1. A 40 kg steel casting [Cp = 0.5 kJ kg^{-1}K^{-1}] and a 50 kg copper casting [Cp = 0.45 kJ kg^{-1}K^{-1}] were allowed to maintain at 500℃ (in a oven) and was then quenched in 200 kg of oil [Cp = 2.5 kJ kg^{-1}K^{-1}] at 20℃. Assume there are no heat losses, what is the change in entropy of (a) the steel casting, (b) the copper casting, and (c) the oil. (10%)

2. A house has a winter heating requirement of 20 kJ s^{-1} and a summer cooling requirement of 80 kJ s^{-1}. Consider a heat-pump installation to maintain the house temperature at 20℃ both in winter and summer. This require the circulation of the refrigerant through interior exchanger coils at 30℃ in winter and 10℃ in summer. (Underground coils provide the heat source in winter and the heat sink in summer). Assume the average ground temperature of the house area is 10℃ in winter and 30℃ in summer. What are the minimum power requirement for winter heating and summer cooling？ (10%)

3. One mole of an ideal gas, initially at 40 ℃ and 1 bar was allowed to changes to 120℃, 10 bar by three different mechanically reversible processes:
   a. The gas is first heated at constant volume until its temperature is 120℃; then it is compressed isothermally until its pressure is 10 bar.
   b. The gas is first heated at constant pressure until its temperature is 120℃; then it is compressed isothermally to 10 bar.
   c. The gas is first compressed isothermally to 10 bar; then it is heated at constant pressure to 120℃.

   Calculate Q, W, $\triangle U$, $\triangle H$ in each case. Take Cp = (7/2)R and Cv = (5/2)R for your calculation. (30%)

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4. The mechanism of a gas-phase catalytic reaction for the decomposition of A into B and C is expressed in the following:

$$A + S \underset{k_{-A}}{\overset{k_A}{\rightleftarrows}} A \cdot S$$

$$A \cdot S \underset{k_{-S}}{\overset{k_S}{\rightleftarrows}} B \cdot S + C$$

$$B \cdot S \underset{k_{-D}}{\overset{k_D}{\rightleftarrows}} S + B$$

There is an adsorbing inert in the feed, which occupies the active site:

$$I + S \underset{k_{-I}}{\overset{k_I}{\rightleftarrows}} I \cdot S$$

If the r.d.s. of this catalytic reaction is the surface reaction, please show:

$$-r_A' = \frac{k(P_A - P_B P_C / K_P)}{1 + K_A P_A + K_B P_B + K_I P_I} \quad \text{where } K_P = \frac{P_B P_C}{P_A}. \text{ (20 \%)}$$

5. A liquid-phase, constant volume well-mixed batch reactor (see the attached figure) for W uniform etching is employed to estimate the undercut of W in a bumping process. The spatially averaged mass transport coefficient of W ions, total exposed surface area of W, and reactor volume is indicative of k, A, and V, respectively. If the removal of W is operated under diffusion control (i.e., the surface concentration of W is saturated, C_S), the etching solution is fresh, and the variations in k, A, and V are negligible during the etching test, please show (a) the concentration of W in the stripping reactor as a function of C_S, time, A, k, and V and (b) the thickness of W having been etched as a function of density (d), molecular weight (M_w) of W, C_S, τ, A, k, and V if the etching time is τ. (30 %)