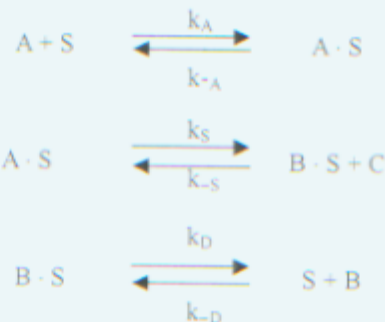


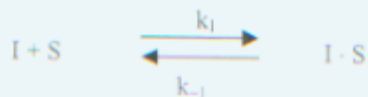
1. A 40 kg steel casting [$C_p = 0.5 \text{ kJ kg}^{-1}\text{K}^{-1}$] and a 50 kg copper casting [$C_p = 0.45 \text{ kJ kg}^{-1}\text{K}^{-1}$] were allowed to maintain at 500°C (in a oven) and was then quenched in 200 kg of oil [$C_p = 2.5 \text{ kJ kg}^{-1}\text{K}^{-1}$] at 20°C . Assume there are 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°C both in winter and summer. This require the circulation of the refrigerant through interior exchanger coils at 30°C in winter and 10°C 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°C in winter and 30°C 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°C and 1 bar was allowed to changes to 120°C , 10 bar by three different mechanically reversible processes:
 - a. The gas is first heated at constant volume until its temperature is 120°C ; 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°C ; 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°C .Calculate Q , W , ΔU , ΔH in each case. Take $C_p = (7/2)R$ and $C_v = (5/2)R$ 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:



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



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

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

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%)

