1. The vapor pressure of diethyl ether is 0.247×10^5 Pa at 0°C and 1.228×10^5 Pa at 40°C.
   (a) Calculate the enthalpy of vaporization
   (b) At what temperature would diethyl ether boil at 1.013×10^5 Pa pressure? (8%)

2. Calculate the heat of formation of propane gas from its elements (a) at constant pressure (b) at constant volume, given that at 298K and one bar pressure:
   heat of combustion of propane = -2220 kJ/mol; heat of formation of liquid water = -286 kJ/mol; heat of formation of carbon dioxide = -393.5 kJ/mol. (8%)

3. From the following data, calculate (a) the standard Gibbs energy change, and (b) the equilibrium constant at 298 K for the reaction $2H_2S(g) + SO_2(g) = 2H_2O(l) + 3S(s)$

substances	$H_2S(g)$	$SO_2(g)$	$H_2O(l)$	$S(s)$
$\Delta H^\circ_{f,298K}$ (kJ/mol)	-22.2	-296.6	-285.9	0
S°_{298K} ($JK^{-1}mol^{-1}$)	205.6	247.9	70.1	31.9

(8%)

4. (a) Given $dH = TdS + VdP$, show that $dS = \frac{C_P}{T}dT - nR\frac{dP}{P}$ for ideal gas. (3%)
   (b) Calculate the entropy change when 2 moles of nitrogen (as an ideal gas) initially at 300K and one bar pressure is heated to 600 K (i) at constant pressure (3%) and (ii) at constant volume. (4%) $C_P = 27\ JK^{-1}mol^{-1}$ for nitrogen.

5. Calculate the root-mean-square speed at 25°C for dust particles of mass 1.00×10^{-10} g/particle suspended in air, assuming that the particle can be considered as a giant molecule. (5%)

6. The radii of a H_2 molecule and an I_2 molecule are 0.109 nm and 0.188 nm, respectively. If $[H_2] = [I_2] = 0.0100M$, calculate the number of collisions per dm^3 per second between a H_2 molecule and an I_2 molecule at 25°C. (At.Wt. H: 1.0079, I: 126.905) (6%)

7. The second-order rate constant for the reaction $CH_3CH_2NO_2 + OH^- \rightarrow H_2O + CH_3\bar{C}HNO_2$ is 39.1 $M^{-1}min^{-1}$ at 0°C. (a) Derive the integrated rate equation (6%) (b) If initially $[CH_3CH_2NO_2]_0 = 4.00 \times 10^{-3}M$, $[NaOH]_0 = 5.00 \times 10^{-3}M$, how long will it take for 50% of $CH_3CH_2NO_2$ to react? (4%)

8. A possible mechanism for the reaction $2NO + O_2 \rightarrow 2NO_2$ is given below:
   $2NO \xrightarrow{k_1} N_2O_2$, $N_2O_2 \xrightarrow{k_2} 2NO$, $N_2O_2 + O_2 \xrightarrow{k_3} 2NO_2$
   (a) Write the rate equation for $d[N_2O_2]/dt$. (4%)
   (b) Apply the steady-state approximation to N_2O_2 to derive the rate law for $d[NO_2]/dt$. (4%)

9. At 25°C, the electric conductivity of pure water is $5.50 \times 10^{-6}\ \Omega^{-1}m^{-1}$ and the electric mobility of OH^- ion is $2.06 \times 10^{-7}\ m^2V^{-1}s^{-1}$. Calculate the electric mobility of H^+ ion at 25°C. (5%)

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10. Molecule CH_2FCl has its CH_2 group on the plane $\sigma(xy)$,
(a) write the 3×3 matrices for all symmetry operations $\hat{R}$ and draw the diagram of CH_2FCl showing the directions of XYZ axes (4%)
(b) Is this molecule optical active? why? (2%)
(c) Is this molecule polar? why? (2%)
(d) does CH_2FCl show pure rotational spectrum? why? (2%)

11. For the atoms He and Li, (a) write the operators of their kinetic energies (b) write the operators of their potential energies (6%)

12. For the rotational spectrum of the rigid molecules of diatomic type: write their (a) energy levels, (b) term values, (c) selection rules, (d) moment of inertia. (8%)

13. For H_2^+ (or $H_AH_B^+$) molecular ion, draw the following diagrams along the internuclear axis R:
(a) MO $\psi_g = \sigma_g 1s$; (b) MO $\psi_u = \sigma_u 1s$; (c) ψ_g^2 and ψ_u^2 ; (d) $1s_{HA}$, (the 1s AO around proton H_A). (8%)