1) (a) Show that $f = P\exp\left(\int_0^P \frac{Z-1}{P}dP\right)$

(b) For a van der Waals gas show that to a first approximation

$$f = P\exp\left(b - \frac{a}{RT}\right)\frac{P}{RT}$$ (18%)

2) Find the compressibility factor at the critical point for a real gas which follows van der Waals equation. (16%)

3) Experimental data show that the vapor-liquid equilibrium for acetone (1) – acetonitrile (2) is well represented by Raoult's law. Vapor pressures are represented by

$$\ln P_1^{sat} = 14.37 - \frac{2787}{t+229.6}$$

$$\ln P_2^{sat} = 14.88 - \frac{3413}{t+250.5}$$

for P_i^{sat} in kPa and t in °C. Find the equilibrium temperature and total pressure if $x_1 = 0.40$ and $y_1 = 0.62$. (16%)

4) The standard electrode potentials of $Ti^{4+}, Ti^{3+}|Pt$ and $Ce^{4+}, Ce^{3+}|Pt$ at 25°C are 0.04 V and 1.61 V, respectively.

(a) Calculate the voltage of the cell at 25°C

$$Pt|Ti^{3+}(a=0.3), Ti^{4+}(a=0.5)\,\|\,Ce^{4+}(a=0.7), Ce^{3+}(a=0.002)|Pt.$$

(b) Write the cell reaction.

(c) Calculate ΔG for the cell reaction as written

(d) Calculate K (16%)

5) A 5-ml container with a hole 10 μm in diameter is filled with hydrogen. This container is placed in an evacuated chamber at 0°C. How long will it take for 90% of the hydrogen to effuse out? (17%)

6) The mechanism of the pyrolysis of the acetaldehyde at 520°C and 0.2 bar is

$$CH_3CHO \xrightarrow{k_1} CH_3 + CHO$$

$$CH_3 + CH_3CHO \xrightarrow{k_2} CH_4 + CH_3CO$$

$$CH_3CO \xrightarrow{k_3} CO + CH_3$$

$$CH_3 + CH_3 \xrightarrow{k_4} C_2H_6$$

What is the rate law for the reaction of acetaldehyde, using the usual assumptions. (17%)

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