Questions:

1. Balance and predict the solubility of each product for the following two reactions:

   $2\ AgNO_{3(aq)} + Na_2CO_{3(aq)} \rightarrow 2\ NaNO_{3(aq)} + Ag_2CO_{3(s)}$

   $CdCl_{2(aq)} + (NH_4)_2S_{(aq)} \rightarrow CdS_{(s)} + 2\ NH_4Cl_{(aq)}$

2. Complete the following reactions, balance, and predict the states of the products:

   $AgNO_{3(aq)} + NaCl_{(aq)} \rightarrow AgCl_{(s)} + NaNO_{3(aq)}$
   $2\ AgNO_{3(aq)} + Na_2S_{(aq)} \rightarrow Ag_2S_{(s)} + 2\ NaNO_{3(aq)}$
   $BaCl_{2(aq)} + K_2SO_{4(aq)} \rightarrow BaSO_{4(s)} + 2KCl_{(aq)}$
   $2\ AgNO_{3(aq)} + Na_2CrO_{4(aq)} \rightarrow 2NaNO_{3(aq)} + Ag_2CrO_{4(s)}$

3. What mass of solid aluminum hydroxide can be produced when 50.0 mL of 0.200 M of aluminum nitrate is added to 200.0 mL of 0.100 M of potassium hydroxide?
   What is the concentration of aluminum ions left over in solution after the reaction is complete?
   $Al(NO_3)_3(aq) + 3\ KOH(aq) \rightarrow 3\ KNO_3(aq) + Al(OH)_3(s)$
   C= n/V, so
   0.200 M $Al(NO_3)_3$ x 0.0500L = 0.0100 mol $Al(NO_3)_3$, which will produce 0.0100 mol $Al(OH)_3$
   0.100 M KOH x 0.2000 L = 0.0200 mol KOH, which will produce (0.0200 mol/3 =) 0.00667 mol $Al(OH)_3$
   The limiting reactant is KOH.
   $$0.0200\ \text{mol KOH} \times \frac{1\ \text{mol}\ Al(OH)_3}{3\ \text{mol KOH}} \times \frac{78.003\ \text{g}\ Al(OH)_3}{1\ \text{mol}\ Al(OH)_3} = 0.520\ \text{g}\ Al(OH)_3$$
   The excess reagent is $Al(NO_3)_3$.
   0.0200 mol KOH requires (0.0200 mol KOH x 1 mol $Al(NO_3)_3$/3 mol KOH =) 0.00667 mol $Al(NO_3)_3$
   Excess moles = 0.0100 – 0.00667 = 0.00333 mol
   Excess concentration = n/V = 0.00333 mol / (0.050 L + 0.200 L) = 0.0133 M

4. If 10.0 mL of a 0.30 mol/L sodium phosphate solution reacts with 20.0 mL of a 0.20 mol/L lead(II) nitrate solution, what is the mass of the precipitate?
   $$3\ Pb(NO_3)_2\ (aq) + 2\ Na_3PO_4\ (aq) \rightarrow Pb_3(PO_4)_2\ (s) + 6\ NaNO_3\ (aq)$$
   NOTE: Your work does not need to match the format below; however, it does have to properly show your logic. Additionally, it should include properly labelled units throughout the problem.
   $$10.0\ mL\ Na_3PO_4\left(\frac{1\ L}{1000\ mL}\right)\left(\frac{0.30\ mol\ Na_3PO_4}{1\ L}\right) = 0.0030\ mol\ Na_3PO_4$$
   $$20.0\ mL\left(\frac{1\ L}{1000\ mL}\right)\left(\frac{0.20\ mol\ Pb(NO_3)_2}{1\ L}\right) = 0.0040\ mol\ Pb(NO_3)_2$$
   Determine limiting reagent.
   Assuming Na_3PO_4 is limiting:
   $$0.0030\ mol\ Na_3PO_4\left(\frac{1\ mol\ Pb_3(PO_4)_2}{2\ mol\ Na_3PO_4}\right) = 0.0015\ mol\ Pb_3(PO_4)_2$$

Assuming $Pb(NO_3)_2$ is limiting:

$$0.0040\ mol\ Pb(NO_3)_2 \left(\frac{1\ mol\ Pb_3(PO_4)_2}{3\ mol\ Pb(NO_3)_2}\right) = 0.0013333\ mol\ Pb_3(PO_4)_2\ (should\ be\ 2\ s.f.)$$

Lead(II) nitrate leads to less product and is the limiting reagent.

To determine mass of the precipitate:

$$0.0013333\ mol\ Pb_3(PO_4)_2 \left(\frac{811.5\ g\ Pb_3(PO_4)_2}{1\ mol\ Pb_3(PO_4)_2}\right) = 1.082026\ g\ Pb_3(PO_4)_2$$

$$\boldsymbol{1.1\ g\ Pb_3(PO_4)_2\ (with\ sig.figs.)}$$

Alternatively, you could use an IRF table to help determine more information at the same time.

	$2Na_3PO_4$	+	$3Pb(NO_3)_2$	→	$Pb_3(PO_4)_2$	+	$6NaNO_3$
Initial (mol)	0.0030		0.0040		0		0
Reaction (mol)	-2x		-3x		+x		+6x
Final (mol)	0.0030-2x		0.0040-3x		x		6x

To solve for reaction value, the limiting reagent must be completely consumed.

$$0.0040 - 3x = 0$$
$$x = 0.0013333$$

Therefore, the IRF table can be completed (values displayed to correct sig. figs.; however unrounded values will be used in future calculations):

	$2Na_3PO_4$	+	$3Pb(NO_3)_2$	→	$Pb_3(PO_4)_2$	+	$6NaNO_3$
I (mol)	0.0030		0.0040		0		0
R (mol)	-2x		-3x		+x		+6x
F (mol)	0.0004		0		0.0013		0.0080

To determine mass of the precipitate:

$$0.0013333\ mol\ Pb_3(PO_4)_2 \left(\frac{811.5\ g\ Pb_3(PO_4)_2}{1\ mol\ Pb_3(PO_4)_2}\right) = 1.082026\ g\ Pb_3(PO_4)_2$$

$$\boldsymbol{1.1\ g\ Pb_3(PO_4)_2\ (with\ sig.figs.)}$$

5. How many grams of precipitate are formed with 100 mL of 0.100M potassium sulfate and 100 mL of 0.200M barium nitrate? Note – it's a double displacement reaction.

   Write out the complete and net ionic equations after the calculations.

$$\mathrm{K_2SO_4(aq) + \ Ba(NO_3)_2(aq) \rightarrow 2KNO_3(aq) + BaSO_4(s)}$$

1) Moles of K_2SO_4:

$$\mathrm{100\ mL\ K_2SO_4 \times \frac{0.100\ mol}{1L} \times \frac{1\ L}{1000\ mL} = 0.0100\ mol\ K_2SO_4}$$

2) Moles of $BaSO_4$ from K_2SO_4:

$$\mathrm{0.0100\ mol\ K_2SO_4 \times \frac{1\ mol\ BaSO_4}{1\ mol\ K_2SO_4} = \boxed{0.0100\ mol\ BaSO_4}}$$

Limiting reactant

3) Moles of $Ba(NO_3)_2$:

$$100\ \mathrm{mL\ Ba(NO_3)_2} \times \frac{0.200\ \mathrm{mol}}{1\mathrm{L}} \times \frac{1\ \mathrm{L}}{1000\ \mathrm{mL}} = 0.0200\ \mathrm{mol\ Ba(NO_3)_2}$$

4) Moles of $BaSO_4$ from $Ba(NO_3)_2$:

$$0.0200\ \mathrm{mol\ Ba(NO_3)_2} \times \frac{1\ \mathrm{mol\ BaSO_4}}{1\ \mathrm{mol\ Ba(NO_3)_2}} = 0.0200\ \mathrm{mol\ BaSO_4}$$

5) Grams of $BaSO_4$ from limiting reactant (K_2SO_4):

$$0.0100\ \mathrm{mol\ BaSO_4} \times \frac{233.390\ \mathrm{g\ BaSO_4}}{\mathrm{mol\ BaSO_4}} = 2.3339\ \mathrm{g\ BaSO_4}$$

Therefore 2.33 g $BaSO_4$

Complete ionic:

$$K^{+}(aq) + {SO_4}^{2-}(aq) + Ba^{2+}(aq) + {NO_3}^{-}(aq) \rightarrow K^{+}(aq) + {NO_3}^{-}(aq) + BaSO_4(s)$$

Net ionic:

$$\mathrm{SO_4}^{2-}(\mathrm{aq}) + \mathrm{Ba}^{2+}(\mathrm{aq}) \rightarrow \mathrm{BaSO_4(s)}$$