

Chemistry 112
Third Hour Exam

Name: _____
(4 points)

Please show all work for partial credit

All problems worth 12 points

1. To make an artificial diamond you must subject carbon to a pressure of 7 gigapascal.

Convert 7 gigapascal to atmospheres

$$7 \text{ GPa} \times \frac{1 \times 10^9 \text{ Pa}}{1 \text{ GPa}} \times \frac{1 \text{ kPa}}{1000 \text{ Pa}} \times \frac{1 \text{ atm}}{101.325 \text{ kPa}} = 69,000 \text{ atm}$$

Convert 7 gigapascal to mm of Hg

$$7 \text{ GPa} \times \frac{1 \times 10^9 \text{ Pa}}{1 \text{ GPa}} \times \frac{1 \text{ kPa}}{1000 \text{ Pa}} \times \frac{1 \text{ atm}}{101.325 \text{ kPa}} \times \frac{760 \text{ mm Hg}}{1 \text{ atm}} = 52,500,000 \text{ mm Hg}$$

Note that 52,500,000 mm of Hg is 52.5 km of mercury. This means that this is the pressure of a column of Mercury about 30 miles high!

2. The Kermit the Frog balloon in the Macy's Thanksgiving parade has a volume of 148000 liters (5,220 cu ft). How many grams of helium does it take to fill Kermit if the temperature is 15 °C and you need to make Kermit's pressure 1.05 atm to make sure he is fully inflated?

$$PV=nRT$$

$$n=PV/RT$$

$$= (1.05 \text{ atm} \times 148000\text{L})/[0.08206 \text{ L}\cdot\text{atm}/\text{K}\cdot\text{mol} \times (15+273)\text{K}]$$

$$= 6.575 \times 10^3 \text{ moles of He}$$

$$6.575 \times 10^3 \text{ moles He} \times 4 \text{ g/mol}$$

$$= 2.63 \times 10^4 \text{ g of He}$$

For the curious

$$= 26.3 \text{ kg of He}$$

= about 58 lbs of helium

I think this is about \$700 worth of helium!

3. Define the following terms:

STP

Standard Temperature and Pressure, 273.15K and 1 Atm.

A non-ideal gas

A gas that does not follow the equation $PV=nRT$. This will happen to any gas at high pressure and low temperature.

rms

Root Mean Square - mathematically the square root of the average of a set of squared numbers. In the gas chapter we had the rms velocity of a gas.

diffusion

A measure of how fast a given gas passes through a space occupied by a second gas.

KMT

Kinetic Molecular Theory. The theory that says that all the properties of a gas can be explained as the result of the gas being composed of tiny particles in constant motion.

partial pressure

That portion of the pressure of a mixture of gases that can be attributed to the pressure of a single gas within that mixture.

4. If the internal energy of a system is increased by 300 J while 75 J of expansion work is done, how much heat was transferred and in which direction, to or from the system?

Internal Energy = $\Delta E = 300\text{J}$

If expansion work is done, then $w = -75\text{ J}$

Therefore

$$\Delta E = q + w$$

$$300 = q - 75$$

$$300 + 75 = q$$

$$q = 375\text{ J}$$

Since this has a positive sign, then this heat is transferred from the surroundings into the system.

5. The overall reaction in a commercial hand warmer pack can be represented as:



A. I want the above reaction to release 100 kJ of heat. How much Fe do I need in my handwarmer?

$$100 \text{ kJ} \times \frac{4 \text{ moles Fe}}{1852 \text{ kJ}} \times \frac{55.85 \text{ g Fe}}{1 \text{ mole Fe}} = 121 \text{ g Fe}$$

B. If I use the above 100 kJ handwarmer to cook my soup instead of warm my hands, how hot will it make a cup of soup (250 grams of water) that is initially 20 °C? (Assume the specific heat capacity of soup is 4.18 J/ °C•g)

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

$$100 \text{ kJ} = 100,000 \text{ J} = \Delta T \times 4.18 \times 250$$

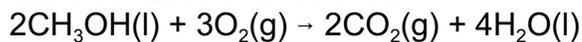
$$\Delta T = 100,000 / (4.18 \times 250)$$

$$= 95.7^\circ$$

$$\text{Since the initial temp is } 20^\circ \text{ C our final temp should be } 20 + 95.7 = 115.7^\circ \text{C}$$

Actually that won't happen because water will boil at 100°C and the heat energy will be used to change liquid water into water vapor, so the temperature will hold at 100°C. But that is a question for next semester!

6. Calculate the ΔH for the reaction



given the following ΔH_f° values:

$$\text{CH}_3\text{OH}(g) \quad -201$$

$$\text{CH}_3\text{OH}(l) \quad -239$$

$$\text{CO}_2(g) \quad -393.5$$

$$\text{H}_2\text{O}(g) \quad -252$$

$$\text{H}_2\text{O}(l) \quad -276$$

$$\Delta H_{\text{rxn}} = \text{sum of products} - \text{sum of reactants}$$

$$= [2(-393.5) + 4(-276)] - [2(-239) + 3(0)]$$

(Remember O_2 is an elemental form so it has a ΔH_f° of 0)

$$= -1413 \text{ kJ}$$

7. You may have heard of 'short wave' radio. The 'short' radio waves have the unique property that, under the right conditions, they can bounce off the ionosphere so a radio operator in the US can talk with a radio operator in Europe. (No big deal now in our age of internet and satellites, but a big deal in the 1940's and 50's)

What is the wavelength of a short wave radio transmitting at a frequency of 5000 kHz

$$c = \lambda v$$

$$3 \times 10^8 \text{ m/sec} = \lambda \times 5000,000 \text{ Hz}$$

$$\lambda = (3 \times 10^8 \text{ m/sec}) / 500,000 \text{ sec}^{-1}$$

$$= 60 \text{ m}$$

(That doesn't sound that short to me!)

What is the energy of a single photon of 5000 kHz shortwave radiation?

$$E = hv$$

$$= 6.626 \times 10^{-34} \text{ J} \cdot \text{sec} \times 5000,000 \text{ sec}^{-1}$$

$$= 3.313 \times 10^{-27} \text{ J}$$

8. Calculate the wavelength associated with an electron (mass $9.11 \times 10^{-31} \text{ kg}$) moving at $0.1 \times$ the speed of light.

$$\lambda = \frac{h}{mv} = \frac{6.626 \times 10^{-34} \text{ J} \cdot \text{sec}}{9.11 \times 10^{-31} \text{ kg} \times 0.1 \times 3 \times 10^8 \text{ m/sec}}$$

$$= 2.4 \times 10^{-11} \text{ m}$$

$$= 0.024 \text{ nm}$$