Paper C2OrG-1

Applications of Ortho-Para Hydrogen Catalyst

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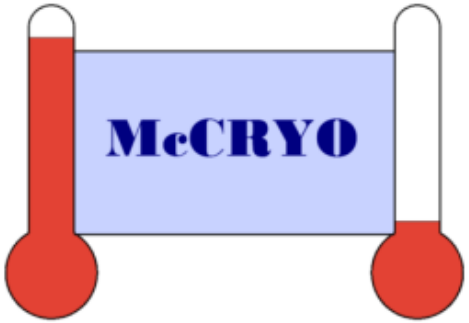
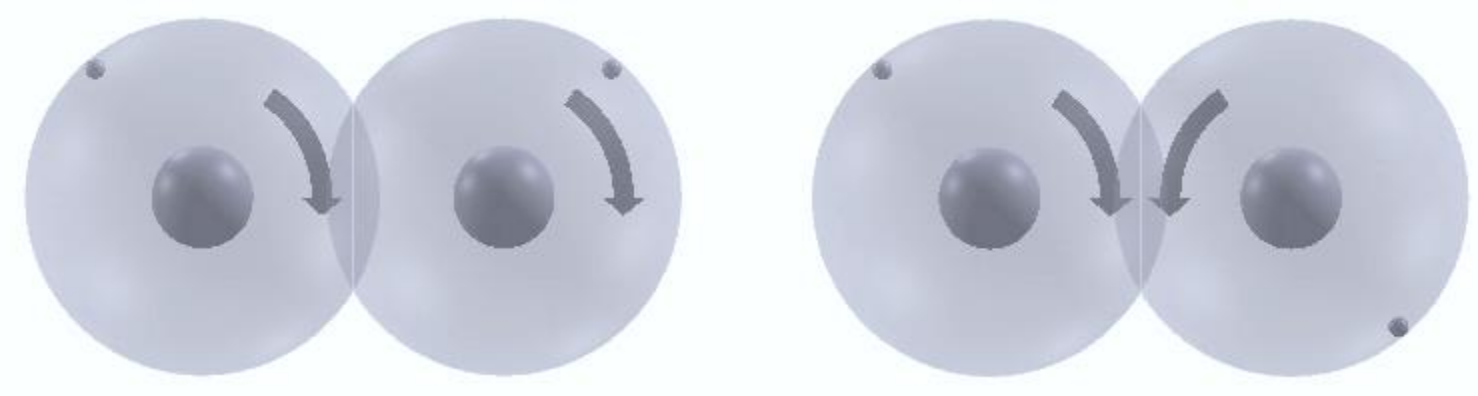




Ortho

Para

Spins

Fermi-Dirac Statistics

Table 1. Ortho-Para properties of hydrogen

Temperature K	Equilibrium Para Percentage	Heat of Conversion Normal to Para kJ/kg
20	99.821	527.138
30	97.021	527.138
40	88.727	527.117
50	77.054	526.845
60	65.569	525.531
70	55.991	521.770
78	50.028	515.500
80	48.537	513.932
90	42.882	500.757
100	38.620	481.671
120	32.959	427.248
150	28.603	322.495
200	25.974	163.774
250	25.264	70.524
300	25.072	27.562

Figure 2. Hydrogen Normal to Para Heat of Conversion

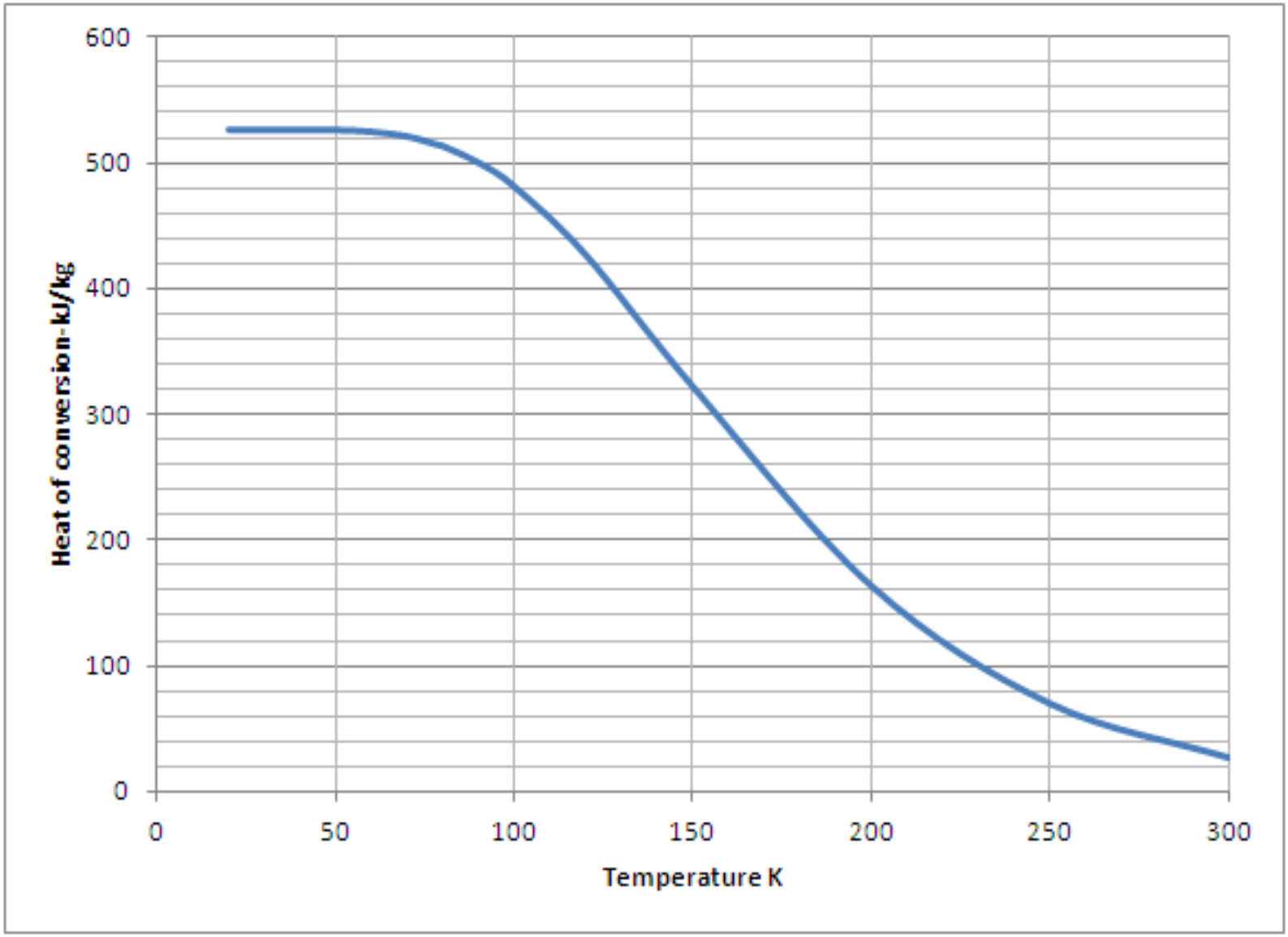
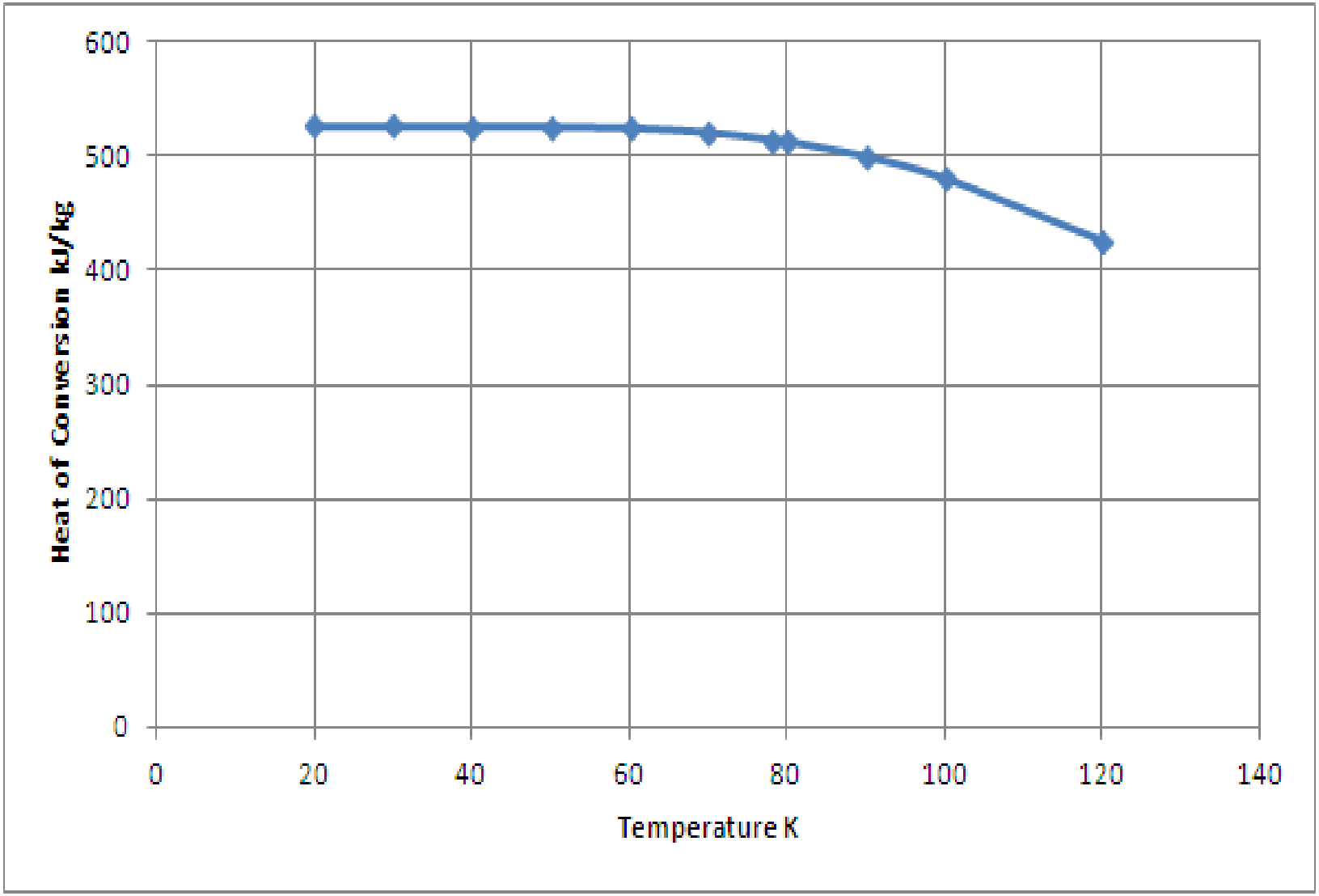


Figure 3. Cold End Heat Of Conversion



Carnot Refrigeration Work

$W_C = (T_W - T_C)/T_C$

$T_W = 300$ K

$T_C = 78$ & 20.27

78 K $W_C = 2.85$ W/W

20.27 K $W_C = 13.80$ W/W

Ratio = 4.8487

Conclusions

1.O-P conversion is most efficient if done at 78 K.
2.No catalyst is needed in heat exchangers colder than 78 K but a small amount of catalyst should be installed in the liquid receiver to bring up the para percentage from 50% to less than 95% at a thermal cost of 11.64 kJ/kg or 2.22% of the total.
3.Gas phase conversion in heat exchangers below 200 K can be effective but it is difficult to balance the extra heat load.
4.Back conversion cooling with catalyst is not useful below 90 K and is most effective in the temperature range from 100 up to 200 K.