Thermo, Introduction

Knight Ch. 18.1-18.4, 18.6

Physics 2C, Spring 2025

Agenda Today (April 17, 2025)

- Thermo Basics
  - Molar Mass, moles vs mass, Avogadro's #
  - Equations of State, pV=nRT=NkT
- Temperature and Temperature Scales
- Thermal Expansion

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ATOMS and MOLECULES: Mass vs Moles

We use *molar mass* (and the periodic table) to convert # to/from mass.

$\frac{N}{V}$ is the number density; this is different from the mass density $\rho = \frac{M}{V}$

Clicker/Poll Question

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A sample of ^{56}Fe (iron-56) has mass M and volume V. A second sample, of ^{112}Cd (cadmium-112), has volume 2V and the same number of atoms. What is the mass of this sample of cadmium?

A. (1/4)M
B. (1/2)M
C. M
D. 2M
E. 4M

Equations of State; pV=NkT=nRT for Ideal Gases

Eq. Of State relates Macroscopic Variables. Ideal gas law is most famous.

Temperature Scales: Fahrenheit vs Celsius vs Kelvin

Kelvin is an absolute temperature scale (okay for pV=nRT); others are not.

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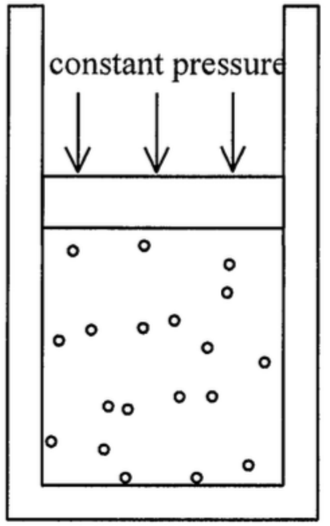
A container with a piston-lid contains an ideal gas at temperature T = 27^{0}C (300K) and volume V_0. The temperature is increased to T_f = 127^{0}C while the pressure is kept constant. What is the new volume?



A. V_0

B. (127/27) V_0

C. (4/3) V_0

D. (3/4) V_0

E. None of these

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Clicker/Poll Question

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)

More Ideal Gas Law Practice I

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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*

More Ideal Gas Law Practice II

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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*

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More Ideal Gas Law Practice III

Question 17.2c Ideal Gas Law III

Two cylinders at the same temperature contain the same gas. If B has twice the volume and half the number of moles as A, how does the pressure in B compare with the pressure in A?

a) $P_B = \frac{1}{2} P_A$

b) $P_B = 2 P_A$

c) $P_B = \frac{1}{4} P_A$

d) $P_B = 4 P_A$

e) $P_B = P_A$

More Ideal Gas Law Practice IV

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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

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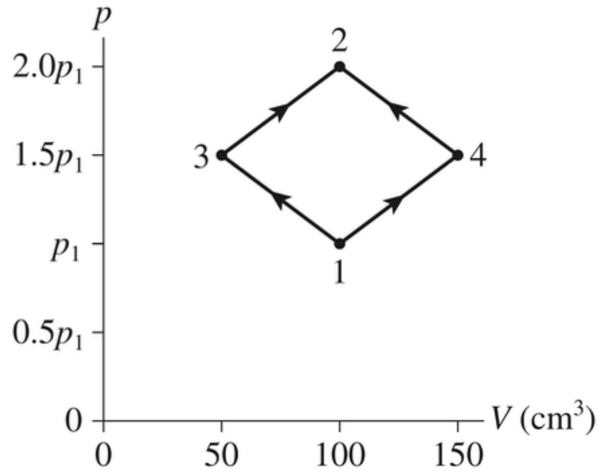
Example

The figure shows two processes by which 1.0 g of Nitrogen gas moves from state 1 to state 2. The temperature of state 1 is 27 degrees C.



A. Which of the four points has the highest temperature? [Answer without calculating all four temperatures!].

B. Find the highest temperature among the 4 points.

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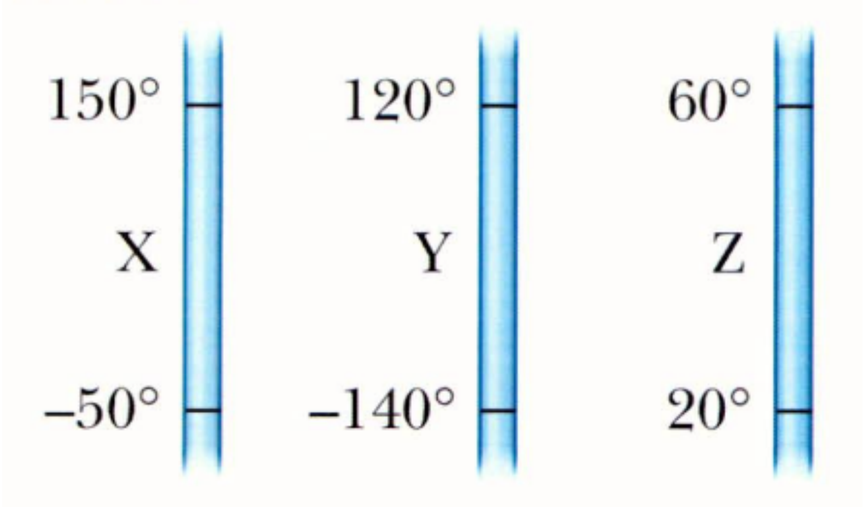
Clicker/Poll Question



The figure to the left shows three temperature scales with the freezing and boiling points of water indicated.

What's biggest: a temperature increase of 10°X, 10°Y, or 10°Z?

A. 10°X
B. 10°Y
C. 10°Z
D. Two or more of these quantities tie for the biggest increase.

Thermal Expansion

Heating up an object tends to increase its size; amount depends on material.

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Clicker/Poll Question

The coefficient of linear expansion for a special alloy of steel is 1.0 x 10^{-5} / K. What is the coefficient of linear expansion in 1/(deg. C)?

A. More than 1.0 x 10^{-5} / (deg C)
B. Less than 1.0 x 10^{-5} / (deg C)
C. Equal to 1.0 x 10^{-5} / (deg C)

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Clicker/Poll Question

You're installing a window of width 1m. The sides seem to have about 0.1mm of "give" overall (this is the thickness of a human hair). How much could the glass be heated and still fit in this space?

Take $\alpha_{glass} = 3 \times 10^{-6}$ / K

A. More than 50 deg C.

B. Equal to 50 deg C.

C. Less than 50 deg C.

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Clicker/Poll Question

The coefficient of linear expansion for a special alloy of steel is 1.0×10^{-5} / K. How much would you have to increase the temperature to increase the area of the plate by 1%?

A. 5 Kelvin

B. 10 Kelvin

C. 50 Kelvin

D. 100 Kelvin

E. None of the above

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Brass has a positive coefficient of thermal expansion α (where $\frac{\Delta L}{L} = \alpha \Delta T$). A ring (annulus) of brass is heated. Does the hole in the middle of the ring get larger or smaller in area?

A. Larger

B. Smaller

C. Stays the same