VIII) Heat Transfer & Changes of State

$S \equiv$ specific heat $\left(\frac{J}{g \cdot °C}\right)$

$c \equiv$ molar heat capacity $\left(\frac{J}{mol \cdot °C}\right)$

Heat transfer w/in a state

$$q = m \cdot S \cdot \Delta T$$

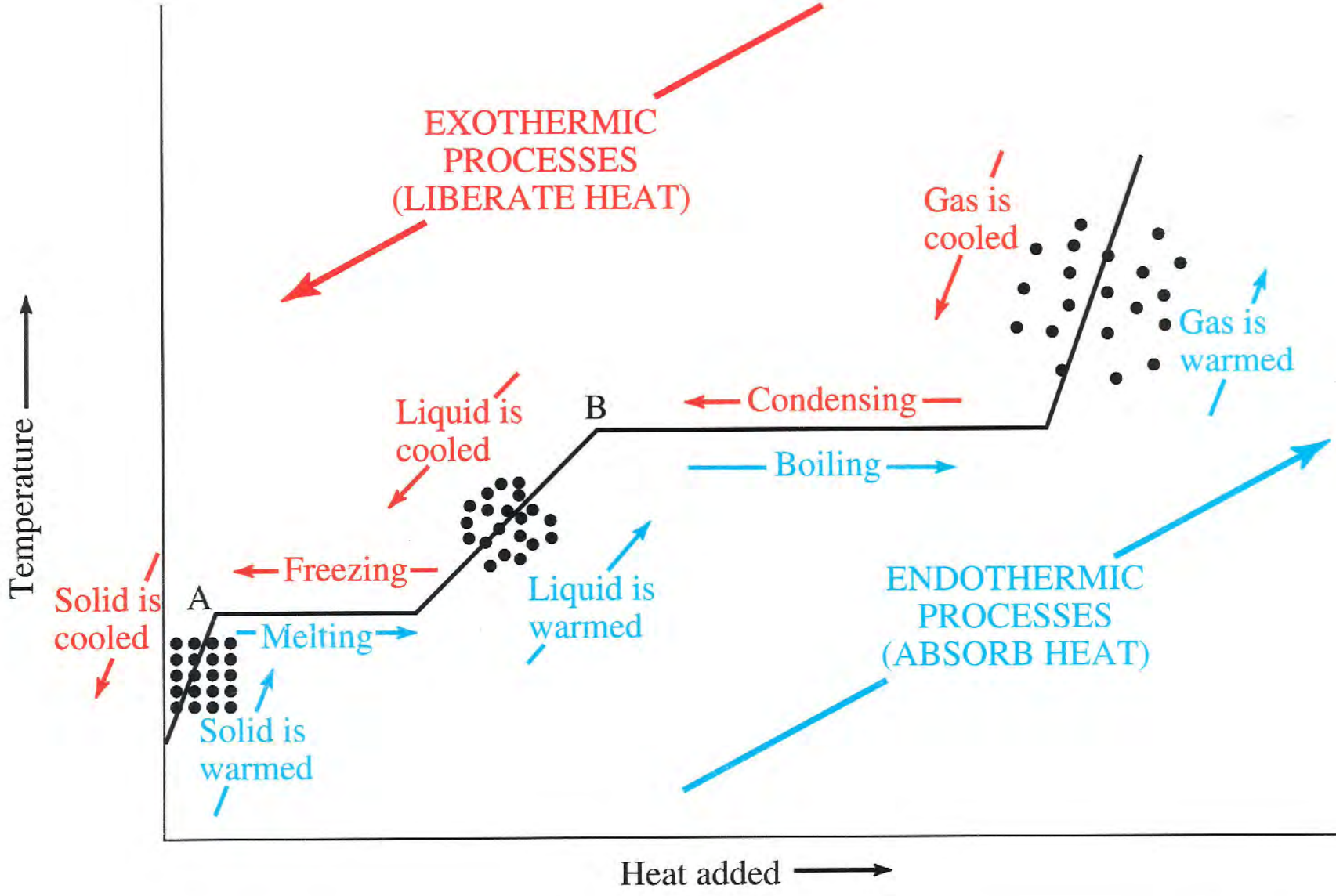
$$q = n \cdot c \cdot \Delta T$$

Heat transfer for Phase Changes

$$q = n \cdot \Delta H$$

Note

$$q_{gained} = -q_{lost}$$


EXOTHERMIC
PROCESSES
(LIBERATE HEAT)
Gas is
cooled
Gas is
warmed
Liquid is
cooled
B
Condensing
Boiling
Freezing
Solid is
cooled
A
Melting
Liquid is
warmed
ENDOTHERMIC
PROCESSES
(ABSORB HEAT)
Solid is
warmed
Temperature
Heat added

A) Ex: Calc. the heat energy req. to convert 1.00 mol of ice at -25°C to liquid water at 90°C.

$S_s = 2.09 \frac{J}{g \cdot °C}$ $S_l = 4.18 \frac{J}{g \cdot °C}$

$\Delta H_{fus} = 6.01 \frac{kJ}{mol}$

Heat req. to raise temp. of a substance,

$$q = m \cdot s \cdot \Delta T$$

$$q_{Total} = q_s + q_{fus} + q_l$$

$$q_s = (18.0\,g)\left(2.09\,\frac{J}{g\cdot°C}\right)[0°C - (-25°C)]$$

$$= 940.5\,J$$

$$= 0.9405\,kJ$$

$$q_{fus} = (1.00\,mol)\left(6.01\,\frac{kJ}{mol}\right)$$

$$= 6.01\,kJ$$

$$q_l = (18.0\,g)\left(4.18\,\frac{J}{g\cdot°C}\right)[90°C - 0°C]$$

$$= 6771.6\,J$$

$$= 6.772\,kJ$$

$$q_{Total} = 0.9405 + 6.01 + 6.772$$

$$= 13.72\,kJ$$

VI) Phase Diagrams

shows relationship between solid, liquid, & gas phases on a single graph

Fig. 11.27

Line CA - V.P. curve of solid

Line AB - V.P. curve of liquid

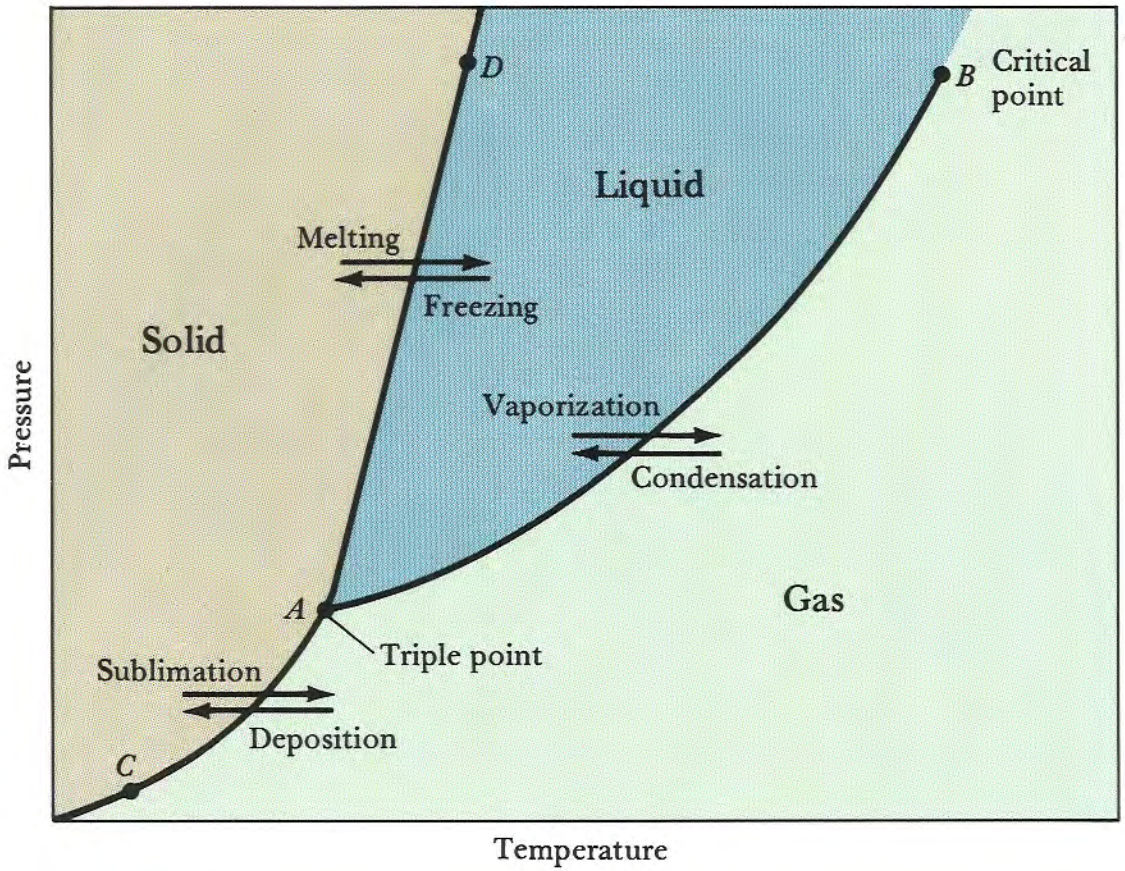
Line AD - solid $\rightleftharpoons$ liq. equil.

Point A - Triple Point
- ALL 3 states exist in equil.

Point B - Critical Point
- beyond B liq. & gas phases are indistinguishable

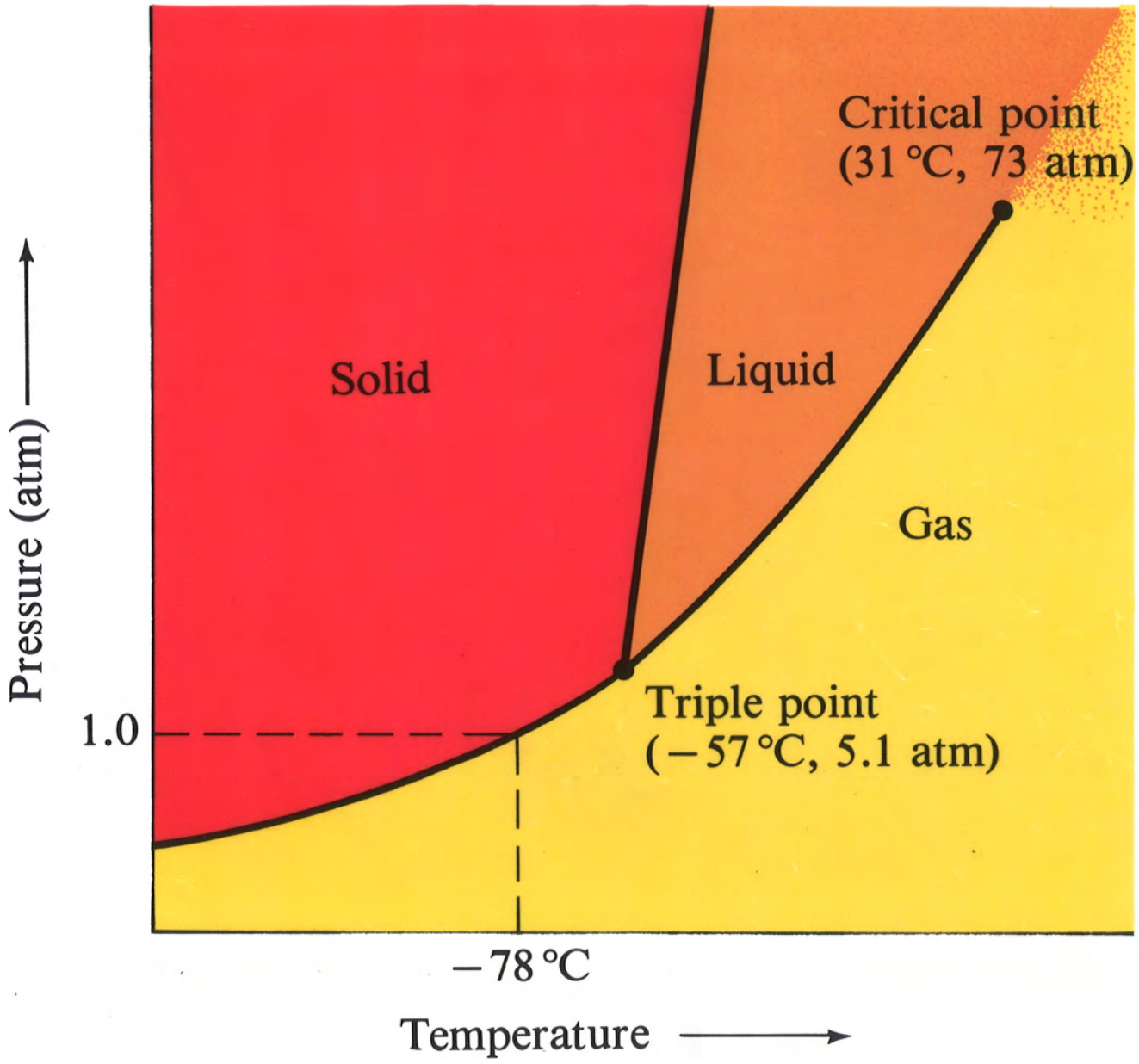
Transparency 83

Figure 11.20 General phase diagram



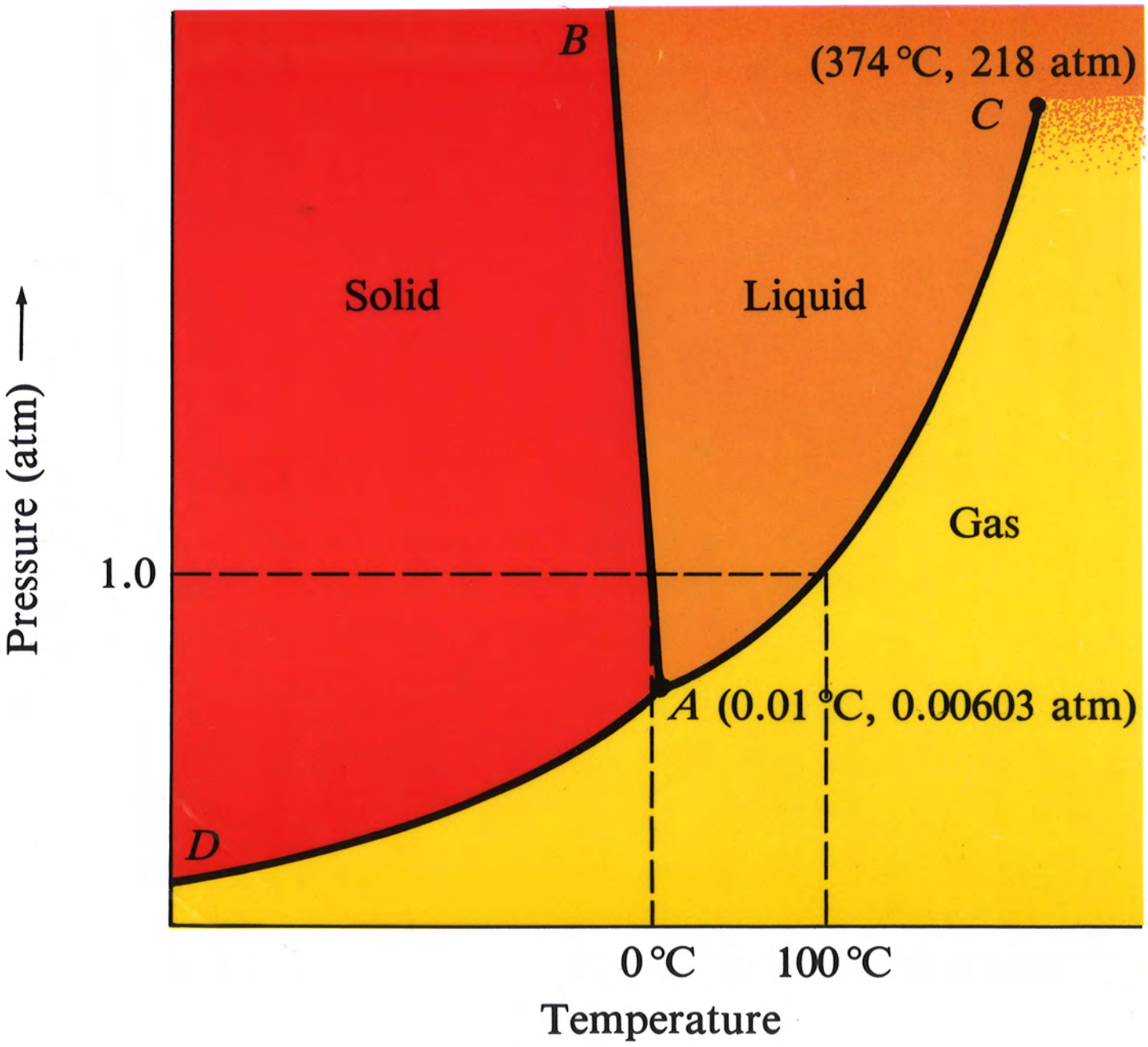
CHEMISTRY: THE CENTRAL SCIENCE
by Brown/Le May/Bursten

Ebbing, GENERAL CHEMISTRY, Third Edition
Figure 11.11A Phase diagram for CO_2



A

Ebbing, GENERAL CHEMISTRY, Third Edition
Figure 11.10 Phase diagram for water



Direction off vertical depends on relative densities of solid & liquid

In general:

$D_s > D_\ell$

inc. P $\Rightarrow$ smaller Vol.

get solid

$s \rightleftharpoons \ell$ line slants right

Exception: H_2O

$D_\ell > D_{ice}$

inc. P $\Rightarrow$ smaller Vol.

get liquid

$s \rightleftharpoons \ell$ line slants left

D) Critical Temp. & Pressure

Can liquefy a gas by compressing it at a suitable temp.

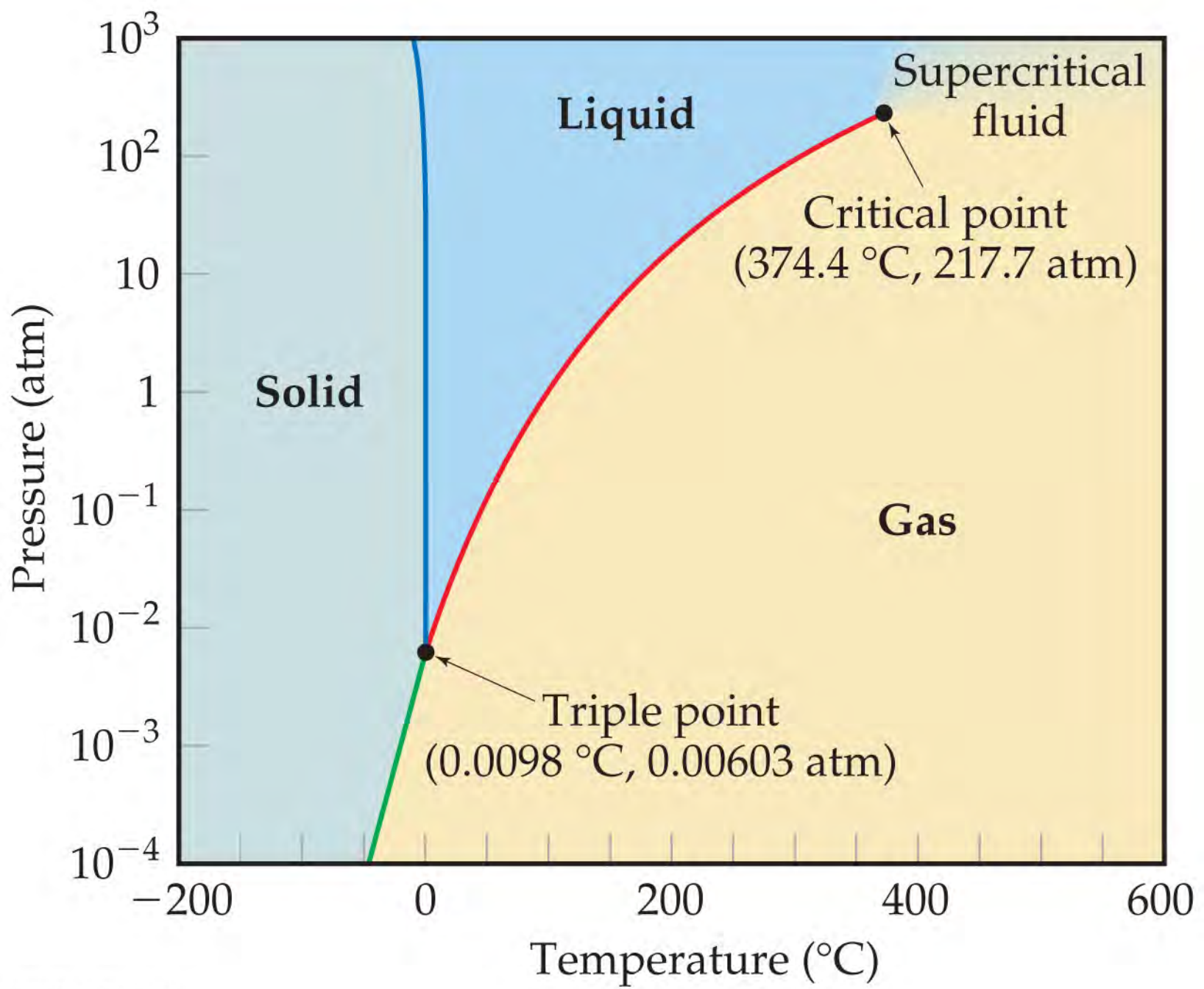
Critical Temp.

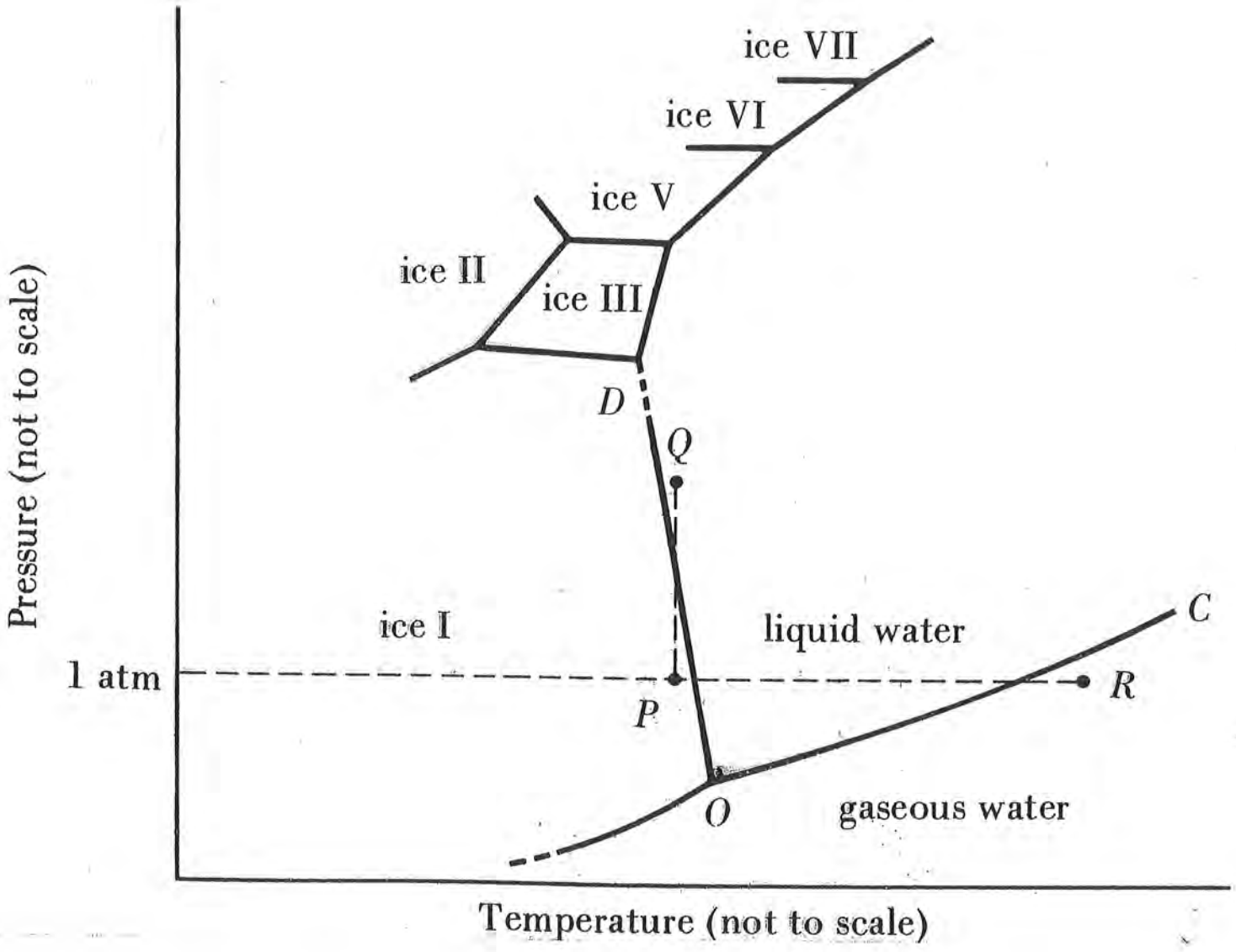
Highest temp. at which a gas can be liquefied, regardless of pressure

Critical Pressure

Pressure req. to cause liquefaction at the critical temp.

He	5.3 K	2.26 atm
O_2	154.4 K	49.7 atm
H_2O	647.2 K	217.7 atm




ice VII
ice VI
ice V
ice II
ice III
D
Q
ice I
liquid water
C
1 atm
R
P
O
gaseous water
Pressure (not to scale)
Temperature (not to scale)