



## The Mole



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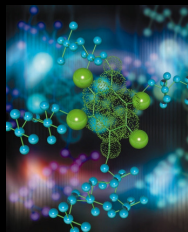
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## Molecules Are Too Small To See

We must “deduce” number of molecules involved in reactions



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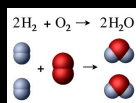
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## Reactions occur at the particulate level:



Molecules “collide” to form new products  
(Collision Theory)



Need way to determine number of reacting atoms



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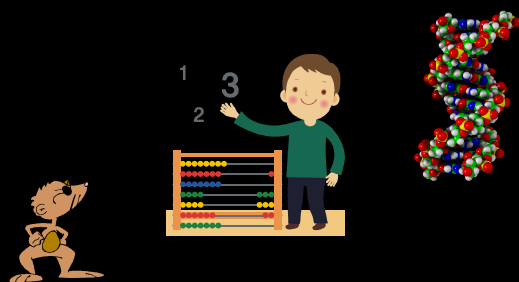
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## The Mole is a Chemist's Way of Counting Atoms & Molecules



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## The Mole

Mole always contains the same number of formula units:  
 $6.02 \times 10^{23}$  (Avogadro's Number)

- 1 mol element =  $6.02 \times 10^{23}$  atoms
- 1 mol diatomic element =  $6.02 \times 10^{23}$  molecules
- 1 mol molecular compound =  $6.02 \times 10^{23}$  molecules
- 1 mol ionic compound =  $6.02 \times 10^{23}$  formula units



So, the "per" expressions:

- 1 mol =  $6.02 \times 10^{23}$  atoms
- 1 mol =  $6.02 \times 10^{23}$  molecules
- 1 mol =  $6.02 \times 10^{23}$  formula units



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## Each Element Has A Different Atomic Mass

# Periodic Table

1 H 1.008																	2 He 4.003						
3 Li 6.941	4 Be 9.012																	5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00	9 F 18.99	10 Ne 20.18
11 Na 22.99	12 Mg 24.31									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 47.88	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.85	27 Co 58.93	28 Ni 58.69	29 Cu 63.55	30 Zn 65.38	31 Ga 69.72	32 Ge 72.64	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 98.91	44 Ru 101.1	45 Rh 101.1	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	58 Ce 140.1	59 Pr 140.9	60 Nd 144.2	61 Pm 144.9	62 Sm 150.4	63 Eu 151.9	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							
72 Hf 178.5	73 Ta 180.9	74 W 183.8	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 209.0	85 At 210.0	86 Rn 222.0									
<div style="display: flex; justify-content: space-between;"><span>← s</span><span>d</span><span>p</span></div>																							
<div style="display: flex; justify-content: space-between;"><span>← f</span></div>																							
<div style="display: flex; justify-content: space-between;"><span>Lanthanides</span><span>Actinides</span></div>																							

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## Each Element or Compound Mole Has Different Mass

12.01 g C  
 1.008 g H  
 2.016 g H<sub>2</sub>  
 32.00 g O<sub>2</sub>  
 18.02 g H<sub>2</sub>O  
 58.44 g NaCl  
 159.7 g Fe<sub>2</sub>O<sub>3</sub>  
 108.0 g N<sub>2</sub>O<sub>5</sub>  
 ~68,000 g Hemoglobin

= Avogadro's number of atoms or molecules



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## The Mole

A Mole always contains same number of particulates (formula units)

But

Since each element /compound has a different mass,

Equal # atoms (a mole) of different elements have a different mass



Periodic Table of Elements															
<div> <div> <div>1</div> <div>H</div> <div>1.008</div> </div> <div> <div>2</div> <div>He</div> <div>4.003</div> </div> </div> <div> <div>3</div> <div>Li</div> <div>6.941</div> </div> <div> <div>4</div> <div>Be</div> <div>9.012</div> </div> <div> <div>5</div> <div>B</div> <div>10.81</div> </div> <div> <div>6</div> <div>C</div> <div>12.01</div> </div> <div> <div>7</div> <div>N</div> <div>14.01</div> </div> <div> <div>8</div> <div>O</div> <div>16.00</div> </div> <div> <div>9</div> <div>F</div> <div>18.998</div> </div> <div> <div>10</div> <div>Ne</div> <div>20.18</div> </div>															
<div> <div>11</div> <div>Na</div> <div>22.99</div> </div> <div> <div>12</div> <div>Mg</div> <div>24.31</div> </div> <div> <div>13</div> <div>Al</div> <div>26.98</div> </div> <div> <div>14</div> <div>Si</div> <div>28.09</div> </div> <div> <div>15</div> <div>P</div> <div>30.97</div> </div> <div> <div>16</div> <div>S</div> <div>32.07</div> </div> <div> <div>17</div> <div>Cl</div> <div>35.45</div> </div> <div> <div>18</div> <div>Ar</div> <div>39.95</div> </div>															
<div> <div>19</div> <div>K</div> <div>39.10</div> </div> <div> <div>20</div> <div>Ca</div> <div>40.08</div> </div> <div> <div>21</div> <div>Sc</div> <div>44.96</div> </div> <div> <div>22</div> <div>Ti</div> <div>47.88</div> </div> <div> <div>23</div> <div>V</div> <div>50.94</div> </div> <div> <div>24</div> <div>Cr</div> <div>52.00</div> </div> <div> <div>25</div> <div>Mn</div> <div>54.94</div> </div> <div> <div>26</div> <div>Fe</div> <div>55.85</div> </div> <div> <div>27</div> <div>Co</div> <div>58.93</div> </div> <div> <div>28</div> <div>Ni</div> <div>58.71</div> </div> <div> <div>29</div> <div>Cu</div> <div>63.55</div> </div> <div> <div>30</div> <div>Zn</div> <div>65.38</div> </div> <div> <div>31</div> <div>Ga</div> <div>69.72</div> </div> <div> <div>32</div> <div>Ge</div> <div>72.64</div> </div> <div> <div>33</div> <div>As</div> <div>74.92</div> </div> <div> <div>34</div> <div>Se</div> <div>78.96</div> </div> <div> <div>35</div> <div>Br</div> <div>79.90</div> </div> <div> <div>36</div> <div>Kr</div> <div>83.80</div> </div>															
<div> <div>37</div> <div>Rb</div> <div>85.47</div> </div> <div> <div>38</div> <div>Sr</div> <div>87.62</div> </div> <div> <div>39</div> <div>Y</div> <div>88.91</div> </div> <div> <div>40</div> <div>Zr</div> <div>91.22</div> </div> <div> <div>41</div> <div>Nb</div> <div>92.91</div> </div> <div> <div>42</div> <div>Mo</div> <div>95.94</div> </div> <div> <div>43</div> <div>Tc</div> <div>98.91</div> </div> <div> <div>44</div> <div>Ru</div> <div>101.07</div> </div> <div> <div>45</div> <div>Rh</div> <div>102.91</div> </div> <div> <div>46</div> <div>Pd</div> <div>106.42</div> </div> <div> <div>47</div> <div>Ag</div> <div>107.87</div> </div> <div> <div>48</div> <div>Cd</div> <div>112.41</div> </div> <div> <div>49</div> <div>In</div> <div>114.82</div> </div> <div> <div>50</div> <div>Sn</div> <div>118.71</div> </div> <div> <div>51</div> <div>Sb</div> <div>121.76</div> </div> <div> <div>52</div> <div>Te</div> <div>127.60</div> </div> <div> <div>53</div> <div>I</div> <div>126.91</div> </div> <div> <div>54</div> <div>Xe</div> <div>131.29</div> </div>															
<div> <div>55</div> <div>Cs</div> <div>132.91</div> </div> <div> <div>56</div> <div>Ba</div> <div>137.33</div> </div> <div> <div>57</div> <div>La</div> <div>138.91</div> </div> <div> <div>58</div> <div>Ce</div> <div>140.12</div> </div> <div> <div>59</div> <div>Pr</div> <div>140.91</div> </div> <div> <div>60</div> <div>Nd</div> <div>144.24</div> </div> <div> <div>61</div> <div>Pm</div> <div>144.91</div> </div> <div> <div>62</div> <div>Sm</div> <div>150.36</div> </div> <div> <div>63</div> <div>Eu</div> <div>151.96</div> </div> <div> <div>64</div> <div>Gd</div> <div>157.25</div> </div> <div> <div>65</div> <div>Tb</div> <div>158.93</div> </div> <div> <div>66</div> <div>Dy</div> <div>162.50</div> </div> <div> <div>67</div> <div>Ho</div> <div>164.93</div> </div> <div> <div>68</div> <div>Er</div> <div>167.26</div> </div> <div> <div>69</div> <div>Tm</div> <div>168.93</div> </div> <div> <div>70</div> <div>Yb</div> <div>173.05</div> </div> <div> <div>71</div> <div>Lu</div> <div>174.97</div> </div>															
<div> <div>72</div> <div>Hf</div> <div>178.49</div> </div> <div> <div>73</div> <div>Ta</div> <div>180.95</div> </div> <div> <div>74</div> <div>W</div> <div>183.84</div> </div> <div> <div>75</div> <div>Re</div> <div>186.21</div> </div> <div> <div>76</div> <div>Os</div> <div>190.23</div> </div> <div> <div>77</div> <div>Ir</div> <div>192.22</div> </div> <div> <div>78</div> <div>Pt</div> <div>195.08</div> </div> <div> <div>79</div> <div>Au</div> <div>196.97</div> </div> <div> <div>80</div> <div>Hg</div> <div>200.59</div> </div> <div> <div>81</div> <div>Tl</div> <div>204.38</div> </div> <div> <div>82</div> <div>Pb</div> <div>207.2</div> </div> <div> <div>83</div> <div>Bi</div> <div>208.98</div> </div> <div> <div>84</div> <div>Po</div> <div>209</div> </div> <div> <div>85</div> <div>At</div> <div>210</div> </div> <div> <div>86</div> <div>Rn</div> <div>222</div> </div>															
<div> <div>87</div> <div>Fr</div> <div>223</div> </div> <div> <div>88</div> <div>Ra</div> <div>226</div> </div> <div> <div>89</div> <div>Ac</div> <div>227</div> </div> <div> <div>90</div> <div>Th</div> <div>232.04</div> </div> <div> <div>91</div> <div>Pa</div> <div>231.04</div> </div> <div> <div>92</div> <div>U</div> <div>238.03</div> </div> <div> <div>93</div> <div>Np</div> <div>237.05</div> </div> <div> <div>94</div> <div>Pu</div> <div>244.06</div> </div> <div> <div>95</div> <div>Am</div> <div>243.06</div> </div> <div> <div>96</div> <div>Cm</div> <div>247.07</div> </div> <div> <div>97</div> <div>Bk</div> <div>247.07</div> </div> <div> <div>98</div> <div>Cf</div> <div>251.08</div> </div> <div> <div>99</div> <div>Es</div> <div>252.08</div> </div> <div> <div>100</div> <div>Fm</div> <div>257.10</div> </div> <div> <div>101</div> <div>Md</div> <div>258.10</div> </div> <div> <div>102</div> <div>No</div> <div>259.10</div> </div> <div> <div>103</div> <div>Lr</div> <div>262.11</div> </div>															

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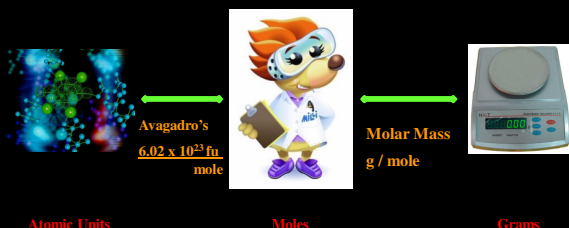
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## Mole Map



Avogadro's Number: From Memory  
 Molar Mass: Calculated from Periodic Table  
 Let the Units Drive the Solution!

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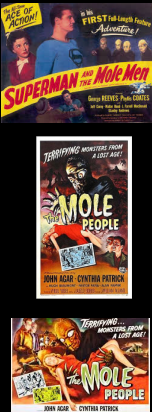
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# Let's Study the Mole, People

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# The Mole Lab

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# Today's Lab



- Work In Pairs
- See Video on The Mole
- Identify Unknown Elements
- Determine Moles and Formula Units for Ionic Compounds
- Determine Moles and Molecules for Molecular Compound

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## Element Identification

Select 3 Element Vials (with different colored dots)

Each vial marked with:

Label (Letter of the Unknown)

Weight of empty vial and cap

Weigh each vial

Mass of unknown vial – mass written on vial = mass unknown

Determine Atomic Mass of the unknown (grams / mole)

mass (grams) unknown / 0.100 mole = unknown atomic mass

Identify Unknown Element

Find element on the periodic table with unknown's atomic mass



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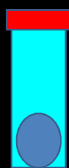
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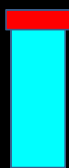
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## Weighing By Difference



Container  
Plus  
Sample  
Weight



Container  
Weight



Sample  
Weight

Technique gives best weight of sample  
(no mechanical loss while weighing)



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## Moles and Formula Units

Weigh each vial

Mass of sample vial – mass written on vial = mass sample

Determine moles of the sample (grams / mole)

mass (grams)  $\times \frac{1 \text{ mole}}{\text{formula mass (g)}} = \# \text{ Moles}$

Identify Number of Formula Units

# moles  $\times \frac{6.02 \times 10^{23} \text{ formula units}}{\text{mole}} = \# \text{ Formula Units}$



Each group determines both NaCl and KNO<sub>3</sub>

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## Moles and Number of molecules

Measure mass of 40.0 mL of deionized water

Tare balance with 50 mL grad cylinder; fill to 40.0 mL

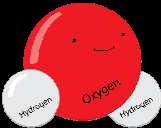

Measure mass

Determine moles of the sample (grams / mole)

mass (grams) x  $\frac{1 \text{ mole}}{\text{molecular mass (g)}}$  = # Moles sample

Identify Number of Formula Units (Molecules)

# moles x  $\frac{6.02 \times 10^{23} \text{ molecules}}{\text{mole}}$  = # Molecules in sample

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## Results

Fill in tables with calculated values

## Conclusion

## Questions

Proper units and sig figs



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## Let's Boldly Go Explore Today's Lab





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