

1. a volume of 1.0 L to 10.1 L

Against an external pressure of 0.50 atm

The gas absorbs 250 J of heat from the surroundings

q, w and ΔU (ΔE)=?

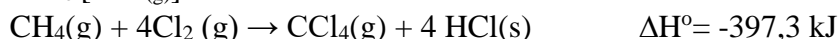
$$q = +250 \text{ J}$$

$$w = -P \times \Delta V = -(0.50 \text{ atm}) \times (10.1 \text{ L} - 1.0 \text{ L}) = -4.55 \text{ atm} \times (101.3 \text{ J/1 L}\cdot\text{atm}) = -460.915 \text{ J}$$

$$\Delta E = \Delta U = q + w = +250 \text{ J} + (-460.915 \text{ J}) = -210.915 \text{ J}$$

2. $\Delta H^\circ_{\text{ol}}[\text{HCl(g)}] = -92.31 \text{ kJ}$

$$\Delta H^\circ_{\text{ol}}[\text{CH}_4(\text{g})] = -74.81 \text{ kJ}$$



The standard enthalpy of formation of $\text{CCl}_4(\text{g})$ at 25 °C and 1 bar.

$$\Delta H^\circ_{\text{rxn}} = [\Delta H^\circ_{\text{ol}}(\text{CCl}_4(\text{g})) + 4\Delta H^\circ_{\text{ol}}(\text{HCl}(\text{g}))] - [\Delta H^\circ_{\text{ol}}(\text{CH}_4(\text{g})) + 4\Delta H^\circ_{\text{ol}}(\text{Cl}_2(\text{g}))]$$

$$-397.3 \text{ kJ} = [\Delta H^\circ_{\text{ol}}(\text{CCl}_4(\text{g})) + 4 \times -92.31 \text{ kJ}] - [-74.81 \text{ kJ} + 4 \times 0 \text{ kJ}]$$

$$\Delta H^\circ_{\text{ol}}(\text{CCl}_4(\text{g})) = -102.87 \text{ kJ}$$

3. 50 g of iron that has an initial temperature of 225 °C and 50 g of gold that has an initial temperature of 25 °C

no heat is lost to the surroundings, what will be the temperature when the two metals reach **thermal equilibrium?**

The specific heat capacity of iron: 0.449 J/g°C and gold: 0.128 J/g°C

$$q_{\text{Au}} + q_{\text{Fe}} = 0$$

$$q_{\text{Au}} = -q_{\text{Fe}}$$

$$q_{\text{Au}} = m_{\text{Au}} \times S_{\text{Au}} \times \Delta t = 50\text{g} \times 0.128 \text{ J/g}^\circ\text{C} \times (t_f - 25^\circ\text{C})$$

$$q_{\text{Fe}} = m_{\text{Fe}} \times S_{\text{Fe}} \times \Delta t = 50\text{g} \times 0.449 \text{ J/g}^\circ\text{C} \times (t_f - 225^\circ\text{C})$$

$$q_{\text{Au}} = -q_{\text{Fe}}$$

$$50\text{g} \times 0.128 \text{ J/g}^\circ\text{C} \times (t_f - 25^\circ\text{C}) = - (50\text{g} \times 0.449 \text{ J/g}^\circ\text{C} \times (t_f - 225^\circ\text{C}))$$

$$t_f = 180.55^\circ\text{C}$$

4. **increasing boiling point:** $\text{CH}_3\text{CH}_2\text{OH}$, $\text{HOCH}_2\text{CH}_2\text{OH}$, $\text{CH}_3\text{CH}_2\text{Cl}$, and $\text{ClCH}_2\text{CH}_2\text{OH}$



5. **increasing boiling point and vapor pressure:** CH_3OH , He, CH_3Cl and N_2

Boiling point: $\text{He} < \text{N}_2 < \text{CH}_3\text{Cl} < \text{CH}_3\text{OH}$

Vapor pressure: $\text{He} > \text{N}_2 > \text{CH}_3\text{Cl} > \text{CH}_3\text{OH}$

6. Europium crystallizes in a body-centered cubic lattice

The density of Eu is 5.26 g/cm³

Calculate the unit cell edge length in pm. (Eu MW:152 g/mol).

$$m = (2 \text{ Eu atoms/1 unit cell}) \times (1 \text{ mol Eu}/6.022 \times 10^{23} \text{ Eu atoms}) \times (152.0 \text{ g Eu}/1 \text{ mol Eu}) = 5.048 \times 10^{-22} \text{ g Eu/unit cell}$$

$$V = (5.048 \times 10^{-22} \text{ g Eu/1 unit cell}) \times (1 \text{ cm}^3/5.26\text{g}) = 9.60 \times 10^{-23} \text{ cm}^3/\text{unit cell}$$

$$a = V^{1/3} = (9.60 \times 10^{-23} \text{ cm}^3)^{1/3} = 4.58 \times 10^{-8} \text{ cm} = 458 \text{ pm}$$

7. The density of an aqueous solution containing 10.0 percent of C_2H_5OH by mass is 0.984 g/mL.

Molality, molarity, what volume of the solution would contain 0.125 mole of ethanol?
 ($M_C=12.01$, $M_H=1.008$, $M_O=16.00$)

Assume 100 g of solution

$0.1 \times 100 \text{ g} = 10 \text{ g ethanol}$

$100 \text{ g} - 10 \text{ g} = 90 \text{ g} = 0.090 \text{ kg water}$

$10 \text{ g ethanol} \times (1 \text{ mol} / 46.07 \text{ g}) = 0.217 \text{ mol ethanol}$

$m = \text{mol solute} / \text{kg solvent} = 0.217 \text{ mol} / 0.090 \text{ kg} = 2.41 \text{ m}$

$100 \text{ g} \times (1 \text{ mL} / 0.984 \text{ g}) = 102 \text{ mL} = 0.102 \text{ L}$

$M = (\text{mol solute} / \text{liters of soln}) = 0.217 \text{ mol} / 0.102 \text{ L} = 2.13 \text{ M}$

$0.125 \text{ mol} \times (1 \text{ L} / 2.13 \text{ mol}) = 0.0587 \text{ L} = 58.7 \text{ mL}$

8. 0.100 g of lysozyme is dissolved in 150 g of water at 25 °C.

Calculate the vapor-pressure lowering, the depression in freezing point, the elevation in boiling point, and the osmotic pressure of this solution.

Molar mass of lysozyme = 13930 g/mol

Molar mass of water = 18.02 g/mol

density of the solution = 1 g/mL

$P_{\text{water}}^0 = 23.76 \text{ mmHg}$ at 25 °C

$K_f = 1.86 \text{ }^\circ\text{C/m}$

$K_b = 0.52 \text{ }^\circ\text{C/m}$

$R = 0.0821 \text{ L.atm/mol.K}$

$n_{\text{lysozyme}} = 0.10 \text{ g} \times (1 \text{ mol} / 13930 \text{ g}) = 7.18 \times 10^{-6} \text{ mol}$

$n_{\text{water}} = 150 \text{ g} \times (1 \text{ mol} / 18.02 \text{ g}) = 8.32 \text{ mol}$

Vapor-pressure lowering:

$\Delta P = X_{\text{lysozyme}} \times P_{\text{water}}^0 = (n_{\text{lysozyme}} / (n_{\text{lysozyme}} + n_{\text{water}})) \times (23.76 \text{ mmHg})$
 $= (7.18 \times 10^{-6} \text{ mol} / (7.18 \times 10^{-6} \text{ mol} + 8.32 \text{ mol})) \times (23.76 \text{ mmHg}) = 2.05 \times 10^{-5} \text{ mmHg}$

Freezing point depression:

$\Delta T_f = K_f \times m = 1.86 \text{ }^\circ\text{C/m} \times (7.18 \times 10^{-6} \text{ mol} / 0.150 \text{ kg}) = 8.90 \times 10^{-5} \text{ }^\circ\text{C}$

Boiling point elevation:

$\Delta T_b = K_b \times m = 0.52 \text{ }^\circ\text{C/m} \times (7.18 \times 10^{-6} \text{ mol} / 0.150 \text{ kg}) = 2.5 \times 10^{-5} \text{ }^\circ\text{C}$

Osmotic pressure:

$\pi = M \times R \times T = (7.18 \times 10^{-6} \text{ mol} / 0.150 \text{ L}) \times 0.0821 \text{ L.atm/mol.K} \times (298 \text{ K})$
 $= 1.17 \times 10^{-3} \text{ atm} = 0.889 \text{ mmHg}$

9. increasing solubility in water: O_2 , $LiCl$, Br_2 , (CH_3OH)

$O_2 < Br_2 < LiCl < CH_3OH$

10. A + B → products

determine the order of the reaction and calculate the rate constant

	[A] (M)	[B] (M)	Rate (M/s)
1	1.50	1.50	3.20×10^{-1}
2	1.50	2.50	3.20×10^{-1}
3	3.00	1.50	6.40×10^{-1}

Compare with first and second sets: Changing [B] does not affect the rate of the reaction, zero order in B

Compare with first and third sets: doubling [A] doubles the rate of the reaction, first order in A

$$\text{Rate} = k \times [\text{A}]$$

$$3.20 \times 10^{-1} \text{ M/s} = k \times (1.50 \text{ M})$$

$$k = 0.212 \text{ s}^{-1}$$

$$\text{Rate}_2/\text{Rate}_1 = (3.20 \times 10^{-1}/3.20 \times 10^{-1}) = 1 = (k \times (1.50)^x \times (2.50)^y) / (k \times (1.50)^x \times (1.50)^y)$$

$y = 0$ Zero order for B

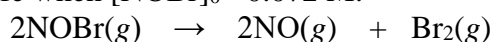
$$\text{Rate}_3/\text{Rate}_1 = (6.40 \times 10^{-1}/3.20 \times 10^{-1}) = 2 = (k \times (3.00)^x \times (1.50)^y) / (k \times (1.50)^x \times (1.50)^y)$$

$X = 1$ First order for A

11. The rate constant for the second-order reaction is $0.80/\text{M} \cdot \text{s}$ at 10°C .

Starting with a concentration of 0.086 M , calculate the concentration of NOBr after 22 s .

Calculate the half-life when $[\text{NOBr}]_0 = 0.072 \text{ M}$.



$$1/[\text{NOBr}]_t = kt + 1/[\text{NOBr}]_0$$

$$1/[\text{NOBr}]_t = (0.80/\text{M}\cdot\text{s})(22\text{s}) + 1/0.086\text{M}$$

$$1/[\text{NOBr}]_t = 29 \text{ M}^{-1}$$

$$[\text{NOBr}]_t = 0.034\text{M}$$

$$t_{1/2} = 1/k[\text{A}]_0 = 1/(0.80/\text{M}\cdot\text{s})(0.072\text{M})$$

$$t_{1/2} = 17 \text{ s}$$

12. The rate constants of some reactions double with every 10-degree rise in temperature.

Assume that a reaction takes place at 295 K and 305 K .

What must the activation energy?

$$\ln(k_2/k_1) = E_a/R \times ((T_2 - T_1)/T_1 \cdot T_2)$$

$$-0.693 = E_a/8.314 \text{ J/K}\cdot\text{mol} \times ((295\text{K} - 305\text{K})/(295\text{K} \cdot 305\text{K}))$$

$$E_a = 5.18 \times 10^4 \text{ J/mol} = 51.8 \text{ kJ/mol}$$