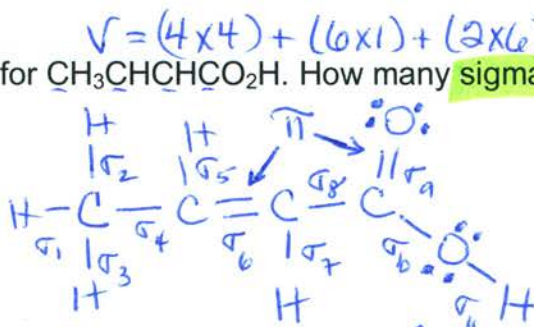


1. Draw the Lewis structure for $\text{CH}_3\text{CHCHCO}_2\text{H}$. How many **sigma and pi bonds** does it contain?

- A) 9 σ and 4 π
- B) 11 σ and 2 π**
- C) 9 σ and 2 π
- D) 13 σ and 0 π
- E) 10 σ and 2 π



Single bonds contain σ
 dbl bonds: $\sigma + \pi$
 triple bonds: $\sigma + 2\pi$

2. How many **anions** are there in 2.50 g of MgBr_2 ?

- A) 8.87×10^{25} anions
- B) 4.43×10^{25} anions
- C) 2.45×10^{22} anions
- D) 1.64×10^{22} anions**
- E) 8.18×10^{21} anions

$2.50 \text{ g MgBr}_2 \times \frac{1 \text{ mole MgBr}_2}{24.30 \text{ g} + 2(79.90 \text{ g})} = 0.01358 \text{ moles MgBr}_2$
 $\frac{184.1 \text{ g MgBr}_2}{1 \text{ mole}}$
 $\times 6.022 \times 10^{23} \frac{\text{molecules}}{1 \text{ mole}} = 8.178 \times 10^{21} \text{ molecules of MgBr}_2$

Anions (Br^-): $8.178 \times 10^{21} \text{ molecules MgBr}_2 \times \frac{2 \text{ mole Br}^-}{1 \text{ molecule MgBr}_2} = 1.64 \times 10^{22} \text{ Br}^- \text{ anions}$

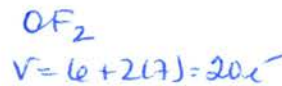
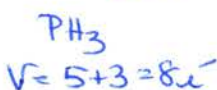
3. Which of the following combinations of quantum numbers (n, l, m_l, m_s) is **NOT allowed**?

- A) 6 3 2 $-\frac{1}{2}$
- B) 5 4 0 $+\frac{1}{2}$
- C) 3 0 0 $+\frac{1}{2}$
- D) 3 1 -1 $-\frac{1}{2}$
- E) 1 1 0 $-\frac{1}{2}$**

$n = 1, 2, 3, 4, \dots$
 $l = (n-1), (n-2), \dots, 0$
 $m_l = \pm l, \pm(l-1), \dots, 0$
 $m_s = +\frac{1}{2} \text{ or } -\frac{1}{2}$

4. Which of the following four molecules are **polar**: PH_3 OF_2 HF SO_3 ?

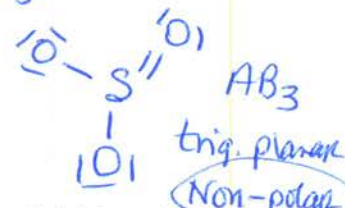
- A) only HF
- B) only HF and OF_2
- C) all except SO_3**
- D) none of these molecules
- E) all of these molecules



$\text{HF}: V = 1 + 7 = 8e^-$



$\text{SO}_3: V = 6 + 3(6) = 24e^-$



5. Identify the **percent yield** when 0.640 moles of CO_2 are formed from the reaction of 4.00 moles of C_8H_{18} with 4.00 moles of O_2 according to: $2\text{C}_8\text{H}_{18}(l) + 25\text{O}_2(g) \rightarrow 16\text{CO}_2(g) + 18\text{H}_2\text{O}(l)$

- A) 2.00%
- B) 12.5%
- C) 20.0%
- D) 25.0%**
- E) 50.0%

$\frac{4.00}{2} = 2.00 \text{ mol}$ (excess)
 $\frac{4.00 \text{ moles}}{25} = 0.16 \text{ mol}$ (LR)

$4.00 \text{ moles O}_2 \times \frac{16 \text{ moles CO}_2}{25 \text{ mol O}_2} = 2.56 \text{ moles of CO}_2 \text{ predicted to form}$ (theoretical yield)

$\% \text{ yield} = \frac{\text{actual}}{\text{theoretical}} \times 100\% = \frac{0.640 \text{ mol}}{2.56 \text{ mol}} \times 100\% = 25.0\%$

6. If the energy change for the transition between the ground state and an excited electronic state is $3.85 \times 10^5 \text{ J/mol}$, what is the wavelength for the photon necessary to induce this transition?

(A) $3.11 \times 10^{-7} \text{ m}$

B) $7.63 \times 10^{-9} \text{ m}$

C) $8.36 \times 10^{-13} \text{ m}$

D) $3.28 \times 10^{-17} \text{ m}$

E) $5.17 \times 10^{-31} \text{ m}$

$$E = 3.85 \times 10^5 \text{ J/mol} = \epsilon N_A = h\nu N_A = hc/\lambda N_A$$

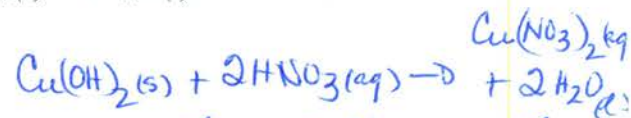
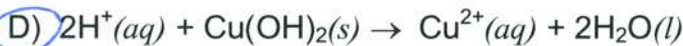
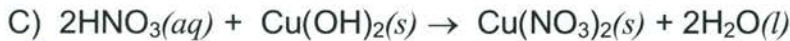
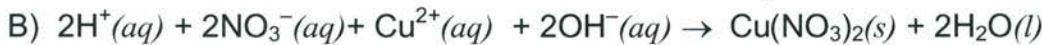
$$\epsilon = 3.85 \times 10^5 \frac{\text{J}}{\text{mol}} \times \frac{1 \text{ mol}}{6.022 \times 10^{23} \text{ photons}} = 6.393 \times 10^{-19} \text{ J/photon}$$

$$\lambda = \frac{hc}{\epsilon} = \frac{6.626 \times 10^{-34} \text{ J}\cdot\text{s} \times 2.998 \times 10^8 \text{ m/s}}{6.393 \times 10^{-19} \text{ J/photon}} = 3.11 \times 10^{-7} \text{ m/photon}$$

+ 0.25 for E

IF E was mistakenly taken as ϵ instead & converted to λ without using N_A then one gets $5.17 \times 10^{-31} \text{ m/mole}$

7. What is the net ionic equation for the acid-base reaction that occurs when nitric acid is added to copper(II) hydroxide?



8. Using Lewis structures and formal charge, which of the following ions is most stable?



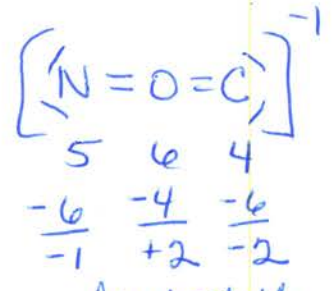
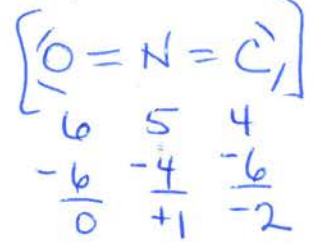
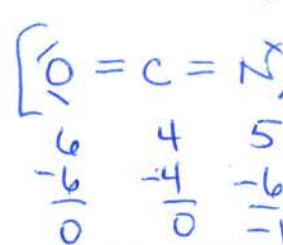
$V = 6 + 4 + 5 + 1 = 16e^-$

A) All of these ions are stable according to Lewis theory.

B) None of these ions is stable according to Lewis theory.



Formal Charges



most stable

least stable

9. What mass of aluminum metal is required to produce 12.5 L of hydrogen gas at exactly 25°C and 1.00 atm, according to $2\text{Al}(\text{s}) + 6\text{H}^+(\text{aq}) \rightarrow 2\text{Al}^{3+}(\text{aq}) + 3\text{H}_2(\text{g})$?

A) 27.6 g

B) 22.6 g

C) 20.7 g

D) 13.8 g

(E) 9.19 g

$$n_{\text{H}_2} = \frac{PV}{RT} = \frac{1.00 \text{ atm} \times 12.5 \text{ L}}{0.0821 \frac{\text{atm}\cdot\text{L}}{\text{mol}\cdot\text{K}} \times 298 \text{ K}} = 0.5109 \text{ moles H}_2$$

$$n_{\text{Al}} = 0.5109 \text{ moles H}_2 \times \frac{2 \text{ mol Al}(\text{s})}{3 \text{ moles H}_2(\text{g})} = 0.3406 \text{ mol Al}$$

$$m_{\text{Al}} = 0.3406 \text{ mol Al} \times \frac{26.98 \text{ g}}{1 \text{ mol}} = 9.19 \text{ g Al}$$

10. Pure acetic acid ($\text{HC}_2\text{H}_3\text{O}_2$, $60.052 \text{ g}\cdot\text{mol}^{-1}$) is a liquid known as *glacial acetic acid*. Calculate the molarity of a solution prepared by dissolving 50.00 mL of glacial acetic acid at 25°C in sufficient water to produce 500.0 mL of solution. The density of glacial acetic acid at 25°C is $1.05 \text{ g}\cdot\text{mL}^{-1}$.

A) $6.31 \times 10^3 \text{ M}$

B) 1.75 M

C) 0.105 M

D) $1.75 \times 10^{-3} \text{ M}$

E) 105 M

$V = 0.5000 \text{ L}$

$m_{\text{HC}_2\text{H}_3\text{O}_2} = V(\text{mL}) \times d(\text{g}) = 50.00 \text{ mL} \times \frac{1.05 \text{ g}}{1 \text{ mL}} = 52.5 \text{ g}$

$n_{\text{HC}_2\text{H}_3\text{O}_2} = 52.5 \text{ g} \times \frac{1 \text{ mol}}{60.052 \text{ g}} = 0.8742 \text{ moles}$

$[\text{HC}_2\text{H}_3\text{O}_2] = \frac{0.8742 \text{ mol}}{0.5000 \text{ L}} = 1.75 \text{ M}$

A Lewis structure for CO_3^{2-} , would include 2 single bonds + one double bond (+ 0.25 marks).

11. Draw the Lewis structure for CO_3^{2-} , including any valid resonance structures.

Which of the following statements is TRUE?

A) The CO_3^{2-} ion contains three C-O double bonds. +0.25 for B

B) The CO_3^{2-} ion contains two C-O single bonds and one C-O double bond.

C) The CO_3^{2-} ion contains three C-O bonds that are equivalent to 4/3 bonds.

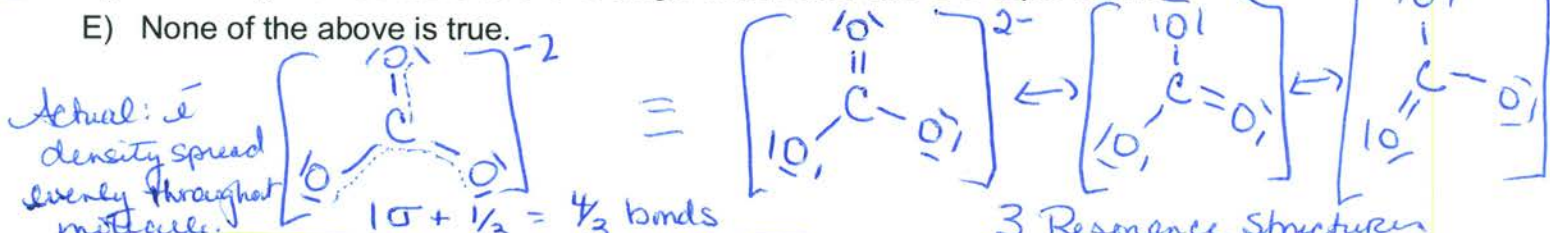
D) The CO_3^{2-} ion contains two C-O single bonds and one C-O triple bond.

E) None of the above is true.

$V = 4 + 3(6) + 2 = 24e^-$

However due to 3 resonance structures, molecule contains 3 C-O bonds that are equivalent to 4/3 bonds.

C



12. The molecular geometry for the chlorate ion (ClO_3^-) is best described as

A) octahedral

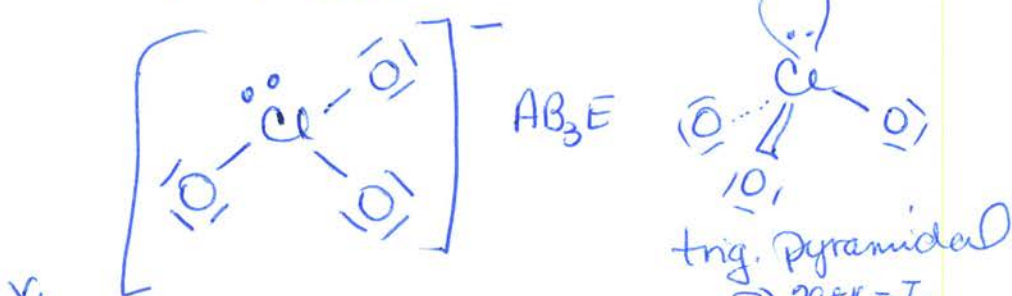
B) "T" shaped

C) tetrahedral

D) trigonal planar

E) trigonal pyramidal

$V = 7 + 3(6) + 1 = 26e^-$



13. A sample of nitrogen occupies 5.50 liters under a pressure of 900 Torr at 25°C . At what temperature will it occupy 10.0 liters at the same pressure?

A) 269°C

B) -109°C

C) 154°C

D) 32°C

E) 370°C

Since both P & n stay the same

$\frac{V_1}{T_1} = \frac{V_2}{T_2}$

$\frac{5.50 \text{ L}}{298 \text{ K}} = \frac{10.0 \text{ L}}{T_2}$

$T_2 = 541.8 \text{ K} - 273.15 \text{ K} = 269^\circ\text{C}$

$P_1 = 900 \text{ Torr} \times \frac{1 \text{ atm}}{760 \text{ Torr}} = 1.184 \text{ atm}$

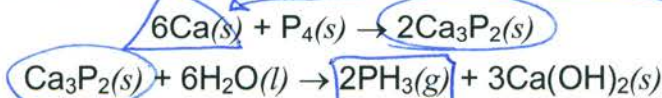
Alternatively, can use $PV = nRT$ to find # moles of gas & then solve for T_2 , i.e.

$n = \frac{PV}{RT} = \frac{1.184 \text{ atm} \times 5.50 \text{ L}}{0.0821 \text{ atm}\cdot\text{L}\cdot\text{mol}^{-1}\cdot\text{K}^{-1} \cdot 298 \text{ K}} = 0.2662 \text{ moles of gas}$

$T_2 = \frac{PV_2}{nR} = \frac{1.184 \text{ atm} \times 10.0 \text{ L}}{0.0821 \text{ atm}\cdot\text{L}\cdot\text{mol}^{-1}\cdot\text{K}^{-1} \cdot 0.2662 \text{ mol}} = 541.8 \text{ K}$

A

14. Phosphine, PH_3 , can be prepared by the two step process:



What is the **maximum number of moles of PH_3** that can be prepared from 80.2 g of calcium?

- A) 0.333 mol
 B) 2.67 mol
 C) 1.00 mol
 D) 0.667 mol
 E) 1.33 mol

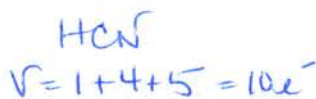
theoretical yield

$$80.2 \text{ g Ca} \times \frac{1 \text{ mol Ca}}{40.08 \text{ g Ca}} = 2.00 \text{ mol Ca}$$

$$\text{moles}_{\text{PH}_3} = 2.00 \text{ mol Ca} \times \frac{2 \text{ mol Ca}_3\text{P}_2}{6 \text{ mol Ca}} \times \frac{2 \text{ mol PH}_3}{1 \text{ mol Ca}_3\text{P}_2} = 1.33 \text{ moles PH}_3$$

15. Place HCN , H_2O and H_3O^+ in order of **increasing X-A-X bond angle**, where A represents the central atom and X represents the outer atoms in each molecule.

- A) $\text{H}_2\text{O} < \text{H}_3\text{O}^+ < \text{HCN}$
 B) $\text{H}_3\text{O}^+ < \text{H}_2\text{O} < \text{HCN}$
 C) $\text{HCN} < \text{H}_3\text{O}^+ < \text{H}_2\text{O}$
 D) $\text{H}_3\text{O}^+ < \text{HCN} < \text{H}_2\text{O}$
 E) $\text{H}_2\text{O} < \text{H}_3\text{O}^+ < \text{HCN}$



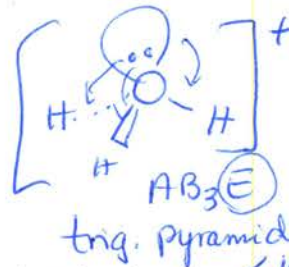
linear
 AB_2
 180°



$$V = 2 + 6 = 8e^-$$



$$V = 3 + 6 - 1 = 8e^-$$

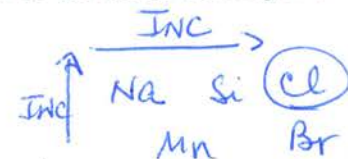


16. Which of the following ground-state electron configurations corresponds to an atom having the **largest electronegativity**?

- A) $[\text{Ne}]3s^1$ $10 + 1 = 11e^- = \text{Na}$
 B) $[\text{Ar}]3d^54s^2$ $18 + 5 + 2 = 25e^- = \text{Mn}$
 C) $[\text{Ne}]3s^23p^2$ $10 + 2 + 2 = 14e^- = \text{Si}$
 D) $[\text{Ne}]3s^23p^5$ $10 + 2 + 5 = 17e^- = \text{Cl}$
 E) $[\text{Ar}]3d^{10}4s^24p^5$ $18 + 10 + 2 + 5 = 35e^- = \text{Br}$

Electroneg. Trends:

(F is the most electroneg.)



17. Arrange the following species **from smallest to largest radius**: Se^{2-} , Sr^{2+} , Rb^+ , Br^- , Ca^{2+}

- A) $\text{Sr}^{2+} < \text{Ca}^{2+} < \text{Rb}^+ < \text{Br}^- < \text{Se}^{2-}$
 B) $\text{Se}^{2-} < \text{Br}^- < \text{Rb}^+ < \text{Sr}^{2+} < \text{Ca}^{2+}$
 C) $\text{Se}^{2-} < \text{Ca}^{2+} < \text{Sr}^{2+} < \text{Rb}^+ < \text{Br}^-$
 D) $\text{Ca}^{2+} < \text{Sr}^{2+} < \text{Rb}^+ < \text{Br}^- < \text{Se}^{2-}$
 E) $\text{Ca}^{2+} < \text{Rb}^+ < \text{Br}^- < \text{Sr}^{2+} < \text{Se}^{2-}$

Cations < atoms < anions

$\text{Rb}^+ (n=5)$

Br^-

$\text{Sr}^{2+}, \text{Ca}^{2+}$

Se^{2-}

$(n=5), (n=4)$

$\text{Br}^- < \text{Se}^{2-}$

$\text{Sr}^{2+} < \text{Rb}^+ (both n=5)$

$\text{Ca}^{2+} < \text{Sr}^{2+} (n=4 \text{ vs. } n=5)$

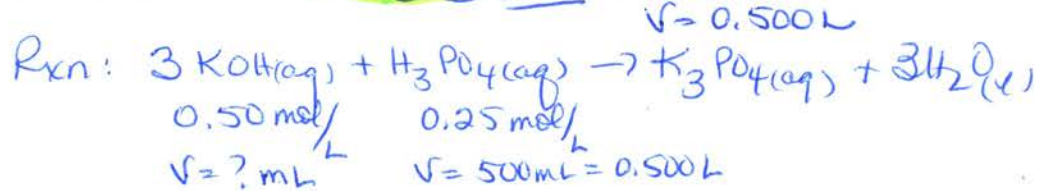
$\therefore \text{Ca}^{2+} < \text{Sr}^{2+} < \text{Rb}^+ < \text{Br}^- < \text{Se}^{2-}$

largest ionic radius

18. What is the cation's ground-state electron configuration in $\text{Co}(\text{C}_2\text{H}_3\text{O}_2)_2 \cdot 4\text{H}_2\text{O}$? Cation: Co^{2+}
- A) $[\text{Ar}] 3d^7 4s^2$
 B) $[\text{Ar}] 3d^5 4s^2$
 C) $[\text{Ar}] 3d^7$
 D) $[\text{Ar}] 3d^{10} 4s^1$
 E) $[\text{Ar}] 3d^6 4s^1$
- $^{27}\text{Co}: [\text{Ar}] 4s^2 3d^7 \rightarrow [\text{Ar}] 3d^7 4s^2$
 $\text{Co}^{2+}: [\text{Ar}] 3d^7$
- grnd-state e^-
Config. for Co.

19. What volume of 0.50 M KOH is required to neutralize completely 500 mL of 0.25 M H_3PO_4 ? weak acid

- A) 1.0×10^3 mL
 B) 7.5×10^2 mL
 C) 5.0×10^2 mL
 D) 2.5×10^2 mL
 E) 83 mL

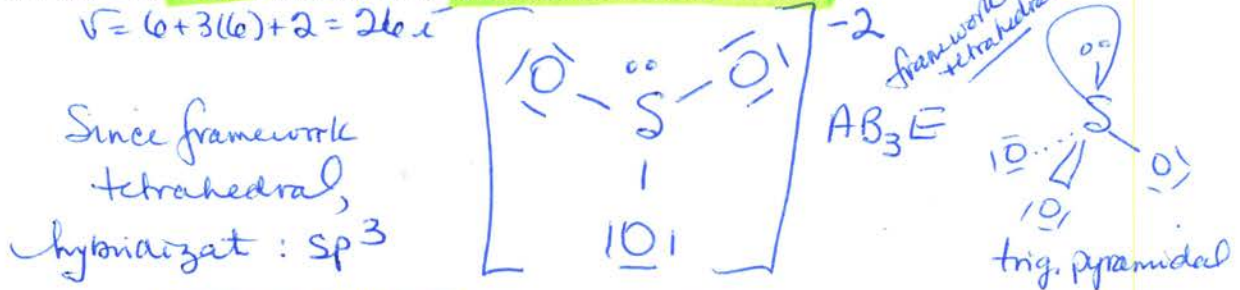


moles KOH: $0.25 \text{ mol H}_3\text{PO}_4 \times \frac{3 \text{ mol KOH}}{1 \text{ mol H}_3\text{PO}_4} = 0.375$

$v = 0.375 \text{ mol KOH} \times \frac{1 \text{ L}}{0.50 \text{ mol KOH}} \times \frac{1000 \text{ mL}}{1 \text{ L}} = 750 \text{ mL OR } 7.5 \times 10^2 \text{ mL}$

20. Draw the Lewis structure for SO_3^{2-} . What is the hybridization on the S atom?

- A) $sp^3 d^2$
 B) sp^2
 C) $sp^3 d$
 D) sp
 E) sp^3



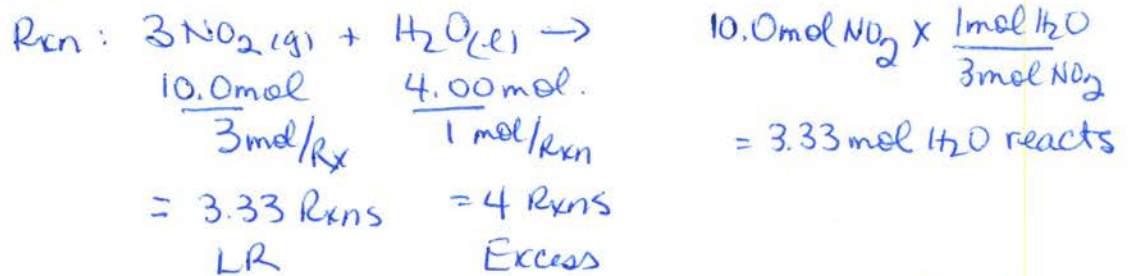
21. Solubility rules predict that a precipitate will form when mixing 0.10 M aqueous solutions of

- A) KOH and $\text{Ba}(\text{NO}_3)_2 \rightarrow \text{KNO}_3(\text{aq}) + \text{Ba}(\text{OH})_2(\text{aq}) - \text{no Rxn}$
 B) NiBr_2 and $\text{AgNO}_3 \rightarrow \text{Ni}(\text{NO}_3)_2(\text{aq}) + \text{AgBr}(\text{s}) - \text{Rxn!}$ NIE: $\text{Ag}^+(\text{aq}) + \text{Br}^-(\text{aq}) \rightarrow \text{AgBr}(\text{s})$
 C) NaI and $\text{KBr} \rightarrow \text{NaBr}(\text{aq}) + \text{KI}(\text{aq}) - \text{no Rxn}$
 D) Li_2CO_3 and $\text{CsI} \rightarrow \text{LiI}(\text{aq}) + \text{Cs}_2\text{CO}_3(\text{aq}) - \text{no Rxn}$
 E) K_2SO_4 and $\text{CrCl}_3 \rightarrow \text{KCl}(\text{aq}) + \text{Cr}_2(\text{SO}_4)_3(\text{aq}) - \text{no Rxn.}$

22. Consider the following reaction: $3\text{NO}_2(\text{g}) + \text{H}_2\text{O}(\text{l}) \rightarrow 2\text{HNO}_3(\text{l}) + \text{NO}(\text{g})$

How many moles of excess reactant remain if 4.00 moles H_2O and 10.0 moles NO_2 are used? LR Quest

- A) 6.00 mol NO_2
 B) 0.67 mol H_2O
 C) 2.00 mol NO_2
 D) 3.70 mol H_2O
 E) 8.00 mol NO_2



moles of excess H_2O : $4.00 - 3.33 \text{ mol} = 0.67 \text{ mol H}_2\text{O}$