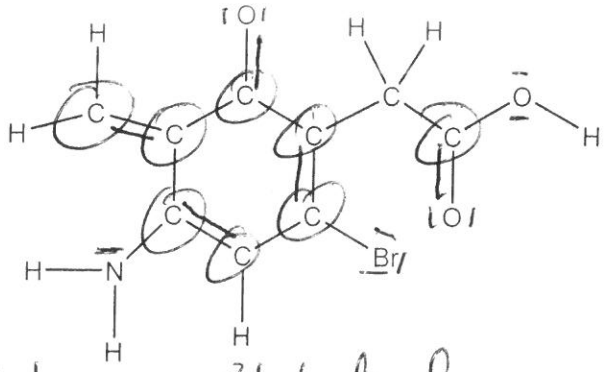
Detaile Key Exam 2 Sp 2021

CHEMISTRY 102
HOUR EXAM II

Spring 2021

1. Complete a Lewis structure for the following organic compound:



Follow the organic "rules" to come up with a Lewis structure.

8 C+N atoms are sp^2 hybridized.

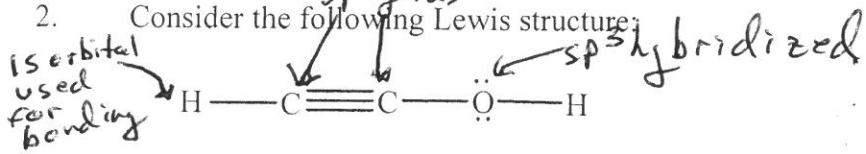
sp^2 hybridized atoms exhibit trigonal planar geometry (120° bond angles). The C and N atoms circled are sp^2 hybridized. The C+N atoms not circled all exhibit tetrahedral geometry (109° bond angles) so they are sp^3 hybridized.

How many C and N atoms in this organic compound are sp^2 hybridized?

a) 5 b) 6 c) 7

(d) 8 e) 9 f) 10

2. Consider the following Lewis structure:



Which of the following statements is **false** concerning the bonding in this compound?

T a) There are 2 pi (π) bonds in this molecule.
Triple bond consists of 1 σ + 2 π bonds.

T b) There are 4 sigma (σ) bonds in this molecule
Every bond has 1 σ bond.

T c) In the H–C sigma (σ) bond, a 1s orbital from hydrogen overlaps with an sp hybrid orbital from carbon to form the sigma bond. The carbons with a triple bond exhibit linear geometry (180° bond angles), so they are sp hybridized.

T d) In the C–O sigma (σ) bond, an sp hybid orbital from carbon overlaps with an sp^3 hybrid orbital from oxygen to form the sigma bond. The oxygen exhibits tetrahedral geometry (109° bond angles), so it is sp^3 hybridized.

(F) e) In the triple bond, three unhybridized p atomic orbitals from each carbon overlap to form the three bonds between the two carbons.

This triple bond consists of 1 σ bond formed from overlap of the sp hybrid orbitals from each C. The other two bonds are π bonds formed from overlap of the unhybridized p atomic orbitals overlapping side-to-side. So only 2 of 3 bonds in a triple bond are formed from overlap of unhybridized p atomic orbitals.

SO_2: 6 + 2(6) = 18 valence electrons

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3. Two valid resonance structures can be drawn for sulfur dioxide, SO_2. Which of the following five statements is **true** regarding the SO_2 molecule?

T a) The pi (π) electrons in SO_2 are delocalized over the entire surface of the molecule. → This explains why the bond lengths are equal. All atoms in SO_2 have an unhybridized p atomic orbital that all overlap.

F b) The central sulfur atom is sp hybridized in one of the resonance structures and sp^2 hybridized in the other resonance structure. S exhibits 120° bond angles. Central S is sp^2 hybridized in each resonance structure.

F c) There are 3 sigma (σ) bonds in SO_2. There are 2 σ and 1 π bond in SO_2. Double bond = 1σ + 1π

F d) All of the sigma bonds (σ) in SO_2 are formed from overlap of unhybridized p atomic orbitals. Sigma bonds are always formed from overlap of hybrid orbitals. π bonds result when unhybridized p atomic orbitals overlap side-to-side.

F e) In any one of the resonance structures, there are 2 pi (π) bonds. Each has 1 π bond.

If base has MOH general formula: $HCl + MOH \rightarrow H_2O + MCl_{(aq)}$

4. A chemist finds a bottle of solid pellets labeled "strong base". She weighs out exactly 100.0 g of the strong base and reacts it with 5.00 *M* HCl. It takes 500.0 mL of the HCl to react completely with the strong base. Which of the following is the formula for the strong base? $\text{mol } OH^- = 0.5000\text{L}\left(\frac{5.00\text{ mol HCl}}{\text{L}}\right)\left(\frac{1\text{ mol } OH^-}{1\text{ mol HCl}}\right) = 2.50\text{ mol MOH}$

a) LiOH (b) NaOH c) KOH

Molar mass = mass/mol = 100.0 g/2.50 mol = 40.0 g/mol (This is NaOH.)

d) RbOH e) $Ba(OH)_2$

If base has $M(OH)_2$ general formula: $2HCl + M(OH)_2 \rightarrow 2H_2O + MCl_{2(aq)}$

Doing the problem the same way gives a molar mass = 80.0 g/mol, this is not $Ba(OH)_2$.

5. In your Chem 103 laboratory, you find a mystery aqueous solution on the shelf. The solution may contain one or more of the following cations: Ni^{2+}, Ag^+, Ca^{2+}, Mn^{2+}. In order to determine the contents you add the following solutions: addition of excess aqueous hydrochloric acid causes a precipitate to form. The precipitate is removed, and excess aqueous potassium sulfate is added and another precipitate forms. The precipitate is removed, and aqueous sodium hydroxide is added to the solution; no precipitate forms upon addition of aqueous sodium hydroxide. Which ion/ions were present in the original mystery solution?

a) Ag^+ only b) Ni^{2+} and Ca^{2+} c) Ni^{2+} and Mn^{2+}

(d) Ag^+ and Ca^{2+} e) Ni^{2+}, Ag^+, Ca^{2+}, and Mn^{2+} are all present.

Precipitate with HCl indicates Ag^+ is present ($AgCl$ is the precipitate). Precipitate with K_2SO_4 indicates Ca^{2+} is present ($CaSO_4$ is the precipitate). Since no precipitate formed when NaOH was added, Mn^{2+} and Ni^{2+} cannot be present; if they were present, $Mn(OH)_2$ and/or $Ni(OH)_2$ precipitates would have formed. So Ag^+ and Ca^{2+} are present.

$\text{mass H in compd} = 0.0891\text{ g } H_2O\left(\frac{1\text{ mol } H_2O}{18.02\text{ g}}\right)\left(\frac{2\text{ mol H}}{1\text{ mol } H_2O}\right)\left(\frac{1.008\text{ g}}{\text{mol H}}\right) = 0.009968\text{ g H}$

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$\text{Mass \% H} = \frac{0.009968\text{ g H}}{0.1920\text{ g caffeine}} \times 100 = 5.191\%\text{ H}$

$\text{mass C in compd} = 0.3482\text{ g } CO_2\left(\frac{1\text{ mol } CO_2}{44.01\text{ g}}\right)\left(\frac{1\text{ mol C}}{1\text{ mol } CO_2}\right)\left(\frac{12.01\text{ g}}{\text{mol C}}\right) = 0.09502\text{ g C}$

6. Caffeine consists of carbon, hydrogen, oxygen, and nitrogen. When 0.1920 g of caffeine is burned in an excess of oxygen, 0.3482 g of carbon dioxide, 0.0891 g of water, and some nitrogen gas are formed. From the nitrogen gas produced, it was determined that caffeine is 28.84% nitrogen by mass. What is the mass percent of hydrogen in caffeine?

Mass N in compound = 0.2884 (0.1920 g) = 0.05537 g N

a) 5.19% H b) 23.20% H c) 1.27% H

$\text{mass O in compd} = 0.1920 - (0.009968\text{ g H} + 0.09502\text{ g C} + 0.05537\text{ g N}) = 0.03164\text{ g O}$

d) 2.60% H e) 8.72% H

So 0.1920 g of $C_aH_bO_cN_d$ contains 0.009968 g H, 0.09502 g C, 0.05537 g N and 0.03164 g O. Now do the empirical formula part to the problem.

7. Caffeine consists of carbon, hydrogen, oxygen, and nitrogen. When 0.1920 g of caffeine is burned in an excess of oxygen, 0.3482 g of carbon dioxide, 0.0891 g of water, and some nitrogen gas are formed. From the nitrogen gas produced, it was determined that caffeine is 28.84% nitrogen by mass. What is the empirical formula for caffeine?

$0.009968\text{ g H}\left(\frac{1\text{ mol H}}{1.008\text{ g}}\right) = 0.009889\text{ mol H}/0.01978 = 5\text{ mol H}$

a) $C_4H_5N_2O$ b) $C_3H_3N_2O$ c) $C_4H_5N_2O_2$

$0.09502\text{ g C}\left(\frac{1\text{ mol C}}{12.01\text{ g}}\right) = 0.007912\text{ mol C}/0.01978 = 4\text{ mol C}$

d) $C_4H_{10}N_4O_4$ e) $C_2H_5N_2O_2$

$0.05537\text{ g N}\left(\frac{1\text{ mol N}}{14.01\text{ g}}\right) = 0.003952\text{ mol N}/0.01978 = 2\text{ mol N}$

$0.03164\text{ g O}\left(\frac{1\text{ mol O}}{16.00\text{ g}}\right) = 0.001978\text{ mol O}/0.01978 = 1\text{ mol O}$

$C_4H_5N_2O$ is the empirical formula of caffeine.

8. A 2.402-g sample of urea contains 1.121 g N, 0.161 g H, 0.480 g C, and the rest oxygen. What is the empirical formula of urea?

$\text{mass O} = 2.402\text{ g urea} - (1.121\text{ g N} + 0.161\text{ g H} + 0.480\text{ g C}) = 0.640\text{ g O}$

$1.121\text{ g N}\left(\frac{1\text{ mol N}}{14.01\text{ g}}\right) = 0.08001\text{ mol N}/0.04 = 2\text{ mol N}$

a) NHCO b) $N_2H_3CO_2$ c) $N_4H_8C_2O$

$0.161\text{ g H}\left(\frac{1\text{ mol H}}{1.008\text{ g}}\right) = 0.1598\text{ mol H}/0.04 = 4\text{ mol H}$

d) N_2H_4CO e) $NH_2C_2O_2$

$0.480\text{ g C}\left(\frac{1\text{ mol C}}{12.01\text{ g}}\right) = 0.03997\text{ mol C}/0.04 = 1\text{ mol C}$

$0.640\text{ g O}\left(\frac{1\text{ mol O}}{16.00\text{ g}}\right) = 0.0400\text{ mol O}/0.04 = 1\text{ mol O}$

N_2H_4CO is the empirical formula of urea.

9. A mixture of 1.00 mol of $H_2(g)$ and 1.00 mol of $CH_4(g)$ is placed in a rigid (constant volume) container at some initial temperature. If the temperature of the container is increased, which of the following statements concerning this increase in temperature is **false**? Assume both gases behave ideally.

An increase in T results in gas particles moving faster, so the gas particles collide with the walls of the container more frequently and more forcefully.

T a) The partial pressure of $H_2(g)$ and the partial pressure of $CH_4(g)$ will both increase as the temperature is increased. As T↑, partial pressure of both gases increase.

T b) The $H_2(g)$ molecules will collide with the container walls more frequently as the temperature is increased. - moving faster at higher T

T c) The $CH_4(g)$ molecules will collide with the container walls more forcefully as the temperature is increased. - moving faster at higher T resulting in more forceful collisions.

T d) At the higher temperature, the $H_2(g)$ molecules will collide with the container walls more frequently as compared to the $CH_4(g)$ molecules. Lighter H_2 moves faster (on average) than the larger CH_4 molecules.

F e) At the higher temperature, the partial pressure of $H_2(g)$ will be greater than the partial pressure of $CH_4(g)$.

We still have equal moles of H_2 and CH_4 in the same container at the same higher temperature. So partial pressures will be equal ($P = \frac{nRT}{V}$).

theoretical yield $= 3.00\text{ g actual}\left(\frac{1.00\text{ g theoretical}}{0.700\text{ g actual}}\right) = 4.286\text{ g aspirin}$ theoretical

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10. An actual yield of 3.00 g of aspirin (molar mass = 180.15 g/mol) are prepared in a laboratory according to the following equation:

$4.286\text{ g asp}\left(\frac{1\text{ mol asp}}{180.15\text{ g}}\right)\left(\frac{1\text{ mol }C_4H_6O_3}{2\text{ mol asp}}\right)\left(\frac{102.09\text{ g}}{\text{mol }C_4H_6O_3}\right) = 1.21\text{ g }C_4H_6O_3$

$$2\,C_7H_6O_3(aq) + C_4H_6O_3(aq) \rightarrow 2\,C_9H_8O_4(s) + H_2O(l)$$

salicylic acid — acetic anhydride — aspirin

If the percent yield of the reaction is 70.0% and salicylic acid (molar mass = 138.12 g/mol) is in excess, what mass of acetic anhydride (molar mass = 102.09 g/mol) was used in the experiment?

a) 0.850 g b) 2.30 g c) 1.21 g d) 3.29 g e) 0.595 g

$2H_2(g) + O_2(g) \rightarrow 2H_2O(g)$ Because P and T are constant, $V \propto n$ (Avogadro's law).

11. At 110.°C and 1.00 atm, 35.2 L of H_2 gas is reacted with 25.3 L of O_2 gas to produce H_2O gas. After the reaction, the H_2O gas is removed. What volume of H_2O gas at 110.°C and 1.00 atm can be produced?

If H_2 limiting: $35.2\text{ L }H_2\left(\frac{2\text{ L }H_2O}{2\text{ L }H_2}\right) = 35.2\text{ L }H_2O$

a) 17.6 L b) 50.6 L c) 25.3 L d) 70.4 L e) 35.2 L

If O_2 limiting: $25.3\text{ L }O_2\left(\frac{2\text{ L }H_2O}{1\text{ L }O_2}\right) = 50.6\text{ L }H_2O$

H_2 produces smallest amount of H_2O, so it is limiting and $35.2\text{ L }H_2O$ can be produced.

12. Consider the reaction of aluminum reacting with oxygen to form aluminum oxide. What mass of aluminum oxide can be produced when 20.0 g of Al is reacted with excess oxygen? $4Al(s) + 3O_2(g) \rightarrow 2Al_2O_3(s)$

a) 37.8 g b) 19.8 g c) 8.2 g d) 75.6 g e) 10.0 g

$20.0\text{ g Al}\left(\frac{1\text{ mol Al}}{26.98\text{ g}}\right)\left(\frac{2\text{ mol }Al_2O_3}{4\text{ mol Al}}\right)\left(\frac{101.96\text{ g}}{1\text{ mol }Al_2O_3}\right) = 37.8\text{ g }Al_2O_3$

13. In the titration of a 42.05 mL sample of commercial vinegar (d = 1.25 g/mL) with 1.20 *M* NaOH solution, it required 56.0 mL of the NaOH solution to react with all of the acetic acid in the vinegar. What is the mass percent of acetic acid in the vinegar? Acetic acid is a monoprotic acid and has a molar mass of 60.05 g/mol. $HC_2H_3O_2$

$HC_2H_3O_2 + NaOH \rightarrow H_2O + NaC_2H_3O_2$

$\text{mass }HC_2H_3O_2 = 0.0560\text{ L}\left(\frac{1.20\text{ mol NaOH}}{\text{L}}\right)\left(\frac{1\text{ mol }HC_2H_3O_2}{1\text{ mol NaOH}}\right)\left(\frac{60.05\text{ g}}{\text{mol }HC_2H_3O_2}\right) = 4.035\text{ g }HC_2H_3O_2$

a) 9.60% b) 3.26% c) 12.0% d) 6.00% e) 7.68%

$\text{mass solution} = 42.05\text{ mL}\left(\frac{1.25\text{ g}}{\text{mL}}\right) = 52.56\text{ g}$; $\text{mass\% }HC_2H_3O_2 = \frac{4.035\text{ g }HC_2H_3O_2}{52.56\text{ g solution}} \times 100 = 7.68\%$

14. Which of the following compounds is expected to have a boiling point very close to NaF?

NaF is ionic. Ionic compounds have much higher boiling points than the covalent compounds in answers a–d. So none of these covalent compounds will have a boiling point close to NaF. Note that H–F exhibits hydrogen bonding, the strongest intermolecular force for covalent compounds. But ionic forces are still much stronger than H-bonding forces.

a) F_2O b) F_2 c) HF d) CF_4

e) None of these compounds will have a boiling point very close to NaF.

molar mass Ar ≈ 40 g/mol; molar mass Ne ≈ 20 g/mol
Since we have equal masses and since the molar mass of

Ne is about ½ that of Ar, there must be twice as many moles of Ne present as compared to the moles of Ar present.

15. You are holding two balloons each filled with the same mass of gas. One balloon contains Ne gas and the other balloon contains Ar gas. Which of the following statements concerning these two balloons is **true**? Assume constant temperature.

At constant P & T (balloons are a constant pressure container), moles of gas is directly related to the volume of gas (Avogadro's law).

a) The balloon filled with Ar gas and the balloon filled with Ne gas will have equal volumes.

(b) The balloon filled with Ne gas will be about twice as large as the balloon filled with Ar gas.
Since we have twice the moles of Ne present, the volume of the Ne balloon will be twice as large as the volume of the Ar balloon.

c) The Ar balloon has an internal pressure which is about twice the pressure inside the Ne balloon.

d) The balloon filed with Ar gas will be about twice as large as the balloon filled with Ne gas.

e) The Ne balloon has an internal pressure which is about twice the pressure inside the Ar balloon.

$\frac{P_1V_1}{n_1T_1} = \frac{P_2V_2}{n_2T_2}$, at constant V, $n_2 = n_1\left(\frac{T_1}{T_2}\right)\left(\frac{P_2}{P_1}\right)$

16. A sample of gas containing 0.50 moles of CO_2 at 25°C exerts a pressure of 0.75 atm. More CO_2 gas is added to the container and the temperature is raised to 50.°C. The resulting pressure is 2.5 atm. How many moles of CO_2 were **added** to the container? Assume that the gas is ideal and that the container volume remains constant.

(a) 1.0 moles b) 0.33 moles c) 1.5 moles

d) 0.83 moles e) 0.50 moles $n_2 = 0.50\text{mol}\left(\frac{298\text{ K}}{323\text{ K}}\right)\left(\frac{2.5\text{atm}}{0.75\text{atm}}\right) = 1.54\text{ mol}$

mol CO_2 added $= n_2 - n_1 = 1.54 - 0.50 = 1.04 =$ 1.0 mol gas added

17. Consider the following compounds (a-e), all of which are liquids at room temperature (20°C). Which compound would freeze first as the temperature is lowered from 20°C?

a) $CH_3CH_2CH_2CH_2{-}\overset{\overset{O}{\Uparrow}}{C}{-}H$ Polar
LDF + dipole

(b) $CH_3CH_2CH_2{-}\overset{\overset{O}{\uparrow}}{C}{-}O{-}H$ Polar
LDF, dipole, H-bonding ← Compound with strongest intermolecular forces, so will freeze first as T lowered.

c) $CH_3CH_2CH_2{-}\overset{\overset{O}{\Uparrow}}{C}{-}CH_3$ Polar
LDF + dipole

d) $CH_3CH_2CH_2CH_2CH_2CH_3$ nonpolar
LDF only (C_6H_{14})

e) $CH_3CH_2CH_2CH_2CH_3$
LDF only (C_5H_{12})

As the temperature is lowered the liquid with the highest freezing point will freeze first. Since its freezing point is closest to 20°C.

Note that the compound with the weakest IMF will have a freezing pt furthest below 20°C and will freeze last as the temp. is lowered from 20°C.

The compound with the weakest IMF will have the highest vapor pressure. Answers d and e are both nonpolar (only contain nonpolar C-C and C-H bonds), so they only have the relatively weak LD forces

18. Consider the following compounds (a-e), all of which are liquids at room temperature (20°C). Which compound has the **highest** vapor pressure at 20°C?

Since answer e has the smaller molar mass vs. answer d, $CH_3CH_2CH_2CH_2CH_3$ will have the highest vapor pressure of these compounds. Note that compounds a, b, and c have similar molar mass to answer d (so their LD forces are all about the same as compound d) but they are all polar so have dipole forces (and H-bonding). All have stronger forces than compound d.

a) $CH_3CH_2CH_2CH_2-\overset{\overset{O}{\|}}{C}-H$ b) $CH_3CH_2CH_2-\overset{\overset{O}{\|}}{C}-O-H$

c) $CH_3CH_2CH_2-\overset{\overset{O}{\|}}{C}-CH_3$ d) $CH_3CH_2CH_2CH_2CH_2CH_3$ (C_6H_{14}, LD only)

e) $CH_3CH_2CH_2CH_2CH_3$ (C_5H_{12}, LD only) ← weakest IMF

19. How many of the following five compounds (I-V) are strong electrolytes when added to water? Strong electrolytes are soluble ionic compounds or strong acids. Insoluble ionic compounds do not dissolve in water; they have no electrolyte designation.

I. $HC_2H_3O_2$ (weak acid, weak electrolyte) II. CH_3OH (covalent, nonelectrolyte) III. $(NH_4)_2CO_3$ (soluble ionic, strong electrolyte) IV. HNO_3 (strong acid, strong electrolyte) V. $FeCO_3$ (not soluble by solubility rules so has no electrolyte designation)

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

e) 5 [All of these compounds (I-V) are strong electrolytes.]

20. Consider the following data concerning an unknown gas Z:

I. At 25°C, gas Z and $CO_2(g)$ have the same average kinetic energy. ✓ at same T, so same KE_{ave} ← doesn't help identify gas

II. At 25°C, gas Z has an effusion rate which is 1.25 times greater than the effusion rate of $N_2O(g)$. $\frac{rate\ Z}{rate\ N_2O} = \sqrt{\frac{M_{N_2O}}{M_Z}}$, $1.25 = \sqrt{\frac{44.02}{M_Z}}$, solving: $M_Z = 28.2\ g/mol$ (this is N_2) — important → allows calculation of molar mass of Z.

III. Gas Z behaves more ideally at 1.00 atm and 25°C than at 100 atm and −75°C. Doesn't help identify gas. All gases behave more ideally at higher temp and lower pressure.

Which of the following could be gas Z?

a) F_2 (38 g/mol) b) Cl_2 (70.9 g/mol) c) CO_2 (44.0 g/mol) d) N_2 (28.0 g/mol) e) ClF (54.5 g/mol)

21. Consider the covalent compounds HCl, Cl_2, Br_2, HBr, and $CH_3CH_2CH_2CH_3$. How many of these 5 compounds is/are expected to have a boiling point greater than Ar?

Ar, 40 g/mol; Ar is nonpolar, so only has LD forces. only HCl has a molar mass less than or equal to 40 g/mol, so only HCl is a possibility for boiling higher than Ar. But HCl (molar mass = 36.5 g/mol) is polar so it has additional dipole forces. So HCl will have a higher boiling point than Ar. the other 4 covalent compounds have molar masses greater than that of Ar, so they all will have higher boiling points.

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

e) 5 (HCl, Cl_2, Br_2, HBr, and $CH_3CH_2CH_2CH_3$ are all expected to have boiling points greater than Ar).

The "a" value is related to the strength of the intermolecular forces. NH_3 can H-bond, while the other covalent compounds can't form the relatively strong H-bonding interactions. NH_3 has the strongest IMF of these five choices, so it will have the largest "a" value.

22. Consider the van der Waals equation where *a* and *b* are some constants:

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

Which of the following gases would be expected to have the largest *a* value in the van der Waals equation?

a) Ar (nonpolar, LDF) b) He (nonpolar, LDF) c) NH_3 (H-bonding + LDF) d) N_2 (nonpolar, LDF) e) CO (polar, LDF + dipole)

23. Consider the van der Waals equation where *a* and *b* are some constants:

The "b" value is related to the size of the gas particles.

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

Of the compounds listed, He has the smallest molar mass and would be the smallest. Therefore, He would have the smallest "b" value.

Which of the following gases would be expected to have the smallest *b* value in the van der Waals equation?

a) Ar b) He c) NH_3 d) N_2 e) CO

24. When magnesium nitrate reacts with sodium hydroxide, a precipitate forms. Which of the following is the **correct** net ionic equation for the precipitation reaction?

$Mg(NO_3)_2$ $NaOH$

$Mg(NO_3)_2(aq) + 2\,NaOH(aq) \rightarrow Mg(OH)_2(s) + 2\,NaNO_3(aq)$ this is the formula equation.

a) $Na^+(aq) + NO_3^-(aq) \rightarrow NaNO_3(s)$

b) $Mg^+(aq) + OH^-(aq) \rightarrow MgOH(s)$

c) $Na^{2+}(aq) + 2\,OH^-(aq) \rightarrow Na(OH)_2(s)$

d) $Mg^{2+}(aq) + 2\,OH^-(aq) \rightarrow Mg(OH)_2(s)$

e) $Mg^+(aq) + OH^{2-}(aq) \rightarrow Mg_2OH(s)$

The spectator ions are Na^+ and NO_3^-. The net ionic equation is: $Mg^{2+}(aq) + 2OH^-(aq) \rightarrow Mg(OH)_2(s)$

$$\text{moles } Mg^{2+} = 0.0500\,L\left(\frac{0.200\,mol\,Mg(NO_3)_2}{L}\right)\left(\frac{1\,mol\,Mg^{2+}}{1\,mol\,Mg(NO_3)_2}\right) = 0.0100\,mol\,Mg^{2+}$$

25. If 50.0 mL of 0.200 *M* magnesium nitrate is added to 200.0 mL of 0.300 *M* sodium hydroxide, how many moles of precipitate will form assuming the reaction has a percent yield of 100%?

$$mol\,OH^- = 0.2000\,L\left(\frac{0.300\,mol\,NaOH}{L}\right)\left(\frac{1\,mol\,OH^-}{1\,mol\,NaOH}\right) = 0.0600\,mol\,OH^-$$

a) 0.0300 mol b) 0.0100 mol c) 0.0600 mol

d) 0.00500 mol e) 0.0200 mol

Set-up the BCA table:

	$Mg^{2+}(aq)$	+ $2OH^-(aq)$	→ $Mg(OH)_2(s)$
Before	0.0100 mol	0.0600 mol	0
Change	−0.0100	−0.0200	+0.0100 mol
After	0	0.0400 mol	0.0100 mol

From the BCA table, Mg^{2+} is limiting and 0.0100 mol $Mg(OH)_2(s)$ can form.

From the BCA table on the previous page, we have 0.0400 mol of excess OH^- after the precipitate forms. The total volume of solution is 0.0500 + 0.2000 = 0.2500 L.

26. If 50.0 mL of 0.200 *M* magnesium nitrate is added to 200.0 mL of 0.300 *M* sodium hydroxide, what is the concentration of hydroxide ions after the reaction has gone to completion?

$[OH^-] = \frac{0.0400 \text{ mol } OH^-}{0.2500 \text{ L}} = 0.160 M$

a) 0.300 *M* b) 0.240 *M* c) 0.160 *M*

d) 0.0800 *M* e) 0.0 *M*

molar mass $CH_2O = 12 + 2(1) + 16 = 30$ g/mol

27. A compound has the empirical formula CH_2O. If the density of the gaseous compound is 1.50 g/L at 125°C and 413 torr, what is the molecular formula of the compound?

$P(\text{molar mass}) = dRT$, molar mass $= dRT/P$

a) CH_2O b) $C_2H_4O_2$ c) $C_3H_6O_3$ d) $C_4H_8O_4$ e) $C_5H_{10}O_5$

$\text{molar mass} = \frac{1.50 \text{ g/L}(0.08206)(398 \text{ K})}{413 \text{ torr}(\frac{1 \text{ atm}}{760 \text{ torr}})} = 90.2$ g/mol; $\frac{90.2}{30.0} \approx 3$, $(CH_2O) \times 3 = C_3H_6O_3$ is molecular formula.

28. SO_2 is produced when substances containing sulfur (coal) are burned. SO_2 released into the atmosphere reacts to form sulfuric acid according to the equation:

$$2\ SO_2(g) + O_2(g) + 2\ H_2O(l) \rightarrow 2\ H_2SO_4(l)$$

If O_2 limiting: $64.0 \text{ g } O_2(\frac{1 \text{ mol } O_2}{32.00 \text{ g}})(\frac{2 \text{ mol } H_2SO_4}{1 \text{ mol } O_2})(\frac{98.09 \text{ g}}{\text{mol } H_2SO_4}) = 392$ g H_2SO_4

If SO_2 limiting: $192 \text{ g } SO_2(\frac{1 \text{ mol } SO_2}{64.07 \text{ g}})(\frac{2 \text{ mol } H_2SO_4}{2 \text{ mol } SO_2})(\frac{98.09 \text{ g}}{\text{mol } H_2SO_4}) = 294$ g H_2SO_4

What mass of H_2SO_4 (molar mass = 98.09 g/mol) can be produced if 64.0 g O_2 and 192 g SO_2 are combined with excess water?

SO_2 produces smallest amount of product, so SO_2 is limiting and 294 g H_2SO_4 can be produced.

a) 98.1 g b) 147 g c) 196 g d) 294 g e) 392 g

29. How many of the following five compounds (I-V) are soluble in water?

I. zinc chloride (soluble) II. lead(II) nitrate (soluble) III. lead(II) sulfate (insoluble)

IV. cobalt(III) sulfide (insoluble) V. magnesium chromate (insoluble)

Applying the solubility rules, only $ZnCl_2$ and $Pb(NO_3)_2$ are soluble.

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

$PbSO_4$, Co_2S_3, and $MgCrO_4$ are all insoluble.

e) 5 (All five of these compounds are soluble in water.)

molar mass $X_2 = 0.105 \text{ g } X_2 / 8.92 \times 10^{20} \text{ molecules } X_2 (\frac{1 \text{ mol } X_2}{6.022 \times 10^{23}}) = 70.9$ g/mol ($X_2 = Cl_2$).

30. An ionic compound MX_3 is prepared according to the following unbalanced chemical equation:

In 100.00 g of MCl_3, mol M $= 54.47 \text{ g Cl}(\frac{1 \text{ mol Cl}}{35.45 \text{ g}})(\frac{1 \text{ mol M}}{3 \text{ mol Cl}}) = 0.5122$ mol M (from formula (MCl_3))

$$M + X_2 \rightarrow MX_3$$

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. Which of the following is the formula for MX_3?

Mass M in 100.00 g $MCl_3 = 100.00 - 54.47 \text{ g Cl} = 45.53$ g M

a) $AlCl_3$ b) CrH_3 c) TiF_3 d) YCl_3 e) $TlBr_3$

Molar mass $M = \frac{45.53 \text{ g M}}{0.5122 \text{ mol M}} = 88.9$ g/mol

From periodic table, M = Y. So $MX_3 = YCl_3$.