

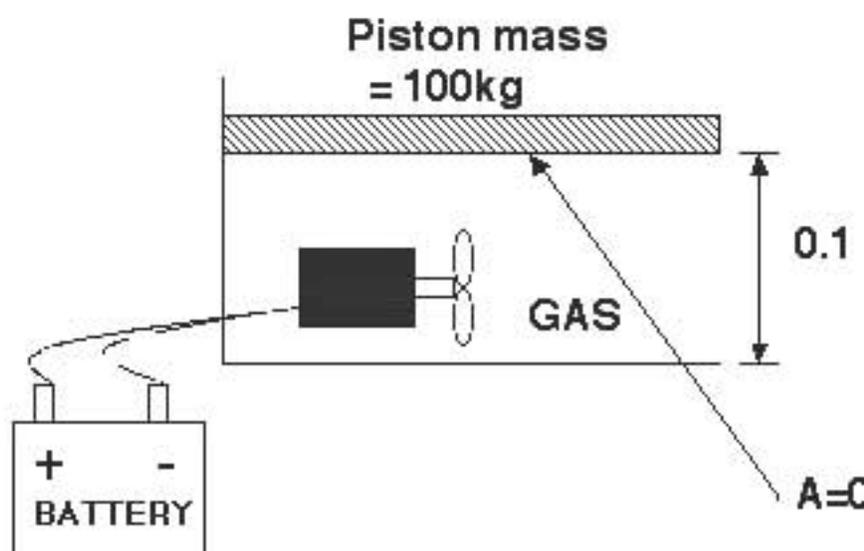
Chapter 4 Question #5

An electric motor draws 3 A from the 12 V battery shown below. After 50 seconds of operation the 100 kg piston is raised a distance of 0.1 m. The area of the piston, which can be considered to move without friction, is 0.05 m², and the atmospheric pressure $P_{\text{atm}} = 10^5 \text{ N/m}^2$.

During the 50s period what is the relationship between the

- work input to the gas from the motor W_i
- work to raise the piston W_p
- work done against the pressure of the atmosphere W_a
- work done by the gas in the chamber W_g ?

- 1) $W_g > W_i > W_p > W_a$
- 2) $W_g > W_a > W_i > W_p$
- 3) $W_i > W_g > W_p > W_a$
- 4) $W_i > W_g > W_a > W_p$
- 5) $W_a > W_g > W_p > W_i$
- 6) $W_a > W_g > W_i > W_p$



Chapter 4 Question 5 Answer:

$$(4) W_i > W_g > W_a > W_p$$

Work input from the motor, W_i :

$$\text{Power input} = 3\text{A} (12\text{V}) = 36 \text{ J/s}, \text{ Time} = 50 \text{ s}$$

$$W_i = 36 \text{ J/s} (50\text{s}) = 1800 \text{ J}$$

Work to raise the piston, W_p :

$$W_p = \text{Force (distance)} = 100\text{kg} (9.8\text{m/s}^2) 0.1\text{m} = 98 \text{ J}$$

Work to push against the atmosphere, W_a :

$$W_a = \text{Force (distance)} = 105 \text{ N/m}^2 (0.05 \text{ m}^2) 0.1\text{m} = 500 \text{ J}$$

Work done by the gas, W_g :

$$W_g = W_p + W_a = 598 \text{ J}$$

(The net work of the system = $598 \text{ J} - 1800 \text{ J} = -1202 \text{ J}$, thus in sum work is done on the system.)

Therefore $W_i > W_g > W_a > W_p$

It is possible to arrive at a different answer if you put a negative sign in front of the work done by the motor. This is a very minor error. Technically, I asked for the work input, so the sign was specified by the word "input", so you shouldn't put a negative in front of it.