Test #1

Materials:
- jar
- measuring cup
- water
- unflavored gelatin (in packets)

Methods:
1. Add ~ one-half cup of (warm or room-temperature) water to a jar.
2. Stir in one packet of unflavored gelatin.
3. Allow to stand undisturbed for +/- 15 minutes.
4. Observe.

Describe what (if anything) changed:
Gelatin is water-soluble. Soon after being mixed, gelatin + water forms a thick, viscous solution. However, the mixture solidifies on standing (actually forms a semi-solid “gel”.) The mixture solidifies because, when added to cold water, gelatin granules swell by absorbing 5-10 times their weight in water...as a dry sponge would.

Compatible? [Could you apply this mixture with a sprayer?]
No, because the mixture is not a liquid anymore—it's a gel that's too viscous to be pumped through a spraying system.

IF incompatible (No), physical or chemical?
Physical

Clue(s)?
Change in size/shape/state (liquid to solid)
Test #2

Materials:
- jar + lid
- measuring cup
- water
- vegetable oil (yellow/corn)
- liquid dish soap (Dawn)

Methods:

Step 1. Fill a jar 1/2 full of water. Add oil until a thin but visible layer sits on top of the water. Put on jar lid and shake. Observe.

Describe what (if anything) changed:
The two ingredients do not mix. One does not dissolve in the other; rather, layers form. The oil layer sits on top of the water layer.

Compatible? [Could you apply this mixture with a sprayer?]
No.
(Actually, you could move both materials through a spraying system, but the components would not be distributed uniformly. Maybe the question in parentheses should be “should”—not “could”—you apply this mixture with a sprayer?)

Step 2. Add several drops of liquid soap. Put the lid back on, and shake. Observe right away, and again after a minute or two.

Describe what (if anything) changed:
Layers disperse, at least up to a point. The oil and water form an emulsion-type suspension...with agitation...a more or less uniform dispersion of one
liquid in another liquid. This happens because the soap acts as a surfactant, “coating” and separating oil droplets. (Micelle formation)

Compatible? [Could you apply this mixture with a sprayer?]
Yes (with agitation).

IF incompatible (No), physical or chemical?
N/A (if of interest or for discussion, change is physical, not chemical)

Clue(s)?
Layers disperse, you can see “beads” of oil suspended in the water vs. layered on top.
Test #3

Materials:
- jar + lid
- water
- cornstarch
- iodine solution

Methods:

Step 1. Put about a cup of water in a jar. Add a few teaspoons of soluble starch (cornstarch). Shake or stir to mix. Observe.

Did you see any sign of a physical or chemical change? 
Yes, physical change (a solution formed; cornstarch will dissolve in water.)

Compatible? [Could you spray this solution or mixture?] 
Yes.

Clue(s)?
Cornstarch + water forms a uniform clear to white-colored solution. (If you use a lot of cornstarch—more that the amount of water used can “handle”—the mixture will be slightly opaque.) However, unless “overloaded”, the mixture is a solution, not a suspension...does not settle or layer.

Step 2. Add a few drops of Iodine (Betadine) solution. Shake or stir to mix. Observe again.

Describe what (if anything) changed:
Solution changes from clear or white to blue-purple.

Did you see any sign of a physical or chemical change?
Yes, chemical change (a new product formed, as indicated by a color change. When adding a vivid/dark orange-colored Betadine solution (iodine + water [and other water-soluble ingredients]) to a clear or white solution (cornstarch + water), you would expect a lighter orange mixture. Instead, a blue-purple solution forms. A color change is an indicator that a new product was formed, which is a sign of a chemical (vs. physical) change. (Note that both products formed by this chemical reaction are water-soluble...no precipitate or layers form.)

Compatible? [Should you spray this solution or mixture?]
No. Although you could move the purple-blue solution through a spraying system, you shouldn't...because you don't know what you're applying. The original components have undergone a chemical change and formed one or several new products...and since you don't know what they are, you have no clue if/how they will act on the target or in the environment.

IF incompatible (No), physical or chemical?
Chemical change.

Clue(s)?
A color change is an indicator that a new product was formed, which is a sign of a chemical change.
Test #4

Materials:
- jar + lid
- measuring cup
- tablespoon
- water
- baking powder / baking soda
- vinegar

Methods:

Step 1. Put about 1 cup of water in a jar. Add a tablespoon of baking powder (or baking soda). Shake or stir to mix. Observe.

Compatible? [Could you apply this mixture with a sprayer?]
Yes, physical change.
(A solution formed; cornstarch will dissolve in water.)

IF incompatible (No), physical or chemical?
N/A
(Physical change = solution composed of baking powder or soda + water.)

Clue(s)?
Baking powder (or soda) + water forms a uniform clear solution. These mixtures are solutions, not suspensions...they do not settle or form layers.

Step 2. Add 1/4 cup of vinegar. Observe again.

Describe what (if anything) changed:
“Fizzing” = gas production.
Did you see any sign of a physical or chemical change?
Yes, a new product (colorless, odorless gas) was produced, and a white precipitate forms and settles out. You may also notice that the container is slightly warmer than before the vinegar was added and the reaction started. Both heat production and formation of one or more new products are indications of a chemical change.

Compatible? [Should you apply this mixture with a sprayer?]  
No. The production of a new product (gas) and white precipitate are indicators of new product formation as a result of a chemical change. (Heat production is a chemical change clue, too.) One component has “gotten away” (the gas) and the other has settled out. Of what remains in the container with the water (a suspension which settles to the bottom)—even if you use agitation, you don’t know what you have left...nor do you know if/how this substance will act on the target or in the environment.

IF incompatible (No), physical or chemical?
Chemical change.

Clue(s)?
Formation of new substances with different properties than those of the materials you started with.
Test #5

Materials:
- clear (glass) jar
- tablespoon
- water
- teabag
- whole milk or cream
- lemon juice

Methods:

Step 1. Make a strong cup of tea in the jar. Add ~ 1 TBSP of whole milk or cream. Stir to mix. Observe.

Compatible? [Could you apply this mixture with a sprayer?]
Yes. Tea + water is a true solution; the added dairy product forms a stable emulsion in the tea-water mixture, which does not settle. The suspended particles are not large enough to "clog up" a spraying system.

IF incompatible (No), physical or chemical?
NA.

Clue(s)?
Homogeneous/uniform and stable mixture…no layers or separation.

Step 2. Add a few drops of lemon juice. [Note: lemon juice is a weak acid.] Stir to mix. Wait and watch for +/- five minutes.

Describe what (if anything) changed:
Floculation. (Large particles form and aggregate into "clumps". Eventually, they will settle on the bottom of the container.)
Compatible? [Could you apply this mixture with a sprayer?]
No. The “clumps” would plug/clog the system.

IF incompatible (No), physical or chemical?
Chemical change, as indicated by the formation of a new product.

Clue(s)?
Formation of a new product (white “clumps”.)
Test #6

Materials:
three jars (labeled 1-2-3)
measuring cup
tablespoon
distilled water
washing soda (*Sodium Carbonate*)
Epsom salts (*Magnesium Sulfate*)

Methods:

Step 1. Add ~ 1 cup of distilled water to jars #1 and #2. Add 1 TBSP of washing soda to jar #1. Add 1 TBSP of Epsom salts to jar #2. Stir or shake to mix. Observe each solution / jar. Are they cloudy (suspensions) or clear (true solutions)?

Both mixtures are clear = true solutions of water + sodium carbonate and water + magnesium sulfate.

Compatible? [Could you apply these mixtures with a sprayer?]
Yes.

IF incompatible (No), physical or chemical?
N/A.

Clue(s)?
Clear and uniform mixtures; true solutions.

Step 2. Next, pour/decant about half of each solution into the third jar. Again, observe.

Describe what (if anything) changed:
Mixture turns cloudy, initially, due to particle formation / appearance of a new white-colored substance; the white substance precipitates (settles to the bottom) and the remaining liquid becomes clear.

Compatible? [Could you apply this mixture with a sprayer?] No. Even with agitation, the precipitate particles would most likely clog the system. And, even if you tried to apply the supernatant liquid, you should not...because you don't know what you’re applying. The original components have undergone a chemical change and formed one or several new products...and since you don't know what they are, you have no clue if/how they will act on the target or in the environment.

IF incompatible (No), physical or chemical? Chemical.

Clue(s)? Formation of a visible new product = magnesium carbonate, which forms a precipitate and settles out because it is not water-soluble. (Sodium sulfate is water-soluble. So, while it too is a newly formed reaction product, you don’t see it.)

The formula for this replacement chemical reaction is:
sodium carbonate + magnesium sulfate ⟷ sodium sulfate + magnesium carbonate
Test #6: NOTES:

- Exact proportions are not critical...but if you use too much of either ingredient to start, all of the washing soda and Epsom salts will not dissolve, which may make the mixtures appear to be incompatible when, in fact, they are not. If the solutions are too weak, the change/precipitate will not be easy to see.
- Washing soda may form a precipitate in “hard” water...so use distilled water or test yours in advance to be sure it is “soft”.
- Washing soda is caustic. Wipe up any spills immediately. Do not get into eyes or mouth. Be certain you have clean water available in case of an accident.

Reaction:
(sodium carbonate + magnesium sulfate → sodium sulfate + magnesium carbonate ↓)
“Layman’s” Definitions of Key Terms:

**Emulsion:** one liquid dispersed (as droplets) in another. Each retains its identity/properties, and agitation is usually necessary to prevent separation.

**Mixture:** two or more substances that are not chemically bound to one another. Mixtures may be separated by physical (not chemical) processes. Mixtures may be uniform and homogeneous (ex. a dilute solution of salt-water) OR non-uniform and heterogeneous (like a piece of granite rock, a bag of M&Ms, or oil and vinegar salad dressing).

**Solution:** a homogenous (uniform) mixture of two or more substances; no settling; clear/transparent.

**Solvent:** a liquid that will dissolve a substance and form a true solution. Common solvents include water, kerosene, acetone, refined oil, and alcohol.

**Suspension:** a non-uniform (noncolloidal) dispersion of relatively coarse particles in a solvent; usually, suspension mixtures will settle without agitation or some other treatment; cloudy.

An emulsion is a type of suspension; it is a mixture of two or more liquids that are not soluble in one another. One is suspended as small droplets in the other (like the fat in homogenized whole milk.)