1. What does the mole represent?
   # atoms in 12 g of Carbon-12

2. How many particles are in 1 mole?
   \(6.02 \times 10^{23}\)

3. What are the three types of representative particles?
   atoms, molecules, formula units

4. Name the representative particles of each substance.
   
   N\(_2\) molecule
   
   Mg atom
   
   Na\(_2\)S formula unit
   
   N\(_2\)O\(_4\) molecule

5. What is Avogadro’s number?
   \(6.02 \times 10^{23}\)

6. What is molar mass?
   \(\text{mass of 1 mole of atoms, molecules, or formula units in grams}\)

7. Find the molar mass of the following formulas:
   
   a. Au
   
   b. O\(_2\)
   
   c. C\(_6\)H\(_{12}\)O\(_6\)
   
   d. Ca(NO\(_3\))\(_2\)

   
   197.0 g mol\(^{-1}\)
   
   32.0 g mol\(^{-1}\)
   
   180.0 g mol\(^{-1}\)
   
   164.1 g mol\(^{-1}\)

8. How many moles are in 2.22 grams of NaF?
   \[
   \frac{2.22 \text{ g NaF}}{42.0 \text{ g mol}^{-1}} = 0.0529 \text{ mol}
   \]

9. How many moles are in 2.50 units of H\(_2\)?

   \[
   \frac{2.50 \text{ units H}_2}{1 \text{ mole H}_2} = 2.50 \text{ moles H}_2
   \]
9. How many grams are in 3.50 moles of Li?
\[
\frac{3.50 \text{ moles}}{1 \text{ mol}} \times 6.9 g = 24.2 g
\]

10. How many moles are in 4.65 x 10^{24} molecules of NO_2?
\[
\frac{4.65 \times 10^{24} \text{ molecules}}{1 \text{ mole}} \times \frac{1 \text{ mole}}{4.62 \times 10^{23}} = 1\text{ mole}
\]

11. What is the mass of 1.00 mol of fluorine molecules?
\[
\text{mass} = \text{molar mass} \times \text{number of moles} = 38.0 g \times 1\text{ mole} = 38.0 g
\]

12. How many fluorine atoms are in 1 mole of CF_4?
\[
\frac{1\text{ mol} \text{ CF}_4}{1\text{ mol}} \times \frac{4 \text{ fluorine atoms}}{1 \text{ molecule}} = 2 \times 10^{24} \text{ atoms}
\]

13. How many formula units are in 35.4 g of NaCl?
\[
\frac{35.4 g \text{ NaCl}}{1\text{ mol}} \times \frac{1\text{ mol} \text{ NaCl}}{58.5 g} \times \frac{1 \text{ formula unit}}{1 \text{ mol} \text{ NaCl}} = 3.64 \times 10^{23} \text{ formula units}
\]

14. Calculate the mass of 2.50 mol of Fe(OH)_2.
\[
\frac{2.50\text{ mol}}{1\text{ mol}} \times 91.8 g = 224.5 g \rightarrow 225 g
\]

15. What is an empirical formula?
- **Lowest whole number ratio of the atoms in a substance**

16. What is a molecular formula?
- **Whole number multiple of the empirical formula**

17. How does the molecular formula and an empirical formula of a compound compare?
- Molecular formula is multiple of empirical formula

18. Which of the following molecular formulas are also empirical formulas? (Please circle)

\[\text{C}_3\text{H}_7\text{O}_3, \quad \text{NaClO}_2, \quad \text{C}_6\text{H}_2\text{O}_6, \quad \text{Na}_2\text{Cr}_2\text{O}_7\]
19. What is a hydrated crystal? Water molecules attached to formula unit (ionic compound)

20. Find the molecular formula of ethylene glycol, which is used as antifreeze. The molar mass is 62g/mol and the empirical formula is CH₃O

   empirical mass = 31.0g  \( \frac{(CH₃O)_x}{(CH₃O)} = (CH₃O)_2 \)

   molecular formula = C₂H₆O₂

\[ 12 + 3 + 16 = 31.0g \]

\[ \text{molar mass} = \frac{62}{31} \]

\( (CH₃O)_2 \rightarrow C₂H₆O₂ \)

21. What is stoichiometry? Quantitative relationships between reactants & products in chemical reactions

22. What quantities are conserved in a chemical reaction? Mass & atoms

23. What is the mole ratio for converting moles of Al to moles of Al₂O₃ in the following equation?

   \[ 4\text{Al} + 3\text{O}_2 \rightarrow 2\text{Al}_2\text{O}_3 \]

   \[ \frac{4 \text{ moles Al}}{2 \text{ moles Al}_2\text{O}_3} \]

24. What is the limiting reactant and how do you identify it? Reactant that controls how much product can be produced (smaller number)

25. What is the excess reactant and how do you identify it? Reactant that is left over (large number)

26. What controls how much product is produced and how much excess reactant is left over? Limiting reactant

27. What is the theoretical yield? If the reaction worked perfectly, how much product could be produced

28. What is the percent yield? \[ \frac{\text{actual}}{\text{theoretical}} \times 100 \]
29. If 3.5 moles of calcium carbide (CaC₂) react with an excess of water, how many moles of acetylene (C₂H₂) will be produced?

\[
\text{CaC}_2 + 2\text{H}_2\text{O} \rightarrow \text{Ca(OH)}_2 + \text{C}_2\text{H}_2
\]

\[
\frac{3.5 \text{ moles CaC}_2}{1 \text{ mol CaC}_2} = 3.5 \text{ moles C}_2\text{H}_2
\]

30. How many grams of propane (C₃H₈) are needed to produce 5.0 moles of CO₂?

\[
\text{C}_3\text{H}_8 + 5\text{O}_2 \rightarrow 3\text{CO}_2 + 4\text{H}_2\text{O}
\]

\[
\frac{5.0 \text{ moles CO}_2}{1 \text{ mol CO}_2} = \frac{73 \text{ grams C}_3\text{H}_8}{1 \text{ mol C}_3\text{H}_8}
\]

31. How many moles of ammonia (NH₃) will be produced when 7.5 grams of N₂ react with excess hydrogen?

\[
\text{N}_2 + 3\text{H}_2 \rightarrow 2\text{NH}_3
\]

\[
\frac{7.5 \text{ g N}_2}{1 \text{ mol N}_2} = \frac{2 \text{ mol NH}_3}{28.01 \text{ g N}_2}
\]

32. How many grams of hydrogen are needed to produce 45.0 grams of methanol from the following reaction?

\[
\text{CO} + 2\text{H}_2 \rightarrow \text{CH}_3\text{OH}
\]

\[
\frac{45.0 \text{ g CH}_3\text{OH}}{32.0 \text{ g CH}_3\text{OH}} = \frac{12.0 \text{ g H}_2}{1 \text{ mol H}_2}
\]

33. If 12.6 grams of lithium react with 95.4 grams of bromine, what is the limiting reagent and how many grams of lithium bromide will be produced?

\[
2\text{Li} + \text{Br}_2 \rightarrow 2\text{LiBr}
\]

\[
\frac{12.6 \text{ g Li}}{1 \text{ mol Li}} = \frac{49 \text{ g Li}}{1 \text{ mol Li}}
\]

\[
\frac{95.4 \text{ g Br}_2}{1 \text{ mol Br}_2} = \frac{159.8 \text{ g Br}_2}{1 \text{ mol Br}_2}
\]

34. Heating calcium carbonate decomposes to produce carbon dioxide and calcium oxide. If 235g of CaCO₃ is heated what is the theoretical yield of CO₂? If your actual yield was 91g of CO₂ what was your percent yield?

\[
\text{CaCO}_3 \rightarrow \text{CaO} + \text{CO}_2
\]

\[
\frac{100.1 \text{ g CaCO}_3}{1 \text{ mol CaCO}_3} = \frac{103 \text{ g CO}_2}{1 \text{ mol CO}_2}
\]

\[
\frac{235 \text{ g CaCO}_3}{1 \text{ mol CaCO}_3} = \frac{203 \text{ g CO}_2}{1 \text{ mol CO}_2}
\]

\[
\frac{91 \text{ g CO}_2}{103 \text{ g CO}_2} \times 100 = 88\% \text{ yield}
\]
Unit 12 - States of Matter

35. What are the main assumptions of the kinetic molecular theory (gases)?
   - Elastic collisions
   - No intermolecular forces
   - Negligible volume
   - Move in constant straight line motion

36. What is the relationship between the average kinetic energy of particles and the Kelvin temperature scale?

   Temperature is a measure of the average kinetic energy of the particles.

37. Compare intermolecular and intramolecular forces.

   Hydrogen bonding: between dipole-dipoles
   Covalent bonding: within covalent bonds
   Ionic bonding: between positive and negative ions

38. What factors determine the physical properties of a liquid?

39. What is effusion?
   Gas escape through small opening

40. What gases effuse/diffuse faster?
   Gases with lower molecular mass

41. What is the ratio of effusion rates of oxygen (O₂) and xenon (Xe) at the same temperature and pressure? (How much faster does O₂ effuse?)

   \[
   \frac{\text{Rate O}_2}{\text{Rate Xe}} = \sqrt{\frac{\text{MM}_{\text{O}_2}}{\text{MM}_{\text{Xe}}}} = \sqrt{\frac{32.0}{131.3}} = 2.03 \text{ times faster}
   \]

42. Calculate the rate of effusion of helium compared to fluorine. Which gas effuses faster?

   \[
   \frac{\text{Rate He}}{\text{Rate F}_2} = \sqrt{\frac{\text{MM}_{\text{He}}}{\text{MM}_{\text{F}_2}}} = \sqrt{\frac{4.0}{38.0}} = 3.1 \text{ times faster}
   \]

43. How does kinetic theory explain the relationship between fluidity, viscosity, surface tension, and capillary action to intermolecular forces?

   Kinetic theory: constant motion of particles
   Intermolecular forces control physical properties, strength of intermolecular forces determine fluidity, viscosity, surface tension, and capillary action.
44. What does energy do to a substance when it is added while in a single state? What does it do differently when you are at a change of state?

At change of state: energy goes into breaking bonds intermolecular forces.

45. What is a phase diagram?

Shows what phase a substance will be in at a specific pressure and temperature

Use the graph below to answer the questions 45-49.

46. Label each region of the graph as solid, liquid, or vapor.

47. What is the triple point? \( P \), \( T \) at \( S, L, G \) can coexist

48. What states of matter are present at the normal melting point? \( S, L \), \( L, G \), \( S, G \)

49. What states of matter are present at the normal boiling point? \( S, L \), \( L, G \), \( S, G \)

50. What states of matter are present at the triple point?

Solid, liquid and gas
Unit 13 - Gases

51. What are the four variables that affect gas behavior?
   - Pressure
   - Volume
   - Temperature
   - Number of gas particles

52. Understand the relationships (directly or inversely proportional) between the following pairs of variables:
   a. Pressure and volume
   b. Pressure and temperature
   c. Pressure and moles
   d. Temperature and volume

\[ \frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2} \]

\[ PV = nRT \]

53. What variables are used in the combined gas law? Pressure, volume & temperature

54. What is STP? Standard temperature and pressure, 0°C = 273 K & 1 atm

55. What is the standard molar volume? 22.4 L = 1 mol

56. What is Avogadro's Principle? Equal volumes of gases at the same temperature contain an equal number of particles.

57. What is an ideal gas? No attractive forces and negligible volume.

58. What is R? Ideal gas law constant

59. When do gases behave less ideally? Low temperature & high pressure

60. What is the total gas pressure, if three gases with partial pressures of 12.0 kPa, 65.3 kPa and 22.2 kPa are mixed together?

\[ P_{total} = P_1 + P_2 + P_3 + \ldots \]

\[ P_{total} = 12.0 + 65.3 + 22.2 = 99.5 \text{ kPa} \]

61. Convert 3.71 atm to kPa

\[ 3.71 \text{ atm} \times \frac{101.325 \text{ kPa}}{1 \text{ atm}} = 376 \text{ kPa} \]
62. What is the partial pressure of dry hydrogen that was collected over water at 28°C if the barometric pressure is 116 kPa and vapor pressure of water at 28°C is 3.4 kPa? 
\[ P_{\text{total}} = P_{\text{gas}} + P_{\text{vap}} \]
\[ 116 \text{ kPa} = P_{\text{gas}} + 3.4 \text{ kPa} \]
\[ P_{\text{gas}} = 116 \text{ kPa} - 3.4 \text{ kPa} = 112.6 \text{ kPa} \]

63. A 10-g sample of krypton occupies 13.2 L at a pressure of 100 kPa. Find the volume of the krypton when the pressure is increased to 520 kPa. 
\[ PV_1 = P_2V_2 \]
\[ (100 \text{ kPa})(13.2 \text{ L}) = (520 \text{ kPa})(V_2) \]
\[ V_2 = \frac{(100 \text{ kPa})(13.2 \text{ L})}{520 \text{ kPa}} = 2.54 \text{ L} \]

64. A balloon filled with helium has a volume of 28.4 L at a temperature of 25°C. What is the volume of the balloon if the temperature is increased to 88°C and the pressure remains constant? 
\[ V_1 = V_2 \]
\[ \frac{T_1}{T_2} = \frac{273 + 25}{273 + 88} = \frac{298}{362} \]
\[ V_2 = V_1 \frac{T_1}{T_2} = 28.4 \text{ L} \times \frac{298}{362} = 23.4 \text{ L} \]

65. A gas has a pressure of 602 kPa at 127°C. What will its temperature be at 329 kPa, if the volume does not change? 
\[ \frac{P_1}{T_1} = \frac{P_2}{T_2} \]
\[ \frac{602 \text{ kPa}}{400 \text{ K}} = \frac{329 \text{ kPa}}{T_2} \]
\[ T_2 = \frac{329 \text{ kPa} \times 400 \text{ K}}{602 \text{ kPa}} = 219 \text{ K} \]
\[ T_2 = -55°C \]

66. A gas has a volume of 2.45 mL at 1.4 atm and 198 K. What is the new pressure if the volume increases to 26.2 mL and the temperature is changed to 278 K? 
\[ P_1V_1 = P_2V_2 \]
\[ \frac{P_1}{T_1} = \frac{P_2}{T_2} \]
\[ \frac{1.4 \text{ atm}}{198 \text{ K}} = \frac{P_2}{278 \text{ K}} \]
\[ P_2 = 0.16 \text{ atm} \]

67. What is the pressure (in atm) of 0.028 g of CO₂ gas, if at 329 K, it has a volume of 8.47 L? 
\[ PV = nRT \]
\[ P(0.547 \text{ L}) = \frac{(8.75 \times 10^{-4} \text{ mol})(2.45 \text{ atm})(329 \text{ K})}{0.0821 \text{ atm L mol}^{-1} \text{ K}^{-1}} \]
\[ P = 0.0043 \text{ atm} \]

68. What is the volume of 0.1042 mol of CO₂ at STP? 
\[ \frac{0.1042 \text{ mol}}{22.4 \text{ L mol}^{-1}} = 2.334 \text{ L} \]
69. What is solvation?
   The process of surrounding solute particles with solvent to form a solution.

70. What is miscible and immiscible?
   Two substances that are not soluble, polar dissolves polar, non-polar dissolves non-polar.

71. Explain the phrase “like dissolves like”.
   Polar dissolves polar, non-polar dissolves non-polar.

72. What factors affect the rate of solvation?
   Mixing, increasing surface area, heating, increasing temperature.

73. How do you make a supersaturated solution?
   Heating up and slowly cooling to dissolve more solute.

74. Define the following terms:
   Solution = homogeneous mixture, can be solid, liquid, or gas.
   Solvent = does the dissolving (typically water).
   Solute = gets dissolved.

75. What is the Tyndall Effect?
   Scattering of light by of dispersed particles in a suspension.

76. Understand the similarities and differences between suspensions, colloids, and solutions.

<table>
<thead>
<tr>
<th></th>
<th>Settle out?</th>
<th>Particle size</th>
<th>Tyndall Effect</th>
<th>Type of mixture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suspension</td>
<td>Y</td>
<td>L</td>
<td>Y</td>
<td>heterogeneous</td>
</tr>
<tr>
<td>Colloid</td>
<td>N</td>
<td>M</td>
<td>Y</td>
<td>heterogeneous</td>
</tr>
<tr>
<td>Solution</td>
<td>N</td>
<td>S</td>
<td>N</td>
<td>homogeneous</td>
</tr>
</tbody>
</table>
77. What is solubility and what factors affect it?
78. How is solid solubility different from gas solubility as it relates to temperature?
79. How is gas solubility related to pressure (Henry’s law)?

\[ \frac{S_1}{P_1} = \frac{S_2}{P_2} \]

80. The solubility of a gas in water is .13 g/L at 42 kPa. What is its solubility at 92 kPa?

\[ \frac{S_1}{P_1} = \frac{S_2}{P_2} \]

81. Calculate the molarity if 2.5 mol of sugar is dissolved to make 645 mL of solution.

\[ M = \frac{mol}{L} = \frac{2.5 \text{ mol}}{0.645 \text{ L}} = 3.9 \text{ M} \]

82. What is the molarity of the solution if 57 mL of a 6.0 M HCl is diluted to 225 mL?

\[ M_1 \times V_1 = M_2 \times V_2 \]

83. Calculate the molality if 23.5 g of NaNO₃ is dissolved in 835 g of H₂O.

\[ \frac{23.5 \text{ g NaNO₃}}{311 \text{ mol NaNO₃}} \times \frac{1 \text{ mol NaNO₃}}{0.2765 \text{ mol H₂O}} \times \frac{0.835 \text{ kg H₂O}}{0.835 \text{ kg}} = 0.33 \text{ m} \]

84. Calculate the % volume (v/v) if 38 mL of rubbing alcohol is mixed to make 340 mL of solution.

\[ \frac{38 \text{ mL}}{340 \text{ mL}} = 11\% \text{ alcohol solution} \]

85. Calculate the % mass (m/m) if 35 g of NaCl is dissolved in 125 g of water.

\[ \frac{35 \text{ g NaCl}}{125 \text{ g}} = 28\% \text{ NaCl solution} \]

88. How many grams of NaCl would be needed to make 2.8 L of a 3.5 M NaCl solution?

\[ \frac{2.8 \text{ L}}{3.5 \text{ mol}} \times \frac{58.5 \text{ g}}{1 \text{ mol}} = 57.3 \text{ g} \]

89. What is a colligative property? Properties that depend on number of solute particles and not on the nature of the particles.

87. Assume 100 g of solution so 16.5 g = NaCl & 83.5 g = H₂O.

Convert NaCl to mol 0.282 mol NaCl/0.0835 g H₂O = 3.38 mol

mol fraction: \( X_{\text{NaCl}} = 0.282/(0.282+4.64) = 0.0573 \)
90. Give three colligative properties and how they are affected when you increase the number of solute particles?
   - Vapor pressure lowering
   - Boiling point elevation
   - Freezing point depression

91. If equal numbers of moles of sugar, NaCl, and CaCl₂ are added to the same amount of water, which will have the greatest effect on the freezing temperature? Why?
   - Sugar = molecule = 1
   - NaCl = 2
   - CaCl₂ = 3
   CaCl₂ b/c most number of particles

92. Calculate the freezing point of a .65 m CaCl₂ solution in water.
   \( \Delta T_f = k_f \cdot m \cdot i \) 
   \[ (K_f \text{water} = .512 °C/m \text{ and } K_f \text{water} = 1.86 °C/m) \]
   \[ \Delta T_f = (1.86)(0.65)(3) = 3.6 °C \]
   New freezing point = 0 - 3.6 = \(-3.6 °C\)

93. Calculate the boiling point of a 24 m sugar solution in water.
   \( \Delta T_B = k_b \cdot m \cdot i \) 
   \[ (K_b \text{water} = .512 °C/m \text{ and } K_f \text{water} = 1.86 °C/m) \]
   \[ \Delta T_B = (0.512)(0.24)(1) = 0.12 °C \]
   \[ 100 °C + 0.12 °C = 100.12 °C \]
Unit 15: Energy and Chemical Change

94. Define and give an example of each of the following:
   a. potential energy: stored energy (water behind a dam) form to another.
   b. chemical energy: energy stored in chemicals (battery) or methane.

95. Define the following:
   a. System: what you are investigating (reaction of interest)
   b. Surroundings: everything else
   c. Universe: System + Surroundings

97. What is enthalpy? heat content of a system at constant pressure.

98. What is a heat of reaction?
   heat (energy) absorbed or released in a chemical reaction.
   
   \[ \Delta H = + = \text{endothermic} \quad \Delta H = - = \text{exothermic} \]

99. What is a thermochemical equation?
   balanced chemical equation that includes states and energy.
   
   endothermic-energy is a reactant, exothermic-energy is a product

100. The specific heat capacity of silver is 0.24 J/g°C. How many joules of energy are needed to warm 254 g of silver from 22.0°C to 43.8°C?

   \[ Q = mc \Delta T = (254 \text{ g})(0.24 \text{ J/g°C})(43.8 - 22.0) = 1329 \text{ J} \]
   
   What is the specific heat capacity of silver (C)? (0.24 J/g°C)
101. What is the specific heat of a substance if it took 955 J of energy to heat 128 g of the substance from 20.5°C to 33.4°C? 
\[ C = \frac{q}{m \Delta T} = \frac{955 \text{ J}}{128 \text{ g} \times (33.4°C - 20.5°C)} = \frac{9.574 \text{ J/g°C}}{C} \]

102. A 15.6-g sample of ethanol absorbs 868 J as it is heated. If the initial temperature of the ethanol was 21.5°C, what is the final temperature of the ethanol? (C$_{\text{ethanol}}$ = 2.44 J/g°C)
\[ q = mc \Delta T \]
\[ 868 \text{ J} = (15.6 \text{ g})(2.44 \text{ J/g°C})(\Delta T) \]
\[ \Delta T = \frac{868 \text{ J}}{(15.6 \text{ g})(2.44 \text{ J/g°C})} = 22.8°C \]
\[ T_f = 22.8°C + 21.5°C = 44.3°C \]

103. How much energy must be removed to cool a 63.7-g sample of water at 70.2°C to ice at -27.8°C?
\[ q = mc \Delta T = (63.7 \text{ g})(4.184 \text{ J/g°C})(18°C) = \frac{-809 \text{ J}}{27.8°C} \]

104. What is the amount of energy needed to melt 142 mol of water?
\[ q = (2.01 \text{ kJ/mol}) \times (142 \text{ mol}) = 278 \text{ kJ} \]

105. What is the amount of energy needed to boil 48.2 g of water?
\[ q = (48.2 \text{ g})(2.68 \text{ kJ/g}) = 109 \text{ kJ} \]

106. Use reactions a, b, and c to determine the ΔH for the following reaction:
\[ \text{C}_2\text{H}_6(g) + 2\text{H}_2\text{(g)} \rightarrow \text{CH}_3\text{OH}(l) \]
106. Use reactions a, b, and c to determine the $\Delta H$ for the following reaction:

\[
\text{CO}_2(g) + 2\text{H}_2(g) \rightarrow \text{CH}_3\text{OH}(l)
\]

a. $2\text{CO}_2(g) + \text{O}_2(g) \rightarrow 2\text{CO}_2(g)$

$\Delta H = -566 \text{ kJ}$

$\frac{2}{2} = -283 \text{ kJ}$

b. $2\text{H}_2(g) + \text{O}_2(g) \rightarrow 2\text{H}_2\text{O}_2(l)$

$\Delta H = -572 \text{ kJ}$

c. $2\text{CH}_3\text{OH}(l) + 3\text{O}_2(g) \rightarrow 2\text{CO}_2(g) + 4\text{H}_2\text{O}_2(l)$

$\Delta H = -1452 \text{ kJ}$

$\frac{\Delta H}{2} = -726 \text{ kJ}$

$\Delta H = -129 \text{ kJ}$

107. Use standard enthalpies of formation to calculate the $\Delta H_{\text{rxn}}$ for the reaction:

\[
2\text{C}_2\text{H}_5\text{OH}(l) + 7\text{O}_2(g) \rightarrow 4\text{CO}_2(g) + 8\text{H}_2\text{O}_2(l)
\]

$\Delta H_{\text{rxn}} = \sum \Delta H_{\text{prod}} - \sum \Delta H_{\text{react}}$

$\Delta H_{\text{rxn}} = -2855 \text{ kJ}$

108. A 16.6 g sample of ethanol absorbs 868 J as it is heated. If the initial temperature of the ethanol was 21.5°C, what is the final temperature of the ethanol? ($C_{\text{ethanol}} = 2.44 \text{ J/g°C}$)

$Q = m \cdot c \cdot \Delta T$

$Q = 16.6 \cdot 2.44 \cdot (T_f - 21.5) = 868 \text{ J}$

$T_f = 44.3°C$

109. Calculate the $\Delta G_{\text{system}}$ and state if the reaction is spontaneous:

$\Delta H_{\text{system}} = 147 \text{ kJ}$, $T = 422 \text{ K}$, $\Delta S_{\text{system}} = -67 \text{ J/K}$

$\Delta G = \Delta H - T \Delta S$

$\Delta G = 147 - (422 \cdot 0.067) = 175 \text{ kJ}$

$\Delta G = + \text{ non-spontaneous}$
110. Use the following data to calculate the specific heat of the water. 
The specific heat capacity of water is 4.184 J/g°C.

<table>
<thead>
<tr>
<th>Mass Data</th>
<th>Metal Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metal Cube</td>
<td>242.2 g</td>
</tr>
<tr>
<td>Styrofoam Cups</td>
<td>3.34 g</td>
</tr>
<tr>
<td>Cups + Water</td>
<td>114.74 g</td>
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<tr>
<td>Water</td>
<td>114 g</td>
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<table>
<thead>
<tr>
<th>Temperature Data</th>
<th></th>
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</thead>
<tbody>
<tr>
<td>Boiling Water</td>
<td>99.5°C</td>
</tr>
<tr>
<td>Water in Cups</td>
<td>22.4°C</td>
</tr>
<tr>
<td>Water + Metal</td>
<td>87.2°C</td>
</tr>
</tbody>
</table>

\[ \Delta T = 87.2° - 22.4° = 4.8 \]

A. What is the heat absorbed by the water? 
\[ q = m c \Delta T = (111.4 \times 4.184 \times 4.8) = 2237 \text{ J} \]

B. What is the specific heat of the metal?

\[ q = m c \Delta T \Rightarrow 2237 = (242.2 \times c) \times (99.8 - 87.2) \]

\[ c = 0.127 \text{ J/g°C} \]

**Unit 16**

- **Reaction Rates**

111. What are the 2 main parts of collision theory? 
- Proper orientation, sufficient energy

112. What is the activated complex and activation energy?
- Minimum energy in order to react.

113. What factors affect the reaction rate and how do they affect the rate?
- Temperature (↑ rate), concentration (↑ rate), particle size (↓ rate)

114. How does a catalyst speed up the reaction rate?
- Reduces activation energy.

115. What is a reaction mechanism?
- Sequence of elementary steps making up a complex reaction.

116. How do you identify the rate determining step in a reaction mechanism?
- Slow step

117. How do you identify an intermediate in a reaction mechanism?
- Produced in one step and consumed in another step

118. How do you identify a catalyst in a reaction mechanism?
- Reactant in step 1 and a product in a later step.
119. Fill in the blanks on the reaction energy diagram with the appropriate letters.
   A. reactants
   B. products
   C. enthalpy change
   D. activation energy
   E. activated complex

120. Is this reaction endothermic or exothermic? **exothermic**

---

121. Use the following data to answer the questions.

<table>
<thead>
<tr>
<th>Trial</th>
<th>Initial [NO] (\text{M})</th>
<th>Initial [H(_2)] (\text{M})</th>
<th>Initial Rate (\text{mol/(L-s)})</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>(4.0 \times 10^{-3})</td>
<td>(2.0 \times 10^{-3})</td>
<td>(1.2 \times 10^{-6})</td>
</tr>
<tr>
<td>2</td>
<td>(8.0 \times 10^{-3})</td>
<td>(2.0 \times 10^{-3})</td>
<td>(4.8 \times 10^{-6})</td>
</tr>
<tr>
<td>3</td>
<td>(4.0 \times 10^{-3})</td>
<td>(4.0 \times 10^{-3})</td>
<td>(2.4 \times 10^{-6})</td>
</tr>
</tbody>
</table>

a. What is the rate law expression for this reaction?

b. What is the overall rate order for the reaction?

\[ k = \frac{[\text{NO}]^2 \cdot [\text{H}_2]}{\text{M}^2} \]

\[ \frac{2 + 1}{3} = \frac{3}{3} \]

(c) Calculate the specific rate constant.

\[ k = \frac{1.2 \times 10^{-5} \cdot [4.0 \times 10^{-3}]^2 \cdot [2.0 \times 10^{-3}]}{3} \]

\[ k = \frac{380}{5} \frac{\text{M}^{-2}}{\text{s}} \]

(d) When the concentration of [NO] is \(0.045\) M and [H\(_2\)] = \(0.025\) M, what is the instantaneous rate?

\[ \text{rate} = k \cdot [\text{NO}]^2 \cdot [\text{H}_2] = (380) \cdot [0.045]^2 \cdot [0.025] = \frac{2.0}{5} \frac{\text{M}}{\text{s}} \]

---

**Unit 17**

**Chemical Equilibrium**
Unit 17: Chemical Equilibrium

122. What is Le Chatelier’s principle? 

123. How do concentration changes, pressure and volume changes, and changes in temperature affect equilibrium? How do they affect the concentrations of reactants and products?

124. \(2 \text{H}_2(\text{g}) + \text{O}_2(\text{g}) + \text{energy} \leftrightarrow 2 \text{H}_2\text{O}(\text{g})\)

For the above reaction tell how the amount of \(\text{O}_2(\text{g})\) present at equilibrium would be affected by each of the following:

<table>
<thead>
<tr>
<th>Shift</th>
<th>([\text{O}_2])</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Some (\text{H}_2) is added. (\rightarrow)</td>
<td>(\uparrow) decrease</td>
</tr>
<tr>
<td>b) Temperature is raised. (\rightarrow)</td>
<td>(\downarrow) decrease</td>
</tr>
<tr>
<td>c) The volume is decreased. (\leftarrow)</td>
<td>(\downarrow) decrease</td>
</tr>
<tr>
<td>d) The pressure decreased. (\leftarrow)</td>
<td>(\uparrow) increase</td>
</tr>
<tr>
<td>e) A catalyst is added.</td>
<td>no change</td>
</tr>
<tr>
<td>f) Some (\text{H}_2\text{O}) is removed. (\rightarrow)</td>
<td>(\downarrow) decrease</td>
</tr>
</tbody>
</table>

125. How does a catalyst affect equilibrium? no effect.

---

Unit 18: Acids and Bases

126. Calculate the \(K_{eq}\) for the following reaction if the \([\text{NH}_3]\) = 0.933 M, \([\text{N}_2]\) = 0.533 M, \([\text{H}_2]\) = 1.600 M. \(\text{N}_2\text{O}_5 + 3\text{H}_2(\text{g}) \rightleftharpoons 2\text{NH}_3\text{O}(\text{g})\)

\[
K_{eq} = \frac{[\text{NH}_3]^2}{[\text{N}_2\text{O}_5][\text{H}_2]^3} = \frac{(0.933)^2}{(0.533)(1.600)^3} = 0.399
\]

127. At 1405 K, the decomposition of hydrogen sulfide has a \(K_{eq}\) of \(2.27 \times 10^{-5}\). What is the \([\text{H}_2]\) if \([\text{S}_2]\) = 0.0640 M and the \([\text{H}_2\text{S}]\) = 0.184 M. \(2\text{H}_2\text{S}(\text{g}) \rightleftharpoons 2\text{H}_2(\text{g}) + \text{S}_2(\text{g})\)

\[
K_{eq} = \frac{[\text{H}_2]^2}{[\text{H}_2\text{S}]^2} = \frac{(x)^2}{(0.0640)^2} = 2.27 \times 10^{-5}
\]

\[
x = 0.038 \text{ M}
\]

128. What is the solubility and \([\text{Cl}^-]\) concentration at equilibrium for \(\text{PbCl}_2\)? \(\text{PbCl}_2(\text{s}) \rightleftharpoons \text{Pb}^{2+}(\text{aq}) + 2\text{Cl}^-\)

\[
K_{sp} = (x)(x)(2x) = 4x^3 = 1.7 \times 10^{-5}
\]

\[
x = 0.0162 \text{ M}
\]

\[
[\text{Cl}^-] = 2x = 0.0162 \times 2 = 0.0324 \text{ M}
\]

May 21-3:32 PM
Unit 18

Acids and Bases

What are common properties that distinguish acids from bases?

What is an Arrhenius acid and base?

What is a Bronsted-Lowery acid and base?

What is the difference between a strong and weak acid/base?

How is the hydronium (hydrogen) ion and the hydroxide ion concentration related to the acidity of a solution and its pH?

What is the pH if the [H+] = 2.5 x 10^-4?

What is the [OH^-] if the pH = 9.2?

What is the pH if the pOH = 12.3?

What is the [OH^-] if the [H+] = 4.5 x 10^-9?

What is the molarity of HNO₃ if 43.33 mL of 0.1000 M KOH solution is needed to neutralize 20.00 mL of the HNO₃?

\[ M_a V_a = M_b V_b \]

\[ (M_a)(20.00) = (43.33)(0.1000) \]

\[ M_a = 0.2167 M \]

Top 3 Life Lessons from Mrs. Lenz

3) Do what you love

2) Share. Save. Spend.

1) Live with integrity