R= 8.31 J/mol K = 0.0821 L atm/mol K = 62.4 L torr/mol K PV = nRT

$R_H = 2.18 \times 10^{-18}$ Joule Energy of a Bohr orbit = $-\frac{R_H}{n^2}$ $h = 6.63 \times 10^{-34}$ J•s

$E = h\nu = \frac{hc}{\lambda}$ $c = 3.0000 \times 10^8$ m/s

$$E_n = (-R_H)\left(\frac{1}{n^2}\right)$$

n is the principal quantum number of the Bohr orbit, or energy level.

When an electron in hydrogen jumps from one energy level to another, the resulting energy is

$E = -2.18 \times 10^{-18}(1/n_f^2 - 1/n_i^2)$ where n_f is the principal quantum number of the destination energy level, and n_i is the principal quantum number of the initial energy level.

The rms velocity, $\mu = \sqrt{\frac{3RT}{M}}$ where M is the molar mass of the gas, in kg per mole.

Some thermodynamic data. (At 298 K)

Substance	ΔH_f *(kJ/mol)*
$CO_2(g)$	–393.5
CO(g)	–110.5
$C_2H_6(g)$	– 84.68
HBr(g)	–36.43
HCl(g)	–92.30
H_2O (*l*)	–285.8
HI(g)	+25.9

specific heat of water is 4.18 J/g°

Brooklyn College
Chemistry Department
Second lecture test, Fall, 2011

Name_____ (1.5 points each)

_____1. When $\Delta H°$ is negative at constant pressure for a given chemical or physical process, it indicates that A) the process is endothermic B) work is being done on the system C) work is being done by the system D) heat is flowing into the system E) the process releases energy in the form of heat

_____2. $\Delta H°$ for the reaction $2\ HCl(g) + I_2(s) \rightarrow 2\ HI(g) + Cl_2(g)$ is A) –66.4 kJ B) +66.4 kJ C) 118.2 kJ D) 236.4 kJ E) –236.4 kJ

_____3. $S(s) + 3\ F_2(g) \rightarrow SF_6(g)$

For the reaction above at standard temperature and pressure, the volume of F_2 required to produce 0.500 mole of SF_6 is A) 67.2 liters B) 33.6 liters C) 22.4 liters D) 11.2 liters E) 1.5 liters

_____4. If the density of a certain compound in the gas phase is 1.89 grams per liter, and the density of oxygen gas at the same temperature and pressure is 1.04 grams per liter, then the approximate molecular mass of the compound is A) 17.6 B) 29.1 C) 35.2 D) 58.2 E) 182

_____5. $C(s) + O_2(g) \rightarrow CO_2(g)$ $\Delta H = -393.5$ kJ

$2C(s) + O_2(g) \rightarrow 2\ CO(g)$ $\Delta H = -221.1$ kJ

The heats of combustion of graphite to CO_2 and CO are given above. What is the standard enthalpy change for the reaction $CO(g) + \frac{1}{2}\ O_2 \rightarrow CO_2(g)$?

A) –283.0 kJ B) –627.1 kJ C) –172.4 kJ D) + 172.4 kJ E) + 627. 1 kJ

_____6. Under the same conditions, what is the ratio of the rate of effusion of CO_2 (MW=44) to the rate of effusion of SF_6 gas (MW = 146) A) 11 B) 3.32 C) 1.82 D) 0.549 E) 0.301

_____7. When a sample of an ideal gas in a sealed rigid container is heated from 25°C to 100°C, all of the following quantities change except the A) pressure of the gas B) density of the gas C) total kinetic energy of the gas sample D) average speed of the gas molecules E) number of collisions per second of the gas molecules

_____8. Given: $NO(g) + \frac{1}{2} O_2(g) \rightarrow NO_2(g)$ $\Delta H° = -59$ kJ

$NO_2(g) + 2 H_2(g) \rightarrow 2 H_2O(g) + \frac{1}{2} N_2(g)$ $\Delta H° = -519$ kJ

$H_2(g) + \frac{1}{2} O_2(g) \rightarrow H_2O(g)$ $\Delta H° = -243$ kJ

What is the heat of formation, $\Delta H°f$ of NO(g) ?

A) + 92 kJ/mol B) +335 kJ/mol C) –820 kJ/mol D) –1063 kJ/mol

_____9. For which chemical equation will the heat of reaction, ΔH, correspond to the molar heat of formation of liquid water?

A) $H_2(g) + \frac{1}{2} O_2(g) \rightarrow H_2O(\ell)$ B) $H(g) + H(g) + O(g) \rightarrow H_2O(\ell)$

C) $2 H_2(g) + \frac{1}{2} O2(g) \rightarrow 2 H_2O(\ell)$ D) $H+(aq) + OH^-(aq) \rightarrow H_2O(\ell)$

$$\frac{PV}{nT}$$

_____10. The pressure, volume, temperature and number of moles of several gases are determined under various conditions. For each of these , the value of the fraction above is calculated, with the pressure in atm, T in Kelvin, n in moles, and V in liters. For which of the following gases would the value of the fraction be closest to 0.0821 Latm/mol K ?

A) Water vapor at 380 K and 1.20 atm
B) Cl_2 gas at 298 K and 5.00 atm.
C) H_2 gas at 500 K and 0.200 atm.
D) Ar gas at 100 K and 10.00 atm.
E) He gas at 10.0 K and 5.00 atm.

This is the same as asking which is most ideal

_____11. The RMS velocity of a gas varies A) directly with the molar mass of the gas B) inversely with the molar mass of the gas C) directly with the Kelvin temperature of the gas D) directly with the square root of the Kelvin temperature E) inversely with the square root of the Kelvin temperature.

_____12. Gases will not behave "ideally" when

A) the particles collide elastically with the container walls
B) the particles collide elastically with each other
C) there are significant attractions between the gas particles
D) there is a significant increase in temperature
E) the particles have a total volume that is negligible compared to the volume of the container.

_____13. A tank contains 32.00 grams of O_2 gas and 16.00 grams of He gas. If the partial pressure of the oxygen gas is 0.400 atm, what is the **total** pressure of the gases in the tank? A) 0.800 atm. B) 0.600 atm C) 1.20 atm D) 1.60 atm E) 2.00 atm

_____14. Samples of Ne gas and He gas are mixed in a tank, where they have the same partial pressures and temperatures. The neon and the helium must also have the same

A) mass B) density C) RMS velocity D) number of particles

_____15. How much heat is needed to raise the temperature of 1.00 **mole** of water from 10.0C to 50.0 C? A) 167 J B) 3.01 kJ C) 9.29 J D) 3760 J E) 40.0 kJ

_____16. The pressure and kelvin temperature of a gas with a volume of 10.00 L are both doubled. The new volume of the gas is A) 10.00 L B) 2.500 L C) 40.00 L D) 5.000 L E) 20.00 L

_____17. 20.00 mL of Ne gas is heated from 127° C to 327° C, with the pressure constant. The new volume of the gas would be A) 10.00 mL B) 30.00 mL C) 40.00 mL D) 51.50mL E) 7.77 mL

18 to 20. Indicate whether each of the following values is positive (+) negative (–) or zero. (0)

0 _____18. ΔH of formation of Br_2 (ℓ)

– _____19. ΔH of formation of Cl_2(ℓ)

\+ _____20. The charge on the nucleus of a chloride ion

_____21. The Rutherford Gold Leaf experiment established that
A) atoms contain three different subatomic particles
B) atoms are mostly empty space
C) variations in atomic mass are caused by different numbers of neutrons
D) the energy of an electron is quantized
E) electrons have a negative charge

_____22. Which could be a correct set of quantum numbers for the valence electrons of an alkaline earth metal (group 2) in the ground state?

	n	l	m_l	m_s (spin)
(A)	4	1	0	-1/2
(B)	1	0	0	+1/2
(C)	3	0	0	–1/2
(D)	2	0	1	+1/2
(E)	4	2	1	-1/2

_____23. In a hydrogen atom, which of the following electron drops would produce the highest frequency of light? A) from n=6 to n=3 B) from n=2 to n=1
C) from n=4 to n=2 D) from n=6 to n=5 D) from n=7 to n=3

_____24. The total number of electron orbitals available in the fourth principal energy level is A) 4 B) 16 C) 9 D) 18 E) 32

_____25. In the Stern-Gerlach experiment, silver atoms were shot through a powerful magnetic field. The stream of atoms divided into two separate paths. This division would **not** be observed with atoms of A) Cu B) Cr C) Mg D) K E) Al

_____26. The Pauli exclusion principle states that A) the velocity of all electromagnetic radiation equals the speed of light B) all particles with mass also have a wave length C) the velocity of an electron and its exact position cannot be known at the same instant D) each electron in an atom has its own unique set of four quantum numbers E) as many electrons as possible remain unpaired within one atomic subshell

27 to 29. Two 10.0 liter vessels, are filled with gases at the same temperature. Vessel A contains 32.0 grams of O_2 gas, while vessel B contains 32.0 grams of CH_4 gas.

A) 1:1 B) 1:2 C) 2:1 D) 1.4:1 E) 1:1.4

A
_____27. The ratio of the densities of the gas in vessel A to the gas in vessel B.

B
_____28. The ratio of the pressures of the gas in vessel A to the gas in vessel B.

A
_____29. The ratio of the average kinetic energies of the gas in vessel A to the gas in vessel B.

_____30. 36.0 kJ of heat are applied to a gas, which then expands, doing 24.0 kJ of work. What is ΔE for the system? A) –12 kJ B) 12 kJ C) 60 kJ D) –60 kJ

_____31. How many orbitals are there on an f sublevel? A) 5 B) 7 C) 14 D) 9

_____32. The "z" axis is pictured as being perpendicular to the orbital known as the A) dxy B) dz^2 C) Pz D) dyz

_____33. How many electrons are there in the third principal energy level of a tin atom in the ground state? A) 8 B) 14 C) 18 D) 2

0.50
_____34. What is the molarity of a solution containing 4.00 grams of NaOH in a total volume of 200. mL ?

0.067M
_____35. 250. mL of water are added to 50.0 mL of 0.400 molar NaOH. What is the molarity of the resulting solution?

250
_____36. How many mL of 0.200 molar H_2SO_4 would be required to completely neutralize 250 mL of 0.400 molar KOH?

0.010
_____37. 50.0 mL of 0.200 molar H_2SO_4 is added to 40.0 mL of 0.300 molar $Ba(OH)_2$. How many moles of $BaSO_4$ are produced?

PROBLEMS: These MUST be answered in the essay booklets.

I. Provide the electron configurations of each of the following atoms and/or ions. You may NOT use condensed configurations. (2 pts each)

A. Mn B. Ga^{3+} C. Ti^{2+} D. Te

II. A 0.110 gram sample of propane, C_3H_8 (MM = 44.1) is burned in excess oxygen to produce H_2O (ℓ) and CO_2(g) (12 points)

A. Write the balanced equation for the reaction.

B. The combustion of the 0.110 grams of C_3H_8 produces enough heat to change the temperature of 232.2 grams of water from 25.00C to 30.75 C.

1. How much heat was produced in the combustion of the 0.110 grams ?

2. What is the value of ΔH of the reaction in part A, in kJ per mole of propane? (the heat of combustion of propane)

C. Based on your answer to B part 2, and the data on the thermo table, what is the heat of formation, ΔHf, of propane gas, in kJ/mol ?

(If you were unable to answer part B, use – 2200 kJ as the heat of combustion)

III. The combustion of ethane, C_2H_6 is the subject of this problem: (12 points)

$2\ C_2H_6(g) + 7\ O_2(g) \rightarrow 4\ CO_{2(g)} + 6\ H_2O(\ell)$

A. Find ΔH for this reaction, as written.

B. How much heat is produced in the combustion of 10.00 gram of ethane?

C. Assume that the 10.00 gram of ethane was originally placed in a 10.00 liter container at a temperature of 300.0 K.

1. What is the pressure of the ethane, in atmospheres?

2. Sufficient oxygen is pumped into the tank to bring the total pressure in the tank to 4.00 atm. What is the partial pressure of the oxygen, assuming that no reaction occurs?

3. What is the partial pressure of the oxygen remaining in the tank after the reaction occurs, using up all of the ethane? Assume that the temperature is brought back to 300.0 K.

IV. Bohr assigned each orbit in the hydrogen atom an energy of $\frac{-2.18 x 10^{-18} \text{ joules}}{n^2}$

A. Find the energies of the 5th and the 2nd Bohr orbits.

B. Find the energy emitted when an electron drops from the fifth to the second orbit.

C. Find the frequency and wave length of the spectral line produced by the transition in part B.

(8 points.)

V. Hydrogen is often prepared in the laboratory by reacting Zinc with dilute HCl.

$Zn(s) + 2\ HCl(aq) \rightarrow ZnCl_2(aq) + H_2(g)$

An experiment requires the production of 250 mL of hydrogen gas at a pressure of 1.00 atm. and a temperature of 296 K.

A. How many moles of hydrogen are produced in the experiment?

B. Assuming that excess zinc is reacted with the hydrochloric acid, and that no more than 100. mL of the hydrochloric acid solution can be used, what is the minimum molarity of HCl that can be used in the experiment, to produce the desired amount of hydrogen? (what molarity of HCl, in 100 mL, will produce the amount of hydrogen indicated in part A)

(6 pts)

Extra Credit. (4 points)

The specific heat of iron is 0.45 joules per gram degree. 50.0 grams of iron, initially at 100.0°C, are added to 50.0 grams of water, initially at 20.0°C. Assuming no loss of heat to the container or to the environment (i.e. all of the heat is transferred from the iron to the water) what is the final temperature of the mixture of iron and water?

.5 point each - Give the last names of the famous scientists with the following first names:

a) Amodeo B) Evangelista C) Erwin D) Werner E) Louis