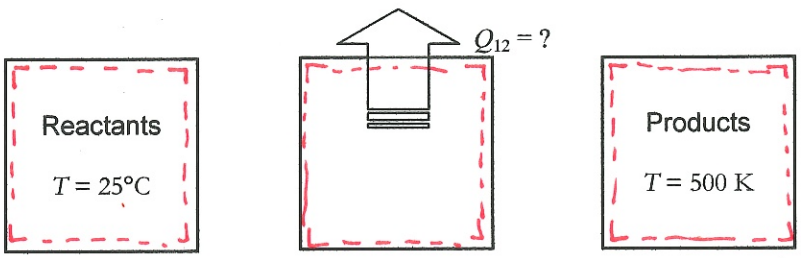
Example

Let us reconsider the dubious bovine flatulence energy source problem. As before, the proposed process combusts methane (CH_4) with air and produces 90% CO_2, 10% CO and no O_2 in the products. This time, however, the reaction occurs in a **closed system at constant volume**. The methane and the air are at 1 bar and 25°C before the combustion process, producing products at T = 500 K after the reaction. Find the amount of heat transfer out (in kJ) for the process.



CoE

$$E_2 - E_1 = -Q_{12,out} - W_{out} \quad (W_{out} \to 0 \text{ (CONST } V)) \longrightarrow \bar{U}_2 - \bar{U}_1 = -Q_{12} \longrightarrow Q_{12,out} = U_1 - U_2$$

$$\boxed{Q_{12,out} = \sum_{RXT} n_i \bar{u}_i - \sum_{PROD} n_i \bar{u}_i} \quad (1)$$

HOW DO WE DEAL W/ $\bar{u}_i$?

$$\bar{h} \equiv \bar{u} + p\bar{v} \Rightarrow \bar{u} = \bar{h} - p\bar{v}$$

ALSO

$$\bar{h} = \bar{h}_f^\circ + \bar{h}(T) - \bar{h}(298K)$$

$$\therefore \bar{u} = \bar{h}_f^\circ + \bar{h}(T) - \bar{h}(298K) - p\bar{v}$$

$$= \bar{h}_f^\circ + (\bar{u}(T) + p\bar{v}) - (\bar{u}(298K) + p\bar{v}(298K)) - p\bar{v}$$

$$\bar{u} = \bar{h}_f^\circ + (\bar{u}(T) - \bar{u}(298)) - p\bar{v}(298K)$$

$$p\bar{v}(298K) = \bar{R}T_{=298K}!$$

$$\boxed{\bar{u} = (\bar{h}_f^\circ - \bar{R}T_{298K}) + \bar{u}(T) - \bar{u}(298K)}$$

REMEMBER CHEM RXN:

$$CH_4 + 1.93O_2 + 7.33N_2 \rightarrow 0.9CO_2 + 0.1CO + 2H_2O + 7.33N_2$$

EQ (1) BECOMES

$$Q_{12,out} = (1)\bar{u}_{CH_4}\Big|_1 + (1.93)\bar{u}_{O_2}\Big|_1 + (7.33)\bar{u}_{N_2}\Big|_1$$

$$- (0.9)\bar{u}_{CO_2}\Big|_2 - (0.1)\bar{u}_{CO}\Big|_2 - (2)\bar{u}_{H_2O}\Big|_2 - (7.33)\bar{u}_{N_2}\Big|_2$$

$$= (1)\left[-74,850 + 0 - \left(8.314 \frac{kJ}{kmol\,K}\right)(298K)\right]$$

$$+ (1.93)\left[0 + \sim\sim - \sim\sim - (8.314)(298)\right]$$

$$+ (7.33)\left[0 + \sim\sim - \sim\sim - (8.314)(298)\right]$$

$$- (0.9)\left[-398,520 + 13,521 - 6885 - (8.314)(298K)\right]$$

$$- (0.1)\left[-110,530 + 10,443 - 6190 - (8.314)(298K)\right]$$

$$- (2)\left[-241,820 + 12,671 - 7425 - (8.314)(298)\right]$$

$$- (7.33)\left[0 + 10,423 - 6190 - (8.314)(298)\right]$$

$$= \boxed{726,217 \text{ kJ}}$$

(PER MOLE of CH_4)

i	T [K]	$\Delta\bar{h}_f^0$ [kJ/kmol]	$\bar{u}(T)$ [kJ/kmol]	$\bar{u}$(298K) [kJ/kmol]
$CO_2)_2$	500	-393,520	13,521	6885
$CO)_2$	500	-110,530	10,443	6190
$H_2O)_2$	500	-241,820	12,671	7425
$N_2)_2$	500	0	10,423	6190
$CH_4)_1$	298	-74,850	—	—
$O_2)_1$	298	0	—	—
$N_2)_1$	298	0	—	—