KEY

Chemistry 1A, Fall2003

Midterm Exam III, Version A
November 13, 2003
(90 min, closed book)

Name:___________________

SID:_____________________

TA Name:________________

- Write your name on every page of this exam.
- This exam is multiple choice. Fill in the Scantron form AND circle your answer on the exam.
- There are 40 multiple choice questions. 3.75 points each
- The questions can be worked in any order. Do those that you can do quickly first, then work the other questions.

Potentially useful relations:

$E = h\nu$
$\lambda\nu = c$
$\lambda_{deBroglie} = h / p = h / mv$
$p = mv$
$E_{kin} = \frac{1}{2} mv^2$
$E_{kin}(e\text{-}) = h\nu - \Phi = h\nu - h\nu_0$

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

$PV = nRT$

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

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

$\Delta E = q + w$
$w = - P_{ext}\Delta V$

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

$N_0 = 6.02214 \times 10^{23}\ mol^{-1}$
$R_\infty = 2.179874 \times 10^{-18}\ J$
$R_\infty = 3.28984 \times 10^{15}\ Hz$
$k = 1.38066 \times 10^{-23}\ J\ K^{-1}$
$h = 6.62608 \times 10^{-34}\ J\ s$
$m_e = 9.101939 \times 10^{-31}\ kg$
$c = 2.99792 \times 10^{8}\ m\ s^{-1}$
Gas Constant:
$R = 8.31451\ J\ K^{-1}\ mol^{-1}$
$R = 8.20578 \times 10^{-2}\ L\ atm\ K^{-1}\ mol^{-1}$
$T (K) = T (C) + 273.15$
$F = 96{,}485\ C / mol$
$1\ V = 1\ J / C$ $1\ nm = 10^{-9}\ m$
$1\ kJ = 1000\ J$
$Cp(H_2O) = 4.184 J/g\ K$

$\Delta G° = \Delta H° - T\Delta S°$
$\Delta H° = \Sigma\ \Delta H°_f$ (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)
$S = k_B \ln W$

for $aA + bB \rightleftarrows cC + dD$

$$Q = \frac{[C]^c[D]^d}{[A]^a[B]^b}$$ At equilibrium, Q = K

$\Delta G° = - RT\ln K$

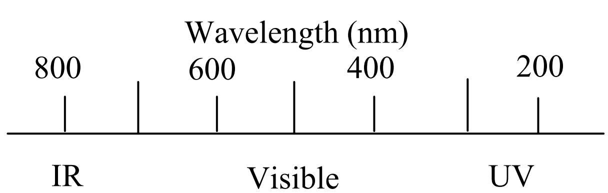
$$\ln K = -\frac{\Delta H°}{R}\frac{1}{T} + \frac{\Delta S°}{R}$$

$\Delta G° = - nF\Delta\mathcal{E}°$

$pX = - \log X$

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

Color and Wavelength of Light



ΔG° of Formation

compound	ΔG° (kJ / mol)
CO_2	-394.36
H_2O (g)	-228.57
$C_6H_{12}O_6$	-910
O_2	0

Name________________________

SECTION 1: EQUILIBRIUM

For questions 1 – 11 consider the following three reactions at 298 K.

I. $2\ SO_3\ (g) \leftrightarrow 3\ O_2\ (g) + 2\ S\ (s)$ K = 0.225 $\Delta H^\circ = +791$ kJ
II. $S\ (s) + O_2\ (g) \leftrightarrow SO_2\ (g)$ K = 225 $\Delta H^\circ = -270$ kJ
III. $2\ SO_3\ (g) \leftrightarrow O_2\ (g) + 2\ SO_2\ (g)$

1.) What is the equilibrium constant for a mixture of O_2, SO_3 and SO_2 gas (rxn. **III**)?

A) 75.5
B) 112
$\boxed{\text{C) } 1.1 \times 10^4}$
D) 2.5×10^{-5}
E) 0.775

2.) What is the value of the equilibrium constant for rxn **I** if at equilibrium the flask contains 0.236 atm SO_3, 0.500 atm O_2, and 0.01 g Sulfur after a temperature change.

A) 0.0909
B) 11.0
C) 1.63×10^{-5}
D) 6.25×10^{-2}
$\boxed{\text{E) } 2.24}$

3.) .What change has occurred if the value of K for rxn **I** is found to be 0.552?

$\boxed{\text{A) An increase in temperature.}}$
B) A decrease in temperature.
C) An increase in pressure.
D) An increase in volume.
E) cannot be determined.

4.) Which is a suitable expression for the reaction quotient for the formation of SO_2 from the elements?

A) $P(O_2) / P(SO_2)$
B) $P(O_2)\ P^2(SO_2) / P(S)$
C) $P(O_2) / P^2(SO_2)P(S)$
$\boxed{\text{D) } P(SO_2) / P(O_2)}$
E) Nothing can be said with the information given.

5.) What is ΔH° for reaction **III**?

A) 333 kJ
$\boxed{\text{B) 251 kJ}}$
C) 1.7×10^3 kJ
D) 5 kJ
E) 76 kJ

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6.) Which is the best arrangement of the relative enthalpies of formation of compounds O_2, SO_3, and SO_2?

ΔH	A)	B)	C)	D)	E)
↑	O_2	O_2	SO_3	SO_2	SO_2
	SO_3	SO_2	SO_2	SO_3	O_2
	SO_2	SO_3	O_2	O_2	SO_3

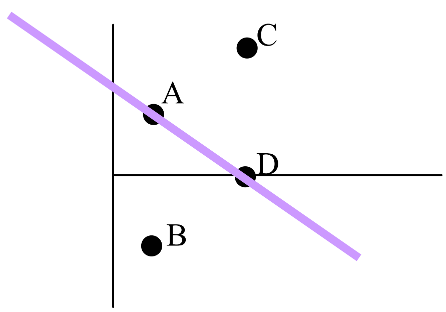
7.) What is the best prediction of ΔS° for reaction **I** at 298K?

A) $\Delta S^\circ > 0$
B) $\Delta S^\circ = 0$
C) $\Delta S^\circ < 0$
D) $\Delta S^\circ \leq 0$
E) $\Delta S^\circ \geq 0$

8.) What can you say about reaction **I** at 298 K?

A) It is exothermic.
B) It is spontaneous.
C) It is not spontaneous.
D) It is at equilibrium. **(this was also accepted because conditions weren't specified)**
E) It releases heat.

9.) The correct plot for lnK vs 1/T for reaction **I** would pass through which pair of points (fill in both points on scantron sheet)?



10.) From which of the following starting conditions would it be impossible for equilibrium to be achieved for reaction **II**?

A) Pure SO_2 (g).
B) A mixture of SO_2 (g), O_2 (g), and S (s).
C) A mixture of SO_2 (g) and O_2 (g).
D) Pure O_2 (g) and S (s).
E) Equilibrium can be achieved from any of these starting conditions.

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11.) Which occurs when adding S (s) to the equilibrium described by reactions **I**, **II** and **III**?

A) A decrease in the pressure of SO_3(g).
B) A decrease the pressure of SO_2(g).
C) An increase in the value of the equilibrium constant.
D) An increase in the total pressure of the system.
E) No change in the equilibrium.

Continue with the next question:

12.) For the reaction

$A(l) + 2D(g) \rightarrow 3X(g) + Z(s)$
having ΔG° = -2400 kJ at 25˚C, the equilibrium mixture __________.
A) will consist almost exclusively of A and D.
B) will consist almost exclusively of A and Z.
C) will consist almost exclusively of X and Z.
D) will consist of significant amounts of A, D, X, and Z.
E) has a composition predictable only if one knows T and ΔH° and ΔS°.

13.) The equilibrium constant for the reaction below at 25˚C is 4.8×10^{-6}. Calculate the equilibrium concentration (mol/L) of Cl_2 (g) if the initial concentration of ICl (g) is 1.33 mol/L. There is no I_2 or Cl_2 initially present.

$2ICl(g) \leftrightarrow I_2(g) + Cl_2(g)$

A) 2.9×10^{-3}
B) 5.8×10^{-3}
C) 3.2×10^{-6}
D) 6.4×10^{-6}
E) 343

14.) Which of the following equilibria, will shift to the left in response to a decrease in volume?

A) $H_2(g) + Cl_2(g) \leftrightarrow 2\,HCl(g)$
B) $2\,SO_3(g) \leftrightarrow 2\,SO_2(g) + O_2(g)$
C) $N_2(g) + 3\,H_2(g) \leftrightarrow 2\,NH_3(g)$
D) $4\,Fe(s) + 3\,O_2(g) \leftrightarrow 2\,Fe_2O_3(s)$
E) $2HI(g) \leftrightarrow H_2(g) + I_2(g)$

Name_________________________

15.) Consider the following reaction at equilibrium:

$$2CO_2(g) \leftrightarrow 2CO(g) + O_2(g) \qquad \Delta H^\circ = -514 \text{ kJ}$$

How can the yield of CO(g) be maximized ?

A) at high temperature and high pressure
B) at high temperature and low pressure
C) at low temperature and low pressure
D) at low temperature and high pressure
E) in the presence of solid carbon

16.) Which is true for every reaction if the temperature is raised?

A) Chemical reactions favor products.
B) Chemical reactions favor reactants.
C) No change is observed.
D) Equilibrium constants increase.
E) None of these.

For the following three questions, consider the equilibrium $PbSO_4$ (s) $\leftrightarrow$ Pb^{2+} (aq) + SO_4^{-2} (aq) which has a $K_{sp} = 1.6 \times 10^{-8}$ at 298 K

17.) What is the concentration of lead ions in water (M) when solid $PbSO_4$ is present?

A) 1.6×10^{-10}
B) 1.3×10^{-4}
C) 1.0
D) 1.1×10^{4}
E) 22.5

18.) What is the concentration of lead ions (M) in 0.01 M $NaSO_4$ ($K_{sp} \sim 10^{8}$) when solid $PbSO_4$ is present?

A) 1.6×10^{-6}
B) 1.3×10^{-4}
C) 1.0
D) 1.1×10^{4}
E) 22.5

19.) What is ΔG° for the dissolution of lead sulfate at 298 K (kJ/mol)?

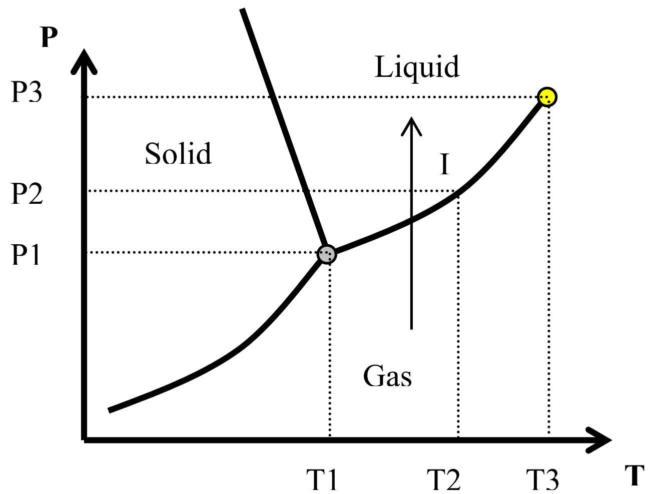
A) 44
B) -13
C) 5.9
D) 1.1×10^{4}
E) 2.3×10^{-3}

Name_________________________

Continue with the next question:

SECTION 2: PHASES OF MATTER

For the following questions consider the phase diagram for water below.



20.) At which point are gas, liquid and solid all in equilibrium?

A) (T2, P2)
B) (T2, P1)
C) (T1, P1)
D) (T3, P1)
E) (T3, P3)

21.) Arrow I corresponds to:

A) Constant pressure
B) Equilibrium
C) Sublimation
D) Condensation
E) Melting

22.) Along the curve containing the points (T2, P2) and (T3, P3):

A) Solid, liquid and gas are all in equilibrium.
B) Liquid and gas are in equilibrium.
C) The vapor pressure is constant.
D) The gas cannot be condensed at any pressure.
E) Only the solid phase is observed.

23.) At the point (T2, P3) the substance is:

A) In equilibrium between liquid and gas.
B) A liquid.
C) A gas.
D) A supercritical fluid.
E) A solid.

24.) Which is true at temperatures above T3?

A) Solid, liquid and gas are all in equilibrium.
B) Liquid and gas are in equilibrium.
C) The vapor pressure is constant.
D) The gas cannot be condensed at any pressure.
E) Only the solid phase is observed.

25.) Which intermolecular force predominates in the condensation of water?

A) H-bonding
B) Van der Wals
C) London
D) Ion-Ion
E) Dipole-Ion

Continue with the next question:

SECTION 3: THERMODYNAMICS

26.) Which one of the following is always positive when a spontaneous process occurs?

A) ΔSsystem
B) $\Delta S_{surroundings}$
C) $\Delta S_{universe}$
D) $\Delta H_{universe}$
E) $\Delta H_{surroundings}$

27.) Which is true of the entropy of the universe?

A) conserved.
B) continually decreasing.
C) continually increasing.
D) equal to zero.
E) equal to the energy, E.

28.) Which is a state function (mark all that apply)?

A) flame heating.
B) enthalpy.
C) entropy.
D) electrical work.
E) none of these.

29.) What is the change in the internal energy (in J) of a system that releases 1000 J of heat and does 225 J of work on the surroundings?

A) -10,155
B) -1225
C) -775
D) 775
E) 1225

Name_________________________

30.) What do you expect the temperature change to be for the rapid, adiabatic compression of a gas from 1.0 atm to 3.0 atm?

A) -10K
B) 100K
C) 0.001K
D) -100K
E) -0.001K

31.) A bar of hot metal is placed in water in an insulated container and the two are allowed to reach thermal equilibrium. When1.0 kg of metal at 100˚C is placed in 2.0 kg of water, the temperature water bath raises from 20˚C to 25˚C. What is the specific heat capacity of the metal (J/g K)?

A) 0.5
B) 1.5
C) 0.22
D) 25
E) .025

32.) Which is the best estimate for the boiling point of benzene (˚C) given that ΔH° of vaporization is 31 kJ/mol and ΔS° of vaporization is 90 J/mol K?

A) 25
B) 45
C) 65
D) 15
E) 5

33.) Which is the first step in a realistic experiment to determine the entropy change for a chemical reaction?

A) Measuring ΔH°.
B) Counting the microstates.
C) Counting the change in microstates.
D) Measuring how the K varies with temperature.
E) The entropy change cannot be measured for chemical reactions.

34.) The value of ΔH° for the following reaction is -3351 kJ.

$$2\ Al(s) + 3O_2(g) \rightarrow 2Al_2O_3(s)$$

What is ΔH° for the formation of 75.0 g of $Al_2O_3(s)$ (kJ)?
A) $-2.51 \times 10^{?}$
B) -1.26×10^{5}
C) -2460
D) -1230
E) +3351

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35.) Which of the following has a non-zeron ΔH_f°?

$\boxed{\text{A) } O_2(l)}$
B) C(graphite)
C) $N_2(g)$
D) $F_2(g)$
E) $Cl_2(g)$

36.) Which one of the following processes is endothermic?

A) $2H_2(g) + O_2(g) \rightarrow 2H_2O(g)$
B) $H_2O(g) \rightarrow H_2O(l)$
C) $CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g)$
$\boxed{\text{D) } H_2O(s) \rightarrow H_2O(l)}$
E) $2Al(s) + Fe_2O_3(s) \rightarrow Al_2O_3(s) + 2Fe(l)$

37.) Which is true for the following reaction under standard conditions?

$C_2H_6(g) \rightarrow C_2H_4(g) + H_2(g)$
ΔH° is 137 kJ and ΔS° is 120 J/K.

A) spontaneous at all temperatures
$\boxed{\text{B) spontaneous only at high temperature}}$
C) spontaneous only at low temperature
D) not spontaneous at all temperatures
E) cannot be determined

38.) Given the following

Substance	ΔH°_f(kJ/mol)
$SO_2(g)$	-297
$SO_3(g)$	-396
$SO_2Cl_2(g)$	-364
$H_2SO_4(l)$	-814
$H_2O(l)$	-286

Calculate the amount of heat (in kJ) evolved when 11.25 g of SO_2 reacts according to the equation:

$SO_2(g) + Cl_2(g) \rightarrow SO_2Cl_2(g)$

A) 100.5
B) 8.550×10^5
C) 47.5
$\boxed{\text{D) } 11.25}$
E) Insufficient data are given. **(this also accepted because the real answer was 11.78)**

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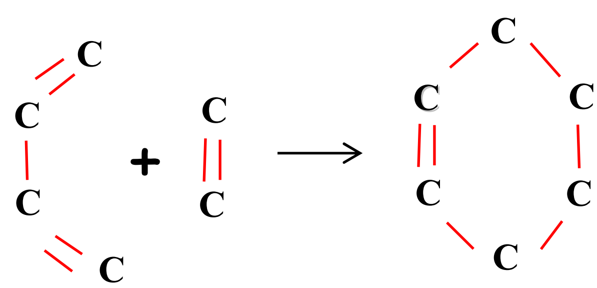
39.) We have seen many times in lecture that heat is given off in the combustion of hydrogen gas. Which of the following is responsible for the heat ?

A) Breaking H-H and O-O bonds.
B) Breaking O-H bonds.
C) Forming H-H bonds and O-O bonds.
D) Forming O-H bonds.
E) Condensation of the water formed.

40.) What can you say about the reaction if the ratio of the C=C double bond strength to the C-C single bond strength is less than two?



A) The reaction is exothermic.
B) The reaction is endothermic.
C) The reaction is spontaneous.
D) The enthalpy change is about zero.