[tex22] Thermodynamics of a classical ideal paramagnetic gas I

Consider 1mol of a paramagnetic gas, specified by the equations of state $pV = RT$ (classical ideal gas) and $M = H/T$ (Curie paramagnet), and by a constant heat capacity $C_{VM} = \frac{3}{2}R$.
(a) Calculate the internal energy $U(T, V, M)$ by integration of the differential $dU = TdS - pdV + HdM$. Show that U only depends on T. (b) Calculate the entropy $S(T, V, M)$ by integration of the differential $dS = (1/T)dU + (p/T)dV - (H/T)dM$. (c) Calculate the Helmholtz potentials $A_M(T, V, M) \doteq U - TS$ and $A_H(T, V, H) \doteq U - TS - MH$. (d) Calculate the Gibbs potentials $G_M(T, p, M) \doteq U - TS + pV$ and $G_H(T, p, H) \doteq U - TS + pV - MH$.

Solution: