{ mol O}/0.3638 = 1.00\text{ mol O}$

a) $C_3H_4O_3$ b) $C_2H_3O_4$ c) $C_{12}H_{18}O_6$
d) $C_9H_{12}O_9$ e) $C_6H_9O_{12}$

Actual compound is $C_9H_{12}O_9$ which has a mass of 3(88) = 264 g/mol.

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?

If Ag_2O limits: $25.0\text{g } Ag_2O\left(\frac{1\text{mol } Ag_2O}{231.85}\right)\left(\frac{2\text{mol } AgC_{10}H_9N_4SO_2}{1\text{mol } Ag_2O}\right)\left(\frac{357.2\text{g}}{\text{mol}}\right) = 77.0\text{ g}$

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

If $C_{10}H_{10}N_4SO_2$ limits: $50.0\text{g}\left(\frac{1\text{mol } C_{10}H_{10}N_4SO_2}{250.3\text{g}}\right)\left(\frac{2\text{mol } AgC_{10}H_9N_4SO_2}{2\text{mol } C_{10}H_{10}N_4SO_2}\right)\left(\frac{357.2\text{g}}{\text{mol}}\right) = 71.4\text{ g}$

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

The $C_{10}H_{10}N_4SO_2$ reactant produces the smallest amount of product, so it is limiting and 71.4 g $AgC_{10}H_9N_4SO_2$ can be produced.

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

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

$P_{O_2} = 734 - 21 = 713\text{ torr}$

$P_{TOT} = P_{O_2} + P_{H_2O}$

$n_{O_2} = \frac{P_{O_2}V}{RT} = \frac{\left(\frac{713}{760}\right)(0.0572\text{L})}{0.08206(295)}$

$n_{O_2} = 2.217\times10^{-3}\text{ mol } O_2$

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.

$\text{mass } NaClO_3 \text{ in mixture} = 2.217\times10^{-3}\text{mol } O_2\left(\frac{2\text{mol } NaClO_3}{3\text{mol } O_2}\right)\left(\frac{106.44\text{g}}{\text{mol } NaClO_3}\right) = 0.1573\text{ g } NaClO_3$

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

$\text{mass \% } NaClO_3 = \frac{0.1573\text{g } NaClO_3}{0.8765\text{g mixture}} \times 100 = 17.9\%$

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?

$H_2SO_3 + 2KOH \rightarrow 2H_2O(\ell) + K_2SO_3(aq)$

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

$\text{mol } H_2SO_3 = 0.0450\text{L}\left(\frac{5.50\text{ mol KOH}}{\text{L}}\right)\left(\frac{1\text{mol } H_2SO_3}{2\text{mol KOH}}\right) = 0.1238\text{ mol } H_2SO_3$

$[H_2SO_3] = \frac{0.1238\text{ mol } H_2SO_3}{0.0220\text{L}} = 5.63\text{ M}$

Assuming 100.00 g compound:
$62.58\text{ g C}\left(\frac{1\text{ mol C}}{12.01\text{ g}}\right) = 5.211\text{ mol C} / 1.737 = 3\text{ mol C}$
$9.63\text{ g H}\left(\frac{1\text{ mol H}}{1.008\text{ g}}\right) = 9.554\text{ mol H} / 1.737 = 5.5\text{ mol H}$

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?

$27.79\text{ g O}\left(\frac{1\text{ mol O}}{16.00\text{ g}}\right) = 1.737\text{ mol O} / 1.737 = 1\text{ mol}$

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

$(C_3H_{5.5}O)_{x2} = C_6H_{11}O_2$ is empirical formula.

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

$n_{H_2O} = 0.356\text{ g } H_2O\left(\frac{1\text{ mol } H_2O}{18.02\text{ g}}\right) = 0.01976\text{ mol } H_2O$; $P_{H_2O} = \frac{n_{H_2O}RT}{V}$

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%.

$P_{H_2O} = \frac{0.01976\text{ mol}\left(0.08206\frac{L\cdot atm}{K\cdot mol}\right)(308\text{ K})}{10.0\text{ L}} = 0.04993\text{ atm}$

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

$P_{H_2O} = 0.04993\text{ atm}\left(\frac{760\text{ torr}}{1\text{ atm}}\right) = 37.9\text{ torr}$

d) 37.9 torr e) 684 torr

$\text{mol } Pb(NO_3)_2 = 0.100\text{ L}\left(\frac{0.100\text{ mol } Pb(NO_3)_2}{\text{L}}\right) = 0.0100\text{ mol } Pb(NO_3)_2$

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.

$\text{mol } (NH_4)_3PO_4 = 0.075\text{ L}\left(\frac{0.100\text{ mol } (NH_4)_3PO_4}{\text{L}}\right) = 0.00750\text{ mol } (NH_4)_3PO_4$

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

Ions in solution = Pb^{2+}, NO_3^-, NH_4^+, and PO_4^{3-}. $Pb_3(PO_4)_2(s)$ is the precipitate, and NH_4^+ and NO_3^- are spectators. The formula equation is:

$3\,Pb(NO_3)_2(aq) + 2\,(NH_4)_3PO_4(aq) \rightarrow Pb_3(PO_4)_2(s) + 6\,NH_4NO_3(aq)$

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

If $Pb(NO_3)_2$ limits: $0.0100\text{ mol } Pb(NO_3)_2\left(\frac{1\text{ mol } Pb_3(PO_4)_2}{3\text{ mol } Pb(NO_3)_2}\right) = 0.00333\text{ mol } Pb_3(PO_4)_2$

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

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

If $(NH_4)_3PO_4$ limits: $0.00750\text{ mol } (NH_4)_3PO_4\left(\frac{1\text{ mol } Pb_3(PO_4)_2}{2\text{ mol } (NH_4)_3PO_4}\right) = 0.00375\text{ mol } Pb_3(PO_4)_2$

d) 0.00375 mol e) 0.00333 mol

$Pb(NO_3)_2$ produces smallest amount of precipitate, so it is limiting and 0.00333 mol can form.

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*

$\text{mol } NH_4^+ = 0.00750\text{ mol } (NH_4)_3PO_4\left(\frac{3\text{ mol } NH_4^+}{1\text{ mol } (NH_4)_3PO_4}\right) = 0.0225\text{ mol } NH_4^+$

$[NH_4^+] = \frac{\text{mol } NH_4^+}{\text{total volume}} = \frac{0.0225\text{ mol } NH_4^+}{0.100\text{ L} + 0.0750\text{ L}} = 0.129\text{ M}$

A gas behaves most ideally at high temps and low pressures. Answer b has the highest temp and the lowest pressure of all the answers.

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

$N_2(g) + 3F_2(g) \rightarrow 2NF_3(g)$ $n_{F_2} = \frac{PV}{RT} = \frac{1atm(1.0L)}{0.08206(273K)} = 0.0446 \text{ mol } F_2$ reacted

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?

mol NF_3 produced $= 0.0446 \text{ mol } F_2 \left(\frac{2 \text{ mol } NF_3}{3 \text{ mol } F_2}\right) = 0.030 \text{ mol } NF_3$

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

$\frac{P_1V_1}{n_1T_1} = \frac{P_2V_2}{n_2T_2}$, $P_2 = P_1\left(\frac{V_1}{V_2}\right)\left(\frac{T_2}{T_1}\right)\left(\frac{n_2}{n_1}\right)$, $n_2 = n_1$ (moles gas are constant)

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?

$P_2 = 0.20 \text{ atm}\left(\frac{10.0L}{3.60L}\right)\left(\frac{280.K}{311 K}\right) = 0.50 \text{ atm}$

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

HNO_3 is a strong acid, so it is a strong electrolyte.

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

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

$C_{12}H_{22}O_{11}$ is a covalent compound that is not an acid, so it is a nonelectrolyte.

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

$HC_2H_3O_2$ is a weak acid, so it is a weak electrolyte.

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

All the sulfur in $BaSO_4$ has to come from the sulfur in $C_{14}H_{10}N_2O_6S_2$. To balance sulfur, 2 moles of $BaSO_4$ must be produced for every 1 mol of $C_{14}H_{10}N_2O_6S_2$.

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

$\text{mass saccharin} = 0.503 \text{ g } BaSO_4\left(\frac{1 \text{ mol } BaSO_4}{233.4 \text{ g}}\right)\left(\frac{1 \text{ mol } C_{14}H_{10}N_2O_6S_2}{2 \text{ mol } BaSO_4}\right)\left(\frac{366.38 \text{ g}}{\text{mol}}\right)$

$= 0.3948 \text{ g } C_{14}H_{10}N_2O_6S_2$ must be present

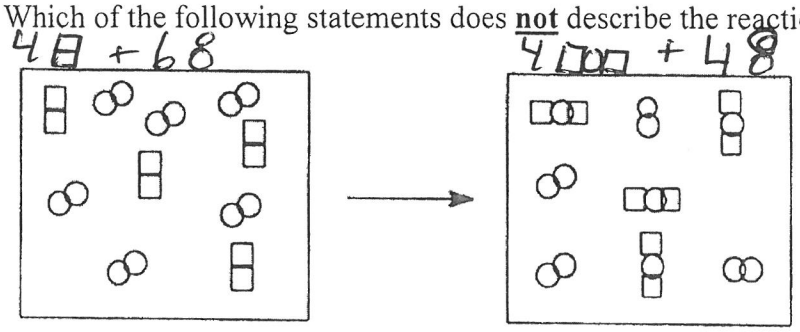
$\text{Mass\%} = \frac{0.3948 \text{ g saccharin}}{0.589 \text{ g mixture}} \times 100 = 67.0\%$

Form
A | B
C | D

From picture, 4⊟ + 2⊗ → 4□□□ with 4⊗ in excess.

23

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



T a) ⊟ and ⊗ combine in a 2:1 mole ratio. 4⊟ reacts with 2⊗, which is a 2:1 mol ratio.

T b) ⊟ is the limiting reactant. ⊟ runs out completely; we have excess ⊗.

F c) The reaction produces two different products. Only □□□ is a product. the ⊗ is excess reactant.

T d) The reactants pictured both represent diatomic elements. ⊟ and ⊗ are diatomic elements like H_2 and O_2.

24

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.

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

$P_{IDEAL} \times V_{IDEAL} = nRT$

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

$P_{measured}$ is too small due to attractive forces. So $P_{meas} < P_{ideal}$.

$V_{measured}$ is too big since some of the volume is taken up by the gas particles themselves. So $V_{meas} > V_{IDEAL}$.

25

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.

$\frac{\text{rate } N_2O}{\text{rate lachrymator}} = \sqrt{\frac{M_{lach}}{M_{N_2O}}} = \sqrt{4} = 2$

In a specific amount of time N_2O travels twice as far as the lachrymator.

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

There are 9 rows between rows 1 and 10. Let x = rows N_2O travels and y = rows lachrymator travels. So $x + y = 9$ and $x = 2y$ from Graham's law calculations.

$x + y = 9$, $2y + y = 9$, $y = 3$ rows and $x = 6$ rows.

N_2O travels from row 1 to row 7, the lachrymator travels from row 10 to row 7. They meet at row 7.

Form A/B C/D

Answer b has the highest bp (137°C) since it can H-bond. Answer d has second highest bp (103°C) since it is polar and has dipole forces that the nonpolar compounds in answers a, c, and e do not have. For the nonpolar compounds, compound c has the largest molar mass, so it boils at the next highest temp (69°C).

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) $CH_3CH_2CH_2CH_2CH_3$ 36°C
C_5H_{12} - nonpolar
- only LDF
72 g/mol

b) $CH_3CH_2CH_2CH_2CH_2OH$ 137°C
H-bonding + LDF
(88 g/mol)

c) $CH_3CH_2CH_2CH_2CH_2CH_3$ 69°C
C_6H_{14} - nonpolar
- only LDF
86 g/mol

d) $HCCH_2CH_2CH_2CH_3$ 103°C
O ← polar bond; compound is polar, so has dipole + LDF
(86 g/mol)

e) CH_3CCH_3 (with CH_3 on each) 9.5°C
C_5H_{12} - nonpolar
- only LDF
72 g/mol

Answers a + e have the same molar mass of 72 g/mol. But answer a is more elongated & leading to great surface area contact with neighboring molecules, compound a boils at 36°C, with compound e boiling at 9.5°C.

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

a) $CH_3CH_2CH_2CH_2CH_3$

b) $CH_3CH_2CH_2CH_2CH_2OH$

c) $CH_3CH_2CH_2CH_2CH_2CH_3$

d) $HCCH_2CH_2CH_2CH_3$ (O double bonded to C)

e) CH_3CCH_3 (with CH_3 on each)

The compound with the lowest vapor pressure has the strongest intermolecular forces. This is compound b which can Hydrogen bond; the other covalent compounds can't H-bond.

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?

Li_3N is the formula of the product (Li^+ and N^{3-} ions).

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

$6\,Li(s) + N_2(g) \rightarrow 2\,Li_3N(s)$ 34.83 g/mol = molar mass of Li_3N

$$20.0\,g\,Li\left(\frac{1\,mol\,Li}{6.94\,g}\right)\left(\frac{2\,mol\,Li_3N}{6\,mol\,Li}\right)\left(\frac{34.83\,g\,Li_3N}{mol\,Li_3N}\right) = 33.5\,g\,Li_3N$$

KF has the strongest forces since it is ionic and the other compounds are covalent. Of the 3 covalent compounds, HF can H-bond. Br2 and ICl have similar strength LDF since molarmasses are about the same. However, ICl is polar, so it has additional dipole forces that the nonpolar Br2 does not have.

29. Consider the following four compounds:

H-bonding LDF+dipole

KF	HF	Br_2	ICl
ionic		LDF only (nonpolar)	polar

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

F a) HF has a higher boiling point than KF because HF can form relatively strong hydrogen bonding intermolecular forces.
(covalent lower ionic) Ionic beats H-bonding (always).

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

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

F d) HF has the strongest London dispersion forces of all these compounds.
KF has ionic forces, which beats out H-bonding in covalent compounds.

F e) ICl has the strongest ionic forces of all these compounds.
→ not ionic as KF is

30. Consider the following five reactions: Apply the solubility rules.

yes I. $Hg_2(NO_3)_2(aq) + CuSO_4(aq) \rightarrow Hg_2SO_4(s) + Cu(NO_3)_2(aq)$

NO II. $Ni(NO_3)_2(aq) + CaCl_2(aq) \rightarrow$ no reaction; all potential products are soluble.

yes III. $K_2CO_3(aq) + MgI_2(aq) \rightarrow MgCO_3(s) + 2KI$

yes IV. $2H_3PO_4(aq) + 3Ca(OH)_2(aq) \rightarrow Ca_3(PO_4)_2(s) + 6H_2O(l)$

yes V. $3Na_2CrO_4(aq) + 2AlBr_3(aq) \rightarrow Al_2(CrO_4)_3(s) + 6NaBr(aq)$

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