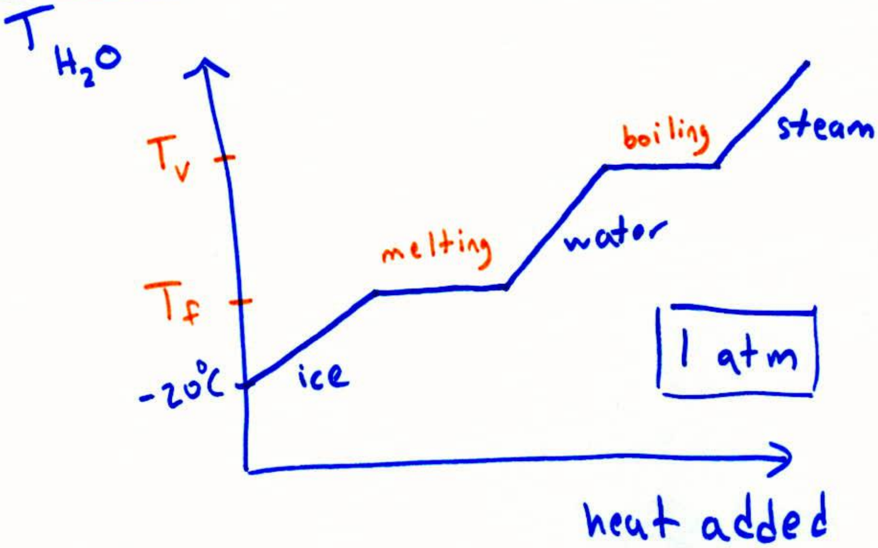
# Physics 2C 1/28

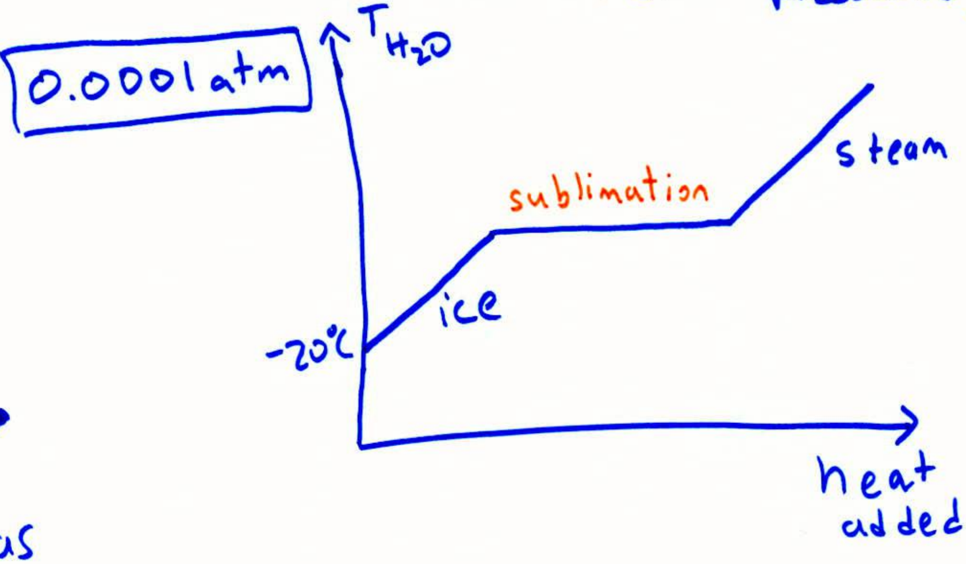
1. Phase Diagrams
2. Macroscopic variable & Ideal Gas Law
3. (Reversible) Gas Law Processes
4. (if time) Start $1^{st}$ Law / $E_{th}$, Q, W

## 1. Phase Diagrams

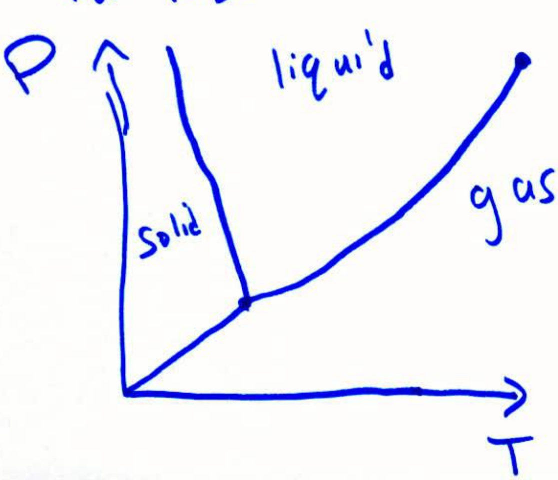
Suppose I have ice @ −20°C @ 1atm

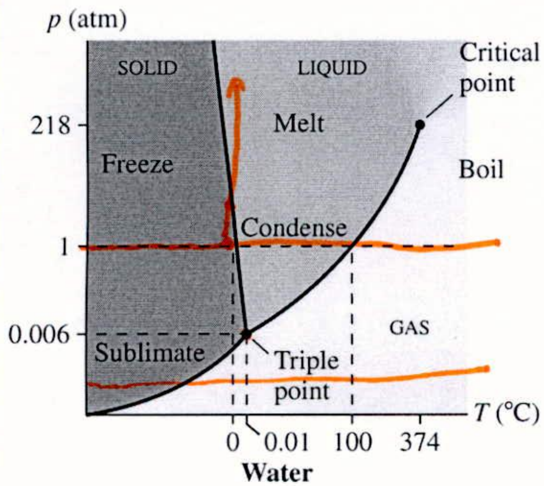


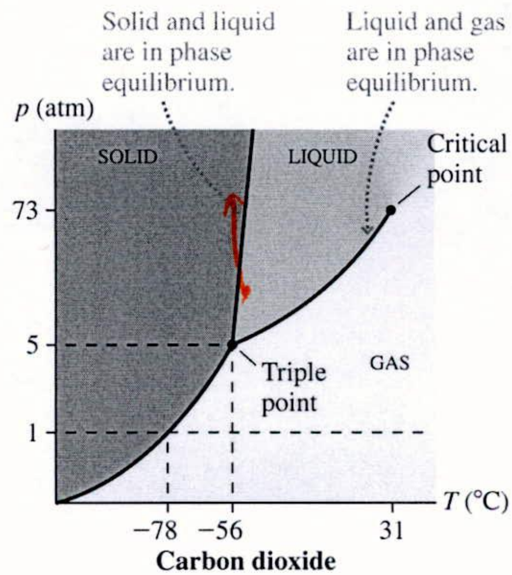

(looks diff. @ diff pressures)

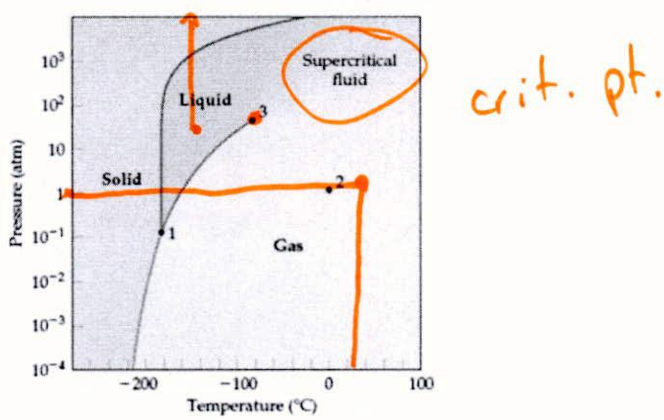



Phase diagram for $H_2O$






# Which of the following is NOT true?

A) The material is a fluid at 1 atm & room temp. True
B) The material sublimates at atmospheric pressure. False
C) The maximum density of the material is in its solid phase. True

## ② Ideal Gas Law

$$pV = nRT$$

number of moles

temperature

universal gas constant

volume

pressure

$R = 8.31\ J/mol\,K$

* same for all gases in thermal eq.
* units matter!
* density low/temp ~~below~~ above cond. point

| Macroscopic (Big) | vs. | Microscopic (small) |
| --- | --- | --- |
| Macro var: average over large system | | Micro var: makes sense for 1 molecule |
| $P, T, V, n, M_{tot}$ | | $v_1, q_1, m_1$ |
| $T \updownarrow v_{rms}$ | | |
| only defined in equilibrium | | |

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2 ways: $pV = nRT$ $\quad R = 8.31\ J/mol\cdot K$ (or $R = 0.0821\ \frac{L\cdot atm}{mol\cdot K}$)

$Pa\cdot m^3 = J$

$$pV = N k_B T$$

number of gas molecules

Boltzmann constant.

$k_B = 1.38\times10^{-23}\ J/K$

## *Question 17.2a* Ideal Gas Law I

Two identical cylinders at the same temperature contain the same gas. If A contains three times as much gas as B, which cylinder has the higher pressure?

a) cylinder A
b) cylinder B
c) both the same
d) it depends on temperature $T$

Ideal gas law: **PV = nRT**

Solve for pressure: $P = \frac{nRT}{V}$

For constant $V$ and $T$, the one with more gas the larger value of $n$) has the higher pressure $P$.

## *Question 17.2b* Ideal Gas Law II

Two identical cylinders at the same pressure contain the same gas. If A contains three times as much gas as B, which cylinder has the higher temperature?

a) cylinder A
b) cylinder B
c) both the same
d) it depends on the pressure $P$

Ideal gas law: **PV = nRT**

Solve for temperature: $T = \frac{PV}{nR}$

For constant $V$ and $P$, the one with less gas (the smaller value of $n$) has the higher temperature $T$.

## *Question 17.2b* Ideal Gas Law II

Two identical cylinders at the same pressure contain the same gas. If A contains three times as much gas as B, which cylinder has the higher temperature?

a) cylinder A

b) cylinder B

c) both the same

d) it depends on the pressure *P*

Ideal gas law: **PV = nRT**

Solve for temperature: $T = \frac{PV}{nR}$

For constant *V* and *P*, the one with less gas (the smaller value of *n*) has the higher temperature *T*.

## *Question 17.3* Soda Bottle

A plastic soda bottle is empty and sits out in the sun, heating the air inside. Now you put the cap on tightly and put the bottle in the fridge. What happens to the bottle as it cools?

a) it expands and may burst

b) it does not change

c) it contracts and the sides collapse inward

d) it is too dark in the fridge to tell

The air inside the bottle is warm, due to heating by the sun. When the bottle is in the fridge, the air cools. As the temperature drops, the pressure in the bottle also drops. Eventually, the pressure inside is sufficiently lower than the pressure outside (atmosphere) to begin to collapse the bottle.

$P_1 V_1 = P_2 V_2$

$V_1 = V_2$ $P_1 = P_2$ $n_1 R T_1 = n_2 R T_2$

Two identical rooms are connected by an open doorway. The temperatures in the two rooms are maintained at different values. Which room contains more air?

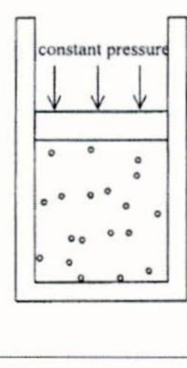
A) The room with the higher temperature.
B) The room with the lower temperature.
C) The room with the higher pressure.
D) Neither (they have the same pressure)
E) Neither (they have the same volume)

$P_0 V_f = n_0 R \frac{4}{3} T_0$ $P_0 V_0 = n_0 R T_0$

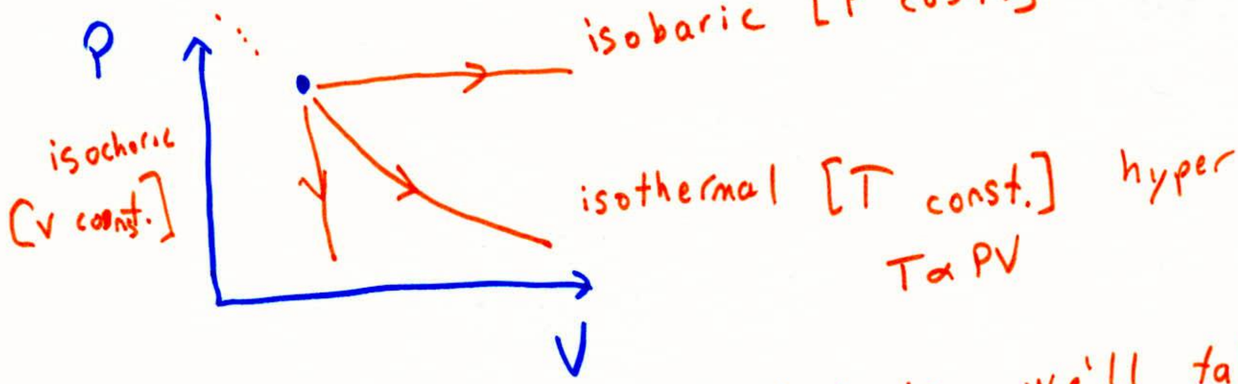
A container with a piston-lid contains an ideal gas at temperature $T_0$ = 27°C (300 K) and volume $V_0$. The temperature is increased to $T_f$ = 127°C while the pressure is kept constant. What is the new volume?

$T_f = \frac{4}{3} T_0$
$P =$

A) $V_0$
B) $(127/27)V_0$
C) $(4/3)V_0$
D) $(3/4)V_0$
E) None of these



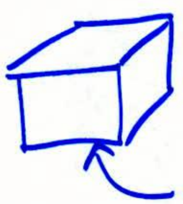
## (3) (Reversible) Gas Processes




quasi-static

1 more: adiabatic we'll talk about next time.

## (4) What is $E_{int}$?




$E_{thermal}$ is a part of this

$E_{int} = E_{th} = U$

(assumption: ignore other contributions to internal energy)

1st Law

$\Delta E_{th} = W + Q$

$\boxed{\text{Cons. of energy}}$

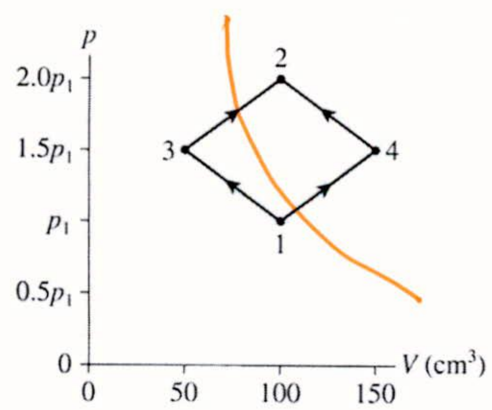
W: mehanical trans. of energy via work

Q: thermal transfer of energy via ~~hea~~ heat

$\boxed{W = W_{on} = -\int p\,dV}$

The figure shows two processes by which 1.0 g of Nitrogen gas moves form state 1 to state 2. The temperature of state 1 is 27°C. Which of the four points has the highest temperature?

- ~~A)~~ 1
- B) 2
- ~~C)~~ 3
- D) 4




$pV = \underline{n}RT$

$T \propto 200 p_1$

$T \propto (150)(1.5) p_1$

$= 225 p_1$