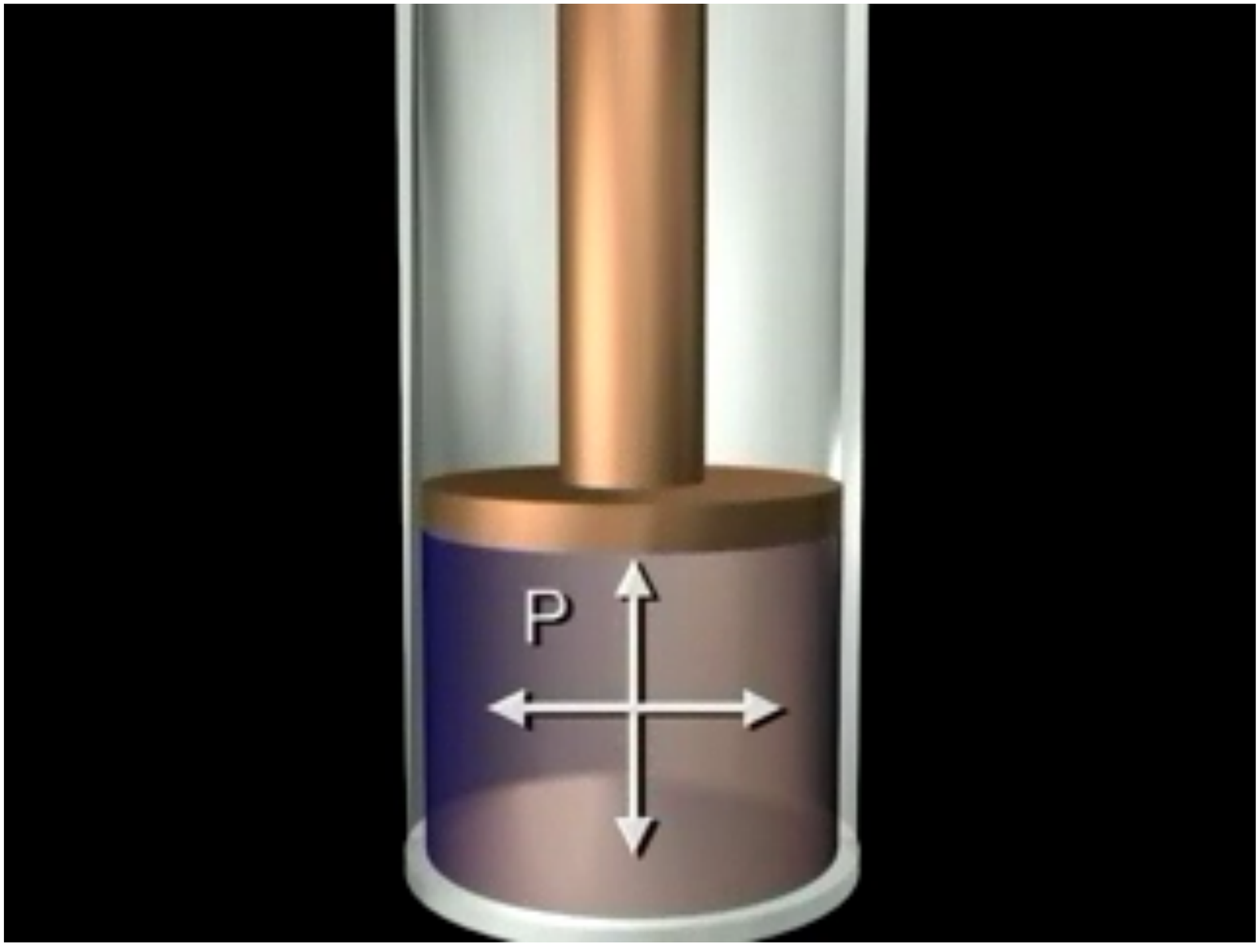
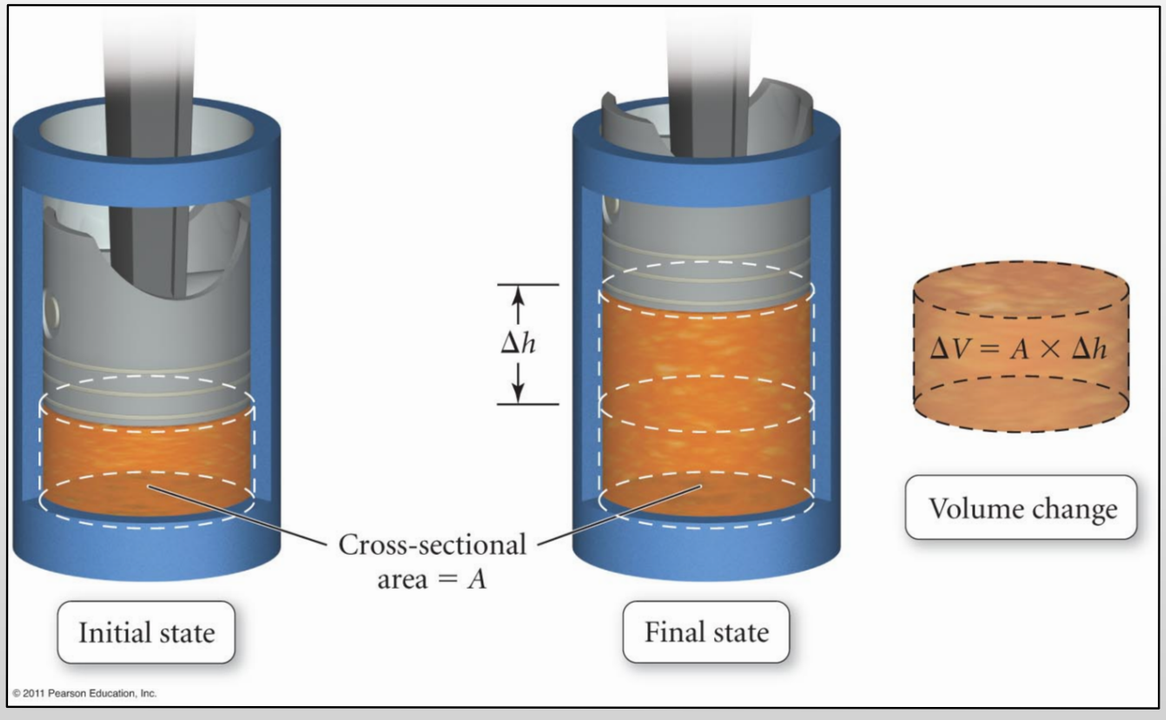

P

Pressure –Volume Work:

Moving of a Piston against External Pressure



$w = F \cdot D$

$P = F / A$ or $F = P \cdot A$

$\Rightarrow w = P \cdot A \cdot D$

$w = P \cdot A \cdot \Delta h$

$w = P \cdot \Delta V$

The system is "doing" work, i.e., w must be negative

$$w = - P \cdot \Delta V$$

What is the work when a balloon is expanded from 0.1L to 1.85L against a pressure of 1 atm ?

Find P, ΔV $\Rightarrow$ w

$$P = 1\,atm \cdot \frac{101325\,Pa}{1\,atm} = 101325\,Pa$$

$$1\,Pa = 1\,kg\,m^{-1}s^{-2}$$

$$\Delta V = V_f - V_i = 1.85L - 0.100L = 1.75L = 1\,dm^3$$

$$L \hat{=} dm^3 \qquad = 1\,dm^3 \cdot \frac{1\,m^3}{1000\,dm^3} = 1.75 \cdot 10^{-3}\,m^3$$

$$w = -P\Delta V = -101325\,Pa \cdot 1.75 \cdot 10^{-3}\,m^3$$

$$kg\,m^{-1}s^{-2}$$

$$w = -177\,kg\,m^2s^{-2} = -177\,J$$

Example: Total energy change

A chemical reaction between two gases releases 110 kJ. The work that is done on the surroundings is 1700 J. Calculate ΔE. Is the reaction endo- or exothermic?

$$\Delta E = q + w$$

$$q = -110\,kJ \cdot \frac{1000\,J}{1\,kJ} = -110000\,J$$

$$w = -1700\,J$$

$$\Delta E = -110000\,J + (-1700\,J) = -111700\,J$$

$$= -112\,kJ$$

Enthalpy H of a system is the sum of internal energy and product of pressure and volume

$$H = E + PV$$

$$\Delta H = \Delta E + P\Delta V \quad \text{(at constant pressure)}$$

since $\Delta E = q + w$

$$\Delta E = q_p + w \quad \text{(at const. pressure)}$$

$$w = -P\Delta V \Leftrightarrow P\Delta V = -w$$

$$\Delta H = (q_p + w) - w$$

$$\Delta H = q_p$$

What is the difference between ΔE and ΔH?

ΔE is the measure of <u>all</u> energy exchanged with the surroundings (heat and work)

ΔH measure of <u>heat</u> exchanged with the surroundings at constant pressure

State whether ΔH is less than, equal to or larger than ΔE

a). an ideal gas is cooled at constant pressure

$\Delta H = \Delta E + P\Delta V$ $P\Delta V$ negative b/c volume decreases

$\Delta H < \Delta E$

b). a mixture of gases undergoes an exothermic reaction in a container of fixed volume

$\Delta H = \Delta E$ b/c $\Delta V = 0$

c). a solid yields a mixture of gases in an exothermic reaction that takes place in a container of variable volume

$\Delta H > \Delta E$ b/c volume increases

The combustion of acetone has the following chemical reaction:

$$C_3H_6O(\ell) + 4O_2(g) \rightarrow 3CO_2(g) + 3H_2O(g)$$

$\Delta H^\circ_{rxn} = -1790\ kJ/mol$

→ standard conditions
273.15 K
100 kPa / 1 bar

$V = 177\ mL$; $d = 0.788\ g/mL$

How much heat is released by 1 b complete combustion?

Concept:

volume → mass → moles → q_p

$$mass = 177\ mL \cdot \frac{0.788\ g}{1\ mL} = 139.5\ g$$

$M_w = 58.08\ g/mol$

$$moles = 139.5\ g \cdot \frac{1\ mol}{58.08\ g} = 2.40\ mol$$

$$q_p = \Delta H = n \cdot \Delta H^\circ_{rxn} = 2.40\ mol \cdot (-1790\ kJ/mol)$$

$$= -4296\ kJ$$