ABBREVIATIONS AND SYMBOLS					
ampere	A	Faraday constant	F	molal	m
atmosphere	atm	formula molar mass	M	molar	M
atomic mass unit	u	free energy	G	molar mass	M
atomic molar mass	A	frequency	ν	mole	mol
Avogadro constant	N_A	gas constant	R	Planck's constant	h
Celsius temperature	°C	gram	g	pressure	P
centi– prefix	c	heat capacity	C_p	rate constant	k
coulomb	C	hour	h	retention factor	R_f
electromotive force	E	joule	J	second	s
energy of activation	E_a	kelvin	K	temperature, K	T
enthalpy	H	kilo– prefix	k	time	t
entropy	S	liter	L	volt	V
equilibrium constant	K	milli– prefix	m		

CONSTANTS
$R = 8.314\ \text{J·mol}^{-1}\text{·K}^{-1}$
$R = 0.0821\ \text{L·atm·mol}^{-1}\text{·K}^{-1}$
$1\ F = 96{,}500\ \text{C·mol}^{-1}$
$1\ F = 96{,}500\ \text{J·V}^{-1}\text{·mol}^{-1}$
$N_A = 6.022 \times 10^{23}\ \text{mol}^{-1}$
$h = 6.626 \times 10^{-34}\ \text{J·s}$
$c = 2.998 \times 10^{8}\ \text{m·s}^{-1}$
$0\ °\text{C} = 273.15\ \text{K}$
$1\ \text{atm} = 760\ \text{mmHg}$

EQUATIONS

$$E = E^\circ - \frac{RT}{nF}\ln Q \qquad \ln K = \left(\frac{-\Delta H}{R}\right)\left(\frac{1}{T}\right) + \text{constant} \qquad \ln\left(\frac{k_2}{k_1}\right) = \frac{E_a}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)$$

PERIODIC TABLE OF THE ELEMENTS

1 1A												13 3A	14 4A	15 5A	16 6A	17 7A	18 8A
1 **H** 1.008	2 2A																2 **He** 4.003
3 **Li** 6.941	4 **Be** 9.012											5 **B** 10.81	6 **C** 12.01	7 **N** 14.01	8 **O** 16.00	9 **F** 19.00	10 **Ne** 20.18
11 **Na** 22.99	12 **Mg** 24.31	3 3B	4 4B	5 5B	6 6B	7 7B	8 8B	9 8B	10 8B	11 1B	12 2B	13 **Al** 26.98	14 **Si** 28.09	15 **P** 30.97	16 **S** 32.07	17 **Cl** 35.45	18 **Ar** 39.95
19 **K** 39.10	20 **Ca** 40.08	21 **Sc** 44.96	22 **Ti** 47.88	23 **V** 50.94	24 **Cr** 52.00	25 **Mn** 54.94	26 **Fe** 55.85	27 **Co** 58.93	28 **Ni** 58.69	29 **Cu** 63.55	30 **Zn** 65.39	31 **Ga** 69.72	32 **Ge** 72.61	33 **As** 74.92	34 **Se** 78.96	35 **Br** 79.90	36 **Kr** 83.80
37 **Rb** 85.47	38 **Sr** 87.62	39 **Y** 88.91	40 **Zr** 91.22	41 **Nb** 92.91	42 **Mo** 95.94	43 **Tc** (98)	44 **Ru** 101.1	45 **Rh** 102.9	46 **Pd** 106.4	47 **Ag** 107.9	48 **Cd** 112.4	49 **In** 114.8	50 **Sn** 118.7	51 **Sb** 121.8	52 **Te** 127.6	53 **I** 126.9	54 **Xe** 131.3
55 **Cs** 132.9	56 **Ba** 137.3	57 **La** 138.9	72 **Hf** 178.5	73 **Ta** 180.9	74 **W** 183.8	75 **Re** 186.2	76 **Os** 190.2	77 **Ir** 192.2	78 **Pt** 195.1	79 **Au** 197.0	80 **Hg** 200.6	81 **Tl** 204.4	82 **Pb** 207.2	83 **Bi** 209.0	84 **Po** (209)	85 **At** (210)	86 **Rn** (222)
87 **Fr** (223)	88 **Ra** (226)	89 **Ac** (227)	104 **Rf** (261)	105 **Db** (262)	106 **Sg** (263)	107 **Bh** (262)	108 **Hs** (265)	109 **Mt** (266)	110 **Ds** (269)	111 **Rg** (272)	112 **Uub** (277)		114 **Uuq** (2??)		116 **Uuh** (2??)		118 **Uuo** (2??)

58 **Ce** 140.1	59 **Pr** 140.9	60 **Nd** 144.2	61 **Pm** (145)	62 **Sm** 150.4	63 **Eu** 152.0	64 **Gd** 157.3	65 **Tb** 158.9	66 **Dy** 162.5	67 **Ho** 164.9	68 **Er** 167.3	69 **Tm** 168.9	70 **Yb** 173.0	71 **Lu** 175.0
90 **Th** 232.0	91 **Pa** 231.0	92 **U** 238.0	93 **Np** (237)	94 **Pu** (244)	95 **Am** (243)	96 **Cm** (247)	97 **Bk** (247)	98 **Cf** (251)	99 **Es** (252)	100 **Fm** (257)	101 **Md** (258)	102 **No** (259)	103 **Lr** (262)

Part I Lab

Team # School / Name

2007 UNITED STATES NATIONAL CHEMISTRY OLYMPIAD
PART III — LABORATORY PRACTICAL

Student Instructions

Introduction

These problems test your ability to design and carry out laboratory experiments and to draw conclusions from your experimental work. You will be graded on your experimental design, on your skills in data collection, and on the accuracy and precision of your results. Clarity of thinking and communication are also components of successful solutions to these problems, so make your written responses as clear and concise as possible.

Safety Considerations

You are required to wear approved eye protection at all times during this laboratory practical. You also must follow all directions given by your examiner for dealing with spills and with disposal of wastes.

Lab Problem 1

You have been given seven pipets that contain solutions of $AgNO_3$, $BaCl_2$, $Cu(NO_3)_2$, $CuSO_4$, $Pb(NO_3)_2$, KI, and $Na_2S_2O_3$, though not necessarily in this order. Using the materials provided, devise and carry out an experiment to correctly determine the contents of each pipet.

Lab Problem 2

Given a sample of an unknown metal carbonate, M_xCO_3, and 3.0M hydrochloric acid, HCl(aq), a balloon, and some laboratory equipment, devise and carry out an experiment by combining these two substances to determine the volume of the gas produced *and* the unknown metal. The possible metals are Ba, Ca, Li, or Na.

Room Temp. = 25°C, Standard Pressure = 1 atm

Answer Sheet for Laboratory Practical **Problem 1**

Answer Sheet for Laboratory Practical **Problem 2**

Student's Name: _____

Student's School: _____ **Date:** _____

Proctor's Name: _____

ACS Section Name : _____ **Student's USNCO test #:** _____

1. Give a brief description of your experimental plan.

Before beginning your experiment, you must get approval (for safety reasons) from the examiner.	**Examiner's Initials:**

2. Record your data and other observations.

3. Calculations and Conclusions.

4. **Conclusions:** The volume of gas produced: The unknown metal:

5. **Sources of Error** in this experiment (please number):

Part 2 Lab

Introduction to Thermochemistry Lab

The Dissolving of Ammonium Nitrate

Procedure:

1. Take two Styrofoam cups to form a calorimeter. (a device to help measure how much heat or energy is lost/gained in a reaction) Place 100 mL of water in one of the cups. Take the initial temperature of water in one of these cups. Take 10 g of ammonium nitrate in the cup and quickly seal the cups together. Place a thermometer through a hole in the cup to record the temperature throughout the experiment. Record the temperature at 30 second intervals until all the ammonium nitrate has dissolved and the temperature has decreased for two consecutive readings. Please wash and rinse cups out when finished.
   ** You will be graded against the theoretical value

Data: Amount of water: _____ mL

Amount of Ammonium nitrate _____ g

Init. Temperature of water _____ °C

Record temperature every 30 sec. (use as many lines as needed) _____

_____ _____ _____ _____ _____ _____

_____ _____ _____ _____ _____ _____

_____ _____

Calculations:

1.) Calculate the amount of heat absorbed by the water. The specific heat constant for water is 4.18 J/g * °C .

2.) Calculate the amount of absorbed by the ammonium nitrate.

3.) Calculate the value of ΔH_{rxn} for the dissolving of ammonium nitrate in water.

** You will be graded against the theoretical value...make sure all the salt has dissolved

Gas Laws Mentor Multiple Choice

1. You are holding two balloons of the same volume. One balloon contains 1.0 g helium. The other balloon contains neon. What is the mass of neon in the balloon?
[A] 5.0 g [B] 4.0 g [C] 1.0 g [D] 0.20 g [E] 20. g

2. You are holding two balloons, an orange balloon and a blue balloon. The orange balloon is filled with neon (Ne) gas, and the blue balloon is filled with argon (Ar) gas. The orange balloon has twice the volume of the blue balloon. Which of the following best represents the mass ratio of Ne:Ar in the balloons?
[A] 1:1 [B] 3:1 [C] 1:3 [D] 1:2 [E] 2:1

3. If the temperature of an ideal gas is raised from 100°C to 200°C, while the pressure remains constant, the volume
[A] remains the same [B] goes to 1/2 the original volume [C] increases by a factor of 100 [D] doubles
[E] none of these

4. You have a certain mass of helium gas in a rigid steel container. You add the same mass of neon gas to this container. Which of the following best describes what happens? Assume temperature is constant.
[A] The pressure in the container more than doubles. [B] The pressure in the container doubles.
[C] The volume of the container more than doubles. [D] The pressure in the container increases but does not double.
[E] The volume of the container doubles.

5. Gaseous chlorine is held in two separate containers at identical temperature and pressure. The volume of container 1 is 1.30 L, and it contains 6.70 mol of the gas. The volume of container 2 is 2.20 L. How many moles of the gas are in container 2?
[A] 11.3 mol [B] 19.2 mol [C] 3.96 mol [D] 0.427 mol [E] none of these

6. Which of the following will give a graph with a straight line and a *y*-intercept of 0?
[A] volume vs. 1/temperature (°C) [B] volume vs. temperature (°C) [C] volume vs. temperature (K)
[D] volume vs. 1/temperature (K) [E] none of these

7. How many moles of $O_2(g)$ are needed to react completely with 52.0 L of $CH_4(g)$ at STP to produce $CO_2(g)$ and $H_2O(g)$ according to the following reaction:

$$CH_4(g) + 2O_2 \rightarrow CO_2(g) + 2H_2O(g)$$

[A] 11.6 [B] 52.0 [C] 4.64 [D] 2.32 [E] none of these

8. The volume of a sample of gas is 650. mL at STP. What volume will the sample occupy at 0.0°C and 950. torr?
[A] 568 mL [B] 650. mL [C] 520. mL [D] 476 mL [E] none of these

9. If temperature and pressure are held constant, the volume and number of moles of a gas are
[A] inversely proportional [B] directly proportional [C] equal [D] independent of each other
[E] not enough information given

10. Which of the following statements is *true* about the kinetic molecular theory?
[A] The volume of a gas particle is considered to be small--about 0.10 mL.
[B] Gas particles repel each other but do not attract one another.
[C] Adding an ideal gas to a closed container will cause an increase in temperature.
[D] Pressure is due to the collisions of the gas particles with the walls of the container.
[E] At least two of these statements are correct.

11. The air in the inner tube of the tire of a racing bike has a pressure of 115 psi. Convert this pressure to atm.
[A] 1690 atm [B] 7.83 atm [C] 32.6 atm [D] 115 atm [E] 0.151 atm

12. What would happen to the average kinetic energy of the molecules of a gas sample if the temperature of the sample increased from 20°C to 40°C?
[A] It would increase. [B] It would become half its value. [C] It would decrease.
[D] It would double. [E] Two of these

13. A vessel with an internal volume of 10.0 L contains 2.80 g of nitrogen gas, 0.403 g of hydrogen gas, and 79.9 g of argon gas. At 25°C, what is the pressure (in atm) inside the vessel?
[A] 2.38 atm [B] 3.20 atm [C] 0.471 atm [D] 6.43 atm [E] 5.62 atm

14. Use the kinetic molecular theory of gases to predict what would happen to a closed sample of a gas whose temperature increased while its volume decreased.
[A] Its pressure would decrease. [B] Its pressure would hold constant. [C] Its pressure would increase.
[D] The average kinetic energy of the molecules of the gas would decrease.
[E] The number of moles of the gas would decrease.

Zinc metal is added to hydrochloric acid to generate hydrogen gas and is collected over a liquid whose vapor pressure is the same as pure water at 20.0°C (18 torr). The volume of the mixture is 1.7 L, and its total pressure is 0.810 atm.

15. Determine the number of moles of hydrogen gas present in the sample.
[A] 42 mol [B] 22 mol [C] 0.056 mol [D] 0.82 mol [E] 1.3 mol

Zinc metal is added to hydrochloric acid to generate hydrogen gas and is collected over a liquid whose vapor pressure is the same as pure water at 20.0°C (18 torr). The volume of the mixture is 1.7 L, and its total pressure is 0.810 atm.

16. Determine the partial pressure of the hydrogen gas in this mixture.
[A] 580 torr [B] 598 torr [C] 562 torr [D] 616 torr [E] 634 torr

17. Consider a steel container filled with 40.0 g of helium gas and 40.0 g of argon gas. What is the ratio of pressures that each gas exerts (helium:argon)?
[A] 1:1 [B] More information is needed to answer this question. [C] 10:1 [D] 1:10 [E] 9:1

18. What volume is occupied by 19.6 g of methane, CH_4, at 27°C and 1.59 atm?
[A] not enough data to calculate [B] 1.71 L [C] 27.7 L [D] 302 L [E] 18.9 L

19. A gas is collected over water at a certain temperature. The total pressure is 762 torr. The vapor pressure of water at this temperature is 17 torr. The partial pressure of the gas collected is
[A] 779 torr [B] 762 torr [C] 17 torr [D] 745 torr [E] none of these

20. A 6.35-L sample of carbon monoxide is collected at 55°C and 0.892 atm. What volume will the gas occupy at 1.05 atm and 20.°C?
[A] 6.10 L [B] 1.96 L [C] 4.82 L [D] 5.46 L [E] none of these

21. Calculate the density of neon gas at 1.00 atm and 25.0°C.
[A] 0.825 g/L [B] 20.2 g/L [C] 9.84 g/L [D] 22.4 g/L [E] None of these.

22. You are playing with a helium balloon on a typically warm California day. Suddenly, the Celsius temperature doubles. Which of the following is true?
[A] The actual temperatures are needed to answer this question. [B] The pressure inside the balloon will double.
[C] The volume of the balloon will decrease. [D] The volume of the balloon will slightly increase.
[E] The volume of the balloon will double.

23. A 4.40-g piece of solid CO_2 (dry ice) is allowed to vaporize (change to $CO_{2(g)}$) in a balloon. The final volume of the balloon is 1.00 L at 300. K. What is the pressure of the gas?
[A] 0.122 atm [B] 246 atm [C] 2.46 atm [D] 122 atm [E] none of these

24. You are holding four balloons each containing 10.0 g of a different gas. The balloon containing which gas is the largest?
[A] He [B] O_2 [C] H_2 [D] Ne [E] All have the same volume.

25. Which of the following statements is *true* concerning ideal gases?

[A] The gas particles in a sample exert attraction for one another.
[B] The temperature of the gas sample is directly related to the average velocity of the gas particles.
[C] A gas exerts pressure as a result of the collisions of the gas molecules with the walls of the container.
[D] At STP, 1.0 L of Ar*(g)* contains about twice the number of atoms as 1.0 L of Ne*(g)* because the molar mass of Ar is about twice that of Ne.
[E] All of these are false.

Thermochemistry Mentor Multiple Choice

26. What is the specific heat capacity of a substance if 2.41×10^4 J are needed to change the temperature of 105.0 g of it from 25.0°C to 250.0°C?

a. 1.02×10^{-4} J/g°C b. 9.18×10^{-4} J/g°C c. 0.918 J/g°C d. 1.02 J/g°C

27. Which statement about enthalpy is true?
a. Heat is given off to the surroundings in endothermic reactions.
b. Some substances have a negative specific heat capacity.
c. Specific heat capacity is the same for all liquids.
d. The sign of ΔH is always negative in exothermic reactions.

28. What happens to the value of ΔH for a thermochemical reaction if the reaction is reversed?

a. ΔH has the same numerical value, and the sign changes.
b. ΔH has the same numerical value, and the sign remains the same.
c. ΔH is the reciprocal of the original value, and the sign changes.
d. ΔH is the reciprocal of the original value, and the sign remains the same.

29. Which is an exothermic process?

a. Ice melting
c. Water boiling
c. Water evaporating
d. Water vapour condensing

30. Which statement is true for the combustion of ethanol?

$C_2H_5OH\ (l) + 3O_2(g) \rightarrow 2CO_2\ (g) + 3H_2O(l)$ $\Delta H = -1370$ kJ

a. The enthalpy change would be the same is gaseous water were produced.
b. The potential energy of the products is less than the potential energy of the reactants.
c. The products of the reaction occupy a larger volume than the reactants.
d. The reaction is endothermic.

31. What is the energy required to evaporate two moles of liquid water given the following equations?

$2H_2(g) + O_2(g) \rightarrow 2H_2O(g)$ $\Delta H = -483.6$ kJ
$2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$ $\Delta H = -571.6$ kJ

a. 44.0 kJ b. 88.0 kJ c. 527.6 kJ d. 1055.2 kJ

32. Which statement correctly describes an endothermic chemical reaction?

a. The products have higher potential energy than the reactants, and the ΔH is negative.
b. The products have higher potential energy than the reactants, and the ΔH is positive.
c. The products have lower potential energy than the reactants, and the ΔH is negative.
d. The products have lower potential energy than the reactants, and the ΔH is positive.

33. Given the thermochemical equation:

$2NO_2\ (g) \rightarrow 2NO(g) + O_2(g)$ $\Delta H = 114$ kJ

what is the ΔH for the reaction $NO(g) + \frac{1}{2} O_2(g) \rightarrow NO_2(g)$?

a. -114 kJ b. -57 kJ c. +57 kJ d. +114 kJ

34. Which process results in the greatest endothermic change for 10.0g of H_2O?

b. Condensation
c. Melting
d. Solidification
e. Vaporization

35. The following decomposition reaction may occur in an air bag.

$2NaN_3(s) \rightarrow 3N_2(g) + 2Na(s)$ $\Delta H = -43.5$ kJ

What is the heat of formation, ΔH_f, for NaN_3?

a. -43.5 kJ b. -21.8 kJ c. 21.8 kJ d. 43.5 kJ

36. Given the following two reactions:

$C(s) + O_2(g) \rightarrow CO_2(g)$ $\Delta H = -393.5$ kJ
$2Fe(s) + 3/2\ O_2(g) \rightarrow Fe_2O_3(s)$ $\Delta H = -824.2$ kJ

Calculate the enthalpy change for $2Fe_2O_3(s) + 3C(s) \rightarrow 4Fe(s) + 3CO_2(g)$

a. -467.9 kJ b. -430.7 kJ c. 430.7 kJ d. 467.9 kJ

37. A substance increases in temperature by 255°C when a 983 g sample of it absorbs 83 200 J of heat. What is the specific heat capacity of the substance?

a. 0.332 J/g°C b. 0.450 J/g°C c. 21.6 J/g°C d. 321 J/g°C

38. The enthalpy change for the following reaction is -184.6 kJ.

$H_2(g) + Cl_2(g) \rightarrow 2HCl(g)$

What is the standard enthalpy of formation, ΔH_f, for HCl(g)?

a. -369.2 kJ b. -184.6 kJ c. -92.3 kJ d. +92.3 kJ

39. Calculate the ΔH for the following reaction using the bond energies given below:

H-H (g) + I-I (g) $\rightarrow$ 2H-I (g)

Bond energies: H-H = 436 kJ/mol, I-I = 151 kJ/mol, H-I = 297 kJ/mol

a. +290 kJ b. -290 kJ c. +7 kJ d. -7 kJ

40. What quantity of heat is evolved with 5.550 mol $H_2O(l)$ is formed from the combustion of $H_2(g)$ and $O_2(g)$?

$H_2(g) + ½\ O_2(g) \rightarrow H_2O(l)$ $\Delta H = -285.8$ kJ

a. 51.44 kJ b. 285.8 kJ c. 1586 kJ d. 2297 kJ

41.As energy is added to a substance, the temperature remains constant. How may the substance be changing?

a. From a gas to a solid
b.From a liquid to a gas
c.From a liquid to a solid
d.In the amount of kinetic energy

42.The addition of 9.54 kJ of heat is required to raise the temperature of 225.0 g of a liquid hydrocarbon from 20.5°C to 45.0°C. What is the heat capacity of this hydrocarbon?

a. 0.94 J/g°C b. 1.73 J/g°C c. 1.88 J/g°C d. 9.42 J/g°C

Team # and School Name: _____

Limiting Reactants and Percent Yield

Box in Answers with Appropriate Units

#1. Aluminum metal reacts with nickel (II) oxide, forming nickel metal and aluminum oxide.

a.) Write the **balanced** chemical reaction for the above.

b.) What is the excess reactant and how many grams of it remain, after a reaction between 4.55 g of aluminum and 9.62 g of nickel (II) oxide?

#2. Sulfur dioxide gas reacts with hydrogen sulfie gas, producing solid sulfur(S_8) and water vapor.

a.) Write the **balanced** chemical reaction for the above.

Suppose 32.4 g of sulfur dioxide are combined with 28.7 g of hydrogen sulfide.

b.) Which reactant is limiting and which is in excess?

c.) How many grams of sulfur can be produced?

d.) How many grams of the excess reactant remain when the reaction is complete?

Team # and School Name: _____

Introductory Thermochemistry Problems

Box in answers with appropriate unit!

#1. How much thermal energy (Joules) is absorbed by 750 grams of water when its temperature increases from 15.4 °C to 86.3°C?

#2. How much thermal energy (joules) is absorbed by 150 grams of water when its temperature decreases from 24.36 °C to 4.40 °C?

#3. Suppose 3260 joules are absorbed by 135 grams of water. If the initial temperature of the water is 21.4 °C, what is the final temperature (Celcius)?

#4. Indicate whether each reaction below is exothermic or endothermic:

a.) $N_{2(g)}$ + $O_{2(g)}$ + thermal energy → 2 NO $_{(g)}$ _____

b.) $S_{(s)}$ + O2 $_{(g)}$ → $SO_{2(g)}$ ΔH rxn = -297 kJ _____

c.) $PCl_{3(g)}$ + $Cl_{2(g)}$ → $PCl_{5\ (g)}$ + thermal energy _____

d.) $H2_{(g)}$ + $I_{2\ (g)}$ → 2 HI $_{(g)}$ ΔH rxn = + 51.8 kJ _____

#5

The standard enthalpy of reaction, $\Delta H°_{rxn}$, for the equation below is –349 kJ.

$$NH_3(g) + {}^7/_4\ O_2(g) \longrightarrow NO_2(g) + {}^3/_2\ H_2O(l)$$

Give the standard enthalpy of reaction for each equation below:

1. ${}^3/_2\ H_2O(l) + NO_2(g) \longrightarrow NH_3(g) + {}^7/_4\ O_2(g)$ $\Delta H°_{rxn}$ =
2. $2\ NH_3(g) + {}^7/_2\ O_2(g) \longrightarrow 2\ NO_2(g) + 3\ H_2O(l)$ $\Delta H°_{rxn}$ =
3. $4\ NH_3(g) + 7\ O_2(g) \longrightarrow 4\ NO_2(g) + 6\ H_2O(l)$ $\Delta H°_{rxn}$ =
4. $2\ NO_2(g) + 3\ H_2O(l) \longrightarrow {}^7/_2\ O_2(g) + 2\ NH_3(g)$ $\Delta H°_{rxn}$ =

#6. A 150 mL sample of 0.20 M NaOH is mixed with 150 mL of 0.20 M HF solution, both of which have a termperature of 24.5 °C. The reaction below occurs, and the temperature of the solution rises to 25.8 °C. What is the ΔH of this reaction?

$$NaOH\ (aq) + HF\ (aq) \rightarrow H2O\ (l) + NaF\ (aq)$$

#7. Write the chemical equation that corresponds to the standard enthalpy of formation of potassium chlorate, $KClO_{3\ (s)}$

#8 When 0.55 g of Na(s) reacts with excess F2(g) to form NaF (s), 13.8 kJ of thermal energy is evolved at standard state conditions. What is the standard enthalpy of formation of NaF(s)?

#9.

Find ΔH°_{rxn} for

(1) $C_2H_2(g) + 2\ H_2(g) \longrightarrow C_2H_6(g)$

using the standard enthalpies of reaction below.

(2) $2\ H_2(g) + O_2(g) \longrightarrow 2\ H_2O(l)$ $\Delta H^\circ_{rxn} = -572$ kJ

(3) $2\ C_2H_2(g) + 5\ O_2(g) \longrightarrow 4\ CO_2(g) + 2\ H_2O(l)$ $\Delta H^\circ_{rxn} = -2598$ kJ

(4) $2\ C_2H_6(g) + 7\ O_2(g) \longrightarrow 4\ CO_2(g) + 6\ H_2O(l)$ $\Delta H^\circ_{rxn} = -3122$ kJ

#10. Use the standard enthalpies of formation in this table to answer the 2 questions below.

Use the standard enthalpies of formation in this table to answer the questions below.

Compound	ΔH_f° (kJ/mol)	Compound	ΔH_f° (kJ/mol)
CO(g)	-110.4	$H_2O(l)$	-285.8
$CO_2(g)$	-393.7	$Fe_2O_3(s)$	-822.2

A. Calculate the standard enthalpy of reaction for the equation

$$Fe_2O_3(s) + 3\ CO(g) \longrightarrow 2\ Fe(s) + 3\ CO_2(g)$$

B. The standard enthalpy of reaction for the equation below is –3535 kJ. Calculate the standard enthalpy of formation of $C_5H_{12}(l)$.

$$C_5H_{12}(l) + 8\ O_2(g) \longrightarrow 5\ CO_2(g) + 6\ H_2O(l)$$

Team # and School Name: _____

Introduction to Gas Law Problems

Box in answers with appropriate units!

#1. A 500.0 mL bottle contains hydrogen gas at 605 torr pressure at 18 °C. How many moles of hydrogen gas does the bottle contain?

#2. A 50.0 L tank designed to hold 250 moles of helium gas can withstand a maximum pressure of 200 atm. At what temperature (K) would the tank reach its maximum pressure?

#3. A small canister of gas has a pressure of 25 atm at 22 °C. What would be the pressure in the canister, if it were taken out of doors on a day when the outside temperature was -26 °C?

#4. Which is denser, helium gas at 1.0 atm and 0°C, or nitrogen gas at 55 torr and 200 °C?

#5. When 0.527 grams of a substance is vaporized, it occupies a volume of 135 mL at 98 °C and 756.3 torr. What is the molar mass of this substance?

#6. Some solid $CaCO_3$ was sealed into a 250 mL flask along with argon gas at a pressure of 610 torr at 22 °C. The flask was heated and some of the $CaCO_3$ decomposed giving off CO_2 gas. After the flask had cooled to 22 °C, the pressure was 840 torr. How many moles of CO_2 were produced?

a.) Write the reaction for the decomposition reaction.

b.) How many moles of CO_2 were produced?

#7. A 40.0 L tank contains a gas at 1820 torr and 23 °C. What would be the pressure in the tank if 0.500 mole of gas were added to the cylinder without changing the temperature?

#8. When the pressure of argon gas is 6.43 atm, at what Celsius temperature will its density be 10.3 g/L?

#9. The density of an unknown gas is 1.31 g/L at 749 torr and 20 oC. What is the molar mass of the gas?

#10. A cruise ship is propelled by steam-driven turbines. Superheated steam (steam at a temperature above the boiling point of water) enter the turbine at 371 °C and 51 atm. When it exits the turbine, a liter of this superheated steam will have expanded to 153 L at 131 torr. What is the Celsius temperature of the steam as it exits the turbine?