1) Let $x =$ fractional abundance of Ga-69 and $y =$ fractional abundance of Ga-71. Then we know that:

$$68.92558x + 70.92470y = 69.723$$ (since the weighted average of the masses must equal the observed mass)

and

$$x + y = 1.00.$$ (Since the total abundance has to be 1.00 or 100%)

Solving this second equation for $x$, we get: $x = 1 - y$

Substituting into the first equation, we get:

$$68.92558(1 - y) + 70.92470y = 69.723$$

$$= 68.92558 - 68.92558y + 70.92470y$$

$$= 0.79742$$

$$y = 0.399$$

$$x = 0.601$$

2) This is a relatively easy problem. Case 1, in which the reactants are present in exactly the right amount to make products, with none left over, demonstrates clearly conservation of mass. Cases 2 and 3 also show this, as the masses of reactants (left-hand side) equals the masses of products (right-hand side.)

Case 2 also shows the law of constant proportions, as the amount of Cl$_2$ that went into the product NaCl, is the same as in Case 1 i.e. 60.66 g; as we started with 70.00g, we have 9.34 g left over.

Case 3 can be analyzed to demonstrate both laws, using simple ratios. In the factor-label method, we get:

$$\frac{50.00 \text{ g NaCl}}{60.66 \text{ g Cl}_2} \times \frac{100.00 \text{ g NaCl}}{60.66 \text{ g Cl}_2} = 82.43 \text{ g NaCl}$$

which is what we get (Constant Proportions). Conservation of mass follows as:

$$\frac{82.43 \text{ g NaCl}}{39.34 \text{ g Na}} \times \frac{39.34 \text{ g Na}}{100 \text{ g NaCl}} = 32.43 \text{ g Na}$$

which is what is used; therefore (50.00-32.43) = 17.57 g Na is what is left over, and is what we are given. (Conservation of Mass.)

3) Copper (II) sulfate pentahydrate has the formula CuSO$_4$$\bullet$5H$_2$O; the monohydrate has formula CuSO$_4$$\bullet$H$_2$O (needed later), and the anhydrous compound as the formula CuSO$_4$. For the second part, look at the following equation with the masses inserted:

$$\text{CuSO}_4$$\$\cdot$5H$_2$O $\rightarrow$ CuSO$_4$ + 5H$_2$O

$$\frac{3.548 \text{ g}}{2.268 \text{ g}} = 1.280 \text{ g}$$ (obtained by conservation of mass)
This last datum implies that each water is “worth” $1.280 \, g / 5 = 0.2560 \, g$ so if the CuSO$_4$ had not lost the last water molecule, the monohydrate CuSO$_4$$\cdot$H$_2$O would mass 2.524 g.

4) From the density and volume of Cl$_2$ gas used, we can get the mass of Cl$_2$ as: $0.5925 \, L / (2.948 \, g / L) = 1.747 \, g$. For the second question, recall the Law of Constant Proportions, and note that we are told we obtain a metal chloride with formula XCl i.e. a 1:1 compound. We know that 5.315 g of X combine with 1.747 g of Cl$_2$; using proportions, we get:

\[
\frac{5.315gX}{1.747gCl} = \frac{ZamuX}{35.453amuCl};
\]

solving for Z amu, we get: $188.4327 \, amu / 1.747 \, g = 107.86 \, amu \, X$, and X is Ag (silver).