

Chemistry - 4311
September 26, 2015

Exam #1

Name Ker

(20) 1. Matching (use a letter only once)

At constant n and V , pressure is t to temperature.

The enthalpy is defined as e.

According to the first law of thermodynamics the change in the internal energy ΔU equals d.

The average kinetic energy of an ideal gas molecule is s.

According to the Boltzmann distribution, the probability a molecule has energy E is proportional to n.

With only P-V work and constant P , q equals h.

$C_p - C_v$ for an ideal gas is i.

The average distance a molecule travels without a collision is called the c.

For an adiabatic process l is zero.

In the van der Waals eq., $(P + an^2/V^2)(V - nb) = nRT$, the an^2/V^2 term corrects for f.

$$c = 3.00 \times 10^8 \text{ m/s}$$

$$h = 6.626 \times 10^{-34} \text{ J s}$$

$$R = 8.314 \text{ J/mol-K}$$

$$R = 1.987 \text{ cal/mol-K}$$

$$R = 0.08206 \text{ L-atm/mol-K}$$

$$N_A = 6.02 \times 10^{23}$$

$$1 \text{ atm} = 101.325 \text{ kPa}$$

$$k_B = 1.381 \times 10^{-23} \text{ J/K}$$

a. volume of molecules

b. $mv^2/2$

c. mean free path

d. $q + w$

e. $H = U + PV$

f. attractive interactions

g. inversely proportional

h. ΔH

i. nR

j. ΔU

k. PV

l. q

m. collision frequency

n. $\exp(-E/RT)$

o. $q - w$

p. $\exp(-E)$

q. w

r. $H = U - PV$

s. $3k_B T/2$

t. proportional

(10) 2. Choose the correct equation.

The expression for isothermal, reversible work is f.

Relationship between ΔH and ΔU at constant pressure is h.

$C_v \Delta T$ equals e for an ideal gas.

C_p equals g.

For the reversible adiabatic expansion or compression of an ideal gas, $dU = dw$ is given by d.

h. $\Delta H = \Delta U + P\Delta V$

i. $(3/2)RdT = dq$

a. ΔH

b. $\Delta U = \Delta H + P\Delta V$

c. $-P_{ex}\Delta V$

d. $C_v dT = -PdV$

e. ΔU

f. $-nRT \ln(V_2/V_1)$

g. $(\partial H/\partial T)_P$

j. $(\partial U/\partial T)_P$

(15) 3. A gas mixture contains 3 moles of CO_2 , 2 moles of Ar, and 5 moles of CH_4 in a 1 liter container at 298K

a. What is the mole fraction of CH_4 ?

$$X_{\text{CH}_4} = \frac{n_{\text{CH}_4}}{n_{\text{total}}} = \frac{5}{10} = 0.5$$

b. What is the pressure of the gas mixture?

$$PV = nRT$$

$$P = \frac{10 \times 0.08206 \times 298}{1} = 244.5 \text{ atm}$$

c. What is the partial pressure of CH_4 ?

$$P_{\text{CH}_4} = X_{\text{CH}_4} P_{\text{total}} = 0.5 \times 244.5 = 122.3 \text{ atm}$$

(5) 4. Show that the ideal gas density is $d = MP/(RT)$, where M is the molecular weight.

$$PV = nRT$$

$$PV = \frac{m}{M} RT$$

$$PM = \frac{m}{V} RT = dRT$$

$$d = \frac{MP}{RT}$$

① Convert N_2 mass in g to kg; 28×10^{-3} kg

② Mole of N_2 is 28×10^{-3} kg, weight of one molecule is 28×10^{-23} kg / N_A

$$J = \text{kg} \times \frac{\text{m}^2}{\text{sec}^2}$$

③ R is 8.314 J/mol-K

(10) 5. The expression for the average speed of a gaseous molecule is $[8k_B T / (\pi m)]^{1/2}$.

What is the average speed of a N_2 molecule in m/sec?

$$\begin{aligned} \langle c \rangle &= \left[\frac{8 \times R / N_A \times 298}{28 \times 10^{-3} \text{ kg} / N_A \times 3.1416} \right]^{1/2} & k_B &= R / N_A \\ &= \left[\frac{8 \times 8.314 \times 298}{28 \times 10^{-3} \times 3.1416} \right]^{1/2} = 475 \text{ m/s} \end{aligned}$$

(15) 6. When 13.5 grams of adenine, $C_5H_5N_5(s)$, are heated from 25 to 75 °C at constant pressure, 735 J of heat is added. What is C_p per mole for adenine?

$$q_p = n \bar{C}_p \Delta T$$

$$M \text{ of adenine} = 135 \text{ g/mole}$$

$$735 = 0.100 \bar{C}_p 50 \text{ K}$$

$$n = \frac{13.5 \text{ g}}{135 \text{ g}} = 0.100$$

$$\bar{C}_p = 147 \text{ J/mol-K}$$

② do not calculate n

(15) 7. $\Delta H_{\text{vap}} = 40.79$ kJ/mol for water at the standard boiling point of 100 °C and 1 atm pressure. Determine q , w , ΔU , and ΔH for boiling one mole of water at the standard boiling point.

$$\textcircled{+3} \Delta H = \Delta H_{\text{vap}} = 40.79 \text{ kJ}$$

$$\textcircled{+4} q_p = \Delta H = 40.79 \text{ kJ}$$

$$\begin{aligned} \textcircled{+4} w &= -P_{\text{ex}} \Delta V = -P_{\text{ex}} (V_g - V_l) \approx -P_{\text{ex}} V_g \\ &= -nRT \end{aligned}$$

$$\textcircled{+4} \Delta U = q + w$$

$$= 40.79 - 3.10$$

$$\Delta U = 37.69 \text{ kJ}$$

$$= -nRT$$

$$= -8.314 \times 373 \text{ K}$$

$$= -3,101 \text{ J}$$

$$= -3.10 \text{ kJ}$$

(10) 8. Bond energies in kJ/mol are H-H (436), O=O (499) and H-O (460). Estimate ΔH_r° for the reaction $\text{H}_2 + 1/2\text{O}_2 \rightarrow \text{H}_2\text{O}$ and also for the reaction $2\text{H}_2 + \text{O}_2 \rightarrow \text{H}_2\text{O}$.



<u>Bonds broken</u>	<u>Bonds formed</u>
2 H-H, 2×436	4 O-H, 4×460
1 O=O, 499	1,840
1,371 kJ	

$$\Delta H_r^\circ \approx \text{Broken} - \text{Formed} = 1,371 - 1,840 = -469 \text{ kJ}$$

ΔH_r° is $1/2$ of this for $\text{H}_2 + 1/2\text{O}_2 \rightarrow \text{H}_2\text{O}$

$$\Delta H_r^\circ \approx -234.5 \text{ kJ}$$

(-1) not (broken - formed)

(-1) incorrect # of O-H