

T18Q4: Level 3 (L.G. 10)

Consider the reaction between 100 mL of 0.41 M iron(II) nitrate with 63 mL of 0.35M potassium phosphate. How many moles of precipitate are formed from this reaction?

- A. 0.011
- B. 0.014
- C. 0.022
- D. 0.041

T18Q4: Solution

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2

$$\text{M} = \frac{\text{moles of Solute}}{\text{volume of Solution (L)}}$$

$$\text{moles} = \text{M} \times \text{vol (L)}$$

$3\text{Fe}(\text{NO}_3)_2$	$2\text{K}_3\text{PO}_4$
$0.41 \text{ M} \times 0.100 \text{ L} = 0.041 \text{ mol}$	$0.35 \text{ M} \times 0.063 \text{ L} = 0.0221 \text{ mol}$
$0.041 \times (1/3)$ $= 0.014 \text{ mol } \text{Fe}_3(\text{PO}_4)_2$	$0.0221 \times (1/2)$ $= 0.011 \text{ mol } \text{Fe}_3(\text{PO}_4)_2$

3 LR
calcs

T17Q6: Level 2 (L.G. 10)

Consider a sealed sample of gas at 33.0°C , 744 mm Hg, and 450 mL. If the pressure is decreased to 725 mm Hg and the temperature is raised to 66.0°C , what is the new volume of the gas?

- A. 512 mL
- B. 124 mL
- C. 417 mL
- D. 483 mL

**CHANGE in the conditions:
Double State Problem**

T17Q6: Solution

Consider a sealed sample of gas at 33.0°C, 744 mm Hg, and 450 mL. If the pressure is decreased to 725 mm Hg and the temperature is raised to 66.0°C, what is the new volume of the gas?

- A. 512 mL
- B. 124 mL
- C. 417 mL
- D. 483 mL

DOUBLE STATE
PROBLEM

$$P_i V_i = \cancel{n_i} T_i$$

$$PV = nRT$$

R is a constant so
it is not included!

T must be in
Kelvin

Units cancel so
can keep mm Hg.
T must be in K!!

$$\begin{aligned}V_f &= [(P_i V_i) / (P_f)] \times (T_f / T_i) \\&= [(744)(450) / (725)] \times [(273 + 66) / (273 + 33)] \\&= 511.58 \text{ mL}\end{aligned}$$

T14Q5: Level 2 (L.G. 4)

For the reaction $\text{N}_2 + 3\text{H}_2 \rightarrow 2\text{NH}_3$,

If you react 21 g hydrogen with 56 g nitrogen, what is the maximum number of grams of NH_3 that can be formed?

- A. 34 g
- B. 68 g
- C. 70 g
- D. 79 g

7
N
14.01

1
H
1.008

T14Q5: Solution

For the reaction $\text{N}_2 + 3\text{H}_2 \rightarrow 2\text{NH}_3$, Step 1

If you react 21 g hydrogen with 56 g nitrogen, what is the maximum number of grams of NH_3 that can be formed?

Step 2

$$21 \text{ g H}_2 / (2.016 \text{ g/mol}) \rightarrow 10.41 \text{ moles H}_2$$

$$56 \text{ g N}_2 / (28.02 \text{ g/mol}) \rightarrow 1.99 \text{ moles N}_2$$

7
N
14.01

1
H
1.008

Step 3

Ratio H_2 to NH_3 is 3:2

$$10.41 \text{ moles H}_2 * (2\text{NH}_3 / 3\text{H}_2) = 6.94 \text{ moles NH}_3$$

Ratio N_2 to NH_3 is 1:2

$$1.99 \text{ moles N}_2 * (2\text{NH}_3 / 1\text{N}_2) = 3.98 \text{ moles NH}_3$$

N_2 is the limiting reagent

Step 4

$$(3.98 \text{ moles NH}_3) * (17.034 \text{ g/mol}) = \underline{\underline{67.8 \text{ grams NH}_3}}$$

T15Q1: Level 2 (L.G. 1)

How many grams of sodium are in 23 g of sodium sulfate?

- A. 32 g
- B. 7.45 g
- C. 6.57 g
- D. 3.73 g
- E. 0.710 g

8
O
16.00

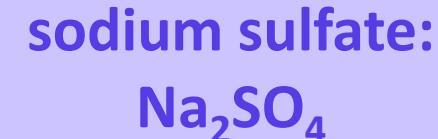
11
Na
22.99

16
S
32.06

T15Q1: Solution

How many grams of sodium are in 23 g of sodium sulfate?

- A. 32 g
- B. 7.45 g
- C. 6.57 g
- D. 3.73 g
- E. 0.710 g



$$M_w \text{ Na}_2\text{SO}_4 = 142.04 \text{ g/mol}$$

8	11	16
O	Na	S
16.00	22.99	32.06

$$\begin{aligned}\% \text{ Na} &= [2(22.99 \text{ g/mol})]/(142.04/\text{mol}) * 100\% \\ &= 32.37 \%\end{aligned}$$

$$\begin{aligned}\text{Grams Na} &= (\% \text{ Na in } \text{Na}_2\text{SO}_4) \times \text{mass of } \text{Na}_2\text{SO}_4 \\ &= (32.37/100) \times 23 \text{ g} \\ &= 7.45 \text{ g}\end{aligned}$$

Can do this is a single step:

$$\text{Grams Na} = [2(22.99 \text{ g/mol})]/(142.04/\text{mol}) \times 23 \text{ g} = 7.45 \text{ g}$$

T13Q7: Level 2 (L.G. 5)

How many fluorine atoms are there in a 38.00 g sample of fluorine gas?

- A. 2.289×10^{25} atoms
- B. 6.023×10^{23} atoms
- C. 1.205×10^{24} atoms
- D. 2.553×10^{24} atoms

9
F
19.000

T13Q7: Solution

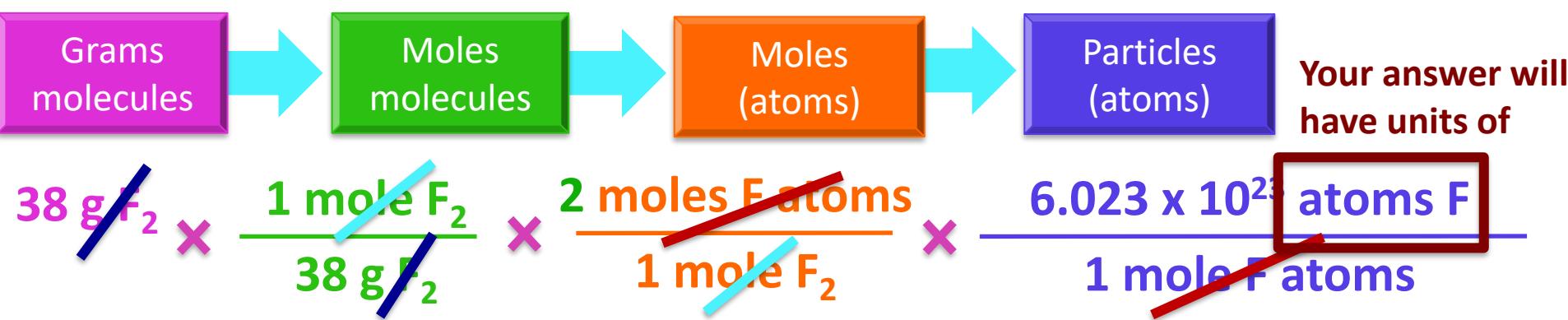
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- D. 2.553×10^{24} atoms

9
F
19.000



$$M_w \text{ of fluorine (F}_2\text{:} \\ 2(19\text{g/mol}) = 38 \text{ g/mol}$$



T14Q8: Level 3 (L.G. 8)

Consider the following chemical reaction:



How many grams of hydrogen carbonate are produced if you react 2.8 g of sodium hydrogen carbonate with 3.1 g of hydrochloric acid and the yield is 45%.

- A. 5.27 grams
- B. 2.37 grams
- C. 2.07 grams
- D. 0.93 grams



T14Q8: Solution

Consider the following chemical reaction:



How many grams of hydrogen carbonate are produced if you react 2.8 g of sodium hydrogen carbonate with 3.1 g of hydrochloric acid and the yield is 45%.



$$2.8 \text{ g} / (84.007 \text{ g/mol}) = 0.033 \text{ moles}$$

$$0.033 \text{ n} \times (1/1) = 0.033 \text{ moles H}_2\text{CO}_3$$



$$3.1 \text{ g} / (36.46 \text{ g/mol}) = 0.085 \text{ moles}$$

$$0.085 \text{ n} \times (1/1) = 0.085 \text{ moles H}_2\text{CO}_3$$

Theoretical Yield:

$$0.033 \text{ moles} \times (62.03 \text{ g/mol}) = 2.07 \text{ grams H}_2\text{CO}_3$$

$$\text{Actual yield} = (2.07 \text{ g}) * (45\% / 100\%) = 0.93 \text{ g H}_2\text{CO}_3$$

T16Q7: Level 2 (L.G. 12)

Which one of the following molecules is predicted to have the lowest boiling point?

- A. H_2S
- B. PH_3
- C. HCl
- D. SiH_4
- E. H_2O

T16Q7: Solution

Which one of the following molecules is predicted to have the lowest boiling point?

- A. H_2S
- B. PH_3
- C. HCl
- D. SiH_4
- E. H_2O

As BP increases IMF must get stronger.
 SiH_4 is the only non-polar molecule thus it has the weakest IMFs (only LDFs).

Make sure you can draw all the Lewis structures and predict the polarity.

T14Q3: Level 2 (L.G. 3)

How many moles of O_2 are required for the complete combustion of 2.2 g of C_3H_8 to form CO_2 and H_2O ?

- A. 0.050 moles of O_2
- B. 0.15 moles of O_2
- C. 0.25 moles of O_2
- D. 0.50 moles of O_2

T14Q3: Solution

How many moles of O₂ are required for the complete combustion of 2.2 g of C₃H₈ to form CO₂ and H₂O?

- A. 0.050 moles of O₂
- B. 0.15 moles of O₂
- C. 0.25 moles of O₂
- D. 0.50 moles of O₂



$$\begin{aligned}\text{M}_w \text{ of C}_3\text{H}_8 \\ = 3(12.01 \text{ g/mol}) + 8(1.008 \text{ g/mol}) \\ = 44.1 \text{ g/mol}\end{aligned}$$

Reaction	C ₃ H ₈	+	5O ₂	→	3CO ₂ + 4H ₂ O
In the vessel before rxn (no coefficient used)	2.2 g		-	-	-
	2.2 g / (44.1 g/n) = 0.049 moles		?		-
What reacted	0.049 moles		0.049 moles x (5/1) = 0.25 moles		-

T15Q3: Level 3 (L.G. 4)

Combustion of a 0.9835 g sample of a compound containing only C, H, and O produced 1.900 g of CO₂ and 1.072 g of H₂O. What is the empirical formula of the compound?

- A. C₂H₅O
- B. C₂H₅O₂
- C. C₄H₁₀O₂
- D. C₄H₁₁O₂

T15Q3: Solution

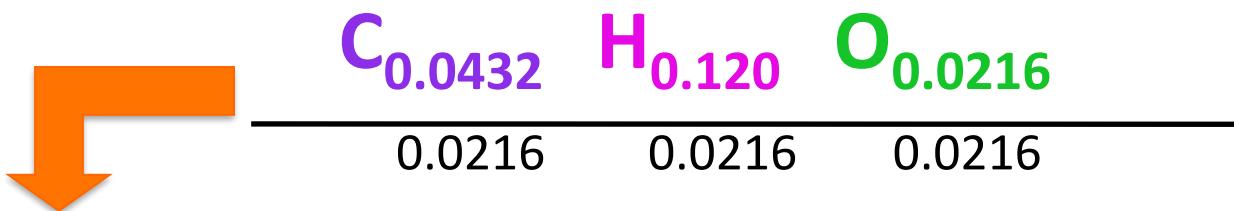
Combustion of a 0.9835 g sample of a compound containing only C, H, and O produced 1.900 g of CO₂ and 1.072 g of H₂O. What is the empirical formula of the compound?



$$\frac{0.518 \text{ g C}}{12.01 \text{ g/mol}}$$

$$\frac{0.120 \text{ g H}}{1.008 \text{ g/mol}}$$

$$\frac{0.345 \text{ g O}}{16.00 \text{ g/mol}}$$



T13Q3: Level 1 (L.G. 8)

How many moles of water are in 3.6 grams of water?

- A. 2.6×10^{24} moles
- B. 64.8 moles
- C. 3.6 moles
- D. 0.20 moles
- E. 0.40 moles

1 H 1.008	8 O 16.00
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T13Q3: Solution

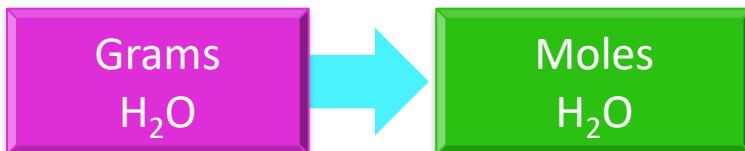
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- A. 2.6×10^{24} moles
- B. 64.8 moles
- C. 3.6 moles
- D. 0.20 moles**
- E. 0.40 moles

1 H 1.008	8 O 16.00
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M_w of water:

$$2(1.008 \text{ g/mol}) + (16.00 \text{ g/mol}) = 18 \text{ g/mol}$$



$$\cancel{3.6 \text{ g H}_2\text{O}} \times \frac{1 \text{ mol H}_2\text{O}}{\cancel{18 \text{ g H}_2\text{O}}} = 0.20 \text{ mol H}_2\text{O}$$

Your answer will have units of moles of H₂O

T16Q5: Level 4 (L.G. 12)

Consider the molecules: H_2O , CO_2 , NH_3 , CCl_4 . The boiling points of these four molecules from lowest boiling point to highest boiling point are -78°C , -34°C , 76°C , 100°C . Place these molecules in order from highest boiling point to lowest boiling point.
(HINT: Both NH_3 and CO_2 are gases at room temperature.)

- A. H_2O , CCl_4 , NH_3 , CO_2
- B. H_2O , NH_3 , CCl_4 , CO_2
- C. NH_3 , CO_2 , CCl_4 , H_2O
- D. H_2O , CCl_4 , CO_2 , NH_3

T16Q5: Solution

Consider the molecules: H_2O , CO_2 , NH_3 , CCl_4 . The boiling points of these four molecules from lowest boiling point to highest boiling point are -78°C , -34°C , 76°C , 100°C . Place these molecules in order from highest boiling point to lowest boiling point.
(HINT: Both NH_3 and CO_2 are gases at room temperature.)

- A. H_2O , CCl_4 , NH_3 , CO_2
- B. H_2O , NH_3 , CCl_4 , CO_2
- C. NH_3 , CO_2 , CCl_4 , H_2O
- D. H_2O , CCl_4 , CO_2 , NH_3

You know the bp of H_2O is 100 so you know H_2O must be first.

NH_3 and CO_2 are gases, so they must have weaker IMF than CCl_4 which is a liquid.

NH_3 is polar and forms hydrogen bonds, whereas CO_2 only has LDF.

T18Q6: Level 2 (L.G. 8)

What precipitate is most likely formed from a solution containing Ba^{+2} , Na^{+1} , OH^{-1} , and CO_3^{-2} ?

- A. NaOH
- B. BaCO_3
- C. Na_2CO_3
- D. Ba(OH)_2

T18Q6: Solution

What precipitate is most likely formed from a solution containing Ba^{+2} , Na^{+1} , OH^{-1} , and CO_3^{-2} ?

A. NaOH → Soluble, bc Na is a group 1 metal

B. BaCO_3

C. Na_2CO_3 → Soluble, bc Na is a group 1 metal

D. Ba(OH)_2 → Slightly soluble, bc OH & Ba^{2+}

2. Alkali metal (Group 1A) salts and NH_4^+ are soluble.

3. F^- , S^{2-} , CO_3^{2-} , CrO_4^{2-} , PO_4^{3-} salts are insoluble, except for those containing Group 1A cations.

6. OH salts are insoluble (except for those containing Group 1A cations and NH_4^+ which are soluble and those containing Ca^{2+} , Sr^{2+} and Ba^{2+} which are slightly soluble).

T17Q8: Level 3 (L.G. 9)

Which of the following samples contains molecules with the greatest average kinetic energy?

- A. 1.0 moles of N_2 at 580 K
- B. 1.0 moles of CO at 140 K
- C. 1.0 moles of N_2O at 298 K
- D. 1.0 moles of CO_2 at 440 K

T17Q8: Solution

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- B. 1.0 moles of CO at 140 K
- C. 1.0 moles of N_2O at 298 K
- D. 1.0 moles of CO_2 at 440 K

KE is based only on the temperature of the gas
The higher the T the higher the KE

T17Q10: Level 3 (L.G. 14)

If the temperature of a gas is raised from 100 °C to 200 °C, the average kinetic energy of the gas will ____.

- A. increase by a factor of 2
- B. increase by a factor of 1.27
- C. increase by a factor of 100
- D. decrease by a factor of 2
- E. decrease by a factor of 100

T17Q10: Solution

If the temperature of a gas is raised from 100 °C to 200 °C, the average kinetic energy of the gas will ____.

- A. increase by a factor of 2
- B. increase by a factor of 1.27
- C. increase by a factor of 100
- D. decrease by a factor of 2
- E. decrease by a factor of 100

$$KE = \frac{3}{2}RT$$

R is a constant

3/2 is a constant

**DOUBLE STATE
PROBLEM**

$$\frac{KE_i}{KE_f} = \frac{T_i}{T_f}$$

$$KE_f = KE_i \left(\frac{T_f}{T_i} \right)$$

FACTOR

$$\begin{aligned} \left(\frac{T_f}{T_i} \right) &= \left(\frac{473}{373} \right) \\ &= 1.27 \end{aligned}$$

T increases so KE increases

T13Q11: Level 2 (L.G. 9)

How many oxygen atoms are found in a 33 g sample of manganese(II) sulfite?

- A. 1.44×10^{23} O atoms
- B. 3.94×10^{23} O atoms
- C. 4.44×10^{23} O atoms
- D. 7.22×10^{23} O atoms

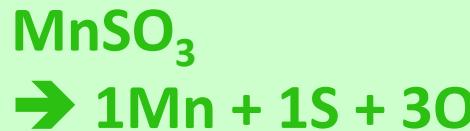
8 O 16.00	16 S 32.07	25 Mn 54.94
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T13Q11: Solution

How many oxygen atoms are found in a 33 g sample of manganese(II) sulfite?

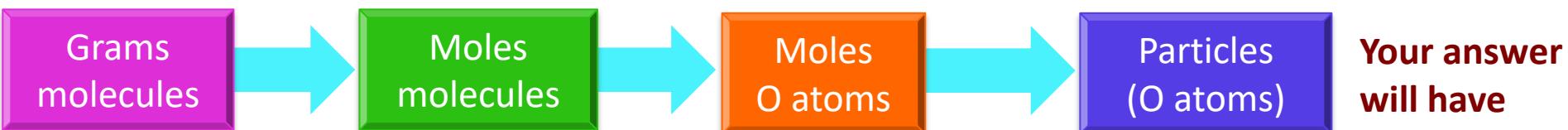
- A. 1.44×10^{23} O atoms
- B. 3.94×10^{23} O atoms
- C. 4.44×10^{23} O atoms
- D. 7.22×10^{23} O atoms

Manganese(II) sulfite:



8	16	25
O	S	Mn
16.00	32.07	54.94

$$M_w \text{ of MnSO}_3: \\ 54.94 \text{ g/mol} + 32.07 \text{ g/mol} + 3(16.00 \text{ g/mol}) = 135.0 \text{ g/mol}$$

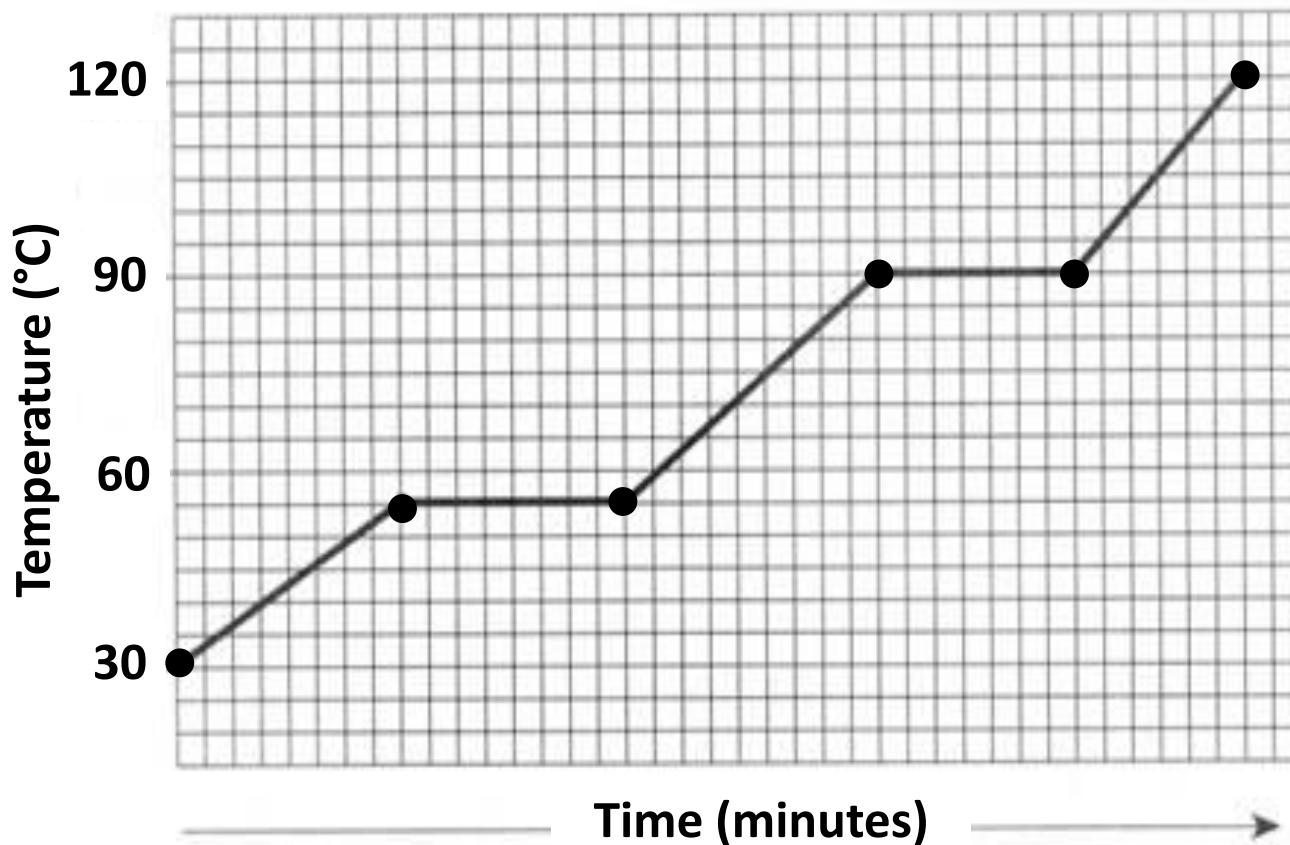


$$\cancel{33 \text{ g MnSO}_3} \times \frac{1 \text{ mole MnSO}_3}{\cancel{135 \text{ g MnSO}_3}} \times \frac{\cancel{3 \text{ mole O}}}{\cancel{1 \text{ mole MnSO}_3}} \times \frac{6.022 \times 10^{23} \text{ atoms O}}{\cancel{1 \text{ mole O}}}$$

T16Q17: Level 1 (L.G. 3)

Consider the heating curve below for substance X. At 75°C substance X exists as a _____.

- A. Solid
- B. liquid
- C. gas
- D. liquid and solid
- E. liquid and gas



T15Q6: Level 3 (L.G. 2)

Carnotite ($K_2(UO_2)_2(VO_4)_2$) and is one of 3 common vanadium ores. Vanadium metal can be extracted from this ore as pure vanadium. If you start with 985 g of carnotite, what is the maximum number of grams of V that can be extracted?

- A. 59.2 grams
- B. 98.5 grams
- C. 118 grams
- D. 120 grams
- E. 130 grams

T15Q6: Solution

Carnotite ($K_2(UO_2)_2(VO_4)_2$) and is one of 3 common vanadium ores. Vanadium metal can be extracted from this ore as pure vanadium. If you start with 985 g of carnotite, what is the maximum number of grams of V that can be extracted?

- A. 59.2 grams
- B. 98.5 grams
- C. 118 grams
- D. 120 grams
- E. 130 grams

% V in $K_2(UO_2)_2(VO_4)_2$:

$$=[(\#V)(M_w \text{ V})/M_w K_2(UO_2)_2(VO_4)_2] \times 100\%$$

$$=[2(50.94)/(848.12 \text{ g/mol})] \times 100\%$$

$$= 12.01\%$$

Mass of V that can be extracted:

$$=(12.01/100) \times (985 \text{ g})$$

$$= 118.32 \text{ g}$$

T13Q9: Level 3 (L.G. 8)

How many moles of ions are there in a sample that is 10 g of magnesium phosphate, $\text{Mg}_3(\text{PO}_4)_2$?

- A. 5.0 moles
- B. 0.49 moles
- C. 0.19 moles
- D. 0.038 moles

8 O 16.00	12 Mg 24.31	15 P 30.97
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T13Q9: Solution

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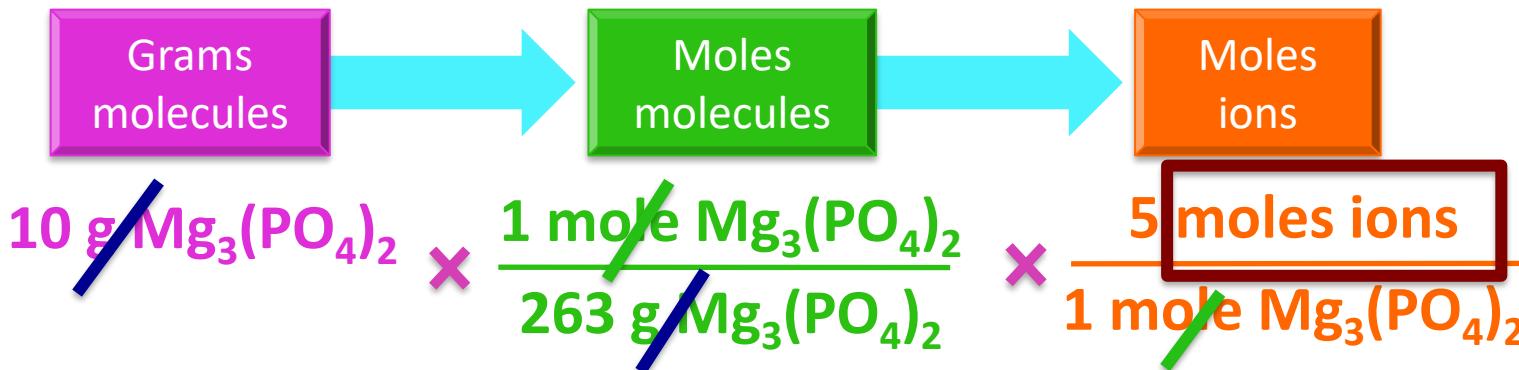


8 O 16.00	12 Mg 24.31	15 P 30.97
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5 ions per 1 molecule

M_w of magnesium phosphate:

$$3(24.31) + 2(30.97) + 8(16.00) = 263 \text{ g/mol}$$



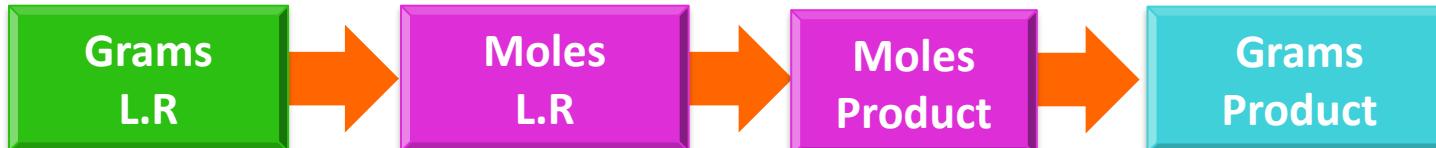
Your answer
will have
units of

T14Q6: Level 2 (L.G. 4)

Consider the chemical reaction that occurs when iron(III) oxide reacts with carbon to produce iron metal and carbon dioxide:



- A. 26.08 g
- B. 19.54 g
- C. 9.05 g
- D. 4.52 g
- E. 2.26 g



T14Q6: Solution

Consider the chemical reaction that occurs when iron(III) oxide reacts with carbon to produce iron metal and carbon dioxide:

$2\text{Fe}_2\text{O}_3 + 3\text{C} \rightarrow 4\text{Fe} + 3\text{CO}_2$ If 13.00 g of Fe_2O_3 reacts completely with 4.20 g of C, how much Fe will be formed?

Fe_2O_3	C
$13 \text{ g} / (159.7 \text{ g/mol}) = 0.081 \text{ moles}$	$4.2 \text{ g} / (12.01 \text{ g/mol}) = 0.350 \text{ moles}$
$0.081 \text{ n} \times (4/2) = 0.162 \text{ moles Fe}$	$0.350 \text{ n} \times (4/3) = 0.467 \text{ moles Fe}$

Theoretical Yield: (grams of product formed if all LR reacts)

$$0.162 \text{ moles} \times (55.85 \text{ g/mol}) = 9.05 \text{ grams Fe}$$

T18Q9: Level 2 (L.G. 9)

Give the **complete ionic equation** for the reaction that occurs when aqueous solutions of lithium sulfide and copper (II) nitrate are mixed:

- A. $\text{Li}^+(\text{aq}) + \text{SO}_4^{2-}(\text{aq}) + \text{Cu}^+(\text{aq}) + \text{NO}_3^-(\text{aq})$
→ $\text{CuS}(\text{s}) + \text{Li}^+(\text{aq}) + \text{NO}_3(\text{aq})$
- B. $\text{Li}^+(\text{aq}) + \text{S}^-(\text{aq}) + \text{Cu}^+(\text{aq}) + \text{NO}_3^-(\text{aq})$
→ $\text{CuS}(\text{s}) + \text{LiNO}_3(\text{aq})$
- C. $2\text{Li}^+(\text{aq}) + \text{S}^{2-}(\text{aq}) + \text{Cu}^{2+}(\text{aq}) + 2\text{NO}_3^-(\text{aq})$
→ $\text{Cu}^{2+}(\text{aq}) + \text{S}^{2-}(\text{aq}) + 2\text{LiNO}_3(\text{s})$
- D. $2\text{Li}^+(\text{aq}) + \text{S}^{2-}(\text{aq}) + \text{Cu}^{2+}(\text{aq}) + 2\text{NO}_3^-(\text{aq})$
→ $\text{CuS}(\text{s}) + 2\text{Li}^+(\text{aq}) + 2\text{NO}_3^-(\text{aq})$