Name _____ AP Chemistry October 29, 2010

AP Chemistry Exam II
Part I: 39 Questions, 40 minutes, Multiple Choice, No Calculator Allowed
Bubble the correct answer on your scantron for each of the following.

For questions 1-6 consider the following system at equilibrium:

$2N_2(g) + O_2(g) \rightleftharpoons 2N_2O(g)$ $\Delta H = -163$ kJ

and select from the following choices:

a. to the right
b. to the left
c. neither
d. in both directions
e. cannot be determined from information provided

1. In which direction will the system move in order to reestablish equilibrium if the temperature is raised?
2. In which direction will the system move in order to reestablish equilibrium if the volume is increased?
3. In which direction will the system move in order to reestablish equilibrium if O_2 is added?
4. In which direction will the system move in order to reestablish equilibrium if a catalyst is added?
5. In which direction will the system move in order to reestablish equilibrium if N_2O is removed?
6. In which direction will the system move in order to reestablish equilibrium if a sample of Kr is added?

7. In expanding from 5.00 to 6.00 liters at a constant pressure of 2.00 atmospheres, a gas absorbs 505.64 joules of energy (101.32 J = 1 liter atm). The change in energy ΔE for the gas is:

a. 50.66 J b. 101.32 J c. 303.00 J d. 505.64 J e. 606.00 J

8. A sample of 3.30 grams of an ideal gas at 150.0 °C and 1.25 atmospheres pressure has a volume of 2.00 liters. What is the molar mass of the gas? The gas constant, R, is 0.0821 L atm mol^{-1} K^{-1}).

a. 0.0218 gram/mole b. 16.2 grams/mole c. 37.0 grams/mole
d. 45.8 grams/mole e. 71.6 grams/mole

9. $CH_4(g) + 2\ O_2(g) \rightarrow CO_2(g) + 2\ H_2O(l)$; $\Delta H = -889.1$ kJ

$\Delta H_f^\circ\ H_2O(l) = -285.8$ kJ / mole

$\Delta H_f^\circ\ CO_2(g) = -393.3$ kJ / mole

What is the standard heat of formation of methane, $\Delta H_f^\circ\ CH_4(g)$, as calculated from the data above?

a. -107.5 kJ/mole b. -75.8 kJ/mole c. -210.0 kJ/mole
d. 75.8 kJ/mole e. 210.0 kJ/mole

10. 6.0 moles of chlorine gas are placed in a 3.0 L flask at 1250 K. At this temperature, the chlorine molecules begin to dissociate into chlorine atoms. What is the value of K_c, if 50.% of the chlorine molecules dissociate when equilibrium has been achieved?

a. 12.0 b. 6.0 c. 4.0 d. 3.0 e. 1.0

11. A sample of 0.1973 mole of nitrogen gas is confined at 37° C and 0.216 atmosphere. What would be the pressure of this sample at 15° C and the same volume?

a. 0.0876 atm b. 0.175 atm c. 0.201 atm d. 0.233 atm e. 0.533 atm

12. $H_2(g) + CO_2(g) \rightleftharpoons H_2O(g) + CO(g)$

Initially, a sealed vessel contained only $H_2(g)$ with a partial pressure of 6 atm and $CO_2(g)$ with a partial pressure of 4 atm. The reaction above was allowed to come to equilibrium at a temperature of 700 K. At equilibrium, the partial pressure due to CO(g) was found to be 2 atm. What is the value of the equilibrium constant K_p, for the reaction?

a. $\frac{1}{24}$ b. $\frac{1}{6}$ c. $\frac{1}{4}$ d. $\frac{1}{3}$ e. $\frac{1}{2}$

13. The density of a gas is directly proportional to its

a. volume b. pressure c. temperature d. kinetic energy e. molecular velocity

14. A 3.00-liter flask initially contains 1.50 mol of gas A and 0.450 mol of gas B. Gas A decomposes according to the following reaction: $3A \rightleftharpoons 2B + C$ The equilibrium concentration of gas C is 0.100 mol/L. Determine the equilibrium concentration of gas A.

a. 0.500 M b. 0.100 M c. 0.200 M d. 0.300 M e. none of these

15. At 25 °C, a sample of NH_3 (molar mass 17 grams) effuses at the rate of 0.050 mole per minute. Under the same conditions, which of the following gases effuses at approximately double that rate?

a. O_2 (molar mass 32 grams) b. He (molar mass 4.0 grams) c. CO_2 (molar mass 44 grams)
d. Cl_2 (molar mass 71 grams) e. CH_4 (molar mass 16 grams)

16. At constant temperature and pressure, the heats of formation for $H_2O(g)$, $CO_2(g)$ and $C_2H_6(g)$ are as follows:

Species	ΔH (kJ/mole)
$H_2O(g)$	-251
$CO_2(g)$	-393
$C_2H_6(g)$	-84

If ΔH values are negative for exothermic reactions, what is the ΔH for 1 mole of C_2H_6 gas to oxidize to carbon dioxide gas and water vapor (temperature and pressure are held constant)?

a. -8730 kJ/mole b. -2910 kJ/mole c. -1455 kJ/mole
d. 1455 kJ/mole e. 2910 kJ/mole

17. Which of the following statements correctly describes the signs of q and w for the following exothermic process at P = 1 atm and T = 370 K? $H_2O(g) \rightarrow H_2O(l)$

a. q is negative, w is positive b. q and w are negative c. q and w are both positive
d. q is positive, w is negative e. q and w are both zero.

18. Calculate the standard enthalpy of formation of acetylene (in $kJ.mol^{-1}$).

$2C_2H_2(g) + 5O_2(g) \rightleftharpoons 4CO_2(g) + 2H_2O(l)$ $\Delta H° = -2243.6$ kJ
$C(s) + O_2(g) \rightleftharpoons CO_2(g)$ $\Delta H° = -393.5$ kJ
$H_2(g) + ½\ O_2(g) \rightleftharpoons H_2O(l)$ $\Delta H° = -285.8$ kJ

a. 49.0 b. 98.0 c. 1121.8 d. 1564.3 e. 147.0

19. A sealed isothermal container initially contained 2 moles of CO gas and 3 moles of H_2 gas. The following reversible reaction occurred: $CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g)$
At equilibrium, there was 1 mole of CH_3OH in the container. What was the total number of moles of gas present in the container at equilibrium?

a. 1 b. 2 c. 3 d. 4 e. 5

20. Which of the following would express the approximate density of carbon dioxide gas at 0°C and 1.00 atm pressure (in grams per liter)?

a. 2 g/L b. 4 g/L c. 6 g/L d. 8 g/L e. none of the above

21. In which of the following reactions does $\Delta H°_f = \Delta H°_{rxn}$?

a. $O(g) + O_2(g) \rightarrow O_3(g)$ b. $H_2(g) + F_2(s) \rightarrow 2HF(g)$ c. $H_2(g) + FeO(s) \rightarrow H_2O(l) + Fe(s)$
d. $C(diamond) + O_2 \rightarrow CO_2(g)$ e. none of the reactions

22. For which reaction does $K_p = K_c$?

a. $2C(s) + O_2(g) \rightleftharpoons 2CO(g)$ b. $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$
c. $2H_2(g) + O_2(g) \rightleftharpoons 2H_2O(g)$ d. $H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$
e. $2S(s) + 3O_2(g) \rightleftharpoons 2SO_3(g)$

23. If the absolute temperature of a sample of gas is increased by a factor of 1.5, by what ratio does the average molecular speed of its molecules increase?

a. 1.2 b. 1.5 c. 2.2 d. 3.0 e. 0.75

24. The density of an unknown gas is 4.20 grams per liter at 3.00 atmospheres pressure and 127 °C. What is the molecular weight of this gas? (R = 0.0821 liter-atm / mole-K)

a. 14.6 b. 46.0 c. 88.0 d. 94.1 e. 138

25. A hydrocarbon gas with an empirical formula CH_2 has a density of 1.88 grams per liter at 0 °C and 1.00 atmosphere. A possible formula for the hydrocarbon is

a. CH_2 b. C_2H_4 c. C_3H_6 d. C_4H_8 e. C_5H_{10}

26. The standard enthalpy of formation for $NH_3(g)$ is -46.1 $kJ.mol^{-1}$. Calculate ΔH° for the reaction:
$2NH_3(g) \rightleftharpoons N_2(g) + 3H_2(g)$

a. -92.2 kJ b. -46.1 kJ c. 46.1 kJ d. 92.2 kJ e. 23.0 kJ

27. Oxygen, which is 16 times as dense as hydrogen, diffuses:

a. 1/16 times as fast. b. 1/4 times as fast. c. 4 times as fast.
d. 16 times as fast e. equally as fast as hydrogen.

28. A gaseous mixture containing 7.0 moles of nitrogen, 2.5 moles of oxygen, and 0.50 mole of helium exerts a total pressure of 0.90 atmosphere. What is the partial pressure of the nitrogen?

a. 6.3 atm b. 0.90 atm c. 0.63 atm d. 0.27 atm e. 0.13 atm

29. A sample of 5.0 grams of an ideal gas at 121 °C and 1.4 atmosphere pressure has a volume of 1.5 liters. Which of the following expressions is correct for the molar mass of the gas? The ideal gas constant, R, is 0.08 (L-atm) / (mole K).

a. [(0.08)(400)] / [(5.0)(1.4)(1.5)] b. [(l.4)(l.5)] / [(5.0)(0.08)(400)]
c. [(0.08)(1.4)(1.5)] / [(5.0)(400)] d. [(5.0)(0.08)(400)] / [(1.4)(1.5)]
e. [(5.0)(0.08)(1.5)] / (1.4)(400)]

30. A piece of metal weighing 418.6 grams was put into a boiling water bath. After 10 minutes, the metal was immediately placed in 250.0 grams of water at 40.0°C. The maximum temperature that the system reached was 50.0 °C. What is the specific heat of the metal? The specific heat of the water is 4.186 J/g°C.

a. 8.00 J/g°C b. 4.00 J/g°C c. 2.00 J/g°C d. 1.00 J/g°C e. 0.500 J/g°C

31. Two metals of equal mass with different heat capacities are subjected to the same amount of heat. Which undergoes the largest change in temperature?

a. The metal with the higher heat capacity b. The metal with the lower heat capacity.
c. Both undergo the same change in temperature d. You need to know the initial temperatures of the metals.
e. You need to know which metals you have.

32. For a certain reaction at 298K, the value of K is 1.2×10^{-1}. At 323K the value of K is 3.4×10^{-3}. This means that the reaction is:

a. endothermic. b. exothermic. c. never favorable.
d. More information is needed. e. None of these.

33. The equilibrium constant for the reaction: $CO(g) + H_2O(g) \rightleftharpoons CO_2(g) + H_2(g)$ is 26 at 50ºC. What is the K_c for $CO_2(g) + H_2(g) \rightleftharpoons CO(g) + H_2O(g)$ at the same temperature?

a. 0.34 b. 1.8×10^{4} c. 0.038 d. 5.7×10^{-5} e. 2.9

34. What is the heat capacity of a substance if it requires 1973 J to change the temperature of 55.0 g mercury from 15.0°C to 60.0°C?

a. 313 J/g °C b. 6.92×10^{-3} J/g °C c. 0.797 J/g °C d. 0.445 J/g °C e. 1.39 J/g °C

35. Given these two standard enthalpies of formation:

Reaction 1: $SO_2 \rightleftharpoons S(s) + O_2(g)$ (g) $\Delta H° = 295$ kJ/mole

Reaction 2: $S(s) + \frac{3}{2} O_2(g) \rightleftharpoons SO_3$ (g) $\Delta H° = -395$ kJ/mole

What is the heat of reaction for $2SO_3(g) \rightleftharpoons 2SO_2(g) + O_2(g)$ under the same conditions?

a. 1380 kJ/mole b. -200. kJ/mole c. 100 kJ/mole
d. 200. kJ/mole e. -100. kJ/mole

36. 73.0 grams of $O_2(g)$ and 73.0 grams of He(g) are in separate containers of equal volume. Both gases are at 197ºC. Which of the following statements is true?

a. Both gases would have the same pressure.
b. The average kinetic energy of the O_2 molecules is greater than that of the He molecules.
c. The pressure of the He(g) would be greater than that of the $O_2(g)$.
d. There are equal numbers of He molecules and O_2 molecules.
e. The average kinetic energy of the He molecules is greater than that of the O_2 molecules.

37. Which one of the following is NOT an assumption of the kinetic theory of gases?

a. Gas particles don't attract each other. b. Gas particles are in constant motion.
c. Gas particles are negligibly small. d. Gas particles undergo elastic collisions.
e. Gas particles undergo a decrease in kinetic energy when passed from a region of high pressure to a region of low pressure.

38. Sulfur trioxide gas dissociates into sulfur dioxide gas and oxygen gas at 1250°C. In an experiment 3.60 moles of sulfur trioxide were placed into an evacuated 3.0 L flask. The concentration of sulfur dioxide gas measured at equilibrium was found to be 0.20 M. What is the equilibrium constant K_c, for the reaction?

a. 8.0×10^{-3} b. 4.0×10^{-3} c. 2.0×10^{-3} d. 1.0×10^{-3} e. 1.6×10^{-4}

39. Given the following information:

Reaction 1: $H_2(g) + ½\ O_2(g) \rightarrow H_2O(l)$ $\Delta H° = -286$ kJ

Reaction 2: $C(s) + O_2(g) \rightarrow CO_2(g)$ $\Delta H° = -394$ kJ

Reaction 3: $2CO_2(g) + H_2O(l) \rightarrow C_2H_2(g) + \frac{5}{2} O_2(g)$ $\Delta H° = 1300$ kJ

Find $\Delta H°$ for the reaction: $C_2H_2(g) \rightarrow 2C(s) + H_2(g)$

a. -226 kJ b. -113 kJ c. 113 kJ d. 226 kJ e. 452 kJ

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AP Chemistry Exam II
Part II: Essays. Show ALL work below. Work should be done in a clear and orderly fashion and in pen.

#1. 2003 - #2 (edited)
A rigid 11.06 L cylinder contains 19.73 g of $Cl_2(g)$ and 19.73 g of $F_2(g)$.
(a) Calculate the total pressure, in atm, of the gas mixture in the cylinder at 298 K.
(b) The temperature of the gas mixture in the cylinder is increased to 370 K. Calculate each of the following.
(i) The mole fraction of $F_2(g)$ in the cylinder
(ii) The partial pressure, in atm, of $F_2(g)$ in the cylinder
(c) If the chlorine molecules travel at a rate of 361 m/s at 370 K, at what rate will the fluorine molecules travel?

A different rigid 3.70 L cylinder contains 0.973 mol of $NO(g)$ at 298 K. A 0.973 mol sample of $O_2(g)$ is added to the cylinder, where a reaction occurs to produce $NO_2(g)$.
(d) Write the balanced equation for the reaction.
(e) Calculate the total pressure, in atm, in the cylinder at 298 K after the reaction is complete.

#2. 1995 - #2 (edited)

Butane, C_4H_{10}, is a hydrocarbon that is commonly used as fuel for in lighters.

(a) Write a balanced equation for the complete combustion of butane gas, which yields $CO_2(g)$ and $H_2O(l)$.
(b) Calculate the volume of air at 73°C and 1.00 atmospheres that is needed to burn completely 37.0 grams of butane. Assume that air is 21.0 percent O_2 by volume.
(c) The heat of combustion of butane is -2,881.9 kJ/mol. Calculate the heat of formation, $\Delta H°_f$, of butane given that $\Delta H°_f$ of $H_2O(l)$ = -285.3 kJ/mol and $\Delta H°_f$ of $CO_2(g)$ = -393.5 kJ/mol.
(d) If the enthalpy of vaporization for $H_2O(l)$ is 44.0 kJ/mol, what is $\Delta H°$ for the combustion reaction above if $H_2O(g)$ is formed instead of $H_2O(l)$?
(e) Assuming that all of the heat evolved in burning 73.0 grams of butane is transferred to 11.06 kilograms of water (specific heat = 4.184 J/g · K), calculate the increase in temperature of the water.

#3. 2008B - #1 (edited)

Answer the following questions regarding the decomposition of arsenic pentafluoride, $AsF_5(g)$.

(a) A 60.55 g sample of $AsF_5(g)$ is introduced into an evacuated 5.50 L container at 176°C.

(i) What is the initial molar concentration of $AsF_5(g)$ in the container?

(ii) What is the initial pressure, in atmospheres, of the $AsF_5(g)$ in the container?

At 176°C, $AsF_5(g)$ decomposes into $AsF_3(g)$ and $F_2(g)$ according to the following chemical equation.

$$AsF_5(g) \rightleftharpoons AsF_3(g) + F_2(g)$$

(b) In terms of molar concentrations, write the equilibrium-constant expression for the decomposition of $AsF_5(g)$.

(c) When equilibrium is established, 55.6 percent of the original number of moles of $AsF_5(g)$ has decomposed.

(i) Calculate the molar concentration of $AsF_5(g)$ at equilibrium.

(ii) Using molar concentrations, calculate the value of the equilibrium constant, K_{eq} , at 176°C.

(d) Calculate the mole fraction of $F_2(g)$ in the container at equilibrium.

#4. 1995 - #1 (edited)

$$H_2O(g) + CO(g) \rightleftharpoons H_2(g) + CO_2(g)$$

When $H_2O(g)$ is mixed with CO(g) at 1,973K, equilibrium is achieved according to the equation above.
In one experiment, the following equilibrium concentrations were measured.

$[H_2O] = [CO] = 0.45$ mol/L
$[H_2] = 0.30$ mol/L
$[CO_2] = 0.40$ mol/L

(a) What is the mole fraction of $CO_2(g)$ in the equilibrium mixture?
(b) Using the equilibrium concentrations given above, calculate the value of K_c, the equilibrium constant for the reaction.
(c) Determine K_p, in terms of K_c for this system.
(d) When the system is heated from 1,973 K to a higher temperature, 37.0 percent of the CO(g) is converted to $CO_2(g)$. Calculate the value of K_c at this higher temperature.
(e) In a different experiment, 0.73 mole of $H_2O(g)$ is mixed with 0.73 mole of CO(g) in a 3.0-liter reaction vessel at 1,973 K. Calculate the equilibrium concentration, in moles per liter, of $H_2(g)$ at this temperature.