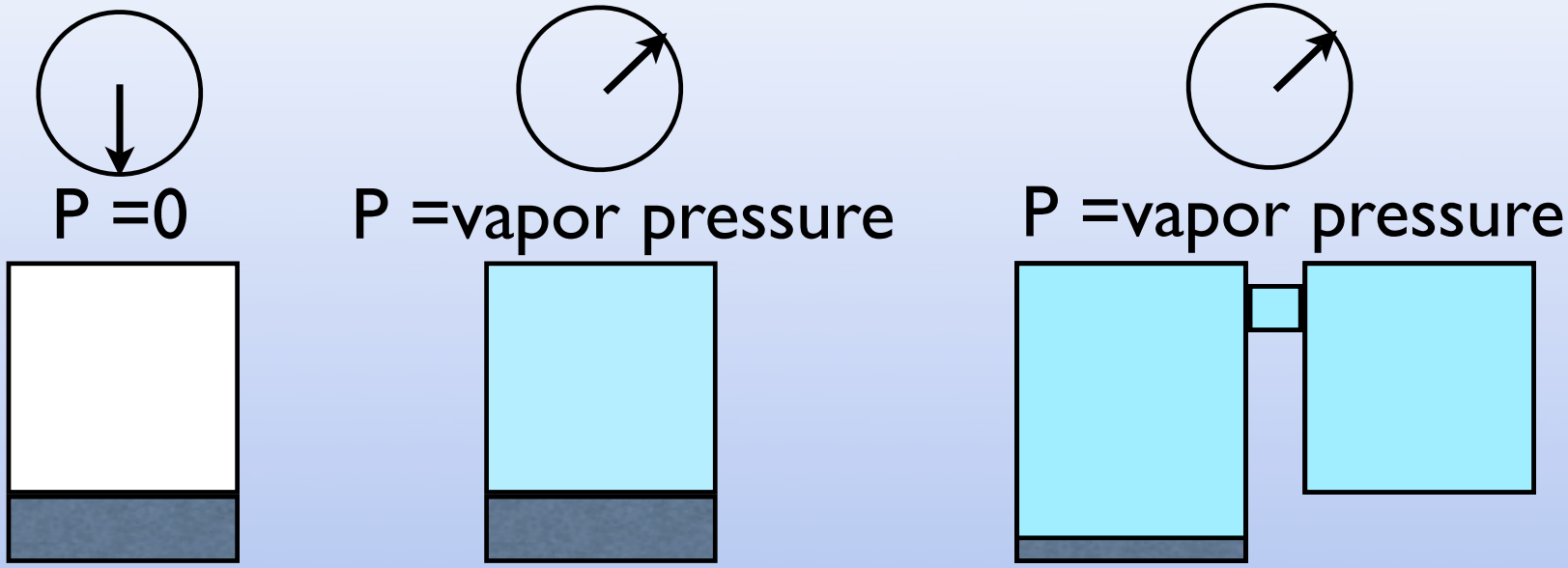
Let's look at how different properties affect vapor pressure



first all liquid

then comes to equilibrium with liquid + vapor with a pressure that is the vapor pressure

then add more volume

At equilibrium there is less liquid, but the same Pressure!

Quick Quiz

You have two containers.
one has a total volume of 2 L and
one has a total volume of 1 L
Into each you place 500 mL of liquid ether
They have the same temperature

Which container has a higher pressure at equilibrium?

A. the 2 L container

B. the 1 L container

C. they are exactly the same ←

D. it depends on the temperature

Another Question

You have two containers
one has a total volume of 2 L and
one has a total volume of 1 L
Into each you place 500 mL of liquid ether

Which container has a greater number of
ether molecules in the gas phase at equilibrium?

A. the 2 L container ←

B. the 1 L container

C. they are exactly the same

D. it depends on the temperature

If we stress the system it adjust to get back to equilibrium

Let's imagine a container with some liquid ethanol,
when we look at the gas above the liquid

actual partial pressure of ethanol

partial pressure at equilibrium = vapor pressure

If $P_{ethanol} > P_{ethanol,eq}$ then there are "too many" molecules in the gas phase.
The gas will **condense** until you get to equilibrium

If $P_{ethanol} < P_{ethanol,eq}$ then there are "too few" molecules in the gas phase.
The liquid will **evaporate** until you get to equilibrium

If **all** the liquid evaporates before getting to equilibrium
then the pressure will never get up to the equilibrium value

If $P_{ethanol} = P_{ethanol,eq}$ the number molecules in the gas phase is "just right"
The system is at equilibrium

Vapor Pressure is determined primarily from $\Delta_{vap}H$
$\Delta_{vap}H$ depends on the intermolecular forces

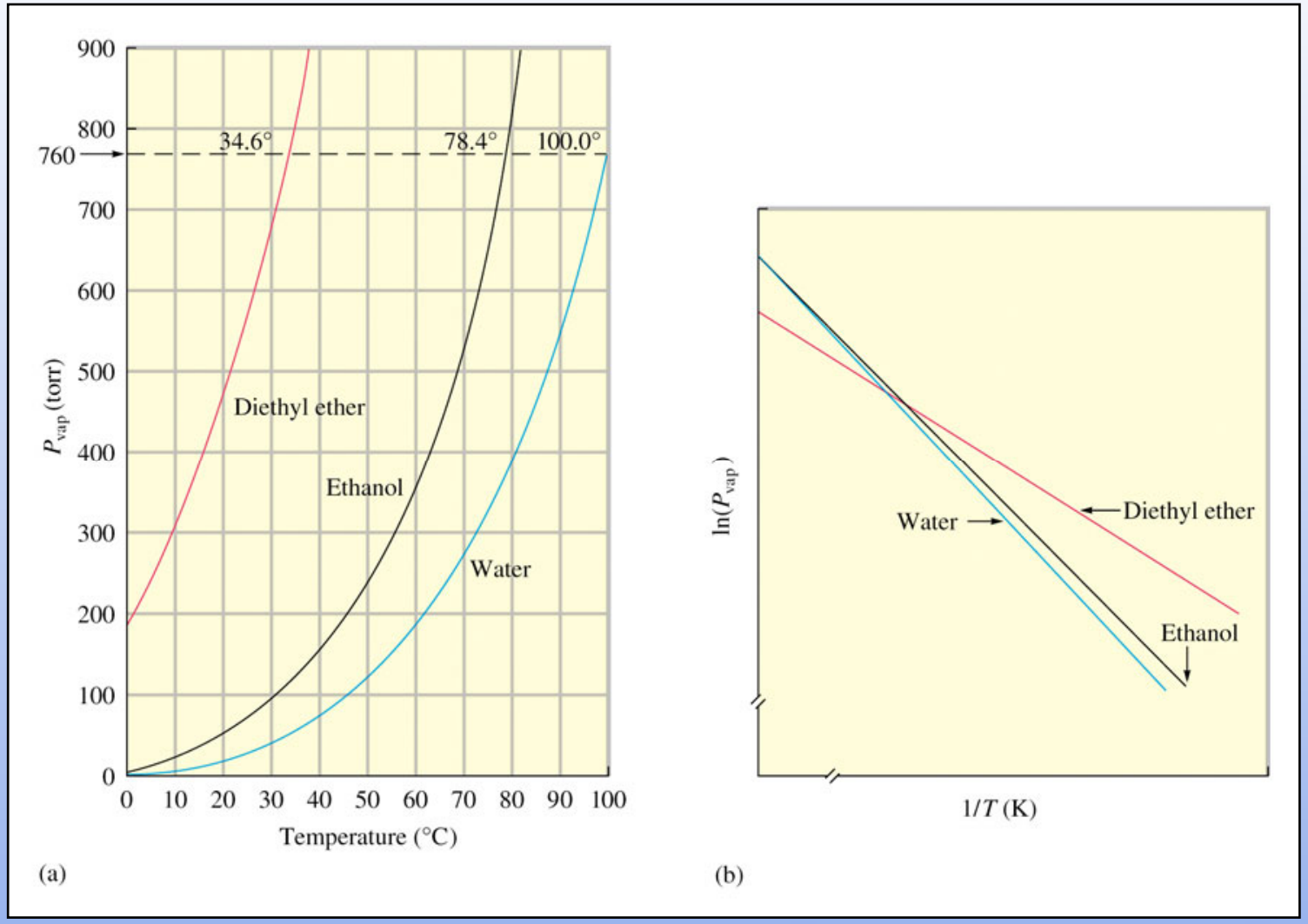
Vapor Pressure is independent of volume
Neither the volume of the gas or liquid matter

To have the equilibrium both gas and liquid must be present

Vapor Pressure is a strong function of temperature

The Vapor Pressure is the
PARTIAL PRESSURE OF THAT SUBSTANCE!

Vapor Pressure as a function of Temperature



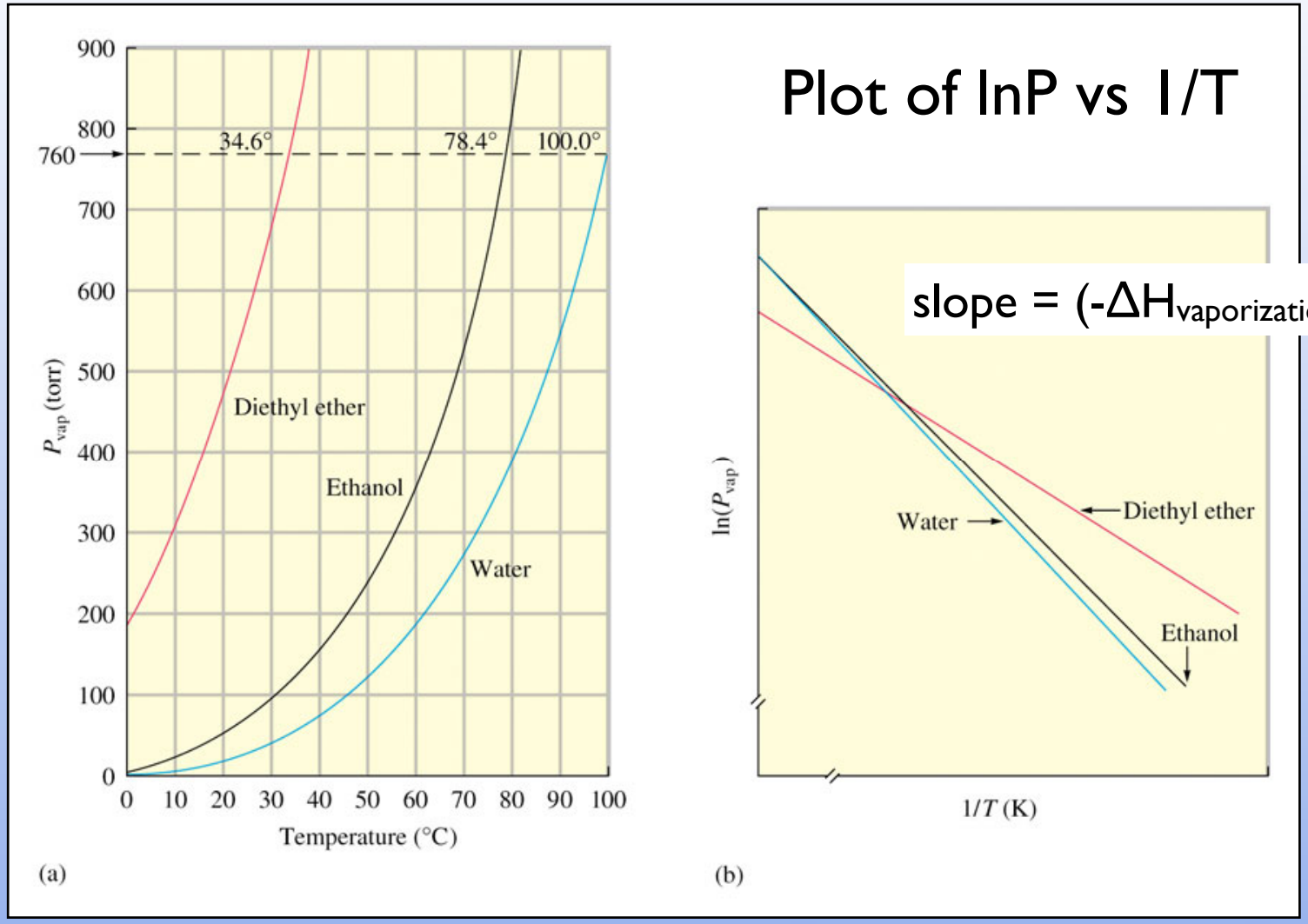
How Does Vapor Pressure Change with T?

$$\ln\left(\frac{P_2}{P_1}\right) = -\frac{\Delta H_{vap}}{R}\left(\frac{1}{T_2} - \frac{1}{T_1}\right)$$

The Claussius-Clapeyron Equation

Relates the vapor pressure P_1 at temperature T_1 to the vapor pressure P_2 at temperature T_2

Plot of lnP vs 1/T



slope = $(-\Delta H_{vaporization})/R$

Boiling

What is the boiling point?

Definition: The boiling point is temperature at which the vapor pressure is equal to prevailing pressure

What is the normal boiling point?

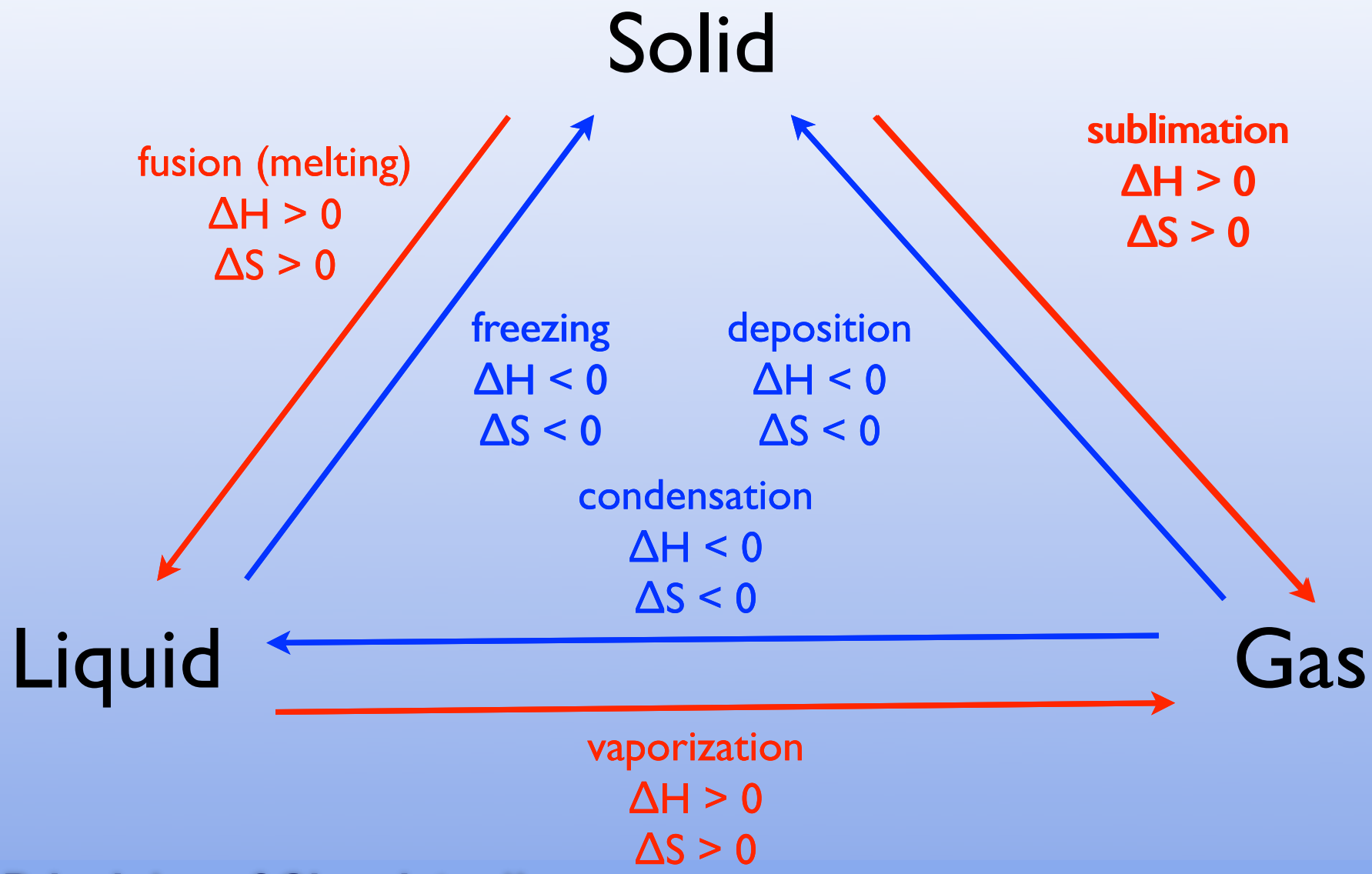
Definition: The normal boiling point is temperature at which the vapor pressure is equal to 1 atm

Note: at the boiling point the **partial** pressure of the substance is equal to the **total** pressure. It cannot get any higher (its the whole thing). At higher temperatures the liquid would have a higher vapor pressure. To achieve this you need to have a higher total pressure.

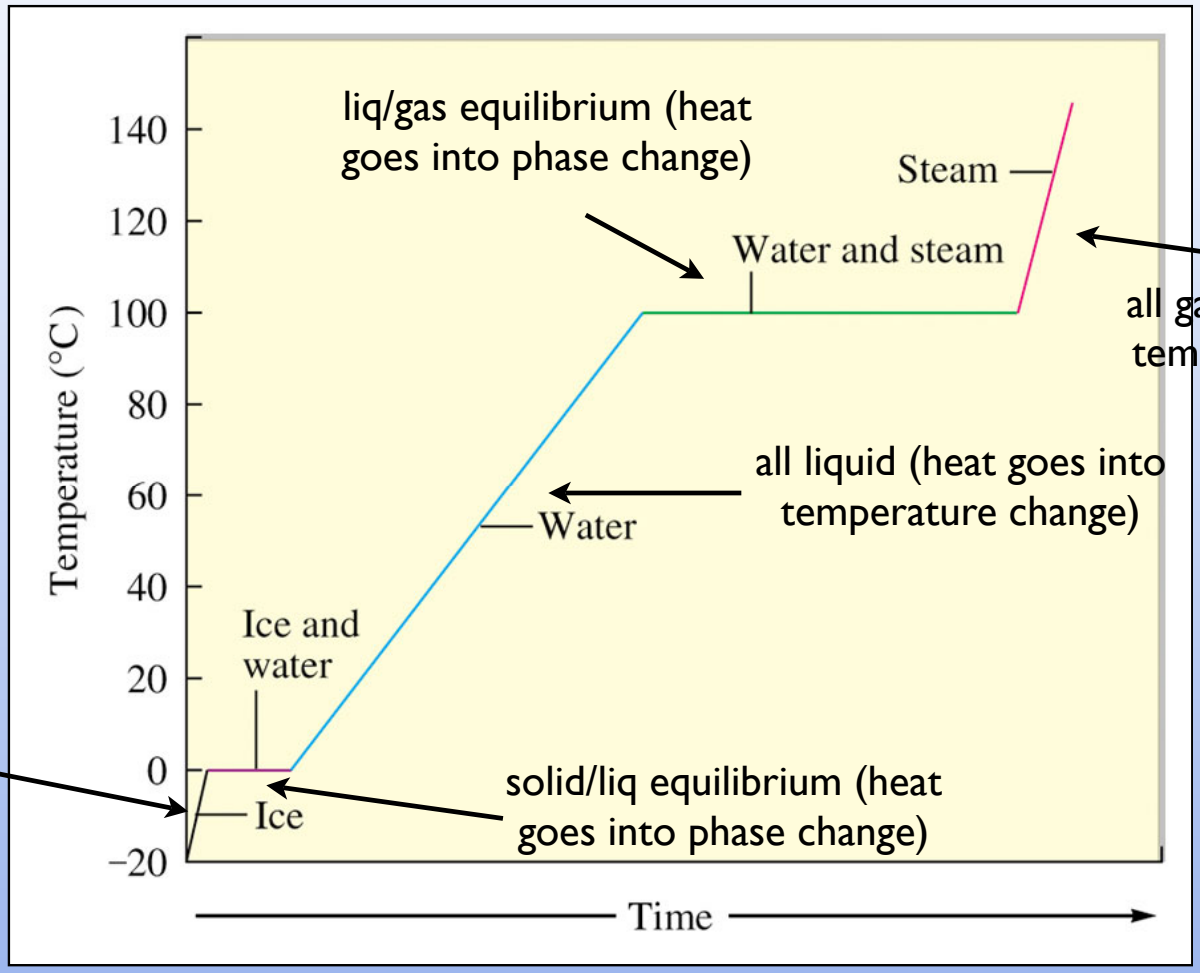
Given that the vapor pressure of water is 24 Torr at 25°C and that the normal boiling point of water is 100 °C, what is the enthlapy of vaporization of water?

Doc Cam

The different phase transitions



Phase Transitions



Previous Thermo

Single Phase
energy into goes into temperature change
at constant P

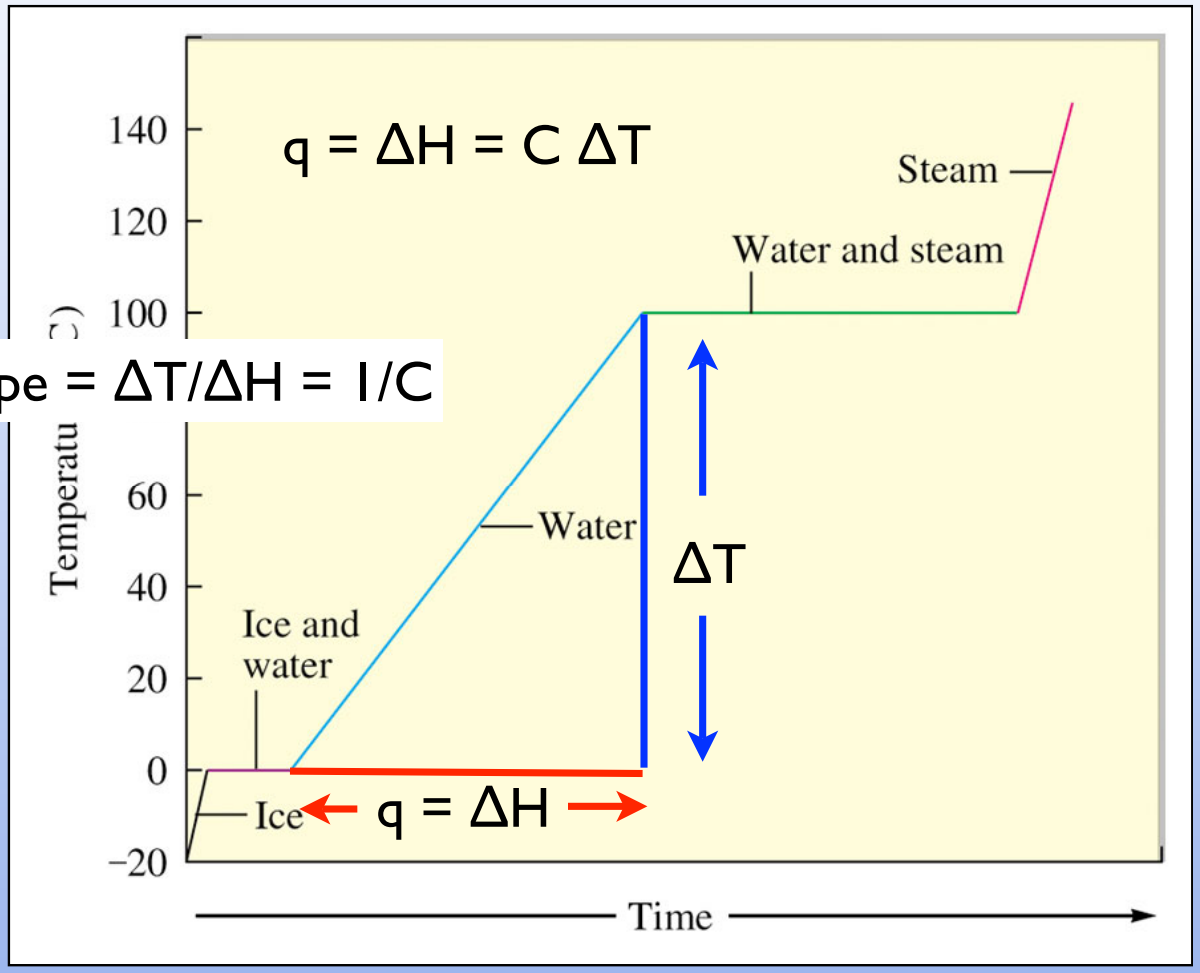
$q = \Delta H = C\Delta T$

you need heat capacity of specific phase (sol,liq, gas)
be careful with the units of heat capacity.
you may need to multiply by a number of moles or a mass!

Phase Change
energy into goes into phase change
(the two phases have the same free energy
but one is higher in enthalpy)

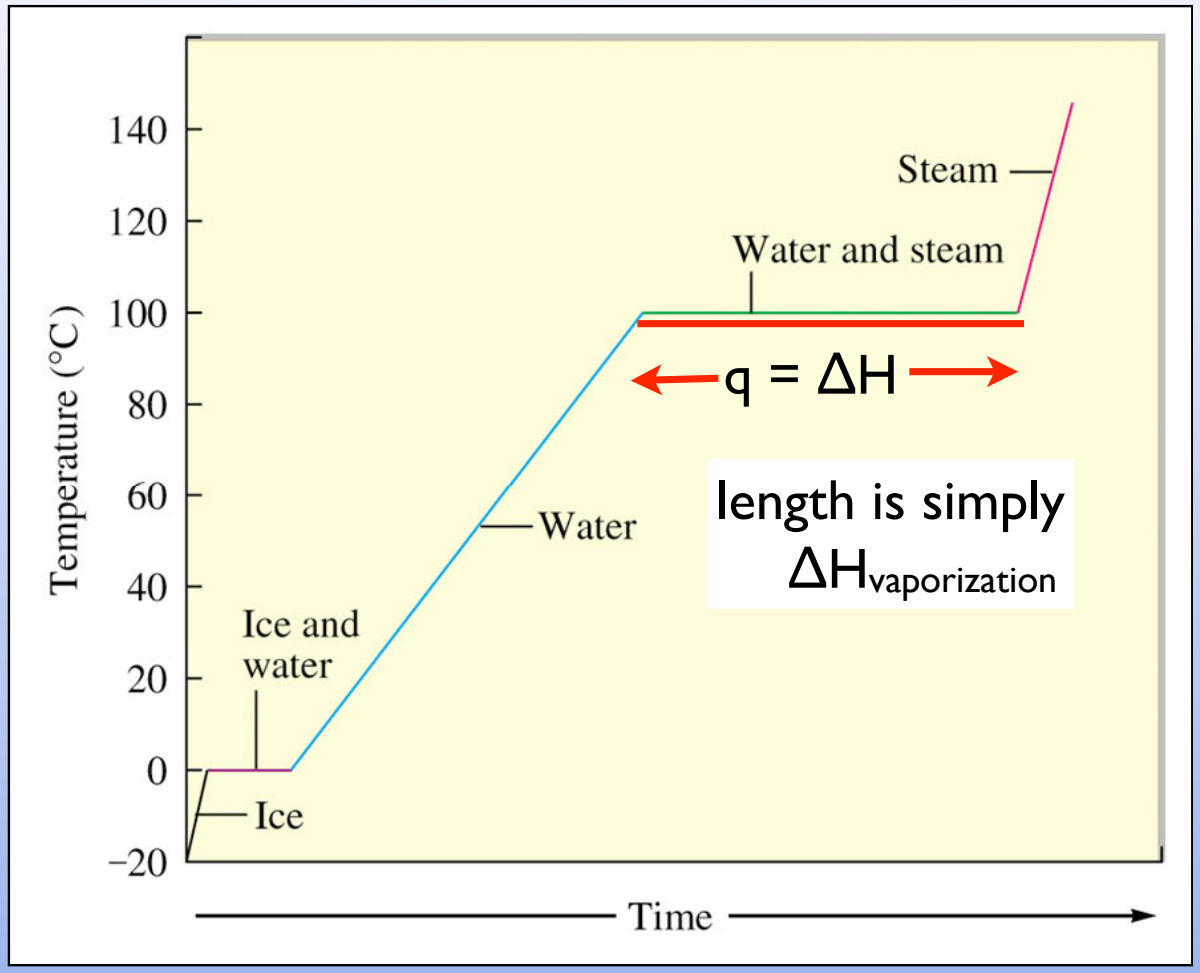
$q = \Delta H_{transition}$ for example $q = \Delta H_{fus}$ for melting

Phase Transitions



Heat →

Phase Transitions

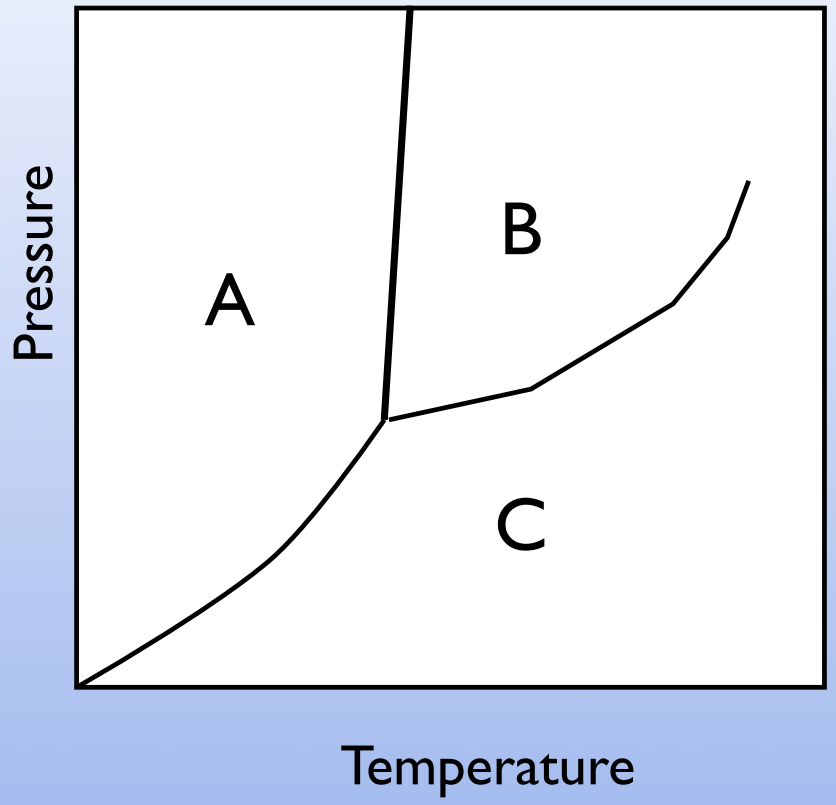


Heat →

Phase Diagrams

The diagram on the right shows different phases for a compound as a function of temperature and pressure

What is the phase labeled "A"?



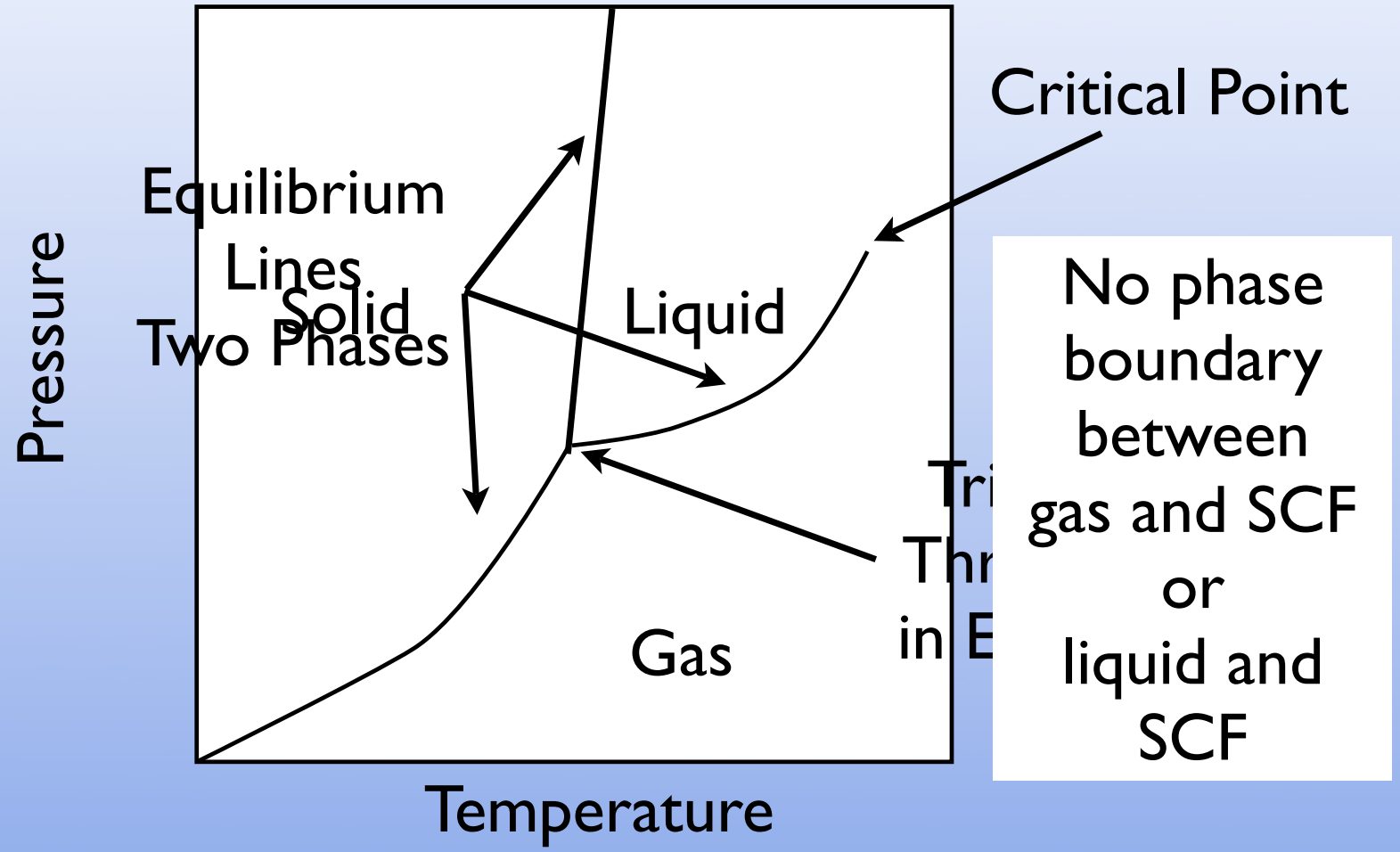
A. solid

B. liquid

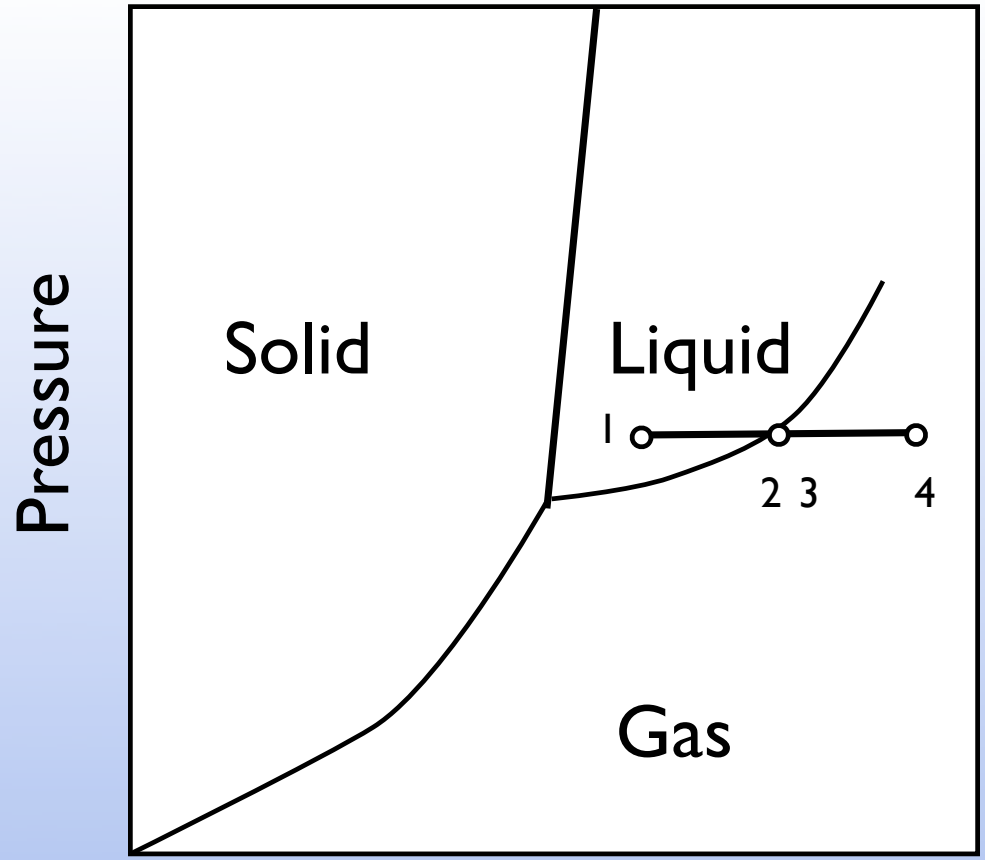
C. gas

D. no way to know

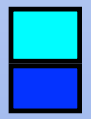
Important Points



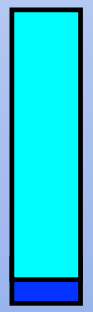
No phase boundary between gas and SCF or liquid and SCF



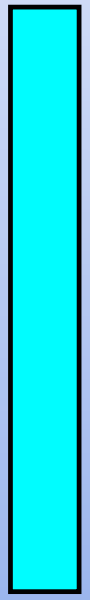
1
all liquid



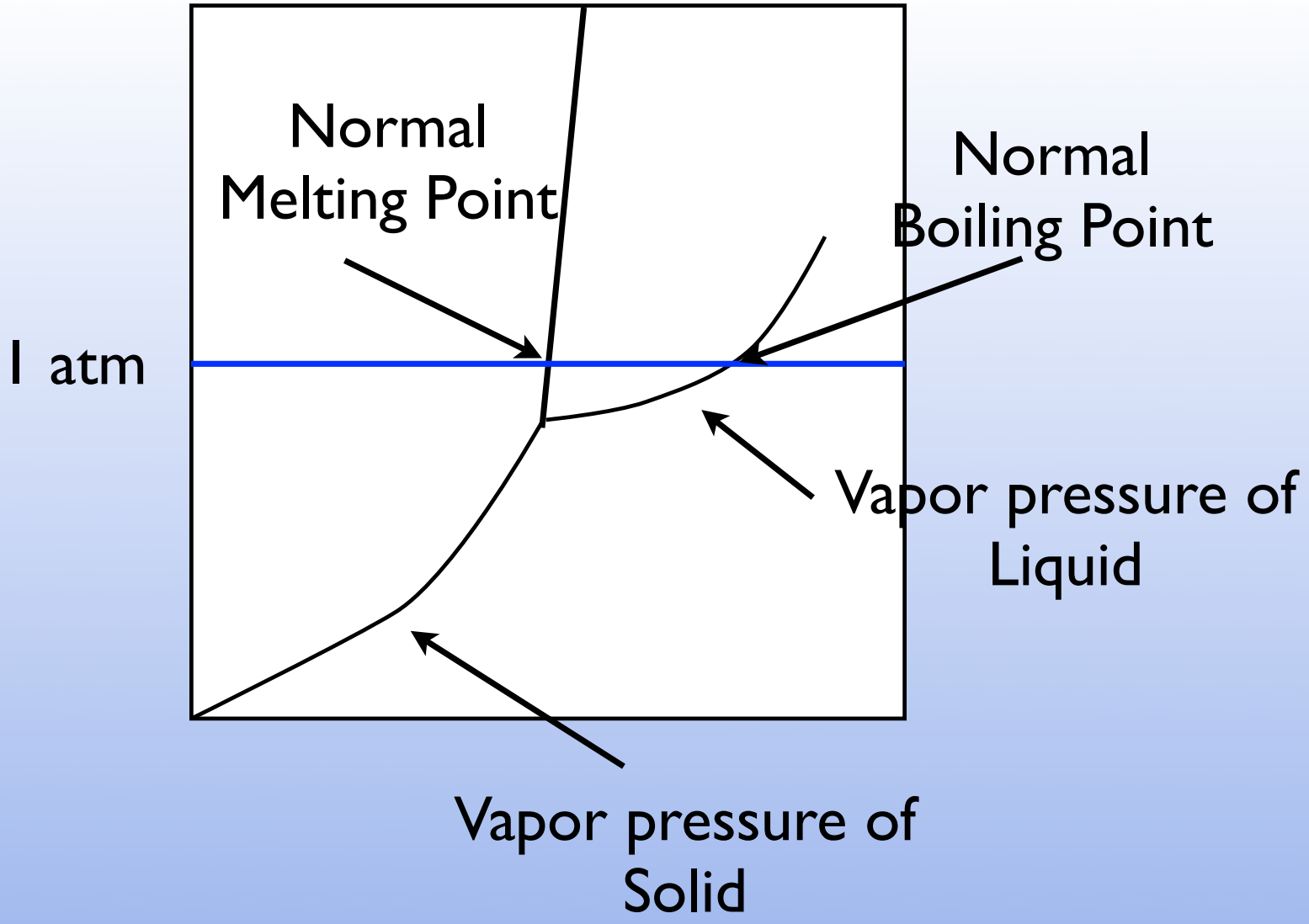
2
liquid and gas



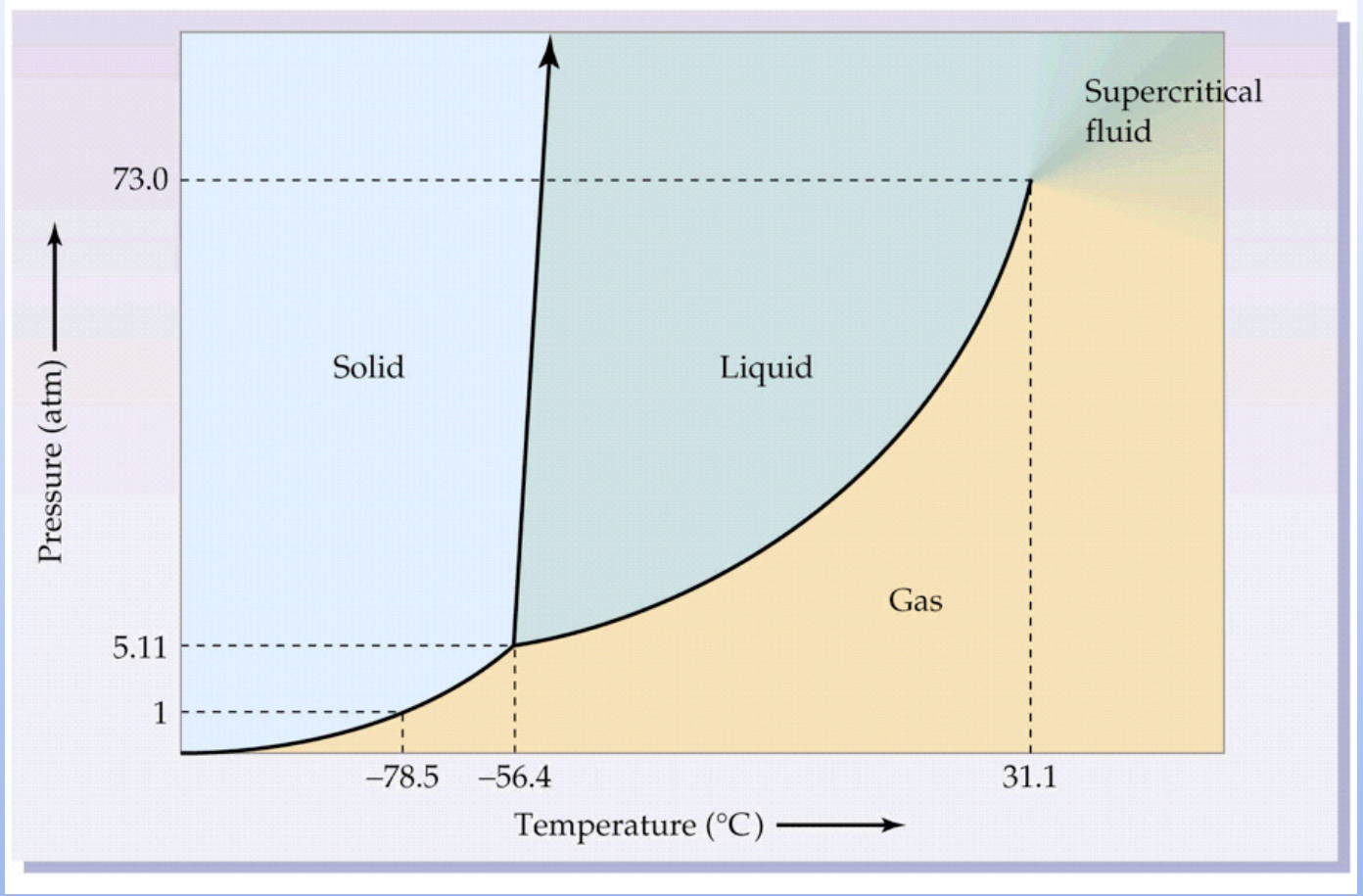
3
liquid and gas



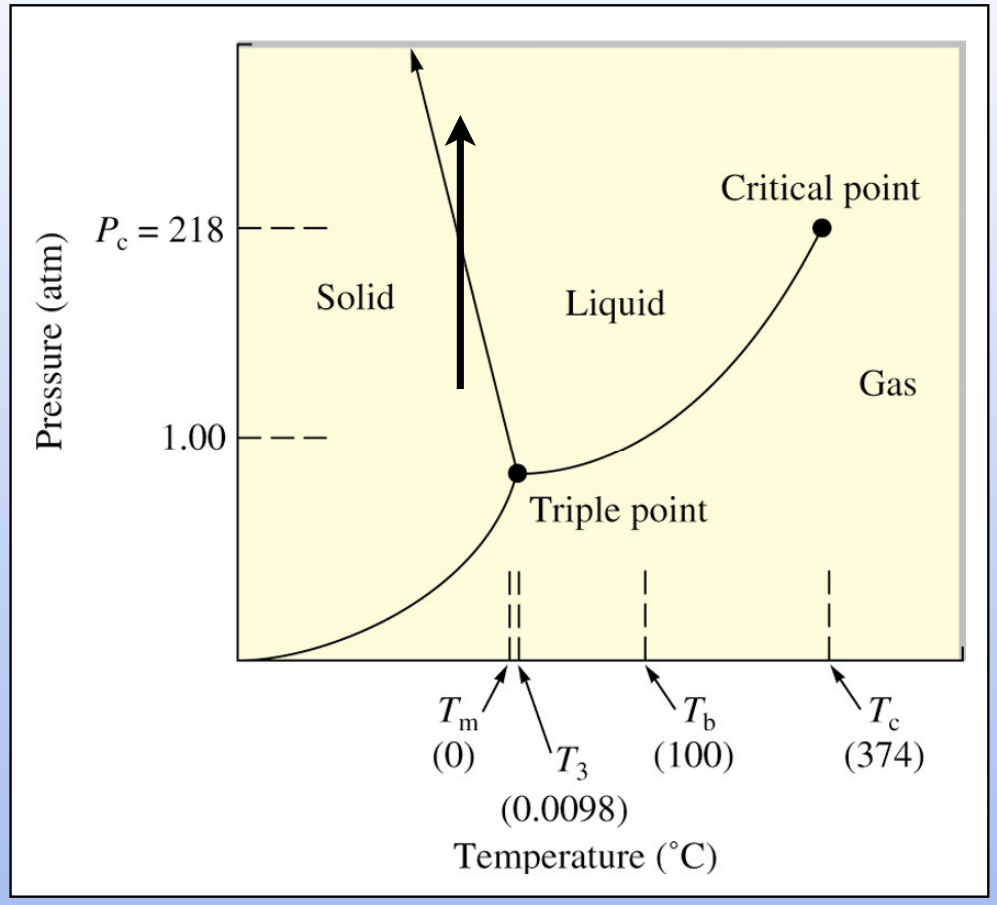
4
all gas


Normal
Melting Point
Normal
Boiling Point
1 atm
Vapor pressure of
Liquid
Vapor pressure of
Solid

Phase Diagram of CO_2

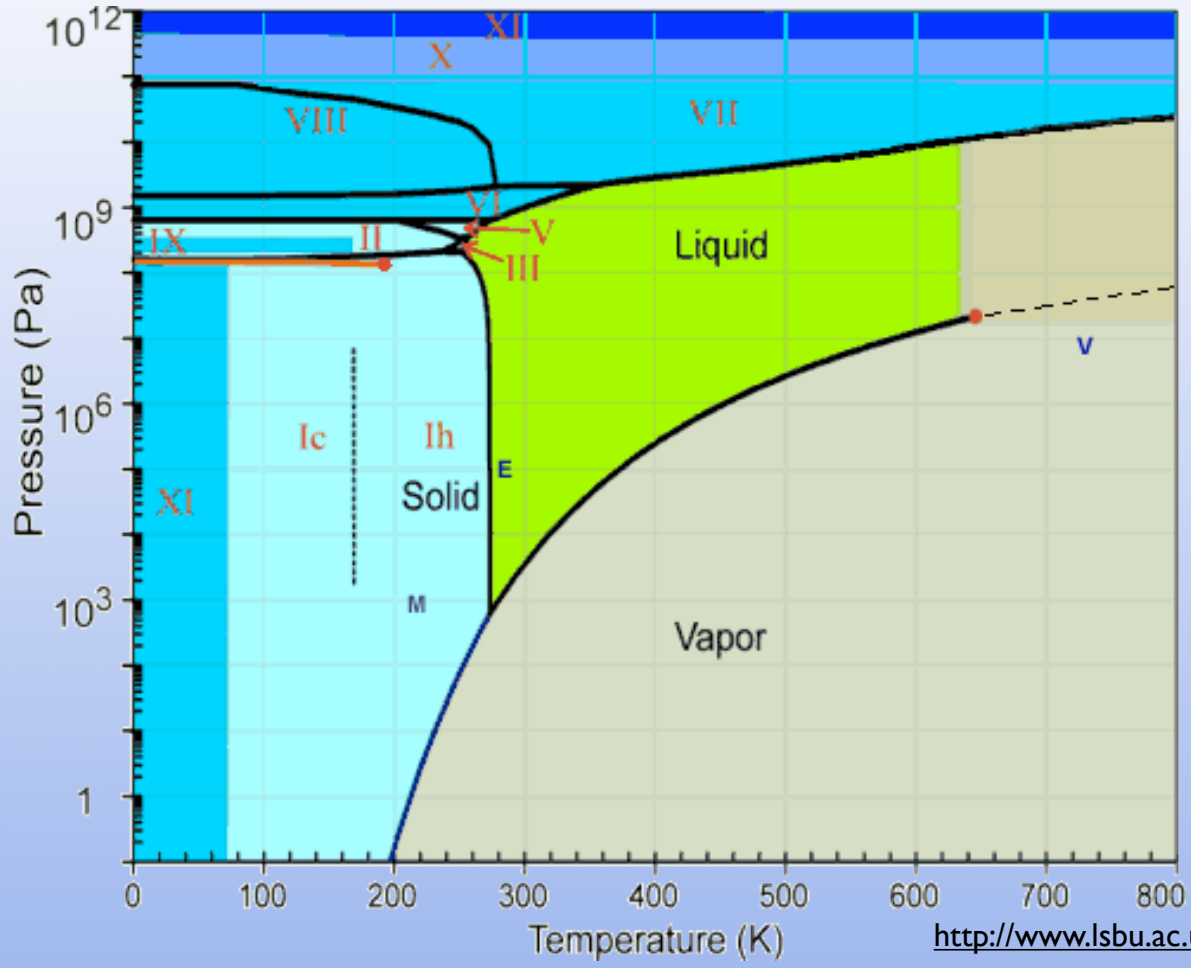


Phase Diagram of Water



At a constant temperature, increasing the pressure will cause ice to melt (it moves to the higher density phase which for water is a liquid)

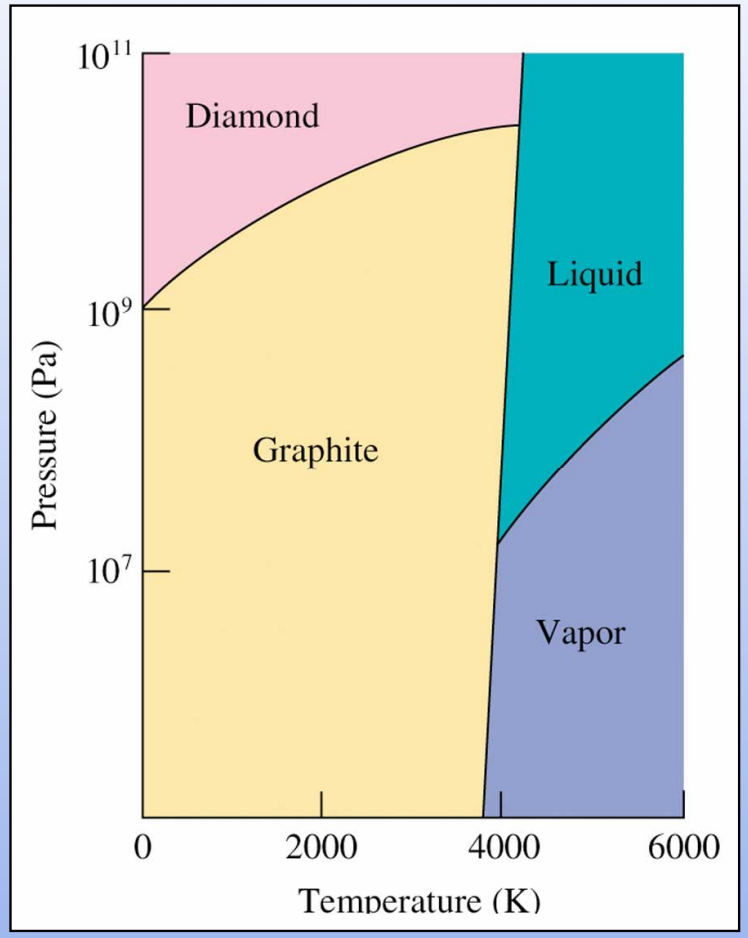
Phase Diagram of Water



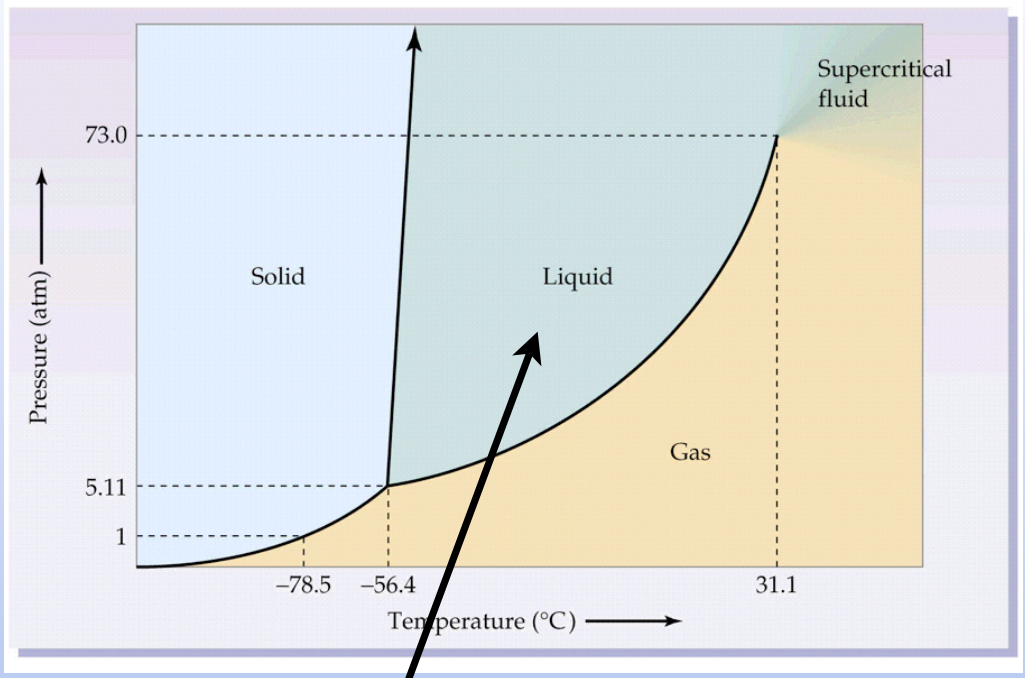
http://www.lsbu.ac.uk/water/images/phase.gif

Many different solid phases. At very high pressure the liquid will solidify

Other Substances



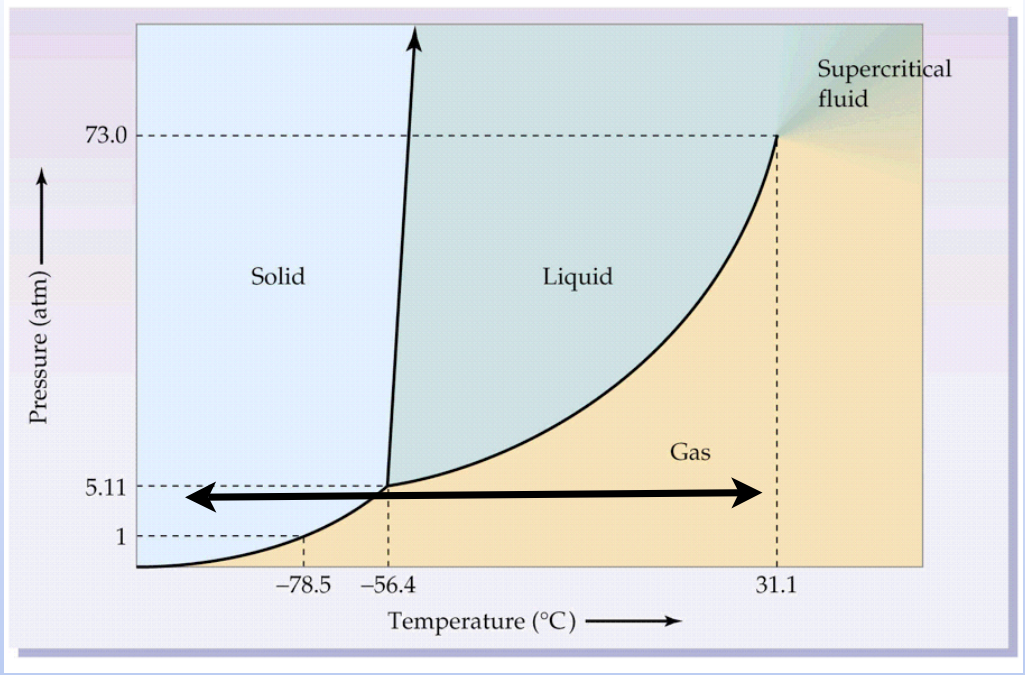
Phase Diagram of CO_2



What is the stable phase at at 20 atm and 0°C?

A. solid B. liquid C. gas D. SCF

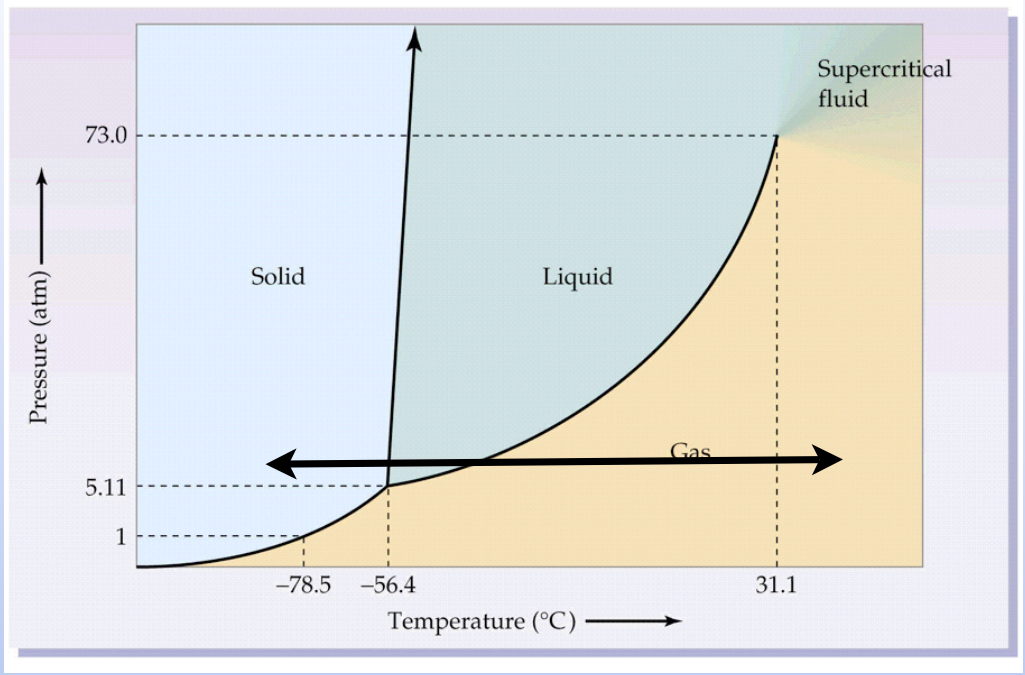
Phase Diagram of CO_2



If I start at -100°C and 5 atm and increase the temperature to 30 °C, how many phase transition occur?

A. 1 B. 2 C. 3 D. 4

Phase Diagram of CO_2



No phase transition going for a liquid or a gas to a SCF

If I start at -100°C and 7 atm and increase the temperature to 35 °C, how many phase transition occur?

A. 1 B. 2 C. 3 D. 4