Session #34: Homework Solutions

Problem #1

For the binary system Cu-Ni the following data are available from cooling experiments:

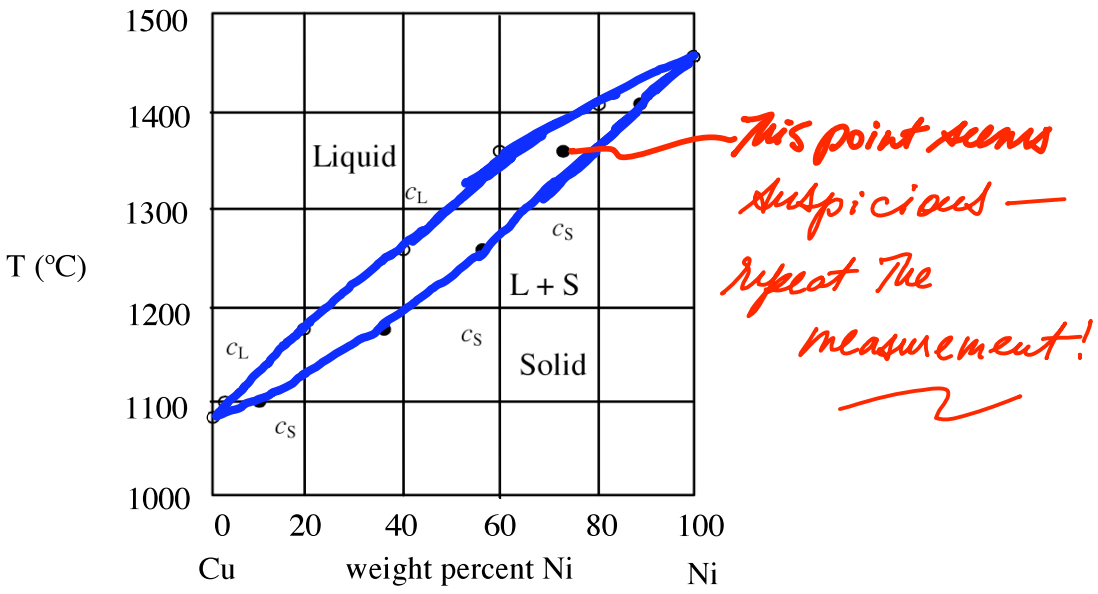
T(°C)	melt composition (atomic % Ni)	composition of solid first formed on cooling (atomic % Ni)
1100	3	10
1180	20	37
1260	40	57
1340	60	73
1410	80	87

(a) From these data and information provided in the Periodic Table, construct the phase diagram (T vs c).

(b) At each of the following (T, c) coordinates, i.e., combinations of temperature and composition, what are the phases present and what are their respective compositions?

T(°C)	composition (atomic % Ni)
1120	15
1200	55
1300	60

Solution



(b)

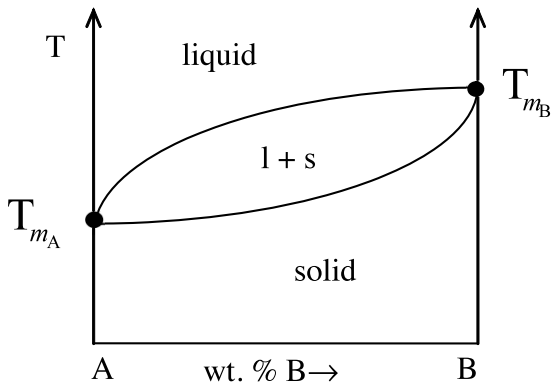
T (°C)	composition (atomic % Ni)	Phase	composition (atomic % Ni)
1120	15	solid liquid	17 07
1200	55	solid	55
1300	60	solid liquid	68 45

Problem #2

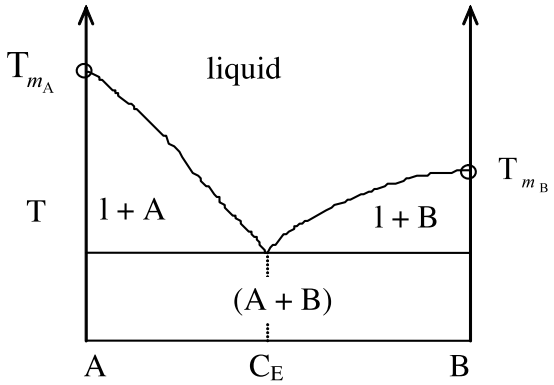
Draw schematic phase diagrams for binary systems with (a) complete liquid and solid solubility, (b) complete liquid but zero solid solubility, and (c) complete liquid and limited solid solubility. (In your sketches label phase fields and give characteristic temperatures.)

Solution

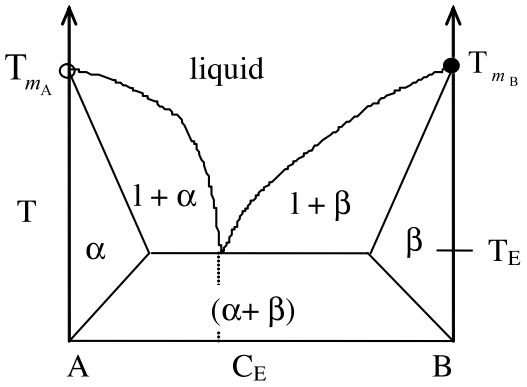
(a)



(b)



(c)

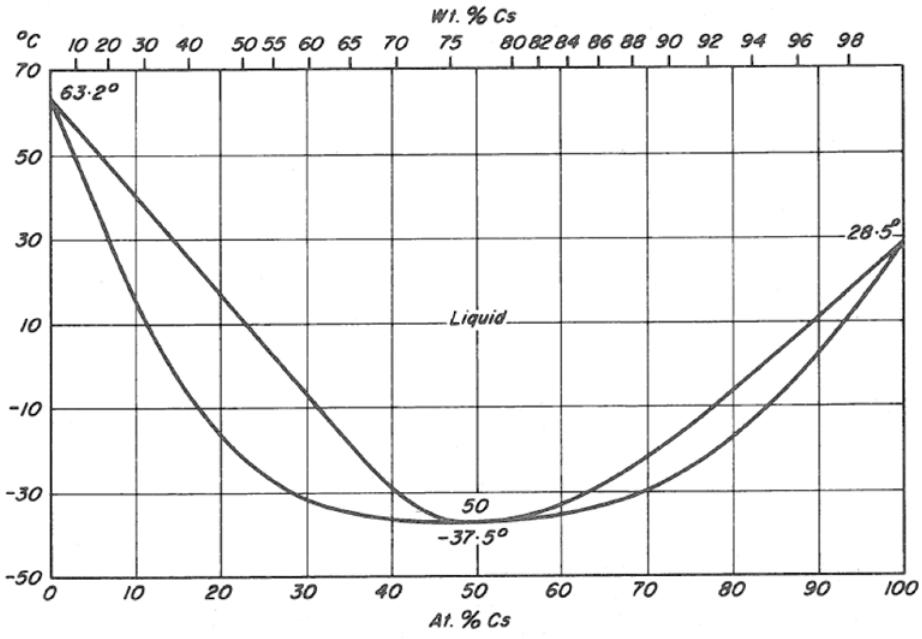


Problem #3

The Cs-K phase diagram is given on the next page. Refer to it in answering the following questions.

(a) For a sample of composition 20 at. % Cs and 80 wt. % K held at 10°C, determine
(i) the composition of the solid phase present at equilibrium
(ii) the composition of the liquid phase present at equilibrium
(iii) the relative amounts of solid and liquid phases present at equilibrium

(b) For a sample of composition 50 at % Cs and 50 at % K held at -37.5°C,
(i) what phases are present at equilibrium?
(ii) what is the composition of each phase?



Solution

(a) (i) 11 at % Cs which we shall designate C^*_{solid}

(ii) 23 at % which we shall designate C^*_{liquid}

(iii) *solid fraction* $= \dfrac{C^*_{liquid} - C}{C^*_{liquid} - C^*_{solid}} = \dfrac{23 - 20}{23 - 11} = 0.25$

(b) (i) one liquid phase and one solid phase

(ii) both phases are identical in composition: 50 at % Cs – 50 at % K

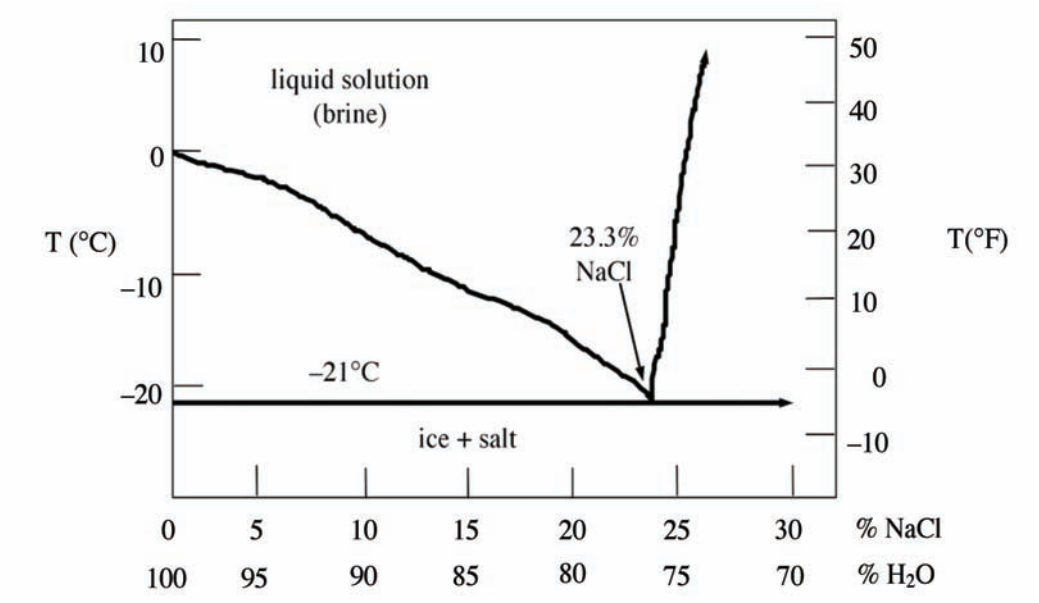
Problem #4

(a) At each of the following coordinates on the binary phase diagram of NaCl – H_2O (see next page) at 1 atmosphere pressure,

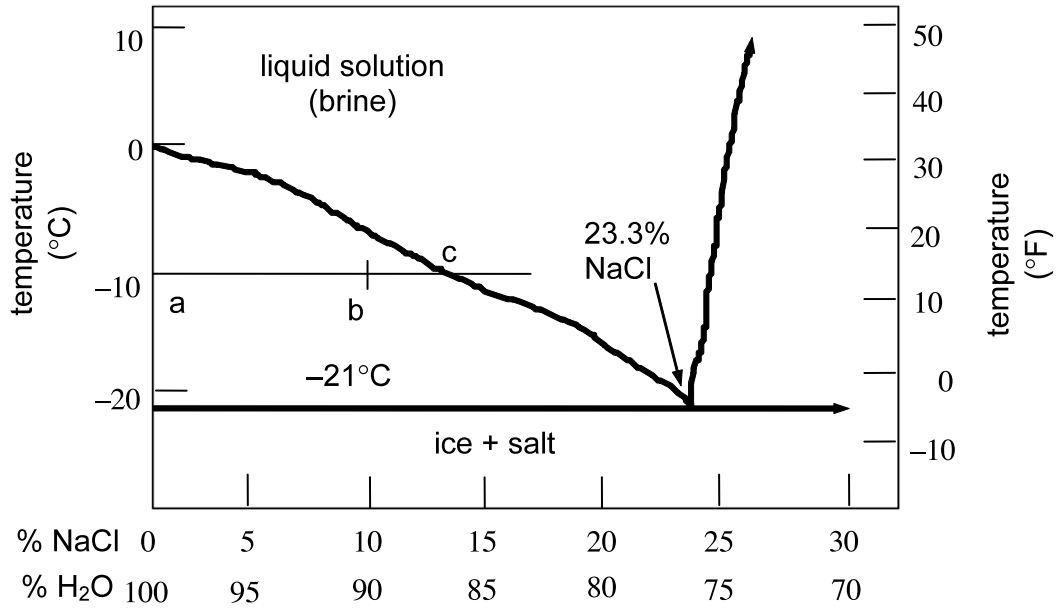
(i) identify the stable phases,
(ii) give their compositions, and
(iii) calculate their relative proportions:

(1) 10% NaCl, 0°C
(2) 10% NaCl, -10°C
(3) 10% NaCl, -25°C

(b) For a solution of 23.3% NaCl in H_2O at –21°C,
(i) identify the stable phases present, and
(ii) give the composition of each phase



Solution



(a) (1) (i) brine -- all liquid
(ii) 10% NaCL in H_2O
(iii) 100% liquid

(2) (i) solid ice (H_2O) + liquid brine
(ii) solid – pure H_2O
liquid ≅ 15% NaCl in liquid H2O
(iii) use lever rule:

$$\% \text{ ice} = \frac{bc}{ac} \times 100 \cong 30\%$$

$$\% \text{ brine} = \frac{ab}{ac} \times 100 \cong 70\%$$

(3) (i) pure ice (H_2O) + pure salt
(ii) ice phase = 100% H_2O; salt phase = 100% NaCl
(iii) 10% NaCl; 90% H_2O

(b) (i) brine (liquid) + 2 solids: NaCl (s) + H_2O (s)

(ii) 23.3% NaCl in water
Pure NaCl (solid)
Pure H_2O (solid)

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