Please show all work for partial credit

1. I am going to mix the following pairs of solutions together. If no reaction occurs write N.R. If a reaction occurs, write the proper chemical formula for the precipitate.

   A. NaCl and Pb(NO₃)₂
      Reaction: 2 NaCl(aq) + Pb(NO₃)₂(aq) → 2NaNO₃(aq) + PbCl₂(s)

   B. Sodium hydroxide and Magnesium chloride
      Reaction: 2NaOH(aq) + MgCl₂(aq) → 2NaCl(aq) + Mg(OH)₂(s)

   C. Na₂S and AlCl₃
      Reaction: 3Na₂S(aq) + 2AlCl₃(aq) → 6NaCl(aq) + Al₂S₃(s)

   D. Potassium carbonate and Chromium(IV) nitrate
      Reaction: 2K₂CO₃(aq) + Cr(NO₃)₄(aq) → 4KNO₃(aq) + Cr(CO₃)₂(s)

   E. Potassium chloride and NaNO₃
      N.R.

2. (10 points) I have just spilled 2 liters of 12M HCl(aq) on the floor. If I want to neutralize this acid before it eats a hole in the floor, how many grams of NaHCO₃ should I mix into the spill to neutralize the acid? (NaHCO₃ is sodium bicarbonate, more commonly known as baking soda! It’s molar mass is 84.001g)

   The neutralization reaction is: HCl(aq) + NaHCO₃(s) → NaCl(aq) + CO₂(g) + H₂O(l)

   \[ M = \text{moles/liters; moles} = M \times \text{liters; moles HCl} = 12(2) = 24 \text{ moles} \]

   In above reaction 1 mole of HCl reacts with 1 mole of NaHCO₃ so

   \[ 24 \text{ moles HCl} \times \left(1 \text{ mole NaHCO}_3/1 \text{ mole HCl}\right) = 24 \text{ moles NaHCO}_3 \]

   \[ 24 \text{ moles NaHCO}_3 \times (84.001g/mole) = 2016 \text{ g or 2.02 kg} \]

   And, no, I wouldn’t calculate this out. I would just start sprinkling the NaHCO₃ on the spill until it stopped fizzing.
3. (10 points) Calculate the oxidation number for C in each of the following compounds:

- **CH₄ (Methane)**
  
  \[ 0 = 1(C) + 4(H) \]
  
  \[ H = +1; \quad 0 = 1(C) + 4(1); \quad 0 - 4 = C \]
  
  \[ C = -4 \]

- **C₂H₄ (Ethene)**

  \[ 0 = 2(C) + 4(H) \]
  
  \[ H = +1; \quad 0 = 2(C) + 4(1); \quad 0 - 4 = 2(C) \]
  
  \[ C = -2 \]

- **C₆H₆ (Benzene)**

  \[ 0 = 6(C) + 6(H) \]
  
  \[ H = +1; \quad 0 = 6(C) + 6(1); \quad 0 - 6 = 6(C) \]
  
  \[ C = -1 \]

- **CH₂O (Formaldehyde)**

  \[ 0 = 1(C) + 2(H) + 1(O) \]
  
  \[ H = +1, O = -2; \quad 0 = 1(C) + 2(1) + 1(-2); \quad 0 = 0 \]
  
  \[ C = 0 \]

- **HCO₂H (Formic acid)**

  \[ 0 = 1(C) + 2(H) + 2(O) \]
  
  \[ H = +1, O = -2; \quad 0 = 1(C) + 2(1) + 2(-2); \quad 0 + 2 = C \]
  
  \[ C = +2 \]

4. (10 points) Balance the following oxidation-reduction reaction under acidic conditions.

\[ \text{Cu(s)} + \text{NO}_3^- (aq) \rightarrow \text{Cu}^{2+} (aq) + \text{NO(g)} \]

\[ \frac{1}{2} \text{ rxns:} \quad \text{Cu(s)} \rightarrow \text{Cu}^{2+} (aq) + 2e^- \]

\[ \text{NO}_3^- (aq) \rightarrow \text{NO(g)} + 2H_2O(l) \]

\[ 4H^+(aq) + \text{NO}_3^- (aq) \rightarrow \text{NO(g)} + 2H_2O(l) \]

\[ 3e^- + 4H^+(aq) + \text{NO}_3^- (aq) \rightarrow \text{NO(g)} + 2H_2O(l) \]

Combining

\[ \times 3 \quad \times 2 \]

\[ 3\text{Cu(s)} \rightarrow 3\text{Cu}^{2+} (aq) + 6e^- \quad 6e^- + 8H^+(aq) + 2\text{NO}_3^- (aq) \rightarrow 2\text{NO(g)} + 4H_2O(l) \]

\[ 3\text{Cu(s)} + 6e^- + 8H^+(aq) + 2\text{NO}_3^- (aq) \rightarrow 3\text{Cu}^{2+} (aq) + 6e^- + 2\text{NO(g)} + 4H_2O(l) \]

\[ 3\text{Cu(s)} + 8H^+(aq) + 2\text{NO}_3^- (aq) \rightarrow 3\text{Cu}^{2+} (aq) + 2\text{NO(g)} + 4H_2O(l) \]

5. (10 points) Balance the following oxidation-reduction reaction under basic conditions.

\[ \text{NO}_2^- (aq) + \text{Al(s)} \rightarrow \text{NH}_3(g) + \text{AlO}_2^- (aq) \]

\[ \frac{1}{2} \text{rxns:} \quad \text{NO}_2^- (aq) \rightarrow \text{NH}_3(aq) \]

\[ \text{Al(s)} \rightarrow \text{AlO}_2^- (aq) \]

\[ 7H^+(aq) + \text{NO}_2^- (aq) \rightarrow \text{NH}_3(aq) + 2H_2O(l) \]

\[ 2H_2O(l) + \text{Al(s)} \rightarrow \text{AlO}_2^- (aq) + 4H^+(aq) \]

\[ 6e^- + 7H^+(aq) + \text{NO}_2^- (aq) \rightarrow \text{NH}_3(aq) + 2H_2O(l) \]

\[ 2H_2O(l) + \text{Al(s)} \rightarrow \text{AlO}_2^- (aq) + 4H^+(aq) + 3e^- \]

Combining

\[ \times 1 \quad \times 2 \]

\[ 6e^- + 7H^+(aq) + \text{NO}_2^- (aq) \rightarrow \text{NH}_3(aq) + 2H_2O(l) \]

\[ 4H_2O(l) + 2\text{Al(s)} \rightarrow 2\text{AlO}_2^- (aq) + 8H^+(aq) + 6e^- \]

\[ 6e^- + 7H^+(aq) + \text{NO}_2^- (aq) + 4H_2O(l) + 2\text{Al(s)} \rightarrow \text{NH}_3(aq) + 2H_2O(l) + 2\text{AlO}_2^- (aq) + 8H^+(aq) + 6e^- \]

\[ \text{NO}_2^- (aq) + 2H_2O(l) + 2\text{Al(s)} \rightarrow \text{NH}_3(aq) + 2\text{AlO}_2^- (aq) + 1H^+(aq) \]

Adding 1 OH⁻ to both sides:

\[ \text{NO}_2^- (aq) + 2H_2O(l) + 2\text{Al(s)} + 1 \text{OH}^- (aq) \rightarrow \text{NH}_3(aq) + 2\text{AlO}_2^- (aq) + 1H^+(aq) + 1 \text{OH}^- (aq) \]

\[ \text{NO}_2^- (aq) + 2H_2O(l) + 2\text{Al(s)} + 1 \text{OH}^- (aq) \rightarrow \text{NH}_3(aq) + 2\text{AlO}_2^- (aq) + 1H^+(aq) + 1 \text{OH}^- (aq) \]

\[ \text{NO}_2^- (aq) + 1H_2O(l) + 2\text{Al(s)} + 1 \text{OH}^- (aq) \rightarrow \text{NH}_3(aq) + 2\text{AlO}_2^- (aq) \]
6. (10 points) Define or give equations for the following terms

Boyle’s Law
Pressure inversely related to volume: \( P = k/V \); or \( PV = k \) or \( P_1 V_1 = P_2 V_2 \)

Avogadro’s Law
Pressure or volume directly related to number of moles
\( P = nK' \) or \( V = nK' \) or \( P/n = K' \) or \( V/n = K' \) or \( P/n = P_2/n_2 \) or \( V/n = V_2/n_2 \)

Dalton’s Law of Partial Pressure
The pressure of a system is equal to the sum of the partial pressures of all of the gases in the system. Or \( P_{\text{tot}} = P_1 + P_2 + P_3 \ldots \)

An Ideal Gas
A gas that follows the equation \( PV = nRT \)

Effusion
The movement of a gas particle in a vacuum

7. (10 points) To fill balloons at Walmart a typical large gas cylinder will be filled with He gas at 2,550 lbs/in\(^2\). Express this pressure in atm.

\[ 2,550 \text{ psi} \times \frac{1 \text{ atm}}{14.7 \text{ psi}} = 173 \text{ atm} \]

8. (10 points) The helium cylinder in problem 7 has a volume of 1.7 cubic feet. How many 2L Balloons will this cylinder fill? (Assume you fill the balloons to a pressure of 1.1 atm) A conversion factor that you might need for this problem is that 1 cm\(^3\) = 1 ml.

To do this problem I used \( P_1 V_1 = nRT = P_2 V_2 \)

Where \( P_1 = 173 \text{ atm} \), \( V_1 = 1.7 \text{ft}^3 \), \( P_2 = 1.1 \text{ atm} \), and \( V_2 \) was the volume I was trying to find

Since the units of \( V \) have to match, I have to convert 1.7 ft\(^3\) to liters

\[ 1.7 \text{ ft}^3 \times (12 \text{ in/ft})^3 \times (2.54 \text{ cm/in})^3 \times (1\text{ml/cm}^3) \times (1\text{L}/1000\text{ml}) = 48.14\text{ liters} \]

Plugging in 173 atm(48.14 liters) = 1.1 atm(X liters) ; \( X = 173(48.14)/1.1 = 7571\text{liters} \)

But each balloon is 2 liters in volume so I have to divide this by 2 to get the number of balloons

\[ 7571/2 = 3,785 \text{ balloons} \] (I can’t have a fraction of a balloon)
9. (10 points) I am going to place 50 g of water in a 1 gallon plastic jug. I am then going to heat the jug to 100°C to turn the water into a gas. Assuming the jug doesn’t blow up right away, how much pressure builds up in the jug. Do you think it might explode? (Note: In finding the answer to this problem I want you to include the pressure due to the air inside the jug as well as the pressure from the water vapor. To simplify the problem assume that the initial volume of the water is negligible so it may be ignored. The initial temperature is 25°C and the initial pressure is 1 atm.)

\[
\text{Pressure from water is calculated using } PV=nRT; \ P = \frac{nRT}{V} \\
n=50g \times \frac{1\text{ mole}}{18g} = 2.78\text{ moles} \\
R = 0.0826 \frac{\text{l-atm}}{\text{K-mol}} \\
T=100+273 = 373K \\
V = 1 \text{ gal} \times (4 \text{ quarts/gal}) \times (1 \text{ liter/1.0567 quarts}) = 3.79\text{ liters} \\
P = 2.78(0.08206)373/3.79 = 22.4 \text{ atm}
\]

Pressure from air is calculated

\[
PV=nRT; \ P_1/T_1 = \frac{nR}{V} = \frac{P_2}{T_2} \\
1\text{ atm/298K} = X/373; \quad X=1(373)/298 = 1.25 \text{ atm}
\]

\[
P \text{ total} = 22.4 + 1.25 = 23.65 \text{ atm}
\]

It probably will blow, especially since the heat will also soften the plastic and make it weaker.

10. (10 points) Give two different reasons why a real gas would deviate from the ideal gas law. In each case predict whether the effect will increase or decrease the pressure of a given system calculated using the ideal gas law.

One reason a real gas deviates from the ideal gas law is that a real gas has a volume that is ignored in the ideal gas law. Since this volume must be subtracted from the volume the gas occupies, the net effect is to make the pressure of a real gas higher than expected. A second reason a real gas deviates from the ideal gas law is that in a real gas there can be intermolecular interactions between the gas molecules. These interactions are usually attractive, and the net effect here is to make the pressure lower than expected in the ideal gas law.