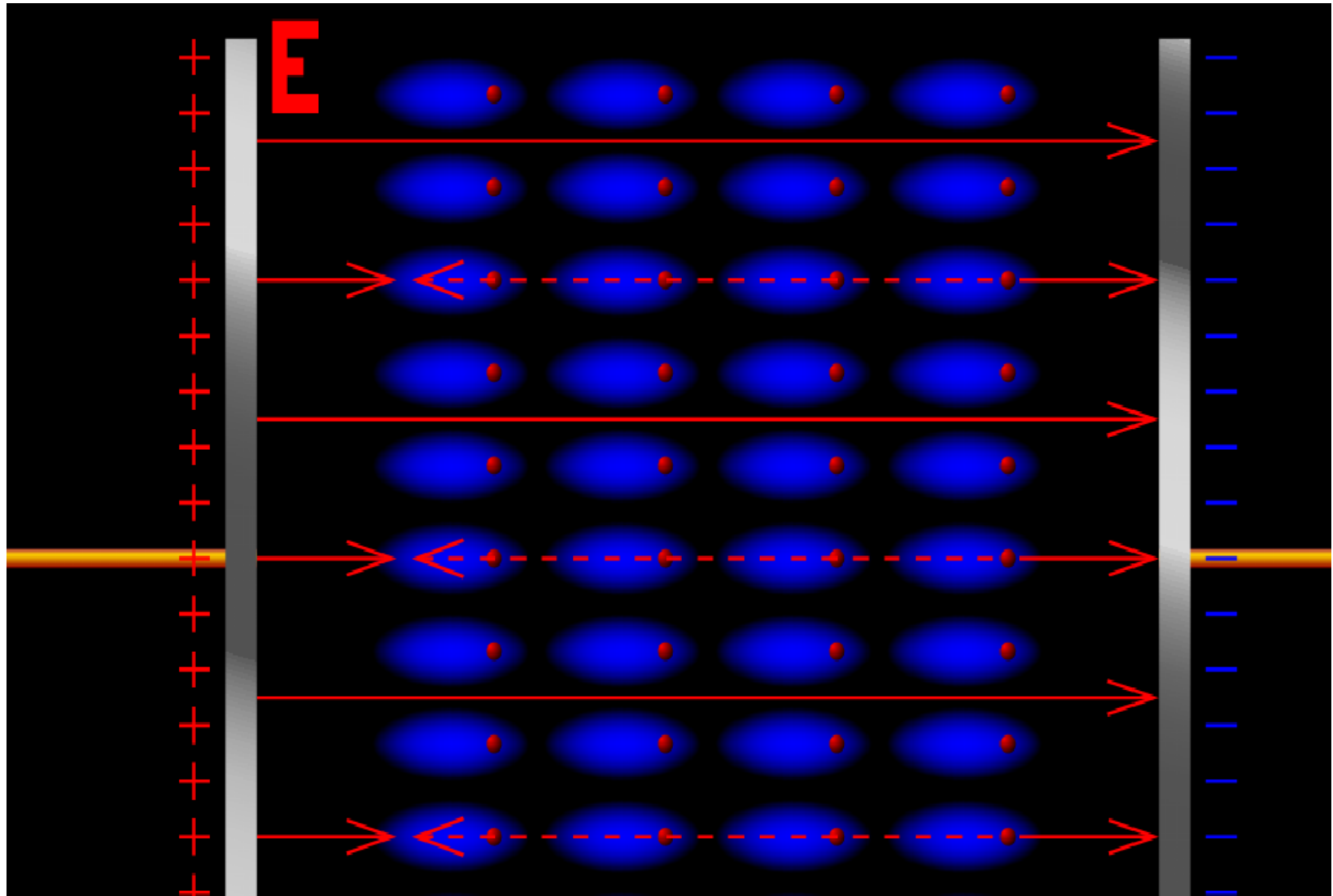
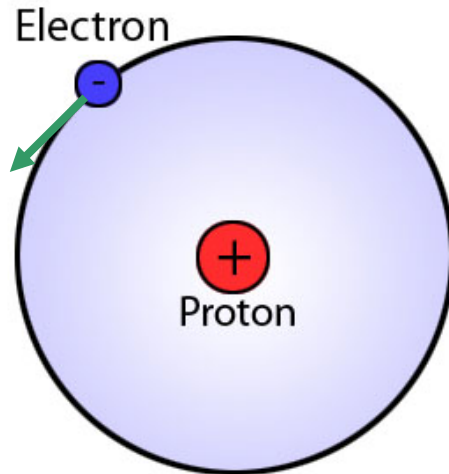


Electricidad

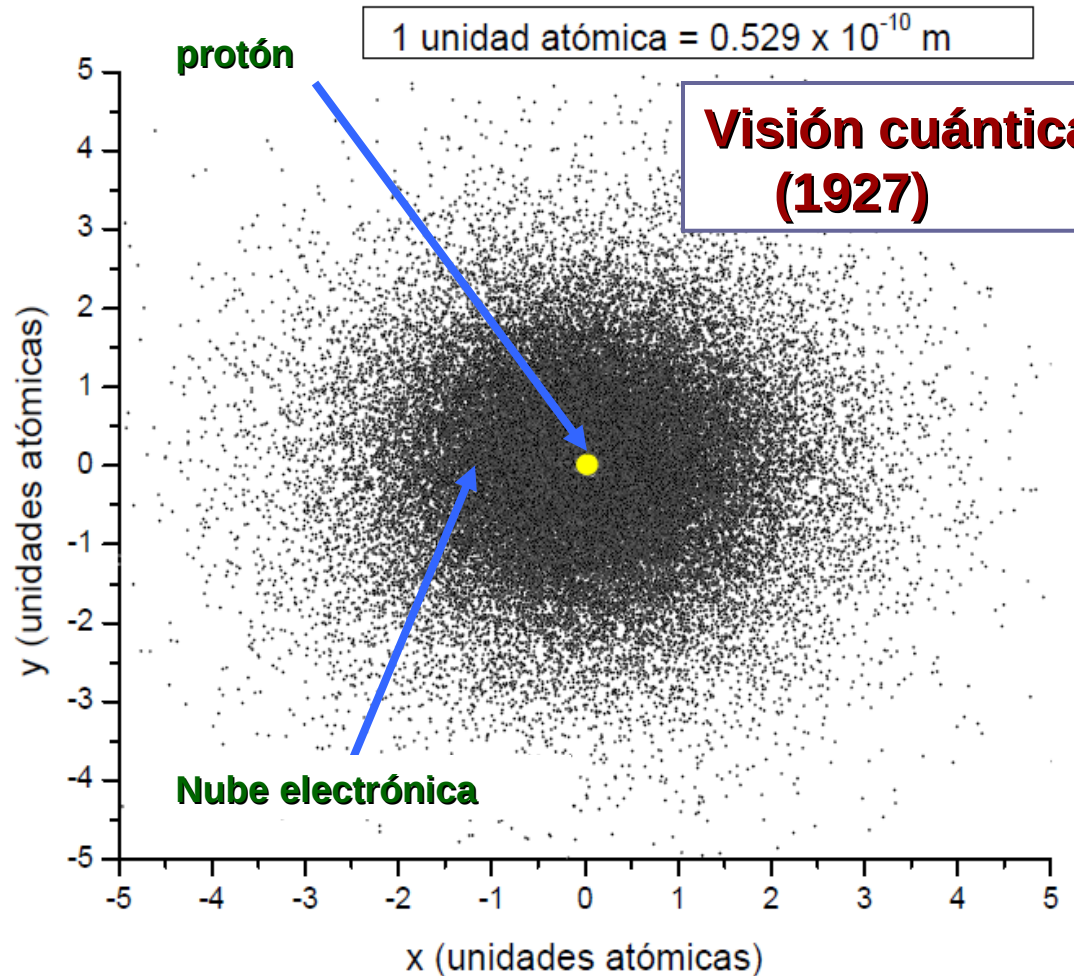


El átomo de hidrógeno

Visión Clásica (1913)



Analogía: imaginarse una gota de agua convertida en vapor. La masa es la misma pero distribuída sobre un mayor volumen espacial



Repaso

Tabla Periódica de los Elementos

Legend for periodic table:

- Alcalinos (Yellow)
- Alcalinotérreos (Orange)
- Metales de transición (Light Blue)
- Lantánidos (Light Purple)
- Actínidos (Light Green)
- Metales del bloque p (Dark Blue)
- No metales (Light Green)
- Gases nobles (Light Blue)

Physical States Legend:

- Solid (White)
- Liquid (Yellow)
- Gas (Red)
- Synthetic (Black)

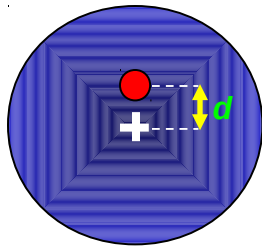
Note: Atomic masses in parentheses are those of the most stable or common isotope.

$$\rho = \frac{q}{\frac{4}{3}\pi a^3}$$

$$E = \frac{qd}{4\pi\epsilon_0 a^3}$$



E



Polarizabilidad Atómica

$$\vec{p} = \alpha \vec{E}$$

Los metales alcalinos son fácilmente polarizables.

Tabla Periódica de los Elementos

Legend:

- Alcalinos (Yellow)
- Alcalinotérreos (Light Yellow)
- Metales de transición (Pink)
- Lantánidos (Light Blue)
- Actínidos (Light Purple)
- Metales del bloque p (Cyan)
- No metales (Green)
- Gases nobles (Light Blue)
- Solid (White box with 'c')
- Liquid (Green box with 'Br')
- Gas (Red box with 'H')
- Synthetic (Black box with 'Tc')

| | | | | | | | | | | | | | | | | | |
|-------------------------------------|---------------------------------|-----------------------------------|---------------------------------|---------------------------------|--------------------------------|------------------------------------|-------------------------------|----------------------------------|--------------------------------|-------------------------------|--------------------------------|-----------------------------------|--------------------------------|----------------------------------|-------------------------------|-------------------------------|-------------------------------|
| 1 1 H Hidrógeno 1.00794 | 2 He Helio 4.002602 | | | | | | | | | | | 13 B Boro 10.811 | 14 C Carbono 12.0107 | 15 N Nitrógeno 14.00674 | 16 O Oxígeno 15.9994 | 17 F Flúor 18.998403 | 18 Ne Neón 20.1797 |
| 3 Li Litio 6.941 | 4 Be Berilio 9.012182 | | | | | | | | | | | 13 Al Aluminio 26.981538 | 14 Si Silicio 28.0855 | 15 P Fósforo 30.973761 | 16 S Azufre 32.066 | 17 Cl Cloro 35.463 | 18 Ar Argón 39.948 |
| 11 Na Sodio 22.989770 | 12 Mg Magnesio 24.3050 | 21 Sc Escandio 44.955910 | 22 Ti Titanio 47.867 | 23 V Vanadio 50.9415 | 24 Cr Cromo 51.9961 | 25 Mn Manganeso 54.938049 | 26 Fe Hierro 55.8457 | 27 Co Cobalto 58.933200 | 28 Ni Níquel 58.6934 | 29 Cu Cobre 63.546 | 30 Zn Zinc 65.409 | 31 Ga Galio 69.723 | 32 Ge Germanio 72.64 | 33 As Arsénico 74.92160 | 34 Se Selenio 78.96 | 35 Br Bromo 79.904 | 36 Kr Kriptón 83.798 |
| 19 K Potasio 39.0983 | 20 Ca Calcio 40.078 | 39 Y Itrio 88.90585 | 40 Zr Circonio 91.224 | 41 Nb Niobio 92.90638 | 42 Mo Molibdeno 95.94 | 43 Tc Technecio (98) | 44 Ru Rutenio 101.07 | 45 Rh Rodio 102.90550 | 46 Pd Paladio 106.42 | 47 Ag Plata 107.8682 | 48 Cd Cadmio 112.411 | 49 In Indio 114.818 | 50 Sn Estaño 118.710 | 51 Sb Antimonio 121.760 | 52 Te Teluro 127.60 | 53 I Yodo 126.90447 | 54 Xe Xenón 131.293 |
| 37 Rb Rubidio 85.4678 | 38 Sr Estroncio 87.62 | 57 to 71 Lantánidos | 72 Hf Hafnio 178.49 | 73 Ta Tántalo 180.9479 | 74 W Wolframio 183.84 | 75 Re Renio 186.207 | 76 Os Osmio 190.23 | 77 Ir Iridio 192.217 | 78 Pt Platino 195.078 | 79 Au Oro 196.96655 | 80 Hg Mercurio 200.59 | 81 Tl Talio 204.3833 | 82 Pb Plomo 207.2 | 83 Bi Bismuto 208.98038 | 84 Po Polonio (209) | 85 At Astatio (210) | 86 Rn Radón (222) |
| 55 Cs Cesio 132.90545 | 56 Ba Bario 137.327 | 89 to 103 Actínidos | 104 Rf Rutherfordio (261) | 105 Db Dubnio (262) | 106 Sg Seaborgio (266) | 107 Bh Bohrio (264) | 108 Hs Hassio (269) | 109 Mt Meitnerio (268) | 110 Ds Darmstadtio (271) | 111 Rg Roentgenio (272) | 112 Uub Ununbio (285) | 113 Uut Ununtrio (284) | 114 Uuq Ununquadio (289) | 115 | 116 | 117 | 118 |
| 87 Fr Francio (223) | 88 Ra Radio (226) | | | | | | | | | | | | | | | | |

Gases Nobles

Atomic masses in parentheses are those of the most stable or common isotope.

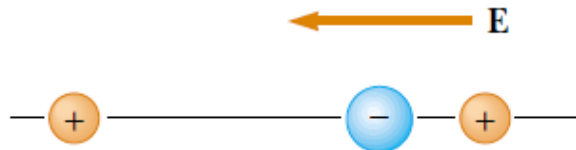
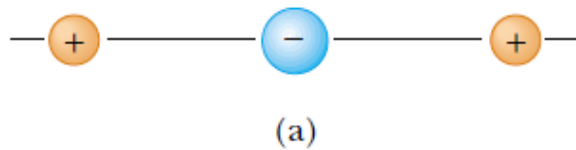
Alcalinos

In 1984 by the International Union of Pure and Applied Chemistry. The names of elements 112-118 are the Latin equivalents of those numbers.

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| | | | | | | | | | | | | | | |
|---------------------------|-------------------------------|--------------------------------------|--------------------------------|----------------------------|-------------------------------|--------------------------------|---------------------------------|---------------------------------|----------------------------------|---------------------------------|------------------------------|--------------------------------|-------------------------------|--------------------------------|
| Lantano 138.9055 | 58 Ce Cerio 140.116 | 59 Pr Praseodimio 140.90765 | 60 Nd Neodimio 144.24 | 61 Pm Prometio (145) | 62 Sm Samario 150.36 | 63 Eu Europio 151.964 | 64 Gd Gadolinio 157.25 | 65 Tb Terbio 158.92534 | 66 Dy Disprosio 162.500 | 67 Ho Holmio 164.93032 | 68 Er Erbio 167.259 | 69 Tm Tulio 168.93421 | 70 Yb Iterbio 173.04 | 71 Lu Lutecio 174.967 |
| 89 Ac Actinio (227) | 90 Th Torio 232.0381 | 91 Pa Protactinio 231.03688 | 92 U Uranio 238.02891 | 93 Np Neptunio (237) | 94 Pu Plutonio (244) | 95 Am Americio (243) | 96 Cm Curio (247) | 97 Bk Berkelio (247) | 98 Cf Californio (251) | 99 Es Einstenio (252) | 100 Fm Fermio (257) | 101 Md Mendelevio (258) | 102 No Nobelio (259) | 103 Lr Lawrencio (262) |

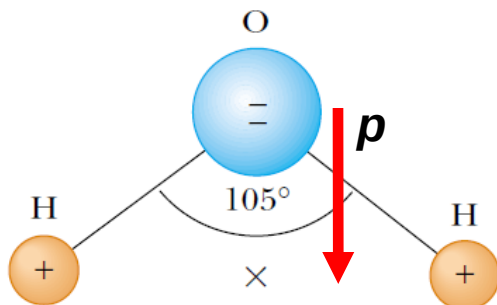
Polarización de moléculas



Molécula no polar

No polariza por igual en distintas direcciones:

p no es necesariamente paralelo a E

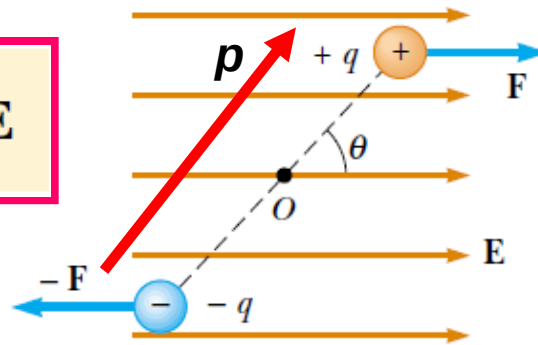


Molécula polar

momento dipolar permanente

Polarización de moléculas

$$\tau = \mathbf{p} \times \mathbf{E}$$

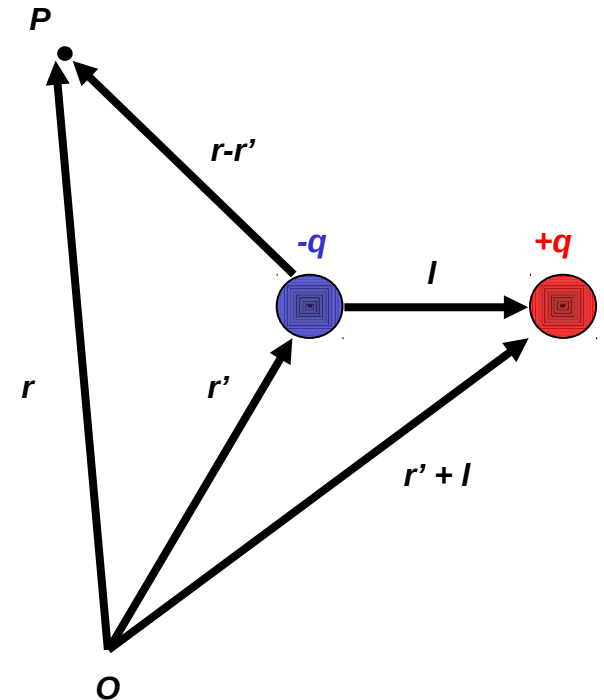


Una molécula polar se orienta ante un campo eléctrico externo

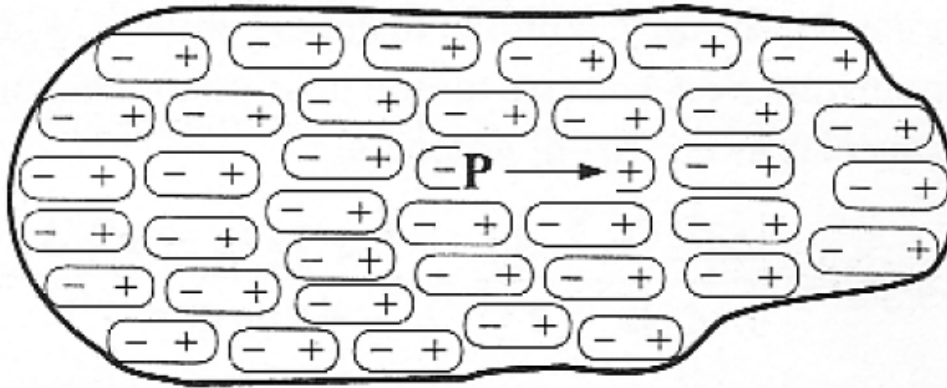
Recordemos

$$V(\mathbf{r}) = \frac{q}{4\pi\epsilon_0} \frac{(\mathbf{r} - \mathbf{r}') \cdot \mathbf{l}}{|\mathbf{r} - \mathbf{r}'|^3}$$

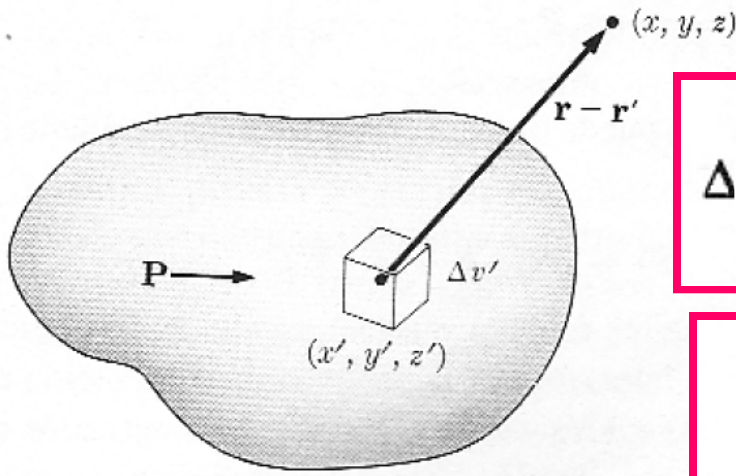
En el límite $l \ll |\mathbf{r} - \mathbf{r}'|$



Vector Polarización



$$\mathbf{P} = \frac{\Delta \mathbf{p}}{\Delta v}$$



Campo fuera de un medio dieléctrico

$$\Delta v(\mathbf{r}) = \frac{\Delta \mathbf{p} \cdot (\mathbf{r} - \mathbf{r}')}{4\pi\epsilon_0 |\mathbf{r} - \mathbf{r}'|^3} = \frac{\mathbf{P}(\mathbf{r}') \cdot (\mathbf{r} - \mathbf{r}') \Delta v'}{4\pi\epsilon_0 |\mathbf{r} - \mathbf{r}'|^3}$$

$$v(\mathbf{r}) = \frac{1}{4\pi\epsilon_0} \int_{V_0} \frac{\mathbf{P}(\mathbf{r}') \cdot (\mathbf{r} - \mathbf{r}') dv'}{|\mathbf{r} - \mathbf{r}'|^3}$$

Polarización

$$v(\mathbf{r}) = \frac{1}{4\pi\epsilon_0} \oint_{S_0} \frac{\mathbf{P} \cdot \mathbf{n} da'}{|\mathbf{r} - \mathbf{r}'|} + \frac{1}{4\pi\epsilon_0} \int_{V_0} \frac{(-\nabla' \cdot \mathbf{P}) dv'}{|\mathbf{r} - \mathbf{r}'|}$$

$$\sigma_P \equiv \mathbf{P} \cdot \mathbf{n} = P_n \quad \rho_P \equiv -\nabla \cdot \mathbf{P}$$

*densidades de
carga de polarización*

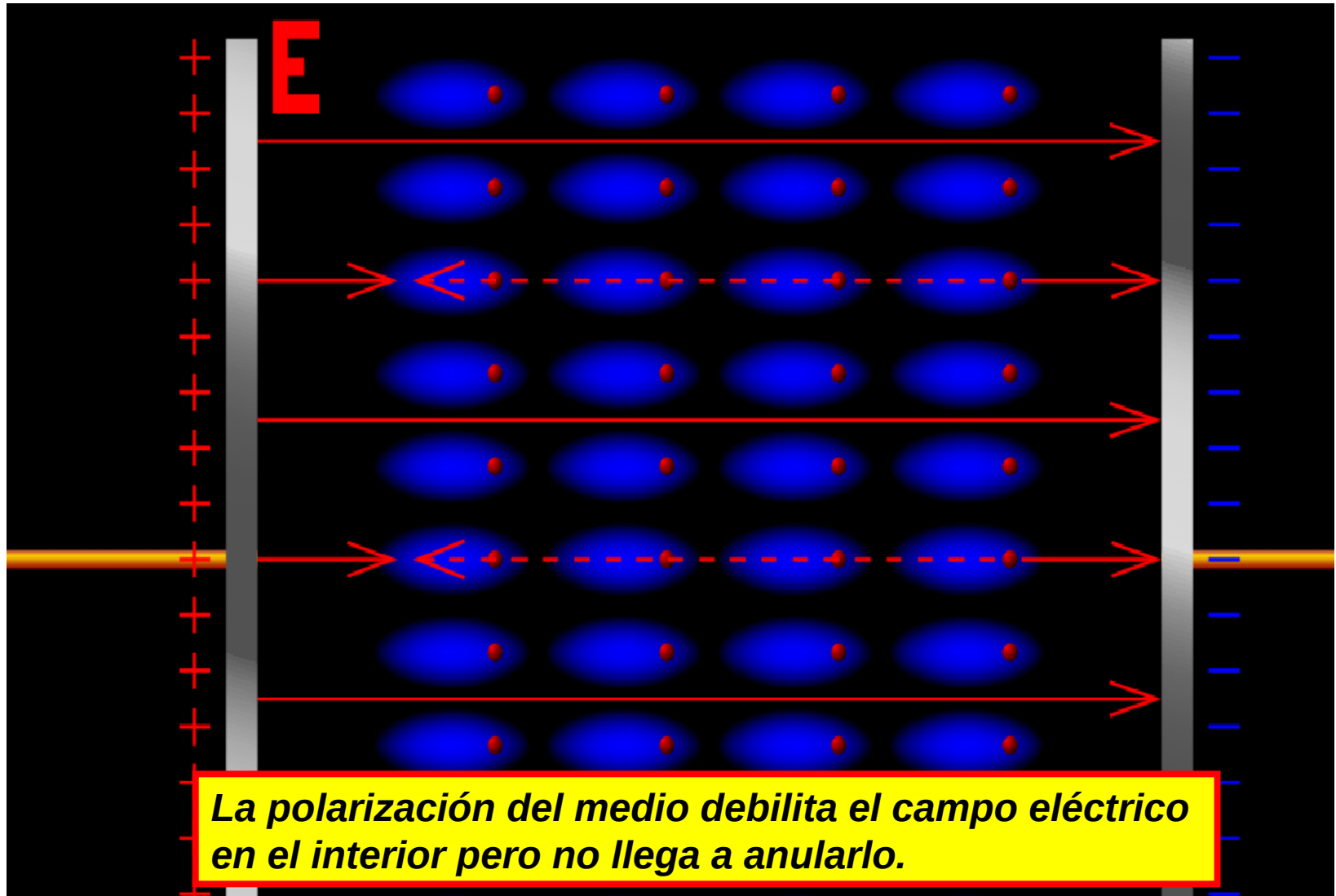
$$v(\mathbf{r}) = \frac{1}{4\pi\epsilon_0} \left[\oint_{S_0} \frac{\sigma_P da'}{|\mathbf{r} - \mathbf{r}'|} + \int_{V_0} \frac{\rho_P dv'}{|\mathbf{r} - \mathbf{r}'|} \right]$$

$$\mathbf{E}(\mathbf{r}) = \frac{1}{4\pi\epsilon_0} \left[\iint_{S_0} \sigma_P \frac{(\mathbf{r} - \mathbf{r}')}{|\mathbf{r} - \mathbf{r}'|^3} da' + \int_{V_0} \rho_P \frac{(\mathbf{r} - \mathbf{r}')}{|\mathbf{r} - \mathbf{r}'|^3} dv' \right]$$

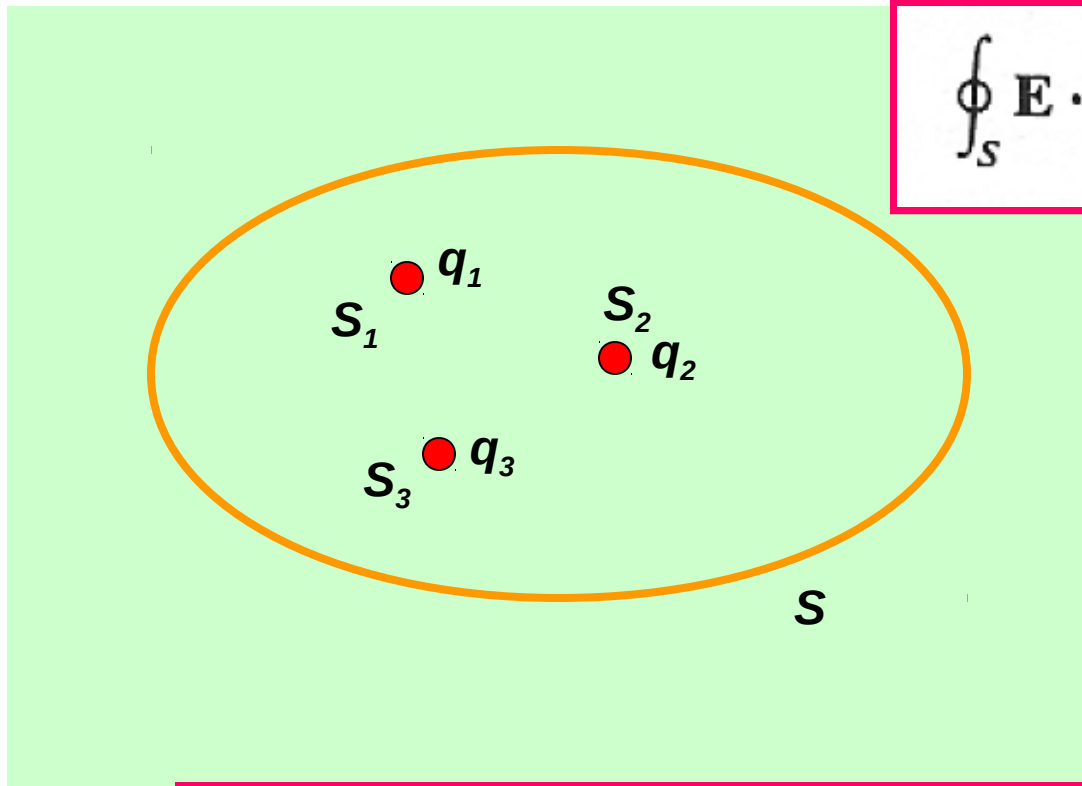
$$Q_P = \int_{V_0} (-\nabla' \cdot \mathbf{P}) dv' + \oint_{S_0} \mathbf{P} \cdot \mathbf{n} da'$$

Carga de polarización

Polarización



Ley de Gauss para dieléctricos



$$\oint_S \mathbf{E} \cdot \mathbf{n} \, da = \frac{1}{\epsilon_0} (Q + Q_P)$$

$$Q = q_1 + q_2 + q_3$$

$$Q_P = \int_{S_1+S_2+S_3} \mathbf{P} \cdot \mathbf{n} \, da + \int_V (-\nabla \cdot \mathbf{P}) \, dv$$

Ley de Gauss para dieléctricos

$$Q_P = -\oint_S \mathbf{P} \cdot \mathbf{n} da$$

$$\oint_S (\epsilon_0 \mathbf{E} + \mathbf{P}) \cdot \mathbf{n} da = Q$$

$$\mathbf{D} = \epsilon_0 \mathbf{E} + \mathbf{P}$$

Vector desplazamiento

$$\oint_S \mathbf{D} \cdot \mathbf{n} da = Q$$

Ley de Gauss para dieléctricos

$$\nabla \cdot \mathbf{D} = \rho$$

Forma diferencial