1. A mixture is 10 mole% ethyl alcohol (C_2H_5OH), 75 mole% ethyl acetate ($C_4H_8O_2$), and 15 mole% acetic acid (CH_3COOH).
(1) Calculate the mass fractions of each compound. (5%)
(2) What is the average molecular weight of the mixture? (5%)
(3) What would be the mass (kg) of a sample containing 25.0 kmol of ethyl acetate? (10%)

2. Acrylonitrile (C_3H_3N) is produced in the reaction of propylene (C_3H_6), ammonia (NH_3), and oxygen:

$$C_3H_6 + NH_3 + \frac{3}{2}O_2 \rightarrow C_3H_3N + 3H_2O$$
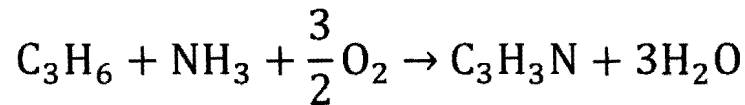
The feed contains 10.0 mole% propylene, 12.0% ammonia, and 78.0% air. Take 100 moles of feed as a basis for the calculation.
(1) Which reactant is limiting? (10%)
(2) What are the percentage by which each of the other reactants is in excess? (10%)
(3) What are the molar amounts of all product gas constituents for a 30% conversion of the limiting reactant? (10%)
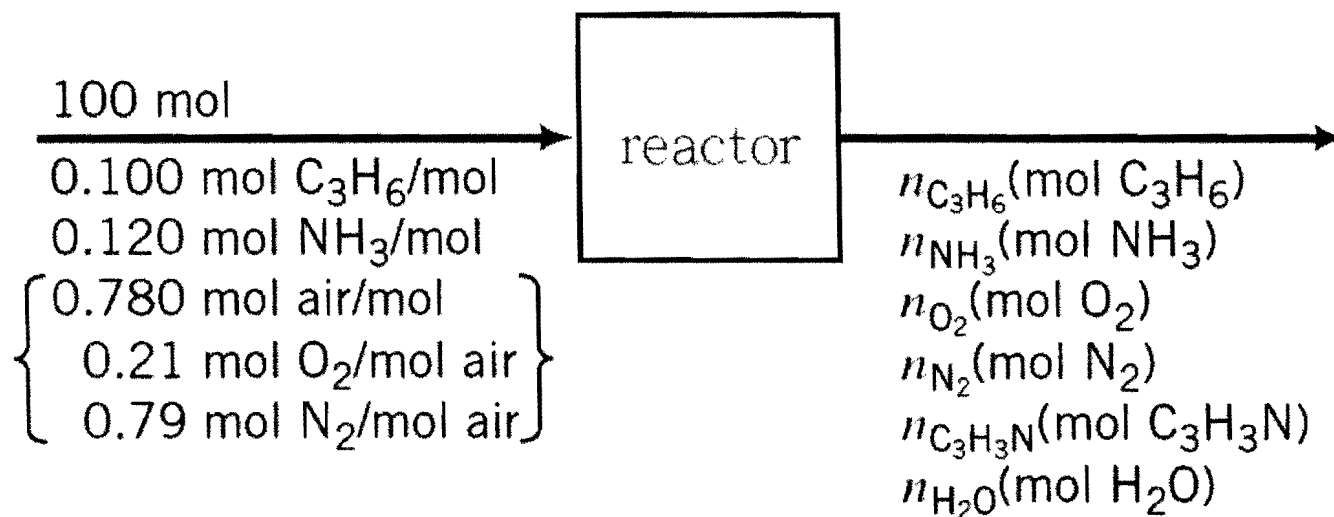
3. A stream containing 10% CH_4 and 90% air by volume is to be heated from 20°C to 300°C. The flow rate of the gas is 2×10^3 liters (STP)/min. The heat capacity of CH_4 and air are:

$$(C_p)_{CH4} = 0.034 \text{ in kJ/mol} \qquad (C_p)_{Air} = 0.03 \text{ kJ/mol}$$

(1) What is the molar flow rate of the inlet gas in mol/min? (10%)
(2) What is the required rate of heat input in kilowatts? (10%)

4. Determine the vapor pressure, specific volume, specific internal energy, and specific enthalpy of **a wet steam with a dryness fraction of 0.9** at 133.5°C. (10%)

Table 1. Properties of Saturated Steam

P(bar)	T(°C)	$\hat{V}$(m³/kg)		$\hat{U}$(kJ/kg)		$\hat{H}$(kJ/kg)		
		Water	Steam	Water	Steam	Water	Evaporation	Steam
1.1	102.3	0.001046	1.549	428.7	2509.2	428.8	2250.8	2679.6
1.2	104.8	0.001048	1.428	439.2	2512.1	439.4	2244.1	2683.4
1.3	107.1	0.001049	1.325	449.1	2514.7	449.2	2237.8	2687.0
1.4	109.3	0.001051	1.236	458.3	2517.2	458.4	2231.9	2690.3
1.5	111.4	0.001053	1.159	467.0	2519.5	467.1	2226.2	2693.4
1.6	113.3	0.001055	1.091	475.2	2521.7	475.4	2220.9	2696.2
1.7	115.2	0.001056	1.031	483.0	2523.7	483.2	2215.7	2699.0
1.8	116.9	0.001058	0.977	490.5	2525.6	490.7	2210.8	2701.5
1.9	118.6	0.001059	0.929	497.6	2527.5	497.8	2206.1	2704.0
2.0	120.2	0.001061	0.885	504.5	2529.2	504.7	2201.6	2706.3
2.2	123.3	0.001064	0.810	517.4	2532.4	517.6	2193.0	2710.6
2.4	126.1	0.001066	0.746	529.4	2535.4	529.6	2184.9	2714.5
2.6	128.7	0.001069	0.693	540.6	2538.1	540.9	2177.3	2718.2
2.8	131.2	0.001071	0.646	551.1	2540.6	551.4	2170.1	2721.5
3.0	133.5	0.001074	0.606	561.1	2543.0	561.4	2163.2	2724.7
3.2	135.8	0.001076	0.570	570.6	2545.2	570.9	2156.7	2727.6
3.4	137.9	0.001078	0.538	579.6	2547.2	579.9	2150.4	2730.3
3.6	139.9	0.001080	0.510	588.1	2549.2	588.5	2144.4	2732.9
3.8	141.8	0.001082	0.485	596.4	2551.0	596.8	2138.6	2735.3
4.0	143.6	0.001084	0.462	604.2	2552.7	604.7	2133.0	2737.6
4.2	145.4	0.001086	0.442	611.8	2554.4	612.3	2127.5	2739.8
4.4	147.1	0.001088	0.423	619.1	2555.9	619.6	2122.3	2741.9
4.6	148.7	0.001089	0.405	626.2	2557.4	626.7	2117.2	2743.9
4.8	150.3	0.001091	0.389	633.0	2558.8	633.5	2112.2	2745.7
5.0	151.8	0.001093	0.375	639.6	2560.2	640.1	2107.4	2747.5
5.5	155.5	0.001097	0.342	655.2	2563.3	655.8	2095.9	2751.7
6.0	158.8	0.001101	0.315	669.8	2566.2	670.4	2085.0	2755.5
6.5	162.0	0.001105	0.292	683.4	2568.7	684.1	2074.7	2758.9
7.0	165.0	0.001108	0.273	696.3	2571.1	697.1	2064.9	2762.0

5. Pure water at 60°F is mixed with 100 g of an aqueous 80 wt% H_2SO_4 solution, also at 60°F. The mixing vessel is insulated well enough to be considered adiabatic.

(1) If 250 g H_2O is mixed with the acid, what will the final solution temperature be? (10%)

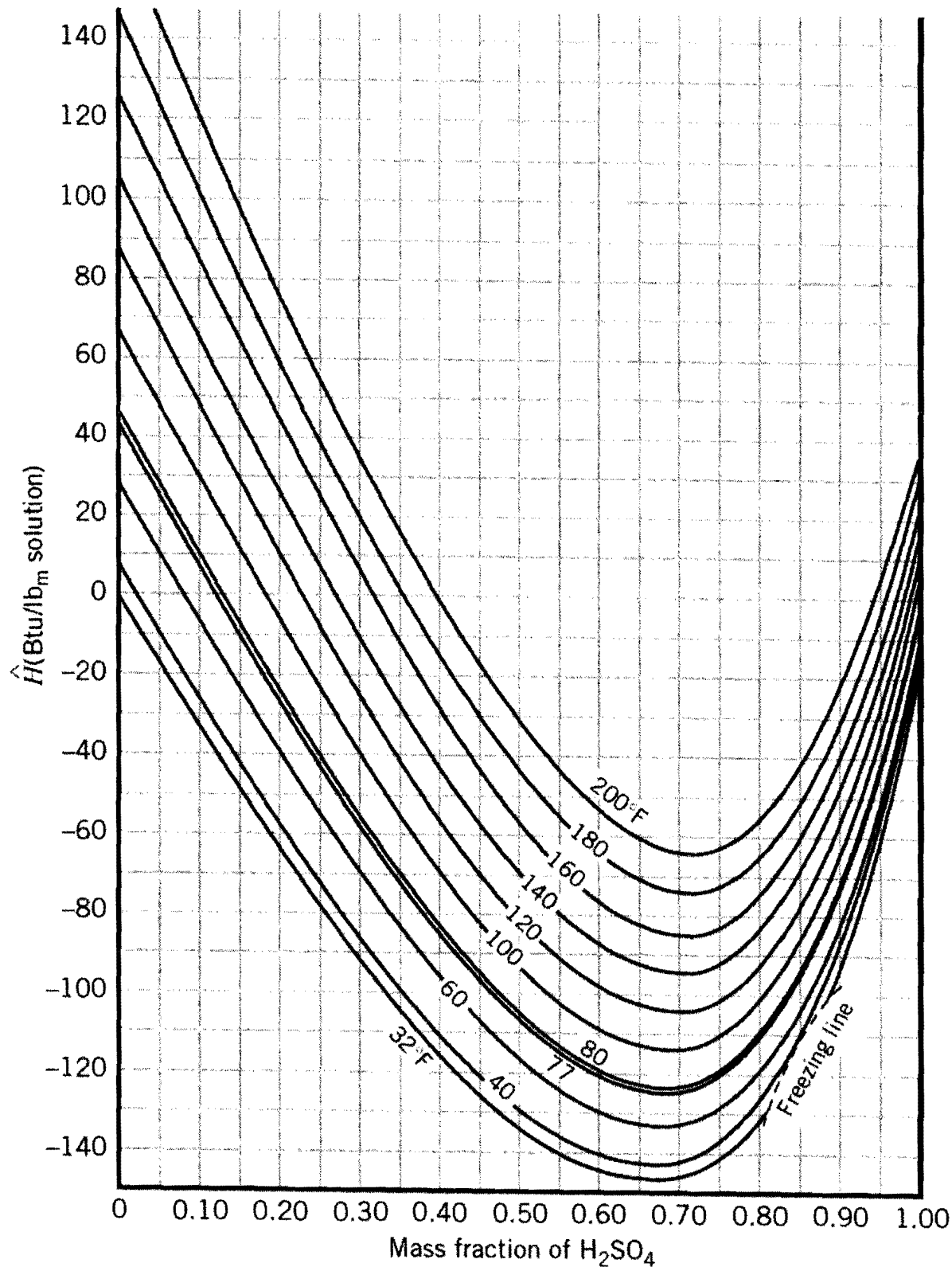(2) What is the maximum attainable solution temperature and how much water must be added to achieve it? (10%)

Figure 1. Enthalpy–concentration chart for H_2SO_4 –H_2O