Chemistry 1A, Spring 2007

Midterm Exam 3
April 9, 2007
(90 min, closed book)

Name:_____KEY_____

SID:_____

TA Name:_____

1.) Write your name on every page of this exam.

2.) This exam has 34 multiple choice questions. Fill in the Scantron form AND circle your answer on the exam.

3.) There is no penalty for guessing, so answer every question.

4.) Some questions may require bubbling in more than one choice to receive credit.

Name_____

$E = h\nu$

$\lambda\nu = c$

$\lambda_{deBroglie} = h / p = h / mv$

E_{kin} (e-) = $h\nu - \Phi = h\nu - h\nu_0$

$$E_n = -\frac{Z^2}{n^2} R_\infty$$

$\Delta x \, \Delta p \sim h$

$p = mv$

Particle in a box (1-D Quantum):

$E_n = h^2n^2/8mL^2$; n = 1, 2, 3...

$PV = nRT$

$$E_{kin} = \frac{3}{2} RT$$

$$v_{rms} = \sqrt{\frac{3RT}{M}}$$

$\Delta E = q + w$

$w = - P_{ext}\Delta V$

$$\Delta E = \frac{3}{2} nR\Delta T$$

$N_0 = 6.02214 \times 10^{23}$ mol^{-1}

$R_\infty = 2.179874 \times 10^{-18}$ J

$R_\infty = 3.28984 \times 10^{15}$ Hz

$k = 1.38066 \times 10^{-23}$ J K^{-1}

$h = 6.62608 \times 10^{-34}$ J s

$m_e = 9.101939 \times 10^{-31}$ kg

$c = 2.99792 \times 10^{8}$ m s^{-1}

Gas Constant:

R = 8.31451 J K^{-1} mol^{-1}

R = 8.20578 x 10^{-2} L atm K^{-1} mol^{-1}

T (K) = T (C) + 273.15

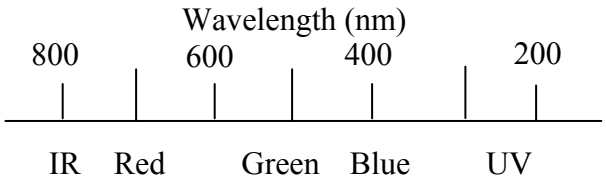
F = 96,485 C / mol

1 V = 1 J / C 1 nm = 10^{-9} m

1 kJ = 1000 J

C_p(water) = 4.184 kJ/^{o}C·g

Color and Wavelength of Light



$\Delta G° = \Delta H° - T\Delta S°$

$\Delta H° = \Sigma \Delta H°_f$ (products) - $\Sigma \Delta H°_f$ (reactants)

$\Delta S° = \Sigma S°$ (products) - $\Sigma S°$ (reactants)

$\Delta G° = \Sigma \Delta G°_f$ (products) - $\Sigma \Delta G°_f$ (reactants)

$S = k_B \ln W$

$\Delta G° = - RT\ln K$

$$\ln K = -\frac{\Delta H°}{R}\frac{1}{T} + \frac{\Delta S°}{R}$$

$\Delta G° = - nF\Delta Є^o$

$pX = - \log X$

$$pH = pK_a + \log\frac{[A^-]}{[HA]}$$

Name_____

1.) A mixture of 1.00 g of H_2 and 1.00 g of He exerts a pressure of 0.480 atm. What is the partial pressure of each gas in the mixture?

A) $P_{H2} = 0.240$ atm $P_{He} = 0.240$ atm
B) $P_{H2} = 0.320$ atm $P_{He} = 0.160$ atm
C) $P_{H2} = 0.160$ atm $P_{He} = 0.320$ atm
D) $P_{H2} = 0.384$ atm $P_{He} = 0.096$ atm
E) $P_{H2} = 0.096$ atm $P_{He} = 0.384$ atm

2.) Consider the balanced reaction for the combustion of octanol:

$$C_8H_{18}O\,(g) + 12\ O_2\,(g) \rightarrow 8\ CO_2\,(g) + 9\ H_2O\,(g)$$

What volume of carbon dioxide gas will be produced from 5.00 g of octanol and a stoichiometric amount of oxygen if the reaction is carried out at 28°C and 0.984 atm?

A) 0.308 L B) 6.89 L C) 7.72 L D) 8.69 L E) 0.966 L

3.) Which change(s) in a sample of ideal gas would have the same effect on the pressure as increasing the velocity of the particles? Mark all that apply.

A) Increase in temperature.
B) Increase in volume.
C) Decrease in pressure
D) Increase in the number of moles of gas.
E) None of these.

4.) What is the pressure required to compress a 1.00 L sample of air at 1.00 atm to 0.400 L at 25°C?

A) 1.0 atm B) 1.5 atm C) 2.0 atm D) 2.5 atm E) 3.0 atm

Name_____

For the next three questions, consider four flasks filled with 1.0 mol of different gasses:

Flask A: O_2 at 760 torr and 10°C.
Flask B: N_2 at 900 torr and 80°C.
Flask C: He at 800 torr and 10°C.
Flask D: He at 500 torr and 80°C.

5.) Which flask(s) will have molecules with the greatest average kinetic energy? B, D

6.) Which flask(s) will have molecules with the greatest root mean square velocity? D

7.) Which flask(s) will have the greatest number of collisions per second with the walls of the container? B

For the next four questions consider a system which releases 546 kJ of heat while its internal energy drops by 125 kJ.

8.) What can you infer about the process? Mark all that apply.

A) Work is involved.
B) The entropy of the system decreases.
C) It is spontaneous.
D) The first law of thermodynamics does not apply.

9.) Based on the information given, which relationship(s) should be used to calculate the amount of work involved? Mark all that apply.

A) $w = -P\,\Delta V$
B) $\Delta E = q + w$
C) $q_{system} = q_{surroundings}$
D) $w = -RT\ln K$
E) $S = k_B \ln W$

10.) How much work is done (if any) in kJ?

A) -125 B) -421 C) +125 D) +421 E) 0

11.) What best characterizes the work done?

A) Work is done on the system.
B) Work is done by the system.
C) Work is done both on and by the system.
D) Cannot determine based on the information provided.

Name_____

12.) A system undergoes a change that can be broken down into two steps: 1) the system does 70 J of work while absorbing 62 J of heat, and 2) the system releases 29 J of heat while 94 J of work is being done on it. What is the overall energy change of the system?

A) +57 J B) -57 J C) +9 J D) -9 J E) +255 J

13.) Consider the chemical reaction that occurs in a hydrogen fuel cell:

$$2\ H_2\ (g) + O_2\ (g) \rightarrow 2\ H_2O\ (l) \qquad \Delta H = -572\ kJ$$

What is the heat change (in kJ) when 186 g of oxygen reacts with excess hydrogen?

A) -5720 B) +5720 C) +3320 D) -3320 E) -1660

14.) Consider the following reactions carried out at a constant temperature and pressure. In which of these will the amount of work done be positive? Hint: only the coefficients of the reactants are given. All species are gas unless otherwise noted.

A) The synthesis reaction of 2 mol SO_2 and 1 mol O_2 to give SO_3.
B) The synthesis reaction of 4 mol NO to give O_2 and N_2.
C) The decomposition reaction of 2 mol CCl_2O to give CO and Cl_2.
D) The combustion of 2 mol CH_3OH.
E) The conversion of 2 mol of solid I_2 to gaseous I_2.

15.) Consider the reaction for which $\Delta H^o \sim 200$ kJ/mol and $\Delta S^o \sim 100$ J/mol

$$CaO\ (s) + CO_2\ (g) \rightarrow CaCO_3\ (g)$$

Under which condition(s) will this reaction be spontaneous?

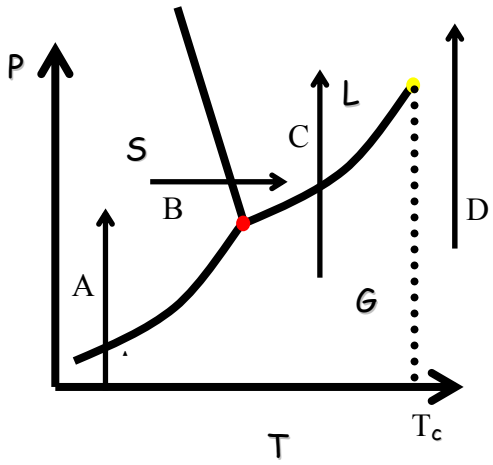
A) At high temperatures.
B) At low temperatures.
C) The reaction will always be spontaneous.
D) The reaction will never be spontaneous.

Name_____

16.) A 46.2 g sample of Cu is heated to 95.4°C and then placed in a calorimeter with 75.0 g of water at 19.6°C. The final temperature of the water is 21.8°C. What is the heat capacity of the Cu in kJ/ °C·g if the calorimeter does not absorb any heat?

A) 0.203 B) -0.203 C) 0.0770 D) -0.0770 E) 4.18

Use the following phase diagram to answer the next three questions:



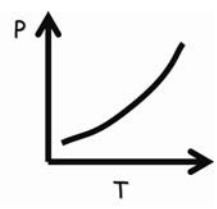
17.) Along which *isotherm(s)* will a phase change be observed? Mark all that apply.

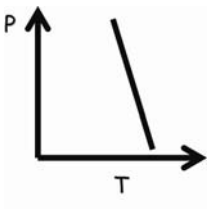
A) A B) B C) C D) D E) none of these

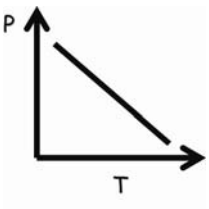
18.) Along which line will there be a positive change in entropy? Mark all that apply.

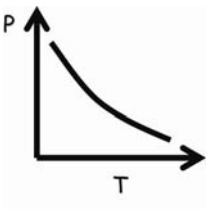
A) A B) B C) C D) D E) none of these

19.) Which of the following represents a plot of the vapor pressure vs. T?

A) 

B) 

C) 

D) 

Name_____

For the next five questions, consider the gas phase reaction $N_2 + 3\ H_2 \leftrightarrow 2\ NH_3$ with an equilibrium constant of K = 0.278 at 800 K. The entropies of formation (in kJ/mol) are: H_2=130.6, N_2=191.5, & NH_3=192.3.

20.) What is the standard entropy change associated with this reaction (J/mol)?

A) –198.7 B) –129.8 C) -99.4 D) 129.8 E) 198.7

21.) Which is the free energy change associated with this reaction in kJ/ mol?

A) –84.0 B) +84.0 C) -8.51 D) +8.51 E) +4.26

22.) Analysis of a reaction mixture yielded the following partial pressures: N_2 = 0.417 atm, H_2= 0.524 atm and NH_3= 0.122 atm. What is the reaction quotient for the reaction?

A) 0.116 B) 0.248 C) 2.90 D) 1.91 E) 0.881

23.) Which best describes the condition of the reaction mixture in the previous question?

A) The reaction mixture is at equilibrium.
B) The reaction mixture is not at equilibrium – it will proceed toward reactants.
C) The reaction mixture is not at equilibrium – it will proceed toward products.
D) Can't tell.

24.) If equilibrium is reached for this reaction, and the volume of the container is then reduced by a factor of two. Which best describes how the reaction mixture will proceed?

A) Toward products.
B) Toward reactants.
C) No change.

Name_____

Consider the following three reactions for the next two questions:

1) $N_2\,(g) + O_2\,(g) \rightarrow 2\,NO\,(g)$ K_1

2) $N_2\,(g) + 2\,O_2\,(g) \rightarrow 2\,NO_2\,(g)$ K_2

3) $2\,NO\,(g) + O_2\,(g) \rightarrow 2\,NO_2\,(g)$ K_3

25.) What is an expression for the reaction quotient for reaction 1?

A) $P_{N2}\,P_{O2} / P_{NO}$
B) $P_{NO} / P_{N2}\,P_{O2}$
C) $P_{N2}\,(P_{O2})^2 / P_{NO}$
D) $P_{NO}\,P_{N2} / (P_{O2})^2$
E) $(P_{NO})^2 / P_{N2}\,P_{O2}$

26.) What is an expression for K_3?

A) K_2/K_1 B) $(K_1)^2\,K_2$ C) $K_1\,K_2$ D) K_1/K_2 E) $1/(K_1)^2$

27.) What is the effect on reaction 3 if the partial pressure of NO is increased at equilibrium?

A) an decrease in the partial pressure of O_2
B) a shift toward reactants
C) a shift toward products
D) a change in the K_1
E) none of these

28.) Given that the reaction is endothermic, what is the effect of increasing the temperature of reaction 1 at equilibrium? Mark all that apply.

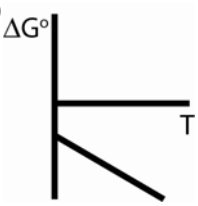
A) An decrease in the partial pressure of O_2.
B) A shift toward reactants.
C) A shift toward products.
D) A change in K_1.
E) None of these.

29.) What is the reaction quotient after the volume is halved for reaction 1 at equilibrium?

A) $Q = K_1$ B) $Q = 2K_1$ C) $Q = ½\,K_1$ D) $Q = ¼\,K_1$ E) $Q = 4K_1$

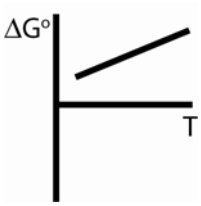
Name_____

30.) Which of the following is the correct plot of ΔG^o vs. T for the evaporation of water?

A) 

B) 

C) 

D) 

31.) The equilibrium position is quantified by the equilibrium constant, K. Which of the following generalized statements regarding K is *false*? Mark all that apply.

A) When K is larger than 1, the equilibrium position favors the formation of products.
B) When K is larger than 1, the value of ΔG^o for the reaction is always negative.
C) When K is equal to 1, the number of moles of reactants is always equal to the number of moles of product.
D) When K is larger than 1, the forward reaction is always occurring faster than the reverse reaction is.
E) When K is smaller than 1, the value of ΔH for the reaction is always negative.

32.) In order to determine the identity of a compound with a molecular formula of C_xH_y you carry out an experiment with a Dumas bulb. In a bath of boiling water, you determine that a 2.0 L Dumas bulb will hold exactly 1.829 g of gaseous unknown. If the atmospheric pressure is 1.0 atm, what is the identity of your unknown?

A) CH_4 B) C_2H_2 C) C_2H_4 D) C_2H_6 E) C_3H_6

33.) Recall the experiment that you did in lab to determine ΔH for the reaction between magnesium oxide and hydrochloric acid. Which of the following would result in ΔH value that is *more exothermic* than the actual value?

A) The top of the calorimeter is not on tightly.
B) The student accidentally put some ice into the calorimeter when determining the calorimeter constant, K_{cal}.
C) The heat capacity of the solution is actually smaller than the heat capacity of pure water.
D) None of the above will result in a low enthalpy of reaction.

Name_____

34.) Potassium thiocynate (KSCN) is a very soluble salt. Iron thiocyanate is a red complex ion that forms from the combination of iron (III) which is yellow and thiocynate ions which are transparent:

$$Fe^{3+} + SCN^{-} \leftrightarrow FeSCN^{2+}$$

The equilibrium constant for the formation of iron thiocynate is moderate. What will happen to the color of the solution as potassium thiocynate is introduced into a test tube containing equal amounts of iron and thiocyanate?

A) The color will not change.
B) The solution will become redder.
C) The solution will become more transparent.
D) The solution will become more yellow.
E) Cannot determine the color change based on the information provided.