This Demonstration shows a ternary phase diagram, including a phase envelope. This diagram is used to represent the phase behavior of mixtures of three components that are only partially miscible over a range of compositions so that phase separation occurs. In the *view diagram* option, the black point, which can be moved to any location within the triangle by clicking on that location, represents the overall composition of the mixture. Each corner of the triangle corresponds to a pure component. The mass fraction of a component in the mixture is read off the axis that is the same color as that component. These axes are labeled by drawing a line through the point; this line is parallel to the base of the triangle that is opposite the corner corresponding to that pure component.

When the black point is in the two-phase region, a tie line (large-dash black line) is shown, and the endpoints of the tie line correspond to the compositions of the two phases (α, β) that are in equilibrium. These compositions are shown when *show α phase* and *show β phase* are selected. Gray tie lines are shown when *show tie lines* is selected, and grid lines are shown when *show grid lines* is selected. The points along the left of the phase envelope boundary belong to the α phase, and the points along the right belong to the β phase. In the *view phases* option, the one- and two-phase regions are labeled. Ternary phase diagrams could also be drawn in terms of mole fractions instead of mass fractions.

This Demonstration models a Carnot cycle as either a heat engine or a heat pump. The temperature differences between the reservoirs and the Carnot cycle are changed with sliders. The entropy changes for the reservoirs (Δ Sh and Δ Sc) and the overall entropy change Δ Stotal are calculated. When the temperature differences between the reservoirs and the engine/pump are zero, the total entropy change is zero and the process is reversible. The entropy change of the engine/pump, which is at steady state, is zero. All energies and entropy changes are per unit time, since these are continuous processes, but the time scale is arbitrary. The cycle efficiency η is calculated for the heat engine, and the coefficient of performance (COP) is calculated for the heat pump. As the temperature differences between the reservoirs and the engine/pump increase, the efficiency/coefficient of performance decreases. For the heat engine, QH is held constant at 1250 J, and for the heat pump, QC is held constant at 600 J.

For the heat engine, the reservoir temperatures are held constant at 275 K and 500 K. For the heat pump, the reservoir temperatures are held constant at 275 K and 325 K.

A piston compresses a vapor-liquid equilibrium mixture of water adiabatically and reversibly. The initial temperature is 425 K, and the initial pressure is 0.5 MPa. Use the sliders to set the *initial vapor quality* (fraction of water that is vapor) and the final pressure. The initial state (green dot) and final state (blue dot) are shown on log pressure versus log volume (*P-V*), log pressure versus temperature (*P-T*), and temperature versus entropy (*T-S*) plots. Select two plots to display from the drop-down menus. The initial vapor quality determines whether the quality increases or decreases as the mixture is compressed.

Compressed-gas dusters spray a gas such as difluoroethane (DFE) to remove dust from electronics. When gas exits the valve, liquid DFE in the container vaporizes to maintain vapor-liquid equilibrium. The energy to vaporize the liquid is obtained by cooling the remaining liquid; the container is modeled as adiabatic in this Demonstration. Decreasing the liquid temperature decreases its saturation pressure, which lowers the driving force, and thus the gas flow rate decreases. For smaller *initial volume fractions of liquid* (change with the slider), the liquid cools faster.

Select a plot (*volume, moles, temperature,* or *pressure*) using the buttons to display how that property changes with time. Animate the duster by clicking the play button next to *spray gas.* Spray continues until the temperature reaches -5oC (if *stop at –5oC* selected); otherwise the spray stops at the time selected by the *time* *sprayed* slider when *adjust stopping time* is selected. In either case, the black dot(s) show the conditions of the duster on the plot. The liquid and vapor DFE are assumed to be in equilibrium at all times, As the spray time increases, the adiabatic approximation becomes less accurate.

This Demonstration shows animations and calculates work for reversible and irreversible expansions and compressions (adiabatic or isothermal) of an ideal diatomic gas in a piston-cylinder system. Select either *compression* or *expansion* using the buttons, and compare two processes side-by-side using drop-down menus. Change the *final pressure* with the slider; the pressure ranges are different for compression and expansion. For adiabatic processes, the final temperature is calculated. Press the *play* button to start compression or expansion. For reversible processes, more weights (blue rectangles) are added to the piston for compression or removed for expansion. For irreversible processes, the external pressure (Pext) is constant at the final value, so the number of weights is fixed, and initially stops (red triangles) prevent the piston from moving until the *play* button is pressed. Animations of reversible processes represent slow processes; irreversible processes are much faster and the piston overshoots the final volume, but these behaviors are not shown in the animations.

A temperature-composition diagram is shown for two liquids (A, B) that are only partially miscible within the region enclosed by the orange/purple (**note that these are suggested colors and currently the curve is black but we want to change it)** curve. Each phase in the two-phase region contains both A and B; the α phase (represented by the purple line, mole fraction = xA) is enriched in A and the β phase (orange line, xA) is enriched in B. Outside the phase envelope, A and B are completely miscible. Sliders for *temperature* and *overall mole fraction of A* ***(Note that need to change slider label)***move the black dot around the diagram. The sizes of the rectangles at the top for pure A and pure B are proportional to the overall mole fraction of that component. The size(s) of the container(s) on the right is/are proportional to the amounts of the phase(s) (either α and β or a single miscible phase) in equilibrium. and the mole fractions are represented by the relative numbers of green (A) and (B) blue circles.

The fugacity f and the fugacity coefficient ϕ are calculated for water by using the Peng–Robinson equation of state. *Pressure* and *volume* are changed with sliders, and the corresponding state is indicated by the black point on the log pressure versus log volume diagram. The fugacity coefficient indicates how much the fluid deviates from ideal-gas behavior (ϕ = 1 for an ideal gas). Selecting *isotherms* displays isotherms on the P-V diagram, and the horizontal solid green line (**Note that current there is no line currently**) represents liquid and vapor in equilibrium. The areas under the curve, which are colored light blue (**on my computer the areas are green- we should change to blue**), are equal when viewed on a linear scale.

This Demonstration illustrates what happens to a binary mixture initially in vapor-liquid equilibrium when a pure component is added at constant temperature and pressure. If both phases remain after the addition, it illustrates how the phase mole fractions (xA is the mole fraction of A in the liquid, yA is the mole fraction of A in the vapor) remain constant. If enough of either pure component is added, the mixture is transformed to a single phase. The initial vapor-liquid mixture contains 4 mol of A and 6 mol of B at a pressure of 130 kPa. Select *add A* or *add* *B* and use the slider to select the amount added. Adding a pure component changes the overall mole fraction of A in the mixture, as represented by the black point in the P-x-y diagram. If the overall mole fraction of A stays within the phase envelope, then xA and yA do not change. Selecting the *mole balance* button shows how this is possible. The size of a rectangle is proportional to the amount of that phase (blue is liquid, green is vapor). For example, adding A increases the vapor-to-liquid ratio, so some of the initial liquid vaporizes, and this amount is determined by a mass balance. For ease of visualization, A is shown being added as a vapor and B as a liquid, but the final equilibrium is the same if A is added as a liquid and B as a vapor because the system is isothermal. For example, if pure A were added as a liquid, it would vaporize to satisfy the mass balances.

Pressure-enthalpy (P-H) and temperature-entropy (T-S) diagrams for refrigerant R-134a are used to demonstrate the ordinary vapor compression (OVC) cycle. You can vary the condenser pressure (high pressure) and the evaporator pressure (low pressure). The coefficient of performance (COP), which is the heat transferred to the evaporator QC divided by the compressor work W, is calculated. Selecting *cycle* from the drop-down menu shows the components of the cycle, and moving the mouse over the circled numbers displays the phases present at those points.

The van der Waals equation of state for water is used to generate isotherms on a pressure-log volume (P-V) diagram and isobars on a temperature-log volume (T-V) diagram. Sliders change the isotherm temperature on the P-Vdiagram and the isobar pressure on the T-V diagram. Liquid and vapor are in equilibrium within the phase envelope, which was generated from data for water. The isotherms and isobars have three solutions in the two-phase region, but the only physically-meaningful conditions are the orange dots, which correspond to saturated liquid and saturated vapor. The saturated liquid volume (VL) and the saturated vapor volume (VV) are displayed. The horizontal, dashed orange line (at Psat and Tsat) represents a mixture of liquid and gas. On the P-Vdiagram, the green area above the orange line is equal to the area below the orange line when plotted on a linear volume scale.

This log pressure versus log volume phase diagram illustrates phase behavior of a single-component (water) and the concept of state functions. Use sliders to move the black dot at constant pressure or constant volume, or check the *drag point* box and drag the dot around the diagram. The piston-cylinder, which represents the volumes of liquid and vapor present, can be viewed on log or linear scale by selecting the appropriate button for *volume representation*. When two phases are present and the linear scale is selected, a pop-out shows a magnified view of the liquid and vapor volumes. Liquid in the cylinder is blue and vapor is green, and the intensities of these colors increase as their densities increase.