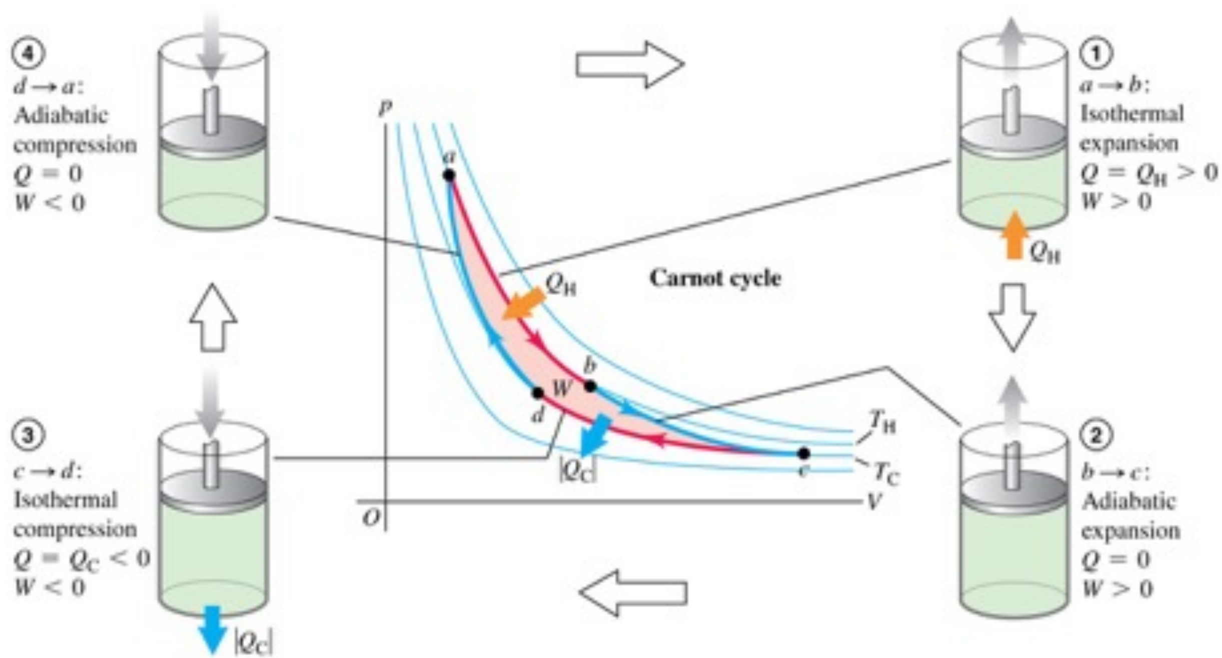
Lecture 8

PHYC 161 Fall 2016

Ex 20.3 Carnot

EXAMPLE 20.3 ANALYZING A CARNOT ENGINE II

Suppose 0.200 mol of an ideal diatomic gas ($\gamma = 1.40$) undergoes a Carnot cycle between 227°C and 27°C, starting at $p_a = 10.0 \times 10^5$ Pa at point a in the pV-diagram of Fig. 20.13. The volume doubles during the isothermal expansion step $a \rightarrow b$. (a) Find the pressure and volume at points a, b, c, and d. (b) Find Q, W, and ΔU for each step and for the entire cycle. (c) Find the efficiency directly from the results of part (b), and compare with the value calculated from Eq. (20.14).



Entropy and the second law

- The second law of thermodynamics can be stated in terms of entropy:

✓ **No process is possible in which the total entropy decreases, when all systems taking part in the process are included.**

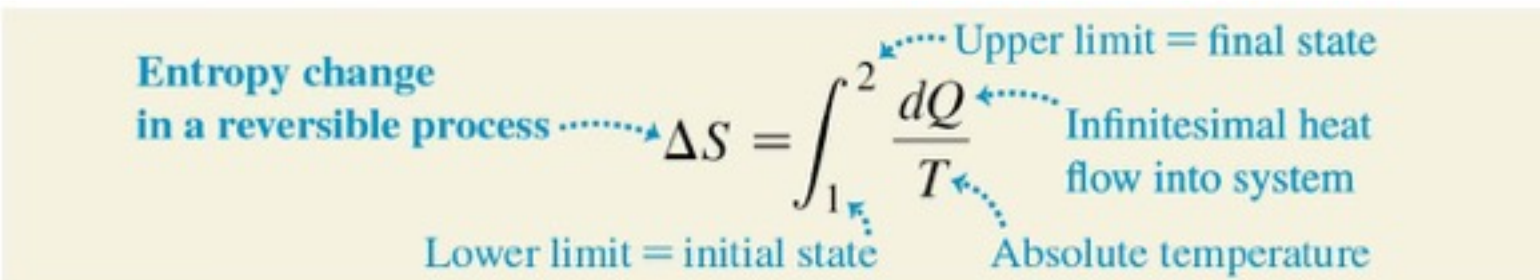
- The entropy of the ink–water system *increases* as the ink mixes with the water.

Entropy in reversible processes

- We introduce the symbol S for the entropy of the system, and we define the infinitesimal entropy change dS during an infinitesimal reversible process at absolute temperature T as:

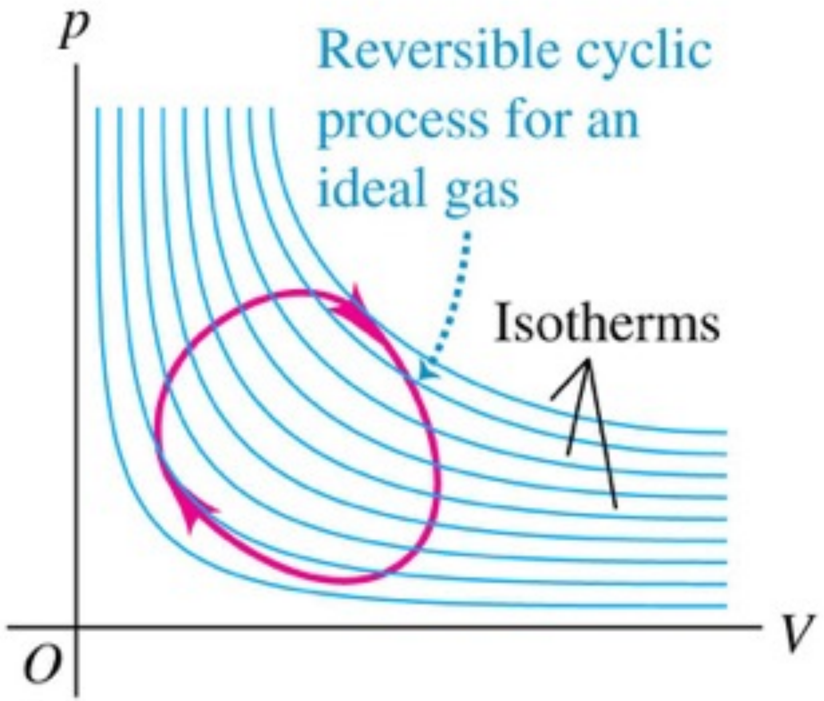
$$dS = \frac{dQ}{T} \quad \text{(infinitesimal reversible process)}$$

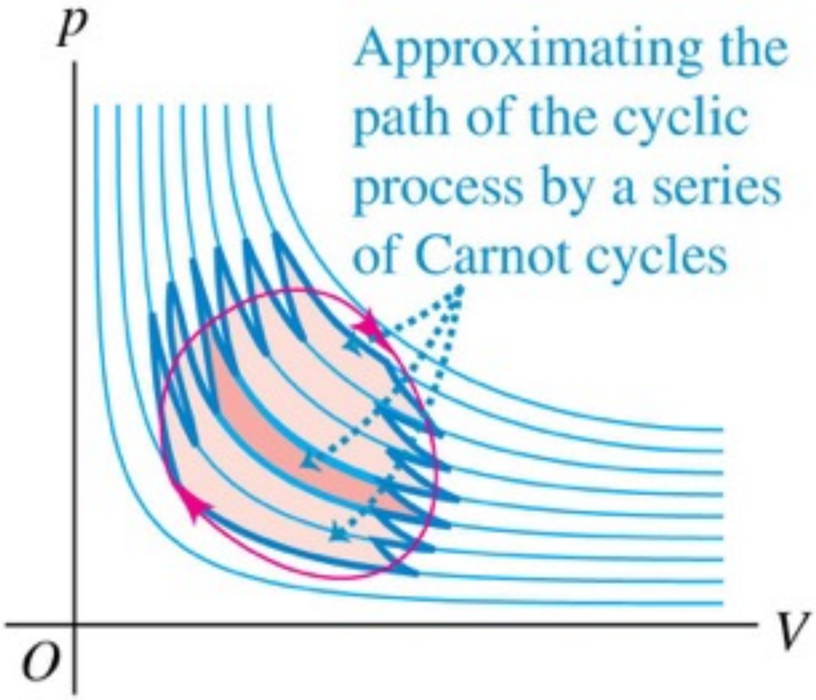
- The total entropy change over any reversible process is:



Entropy in cyclic processes

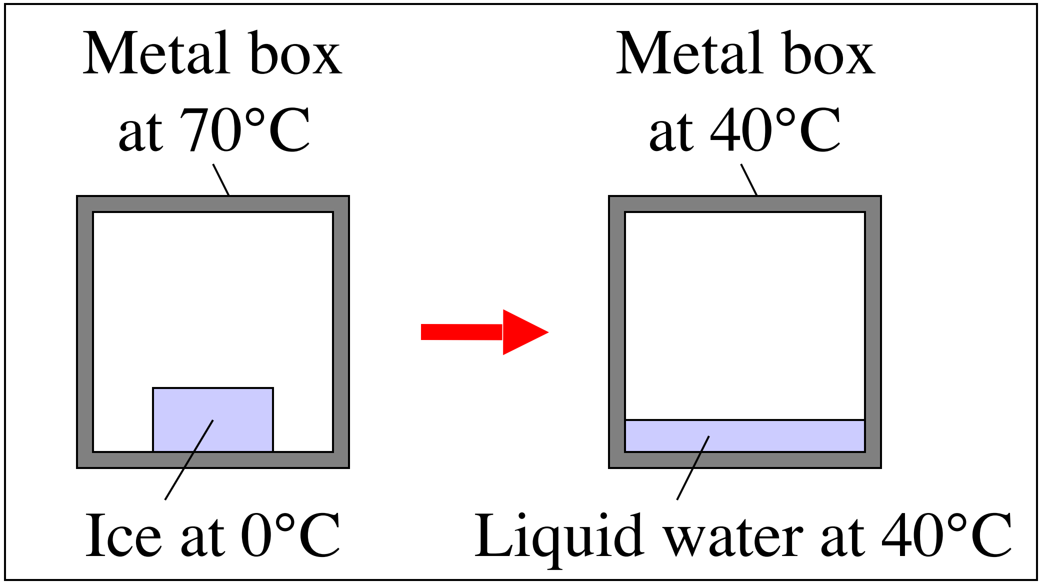
- The total entropy change in one cycle of any Carnot engine is zero.
- This result can be generalized to show that the total entropy change during *any* reversible cyclic process is zero.





Q20.8

You put an ice cube at 0°C inside a large metal box at 70°C. The ice melts and the entropy of the ice increases. Which statement is correct?



A. Entropy of the metal box is unchanged; total entropy increases.

B. Entropy of the metal box decreases; total entropy decreases.

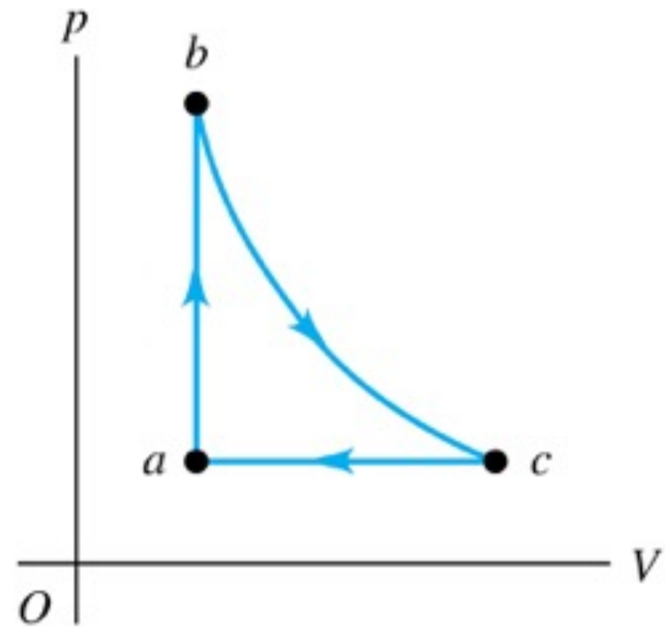
C. Entropy of the metal box decreases; total entropy is unchanged.

D. Entropy of the metal box decreases; total entropy increases.

E. none of the above

Q20.9

An ideal gas is taken around the cycle shown in this *p*-*V* diagram, from *a* to *b* to *c* and back to *a*. Process $b \rightarrow c$ is *isothermal*. What can you conclude about the net entropy change of the *gas* during the cycle?



A. It is positive.

B. It is negative.

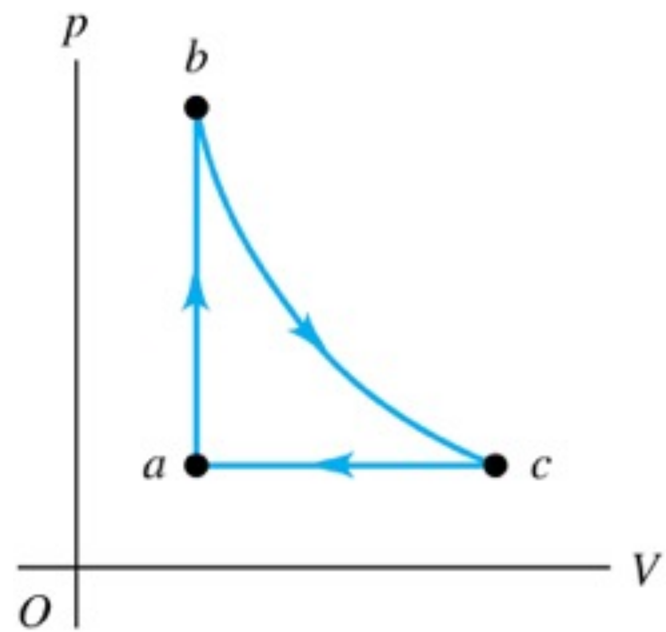
C. It is zero.

D. Two of A, B, and C are possible.

E. All three of A, B, and C are possible.

Q20.10

An ideal gas is taken around the cycle shown in this *p*-*V* diagram, from *a* to *b* to *c* and back to *a*. Process $b \rightarrow c$ is *isothermal*. What can you conclude about the net entropy change of the *gas and its environment* during the cycle?



A. It is positive.

B. It is negative.

C. It is zero.

D. Two of A, B, and C are possible.

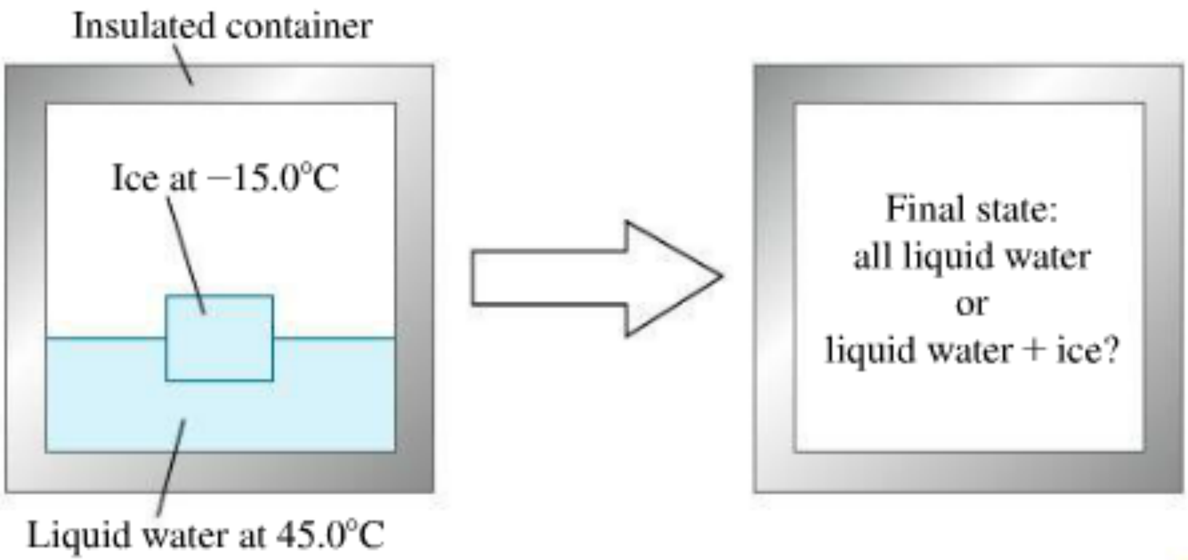
E. All three of A, B, and C are possible.

Ch 20 Bridging problem—calorimetry, entropy

BRIDGING PROBLEM ENTROPY CHANGES: COLD ICE

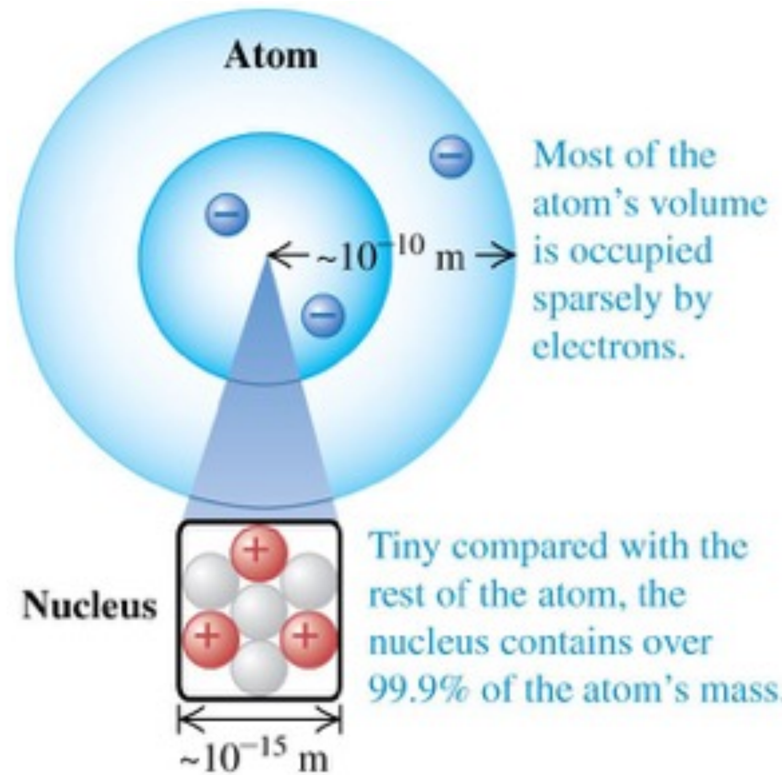
An insulated container of negligible mass holds 0.600 kg of water at 45.0°C. You put a 0.0500-kg ice cube at −15.0°C in the water (**Fig. 20.23**). (a) Calculate the final temperature of the water once the ice has melted. (b) Calculate the change in entropy of the system.

20.23 What becomes of this ice–water mixture?



Electric charge and the structure of matter

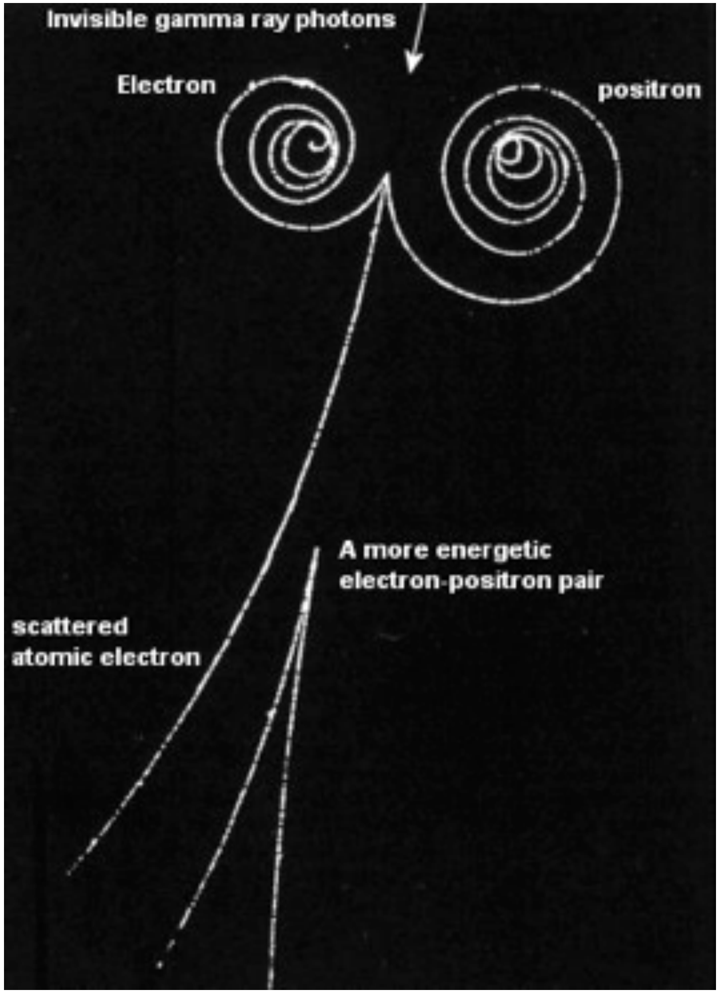
- The particles of the atom are the negative *electrons* (dark blue spheres in this figure), the positive *protons* (red spheres), and the uncharged *neutrons* (gray spheres).
- Protons and neutrons make up the tiny dense nucleus, which is surrounded by electrons.



Atomic number = # protons
Atomic mass = # protons + # neutrons

Conservation of charge - why?

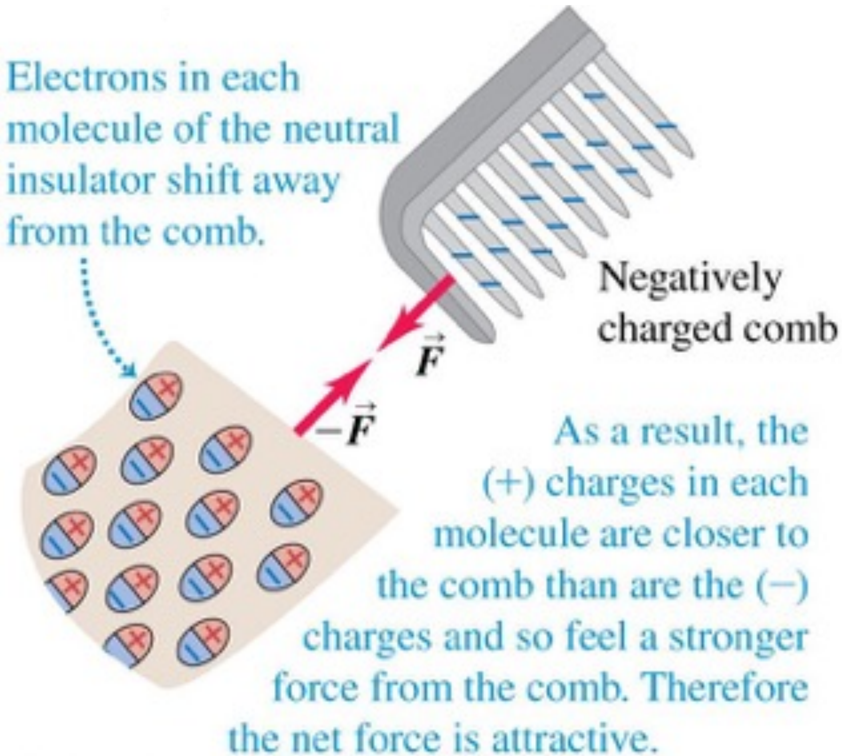
- The proton and electron have the same magnitude charge.
- The magnitude of charge of the electron or proton is a natural unit of charge. All observable charge is ***quantized*** in this unit.
- The universal **principle of charge conservation** states that the algebraic sum of all the electric charges in any closed system is constant.



pair production in a bubble chamber

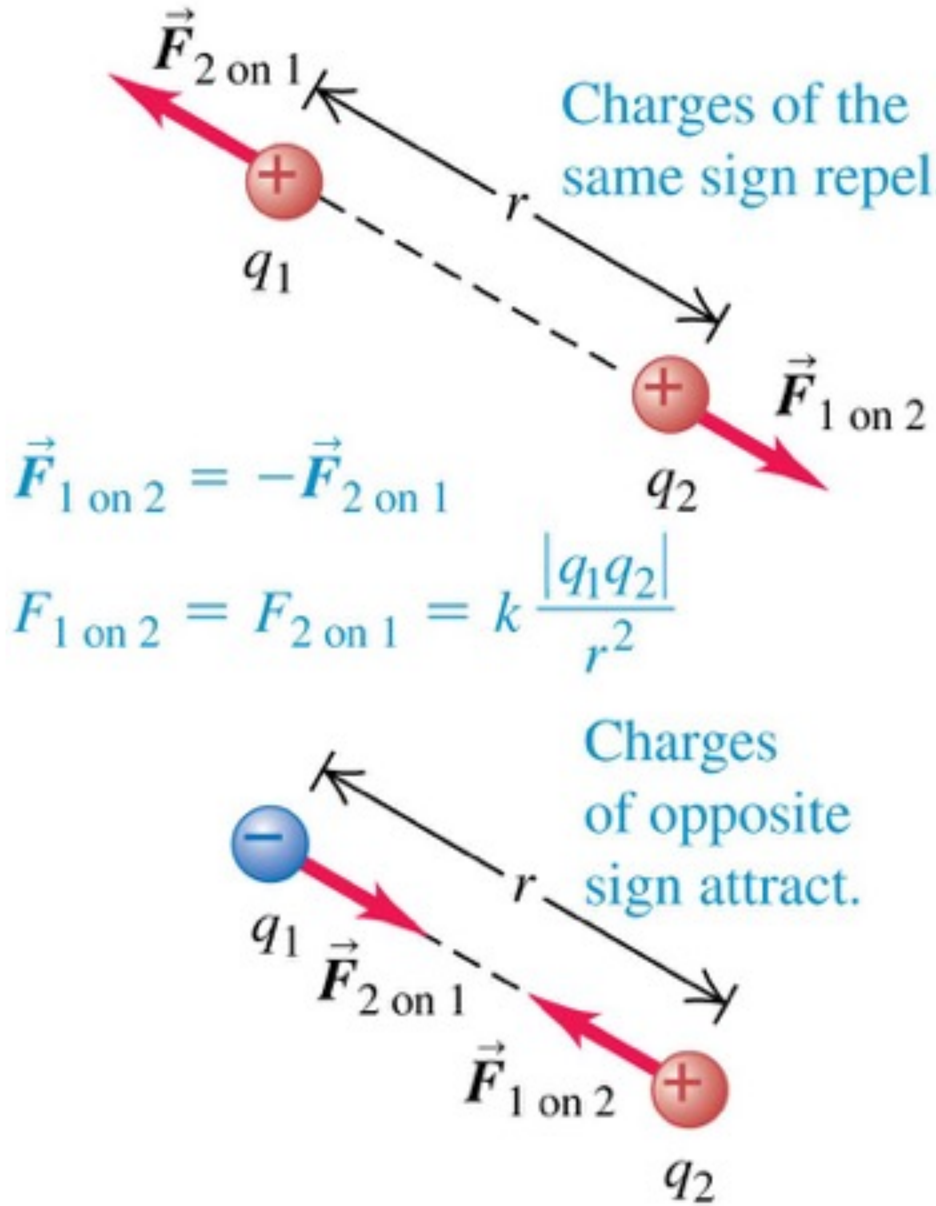
Electric forces on uncharged objects

- The negatively charged plastic comb causes a slight shifting of charge within the molecules of the neutral insulator, an effect called **polarization**.



Coulomb's Law

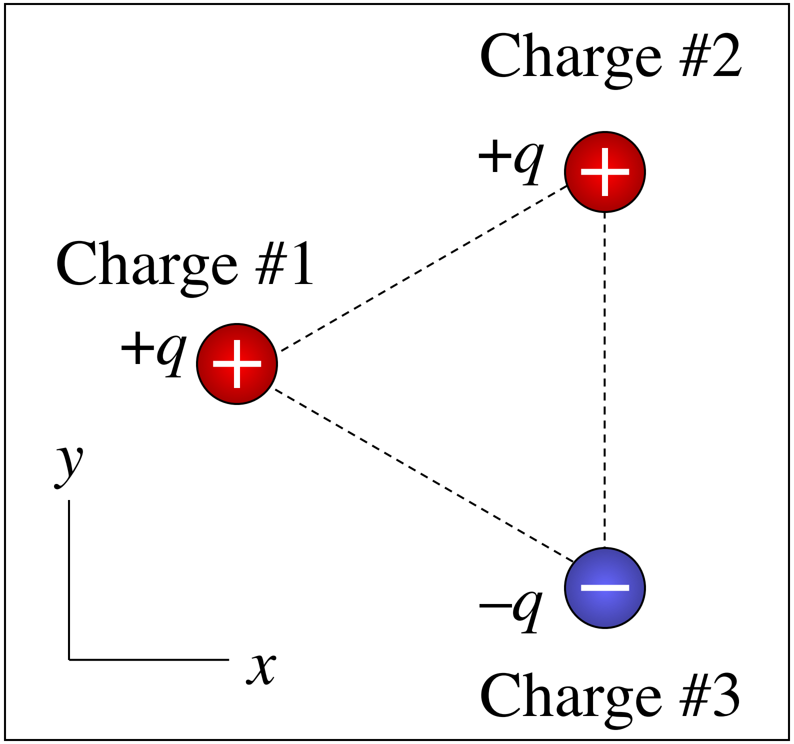
- **Coulomb's Law**: The magnitude of the electric force between two point charges is directly proportional to the product of their charges and inversely proportional to the square of the distance between them.



$$F = k\frac{|q_1 q_2|}{r^2}$$

Q21.3

Three point charges lie at the vertices of an equilateral triangle as shown. All three charges have the same magnitude, but charges #1 and #2 are positive ($+q$) and charge #3 is negative ($-q$). The net electric force that charges #2 and #3 exert on charge #1 is in



A. the $+x$-direction.

B. the $-x$-direction.

C. the $+y$-direction.

D. the $-y$-direction.

E. none of the above.