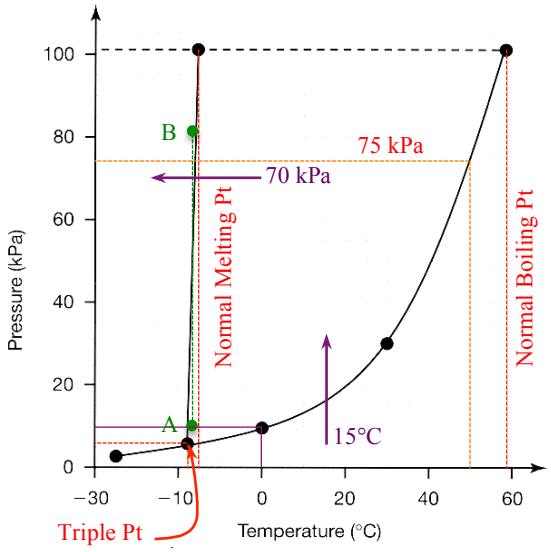
WKS
Phase Diagrams

Name Answer Key

1) At standard temperature and pressure, bromine (Br_2) is a red liquid. Use the phase diagram for bromine is (shown at the right) to answer the following questions. *Note: 1 atm = 101.3 kPa. Thus, 101.3 kPa is the pressure for all "normal" mp and bp's.*



a) Label each region of the graph as *solid*, *liquid*, or *gas*.

b) Label the *triple point*, *normal melting point*, and *normal boiling point* on the graph and estimate their values in the spaces below.

Normal Melting Point = –8°C

Normal Boiling Point = 59°C

Triple Point: P = 5 kPa T = –9°C

c) Explain the significance of the triple point?
The triple point is the pressure and temperature at which all 3 phases coexist *in equilibrium*.

d) When external pressure is increased, what happens to bromine's melting point? **Increase or decrease**

e) Based on the slope of the melting-point curve in the phase diagram, would you characterize the solid phase of bromine as **more dense** or **less dense** than the liquid phase of bromine? *Explain your reasoning.*
Since the solid-liquid phase boundary has a positive slope, as the pressure is increased (points A → B), the density increases and the Br_2 transitions from liquid to solid.

f) What is the boiling point of bromine when the external pressure is 75 kPa? 50°C

g) Bromine vapor at 15°C (**condenses, sublimes**) when the pressure is raised to 50 kPa.

h) Bromine liquid at 70 kPa (**vaporizes, freezes**) when the temperature is decreased to –15°C.

i) What is the vapor pressure of liquid bromine at 0°C? 10 kPa

2) a) What is sublimation?
The change directly from solid phase to gas phase.

b) Give two examples of common substances that sublime at ordinary temperatures.
I_2 and CO_2 were given in class. H_2O sublimes as well, but only at low temperatures (snow on a cold, sunny day, ice cubes in the freezer). Other examples found by searching the internet are naphthalene, $C_{10}H_8$, and arsenic.

3) What is meant by the normal freezing point of a substance?
The temperature at which a substance changes from liquid to solid (or solid to liquid) at 1 atm pressure.

4) Use the phase diagram of water (shown at right), to answer the following questions:

a) What phase change occurs when water goes from 100°C to −50°C at 0.3 kPa? deposition

b) What would happen to solid ice (originally at −5°C and 1 atm), if the external pressure is greatly increased?
It would melt.

c) By just looking at the phase diagram, how is one able to tell that solid water is less dense than liquid water?
Because the solid-liquid boundary has a negative slope (up & to the left)

d) Point "D" on the diagram is the critical point for water. Thus, the critical temperature is 374°C for water. What exists above this critical temperature?
A supercritical fluid, essentially a gas with a density about ½ that of a liquid.