

Chemistry 112  
Third Hour Exam

Name: \_\_\_\_\_

Please show all work for partial credit

1. (10 points) Given the equation:

$$u_{rms} = \sqrt{\frac{3RT}{M}}$$

Calculate the root mean square velocity for water vapor in steam at, 150°C.

$$\begin{aligned} u_{rms} &= \sqrt{\frac{3 \cdot 8.3145(J / K \cdot mol)423.15(K)}{.018(kg / mol)}} \\ &= \sqrt{586380(J / kg)} \\ &= \sqrt{586380(kg \cdot m^2 / s^2) / kg} \\ &= \sqrt{586380(m^2 / s^2)} \\ &= 766m / s \end{aligned}$$

2. (10 points) What are diffusion and effusion?

Diffusion refers to the movement of a gas particle in the presence of other gas molecules, while effusion refers to the movement of a gas particle in a vacuum.

3. (10 points) In the van der Waals equation for a real gas:

$$P_{obs} = \frac{nRT}{V - nb} - a\left(\frac{n}{V}\right)^2$$

What are a and b, and how do they correct for the non-ideality of the gas equation?

Both a and b are corrections terms to the ideal gas law. A is a correction term that compensates for inter-particle interactions in the gas, while the b term corrects for the actual volume of the gas particle.

4. (10 points) Calculate  $\Delta E$  for the following situations:

a.  $q = +50 \text{ kJ}$ ,  $w = -40 \text{ kJ}$        $+10 \text{ kJ}$

b.  $q = -50 \text{ kJ}$ ,  $w = -20 \text{ kJ}$        $-70 \text{ kJ}$

c.  $q = +25 \text{ kJ}$ ,  $w = 0 \text{ kJ}$        $+25 \text{ kJ}$

d. In which of these cases do the surroundings do work on the system?

If the surroundings work on the system, then  $w$  is +. I accepted either none or c.

5. (10 points) The volume of an ideal gas is **increased** from 75 mL to 3.4 L at a constant pressure of 2.35 atm. Calculate the work associated with this process.

$$W = -P\Delta V$$

$$\begin{aligned}\Delta V &= V_{\text{final}} - V_{\text{initial}} \\ &= 3.4 \text{ L} - .075 \text{ L} = +3.325 \text{ L}\end{aligned}$$

$$W = -2.35 \text{ atm} \times 3.325 \text{ L} = -7.81 \text{ L atm}$$

This could get converted into J, but that was not a required part of the problem

6. (10 points) I have a reaction  $A \rightarrow 2B$ . I will perform this reaction in a constant pressure calorimeter containing 87 grams of water. As the reaction occurs the water changes temperature from  $25^\circ\text{C}$  to  $12.6^\circ\text{C}$ . What is the  $\Delta H$  of this reaction. (The specific heat capacity of water is  $4.18 \text{ J}/^\circ\text{C}\cdot\text{g}$ , assume I have 0.1 moles of A to start the reaction.)

$$\begin{aligned}\text{Energy} &= \text{S.H.C} \times g \times \Delta T \\ &= 4.18 \text{ J}/^\circ\text{C}\cdot\text{g} \times 87 \text{ g} \times 12.4^\circ\text{C} \\ &= 4,509 \text{ J}\end{aligned}$$

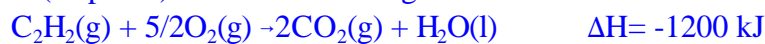
Since the temperature got colder, the + sign is appropriate.

Also

$$4,509 \text{ J}/0.1 \text{ mole} = X \text{ J}/1.0 \text{ mole}$$

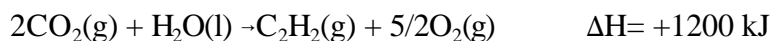
$$= +45,090 \text{ J}/1 \text{ mole A or } 45.1 \text{ kJ/mole}$$

7. (10 points) Given the following data:



Calculate  $\Delta\text{H}$  for the reaction  $2\text{C}(\text{s}) + \text{H}_2(\text{g}) \rightarrow \text{C}_2\text{H}_2(\text{g})$

Reverse the first reaction



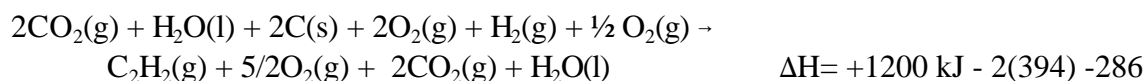
Next reaction goes forward, but you need to double the amounts:



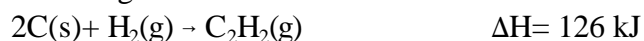
Final reaction goes forward:



Net:



Removing common terms



8. Calculate  $\Delta\text{H}$  for the reaction  $2\text{Na}(\text{s}) + 2\text{H}_2\text{O}(\text{l}) \rightarrow 2\text{Na}^+(\text{aq}) + \text{H}_2(\text{g}) + 2 \text{OH}^-(\text{aq})$

From the following heats of reaction:

Substance       $\Delta\text{H}_f^\circ$  (kJ/mole)

$\text{Na}^+(\text{aq})$       -230

$\text{H}_2\text{O}(\text{l})$       -286

$\text{OH}^-(\text{aq})$       -230

$$\Delta\text{H}_{\text{rxn}}^\circ = \sum n_p \Delta\text{H}_f^\circ - \sum n_r \Delta\text{H}_f^\circ$$

Note:  $\text{Na}(\text{s})$  and  $\text{H}_2(\text{g})$  are the normal forms of these elements at STP, so their  $\Delta\text{H}_f^\circ = 0.00$

$$\begin{aligned} \Delta\text{H}_{\text{rxn}}^\circ &= [2(-230) + 0 + 2(-230)] - [2(0) + 2(-286)] \\ &= -460 - 460 + 572 \\ &= -348 \text{ kJ/mole} \end{aligned}$$

9. (10 points) Proteins absorbs light with a wavelength of 280 nm.

A. What is the frequency of this light

$$c = \lambda \nu$$

$$3 \times 10^8 \text{ (m/s)} = 280 \times 10^{-9} \text{ m } X$$

$$X = 3 \times 10^8 \text{ (m/s)} / 280 \times 10^{-9} \text{ m} = 1.07 \times 10^{15} \text{ sec}^{-1} \text{ or Hz}$$

B. What is the energy of 1 mole of photons with this frequency?

$$E = h\nu \text{ (Energy of 1 photon)}$$

$$= 6.63 \times 10^{-34} \text{ (Js)} \times 1.07 \times 10^{15} \text{ s}^{-1}$$

$$= 7.10 \times 10^{-19} \text{ J per photon}$$

$$7.10 \times 10^{-19} \text{ J/photon} \times 6.022 \times 10^{23} \text{ photons/mole}$$

$$= 428 \text{ kJ/mole}$$

10. (10 points) What is the wavelength of an electron (mass =  $9.11 \times 10^{-31} \text{ kg}$ ) traveling at  $7.5 \times 10^8 \text{ m/s}$ ?

$$m = \frac{h}{\nu \lambda}; \lambda = \frac{h}{m\nu}$$

$$\lambda = 6.63 \times 10^{-34} \text{ Js} / (7.5 \times 10^8 \text{ m/s} \times 9.11 \times 10^{-31} \text{ kg})$$

$$J = \text{kg m}^2/\text{s}^2$$

$$\lambda = 9.7 \times 10^{-13} \text{ m}$$