CHEMISTRY 311 PHYSICAL CHEMISTRY
Homework Assignment # 9

1. The following cooling curve data are given for the Antimony-Cadmium system:

Cd (wt %)	0	20	37.5	47.5	50	58	70	93	100
Inflection in cooling curve, °C	-	550	461	-	419	-	400	-	-
Plateau in cooling curve, °C	630	410	410	410	410	439	295	295	321

Construct the phase diagram assuming that no breaks other than these occur in any cooling curve. Label the diagram completely, i.e., in each region, specify the phases present and in the case of solid phases, identify the solid. Find the formula of any compound(s) formed.

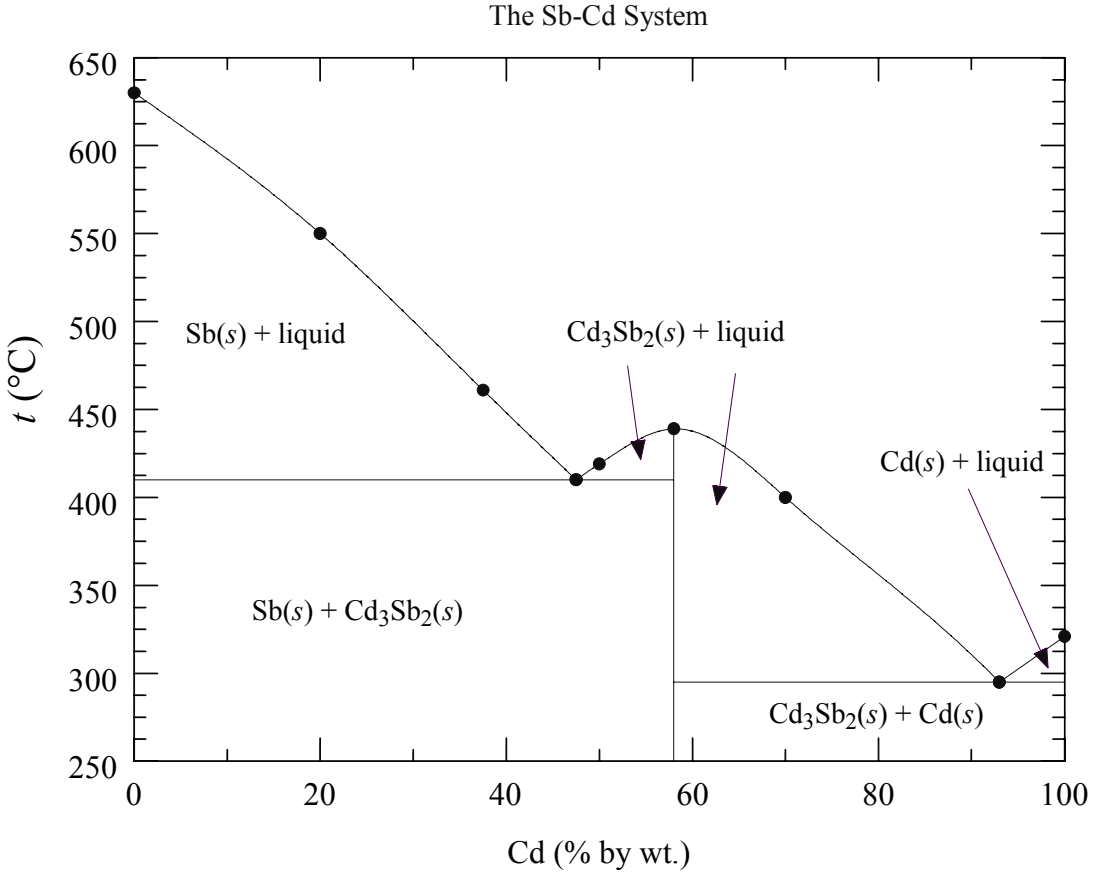
Answer

The phase diagram is shown in the figure below. The compound formed corresponds to 58 wt% of Cd. We find the formula for this compound as follows:

100.00 g of compound contains 58.00 g of Cd and 42.00 g of Sb. Therefore, we calculate the mole ratio of Cd:Sb as

$$\frac{58.00 \text{ g Cd}}{112.411 \text{ g mol}^{-1}} : \frac{42.00 \text{ g Sb}}{121.757 \text{ g mol}^{-1}} \text{ or } 0.51596 \text{ mol Cd} : 0.34495 \text{ mol Sb.}$$

Dividing by the smallest number, we get the Cd : Sb ratio as 1.5 : 1.0. Therefore, the formula of the compound is Cd_3Sb_2.



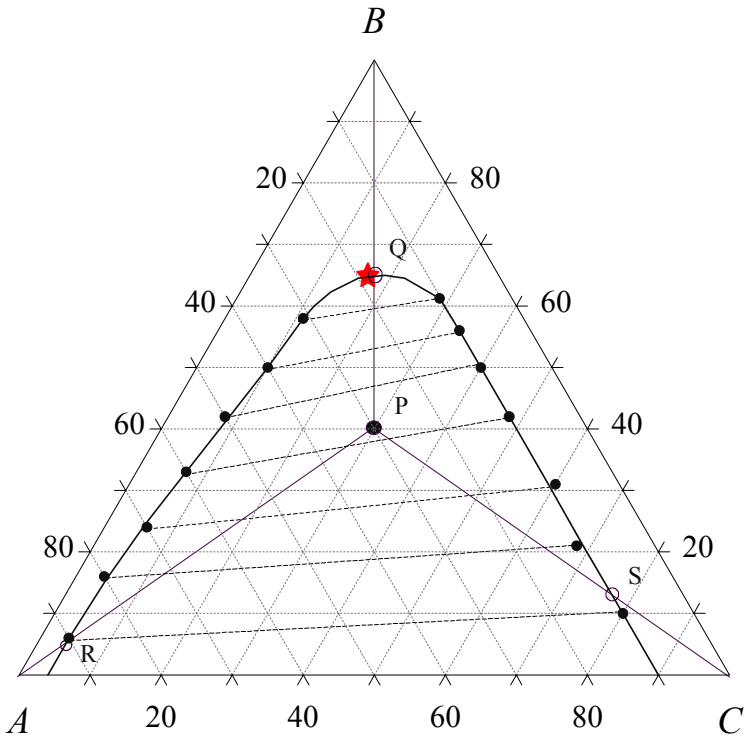
2. The following data are for a three-component system made up of three partially miscible liquids A, B, and C. The equilibrium compositions of the two layers formed when B is added to a solution of moderate amounts of C in A and to a solution of moderate amounts of A in C are given below.

Layer rich in A		Layer rich in C	
x_A	x_B	x_B	x_C
0.900	0.060	0.100	0.800
0.800	0.160	0.210	0.6800
0.700	0.240	0.310	0.600
0.600	0.330	0.420	0.480
0.500	0.420	0.500	0.400
0.400	0.500	0.560	0.340
0.310	0.580	0.600	0.280

(a) Construct the phase diagram showing the tie-lines connecting the equilibrium compositions
(b) Identify the critical point composition
(c) A solution is prepared such that the mole fractions of A, B, and C are, respectively, 0.30, 0.40, 0.30. How many phases will be present when the solution is allowed to equilibrate?
(d) If we wish to generate a system containing a single phase by adding various amounts of A, B, or C to the solution on part (c), identify the compositions at which the single phase would result by the addition of (i) A, (ii) B, and (iii) C.

Answer

(a) The phase diagram with tie lines is shown below.



(b) The point marked by the star in the figure is the approximate location of the critical point. The composition at this point is $(x_A, x_B, x_C) = (0.18, 0.65, 0.17)$.

(c) The point P on the graph represents the composition of the solution. Since this falls in the two-phase region, two layers will form.

(d) The total composition of the system will move along the lines PQ, PR, and PS, respectively, when B, A, and C are added. When the compositions corresponding to the points Q, R and S are reached, a single phase will result. Therefore,

1. The point R: $(x_A, x_B, x_C) = (0.90, 0.05, 0.05)$.
2. The point Q: $(x_A, x_B, x_C) = (0.17, 0.65, 0.18)$.
3. The point S: $(x_A, x_B, x_C) = (0.10, 0.12, 0.78)$.