

Name: _____

Chem 112
Hour Exam III

1 Calculate ΔE

A (5 points) A gas absorbs 45 kJ of heat and does 29 kJ of work.

$$q = +45$$

$$w = -29$$

$$\Delta E = q + w = +45 - 29 = \mathbf{16\text{kJ}}$$

B (5 points) A system releases 125 kJ of heat while 104 kJ of work is done on it.

$$q = -125$$

$$w = +104$$

$$\Delta E = q + w = -125 + 104 = \mathbf{-21\text{kJ}}$$

2. (10 points) A balloon filled with 39.1 mol of helium has a volume of 876L at 0.0 °C and 1 atm. pressure. When the temperature is increased to 38.0 °C the balloon expands to a volume of 998 L. Calculate q, w, and ΔE for the helium in the balloon (The molar heat capacity for He gas is 20.8 J/°C·mol)

$$w = -p\Delta V$$

$$= -1 \times (998 - 876)$$

$$= -122 \text{ l}\cdot\text{atm} \times 101.3 \text{ J/l}\cdot\text{atm} = -12.36\text{kJ}$$

$$q = \text{Moles} \times \text{Molar heat capacity} \times \Delta T$$

$$= 39.1 \times 20.8 \times (38 - 0)$$

$$= 30.90 \text{ kJ}$$

$$\Delta E = q + w = 30.90 - 12.36 = \mathbf{18.54\text{kJ}}$$

3. (15 points) In a coffee-cup calorimeter 50.0 ml of .1M AgNO₃ is mixed with 50.0 mL of .1 M HCl.

A. Write a balanced chemical equation for the reaction that occurs when these solutions are mixed.



B. If the two solutions were initially at 22.60 °C, and the final mixed solution is 23.4°C, calculate the heat released by the reaction. (The Specific Heat capacity for water is 4.18 J/°C·g)

$$\text{Heat} = g \times \text{S.H.C.} \times \Delta T$$

$$g = (50\text{ml} + 50\text{ ml}) \times 1\text{g/ml (density of water)}$$

$$= 100 \times 4.18 \times (23.4 - 22.6)$$

$$= 334.4 \text{ J}$$

solution got warmer so heat released, so should have - sign

$$= \mathbf{-334.4\text{J}}$$

C. What kind of energy have we measured in this experiment (ΔH , ΔE , or ΔG)
What is the molar enthalpy for this reaction (in terms of J/mole of Ag⁺(aq))

Heat released in a constant pressure calorimeter is ΔH

$$\text{Moles Ag}^+ = \text{Molarity} \times \text{Volume} = .1\text{ mol/l} \times (.05\text{ l}) = .005\text{ mol}$$

$$\text{Moles Cl}^- = \text{Molarity} \times \text{Volume} = .1\text{ mol/l} \times (.05\text{ l}) = .005\text{ mol}$$

So both run out at same time, both are limiting so

$$-334.4\text{J} / .005\text{ moles} = \mathbf{-66.88\text{kJ}}$$

4. (15 points) I have a 15 g sample of Ni that is at 90°C, and I am going to drop it into 50 g of water that is at 5°C. Assuming the system is adiabatic, what is the temperature of the system when it comes to equilibrium? (The specific heat capacity for water is 4.18 and the specific heat capacity for Ni is .444 J/°C·g)

Heat lost by Ni = heat gained by water

$$15 \times .444 \times (90 - X) = 50 \times 4.18 \times (X - 5)$$

$$6.66(90 - X) = 209(X - 5)$$

$$599.5 - 6.66X = 209X - 1045$$

$$599.5 + 1045 = 209X + 6.66X$$

$$1644.5 = 215.66X$$

$$X = 1644.5 / 215.66$$

$$= \mathbf{7.63^\circ\text{C}}$$

5. (15 points) Calculate ΔH for the reaction $B_2H_6(g) + 3O_2(g) \rightarrow B_2O_3(s) + 3H_2O(g)$ given the following data:

	ΔH
$2B(s) + 3/2 O_2(g) \rightarrow B_2O_3(s)$	-1273 kJ
$H_2(g) + 1/2 O_2(g) \rightarrow H_2O(l)$	-286 kJ
$H_2O(l) \rightarrow H_2O(g)$	+44 kJ
$2B(s) + 3H_2(g) \rightarrow B_2H_6(g)$	+36 kJ

Match product B_2O_3



Match Product $3H_2O(g)$



But I need 3 so



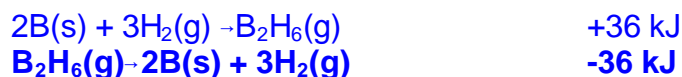
This gives me a $H_2O(l)$ reactant that does NOT appear in the equation so I want to get rid of it by cancelling it out



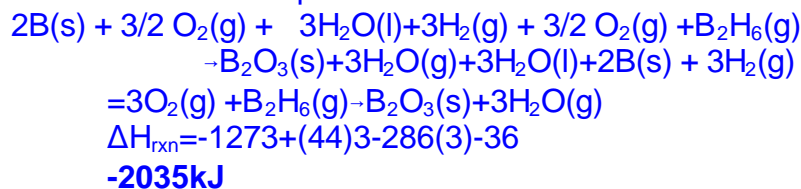
Again I need 3 so:



Match reactants



I have used all the equations so let's see if it cancels



6. (15 points) Calculate ΔH_{rxn} for the reaction: $C_2H_5OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(g)$

Given the following ΔH_f° values

	ΔH_f°
$C_2H_5OH(l)$	-278
$CO_2(g)$	-393.5
$H_2O(l)$	-286
$H_2O(g)$	-242

$\Delta H_{rxn} = \text{Product} - \text{reactants}$

$$= [3(-242) + 2(-393.5)] - [1(-278) + 3(0)] \\ = -1235 \text{ kJ}$$

7.(10 points) Use the Bohr equation (given below) to calculate the energy associated with moving an electron from the $n=3$ orbital to the $n=6$ orbital in a hydrogen atom.

$$E = -2.178 \times 10^{-18} \text{J} (Z^2/n^2)$$

What is the wavelength of light associated with this energy? Would this light be emitted or absorbed as the electron moves from the $n=3$ to the $n=6$ orbital?

$$E_3 = -2.178 \times 10^{-18} \text{J} (1/3^2) = -.242 \times 10^{-18}$$

$$E_6 = -2.178 \times 10^{-18} \text{J} (1/6^2) = -.0605 \times 10^{-18}$$

$$\Delta E = E_6 - E_3 = -.0605 \times 10^{-18} - (-.242 \times 10^{-18})$$

$$= +.1815 \times 10^{-18} \text{J}$$

+ means light is emitted

$$\Delta E = h\nu = hc/\lambda$$

$$.1815 \times 10^{-18} = (6.626 \times 10^{-34} \text{J}\cdot\text{s} \times 3.00 \times 10^8 \text{m/s})/\lambda$$

$$\lambda = (6.626 \times 10^{-34} \text{J}\cdot\text{s} \times 3.00 \times 10^8 \text{m/s}) / (.1815 \times 10^{-18} \text{J})$$

$$= 1.09 \times 10^{-6} \text{m}$$

$$= \mathbf{1.09 \mu\text{m}}$$

8.(10 points) For each of the four quantum numbers associated with an atom give the name of the quantum number, its usual abbreviation, its physical meaning, and its range of values.

Principal quantum number (n)

n is any positive integer >0 , corresponds to energy or size

Angular momentum quantum number (ℓ)

ℓ = any positive integer between 0 and n , inclusive, corresponds to shape of orbital

Magnetic Quantum number (m_ℓ)

m_ℓ is any integer between $-\ell$ and $+\ell$ inclusive, corresponds to orientation of orbital

Electron spin quantum number (m_s)

$m_s = +1/2$ or $-1/2$ corresponds to spin of electron in orbital